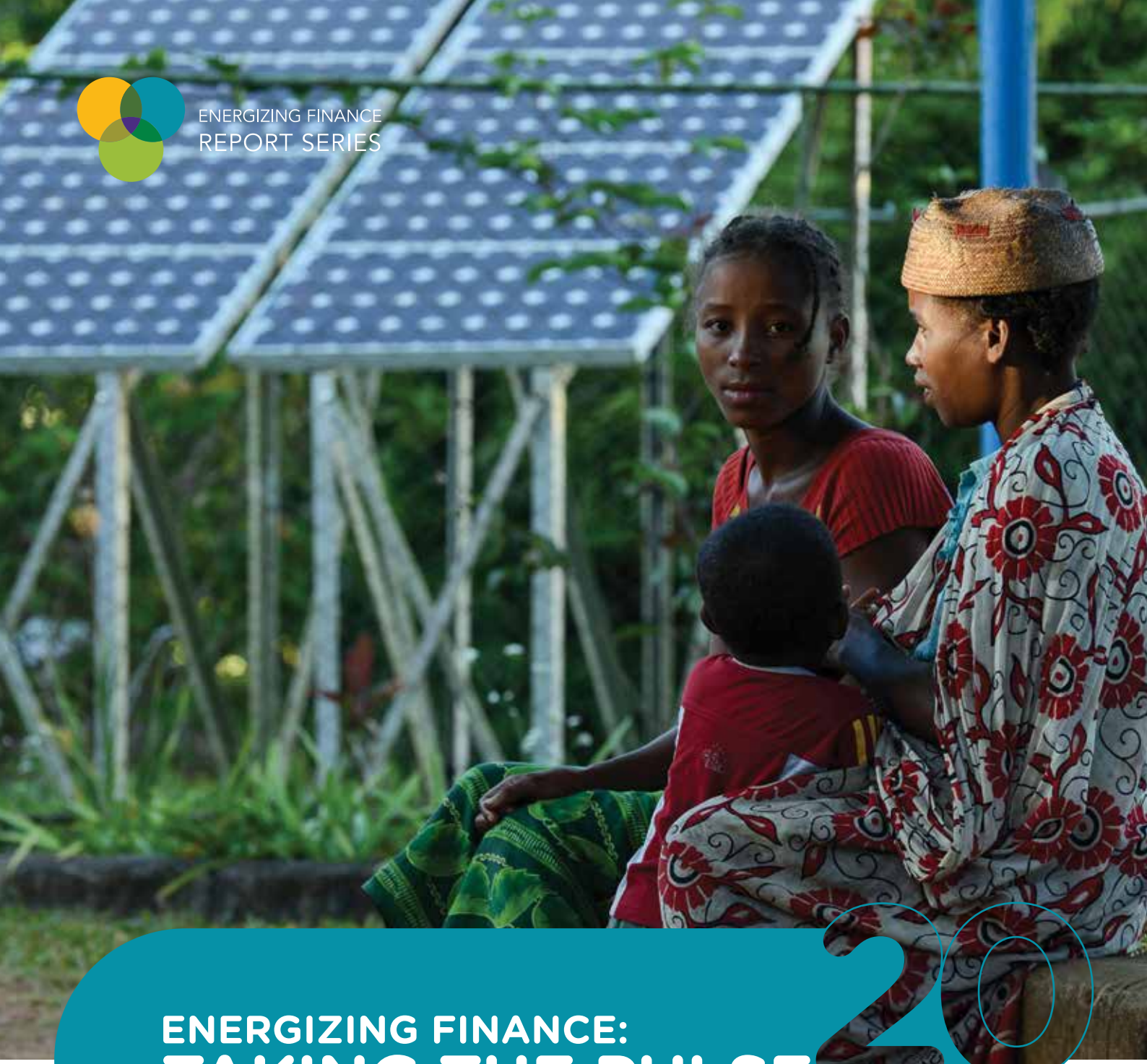

ENERGIZING FINANCE
REPORT SERIES

ENERGIZING FINANCE: TAKING THE PULSE 2019

SUSTAINABLE ENERGY FOR ALL

E3 ANALYTICS

CATALYST
OFF GRID ADVISORS

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FOREWORD

Sustainable Development Goal 7 (SDG7) – affordable, reliable, sustainable and modern energy for all – presents a monumental challenge, one that the world is nowhere near on track to achieving. We have only a decade left to bring electricity access to 840 million people and clean cooking solutions to 3.3 billion people. But what is the price tag for delivering energy access to these people? How much finance must be mobilized, what type of finance, and where should it flow?

These are the questions that Sustainable Energy for All (SEforALL) seeks to answer as part of its *Energizing Finance* research series. This series was developed to provide a clear and comprehensive view of current finance commitments for energy access solutions and determine what finance is needed to attain SDG7.

Taking the Pulse 2019 details the energy access financing challenge faced in three countries: Madagascar, the Philippines and Uganda. The report provides crucial insights into how national contexts shape finance flows for electricity and clean cooking access. Each of these countries has its own unique set of energy needs, existing infrastructure, policies and regulations. *Taking the Pulse 2019* drills down into these contexts to assess each country's financing needs to achieve universal energy access through mini-grids, stand-alone solar and various clean cooking solutions. It also takes into account the costs of overcoming affordability gaps, which, if left unfilled, will leave many people behind.

The work was carried out by Catalyst Off-Grid Advisors in association with E3 Analytics.

The granularity of analysis presented in *Taking the Pulse 2019* is of paramount importance at a time when the world needs data and evidence to inform and empower a broad set of stakeholders. Data and evidence underpin the investment decisions that will determine whether we succeed in delivering SDG7.

Taking the Pulse 2019 finds that USD 6.4 billion in aggregate investment is needed by 2030 in the three focus countries to deliver the mini-grid, stand-alone solar and improved cookstove solutions that will enable SDG7. The report then probes what kind of capital this is, providing estimates of the different grant, equity, debt and affordability gap financing that will be necessary to deliver these energy access solutions.

In forecasting those technologies that will fill existing energy access gaps by 2030 and the source of funds required to scale them, the report highlights financing needs, mainly for national governments, development partners, impact investors and commercial financiers. It then goes a step further by presenting policy recommendations that would help ensure these opportunities are seized.

As an example, *Taking the Pulse 2019* highlights how Uganda, which historically relied on grid expansion and densification to provide residential electricity access, now has stand-alone solar connecting an equal percentage of households. The report forecasts that stand-alone solar will account for 52 percent of new household connections by 2030 and require an average of USD 160 million per year, of which about USD 30 million will be utilized to address the affordability gap. By comparison, *Energizing Finance: Understanding the Landscape 2019* tracked USD 34 million in commitments for stand-alone solar in Uganda in 2017.

This is just a small flavor of the findings in the pages that follow, which are relevant well beyond the borders of Madagascar, the Philippines and Uganda. Pathways and strategies to mobilize the right types of finance for electricity access and clean cooking solutions can support the 20 high-impact countries identified in *Energizing Finance,* and many others, with a more granular understanding of specific decisions needed to deliver sustainable energy for all.

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EXECUTIVE SUMMARY

Some 840 million people lack access to modern, affordable, and reliable electricity, while some 3 billion lack access to clean cooking technologies worldwide.[1] Delivering modern energy services to all citizens by 2030 is a key Sustainable Development Goal agreed by the United Nations General Assembly.[2] Achieving it requires major shifts in how finance is provided to enterprises supplying decentralized energy services and a systemic change in global financing mechanisms supporting the sector. This report is a follow on to the *Taking the Pulse 2017* report. It provides detailed analysis of key unmet financing needs and discusses the barriers that need to be addressed so that private enterprises can deliver energy access solutions at an exponentially larger scale.

This edition of *Taking the Pulse* relied heavily on an empirically-based model to derive projected financing needs for each of the report's three focus countries: Madagascar, the Philippines and Uganda. This quantitative research was informed and complemented by dozens of interviews conducted in each country with senior-level officials from government agencies, enterprises and development organizations working to increase energy access. The report examines past trends with respect to grid, mini-grid and stand-alone solar electrification activities. It then establishes business as usual scenarios to illustrate the Sustainable Development Goal 7 (SDG7)[3] deficit and models forecast scenarios of the expected contributions that the electricity grid, mini-grids, and stand-alone solar solutions would make to achieve universal access to electricity. In respect of clean cooking, the report documents past trends with respect to the use of clean fuels (specifically liquefied petroleum gas (LPG), biogas, and ethanol) and improved cookstoves (ICS), which rely on wood and charcoal as fuel sources, but are industrially manufactured to be cleaner than artisanal stoves. It models forecast scenarios for uptake of clean fuels and ICS to achieve universal clean cooking access in each of the focus countries. The report then utilizes the electrification and cooking forecasts to establish the volume and blend of capital that would be required for enterprises to deliver energy services to individual households.

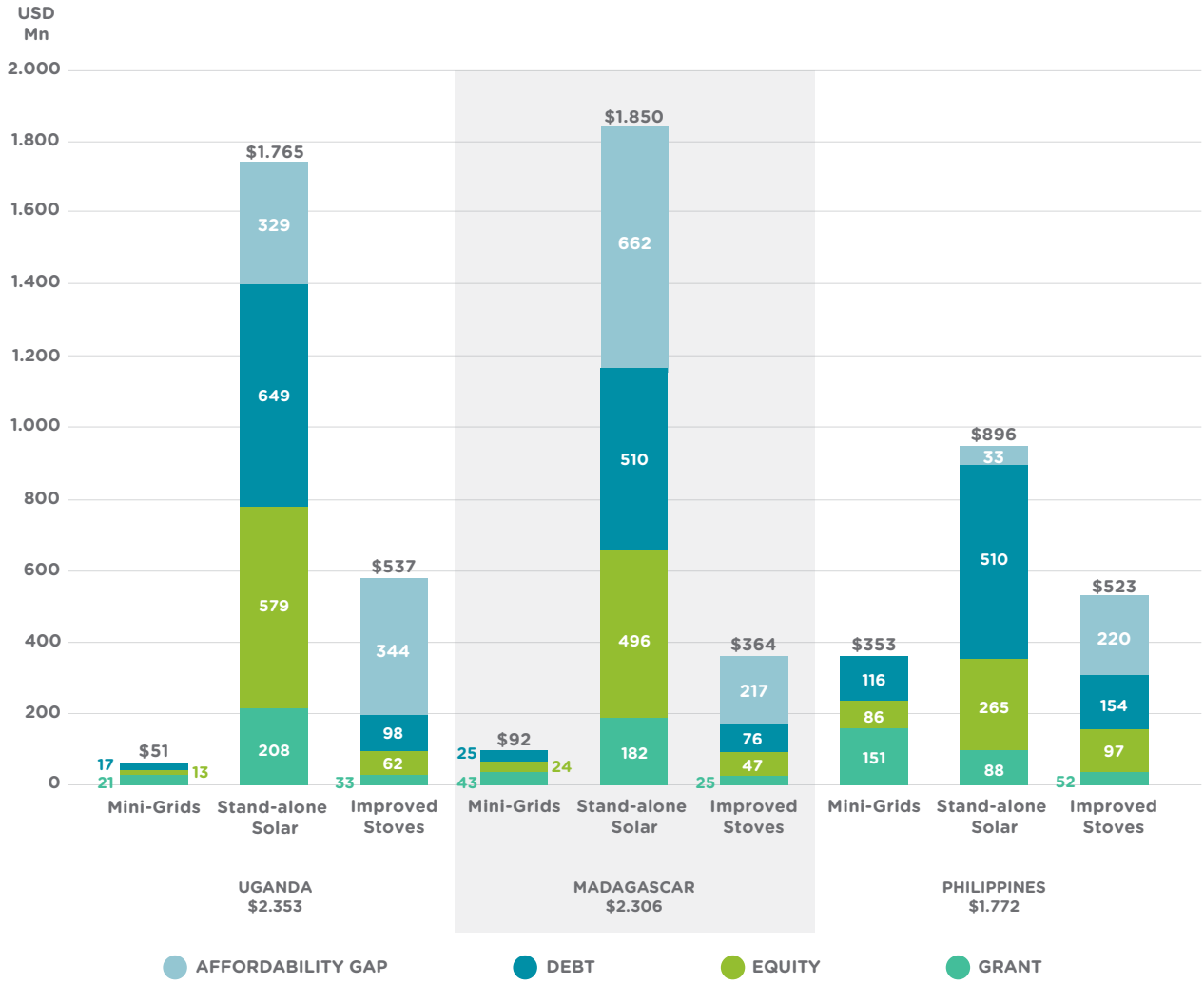
The report contains chapters for each of the focus countries. These countries belong to the 20 high-impact countries (HICs) whose efforts to increase access to electricity and clean cooking can make the most difference on a global scale,[4] and represent three highly different energy markets across Sub-Saharan Africa and Asia. Each chapter begins with a summary of key findings in respect of that focus country. It then provides an overview of the sector context, a description of the current state of household electrification and cooking, descriptions of the forecast scenarios to achieve universal electrification and cooking, and a detailed discussion of the financing requirements associated with these scenarios. Each chapter discusses affordability considerations with

[1] United Nations Economic and Social Council. "Special edition: Progress towards the Sustainable Development Goals, Report of the Secretary General". 2019.
[2] In September 2015, world leaders agreed on 17 Sustainable Development Goals (SDGs). SDG7 calls for secure access to affordable, reliable, sustainable and modern energy for all by 2030.
[3] SDG7 seeks to ensure access to affordable, reliable, sustainable and modern energy for all. For additional details, please see: https://sustainabledevelopment.un.org/sdg7

[4] International Energy Agency (IEA) and the World Bank. (2015). "Global Tracking Framework: Sustainable Energy for All 2015 – Progress Toward Sustainable Energy." World Bank, Washington D.C.

Figure ES 1

Volume and Blend of Financing Required per Technology and Country to Close the Energy Access Gap



respect to household electrification and cooking, and touches upon the key challenges and opportunities that confront the focus countries. In addition to the country chapters, the report includes a methodology chapter, providing a detailed description of *Taking the Pulse 2019's* quantitative methodology, including outlining the structure, inputs, and assumptions that underpinned the Excel-based model developed as part of this report, which generated the key financing outputs that are its primary focus. It also describes the way in which qualitative methods were used as part of the research process in each of the focus countries.

THE COSTS OF ACHIEVING UNIVERSAL ENERGY ACCESS IN MADAGASCAR, THE PHILIPPINES, AND UGANDA

This edition of *Taking the Pulse* forecasts that by 2030 the electricity grid will service 87.5 percent of households in the Philippines, 47 percent in Uganda, and 13.8 percent in Madagascar. The access deficit in each of these countries will require **USD 6.4 billion** in total financing for off-grid electricity and clean cooking solutions to achieve SDG7 in the three focus countries (Madagascar – USD 2.3 billion; the Philippines – USD 1.8 billion; and Uganda – USD 2.3 billion). These totals do not include

the financing requirements associated with grid expansion or the increased use of clean fuels for cooking, both of which were beyond the scope of this report. Figure ES 1 summarizes the volume and blend of financing that is required in each of the focus countries.

- Of this total, just over **USD 800 million** will need to be in the form of **grants** to electricity and clean cooking enterprises. These grants are non-repayable funds given by one party, often a government agency, corporation, foundation or trust, to an energy access enterprise. Grant providers are typically seeking impact via their financial support and can play an important catalytic role in attracting follow-on funders.

- Approximately **USD 1.7 billion** of this financing should be in the form of **equity.** Equity financing is the process of raising capital through the sale of shares in a business.

- One third of the financing needs in the three focus countries is projected to be in the form of **debt (USD 2.1 billion).** Businesses selling stand-alone solar products or ICS will frequently borrow funds to enable them to purchase product inventory. For businesses that utilize a pay-as-you-go model whereby customers pay in installments for a product or service over time, there is also a need for enterprises to borrow capital from external parties to have sufficient liquidity to extend loans to their customers. Mini-grids entail significant up-front capital investment in the assets themselves. Ideally, a significant portion of these costs would be financed via debt which would be paid back over a 10-15 year term as they generate revenues from their customers.

- Household ability to pay for energy access often presents a major obstacle to adoption (for households) and scaling (for enterprises). This edition of *Taking the Pulse* has modeled out the forecast affordability challenge in each of the focus countries. An estimated **USD 1.8 billion** is required in **affordability gap financing.** There are several approaches that can be taken to address the affordability challenge. One option is to provide public assistance to consumers, which can be structured through "energy safety net" mechanisms[5] such as conditional cash transfers, vouchers and coupons or other modalities to enable households to afford the out of pocket expense for energy access solutions.

Taking the Pulse 2019 findings with respect to the volume and blend of capital needed to deliver universal energy access in Madagascar, the Philippines, and Uganda are striking. So too are the report's findings with respect to how each country's access targets will be met. As the report demonstrates, grid electrification will play a meaningful role in achieving SDG7 in all three focus countries. However, constructing grid infrastructure is extremely resource and time intensive, and in each of the focus countries it cannot deliver access to all households because of geographic and demographic considerations, financing realities, or the capacity of power utilities to significantly outpace their past performance in delivering new connections to households. This is where mini-grids and stand-alone solar solutions come into play. These technologies and associated business models can deliver access, often more quickly and less expensively than the grid.

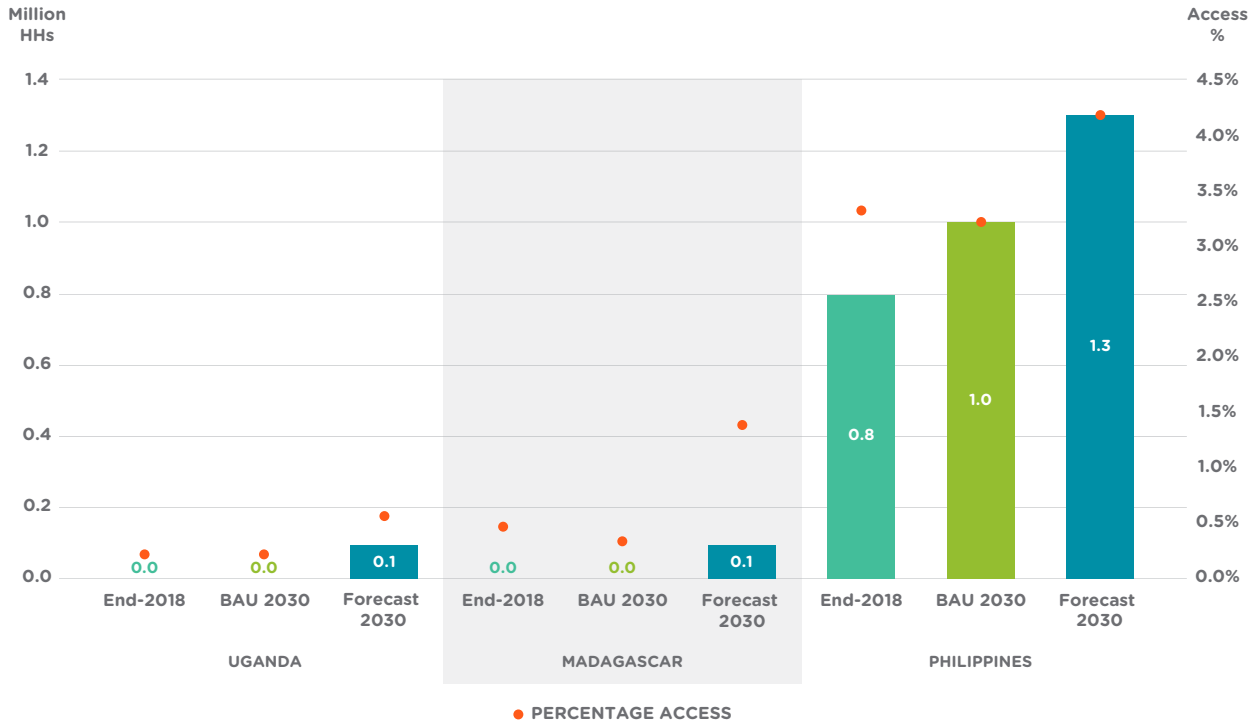
On the cooking side, the increased use of clean fuels faces similar challenges to those confronting the electricity grid. Massive capital investment is required and entire value chains associated with the use of clean fuels at scale must be created.

While *Taking the Pulse 2019* forecasts meaningful increases in the availability and uptake of clean fuels, it relies upon existing cookstove technology to deliver the deficit. Modern, industrially produced cook-

[5] SEforALL, in partnership with ODI and CAFOD, will release a report in early 2020 exploring the use of energy safety nets-social assistance mechanisms to enable and secure access to affordable modern energy for the poorest in society.

Figure ES 2

Mini-Grid Historical, Business as Usual, and Forecast Scenarios, Total Household Connections



stoves deliver performance that provides acceptable cooking efficiency and reduces emissions. However, as is the case with mini-grids and stand-alone solar solutions, the main challenge associated with achieving universal access to ICS lies in getting these products to consumers and making sure that industrial stoves are adopted at household level once they are made available.

MINI-GRID CONTRIBUTIONS TO UNIVERSAL ACCESS

The mini-grid markets of each of the three focus countries are a study of contrasts. This statement is applicable both to their historical contributions toward universal access, and to their future role in delivering SDG7. Figure ES 2 summarizes the number of total households electrified under three different scenarios: a current snapshot of mini-grid access as of the end of 2018, a business as usual (BAU) scenario where historical rates of new connections are maintained through to 2030, and the forecast scenario that underpins the financing requirements described in the preceding section. Beyond financing, the forecast scenario will require strong execution capabilities by mini-grid developers.

In the **Philippines,** mini-grids currently deliver electricity access to approximately 800,000 households. As an archipelago comprised of over 7,500 islands, delivering energy access through mini-grid installations has been an absolute necessity. Many sites that host these mini-grids were characterized as having sufficient population density, associated economic activity, and load demand to justify the substantial capital investments they require. Furthermore, the government made significant efforts to establish an enabling environment that would permit these mini-grids to be deployed, and to provide the capital required for their realization. Given the Philippines' existing high access rate and the prevalence of mini-grids throughout the country, the forecast scenario has mini-grids delivering access to approximately 1.2

million households in total with a capital requirement of USD 354 million, translating to an average annual financing need of approximately USD 32 million through 2030. However, the *Understanding the Landscape 2019* report did not track any mini-grid financing commitments for the Philippines in 2017.

In stark contrast, **Uganda** currently only has 11 mini-grids that deliver access to approximately 4,000 households. Uganda's historical focus has been on grid expansion and densification as the primary modality to deliver residential electricity access. Uganda recently completed a least-cost master planning exercise, through which it identified 320 new sites for mini-grids. *Taking the Pulse 2019* uses these plans and forecasts a significant scaling up of mini-grid contributions to access targets, with approximately 70,000 households receiving access from them by 2030 and a total capital requirement of USD 51 million, averaging out to USD 4.6 million per year. *Understanding the Landscape 2019* tracked only USD 1.4 million in commitments for Ugandan mini-grid financing in 2017. To achieve these ambitious targets, Uganda must prioritize the development of a mini-grid regulatory framework that will clarify the roles and responsibilities of the public and private sectors, and provide visibility around licensing, tariff setting, grid encroachment, technology standards, and subsidy policies to address affordability constraints.

Madagascar's significant infrastructure deficits (particularly road infrastructure) made the build out of mini-grids in isolated pockets of population a necessity. As such, there are approximately 110 mini-grids currently in the country, serving about 24,000 households. The report forecasts 530 new mini-grids, yielding just over 130,000 households that would gain new access, and a total capital requirement of USD 92 million, averaging USD 8.4 million per year. As was the case in Uganda, better clarity around the rules of the game and associated regulations would crowd in the private sector to help finance and develop the mini-grids in the forecast scenario. Absent this clarity, the government would need to rely on substantial concessional financing from development partners to fund the mini-grids and would likely limit its leveraging of the private sector to build and perhaps operate the mini-grids on the government's behalf.

STAND-ALONE SOLAR CONTRIBUTIONS TO UNIVERSAL ACCESS

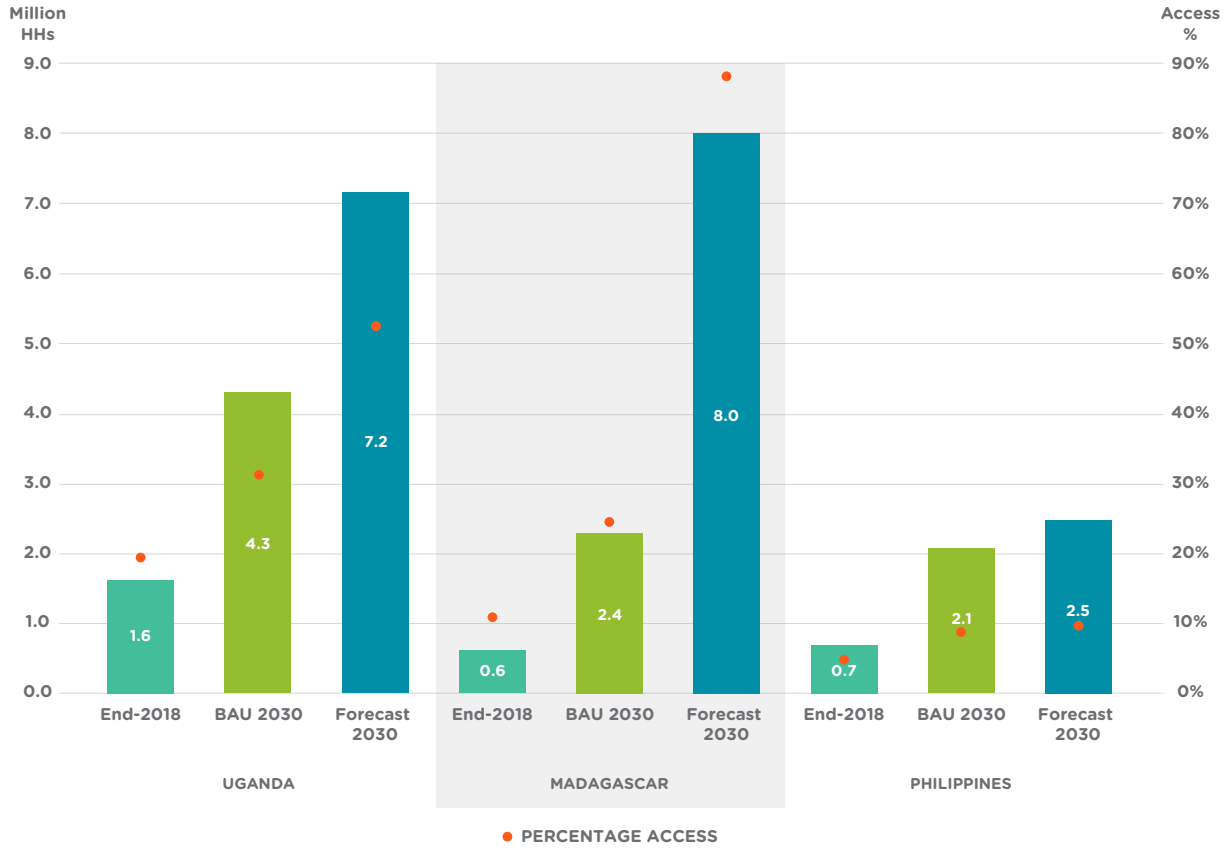
The stand-alone solar story that emerges from the three focus countries is a similar study in contrasts to that of mini-grids. Each country has a distinct trajectory, though common themes explain their relative performance. As Figure ES 3 illustrates, stand-alone solar's contribution toward SDG7 in each of the markets is considerable and will necessitate substantial capital and execution capabilities to deliver on the forecast scenarios. These scenarios assume that stand-alone solutions will need to deliver access to those households not served either by the grid or mini-grids, creating varying degrees of challenge in each country.

Uganda has been one of stand-alone solar's success stories to date. The country hosts three major international players (M-KOPA, Fenix International, and Solar Now) that have attracted significant volumes of investment over the past 5 years. This financing, coupled with robust consumer demand and strong delivery from businesses, has yielded a significant contribution towards access to electricity in Uganda. The forecast scenario envisages stand-alone solar will account for 5.3 million new household connections over the 2020-2030 period (accounting for over 52 percent total new connections) and require USD 1.76 billion in finance[6], of which USD 329 million will be utilized to address the affordability gap. As illustrated in Figure ES 3, this represents a substantial increase compared to the BAU scenario. For this to be realized, the Ugandan market will need to see several additional enterprises begin to operate at scale, and those that are already at scale will need to sustain their pace of growth. Also, while an increasing number of households are served with stand-alone solutions, those that do not adopt will likely be constrained by

[6] This translates to an average annual financing need of USD 160 million. In contrast, the 2019 edition of *Understanding the Landscape* tracked USD 33.7 million in commitments for stand-alone solar in 2017.

Figure ES 3

Stand-Alone Solar Historical, BAU, and Forecast Scenarios, Total Household Connections



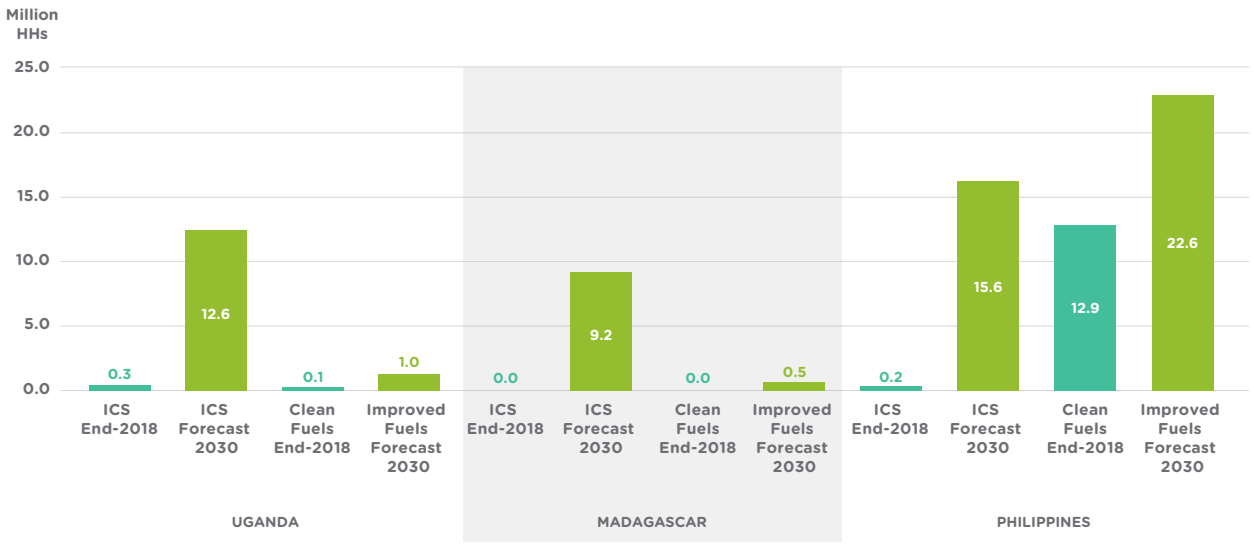
affordability challenges. As such, Uganda will need to develop creative ways to ensure that all households can afford access to modern and reliable electricity services.

Given infrastructure deficits and recent political challenges in **Madagascar,** it is somewhat surprising to see the current, relatively low level of stand-alone solar adoption. Nevertheless, stand-alone solar's contribution in the forecast scenario is massive. This in turn gives rise to huge financing needs, and more importantly, the need for scalable enterprises to be fostered in the market. The forecast scenario envisages stand-alone solar will account for 8 million household connections over the 2020-2030 period and require USD 1.85 billion in finance, of which USD 662 million will be utilized to address the affordability gap. At present, there are few significant players and those that exist are still experimenting with their business model and therefore not yet operating at scale. Madagascar's affordability challenge is even more acute than Uganda's – over 60 percent of households would be unable to afford the most basic level of access absent some form of intervention to lower the consumer-facing product cost.

The **Philippines** is a different story altogether. Given the high penetration rates of the grid and mini-grids, uptake of stand-alone solar has been relatively modest to date. However, it has been meaningful enough to paint a picture whereby the BAU scenario is not wildly different from the forecast scenario. The forecast scenario envisages stand-alone solar will account for 2.5 million household connections over the 2020-2030 period and require USD 897 million

Figure ES 4

Role of ICS and Clean Fuels in Access to Clean Cooking: Historical, BAU and Forecast Scenarios



in finance[7], of which USD 33 million will be utilized to address the affordability gap. However, these figures mask the implementation challenge that underpins this forecast. The households that need to benefit from stand-alone solar in the Philippines will be the true last mile, representing those that are in isolated areas, often characterized by low population density. The cost of reaching these households will be high and running a profitable enterprise in serving these pockets will be very difficult. Here again, stakeholders in the Philippines may need to be creative, and think of blending public-private approaches to both finance and delivery to these households.

ACHIEVING UNIVERSAL ACCESS TO CLEAN COOKING

As explained above, the *Taking the Pulse* report series has to date not attempted to model out the costs associated with delivering cooking solutions via clean fuels. This would include the cost of building out large-scale LPG and ethanol distribution infrastructure as well as capturing the finance required to distribute and/or install cooking hardware. Nevertheless, *Taking the Pulse 2019* does make projections regarding increased uptake of clean fuels and presents these in the forecast scenarios. For the currently underserved households, the report assumes that improved access will be delivered by an ICS that either burns wood (or other biomass) or charcoal. As outlined in Figure ES 4, current utilization rates in Uganda and Madagascar are almost zero, while the Philippines has a compelling clean fuels usage rate already.

More than half of the households in the **Philippines** cook with electricity or a clean fuel (predominantly LPG). The success of the country's LPG industry is a testament to household utilization rates once LPG is available in the market. This trend can also partly be explained by the fact that Filipino households have much higher incomes on average than those in Madagascar or Uganda, making affordability less of a barrier to uptake. Going forward, clean fuels are expected to encounter some of the challenges of their electrification counterparts: it will be difficult to allocate the significant costs associated with building out the infrastructure and supply chain needed to serve the more rural, remote and less populated

[7] Necessitating USD 81.5 million in annual financing; *Understanding the Landscape* tracked a mere USD 3 million in commitments for stand-alone solar in the Philippines in 2017.

areas. As a result, the use of ICS will need to flourish. This in turn will require significant investment in business models that can overcome the challenges associated with serving dispersed, hard to reach households. The forecast scenario requires USD 523 million in finance, of which USD 220 million will be utilized to address the affordability gap.

Uganda has several enterprises and development partner programs that have worked on commercializing ICS. Despite these efforts, uptake remains extremely low and is attributed to households' unwillingness to shift away from traditional cooking methods and affordability constraints on purchasing industrial ICS. Though there has been some experimentation with clean fuels and the forecast scenario envisages a significant uptick in clean fuel use, its overall contribution towards the SDG7 target will remain modest. The forecast scenario requires USD 537 million in finance, of which USD 344 million will be utilized to address the affordability gap.

Madagascar faces the same challenges as Uganda, only more acutely. Affordability constraints are even greater, and infrastructure deficits in-country will severely challenge the ability of enterprises to serve remote households. The forecast scenario will require USD 365 million in finance, of which USD 217 million will be utilized to address the affordability gap.

KEY TAKEAWAYS FOR STAKEHOLDERS

For ***development partners*** (multilateral and bilateral organizations):

- Help create the appropriate enabling environment for mini-grids, including supporting integrated electrification planning that more clearly identifies the proportion of households that will require off-grid solutions, before committing capital to the sector.

- Support efforts to build a methodology to collect and analyze data on environmental and social impacts as well as financial performance of the electricity and cooking sectors.

- On stand-alone solar, avoid the temptation to declare victory because one or two stand-alone solar companies or markets see rapid growth. As previous research shows, this pales in comparison to what is needed.[8]

- Promote inclusive definitions of electricity access, based on the Multi-Tier Framework typology[9]. The role that solar lanterns can play in delivering fractional Tier 1 access at household level must be considered and is a crucial given the affordability challenge many households will face with respect to a multi-light point stand-alone system.

- With respect to clean cooking, support efforts to better understand clean fuels business models and what it would take to dramatically scale their use. Adoption of clean fuels is the key to unlocking a more climate and health friendly cooking future.

- Companies, funders and investors require a much deeper understanding of the factors that will produce sustainable consumer adoption of clean cooking solutions. Understanding, testing, and prioritizing the clean cooking product fit with consumers, predominately women, must be prioritized alongside sustained consumer awareness programs.

For ***governments*** of the 20 HICs:

- When it comes to energy access, transparent and predictable policy and regulation are critical enablers. To accelerate access, governments should champion the development of robust policy and regulatory regimes, particularly with respect to mini-grids, whose development is greatly inhibited without it.

- Invest in developing an integrated electrification pathway, an inclusive planning approach that supports using grid, mini-grid, and off-grid technologies to provide electricity and the associated energy services necessary to meet human needs and

[8] See https://shellfoundation.org/app/uploads/2018/10/Achieving-SDG-7-The-Need-to-Disrupt-Off-Grid-Electricity-Financing-in-Africa.pdf

[9] Bhatia, M. & Angelou, N., 2015. Beyond Connections – Energy Access Redefined, Washington: Energy Sector Management Assistance Program.

contribute to sustainable development.[10] These pathways provide clarity to entrepreneurs as to where to focus their resources and will also help them crowd in the private capital needed to scale their businesses.

- Take the lead in enabling blended finance for energy access. Governments have the ability to secure concessional financing from multilateral and bilateral development partners that can be used to provide risk-tolerant financing to enterprises. This can in turn crowd in more commercial capital from investors.

- Make sure the delivery of energy access is inclusive and benefits all households in a given country. This may necessitate incentives for enterprises to expand into underserved areas and will certainly require significant funding and new measures to enhance consumer affordability. Inclusivity also requires a definition of electricity access that recognizes the important role that single light point products (e.g. solar lanterns) can play in contributing toward SDG7.

For ***investors*** (including commercial, impact, and development finance institutions):

- Each focus country needs dozens of energy access enterprises that deliver mini-grid, standalone solar, or clean cooking solutions. Investors need to support early stage enterprises, and even go so far as to provide start-up capital to new generations of businesses.

- Investors bring important global perspectives and good practice, particularly in regard to what it takes to build and scale energy access enterprises. This knowledge should be shared with enterprises through bespoke advisory support.

- In addition to international firms, investors also need to support indigenous enterprises that know their local markets and customers well.

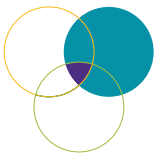
- Development finance institutions need to continue to play a prominent role, providing significant volumes of risk-tolerant capital that will help prove out energy access enterprise business models and crowd in more commercially oriented investors.

For energy access ***enterprises:***

- Be realistic regarding the amount of time and resources (both human and financial) that are required to build and scale energy access enterprises. Setting appropriate ambitions will be critical to succeeding in raising investor capital, delivering on expectations and validating the role that enterprises can play in delivering energy access.

- There is much to be learned from industry peers, at global, national, and local levels. Most energy access business models are yet to prove themselves profitable and doing so will require significant adjustments to ensure they are viable in each market. While competition can be a good thing, so too can collaboration. Enterprises should look to learn from one another and help find solutions to the challenges that make scaling energy access difficult.

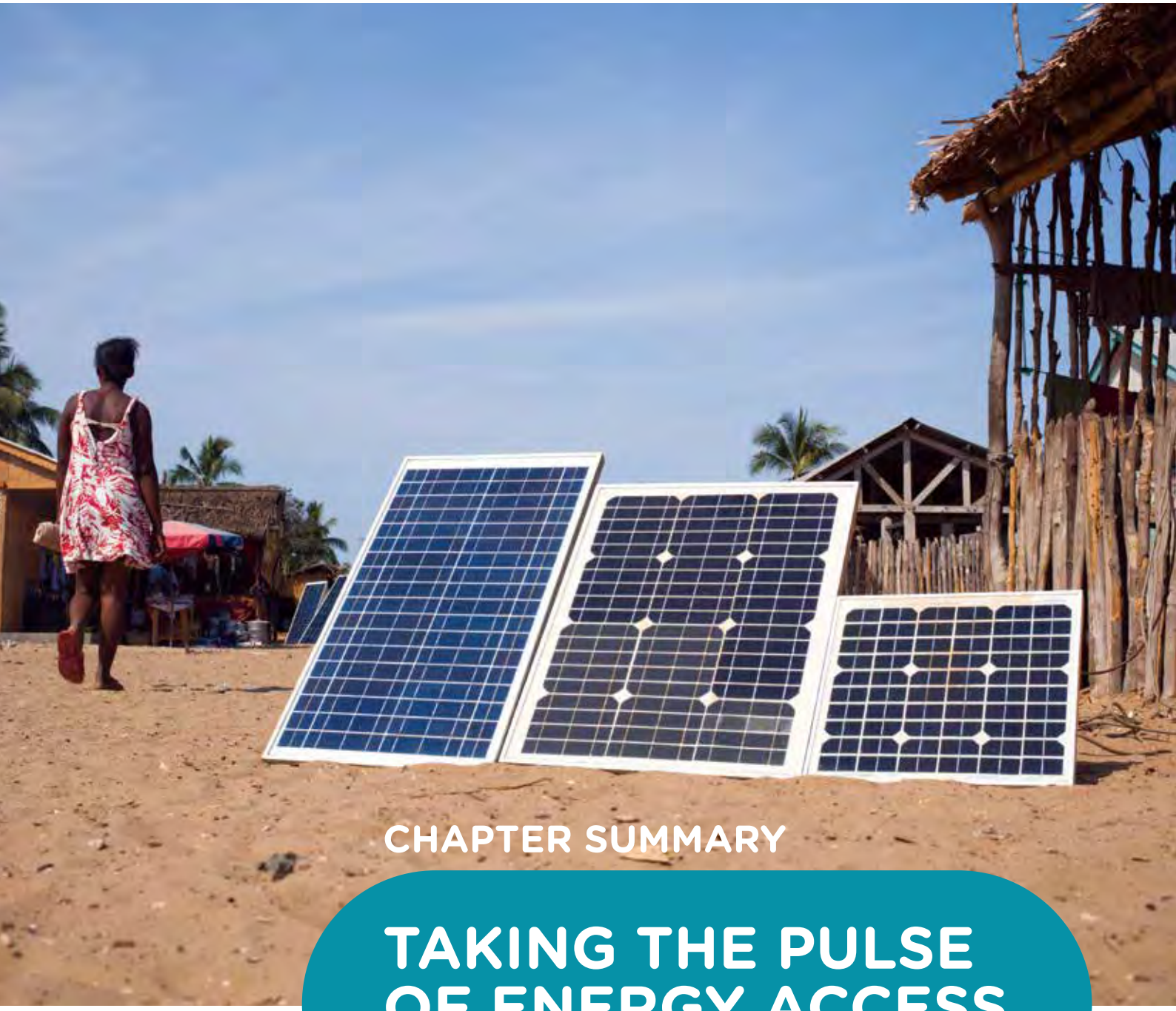
[10] For more information on integrated electrification pathways, see https://www.seforall.org/publications/integrated-electrification-pathways-for-universal-access-to-electricity



ABBREVIATIONS

ADER	Rural Electrification Agency
ADES	Association pour le Développement de l'Energie Solaire
AfDB	African Development Bank
ARELEC	Electricity Sector Regulator
BAU	Business as usual
BOREALE	Best Options for Rural Energy and Access to Light and Electricity
CAPEX	Capital expenditures
CCM	Clean Cooking Madagascar
CERs	Certified emission reductions
Ci-Dev	World Bank's Carbon Initiative for Development
EMDs	Ethanol Micro Distilleries
EU	European Union
GDP	Gross domestic product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GoM	Government of Madagascar
ICS	Improved cookstoves
IEC	International Electrotechnical Commission
IPPs	Independent Power Producers
IWA	International Workshop Agreement
JIRAMA	Jiro sy Rano Malagasy

kW	Kilowatt
LEAD	Least-Cost Electricity Access Development
LPG	Liquefied petroleum gas
MEEH	Ministry of Energy, Water, and Hydrocarbons
MoI	Ministry of Industry
MTF	Multi-Tier Framework
MW	Megawatt
NEP 2015-2030	New Energy Policy
NGO	Nongovernmental organizations
NMS	Norwegian Missionary Society
OGS	Off-grid solar
ORE	Energy Regulation Office
PAYG	Pay-as-you-go
PPP	Public-private partnership
PovCal	World Bank poverty calculator
PV	Photovoltaic
QV	Lighting Global quality-verified
RISE	Regulatory Indicators for Sustainable Energy
SME	Small- and medium-enterprises
SDG7	Sustainable Development Goal 7



CHAPTER SUMMARY

TAKING THE PULSE OF ENERGY ACCESS IN MADAGASCAR

Plans by the Government of Madagascar to expand electricity access have been constrained in recent years by slow expansion of the electricity grid. While grid service remains largely unchanged since 2010 at 11 percent, stand-alone solar for households has begun to transform the electricity market in the country, providing electricity to almost 10 percent of households, which represents almost half of the households with energy access. New grid connections are expected to reach an additional 600,000 households by 2030 (increasing grid access by 2.4 percent). The mini-grid sector, currently providing access to less than 1 percent of households, is expected to have a modest impact. The deficit left by grid connections and mini-grids must be addressed by stand-alone solar but moving towards the SDG7 goal of universal access by 2030 will require a solution to the affordability challenge that will constrain stand-alone solar adoption by households with limited willingness and ability to pay.

If Madagascar follows a business as usual (BAU) scenario—allowing markets to continue developing based on current levels of support from the private sector, government agencies and development partners—grid coverage would actually decline to cover 9 percent of households by 2030 since the current pace of grid expansion is not keeping up with population growth. In a forecast scenario, where key stakeholders in Madagascar's electricity sector commit all resources required to achieve universal access, grid connections would increase to 14 percent of households, representing 600,000 new grid connections between 2020 and 2030. Madagascar has about 160 mini-grids, servicing approximately 24,000 households located primarily in larger urban areas, far from the capital. The growth in mini-grids, particularly in rural areas, has largely been hindered by the ability of Malagasy households to afford this type of electricity service, highlighting the significant importance affordability support will have to play in increasing the deployment of this technology. In the forecast scenario, there is a significant uptick in mini-grid deployment (with 530 new mini-grids built), with the technology delivering electricity access to some 131,000 households by 2030. A cumulative financing of USD 92 million will be needed for mini-grids in this scenario, necessitating annual commitments averaging approximately USD 8.4 million. By way of comparison, the *Energizing Finance* Series' *Understanding the Landscape 2019* report tracked USD 16.6 million in commitments for mini-grids in Madagascar in 2017. In a BAU scenario, stand-alone solar would provide electricity to 25 percent of households. In the forecast scenario, stand-alone solar would deliver access to 84.8 percent of households, representing 7.4 million new connections during the same period. To reach this level of growth, stand-alone solar requires USD 1.8 billion of cumulative financing to address enterprise financing needs (necessitating average annual financing of approximately USD 164 million). When looking at financing flows, the *Understanding the Landscape 2019* report tracked USD 12.7 million in commitments for stand-alone solar in Madagascar in 2017. A further USD 662 million will be required to address affordability constraints.

Madagascar has the largest clean cooking deficit in Africa, with less than 1 percent of households using clean fuels, and a fraction of a percent of households using improved wood or charcoal stoves.[10]

Table CS 1

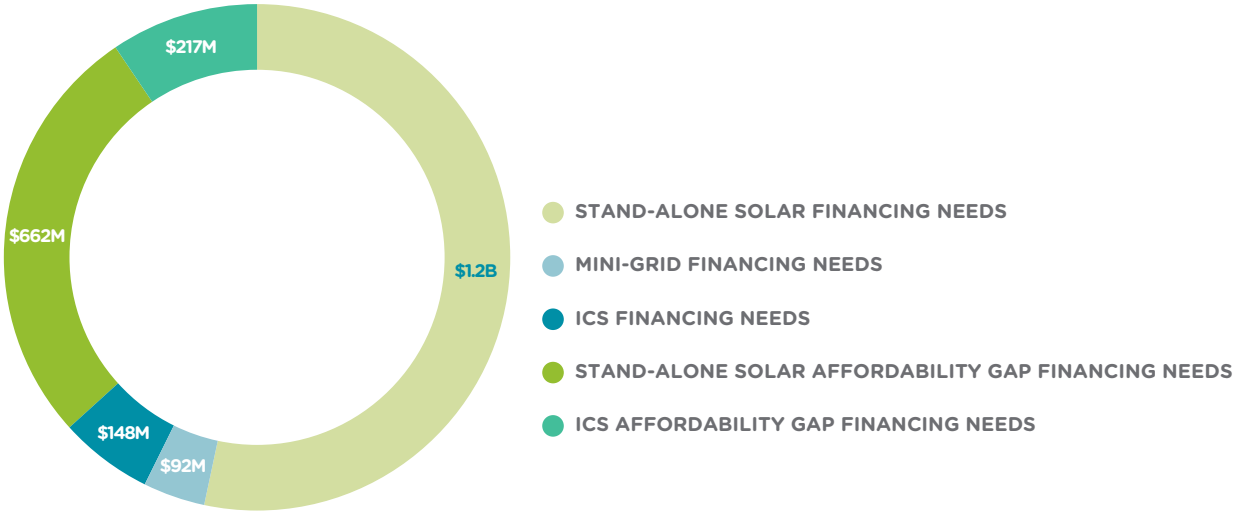
Madagascar: Key Figures

Year end	2018	2030
Population (millions)	26.3	35.6
Households (millions)	6.2	9.5
Grid Access (%)	11.4	13.8
Mini-Grid Access (%)	0.4	1.4
Stand-Alone Solar Access (%)	9.4	84.8
Clean Fuels Use (%)	0.6	5.2
ICS Usage (%)	0.3	100

[10] Key figures in this table reflect, for end-2018, best estimates based on the most up-to-date figures available from various official and unofficial sources, extrapolated by leveraging recent trends. For end-2030, figures reflect model outputs for the forecast scenario, i.e., whereby SDG7 is met for electricity and clean cooking access.

Figure CS 1

Closing the Access Gap in Madagascar: USD 2.3 Billion Required for Off-Grid Electricity and Improved Cooking Solutions



The country's clean cooking market is dominated by small-scale producers who primarily manufacture charcoal-burning stoves as well as some wood-burning stoves, which are less common. While small-scale improved cookstoves (ICS) producers have a strong presence in the clean cooking sector, there is scarce available data on their activities. In urban areas, charcoal is the source of fuel most widely used whereas, in rural areas, the leading fuel source is wood[11] – a trend that is consistent with household income largely determining which type of fuel sources households use. High-income households tend to be located in urban areas, while lower-income households tend to live in rural areas.

Compared to most markets in East Africa, Madagascar's liquefied petroleum gas (LPG) market is relatively underdeveloped since the country has neither its own oil refineries nor oil products, meaning that most LPG products have to be imported. While the biogas market has benefited from donor support, its residential use remains limited. Ethanol, on the other hand, has demonstrated some uptake, with a few micro-distilleries supplying ethanol fuel to local customers and other ethanol products coming from either South Africa or Mauritius. In the forecast, the use of clean fuels—LPG, biogas, and ethanol—will increase by 5 percentage points (half a million households) with further growth constrained by affordability and logistical challenges. By 2030, over 9 million households (95 percent of households) are expected to continue cooking with wood and charcoal as either a primary or secondary source. Madagascar will need USD 148 million of financing for enterprises and USD 217 million for affordability gap financing to help 90 percent of households afford a basic improved cookstove.

There are a number of supportive actions that will need to be taken to facilitate investment and achieve universal electrification in Madagascar. These are summarized as follows:

For mini-grids:

- Madagascar has an existing regulatory framework that applies to mini-grids thanks to the 2015 public-private partnership (PPP) law. The key to the future growth of the sector lies in this framework being applied in a consistent, transparent way so as to de-risk private sector participation.

[11] Per a 2010 household survey, 94.5 percent of households using wood for cooking collect it themselves and do not pay for it.

- Provide financing that would help de-risk and incentivize the private sector to accelerate mini-grid deployments in Madagascar, including via concessionary public sources of capital.

For stand-alone solar:

- Given the challenging operating context that Madagascar presents to the private sector, improve market intelligence and provide both fiscal and non-fiscal incentives to help them both enter and scale up operations in the market.

- Given Madagascar's profound challenges with household ability to pay, support initiatives that aim to increase household affordability, particularly in difficult to serve areas of the country.

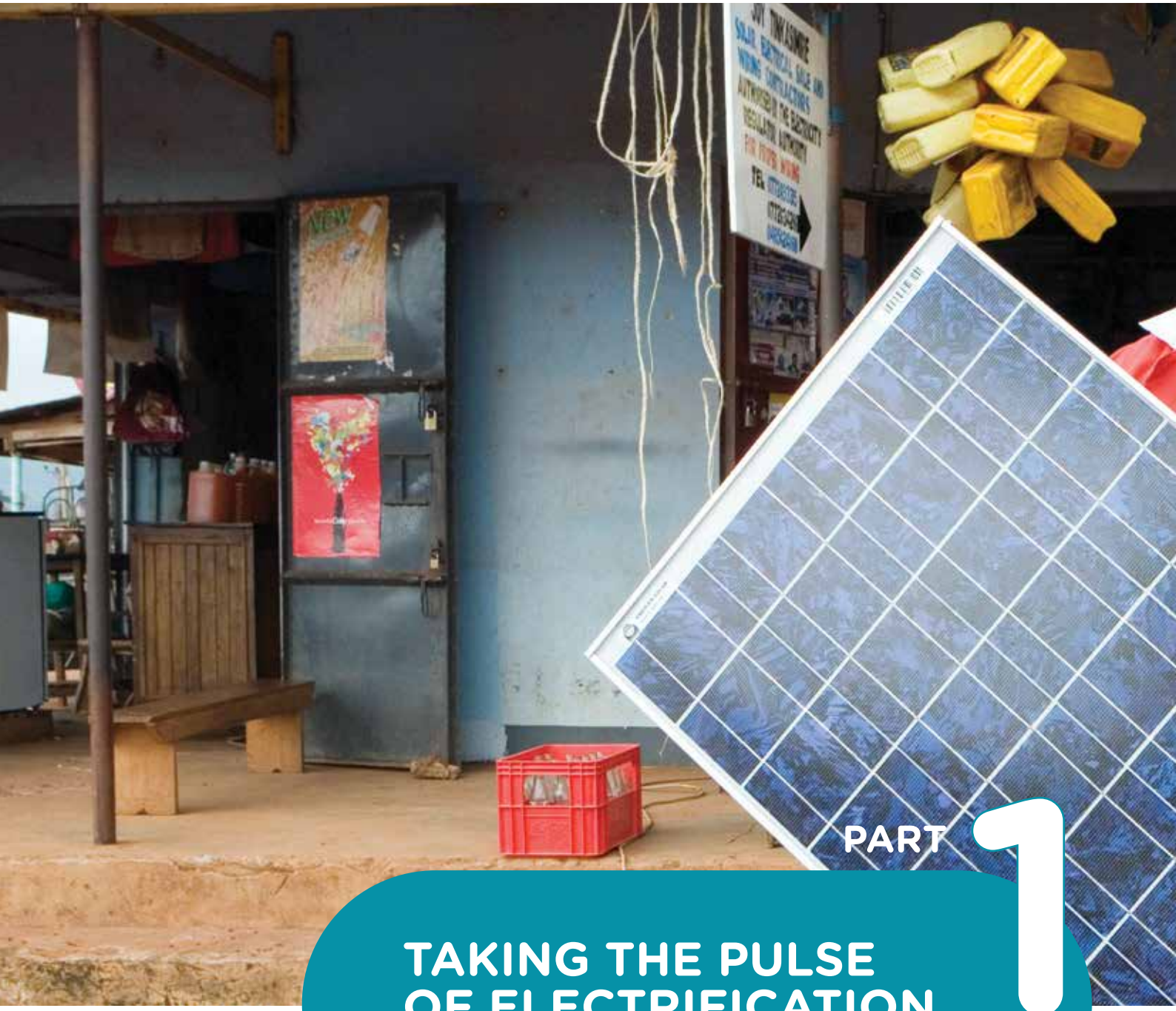
- Although Madagascar's off-grid solar market is already robust, the vast majority of products sold are not quality-verified. As such, the adoption and enforcement of International Electrotechnical Commission (IEC) quality standards and the operationalization of import duty and value added taxes (VAT) exemptions to these standards is a critical next step to protect consumers and decrease competition from poor quality products.

For improved cooking:

- Madagascar has one of the lowest ICS adoption rates in the world. As such, develop and deliver public awareness campaigns on the benefits of clean cookstoves adoption to encourage behavior change.

- As was the case with stand-alone solar, given Madagascar's ability to pay challenges, support initiatives to enhance household affordability, particularly for the uptake of industrial cookstoves and the use of clean fuels.

- Increase data collection around small-scale producers to obtain a better glimpse into Madagascar's clean cooking market.



PART 1

TAKING THE PULSE OF ELECTRIFICATION IN MADAGASCAR

SECTOR CONTEXT

Government Electrification Strategy

The Ministry of Energy, Water, and Hydrocarbons (*Ministère de l'Energie, de l'Eau et des Hydrocarbures,* MEEH) is responsible for setting Madagascar's energy policy and providing strategic coordination to its energy sector. MEEH also oversees *Jiro sy Rano Malagasy* (JIRAMA), which is the country's electric utility and water services company. JIRAMA is a vertically integrated and fully state-owned enterprise that operates the majority of the country's grid infrastructure. It is responsible for transmission, distribution and about half of the country's electricity generation capacity. The utility owns and operates three separate grid networks in the cities of Antananarivo, Toamasina, and Fianarantsoa.

Other players include private sector companies that supply power to JIRAMA either as Independent Power Producers (IPPs) or through rental power agreements. While JIRAMA does not have a legal monopoly over the power market, it is usually the off-taker for all grid-connected generation plants, particularly in areas in which it operates due to long-term concessions.[12] However, JIRAMA has long suffered operational difficulties (e.g. theft, vandalism, hardware failure) and financial shortfalls, resulting in its insolvency in recent years and inability to expand the grid throughout the country. Grid access rates, for example, fell from 15 percent in 2008 to 13 percent in 2015. During that same time period, JIRAMA's operating margins declined by 59 percent, increasing its liability from 1.3 percent of gross domestic product (GDP) in 2008 to 5.6 percent of GDP in 2015.[13]

Other key agencies involved in the energy sector are: (1) the Electricity Sector Regulator (*Autorité de Regulation de l'Electricité,* ARELEC), which regulates tariffs and market entry; (2) the Rural Electrification Agency (*Agence de Développement de l'Electrification Rurale,* ADER), which is tasked with implementing all rural electrification activities, including both on- and off-grid systems, and; (3) the Energy Regulation Office (*Office de Régulation de l'Electricité,* ORE), which is responsible for monitoring and overseeing quality norms. ORE plays a critical role in ensuring that high-quality, stand-alone solar products are entering the Malagasy market, but struggles to fulfill this mandate since its financing comes from JIRAMA, which itself is in financial distress.

In 2015, the Government of Madagascar launched its New Energy Policy (NEP 2015-2030) targeting electrification of at least 70 percent by 2030 through grid and off-grid energy solutions. As a continuation of the NEP 2015-2030, the recently approved *Stratégie Nationale d'Electrification* aims to achieve 70 percent energy access by targeting the following areas for service delivery:

- Extension of the grid
- Development of mini-grids (using such electricity sources as small hydro, solar, biogas from rice bales, and diesel)
- Extension of stand-alone solar, including solar home systems and solar lanterns.

More recently, in 2019, the MEEH identified two new strategic objectives for the energy sector:[14]

1. Ensure that 50 percent of the population will have electricity access at a "socially acceptable" price by 2023
2. Double the country's electricity generation capacity in five years, achieving approximately 800 megawatt (MW) by the end of 2023.

To achieve these two strategic objectives, the government has identified five areas that require attention: (1) reducing load shedding and controlling the price of electricity; (2) bringing electricity access to the largest number of people; (3) identifying energy supply development zones; (4) reducing the environmental impact of energy (e.g., accelerate clean cooking), and; (5) developing and implementing a NEP in case of emergencies (e.g., deployment of solar kits and generators during natural disasters).

Stand-Alone Solar

At the end of 2018, it was estimated that nearly 10 percent of households had electricity access delivered through stand-alone solar systems.

The slow expansion of the public electricity service in Madagascar has enabled the private sector to play a more prominent role in filling the energy access gap.[15] Stand-alone solar companies that distribute and oper-

[12] Include BV. "Off-Grid Solar Market Assessment Madagascar" July 2018.
[13] Ibid.
[14] Ministère de l'Energie, de l'Eau et des Hydrocarbures. 2019. "Ministère de l'Energie, de l'Eau et des Hydrocarbures : Contrat de Performance 2019".
[15] The World Bank. 2019. "International Development Association Project Appraisal Document on a Proposed credit in the amount of SDR 107.9 Million (USD 150 Million Equivalent) to the Republic of Madagascar for the Least Cost Electricity Access Development (LEAD) Project".

ate stand-alone solar systems are estimated to serve almost as many households as the grid system.[16] They offer solar lanterns or solar home systems products to customers on a cash sale, lease-to-own, or rental basis. By the end of 2018, nearly a million stand-alone solar products had been sold in the country, mostly in the preceding three to five years, although the majority of these were of low quality and sold through informal channels, such as roadside vendors.[17] No quality standards are currently in place, a factor contributing to poor quality and after-sale service in an already underdeveloped sector.[18]

The majority of rural Malagasy households are more likely to pay for off-grid technology (e.g., pico-solar and stand-alone solar systems) than mini-grids or grid connections since they are oftentimes cheaper and provide the same, or better, electricity service.[19] The main distributors of stand-alone solar services and products are Jiro-ve; HERi; Baobab+; Orange, Majinco; Power Technology; SQVision; MadaGreen, and WeConnex. Only four of the distributors are identified as selling Lighting Global quality-verified (QV) products[20], and only four out of the nine companies listed and operating in the country offer pay-as-you-go (PAYG) and/or credit services to their customers. However, the two largest mobile telecom companies in Madagascar (Orange and Telma) have launched or are in the process of launching their own stand-alone solar PAYG pilots.

Table 1.1

Overview of Stand-Alone Business Models in Madagascar[21]

Formal Distributors	Product Types	Business Model(s)	Credit/PAYG Offered
Jiro-ve	Non-QV solar lanterns	Small solar lanterns rented to customers through 31 franchisees	Yes
HERi	QV solar lanterns	Variety of solar lanterns rented to customers through 110 kiosks; PAYG sales to be launched soon	Yes
Baobab+	QV pico-PV (pico-photovoltaic) systems	Pico-PV products sold through MFI top-up loans and through agent network	Yes
Orange	QV pico-PV and stand-alone solar	Pico-PV and stand-alone solar products rented to consumers through a subset of Orange agent network	Yes
Majinco	Non-QV, QV pico-PV, stand-alone solar	Pico-PV and stand-alone solar products sold on a cash basis through store network	No
Power Technology	Non-QV stand-alone solar	Stand-alone solar sold on a cash basis through single outlet and 20-person sales agent network	No
SQVision	Non-QV stand-alone solar	Stand-alone solar sold on a cash basis through a network of sales agents; PAYG sales being investigated	No
MadaGreen	Non-QV stand-alone solar	Stand-alone solar sold on a cash basis to wealthier households and small- and medium-enterprises (SMEs)	No
WeConnex	Non-QV stand-alone solar	Stand-alone solar sold through partner outlets on a cash basis	No

[16] Ibid.
[17] Enclude BV. "Off-Grid Solar Market Assessment Madagascar" July 2018
[18] The World Bank. 2019. "International Development Association Project Appraisal Document on a Proposed credit in the amount of SDR 107.9 Million (USD 150 Million Equivalent) to the Republic of Madagascar for the Least Cost Electricity Access Development (LEAD) Project".
[19] Ibid.
[20] Lighting Global, the World Bank Group's platform to support sustainable growth of the global off-grid lighting market, sets standards for quality, durability, and truth in advertising.
[21] The World Bank. 2019. "International Development Association Project Appraisal Document on a Proposed credit in the amount of SDR 107.9 Million (USD 150 Million Equivalent) to the Republic of Madagascar for the Least Cost Electricity Access Development (LEAD) Project".

Table 1.2

Major Development Partners and their Main Programs

Development Partners	Key Programs
The World Bank	• Financing grid extension and densification • Financing off-grid electrification • Technical support for electrification planning • Improving utility performance • Financing feasibility studies for hydro mini-grids
African Development Bank (AfDB)	• Providing legal support to MEEH • Financing interconnection between Antananarivo and Tamatave
Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ)	• Financing PV mini-grids • Technical support to MEH and ADER
European Union (EU)	• Financing PV mini-grids • Financed 10 mini-hydro plants

Many international development partners are supporting a wide range of programs to advance energy access through stand-alone solar solutions, cultivating market growth and stimulating capital investment, as noted in the World Bank's 2019 project appraisal document for Least-cost Electricity Access Development (LEAD) project.[22] Key development partners and their programs that are actively supporting OGS are outlined in Table 1.2 above.

The Malagasy stand-alone solar market is still nascent and continued market growth will depend on increased consumer awareness, a rigorous quality assurance framework, and financing to help companies access hard-to-reach rural areas. Affordability gap financing will also be required to address affordability concerns. Households in the bottom third of the income pyramid will have particularly acute affordability issues without financial support from third parties.[23] The affordability challenge is discussed in more detail later in this chapter.

Mini-Grids

Modern mini-grid developers are at a nascent stage in Madagascar with many fundamentals of the business model still to be worked out. While Madagascar has about 30 different organizations providing electricity via more than 100 mini-grids, the majority of the grids are powered by 40 kilowatt (kW) to 200 kW diesel or hydropower generation and are heavily government subsidized. JIRAMA itself also owns and operates a further 50 isolated mini-grids, serving cities and villages out of reach of its three larger grids.[24] Together, these mini-grids serve approximately 24,000 households, primarily in areas far from the capital. The government has granted mini-grid concessions to private operators to electrify rural villages since 2004. However, their contribution to the mini-grid sector has been minor.[25] The majority of these private contracts have been obtained through ADER via ad-hoc proposals and were accompanied by significant (capital expenditure)

[22] The World Bank. 2019. "International Development Association Project Appraisal Document on a Proposed credit in the amount of SDR 107.9 Million (USD 150 Million Equivalent) to the Republic of Madagascar for the Least Cost Electricity Access Development (LEAD) Project".
[23] Ibid.
[24] Ibid.
[25] The World Bank. 2019. "International Development Association Project Appraisal Document on a Proposed credit in the amount of SDR 107.9 Million (USD 150 Million Equivalent) to the Republic of Madagascar for the Least Cost Electricity Access Development (LEAD) Project".

CAPEX subsidies.[26] One company noted that subsidies were expected to account for at least 50 percent of CAPEX to be able to support lower tariffs.[27]

Mini-grid growth has been constrained by the ability of Malagasy households to pay for electricity service (i.e., their low purchasing power). According to one interviewee, mini-grids tariffs can sometimes be three times higher than services offered by JIRAMA, making it harder for private sector companies to operate profitably if grants are not readily available to subsidize the low tariffs imposed in the country.[28] Additionally, Madagascar's rugged landscape, particularly in rural areas, makes the installation, operation, and maintenance of mini-grids challenging. Despite the falling price of technology, construction of new mini-grids is still hampered by the high and often prohibitive cost of connections.[29]

Several international development partners are supporting the development of mini-grids in Madagascar. GIZ has been supporting a number of PV mini-grids in close collaboration with ADER, providing technical assistance and developing mini-grid concession schemes, as well as providing overall logistical and financial support. The EU has also been actively engaged in the development of mini-grids, providing subsidies to small hydro mini-grids through its Energy Facility. It has also supported and financed some stand-alone solar companies operating in the country, such as HERi and Jiro-VE.[30] Fondem, an international nongovernmental organization (NGO), has been one of the most active mini-grid supporters within Madagascar, focusing primarily on solar PV mini-grids. Fondem has already deployed four 7.5 kW mini-grids, two 10 kW mini-grids and one 15 kW mini-grid, some of which were co-financed by the EU through the Best Options for Rural Energy and Access to Light and Electricity (BOREALE) program.[31]

[26] Ibid.
[27] Based on in-country interviews.
[28] Based on in-country interviews.
[29] Ibid.
[30] Ibid.
[31] Fondem. 2017. PROJET BOREALE. http://www.fondem.ong/projets/boreale/

CURRENT STATE OF ENERGY ACCESS

Defining Energy Access

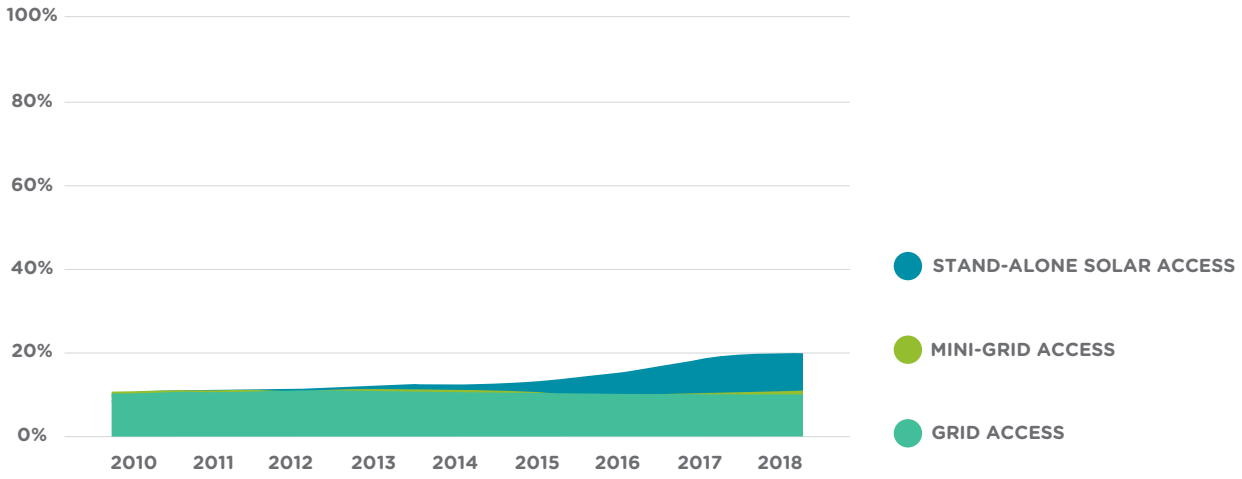
Taking the Pulse uses the globally accepted Multi-Tier Framework (MTF) to define energy access.[32] The MTF establishes five "tiers" of household electrification that are based on capacity, duration, reliability, quality, affordability, legality and health and safety impacts. The MTF is often referred to as the "energy access ladder", whereby households may graduate from one level of service to another depending on what sources of electrification they have access to, what they need, and what they can afford. Tier 0 represents a household that uses stopgap measures to meet their basic electrification needs, often using fuel-based lighting (e.g. kerosene lanterns, candles) or battery-operated flashlights for lighting needs, and relying on third-parties to power their devices (most notably cell phones). Tier 1 and 2 services are most often delivered by "stand-alone solar solutions", frequently in the form of single or multi-light point systems that derive their power via solar PV panels. Tiers 3 through 5 are most typically met by connections to a centralized or localized grid (i.e. a "mini-grid"). However, it is important to note that having a grid connection can also qualify as Tier 1 (or as low as Tier 0 if power is available for less than four hours per day) if the MTF duration criteria are not met. More details on the MTF can be found in the *Taking the Pulse* methodology chapter.

Tier 1 stipulates either a certain level of installed capacity (in terms of power and capacity) or a level of service, which is expressed in lumen hours. Lumen hours is the unit of measure for the brightness of light. *Taking the Pulse* establishes the minimum level of electricity service based off the MTF service metric in lumens. It stipulates that fractional Tier 1 access counts toward the SDG7 goals. This means a single-light-point solar lantern that has the functionality to charge phones (one of the MTF service criteria) counts toward access goals. However, since the lumen output of most solar lanterns is less than the MTF Tier 1 requirement of 1,000 lumen hours per day, this contribution is "fractional" given that the lantern does not deliver full service to all mem-

[32] Bhatia, M. & Angelou, N., 2015. Beyond Connections – Energy Access Redefined, Washington: Energy Sector Management Assistance Program.

Figure 1.1

Historical Electricity Access in Madagascar[33]



bers of a typical household. *Taking the Pulse* assumes in its modeling that a lantern delivers sufficient lumen output to provide access to 60 percent of household members—in line with the capabilities of the typical modern lantern. As such, households would need to have two lanterns in order to achieve full Tier 1 access. This is a critical methodological point, as lanterns are often more affordable than multi-light point systems. As such, this impacts the overall financing needs required to achieve universal access in a given market. The methodology chapter discusses how levels of service are derived in the model, and the assumptions that underpin them.

State of Electricity Access in Madagascar

Based on outputs from the model developed as part of this report (see the methodology section), at the end of 2018, 21 percent of households in Madagascar had Tier 1[34] equivalent or higher electricity access per the MTF.

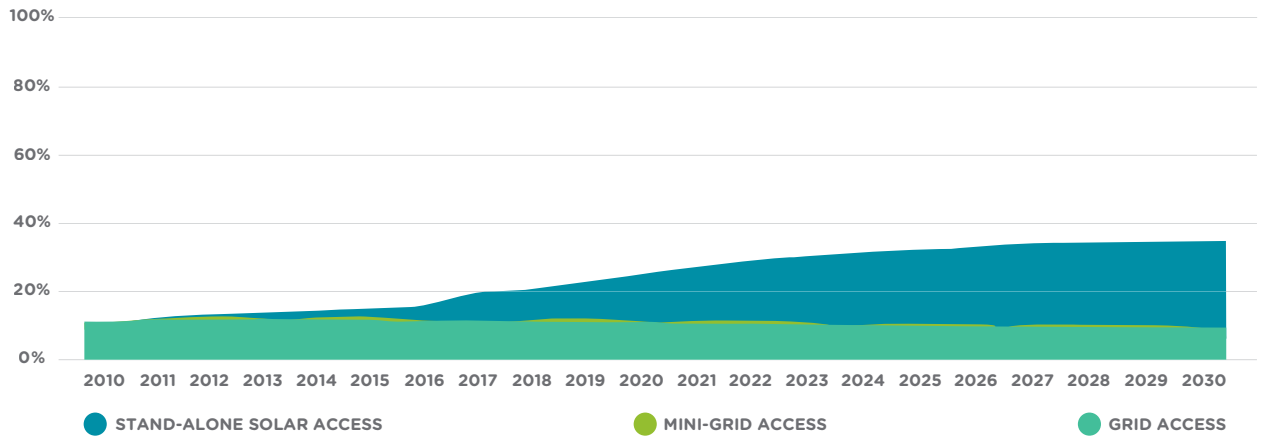
Grid access in Madagascar stands at 11.4 percent, roughly the same level as in 2010—as seen in Figure 1.1 above. This electrification rate is among the lowest in Africa.[35] Access through stand-alone solar, which was negligible at the start of the decade, now accounts for 9.4 percent of Malagasy household connectivity. This figure includes households with fractional Tier 1 access from a solar lantern that provides access to a share of the household.[36] Mini-grid access as a share of total electricity access in Madagascar, covering approximately 24,000 households of the country's 6.2 million, is minor, equal to less than 0.5 percent of households.

As seen in Figure 1.2, the model outputs show that if Madagascar continues to expand grid access at the pace seen in recent years, following a business as usual (BAU) scenario, grid coverage will actually fall relative to current levels (given that it is not keeping pace with population growth), and will stand at 9 percent in 2030. In contrast, stand-alone solar access, following its current trajectory, can be expected to reach 25 percent. This projection assumes an annual net increase of 150,000 households with Tier 1 equivalent access through 2030. With the low

[33] Authors' analysis.
[34] Tier 1 is the most basic level of electricity access, providing task lighting and phone charging for at least four hours a day, including at least one hour in the evening.
[36] A lantern will often not provide the 1,000 lumen-hours required to provide Tier 1 access to all members of a household. Therefore, it is possible to instead determine the share (or number of members) of a household that effectively gain access from the ownership of a lantern. This fractional household access allows for the positive impacts of smaller lanterns to be captured in total access figures.

Figure 1.2

Madagascar BAU Electricity Access Scenario



number of current connections, extrapolating forward the BAU mini-grid scenario would be near-imperceptible (0.3 percent – just over 30,000 total households with access). In the aggregate, the BAU scenario shows that Madagascar would provide energy access for 34 percent of households in 2030, leaving an energy access gap of 66 percent.

CLOSING MADAGASCAR'S ELECTRIFICATION ACCESS GAP

Achieving universal energy access in Madagascar by 2030 will require acceleration across both on-grid and off-grid technologies. The forward-looking projections modeled in Figure 1.3 below illustrate the target for Madagascar to achieve universal energy access by that time. The key assumptions driving this scenario are as follows:

- Grid connectivity would increase to 14 percent, supported by grid connections to reach an additional 2.4 percent of households. A total of 600,000 new grid connections would be realized between 2020 and 2030, fueled in the first half of the decade primarily by a World Bank grid extension and densification program. In later years, it is assumed that additional financing from development partners would support further grid electrification efforts.

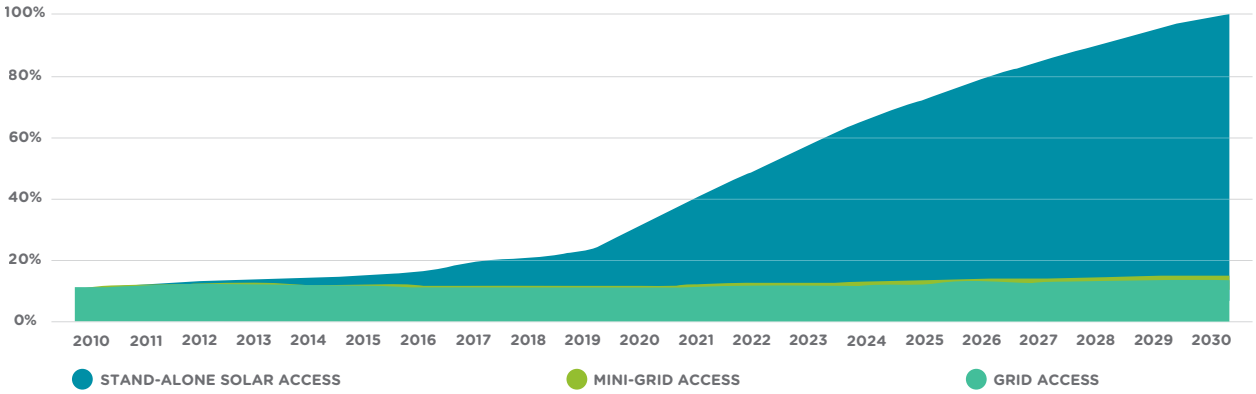
- The relatively limited growth in grid coverage would leave significant opportunities for mini-grids in the forecast scenario. As such, a significant scale-up in support for mini-grids from development partners and the private sector would yield over 100,000 new mini-grid connections, thereby yielding a mini-grid access rate of 1.4 percent.

Once grid and mini-grid contributions are derived, the model assumes that the remaining electrification access deficit will need to be filled by off-grid solar (OGS). As a result, Madagascar will be counting on stand-alone solar to deliver access to the remaining 85 percent of households in order to achieve universal access by 2030.

The following sections will discuss the Malagasy mini-grid and stand-alone solar sectors in more detail, including providing an overview of key actors, their challenges, and the detailed financing needs each will require to make its respective contribution toward achieving SDG7.

Figure 1.3

Forecast Electricity Access in Madagascar (All Technologies)



Mini-Grid Contributions Toward Achieving SDG7

The forecast model projects that 530 new mini-grids will be built during the period 2020-2030, resulting in 106,000 new household mini-grid connections. This represents a 330 percent increase in connections compared to the BAU scenario. Although this is a substantial increase from the base case observed in 2019, it still means that mini-grid contributions to the SDG7 challenge will remain modest, at 1.4 percent of total connections.

Mini-Grid Financing Needs

Taking the Pulse establishes that mini-grids will deliver a minimum of Tier 3 electricity services.[37] The model therefore includes assumptions around the cost of delivering this level of service. This is a minimum and does not preclude the development of mini-grids that are capable of delivering Tier 4 or 5 access. However, if either of these levels of service were to be considered the minimum, the overall costs of delivering

[37] Based on the MTF; see the methodology chapter for additional detail on the MTF.

Figure 1.4

Mini-Grid Electricity Access Forecast in Madagascar

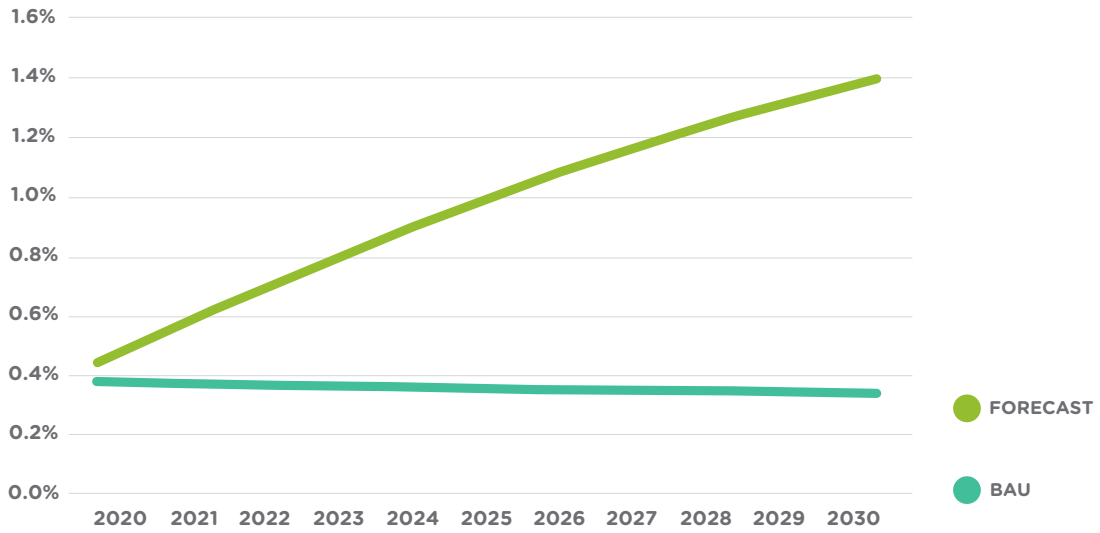
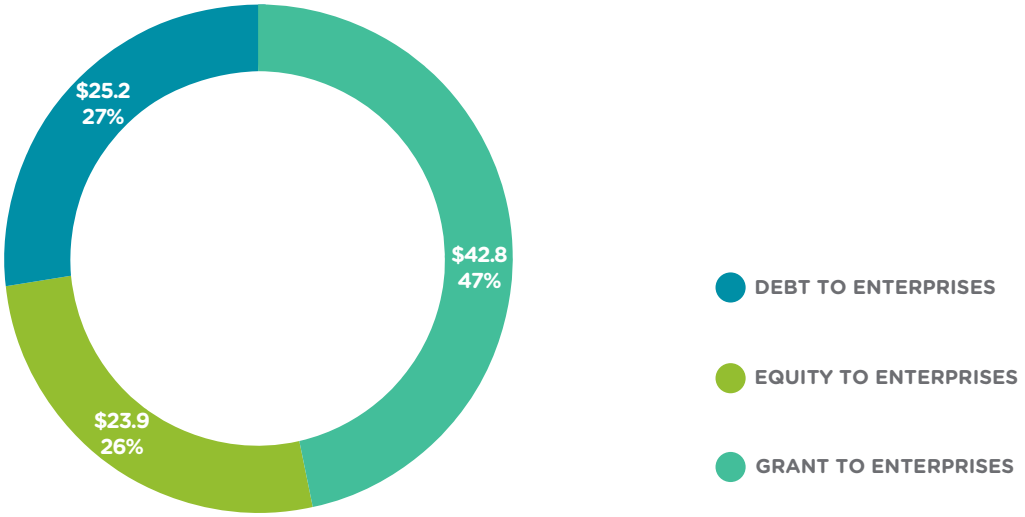


Figure 1.5

Cumulative Financing Need for Mini-Grid Enterprises in Madagascar (Million USD)



energy access via mini-grid solutions would increase considerably. New mini-grid development envisaged in the forecast scenario above will require a cumulative financing need of USD 92 million, as seen in Figure 1.5 above. The model assumes each mini-grid will support 200 households and two large anchor clients that consume at least one-third of the mini-grids' generated electricity and that connections will cost between USD 650-1,050 per connection, depending on the maturity of the mini-grid developer. A mature developer, by virtue of experience deploying at least 25 mini-grids, is expected to be able to develop new mini-grids at lower upfront cost than its peers. In reality, the mature developer is also more likely to ensure that mini-grids are efficiently exploited and thus more economically viable going forward.

Mini-grid projects rely on a blend of grants and equity to finance early-stage development costs, operational costs, and leverage for the additional debt financing needed to build and maintain infrastructure. Due to challenges regarding sustainability and sector growth, the analysis of financing needs for mini-grid development assumes that international development agencies, local government agencies, trusts and foundations, and other investors will provide grants to cover 47 percent of enterprise financing, while venture capital, private equity, impact funders, and other equity investors will contribute 26 percent. The remaining 27 percent of enterprise financing would come from debt.

Affordability of Mini-Grids

Project developers have difficulty setting cost reflective tariffs that recoup installation costs and operating expenses while staying within a rural household's willingness and ability to pay for electricity. One company noted that the government's inability to mobilize and deploy grants quickly to companies could hinder the scale-up of mini-grids in rural areas at low and affordable rates.[38] In the absence of an anchor customer with substantial energy needs, such as an agricultural facility, a cottage industry, or a mobile phone tower, mini-grid projects require subsidies to offset the tariff charged to energy users or buy down the connection cost.

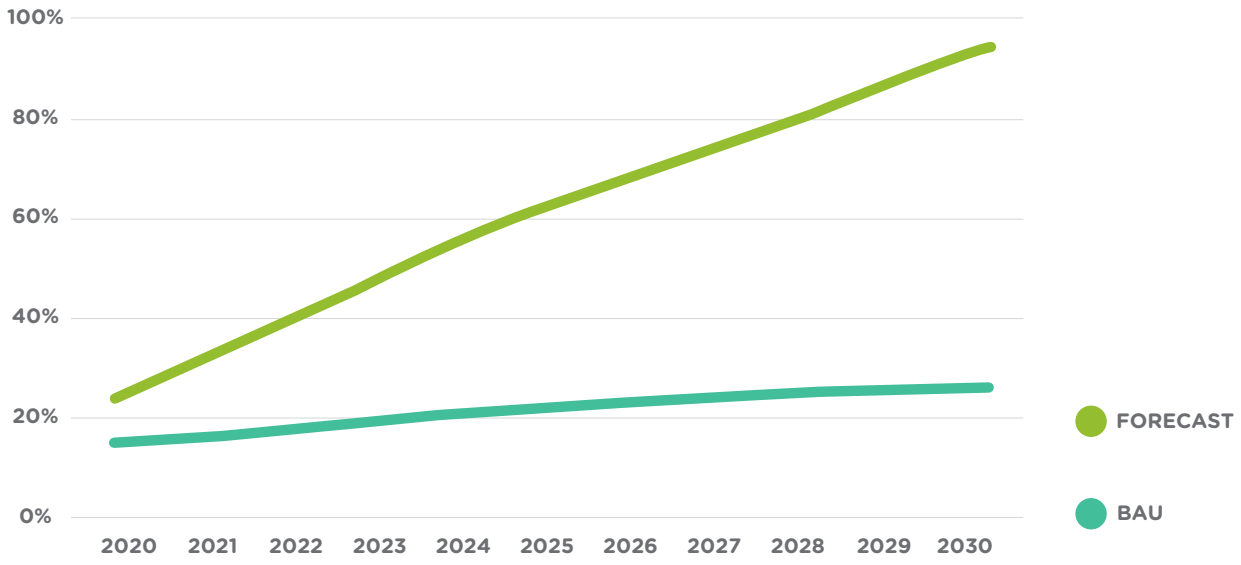
Key Challenges and Opportunities Relative to MGs Delivering on SDG7 Targets

The Malagasy mini-grid sector faces various challenges including but not limited to high cost of connections,

[38] Based on in-country interviews.

Figure 1.6

Stand-Alone Solar Electricity Access Forecast in Madagascar



policy bias towards grid and fear of intrusion in mini-grid service areas due to the lack of a central registry for new electrification projects. Not being able to access financing, including financing in the local currency, makes it difficult for companies to scale-up mini-grids, particularly since the country's energy ecosystem is not yet mature nor is its political climate stable, according to one interviewee.[39]

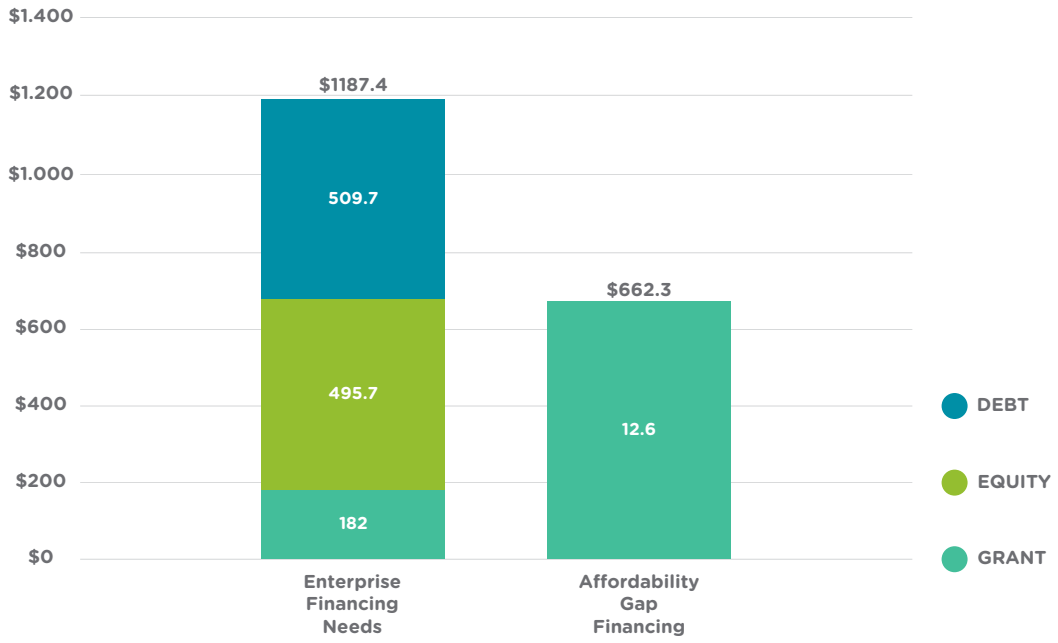
Mini-grid operators in Madagascar are providing electricity to around 200 villages, serving approximately 24,000 customers. On the plus side, the industry has slightly benefited from the decline in the cost of solar PV hardware, battery storage, and metering technology over the past decade. However, despite falling technological costs, the construction of new mini-grids is still significantly hampered by the high and often prohibitive cost of connections resulting from the need to build expensive distribution networks for small numbers of poor customers living in sparsely populated regions.[40] In addition, the policy bias and vested interest of stakeholders in the power sector, including JIRAMA, power producers and others invested in the status quo may weaken the development of mini-grid and stand-alone solar solutions, as both are perceived as a threat to their business.[41]

Moreover, the lack of a central registry for new electrification projects has led to conflicts at certain attractive hydroelectric sites between planned vertically-integrated mini-grid projects and planned generation only projects. To address this, in December 2015, the Government of Madagascar passed a law on PPPs to provide a legal definition for the roles, obligations, and the rights of private partners. This new law improves Madagascar's concessions processes and energy policies.[42] [43]

[39] Based on in-county interview.
[40] The World Bank. 2019. "International Development Association Project Appraisal Document on a Proposed credit in the amount of SDR 107.9 Million (USD 150 Million Equivalent) to the Republic of Madagascar for the Least Cost Electricity Access Development (LEAD) Project".
[41] The World Bank. 2015. "Evaluation of Rural Electrification Concessions in sub-Saharan Africa (Detailed case Study: Madagascar)".
[42] Ibid.
[43] The African Legal Support Facility (ALSF). Profil Pays PPP – Madagascar http://www.aflsf.org/sites/default/files/PPP%20Country%20Profile%20-%20Madagascar.pdf

Figure 1.7

Cumulative Financing Needs for Stand-Alone Solar Enterprises in Madagascar (Million USD)



STAND-ALONE SOLAR CONTRIBUTIONS TOWARD SDG7

In a BAU scenario, stand-alone solar for households is expected to reach 25 percent, whereby net new systems deployed (gross additions minus retirements) range from 110,000-190,000 Tier 1 equivalents per year through 2030. This scenario reflects the general slowdown in stand-alone solar product sales witnessed across many solar markets in recent years as affordability and accessibility constraints become more acute as the sector moves into more remote, less well-off areas of the country. As one company noted, one of the biggest barriers in scaling-up stand-alone solar solutions is customer affordability, where the target market is earning around USD 1.66 a day.[44]

The forecast model, however, projects that stand-alone solar will provide 7.3 million new households with access in the period 2020-2030 (84.8 percent of electrified households by 2030). This is a 240 percent increase from the BAU scenario and will require tremendous financing and execution capability to achieve. One company operating in the industry noted that the government's ability to efficiently support and facilitate the development of private sector enterprises in the country will have significant implications on how quickly stand-alone solar will take off in the next five years.[45]

Stand-Alone Solar Financing Needs

To reach the additional 7.3 million households envisaged in the forecast scenario outlined above, stand-alone solar enterprises in Madagascar have a cumulative financing need of USD 1.19 billion, as seen in Figure 1.8 below. This figure is driven by three key assumptions:

- PAYG companies require long-term, up-front financing to accommodate the payment schedule of their customers—which is often 12 to 18 months but can extend to three years or more. This means that the initial financing challenge resides with the solar enterprises themselves. Debt

[44] Based on in-country interview.

[45] Based on in-country interview.

is the most appropriate form for this financing to take, as it will enable stand-alone solar companies to import inventory, and in some cases, extend loans to their customers. As those systems are purchased, loans can be repaid.[46]

- Stand-alone solar systems are assumed to have a lifetime of four years and, as such, households purchasing a system in a given year are projected to require a new system to maintain access fully four years later. A country with a high rate of stand-alone solar access more than four years prior to 2030 is therefore likely to have higher proportional financing needs than a country that makes rapid gains in OGS access closer to 2030.

- Madagascar will also require USD 662 million in affordability gap financing to achieve universal electricity access. A more detailed explanation of consumer affordability is provided below.

The model assumes that stand-alone solar enterprises are at different stages of maturity during the forecast period (pilot, validation, scale-up, mature). The blend of capital associated with these stages varies, as summarized in Table 1.3 below. Early-stage enterprises will be more reliant on grant financing and risk tolerant early equity, while more mature businesses will seek to leverage their equity financing to secure significant debt that will finance their consumer receivables and inventory finance needs.

Stand-alone solar projects benefit from increasing access to debt, limiting the need for grants in the financing mix. As noted in Figure 1.7, grants are expected to provide 15 percent of total enterprise financing through 2030, largely due to the need to incentivize companies to establish sales channels in underserved rural areas. Equity finance covering 42 percent of enterprise needs will support ongoing operational activities, while debt will contribute the remaining 43 percent of enterprise capital needs.

Affordability of Solar Home Systems

The estimated affordability constraints outlined above were determined by leveraging the World Bank PovCal tool to create Malagasy household consumption curves, i.e., charting the percentage of households with consumption at or below specific dollar amounts. Then, by assuming that households are willing to allocate no more than 5 percent of their monthly expenditure on electricity access (a threshold often used by practitioners to define electricity affordability), it is possible to determine the percentage of households that can afford the USD 3.30 that is modeled out as a proxy for what the monthly cost for a PAYG lantern would be. Prompt 1 on Figure 1.8 illustrates that approximately 60 percent of households could afford this, while the remaining 40 percent would require some sort of support to be able

[46] Uganda Off-grid Energy Market Accelerator. 2018. "Mapping the Ugandan off-grid energy market".

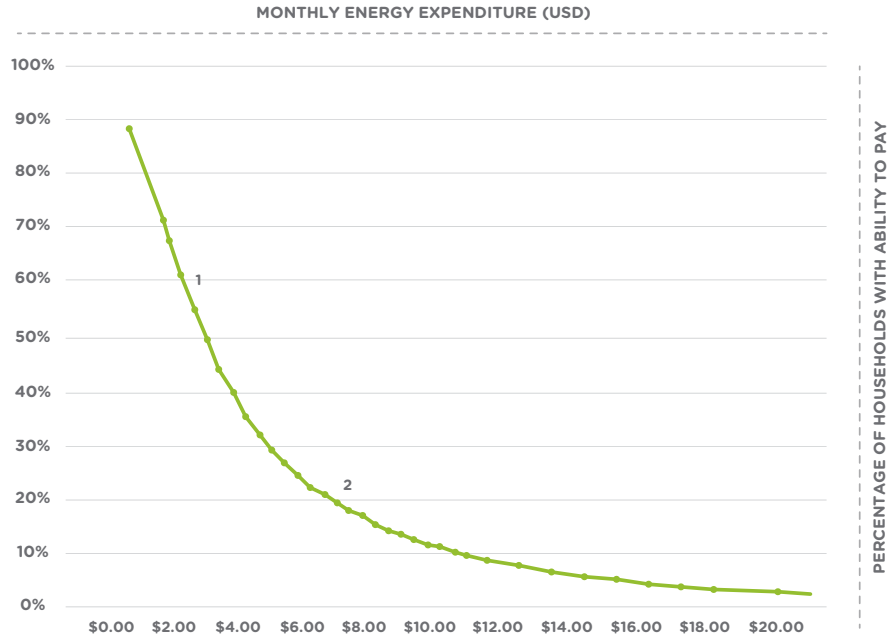
Table 1.3

Model Assumptions of Capital Blend by Stand-Alone Solar Company Maturity

	Pilot	Validation	Scale-Up	Mature
Grant	20%	30%	10%	5%
Equity	80%	55%	45%	15%
Debt	0%	15%	45%	80%

Figure 1.8

Madagascar's Ability to Pay at 5% of Monthly Consumption on Electricity Access



to pay this amount. Along similar lines, Prompt 2 on Figure 1.8 illustrates that only 20 percent of households could afford the USD 7.50 that is modeled as a proxy for the cost of a multi-light point stand-alone solar system that delivers Tier 1 electricity services. The *Taking the Pulse* methodology chapter provides a more detailed discussion of how affordability was estimated.

Key Challenges and Opportunities Relative to Stand-Alone Solar Delivering on SDG7 Targets

Stand-alone solar has immense potential to deliver energy access in Madagascar, with most regions receiving over 2,800 hours of sunshine per year.[47] The country's low population density makes the extension of the grid extremely costly, while the population's affordability challenge—particularly in rural areas—constrains the mini-grid sector's ability to grow quickly. These challenges, combined with JIRAMA's financial woes, make it all the more imperative to scale up stand-alone solar solutions in Madagascar to deliver on SDG7.

The sector faces major challenges which affect both customers (demand side) and private sector enterprises (supply side). These include lack of quality and after-sales services, weak distribution network for solution providers, low purchasing power among consumers, including lack of access to SMEs financing for solar distributors, high costs of rural distribution due to Madagascar's relatively large size, lack of government incentives and the lack of local human capital to fill management and key technical positions.[48] By way of a start, the government is working to tackle the issue of low-quality products by adopting the Lighting Global standards for stand-alone solar systems and tying import duty and VAT exemptions to these standards. It will be equally as important for the GoM to enforce the use of higher-quality products – once the standard is adopted – to address these challenges.

Low-quality products have led to lower consumer confidence. Currently, only four businesses have been identified as consistently selling Lighting Global quality-verified products, Baobab+, HERi, Orange

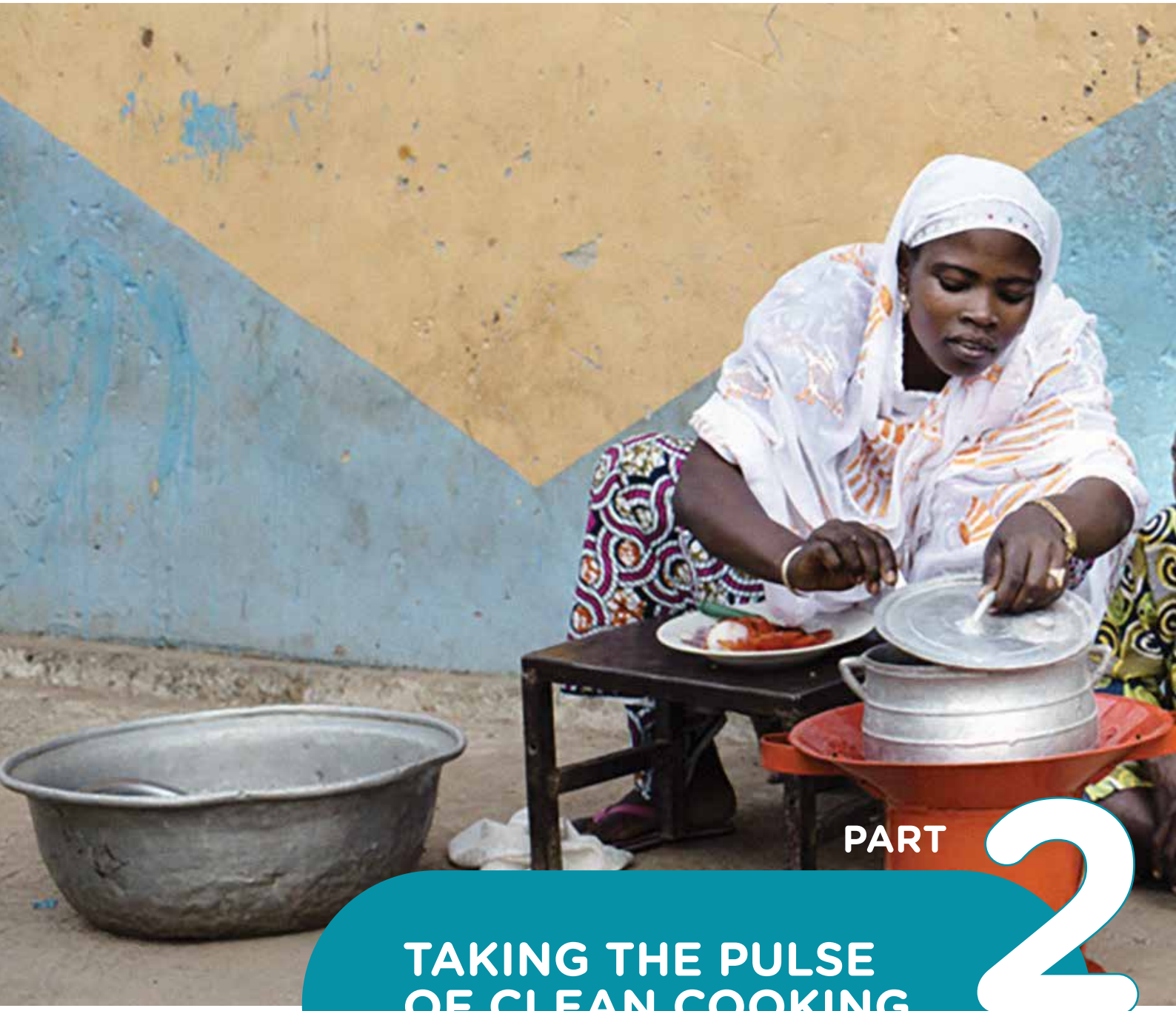
[47] Get Invest. Mobilizing Renewable Energy Investments. Madagascar Renewable Energy Potential at: https://www.get-invest.eu/market-information/madagascar/renewable-energy-potential/

[48] Ibid.

and Majinco. As noted by a private sector company that operates in that sector, higher-quality stand-alone solar products with longer warranty and better service oftentimes fail to attract new customers because lower-cost products remain more attractive for the Malagasy consumer.[49] The lack of differentiation of fiscal incentives between low- and high-quality products also discourages private sector enterprises from selling high-quality products. On the distribution side, the footprint of stand-alone solar providers in remote areas of the country is extremely limited (most systems are sold to higher-income households in cities and rural towns). This makes purchasing those products even more expensive for rural customers as they must travel to cities to buy them.[50] The GoM could explore other fiscal incentives that would encourage private sector enterprises to sell more products in harder to reach locations, such as rural areas, as a means to reduce cost for rural consumers.

[49] Based on in-country interview.

[50] Ibid.



PART 2

TAKING THE PULSE OF CLEAN COOKING IN MADAGASCAR

INTRODUCTION

Government Initiatives

The Government of Madagascar (GoM) has a relatively robust clean cooking policy guided by the country's overarching energy policy.[51] Under this policy, the country has established several cooking-related targets to achieve by 2030, including:

- 70 percent access to energy-efficient cookstoves.
- 50 percent of wood to be sourced from legal and sustainable forest resources.
- 20 percent of charcoal to be 'green' having been produced efficiently and from legal and sustainable forest resources.

[51] Madagascar's primary energy policy is called 'La Nouvelle Politique de l'Energie 2015-2030'.

The government has established a tracking framework to measure achievement in clean cooking and standards to assess efficiency, emissions, and safety of clean cooking solutions.[52] As of 2018, Madagascar had a score of 50 (out of 100) in robustness of its clean cooking policy framework according to the Regulatory Indicators for Sustainable Energy (RISE) score.[53] The government is also actively promoting ethanol as a household cooking fuel to reduce the use of firewood and charcoal. In July 2014 the government set forth a decree to promote ethanol cooking through the following means: i) exemption of heavy alcohol tax for ethanol fuel production and exemption of import tax on imported ethanol stoves; ii) setting performance and quality standards for ethanol fuel; and iii) designation of the Ministry of Industry (MoI) to be technically responsible for approving Ethanol Micro Distilleries (EMDs) and promoting ethanol clean cooking. Since the decree was passed, private-sector interest in ethanol cooking has increased; the MoI received applications from four distilleries, and 528 stoves have been sold in the Malagasy market.[54]

The government has begun to partner with international organizations and NGOs active in the cooking space. One example of this is the financial support GoM provided to ADES (the *Association pour le Développement de l'Energie Solaire*), a Swiss-Malagasy energy NGO. Through its financial support, ADES is able to sell solar box cleaners[55] at a subsidized price of USD 20, with a local production price of USD 46.[56]

CURRENT SECTOR ECOSYSTEM

Defining Clean Cooking

Taking the Pulse uses the MTF[57] to establish the minimum definition of "improved cooking" that counts toward the SDG7 goal of universal access. The MTF measures household access to cooking based on indoor air quality, cookstove efficiency and convenience, and the safety, affordability, quality and availability of the primary fuel.

Taking the Pulse has two main ways in which it defines access to improved cooking solutions. The first, which is the primary focus of the report, centers on moving households away from traditional cooking solutions (typically using a three-stone fire or artisanal or semi-industrial cookstove) which do little to improve cooking efficiency and/or reduce emissions. As such, the report models the cost of what it would take for these households to adopt improved "industrial" cookstoves, which typically entail centralized, large-scale production that uses quality components, manufactures with precision tools and employs considerable levels of automation. The focus is typically on rocket stoves, which have an insulated, L-shaped combustion chamber that improves combustion efficiency and reduces emissions. However, it is important to note that use of these stoves necessitates the continued use of either wood or charcoal as a fuel source. *Taking the Pulse* defines the minimum level of improved cooking access as ICS that meet International Workshop Agreement (IWA) minimum standards on fuel efficiency and emissions.

Related to clean fuels, the report focuses on three primary ones that are considered to have significant potential. These are a sub-set of cooking solutions that deliver high performance in terms of reducing household air pollution—often (although not always) regardless of the type of cookstove used: biogas, LPG, electricity, ethanol, natural gas, and solar cookers, collectively called "BLEENS"[58]. Given that *Taking the Pulse* only focuses on biogas, LPG, and ethanol, it adopts the term "clean fuels" in discussing them. The report forecasts the expected uptake of clean fuels over time, but does not cost out the financing that would be required to achieve these forecasts. This is because it was not in the scope

[52] Regulatory Indicator for Sustainable Energy (RISE). 2017. Madagascar http://rise.worldbank.org/country/madagascar#modal-container-web-link-doc
[53] The RISE scores highlight a country's policies and regulations in the energy sector organized by four pillars: energy access, energy efficiency, renewable energy and clean cooking. The scores are out of 100 and a lower score indicates poor performance whereas a high score indicates good performance.
[54] The World Bank. 2016. "Project Information Document (PID) Appraisal Stage: MG ethanol clean cooking climate finance program (P154440)".
[55] Solar box cookers are the most popular type of solar cookers. They are made of any material such wood, air plastic, cardboard). They can reach a maximum temperature of 1500 C. (Source: (Solar Cooker n.d.)).
[56] Fandom. 2019. Solarcooking. https://solarcooking.fandom.com/wiki/Madagascar
[57] Bhatia, M. & Angelou, N., 2015. Beyond Connections – Energy Access Redefined, Washington: Energy Sector Management Assistance Program.
[58] Ibid.

of this report given the complexity surrounding the costing of delivering clean fuels for cooking.[59]

Clean Cooking in Madagascar

Madagascar has the largest clean cooking deficit in Africa, with less than 1 percent of households using clean fuels and a fraction of a percent of households using improved wood or charcoal stoves.[60] Madagascar's cookstove market is dominated by small-scale producers that are scattered around the country, producing mostly artisanal stoves. Many of these producers manufacture charcoal-burning stoves, while a few produce wood-burning stoves. Although production is small scale, stove manufacturers are still quite uniform in the materials they use to produce stoves. These materials include clay, concrete, sheet metal, sand, and/or dung. Despite this uniformity, there is considerable innovation, especially in stove design.[61] There is scarce available data on the number of these small-scale producers.

Malagasy households predominantly use solid fuels irrespective of geography. However, in urban areas, charcoal is the most widely used fuel source whereas, in rural areas, the leading fuel source is wood. Other solid fuels used by roughly 1 percent of households or less include coal, straw, branches, grass, and agricultural residues. Household income also affects cooking fuel in Madagascar, as high-income households tend to use charcoal while those with lower household income tend to use wood.

Semi-industrial ICS production is nascent in Madagascar. NGOs and international organizations play a significant role in filling this gap in the market. ADES—one of the prominent stakeholders and an implementing partner of Energising Development (EnDEV)—has been producing efficient wood, charcoal, and solar cookstoves in Madagascar since 2002 and selling them at a reduced price to local households.[62] Before ADES started its work, there were hardly any market channels for semi-industrial cooking solutions in Madagascar. Since its inception, it has sold over 170,000 stoves and created some 400 jobs.[63]

Other cookstove programs have commenced operations in the wake of ADES. One of them is Clean Cooking Madagascar (CCM) which is fully funded by Green Development AS, a Norwegian company which aims to reduce household air pollution by increasing access to modern energy solutions at household level. With this goal in mind, CCM and Green Development AS are currently promoting the use of ethanol stoves for cooking. CCM promotes three ethanol-based stoves which are produced outside of Madagascar.[64] Another local nonprofit organization called Zahana has developed an easy to build cookstove which can reduce the need for firewood by half using simple technologies such as bricks and mud. This organization follows an incremental approach to the promotion of ICS by starting with environmentally-friendly wood burning stoves. Its long-term goal is to introduce modern technologies such as solar cooking.[65]

LPG Market

Compared to other markets in East Africa, the LPG market in Madagascar is also relatively under-developed. Since Madagascar does not have its own oil refinery, oil products such as LPG must be imported. The main LPG companies include a few major oil companies, such as Total, which sell LPG cylinders at some of their petrol stations, and a few local players such as Jovena, Galana, and Vito Gaz. Vito Gaz is a private company in Madagascar that has been in operation since 2001 as an independent importer, distributor, and retailer of LPG.[66] The company currently has two storage sites and its own import terminal, as well as two re-fill-

[59] In addition to the financing needs for distribution and/or installation of the cooking hardware, scaling LPG and ethanol uptake requires the build-out of large-scale distribution infrastructure, particularly related to shipping, storage, and processing of fuels.
[60] Energy Sector Management Assistance Program. 2015. "Beyond Connections: Energy Access Redefined".
[61] Klug, Thomas. 2018. "Understanding the Impacts of Traditional Cooking Practices in Rural Madagascar and a Way Forward with Improved Cookstoves".
[62] My Climate. 2017. My Climate. https://www.myclimate.org/information/climate-protection-projects/detail-climate-protection-projects/show/Project/madagascar-efficient-cook-stoves-solar-7116/
[63] ADES. 2019. adesolaire. http://www.adesolaire.org/en/ades-in-madagascar-en/our-program-en
[64] Clean Cooking Madagascar. 2017. Madagascar Ethanol Stove Program http://madagascarethanolstoveprogram.org/clean-cooking-madagascar/
[65] Zahana. 2019. Zahana.org. https://zahana.org/Site_With_Pix/Cookstove.html
[66] ViTOGAZ. 2019. http://www.vitogaz.mg/presentation.php

ing stations, one in the northwest in Mahajanga and one in the capital city, Antananarivo. Vito Gaz currently has 14 accredited distributors as well as 640 individual retailers throughout the island. The company's main cannister sizes include 9-kilogram (kg), 12.5kg, 25kg, and 39kg. Its total storage capacity is 2,850 tons of LPG, which is sufficient to meet the annual needs of between 104,000 and 126,000 households.[67] [68]

The company's current customers also include a substantial share of commercial and industrial clients, including bakeries, roasteries, restaurants, hotels, and a range of others, which means that household consumption represents only a portion of total sales.[69] Growth in the market has been stable, rather than exponential, and there are currently no incentives or government programs to support the adoption of LPG as a clean cooking fuel.

Biogas Market

Biogas has benefited from donor and other support over the last decade but remains very limited in scope. The sector has been mainly supported by development aid from the Norwegian Missionary Society (NMS) and the People's Republic of China,[70] which collaborated on a biogas partnership from 2009 to 2015. The most recent figures available (2015) indicate that 492 household biodigesters have been built in Madagascar, using a standard 10m^3 fixed-dome design and a solid concrete dome as a mold, as well as eight institutional digesters (between 30m^3 and 40m^3).[71] Such systems can last twenty years or more provided adequate maintenance is conducted. An earlier model based on a plastic, tubular design was used from 2005-2007, as they were more affordable, but the systems were not sufficiently reliable and only lasted three years on average. Aside from these efforts, there is currently little notable activity in the residential biogas market, although the program mentioned above appears to have raised sufficient awareness for biogas to be included as a priority in the Ministry's guidance for activities to be undertaken in 2019.

The main constraint on the supply side is the lack of companies equipped and trained to install systems. Market activity has been dependent on the presence of active donor support, and once this support and technical assistance has lapsed, so too has demand. As such, although Madagascar has about 492 biogas installations country-wide, the potential for future growth appears limited in the absence of further interventions. On the demand side, the main barrier remains the high upfront cost of the systems, along with the lack of companies and workers trained to build the systems well. The cost of constructing biogas systems ranges from between USD 500-800. Given that average GDP per capita in Madagascar is currently around USD 450 per year, the upfront cost of a biogas system is beyond the reach of the vast majority of households.

Ethanol Market

Although the ethanol market is fledgling, there are a few signs of activity. There are currently three ethanol micro-distilleries in operation supplying ethanol fuel to local customers. In addition, a number of suppliers have begun importing ethanol as well, mainly from South Africa and Mauritius. A few different stove models are also available on the market ranging from USD 20-30 each. According to a recent feasibility study conducted for the World Bank, ethanol can be produced in the range of USD 0.50-0.60 per liter, but due to the early stage of development of the current distilleries, their production costs are approximately twice as high. The current sales price for domestically produced ethanol is roughly USD 1.50 per liter. On the portion that is imported, companies pay sizeable import duties, which in some cases (depending on the countries from which one is importing) can more than double the price of the fuel.

Another key driver of the ethanol market to date has been the work undertaken as part of the World Bank's Carbon Initiative for Development (Ci-Dev), which is a development-focused trust fund set up by the World

[67] This is based on field research in Sub-Saharan Africa indicating annual household LPG consumption of between 22.6 and 27.3 kg.
[68] Economic Consulting Associates, The Global LPG Partnership. 2017. "Econometric analysis of potential LPG Household cooking market in Ghana".
[69] ViTOGAZ. 2019. http://www.vitogaz.mg/presentation.php
[70] Oméga Razanakoto, Lars Kåre Grimsby, Guo Jing, Elisabeth Rabakonandrianina. 2015. "Final Evaluation of the International NMS Biogas Partnership Program".
[71] Ibid.

Bank that uses carbon credits to help accelerate market transformation and spur the adoption of clean technologies. Ci-Dev signed an "emissions reduction purchase agreement" in 2016 with Green Development AS, a company focused on carbon financing. The agreement involved the purchase of 1.1 million certified emission reductions (CERs) that are to be generated through the end of 2024 through a range of activities, including ethanol cooking.

The aims of the initiative are to make ethanol cookstoves more affordable to end-users, to support establishment of two pilot ethanol micro-distilleries (including a training center), and to provide capacity building and technical assistance to private sector and government partners.

In light of the relatively low-price of charcoal compared to ethanol, the main impetus for the market's development has been institutional and donor support focused on creating a local ethanol industry. Within the ethanol industry, the view of many donors and other activities in the sector is that if the cost of the stoves can be brought down, then demand will come. If the price of ethanol could be brought down to between USD 0.80-0.90 cents per liter, one local interviewee with deep knowledge of the local market estimates it would be within the range of affordability (between USD 10-15) required to drive demand.[72]

In recent months, the newly elected Government of Madagascar has signaled interest in promoting ethanol cooking; this could help build on NGO and donor-funded efforts to advance the sector.

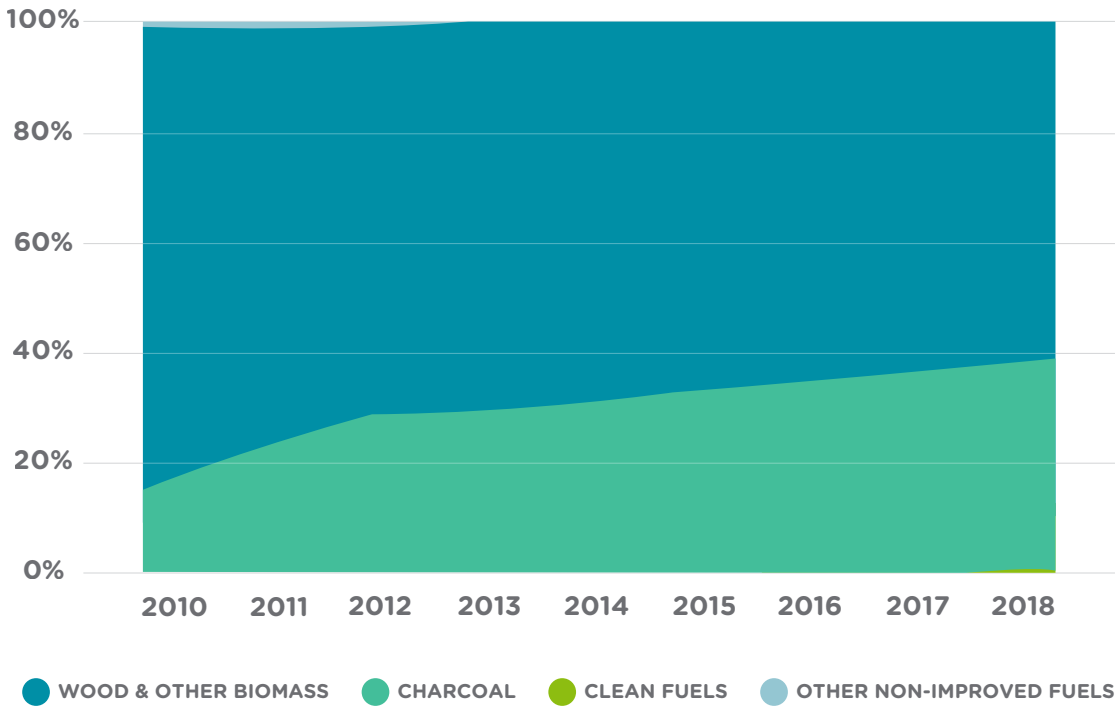
Current State of Clean Cooking Access

By the end of 2018, approximately 0.6 percent of Malagasy households were using clean fuels and just 0.3 percent of the households cooking with charcoal, wood or other biomass were thought to be using ICS. A staggering 99 percent of households still do not employ clean cooking solutions.

[72] Based on in-country interviews.

Figure 2.1

Historical Cooking Fuel Breakdown in Madagascar



Based on outputs from the model developed as part of this report (see methodology chapter for details), it is estimated that at the end of 2018 some 38 percent of households cooked with charcoal, and a further 61 percent cooked with wood or other biomass. Of the less than 1 percent of households that cook with clean fuels, approximately 0.4 percent cook with LPG, 0.1 percent with electricity, and 0.2 percent with ethanol. The remaining households (fully 99 percent) use a three-stone fire or an artisanal or semi-industrial cookstove that does not improve cooking efficiency and/or emissions enough to be deemed an ICS. All Malagasy households report that they cook at home, according to survey data.

CLOSING THE CLEAN COOKING ACCESS GAP IN MADAGASCAR

Figure 2.2 illustrates the scope of the clean cooking challenge in Madagascar. The model projects that households using clean fuels will increase to a total of just 5 percent, equivalent to 0.5 million households from the low existing rate of 0.6 percent, however, a considerable share of these are expected to engage in fuel stacking. Over 9 million households are expected to continue to cook with wood and charcoal as either a primary or secondary source. The challenge will be to shift all of these households away from traditional cooking technologies (namely three-stone fires and lower-quality semi-industrial stoves) and onto higher-quality industrial improved wood and charcoal stoves, as illustrated by the white line representing required penetration of ICS over the period 2020-2030.

Wood and Charcoal ICS Contributions Toward Achieving SDG7

The analysis now focuses on the forward-looking projections through to 2030 and modeling what it would take for Madagascar to achieve universal clean cooking access by that time. Figure 2.3 below illustrates the model outputs through to 2030. The key assumptions are as follows:

- The minimum definition of access is high-quality industrial ICS that meet international minimum standards on fuel efficiency and emissions.
- The assumed retail price is USD 25 for an industrial wood stove and USD 36 for an industrial charcoal stove.
- Going forward, urbanization is expected to drive higher rates of charcoal use in Madagascar.
- The penetration of clean fuels is expected to be limited to just over 5 percent of households due to affordability constraints, and also logistical issues. Madagascar is 90 percent the size of France (with less than half the population) and its internal road systems are unreliable, particularly during the rainy season.

Figure 2.2

Cooking Fuel Breakdown and ICS Penetration Forecast in Madagascar

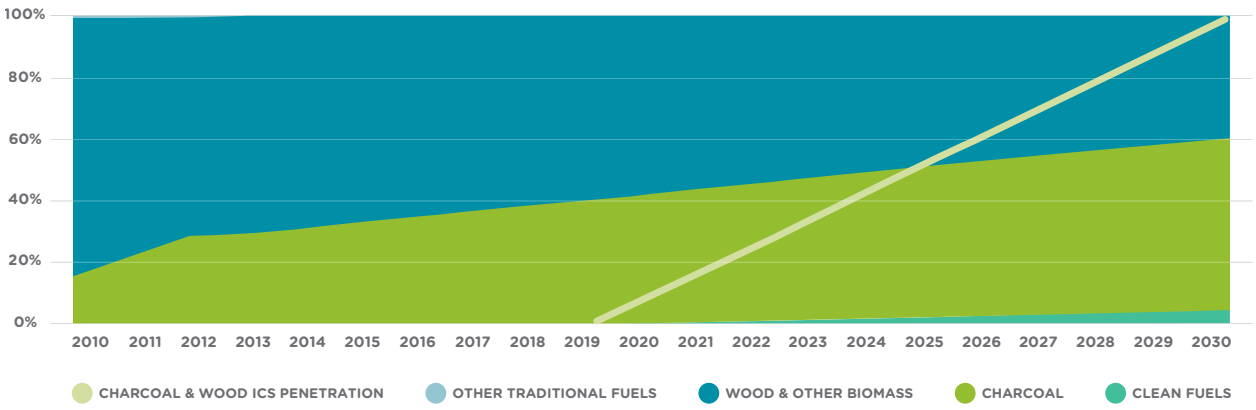
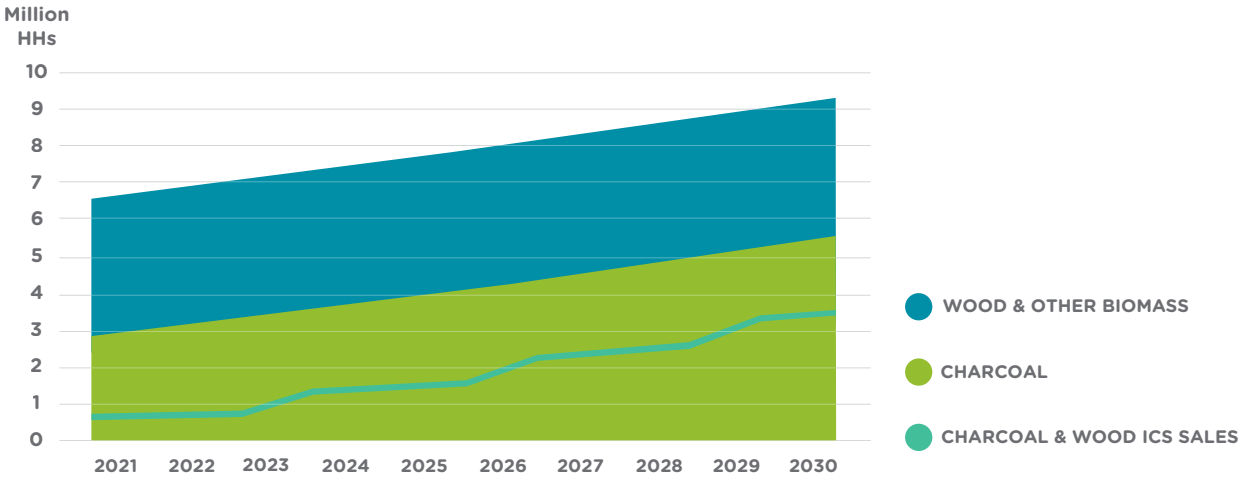


Figure 2.3

Traditional Cooking Fuel Use & ICS Sales Forecast in Madagascar



This makes considerable clean fuel uptake outside of the capital and port cities rather unlikely by 2030.

- Electricity use in cooking is unlikely to increase significantly due to both the lack of grid reliability and the high cost of electricity.

- Clean fuels households are likely to continue to fuel stack in considerable numbers and will thus also need to purchase charcoal ICS.

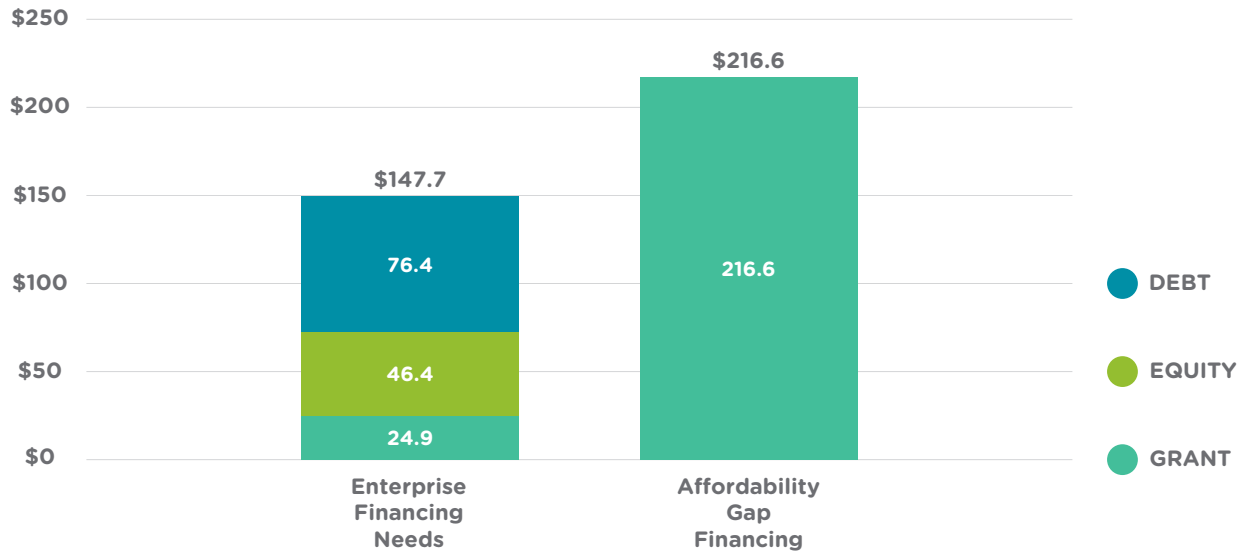
The model assumes that the population will grow at a rate of 2.6 percent per annum. It also assumes that stoves must be replaced at three-year intervals.

Financing Needs of ICS (Charcoal and Wood)

To achieve the scenario in Figure 2.3 above, ICS have a cumulative financing need of USD 148 million for enterprises and USD 217 million for affordability gap financing, with the breakdown of the former illustrated in Figure 2.4 below.

Figure 2.4

Cumulative ICS Enterprise Finance Needs in Madagascar (Million USD)



Grants to enterprises represent 17 percent (USD 24.9 million) of the capital mix used to lower costs associated with proving out the business model and displacing additional equity financing needs. Another 32 percent (USD 46.8 million) of financing needs will be in the form of equity investments in businesses that turn profitable at the scale-up phase, wherein they have sold about 5,000 ICS units. Debt financing accounts for 52 percent (USD 76.4 million) of the capital mix. This is inventory finance to enable retailers to purchase stock of stoves and then repay those loans once sales are completed. The model assumes that all stoves are sold on a cash sale basis.

Consumer Affordability

According to the forecast scenario, Madagascar will require up to USD 217 million in affordability gap financing to help the 90 percent of households that cook with wood but cannot afford an industrial cookstove. The model assumes that households save an amount equivalent to 2 percent of total monthly household consumption for a period of three months in order to buy an ICS. The model also assumes that if a household can afford to buy charcoal, then there is no affordability gap in buying a stove. Since charcoal is expensive—relative to firewood—and the charcoal stove enhances efficiency, purchasing an improved stove should be a selling proposition and compelling to consumers.

KEY CHALLENGES AND OPPORTUNITIES: MADAGASCAR'S SDG7 COOKING TARGETS

Organizations involved in production and marketing of ICS technology in Madagascar face considerable challenges including, but not limited to: lack of customer awareness, limited capacity due to lack of financing, consumer affordability challenges, and a lack of data.

Changing centuries-old cooking habits is not easy. Many cookstove projects in Madagascar have reasonable success while their representatives are still on-site supervising installation and use, but find that soon after their departure the stoves are repurposed as flower pots or doorstops, and people return to their original cooking methods.[73] To address this, many organizations have customer awareness creation at the core of their programs. ADES, for example, conducts training to inform local communities on how to use energy-efficient ovens as well as awareness raising initiatives regarding environment and climate protection.[74] However, small local producers do not have the resources for such programs, and the responsibility falls to the government and other engaged stakeholders to support them through campaigns showcasing the economic and health argument of clean cookstoves as well as the positive gender impact. As noted above, the lack of available data regarding small-scale producers in Madagascar is another major impediment in reaching clean cooking targets. The government and other engaged stakeholders would be better equipped to reach clean cooking targets with improved data collection on small-scale producers and consumer preferences, predominantly from women, for solutions and approaches that will be sustainably adopted.

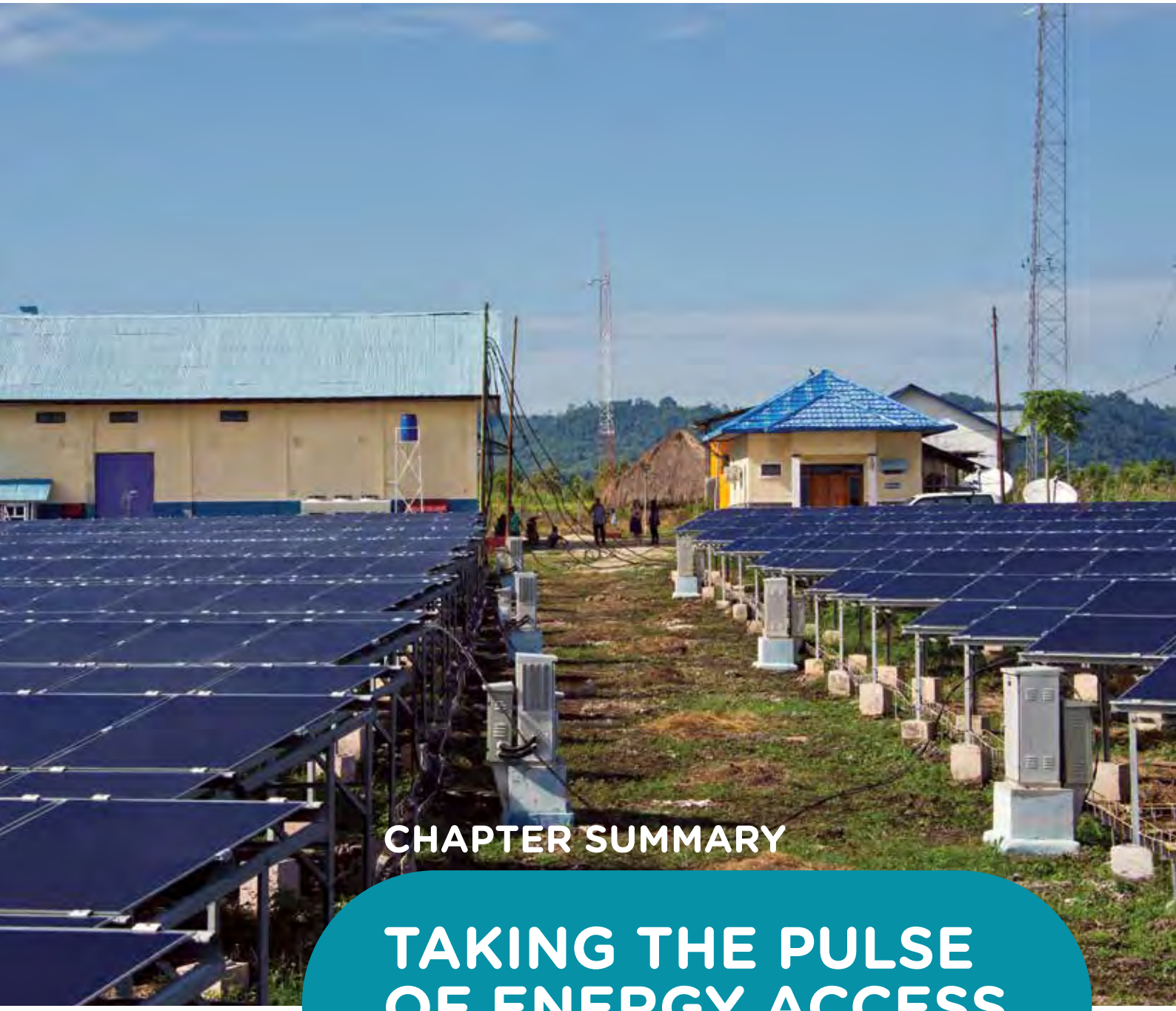
Most local producers are incapable of producing semi-industrial let alone industrial-level cookstoves. According to a survey conducted among local producers in the Sava region, most produce largely uniform products, which are charcoal-burning stoves. They have limited business capability as they do not employ additional workers and are very localized with no distribution network outside of their existing market.[75] On the financing side, many organizations are also utilizing innovative financing schemes such as carbon financing to support their ongoing programs including user training, cooking demonstrations, and school programs that guarantee long term usage and adoption of new cooking technologies.

As illustrated in Figure 2.4, affordability of cookstoves is a major challenge in Madagascar. The relative price

[73] Becker, Elena. 2015. "Malagasy Cookstove Use and the Potential for Alternative Models: A Case Study in Madagascar's Vakinankaratra region." Acadamia.edu.
[74] ADES. 2019. adesolaire. http://www.adesolaire.org/en/ades-in-madagascar-en/our-program-en
[75] Klug, Thomas. 2018. "Understanding the Impacts of Traditional Cooking Practices in Rural Madagascar and a Way Forward with Improved Cookstoves".

of charcoal compared to other substitute fuels is cheap. However, rising firewood and charcoal costs over the past few years are making ICS more appealing.[76] One way to improve affordability is to introduce duty exemptions on cookstoves and cookstove components. Another option would be to impose taxes on charcoal and firewood, to the extent possible, to decrease deforestation and wood use. The government is currently providing subsidies for solar cookers; extending this subsidy to other ICS solutions is another option to increase affordability.

[76] Fondem. 2017. PROJET BOREALE. http://www.fondem.ong/projets/boreale/



CHAPTER SUMMARY

TAKING THE PULSE OF ENERGY ACCESS IN THE PHILIPPINES

Table CS 1

Philippines: Key Figures[77]

Year end	2018	2030
Population (millions)	106.5	125.4
Households (millions)	24.5	30.9
Grid Access (%)	82.3	87.5
Mini-Grid Access (%)	3.3	4.1
Stand-Alone Solar Access (%)	2.9	8.4
Clean Fuels Use (%)	53	73
ICS Usage (%)	0.9	100

The Government of the Philippines has made universal electrification a national priority and has an urbanization rate over 50 percent[78], which helps to explain why it has already achieved nearly 90 percent household electrification and universal electrification of all municipalities. Off-grid electrification has been central to accomplishing this since the Philippines' island geography makes achieving universal electrification through grid extension too costly. As such, mini-grids and stand-alone systems have a critical role to play. While mini-grids in particular have transformed the electricity market in the Philippines, universal access by 2030 will still require acceleration across grid-based and off-grid technologies to keep pace with rapid population growth. If the Philippines follows a business as usual scenario, allowing markets to continue developing based on current levels of support from government agencies and development partners, grid coverage would remain relatively unchanged by 2030, with 82 percent of households electrified.

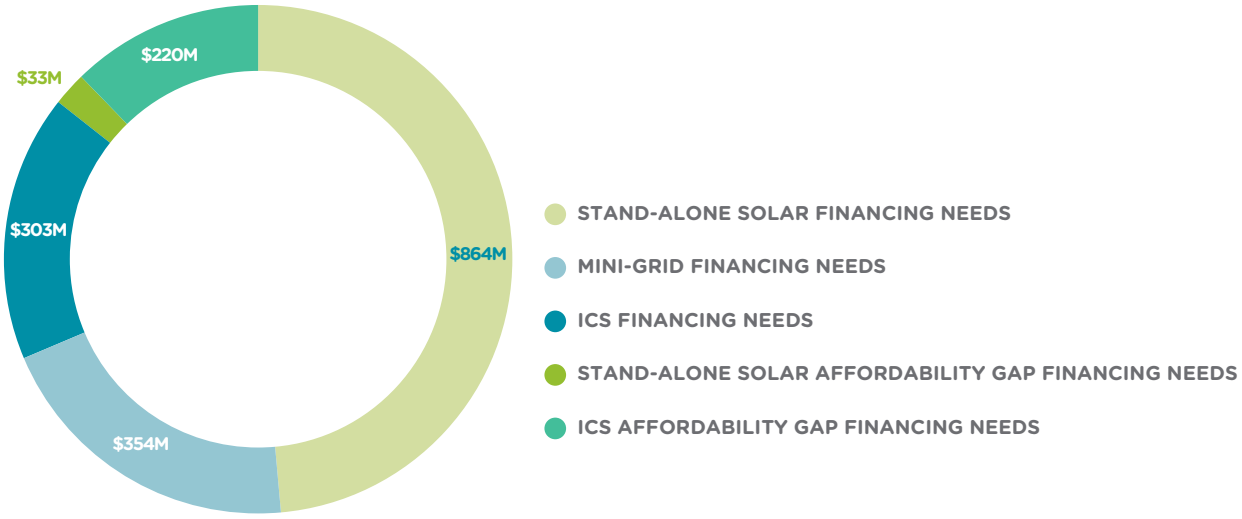
The Philippines is in an advanced stage of mini-grid deployment, with the technology serving over 800,000 households (three percent of households in the country) and various commercial and small industrial customers. The majority of these mini-grids were built and operated by the National Power Corporation – Small Power Utility Group (NPC-SPUG), which benefited greatly from subsidies by the government, and thus enabled the company to extend below-commercial tariffs to rural populations, overcoming the affordability challenge faced in other countries with mini-grid deployment targets. In the forecast scenario, where key stakeholders in the Philippines' electricity sector commit all resources required to achieve universal access, grid connections would increase to 88 percent of households and mini-grids would increase to approximately 4 percent of households and deliver electricity access to over 1.25 million households by 2030. Achieving this growth will require a total of USD 354 million in financing. By way of comparison, the *Energizing Finance* Series' *Understanding the Landscape 2019* report did not track any commitments for mini-grids in the Philippines in 2017. While stand-alone solar has had an impact similar to that of mini-grids with regards to electrifying the country, its 3 percent penetration rate is relatively low compared to other markets working hard to achieve universal access. In the forecast, stand-alone solar will account for 2.1 million new household connections between 2020-2025 (or 35 percent of new connections over the same period). However, stand-alone solar is also expected to decline beyond 2025, as a share of households with access to stand-alone solar is eventually expected to become grid- or mini-grid-connected as grid and mini-grid services expand. To fill the gaps left by the grid and mini-grids, significant capital and private sector capacity will still be required for stand-alone solar, with a cumulative of USD 897 million in financing needed. A total of USD 1.25 billion in financing will be required in the Philippines to achieve the forecast scenarios across all off-grid solar (OGS) technologies. When looking at financing flows, the *Understanding the Landscape 2019* report tracked a mere USD 3 million in commitments for stand-alone solar in the Philippines in 2017.

[77] Key figures in this table reflect, for end-2018, best estimates based on the most up-to-date figures available from various official and unofficial sources, extrapolated by leveraging recent trends. For end-2030, figures reflect model outputs for the forecast scenario, i.e., whereby SDG7 is met for electricity and clean cooking access.

[78] Philippines Statistics Authority. 2019. Urban Population in the Philippines (Results of the 2015 Census of Population). Link: http://www.psa.gov.ph/content/urban-population-philippines-results-2015-census-population

Figure CS 1

Closing the Access Gap in the Philippines: USD 1.8 Billion Required for Off-Grid Electricity and Improved Cooking Solutions



The Philippines does not have any clean cooking policy in place, and nearly 70 percent of households are known to cook at least part of the time with charcoal or other biomass. Of these households only a small fraction is using improved cookstoves (ICS). That said, by the end of 2018, approximately 53 percent of Filipino households were cooking at least some of their meals with a clean fuel, such as liquefied petroleum gas (LPG) or electricity, and approximately 1 percent of households cooking with charcoal or wood were doing so on ICS. Meanwhile, there is limited activity in the biogas and ethanol sector. However, more than 17 million Filipino households (72 percent of households) still lack full access to clean cooking due to the prevalence of stove stacking and the limited uptake of industrial wood and charcoal ICS. The vast majority of Filipino households that continue to use traditional fuels do so on artisanal or semi-industrial cookstoves that do not improve cooking efficiency enough to be considered an ICS.

In the forecast, the use of clean fuels will increase significantly to a total of 73 percent of households, representing nearly 10 million new households cooking with modern fuels. However, a considerable share of households cooking with electricity or LPG are expected to continue fuel stacking, with charcoal remaining an important secondary or tertiary household fuel. As such, in 2030, nearly 16 million households (51 percent of total households in the Philippines) are expected to continue to cook at least some of their meals with charcoal and wood or other biomass. ICS will need a total of USD 303 million of enterprise financing alone. The Philippines will also require up to USD 220 million in affordability gap financing to help the estimated 14.3 percent of households who currently struggle to purchase an ICS.

There are a number of supportive actions that will need to be taken to facilitate investment and achieve universal electrification. These are summarized as follows:

For mini-grids:

- Develop a comprehensive mini-grid regulatory framework that encourages cooperation between cooperatives and technology providers as well as increases access to subsidies in underserved areas.

- Establish a regulation that differentiates large-scale projects from small-scale projects to encourage broader private sector participation in this sector.

For stand-alone solar:

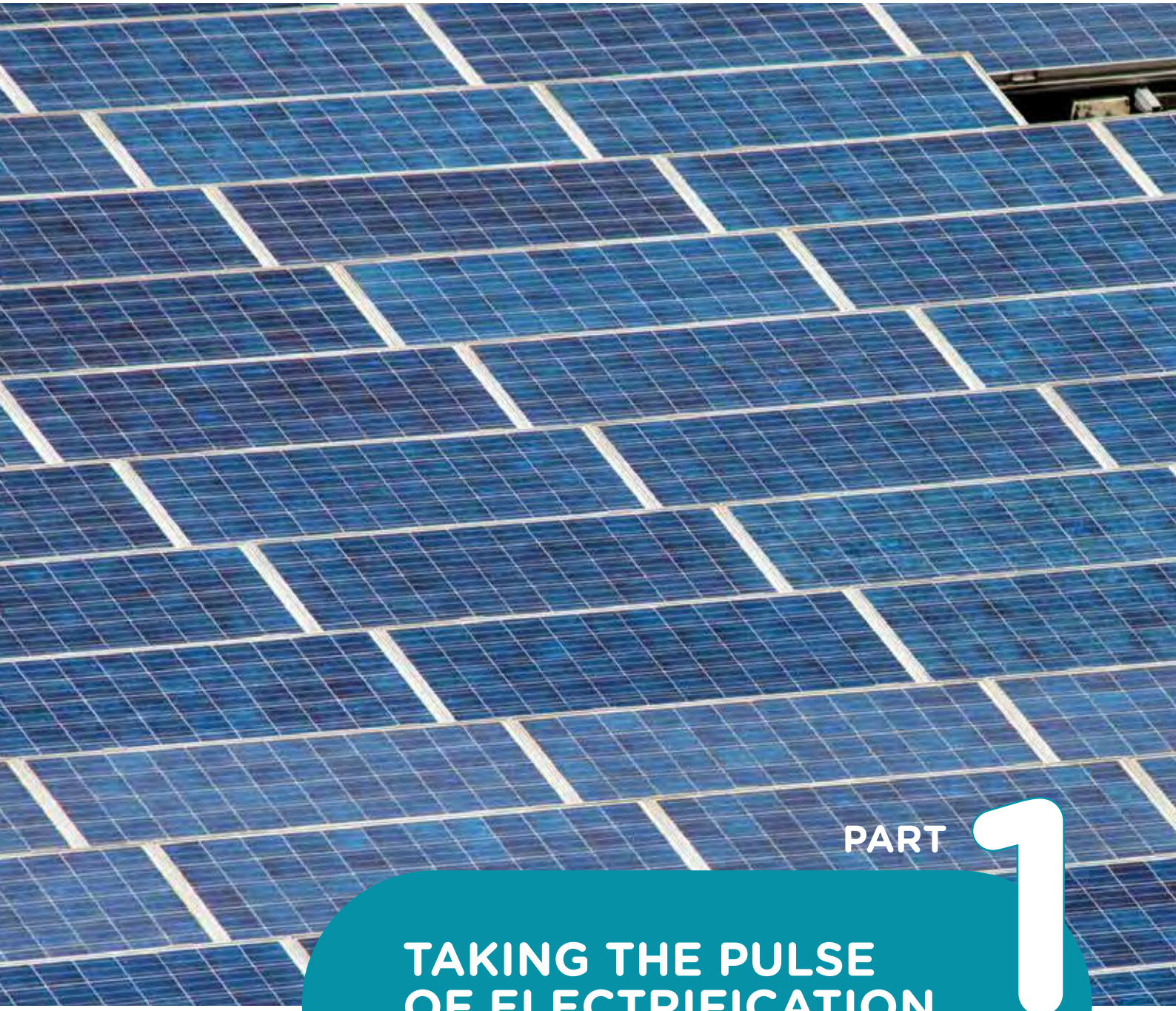
- Streamline and simplify the registration processes to encourage additional private sector participation in the stand-alone solar market.

- Improve data collection efforts on stand-alone solar in the country to obtain in-depth and up-to-date market data for both companies and consumers.

For improved cooking:

- Introduce clean cooking targets and associated policy measures to reach Sustainable Development Goal 7 (SDG7), mirroring the country's universal electrification efforts, through regulatory reforms, subsidies and other related support programs.

- Develop and deliver public awareness campaigns on the benefits of clean cookstove adoption to encourage behavior change.



PART 1

TAKING THE PULSE OF ELECTRIFICATION IN THE PHILIPPINES

SECTOR CONTEXT

Government Electrification Strategy

The Philippines consists of more than 7,100 islands, of which approximately 2,000 are inhabited. This complex geography and population distribution places technical and financial limitations on how much grid expansion can contribute to last mile electrification, which is why distributed electricity has already played an essential role in the country's electrification to date. In fact, all cities and municipalities in the Philippines have already been electrified, and government supported programs and activities have resulted in near universal barangay (i.e., village-level) electrification as well.[79] Electrifi-

[79] Department of Energy. 2016. "Missionary Electrification Development Plan".

cation at household level increased from just under 80 percent in 2010 to near 90 percent by the end of 2018. Ultimately, some 21.8 million of a total 24.5 million households have been electrified via the grid, mini-grids, or stand-alone solar systems. The majority of the 2.6 million remaining un-electrified households are located in the remotest areas of the country and deemed the most difficult to serve.[80] The government's plan for achieving energy security is detailed in the Department of Energy's Philippine Energy Plan (PEP) 2017-2040. The National Renewable Energy Program (NREP) was also developed in 2011 to set out a roadmap for maximizing the use of local renewable energy resources, through efforts such as a 2015 feed-in tariff program.[81]

The Household Unified Strategic Electrification (HOUSE) Team coordinates the Government of Philippines' (GoP) overall electrification efforts. The team is comprised of representatives from the Department of Energy (DoE), the National Electrification Administration (NEA), NPC-SPUG, the Department of Budget and Management and the Department of Interior and Local Government, and it has developed several programs to tackle electrification of off-grid areas. Responsibility for "missionary" electrification, or the "provision of basic electricity service in unviable areas with the aim of bringing the operations, in these areas, to viability levels" as outlined in the Electric Power Industry Reform Act, is divided among a number of public and private actors. Either a distributed utility (DU), Qualified Third Party (QTP), New Power Provider (NPP) or NPC-SPUG may be responsible for missionary electrification depending on viability and profitability of electrifying an area. For example, NPC-SPUG, whose mandate as a government-owned and controlled corporation is to implement missionary electrification projects, is responsible for the electrification of areas which are unviable for DUs and QTPs to electrify.[82]

Off-Grid Solutions

Mini-grids are at an advanced stage of development in the Philippines, serving over 800,000 households (approximately 3 percent of households) and various commercial and small industrial customers. The majority of these mini-grids were built and operated by NPC-SPUG. NPC-SPUG is granted immediate access to the Universal Charge for Missionary Electrification (UCME) subsidy. This allows NPC-SPUG to extend an affordable tariff to rural households serviced by their mini-grids, despite incurring substantial operational and transportation costs from diesel generation, and solves one of the main affordability challenges that plague mini-grid development in other countries. The large-scale areas still available for private-sector participation in the Philippines are composed of 14 missionary areas called First Wave Areas and 15 medium-scale areas called Second Wave Areas. The government, electric cooperatives, and the NPC-SPUG have already developed the more viable areas. Eight NPPs have taken over the First Wave Areas, but efforts to privatize the Second Wave Areas have not been as successful, due to the low desirability of these sites. Also, few mini-grid companies were selected through the competitive selection process to register as a QTP or NPP to deliver energy services.[83] In real terms, only one company has managed to register as a QTP and only 15 companies as an NPP, due to the onerous and bureaucratic process.[84] Finally, the DoE also applies the same rigorous approval processes it designed for large-scale energy projects to approving sub-megawatt off-grid electrification projects. According to one mini-grid company, getting all the requisite approvals can take up to six months which is costly from a working and overhead capital perspective.[85] While this level of oversight is necessary for national-scale projects, it dramatically increases the transaction cost of smaller projects and renders them commercially difficult to pursue.[86]

[80] Ibid.
[81] Asian Development Bank. 2018. "Philippines Energy Sector Assessment, Strategy, and Road Map".
[82] International Renewable Energy Agency. 2017. "Accelerating Renewable Mini-grid Deployment: A Study on Philippines".
[83] Ibid.
[84] Ibid.
[85] Ibid.
[86] Ibid.

Table 1.1

Major Development Partners and Their Main Programs[87]

Development Partners	Key Programs Targeting Private Sector
European Union (EU)	EU-Philippines Access to Sustainable Energy Program (ASEP) • ASEP provides solar home systems coupled with livelihood activities to poor households • EU provided USD 23.5 million for the ASEP project
Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ)	• Provides capacity building initiatives to DoE as part of the ASEP program • Supports the DoE on policy and strategy, developing planning tools and business models
The World Bank	• Partner of ASEP project • Provided USD 44 million in guarantees to electric cooperatives, which is expected to support them to expand their electricity network, invest in renewable energy and enhance energy access to the poor
Asian Development Bank (ADB)	• Development of renewable business models using five energy sources: micro hydro, solar PV, small wind, and other indigenous sources • Provide technical assistance to community-based organization to enhance ownership of projects • Provide microcredits to household to cover cost of electricity

It should be noted, however, that despite the high levels of regulation, the DoE's solar PV mainstreaming program has provided a framework for mini-grid developers to enter the market in the Philippines and leverage the tariff for solar as a service, which is set by the Energy Regulatory Commission at PHP 8.00 / day for 88 watt-hours of solar.[88]

According to an International Renewable Energy Agency (IRENA) study, accelerating mini-grid deployments in the Philippines will require:

- Clarifying roles and responsibilities on rural electrification.
- Ensuring comprehensive electrification planning.
- Clarifying the government subsidy approach.
- Streamlining regulatory and administrative policies.
- Increasing availability of financing[89].

Stand-alone solar has played a limited role in the electrification of the Philippines, and to date, has delivered energy access to just 3 percent of households across the country, mostly in remote, hard to reach areas. There are a limited number of off-grid solar companies operating in the Philippines due to

[87] GIZ. 2016. GIZ.de. https://www.giz.de/en/worldwide/62913.html
[88] Based on in-country Interviews.
[89] International Renewable Energy Agency.2017." Accelerating Renewable Mini-Grid Deployment: A Study on Philippines".

the government's strict regulatory controls on electrification and the need to obtain accreditation as a QTP or NPP to benefit from the government's subsidy fund and access franchise territories. Lack of accreditation limits access to financing for these companies, and the majority of electrification through stand-alone solar systems is currently being driven by distribution utilities in a fee-for-service business model, where the distribution utilities own, install and maintain photovoltaic (PV) solar home systems and the consumer pays a one-time participation fee and a monthly fixed fee equivalent to the government-approved solar home system tariff.[90]

Many international development partners are supporting initiatives to improve the policy and enabling environment for the wide range of government ministries involved in the power sector and missionary electrification more broadly. Partners include the Asian Development Bank (ADB), the World Bank, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), and European Union (EU) among others. One of the programs, Access to Sustainable Energy Program (ASEP), has partnered with the DoE to electrify 100,000 households by 2020.

[90] Ibid.

CURRENT STATE OF ELECTRICITY ACCESS

Defining Energy Access

Taking the Pulse uses the globally accepted Multi-Tier Framework (MTF) to define energy access.[91] The MTF establishes five "tiers" of household electrification that are based on capacity, duration, reliability, quality, affordability, legality and health and safety impacts. The MTF is often referred to as the "energy access ladder", whereby households may graduate from one level of service to another depending on what sources of electrification they have access to, what they need, and what they can afford. Tier 0 represents a household that uses stopgap measures to meet their basic electrification needs, often using fuel-based lighting (e.g. kerosene lanterns, candles) or battery-operated flashlights for lighting needs, and relying on third-parties to power their devices (most notably cell phones). Tier 1 and 2 services are most often delivered by "stand-alone solar solutions", frequently in the form of single or multi-light point systems that derive their power via solar PV panels. Tiers 3 through 5 are most typically met by connections to a centralized or localized grid (i.e. a "mini-grid"). However, it is important to note that having

[91] Bhatia, M. & Angelou, N., 2015. Beyond Connections – Energy Access Redefined, Washington: Energy Sector Management Assistance Program.

Figure 1.1

Historical Electricity Access in the Philippines

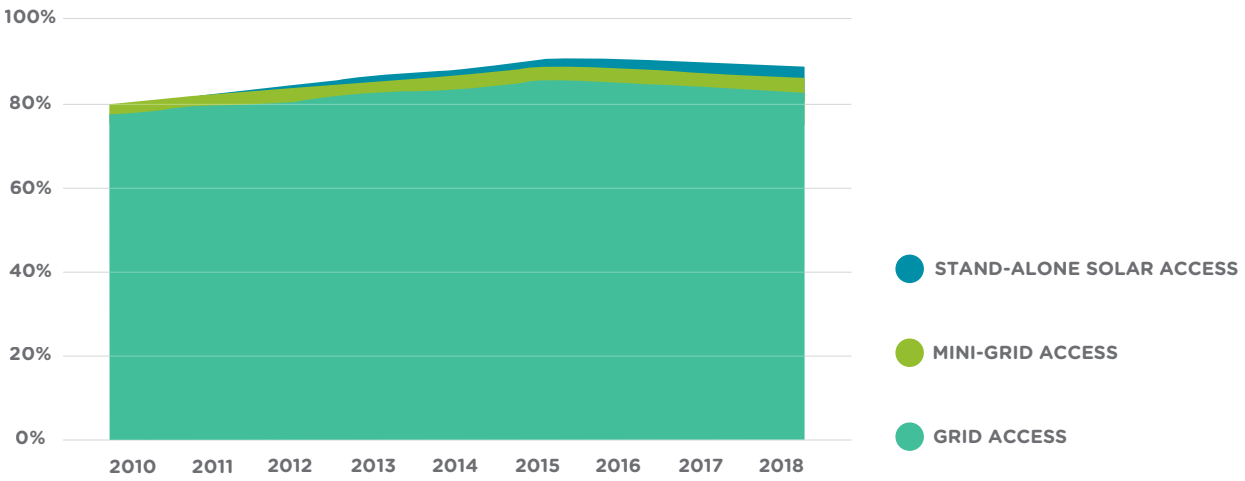
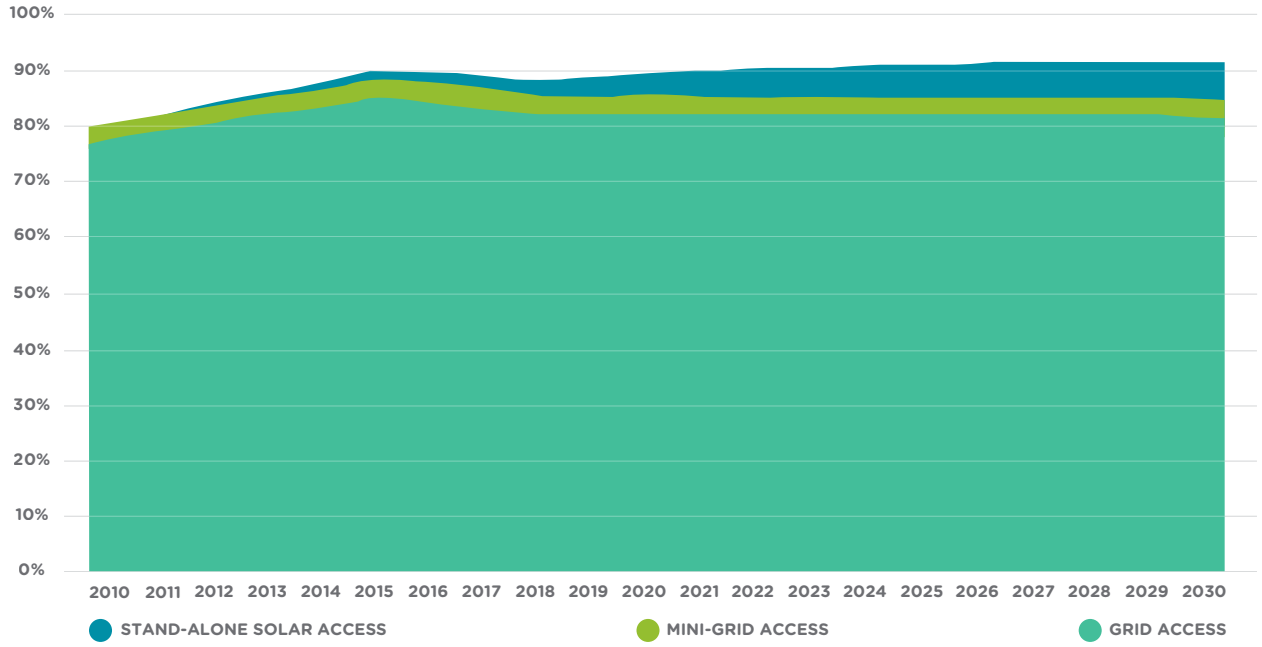


Figure 1.2

Philippines Business as Usual Electricity Access Scenario



a grid connection can also qualify as Tier 1 (or as low as Tier 0 if power is available for less than four hours per day) if the MTF duration criteria are not met. More details on the MTF can be found in the *Taking the Pulse* methodology chapter.

Tier 1 stipulates either a certain level of installed capacity (in terms of power and capacity) or a level of service, which is expressed in lumen hours. Lumen hours is the unit of measure for the brightness of light. *Taking the Pulse* establishes the minimum level of electricity service based on the MTF service metric in lumens. It stipulates that fractional Tier 1 access counts toward the SDG7 goals. This means a single-light-point solar lantern that has the functionality to charge phones (one of the MTF service criteria) counts toward access goals. However, since the lumen output of most solar lanterns is less than the MTF Tier 1 requirement of 1,000 lumen hours per day, this contribution is "fractional" given that the lantern does not deliver full service to all members of a typical household. *Taking the Pulse* assumes in its modeling that a lantern delivers sufficient lumen output to provide access to 60 percent of household members—in line with the capabilities of the typical modern lantern. As such, households would need to have two lanterns in order to achieve full Tier 1 access.

This is a critical methodological point, as lanterns are often more affordable than multi-light point systems. As such, this impacts the overall financing needs required to achieve universal access in a given market. The methodology chapter discusses how levels of service are derived in the model, and the assumptions that underpin them.

State of Electricity Access in the Philippines

At the end of 2018, 88.5 percent of households in the Philippines had electricity access.[92] As seen in Figure 1.1 above, the Philippines has expanded grid access almost 9 percent since 2010. Stand-alone solar access, which was negligible at the start of the decade, now accounts for about 3 percent of Filipino household connectivity. Mini-grid access as a share of total electricity access in the Philippines, covering over 800,000 households in a country of 24.5 million households, is also about 3 percent.

[92] Bhatia, M. and Angelou, N. (2015). Beyond Connections: Energy Access Redefined. ESMAP Technical Report. Washington, DC: World Bank. Available at: https://openknowledge.worldbank.org/handle/10986/24368

As seen in Figure 1.2, the model outputs show that if the Philippines continues to expand grid access at the pace seen in recent years, following a business as usual (BAU) scenario, population growth in the Philippines is likely to fully offset the impact of new grid connections, resulting in grid coverage of 82 percent in 2030—similar to today. Stand-alone solar access, following its current trajectory, can be expected to reach 7 percent. This projection assumes an annual net increase of 110,000 households gaining access through 2030. Extrapolating forward, the BAU mini-grid scenario would remain unchanged at a 3 percent share of total household access. In the aggregate, the BAU scenario shows that the Philippines would provide energy access for 92 percent of households in 2030, leaving an access gap of 8 percent.

CLOSING THE PHILIPPINES' ELECTRIFICATION ACCESS GAP

Achieving and maintaining universal electricity access by 2030 in the Philippines will require acceleration across grid-based and off-grid technologies. In fact, the forward-looking projections modeled in Figure 1.3 below illustrate the targets for the Philippines to achieve universal energy access by the end of 2025,[93] per the government's current objectives, and then maintain universal access through 2030. The key assumptions driving this scenario are as follows:

- Grid connectivity increases to 85 percent in 2025 and 88 percent in 2030, with some 6.6 million new connections added over the entire period.

- Mini-grid initiatives backed by the government have already greatly contributed to the high electrification rate in the Philippines; new mini-grid connections will be leveraged to connect some 0.24 million additional households by the end of 2025 and a further 0.2 million through the end of 2030. These 2,200 new mini-grids will result in mini-grid access reaching 4.1 percent.

- The electrification access deficit that remains from grid and mini-grid expansion will need to be filled by off-grid solar. As a result, the Philippines will be counting on stand-alone solar to deliver access to the remaining 8 percent of households in 2030 that do not have grid or mini-grid access. This will prove challenging since the economics of reaching the last mile via stand-alone solar are not attractive for most private companies because the areas are hard to reach, affordability is low, and access to public funding for private companies is nonexistent for those not registered as an NPP or QTP.

[93] Department of Energy. 2016. "Power Development Plan: 2016- 2040".

Figure 1.3

Forecast Electricity Access in the Philippines

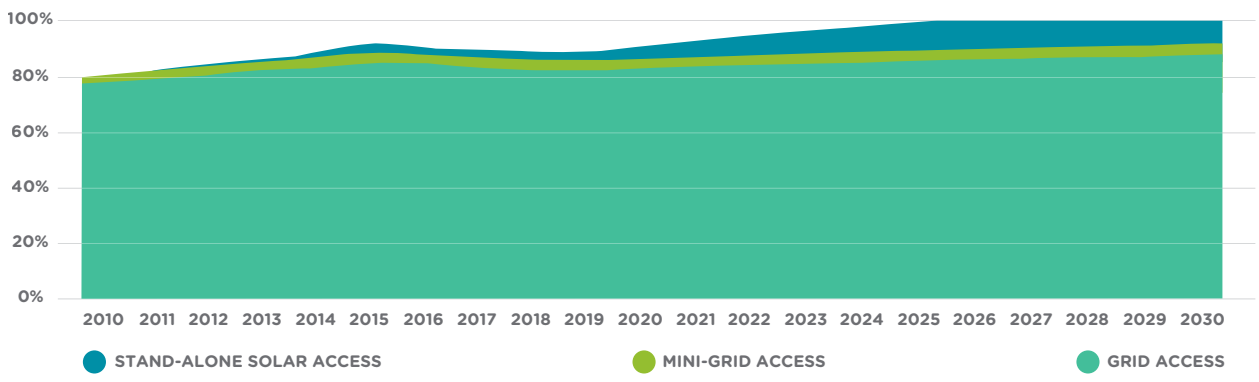
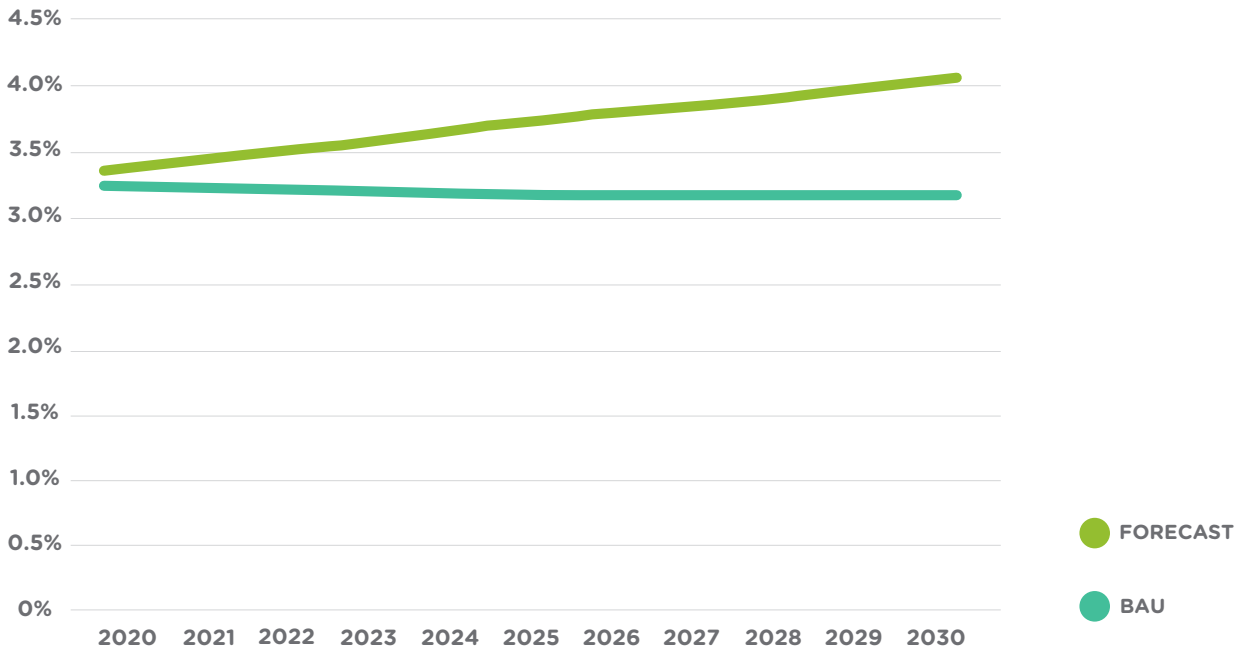


Figure 1.4

Mini-Grid Electricity Access Forecast in the Philippines



Mini-Grid Contributions Toward Achieving SDG7

The forecast model projects that new mini-grids will account for some 440,000 new household connections in the Philippines over the period 2020-2030. This represents an approximately 57 percent increase in new connections compared to the end of 2018. This also means that mini-grids will deliver electricity access to over 1.25 million households by 2030. Though this is a substantial increase from the base case and a much larger portion of households than the other case studies in this report, it still means that mini-grid contributions to the SDG7 challenge will remain relatively modest, at 4.1 percent of total connections.

Mini-Grid Financing Needs

Taking the Pulse establishes that mini-grids will deliver a minimum of Tier 3 electricity services. The model therefore includes assumptions around the cost or delivering this level of service. This is a minimum and

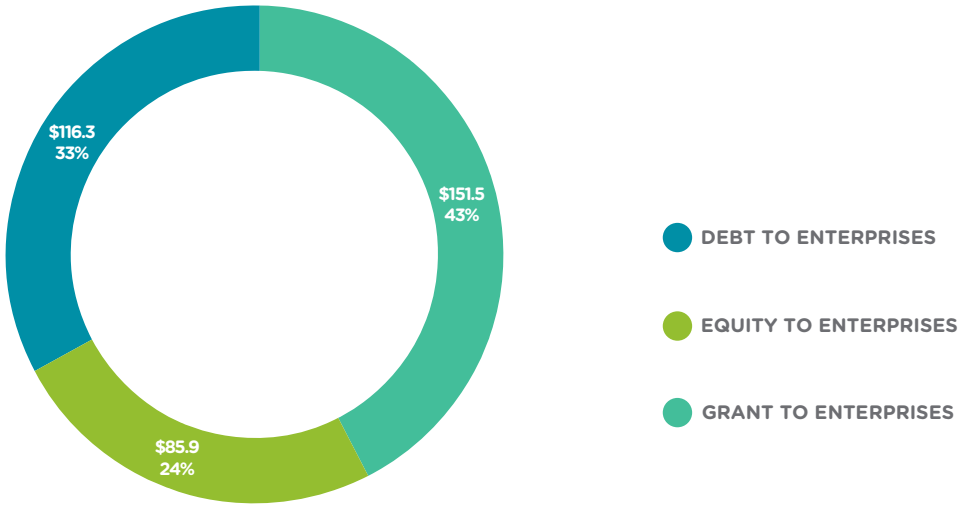
Table 1.2

Model Assumptions of Capital Blend by Mini-Grid Company Maturity

	Pilot	Validation	Scale-Up	Mature
Grant	75%	50%	40%	30%
Equity	25%	30%	30%	20%
Debt	0%	20%	30%	50%

Figure 1.5

Cumulative Financing Need for Mini-Grid Enterprises in the Philippines (Million USD)



does not preclude the development of mini-grids that are capable of delivering Tier 4 or 5 access. However, if either of these levels of service were to be considered the minimum, the overall costs of delivering energy access via mini-grid solutions would increase considerably. To achieve the 330,000 new mini-grid connections envisaged in the forecast scenario outlined above, mini-grids will have a cumulative financing need of USD 353.7 million, as seen in Figure 1.5 above. This assumes that each mini-grid will support 200 households and two large anchor clients that consume over a third of the mini-grids generated electricity and that connections will cost between USD 650-1,050 per connection, depending on the maturity of the mini-grid developer.

Mini-grid projects rely on a blend of grants and equity to finance early-stage development costs, operational costs, and leverage for the additional debt financing needed to build and maintain infrastructure, as illustrated in the diagram above. In the model, the blend of capital is directly tied to the companies' stage of growth, where pilot stage companies obtain closer to 75 percent grant funding and little to no debt, and mature companies require 30 percent grants and are much more reliant on debt.

The analysis of financing needs for mini-grid development assumes that international development agencies, local government agencies, trusts and foundations, and other investors will provide grants to cover 43 percent of enterprise financing, while venture capital, private equity, impact funders, and other equity investors will contribute 24 percent. The remaining 33 percent of enterprise financing would come from debt. Interviewees in the Philippines expressly noted that impact funding and concessional funding for energy access projects are increasingly being concentrated in Africa, which makes fundraising in Asia more difficult.[94] In addition, local commercial banks in the Philippines do not offer project-based financing for small- and medium enterprises (SMEs). As a result, the borrowing capacity of SMEs is capped by their balance sheet, which subsequently limits how much these companies can participate in government tenders.[95]

Affordability of Mini-Grids

Subsidies have played an important role in the Philippines market, thanks to the establishment of the UCME Fund, which provides subsidies in areas not interconnected to the main grids. Aside from NPC-

[94] Based on in-country interviews.
[95] Based on in-country interviews.

SPUG, NPPs and QTPs (which can be conventional or renewable energy developers) are eligible to tap the UCME.[96] As of 2015, only 1 QTP and 15 NPPs had been certified by the Department of Energy, thus limiting the number of private sector companies accessing the Fund.[97] After qualifying, the accredited entity must negotiate a reasonable, unsubsidized electricity tariff with the Energy Regulatory Commission (ERC). This baseline rate will be designated as the True Cost Generation Rate or "TCGR" and used as a reference point for computing the UCME subsidy. After establishing the TCGR, the ERC will then determine the appropriate Subsidized-Approved Generation Rate (SAGR) for the off-grid site being proposed for electrification. The difference between the TCGR and SAGR will constitute the UCME Subsidy that the accredited entity will be able to access.

Unfortunately, the subsidy disbursement of the UCME fund is above its replenishment rate and demand for subsidies is increasing due to the growing per capita energy demand and population size of existing SPUG Areas. Due to this burden on the UCME fund, it can no longer subsidize new missionary areas. To make the UCME sustainable, the DoE must now impose a graduation pathway for SPUG areas that no longer require a subsidy, most likely a lengthy and politically challenging process, so that new missionary areas can benefit from the fund.

Key Challenges and Opportunities Relative to Mini-Grids Delivering on SDG7 Targets

Mini-grid growth is constrained by a complex and competitive selection process with stringent oversight for small-scale projects and limited access to subsidies for off-grid electrification.[98] The Philippines has a one-size-fits-all approach to energy regulations, where regulations designed to limit the social and environmental impacts of large-scale projects are also being applied to small-scale, off-grid projects. One mini-grid developer reported having to secure 190 signatures from national and local government agencies to implement a 45-kilowatt (kW) hybrid mini-grid, adding time and cost to the development process.[99] Another noted that, at a country level, the blanket application of policies and regulations that govern multi-megawatt installations onto small, missionary electrification projects discouraged broader private sector participation. This issue extends project development timelines and costs to levels that are not financially attractive.[100] Policies will need to be streamlined and procurement rules simplified to encourage additional private sector mini-grid development and increased interest in participating in the electrification of off-grid, commercially unviable areas.[101]

In addition to overhauling the policy and procurement procedures governing mini-grid development, access to local finance will also play a critical role. This can be done by extending the NEA's rural electrification grant funding to apply to off-grid technologies in addition to grid extension efforts or by offering other government-financed de-risking mechanisms to promote local financial institutions to finance mini-grid projects.[102] Also, as outlined earlier in this chapter, the UCME fund is one of the most established sources of rural electrification subsidy in the Philippines. If the UCME is rationalized and a graduation policy is introduced for more prosperous SPUG areas, a substantial portion of the UCME can be diverted to truly missionary areas.

Finally, determining tariff levels for off-grid rural electrification is a complex and time-consuming process. The process is managed by the ERC, who evaluates every application and conducts all requisite public hearings that must be conducted to finalize tariff levels. ERC is understaffed and over-burdened to finalize tariff levels. Current tariff levels are also based on on-grid cost calculations. A distinct tariff determination process should be adopted for off-grid projects, which takes into account the higher generation and operating costs associated with mini-grids.[103]

[96] Department of Energy. 2016. "Missionary Electrification Development Plan".
[97] Department of Energy. 2016. "Missionary Electrification Development Plan".
[98] International Renewable Energy Agency. 2017. "Accelerating Renewable Mini-grid Deployment: A Study on Philippines".
[99] Ibid.
[100] Based on in-country interviews.
[101] Ibid.
[102] Ibid.
[103] Ibid.

STAND-ALONE SOLAR CONTRIBUTION TOWARD SDG7

In a BAU scenario, stand-alone solar access is expected to reach 7 percent, whereby net new household connections (gross additions minus retirements) averages 110,000 Tier 1 equivalent or higher per year through 2030 (of which 750,000 new connections would occur over the period 2020-2025). The forecast model projects that new stand-alone solar will account for 2.1 million new household connections between 2020-2025, peaking at 10.5 percent of electrified households. This represents an increase of over 300 percent in new connections from stand-alone solar compared to 2018. However, beyond 2025, the share of households with stand-alone solar systems is forecast to drop off as a notable share of them become connected to the grid and mini-grids. This is because a share of new grid and mini-grid connections will be installed in households previously relying on stand-alone solar. Thus, by 2030, stand-alone solar systems would be delivering electricity access to some 2.5 million households. While this is a relatively small increase from the BAU scenario in 2030, achieving the short-term 2025 target will require a great deal of capital and private sector capacity building.

Financing needs

To achieve the connections envisaged in the forecast scenario outlined above, stand-alone solar will have a cumulative financing need of USD 864 million as seen in Figure 1.7. The outputs depicted in this figure are based on two key assumptions:

- Stand-alone solar systems are assumed to have a lifetime of four years and, as such, households purchasing a system in a given year are projected to require a new system to maintain access fully four years later. A country with a high rate of stand-alone solar access more than four years prior to 2030 is therefore likely to have higher proportional financing needs than a country that makes rapid gains in off-grid solar access closer to 2030.

- The Philippines will require about USD 33 million in affordability gap financing to achieve universal electricity access. A more detailed explanation of consumer affordability is provided below.

The model assumes that OGS businesses are at different stages of maturity during the forecast

Figure 1.6

Stand-Alone Solar Electricity Access Forecast in the Philippines

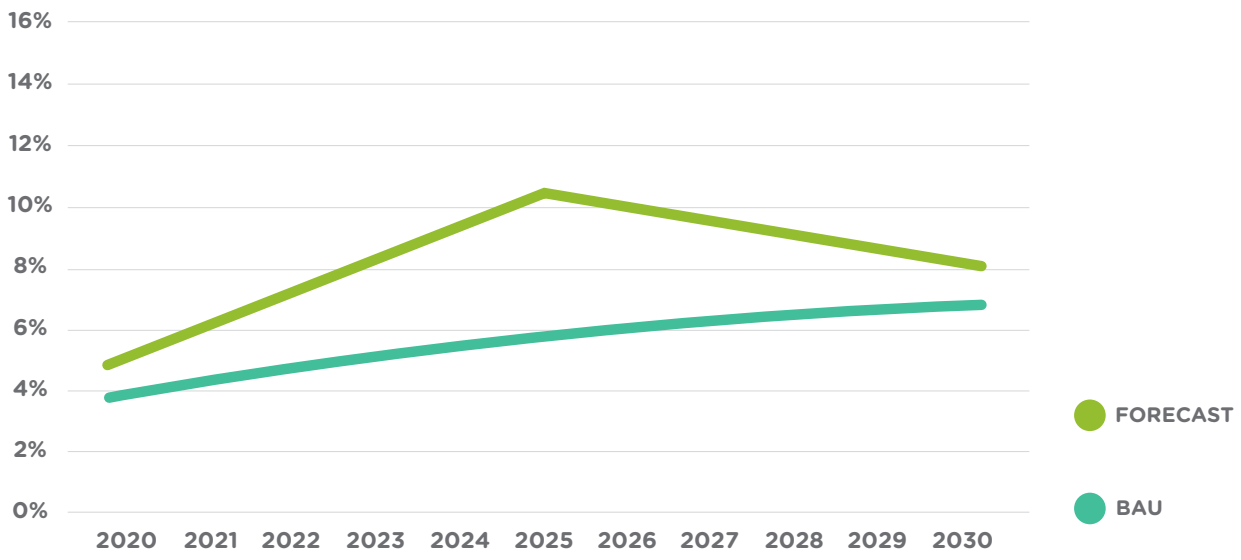
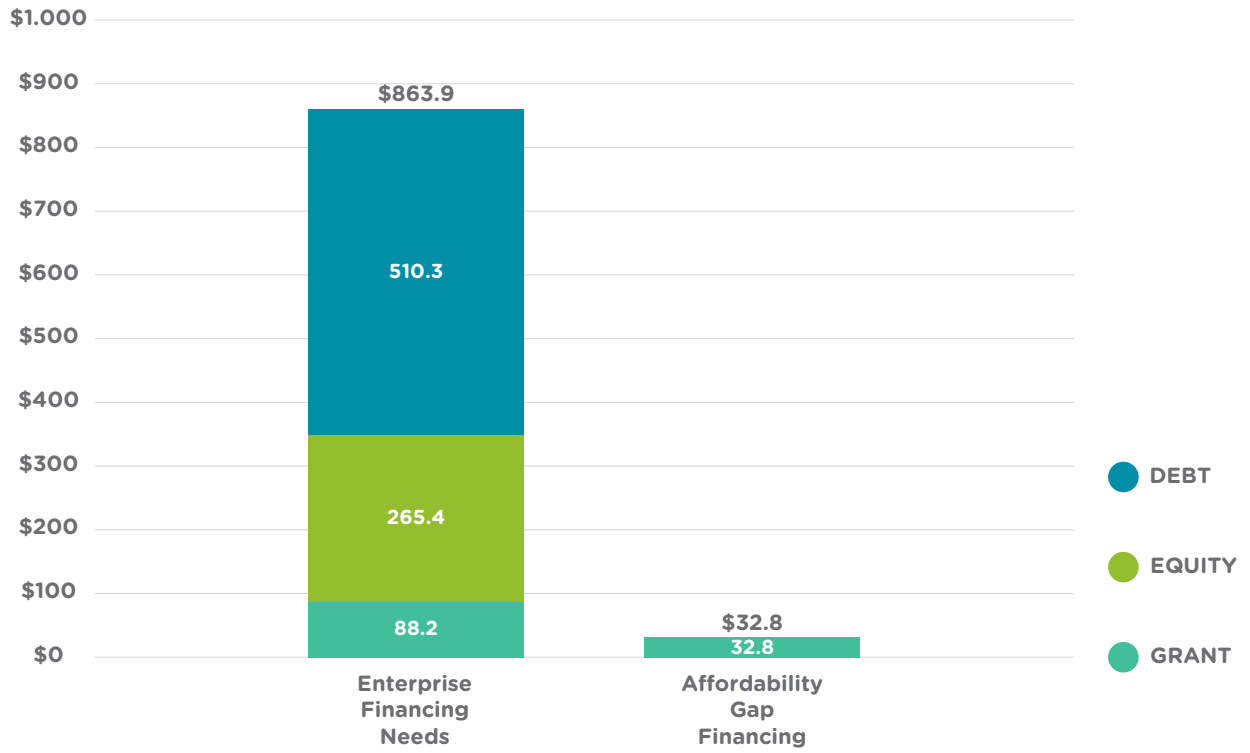


Figure 1.7

Cumulative Financing Needs to Achieve Stand-Alone Solar Targets in the Philippines (Million USD)



period (pilot, validation, scale-up, mature). The blend of capital associated with these stages varies, as summarized in Table 1.3 below. Early-stage enterprises will be more reliant on grant financing and risk tolerant early equity, while more mature businesses will seek to leverage their equity financing to secure significant debt that will finance their consumer receivables and inventory finance needs.

Through 2030, grants are expected to continue to provide 10 percent of enterprise financing, largely due to the need to incentivize companies to expand sales channels into underserved rural areas. Equity finance covering 31 percent of enterprise needs will support ongoing operational activities, while lenders will contribute the remaining 59 percent of enterprise capital needs, accounting for low-cost funds to commercialize loans to solar service providers.

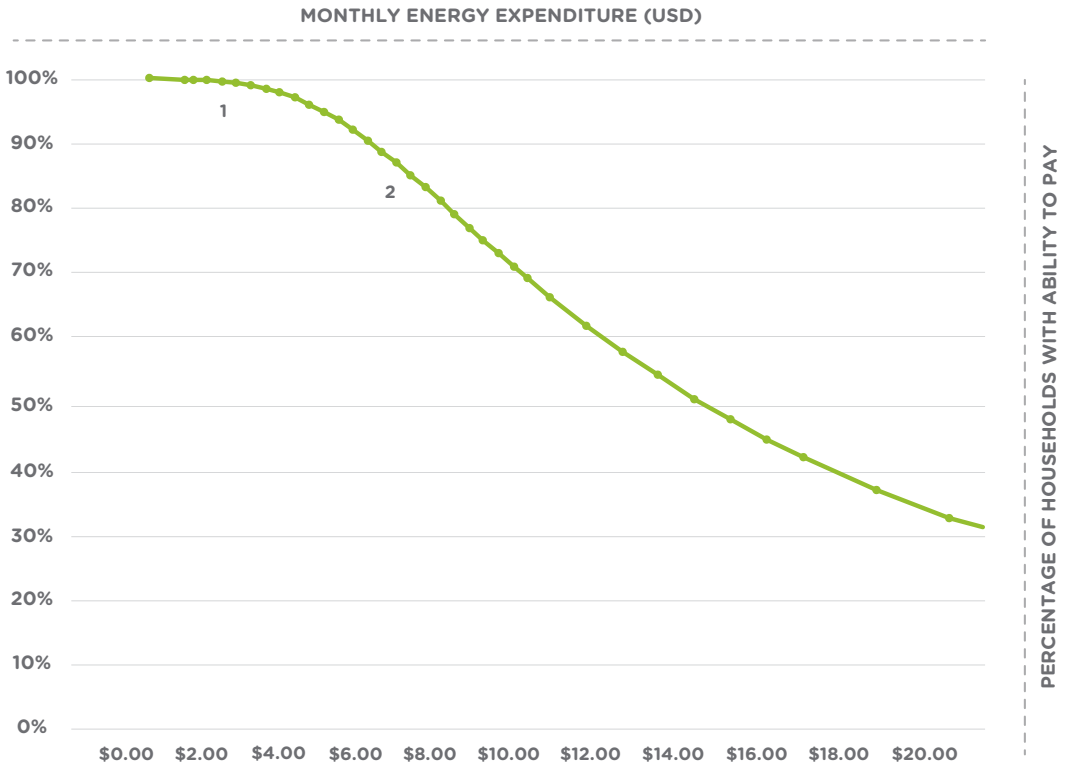
Table 1.3

Model Assumptions of Capital Blend by Stand-Alone Solar Company Maturity

	Pilot	Validation	Scale-Up	Mature
Grant	20%	30%	10%	5%
Equity	80%	55%	45%	15%
Debt	0%	15%	45%	80%

Figure 1.8

Philippines' Ability to Pay at 5% of Monthly Consumption on Electricity Access



Affordability of Solar Home Systems

In 2015, some 22 percent of Filipinos lived under the national poverty line. While this rate has been dropping, a sizable share of households is expected to have difficulty affording basic stand-alone solar products. While a relatively small share—fewer than 1 percent—of households are estimated to be unable to afford the USD 3.30 per month[104] (see label "1" on Figure 1.8) to buy a solar lantern on a pay-as-you-go (PAYG) basis, more than 15 percent of all households are unable to afford a full Tier 1 solar home system at a cost of USD 7.5 per month,[105] as illustrated in Figure 1.8 on label "2". As noted in the previous section, this is why the forecast scenario takes into account the need for affordability gap financing.

The estimated affordability constraints outlined above were determined by leveraging the World Bank poverty calculator (PovCal) to create Filipino household consumption curves, i.e., charting the percentage of households with consumption at or below specific dollar amounts.[106] Then, by assuming that households are willing to allocate no more than 5 percent of their monthly consumption on electricity access (a threshold regularly used by practitioners to define electricity affordability), the model is able to estimate the percentage of households that cannot afford either the USD 3.3 a month for a PAYG lantern (Prompt 1 in Figure 1.8) or, separately, the USD 7.5 for a Tier 1 solar home system (Prompt 2 in Figure 1.8). Compared to the other two countries (Madagascar and Uganda) that are profiled in this edition of *Taking the Pulse*, the Philippines' affordability challenge is comparatively small, with nearly all homes being able to afford a solar lantern when paid for in installments, and over 85 percent being able to afford a multi-light point system that is paid for in installments.

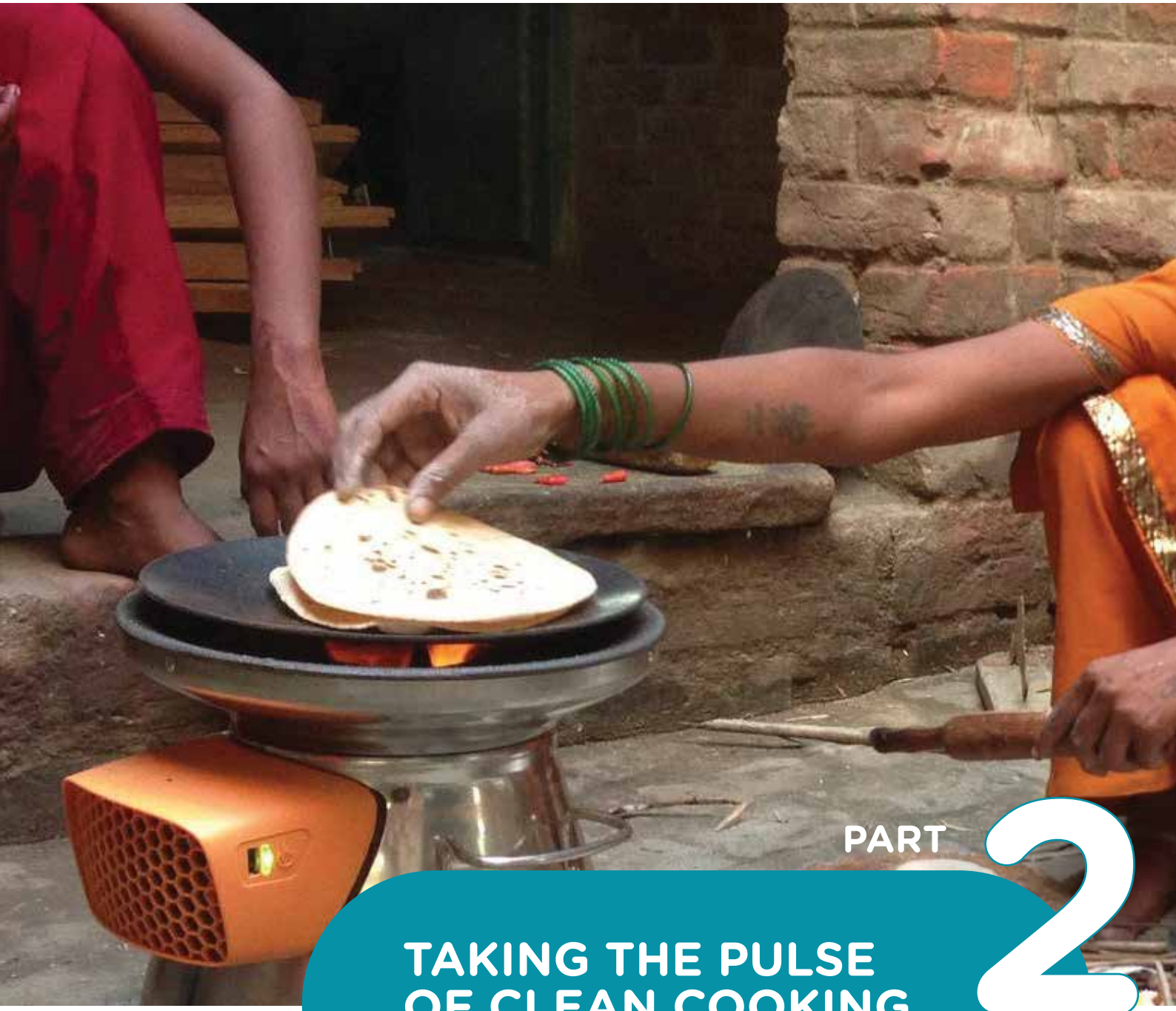
[104] The model assumes this retail price point for a household to purchase a quality verified mid-range lantern, paid for installments over 12 months.
[105] The methodology chapter discusses the approach to modeling affordability in detail.
[106] The methodology chapter discusses the approach to modeling affordability in detail.

Key Challenges and Opportunities Relative to Stand-Alone Solar Delivering on SDG7 Targets

Though mini-grids are expected to play the central role in the electrification of the Philippines, stand-alone solar can still contribute in important ways. As such, it is imperative that key challenges are addressed. First, heavy regulation of the electricity sector can discourage stand-alone solar companies from entering the market, since company certification is requisite to access government funding and, as mentioned in previous sections, is cumbersome to achieve.

Second, the Philippines lacks a comprehensive integrated electrification plan. GIS technology can be leveraged to reconcile population density and energy demand data, renewable energy potential, and the grid expansion timeline, and to identify areas that will remain off-grid for the next five to ten years because of economic or resource constraints. These areas would then become the target market for the government's rural electrification efforts. The sites that can be developed commercially could be immediately tendered to the private sector. The privatization of SPUG Areas could also be accelerated to provide additional sites where the private sector can operate. Sites that require partial subsidies can then be supported by the UCME Fund, pending the development of the graduation program recommended earlier in this chapter. Additionally, sites that require a full subsidy can be supported by a combination of public funding and donor support.

Third, given widespread access to grid and mini-grid electricity, stand-alone solar is often viewed as an inferior source of energy. Awareness raising campaigns could help raise the profile of stand-alone solar and encourage adoption. Finally, consumer affordability will be a challenge in electrifying the last mile, as those communities will be the least well off and most likely to have difficulty in paying for electrification services. For the Philippines to reach 2030 access goals, affordability gap financing from government and development agencies will be an imperative, whether through the UCME or other facilities.



PART 2

TAKING THE PULSE OF CLEAN COOKING IN THE PHILIPPINES

INTRODUCTION

Government Initiatives

Desk research undertaken during preparation of this report found nearly no existing documentation on the cooking sector in the Philippines. Furthermore, it is believed that there are no government policies that promote the use of clean cooking technologies.[107]

Numerous small-scale cookstove manufacturers do operate in the Philippines, but few have achieved operational scale due to lack of funds and limited relationships with distributors. Most stoves are produced to order and sold within a 30-kilometer (km) radius of the factory because transportation costs are high.[108] LPG, charcoal, and wood are the predominant fuel sources, with LPG most predominant in urban areas.

[107] Regulatory Indicators for Sustainable Energy. 2017. Philippines. http://rise.worldbank.org/country/philippines.

[108] StovePlus. 2015. "Exploratory Mission report".

CURRENT SECTOR ECOSYSTEM[109]

Defining Clean Cooking

Taking the Pulse uses the MTF[110] to establish the minimum definition of "improved cooking" that counts toward the SDG7 goal of universal access. The MTF measures household access to cooking based on indoor air quality, cookstove efficiency, convenience, and safety, affordability, quality and availability of the primary fuel. The report has two main ways in which it defines access to improved cooking solutions. The first, which is the primary focus of the report, centers on moving households away from traditional cooking solutions (typically using a three-stone fire or artisanal or semi-industrial cookstove) all of which do little to improve cooking efficiency and/or reduce emissions. As such, the report models out the cost of what it would take for these households to adopt improved "industrial" cookstoves, which typically entail centralized, large-scale production that uses quality components, manufactures with precision tools and employs considerable levels of automation. The focus is typically on rocket stoves, which have an insulated, L-shaped combustion chamber that improves combustion efficiency and reduces emissions. However, it is important to note that use of these stoves necessitates the continued use of either wood or charcoal as a fuel source. *Taking the Pulse* defines the minimum level of improved cooking access as ICS that meet International Workshop Agreement (IWA) minimum standards on fuel efficiency and emissions.

Related to clean fuels, the report focuses on three primary ones that are considered to have significant potential. These are a sub-set of cooking solutions that deliver high performance in terms of reducing household air pollution—often (although not always) regardless of the type of cookstove used: biogas, LPG, electricity, ethanol, natural gas, and solar cookers, collectively called "BLEENS"[111]. Given that *Taking the Pulse* only focuses on biogas, LPG, and ethanol, it adopts the term "clean fuels" in discussing them. The report forecasts the expected uptake of clean fuels over time but does not cost out the financing that would be required to achieve these forecasts. This is because it was not in the scope of this report given the complexity surrounding the costing of delivering clean fuels for cooking.[112]

Clean Cooking in the Philippines

Per our modeling, 53 percent of the Filipino households are now using clean fuels to cook at least a share of their meals. The majority of the clean cooking is accounted for by LPG, which has experienced rapid growth since the 1990s. Biogas activity is very limited for household cooking. While there is biogas generation in the livestock sector, there is no notable activity in the residential biogas market currently. Similarly, there is little sign of activity on ethanol. While there is domestic ethanol production from the local sugarcane industry, the main market for this ethanol is the transport sector, that blends it with gasoline.

LPG Market

Over 40 percent of households in the Philippines use LPG currently, and industry sources indicate that due to the competitive economics, improvements to product availability, and improved safety, LPG demand for household cooking is projected to be the primary fuel source contributing to clean, post-firewood and charcoal-based cooking in the country.

The LPG industry is concentrated mainly in urban and peri-urban regions of the country, and on the main islands, but is starting to spread more widely throughout the Philippines, driven by larger companies building out their distribution infrastructure.

The Philippines LPG industry includes a wide range of actors. The two major companies are Pascal Re-

[109] As there is no active biogas or ethanol market for cooking in the Philippines, it is not discussed in this chapter.
[110] Bhatia, M. & Angelou, N., 2015. Beyond Connections – Energy Access Redefined, Washington: Energy Sector Management Assistance Program.
[111] Bhatia, M. & Angelou, N., 2015. Beyond Connections – Energy Access Redefined, Washington: Energy Sector Management Assistance Program.
[112] In addition to the financing needs for distribution and/or installation of the cooking hardware, scaling LPG and ethanol uptake requires the build-out of large-scale distribution infrastructure, particularly related to shipping, storage, and processing of fuels.

sources Energy Inc. (PR Gaz) and Brent Gas.[113] Both companies are integrated players in the market, participating in importing and selling LPG and also refilling it. There are also other companies which specialize in the import and selling of LPG[114], LPG refilling[115] and cylinder manufacture.[116] PR Gaz, one of the main players in the LPG cooking market, has been operating in the country since 2000 and focuses specifically on reaching customers in rural areas and helping them transition to cleaner LPG fuels.[117]

PR Gaz has improved and automated the refilling process and is now in the process of expanding its supply and distribution network. For the last mile, the company is making use of sari-sari (neighborhood sundry) stores, so that the business model leverages established distribution networks and reaches customers where they currently shop. Sari-sari stores are given a stock of cylinders, and PR Gaz's initial sales package is comprised of two Gaz Lite cylinders, along with one LPG cookstove. This ensures that the client always has a spare LPG cylinder. PR Gaz provides the after-sales service, picking up the cylinders and filling them up. The company has recently built its own refilling operations and is even looking at manufacturing the cylinders itself, rather than importing them, though this is likely a few years off.

PR Gaz aims to expand to supply 1 million families through a wide range of sari-sari stores by 2020 with its Gaz Lite technology, a smaller and more affordable format for individual households. The larger cylinders (e.g., 11kg or larger) are often too expensive for households to afford upfront, especially in rural areas, and PR Gaz is now addressing this affordability barrier by offering a smaller, more compact cylinder. PR Gaz has also partnered with the Microfinance Council of the Philippines, Inc. (MCPI) to develop a loan product for households using LPG for cooking. Households availing themselves of this microloan pay USD 0.80 per week for a period of 30 weeks for a single burner stove and two LPG cylinders. As one interviewee noted, assisting consumers to purchase an entry level LPG stove, which is the major affordability challenge for low-income households, will help unlock the LPG market. The cost to refill an LPG cylinder is lower than the cost of their current fuel sources like kerosene and coal, which means households that already use kerosene and coal will be able to afford refills after their loan has been paid off.[118] As of 1 June 2019, the estimated price of household LPG in Metro Manila ranged from PHP 539.25-716.25 per 11-kilogram cylinder (USD 10.42-13.84), which works out to a per-kg price range of between USD 0.94-1.26.

The other major player in the LPG cooking market is Brent Gas, which is a fully integrated LPG company that caters to retail, commercial, and industrial market segments in the Philippines, located mainly in the region of Luzon in the north, as well as in Visayas. It has 250 stores, 13 refilling plants, 3-cylinder manufacturing and repair facilities, and over 1,000 employees. Brent Gas provides an integrated LPG service to its customers, including a range of LPG cylinder sizes ranging from 2.7kg up to 50kg.[120]

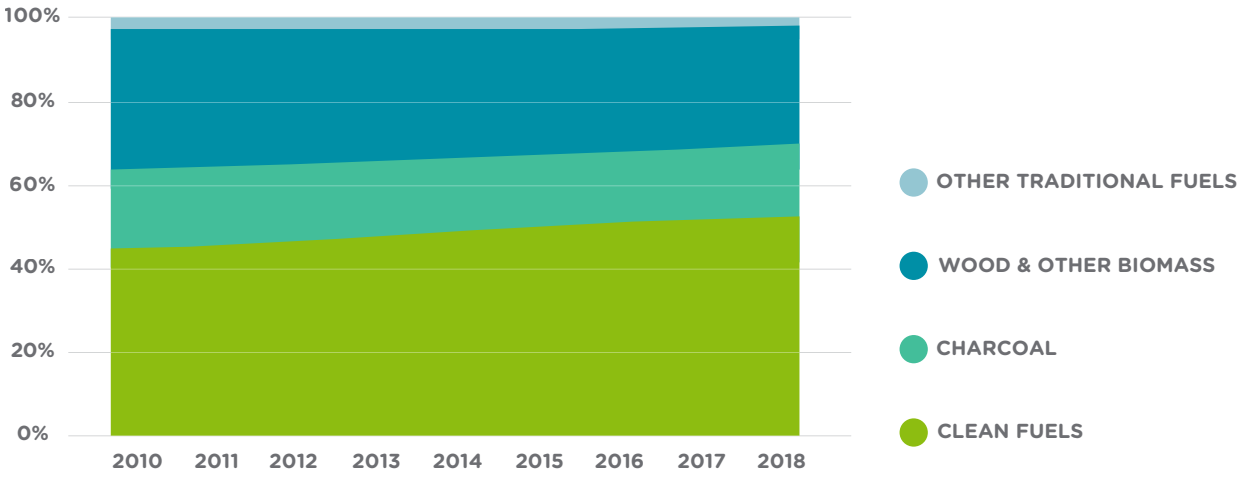
Although the LPG market is growing steadily and benefits from a wide range of players, including the fact that the Philippines has two local refineries,[121] there are still some challenges that hinder the complete success of the market. The SWOT analysis below outlines these along with the market strengths.

- **Strengths:** the LPG market is well-established and with over 40 percent of households already using the fuel, awareness is relatively high; there is a competitive market with a range of differ-

[113] Philippine Liquefied Petroleum Gas Association, Inc. 2018. http://plpga.org/members/
[114] Some of the bulk importers include Pryce Gas inc, Macro LPG Company and South Pacific Inc.
[115] Some of the major LPG refilling companies include Aral Merchandising, Caimol Marketing, Extra Ordinaire, Island Air, Masanga, Metro, Northern, Republic, Royal, Subic and World's Best Gas Inc.
[116] FSC Metal Corporation is one of the companies which entirely focuses on cylinder manufacturing.
[117] Energy for All Asia. n.d. https://energyforall.asia/projects/gaz-lite-2f65c190-2d27-4165-90ea-1a210321f4d9
[118] Based on In-country Interview.
[119] Department of Energy. 2016. "Missionary Electrification Development Plan".
[120] Brent Gas. 2018. Brent Gas. 01 04. https://www.brentgas.com.ph/pr-is-now-brent-gas/
[121] Domingo, Ronnel W. 2018. Business Inquirer. 09 24. https://business.inquirer.net/257773/petron-shell-refineries-output-14

Figure 2.1

Historical Cooking Fuel Breakdown in the Philippines



ent suppliers; and the Philippines is also home to two oil refineries, enabling LPG to be procured locally rather than imported. Income levels are also somewhat higher, and with over 50 percent of residents living in urban areas, there is a greater number of households able to afford cleaner fuels like LPG.

- **Weaknesses:** Distribution is one of the main issues for LPG: the Philippines comprises over 7,000 different islands, making the distribution network one of the biggest challenges to achieving universal access to clean cooking fuels. The geography of the archipelago, combined with all the associated logistical challenges of ensuring fuel and cylinder delivery, as well as maintaining the delivery infrastructure in place, makes it difficult to ensure that both cylinders and fuel are available in rural regions and on the smaller islands. In addition, LPG delivery infrastructure is relatively capital intensive, which means it takes time to raise financing and build-out.

- **Opportunities:** the availability of smaller cylinders, combined with rising income levels which support affordability (particularly in urban areas) make LPG an increasingly attractive option for a growing number of households in the country. Efforts are also underway to introduce tighter safety standards, including regulations on the cylinders, which should help (at least partially) address consumer concerns around their safety. Additionally, consumer finance products are emerging, notably via the MCPI, which are helping address the upfront cost barrier.

- **Threats:** There are a range of problems that continue to persist, notably with regard to the issue of safety, such as:

  - o Uneven quality of cylinders across various suppliers.

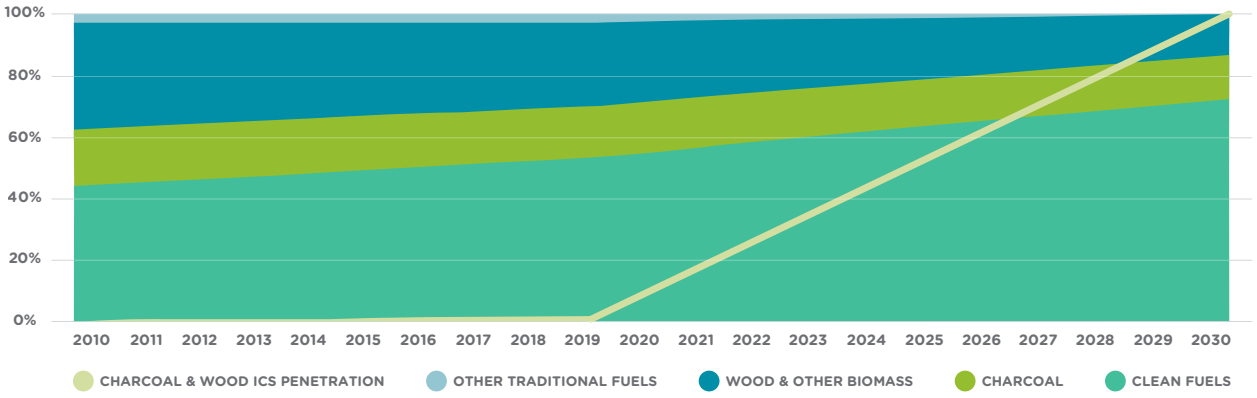
  - o Illegal re-filling of cylinders which has sometimes led to explosions, resulting in safety concerns about LPG use and therefore hindering its market adoption in certain areas.[122]

    - – This suggests that quality standards and higher quality cylinders are needed to improve customer confidence in the safety of cylinders.

[122] The Gaz Lite Project in the Philippines. 2017. "Business Development for Improved Cookstoves and Innovative Fuels".

Figure 2.2

Cooking Fuel Breakdown and ICS Penetration Forecast in the Philippines



Current State of Clean Cooking Access

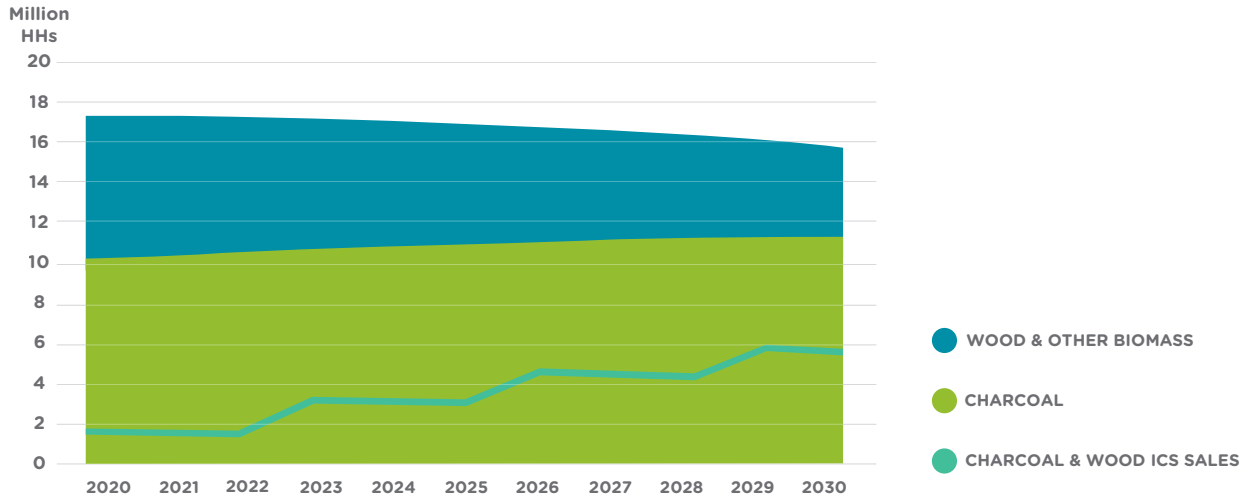
By the end of 2018, it is estimated that approximately 53 percent of Filipino households were cooking at least a share of their meals with clean fuels, particularly LPG and electricity. A very small share of households currently use biogas. Just one percent of households cooking with charcoal or wood were thought to be doing so ICS. As such, over 17 million Filipino households (72 percent) are still estimated to lack full access to clean cooking due to the prevalence of stove stacking and the limited uptake of wood and charcoal ICS.

Of the nearly 13 million households using clean fuels (53 percent of the total), some 6 million are thought to "fuel stack"[123] with charcoal, wood, or biomass residues, meaning they will require ICS for these secondary fuels. Nearly 12 million Filipino households (47 percent of the total) still cook exclusively with traditional fuels.

[123] Fuel Stacking is the phenomenon of end users retaining traditional cooking solutions for use alongside clean or improved solutions to accommodate both diverse household cooking needs and the force of tradition.

Figure 2.3

Philippines – Forecast Traditional Cooking Fuel Use and ICS Sales



CLOSING THE CLEAN COOKING ACCESS GAP IN THE PHILIPPINES

Figure 2.2 illustrates the scope of the clean cooking challenge in the Philippines. The model projects that households using clean fuels will increase significantly to a total of 73 percent (representing nearly 10 million new households cooking with modern fuels). However, a considerable share of households cooking with electricity or LPG are expected to continue fuel stacking, with charcoal remaining an important secondary or tertiary household fuel. As such, nearly 16 million households (51 percent of total households in the Philippines) are expected to continue to cook at least some of their meals with charcoal, wood or other biomass. The challenge will be to shift all of these households away from traditional cooking technologies (namely three-stone fires and lower-quality semi-industrial stoves) and onto high-quality industrial improved wood and charcoal stoves, as illustrated by the white line representing required penetration of ICS over the period 2020-2030.

Wood and Charcoal ICS Contributions Toward Achieving SDG7

The analysis now focuses on the forward-looking projections through to 2030 and modeling out what it would take for the Philippines to achieve universal clean cooking access by that time. Figure 2.3 above illustrates the model outputs through to 2030. The key considerations are as follows:

- The minimum definition of access is high-quality industrial ICS that meets international minimum standards on fuel efficiency and emissions.
- The assumed retail price is USD 25 for an industrial wood stove and USD 36 for an industrial charcoal stove.[124]
- Going forward, the greater availability of LPG, particularly in smaller, more affordable cylinders,

[124] By comparison, the retail prices for much higher quality industrial wood and charcoal stoves is assumed to be USD 25 and USD 36, respectively.

Figure 2.4

Cumulative ICS Enterprise Finance Needs in Philippines (Million USD)

is expected to drive clean fuel use. The cost of LPG itself is relatively low in the Philippines and can compete with charcoal, but distribution infrastructure and geography along with fuel availability and the upfront cost of equipment have been a barrier to entry.

- While the use of electricity and LPG is expected to reach over 70 percent by 2030, considerable fuel stacking is expected to continue, with few households relying exclusively on any one clean fuel, particularly electricity.

- Considerable sales of ICS, particularly for charcoal, will be required through 2030.

- The model assumes that the population will grow at a rate of 1.4 percent per annum.

- Stoves are assumed to be replaced at three-year intervals.

The forecast model projects that 12.2 million improved wood stoves and 26.1 million charcoal stoves will be sold during the period 2020-2030. This is driven in large part by the fact that wood and charcoal are expected to still serve 15.6 million households by 2030, roughly half of whom are also expected to be using clean fuels.

Financing Needs of ICS (charcoal and wood)

To achieve the aforementioned targets in Figure 2.3, ICS have a cumulative financing need of USD 303 million for enterprises alone, as seen in Figure 2.4 above.

Grants to enterprises represent 17 percent of the capital mix used to lower costs associated with proving out business models and displacing additional equity financing needs. Another 32 percent of financing needs will be in the form of equity investments in businesses that turn profitable at the scale-up phase, wherein they have sold about 5,000 ICS units. Debt financing accounts for 51 percent of the capital mix. This is inventory finance to enable retailers to purchase stock of stoves and then repay those loans once sales are completed. The model assumes that all stoves are sold on a cash sale basis.

Consumer Affordability

According to the forecast scenario, the Philippines will require USD 220 million in affordability gap financing to help the estimated 14.3 percent of households that cook with wood but cannot afford an industrial cookstove. The model[125] assumes that households save an amount equivalent to 2 percent of total monthly household consumption for 3 months in order to buy a basic stove. The model also assumes that if a household can afford to buy charcoal, which costs considerably more on a monthly basis than the purchase price of a semi-industrial stove, then there is no affordability gap in buying a stove. Since charcoal is expensive and industrial stoves enhance efficiency considerably, purchasing a stove should be compelling to consumers, so long as they understand this benefit. With respect to clean fuels, the relatively high upfront cost of an initial LPG kit (including the cost of the cylinder, burner, hose, and regulator) remains one of the main barriers to rapid demand-side uptake of industrial stoves. Volatile pricing for LPG (linked to the crude markets) and relatively high number of households living beneath the poverty line are also barriers.

According to the ADB, 21.6 percent of the population (21.97 million in 2015) live below the poverty line (USD 3.20 per day).[126] The proportion of the population earning less than USD 1.90 per day is estimated in 2015 at 7.8 percent (7.93 million inhabitants). However, in terms of affordability, LPG positions relatively well.

The availability of affordability gap financing can help overcome the affordability barrier, particularly for the estimated 29 percent of the population that is living on less than USD 3.20 per day.

[125] The methodology chapter provides more details on how affordability was modeled.
[126] Asian Development Bank. 2018. "Philippines Energy Sector Assessment, Strategy, and Road Map".

KEY CHALLENGES AND OPPORTUNITIES: THE PHILIPPINES SDG7 COOKING TARGETS

The Philippines market has a number of challenges to overcome to tackle the low adoption of ICS and take advantage of the existing momentum in the use of clean fuels, especially LPG. The first step will be to tackle the dearth of government support and regulation for the cooking sector. The government's energy access strategy has been dominated by its efforts to meet its universal electrification targets, which has meant that cooking has benefited from far less strategic, institutional and policy-related support than the electricity sector. However, the government has an opportunity to turn its attention to clean cooking and define targets to support the deployment of ICS technology and the adoption of clean fuels. Global cooking experts can assist it to develop policies and programs best suited to the Philippines context.

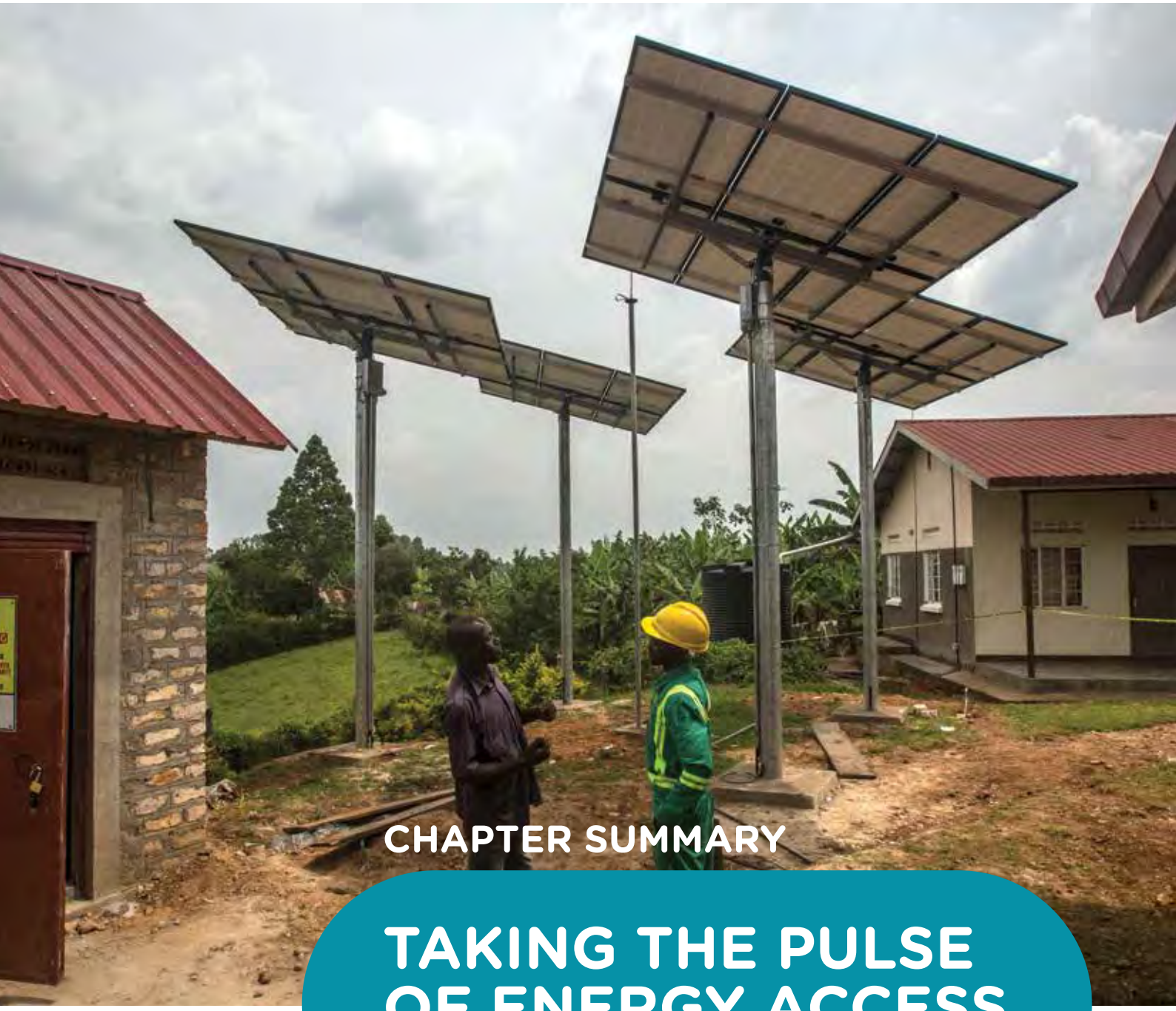
As the policy environment is being developed, the shortage of cookstove manufacturers, clean fuel producers, and cookstove distributers can also be addressed. Among the cookstove manufacturers surveyed by Geres in the Philippines, there was only one semi-industrial producer of charcoal stoves offering a patterned stove made out of aluminum and cement.[127] In the LPG space, only one sophisticated producer was identified. Targeted funds from government and development partners should encourage an increase in the number of ICS manufacturers and distributors. These funds should also increase efforts from clean fuels companies to reach beyond urban and peri-urban areas and build on the work companies like PR Gaz and Brent Gas are doing to increase affordability of their LPG solutions.

[127] StovePlus. 2015. "Exploratory Mission report".

There is also a lack of general awareness about the advantages of switching to ICS that needs to be addressed. Minimal public and donor resources have been dedicated to informing households about the potential cost savings and health benefits of switching to ICS and cleaner fuels. ICS companies are largely SMEs and do not have the resources to finance information and dissemination campaigns. For these reasons, the demand and willingness to pay for more efficient versions of existing fuelwood and charcoal stoves remain low. Consumer awareness campaigns complement the policy framework and financing mechanisms that have already been recommended will also help to address the low volume of ICS and clean fuel providers outlined above.

Finally, access to end-user financing remains a barrier to adoption. While the MCPI is working with a number of multilateral financial institutions to educate on the importance of these loan products and help members to structure them, interest has been limited, in some part due to the fact that only a few manufacturers of high quality ICS exist and also in part because of the low priority of the cooking sector. Government and development partners should be showcasing efforts like this to encourage other local financial institutions and companies to offer loan programs for cookstoves, similar to the PAYG schemes that have helped to progress stand-alone solar adoption. The government and development partners can then build out a diversity of affordability gap financing mechanisms to complement these early efforts.

Altogether, these efforts become a holistic cooking agenda that will increase supply, drive demand, and create a well-financed, supported, and regulated cooking sector.



CHAPTER SUMMARY

TAKING THE PULSE OF ENERGY ACCESS IN UGANDA

Table CS 1

Uganda: Key Figures[128]

Year end	2018	2030
Population (millions)	37.7	55.4
Households (millions)	8.9	13.8
Grid Access (%)	19	47
Mini-Grid Access (%)	.04	.5
Stand-Alone Solar Access (%)	19	52.8
Clean Fuels Use (%)	1.3	7.5
ICS Usage (%)	4.2	100

Uganda has made solid progress in expanding electricity access in recent years, aided by rapid growth in the market for stand-alone household solutions and steady expansion of the electricity grid. When combined, the existing electricity grid, mini-grids, and stand-alone solar currently provide electricity to almost 38 percent of households in Uganda, leaving an access deficit of 62 percent. In looking towards the Sustainable Development Goals (SDG7) target date of universal access[129] by 2030, grid expansion will play a significant role in closing the electrification access gap; this report forecasts 4.7 million new grid connections, representing a fourfold increase in annual connections compared to recent connection trends. Uganda currently only has 11 operational mini-grids, servicing approximately 4,000 households. Development of the mini-grid sector has been hampered by an unclear regulatory framework that has limited private sector participation, while public resources have focused on the expansion and densification of the main electricity grid. The report forecasts a thirtyfold increase in mini-grid deployment through to 2030 (with 320 new mini-grids to be built), though their impact on universal access will remain modest given that each is expected to serve an average of 200 customers. This will require a total of over USD 50 million in debt, equity and grant financing. By way of comparison, *Energizing Finance: Understanding the Landscape 2019* tracked USD 1.4 million in commitments for Ugandan mini-grids in 2017. Stand-alone solar has transformed the electricity market in Uganda over the past five years, and currently delivers access to 19 percent of Ugandan households. Meeting the contributions of stand-alone solar to the 2030 target will necessitate reaching 52 percent of Ugandan households, which translates into supplying 5.3 million new household connections during the period 2020-2030 at a total cost of approximately USD 1.4 billion. When looking at financing flows, the *Understanding the Landscape 2019* report tracked USD 33.7 million in commitments for stand-alone solar in Uganda in 2017. Furthermore, a solution will need to be found for the affordability challenge given that over half of households are unable to pay for access to Tier 1 electricity access. The affordability gap related to stand-alone solar is estimated to be a total of USD 330 million.

Ninety-five percent of all Ugandan households rely on charcoal, wood, or other forms of biomass for their household cooking needs.[130] Despite this, ICS use remains extremely low at around 1 percent. The use of clean fuels (such as liquefied petroleum gas (LPG), biogas, and ethanol) also remains under 1 percent. A competitive market of LPG suppliers is beginning to emerge (though only 0.7 percent of households use it for cooking), with over ten medium-to-large sized companies currently operating in the market. The report forecasts that the use of clean fuels will grow to ten times where it currently stands, contributing 7.5 percent of cooking access. The remaining 12.2 million households (88.7 percent of the total) are expected to continue to cook with wood and charcoal. The challenge will be to shift all these households away from traditional cooking technologies (namely three-stone fires and lower-quality semi-industrial stoves) and onto high-quality industrial improved wood and charcoal stoves. ICS have a cumulative financing need of USD 193 million for enterprises alone. Uganda will also re-

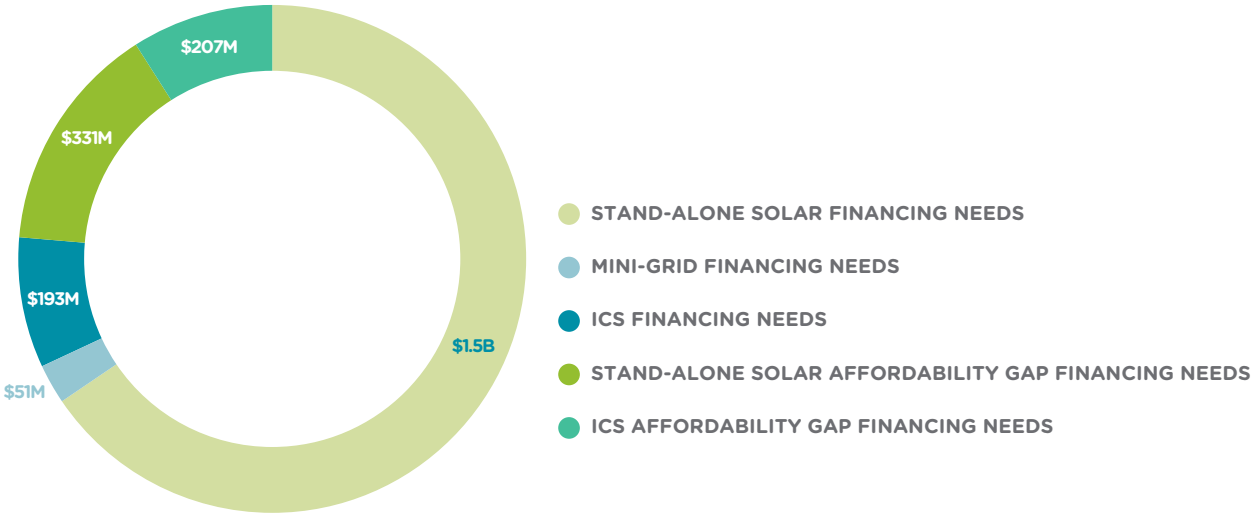
[128] Key figures in this table reflect, for end-2018, best estimates based on the most up-to-date figures available from various official and unofficial sources, extrapolated by leveraging recent trends. For end-2030, figures reflect model outputs for the forecast scenario, i.e., whereby SDG7 is met for electricity and clean cooking access.

[129] SDG7 seeks to ensure access to affordable, reliable, and sustainable modern energy for all. For additional details, please see: https://sustainabledevelopment.un.org/sdg7

[130] UBOS. 2017. "The Uganda National Household Survey 2016/17".

Figure CS 1

Closing the Access Gap in Uganda: USD 2.3 Billion Required for Off-Grid Electricity and Improved Cooking Solutions



quire a cumulative of USD 207 million in affordability gap financing to help the 81 percent of households that cook with wood but cannot afford ICS.

There are several supportive actions that will need to be taken to facilitate investment and achieve universal electrification. These are summarized as follows:

For mini-grids:

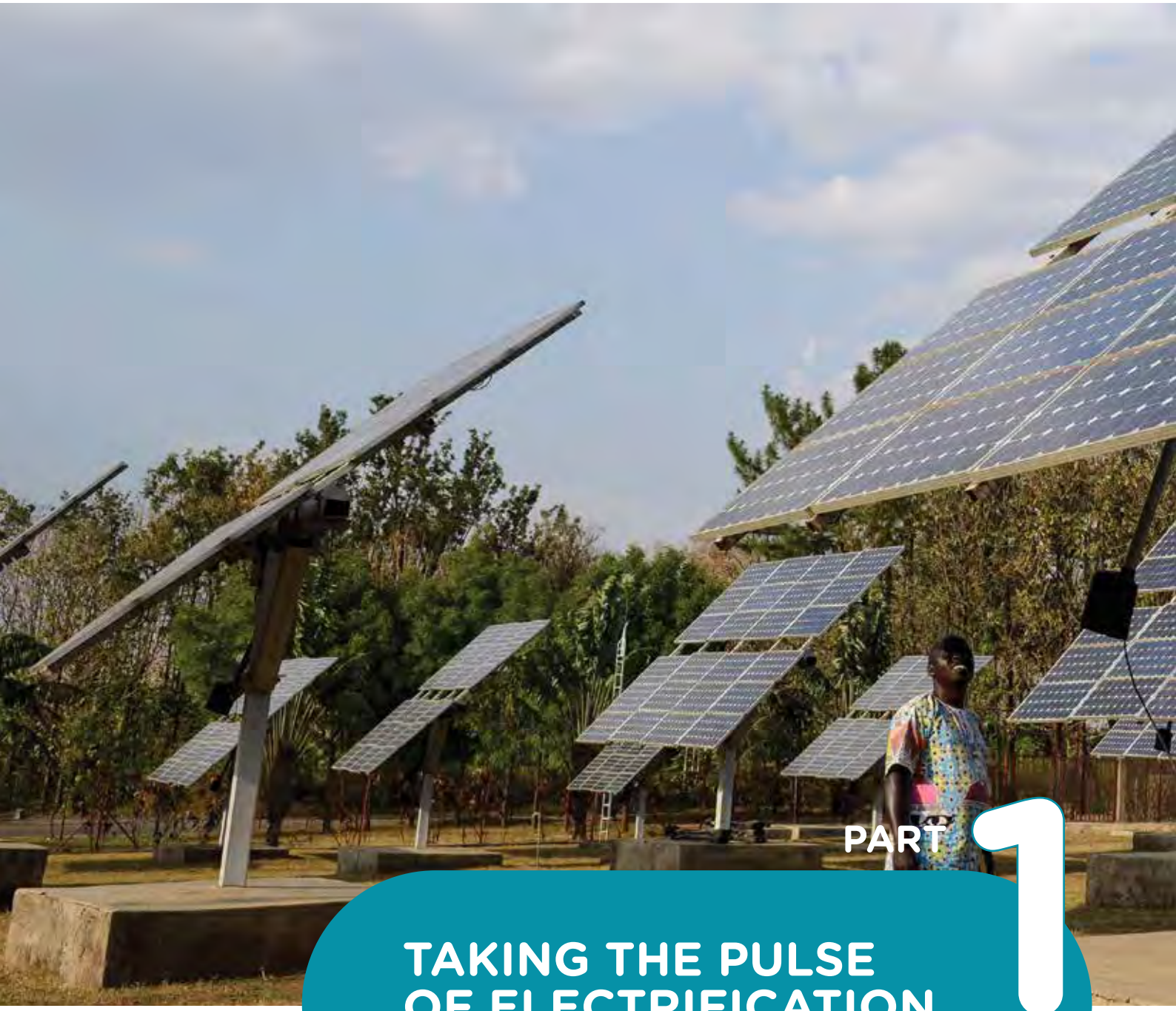
- Develop a comprehensive mini-grid regulatory framework that clearly stipulates the rules of the game around tariff setting, grid encroachment, licensing and permitting, technical quality standards, and end-user subsidies.
- Strengthen the capacity of government officials to effectively monitor and enforce the rollout of the regulatory framework.
- Provide financing that would help de-risk and incentivize the private sector to accelerate mini-grid deployments in Uganda.

For stand-alone solar:

- Improve market intelligence to help the private sector to effectively scale and encourage commercial investment.
- Implement initiatives to enhance household affordability, particularly in difficult to serve areas of the country.
- Foster adoption and enforcement of International Electrotechnical Commission (IEC) quality standards to protect consumers and decrease competition from poor quality products.

For improved cooking:

- Develop and deliver public awareness campaigns on the benefits of clean cookstoves adoption to encourage behavior change.
- Support initiatives to enhance household affordability, particularly for the uptake of industrial cookstoves and the use of clean fuels.
- Kickstart the scaled-up adoption of clean fuels.



PART 1

TAKING THE PULSE OF ELECTRIFICATION IN UGANDA

SECTOR CONTEXT

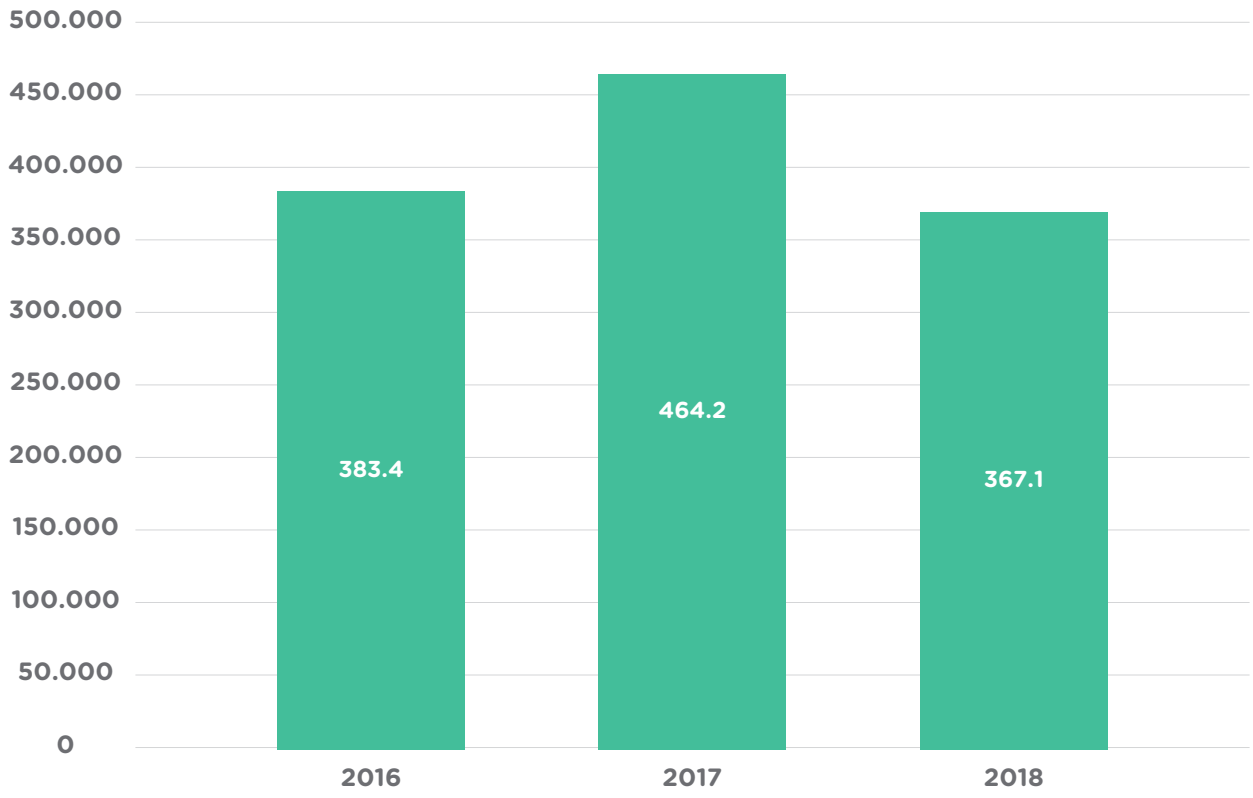
Government Electrification Strategy

The Rural Electrification Strategy and Plan (RESP) details a ten-year plan to expand access to electricity in 13 energy service territories outside the concession area controlled by Umeme Limited, Uganda's main electricity distribution company. Private service providers operate government-owned assets, via the Rural Electrification Agency (REA), in seven territories. The Uganda Electricity Distribution Company Ltd. operates assets in the remaining six service territories until REA grants concessions in a competitive bidding process.

REA has created a complementary plan, the Off-Grid Strategy, to address the policy needs of the

Figure 1.1

Annual Stand-Alone Solar Sales 2016-2018[131]



rapidly growing stand-alone solar sector. The Off-Grid Strategy is currently awaiting approval from the Ugandan Council of Ministers.

Stand-Alone Solar

Between 2016 and 2018, stand-alone solar emerged as a significant source of electricity in Uganda and grew to deliver energy access for 19 percent of households across the country.

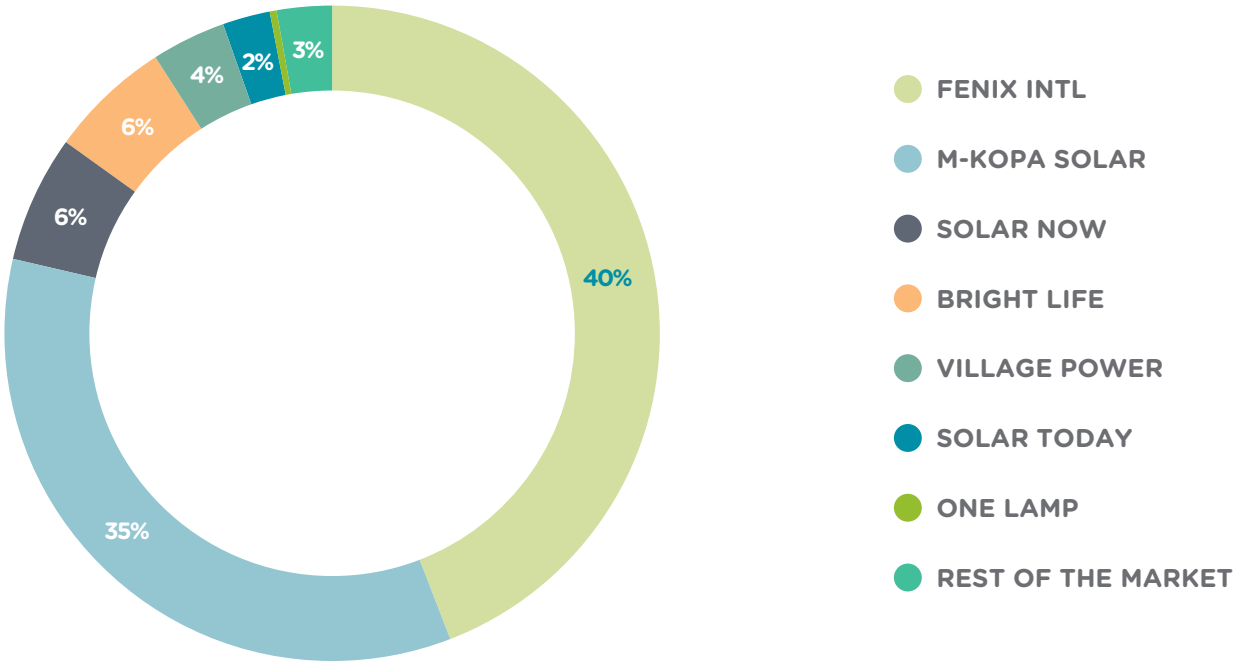
In 2018, about 370,000 high-quality stand-alone solar solutions were purchased by Ugandan households, 61 percent of them on a pay-as-you-go (PAYG) basis, according to the Global Off-Grid Lighting Association (GOGLA). This is a 20 percent decline from the total volume of stand-alone product sold in 2017. One cause of the decline was the 1 percent levy on sending, receiving, and depositing of funds through mobile money, which was introduced by the government in May 2018. Though the levy was reduced to 0.5 percent and restricted to withdrawals, the uncertainty caused by this policy change might have contributed to the decline of PAYG solar sales. Second, broader regional issues, like the widespread drought, affected solar sales across East Africa, as poor harvest impacted household cash flow. In addition, the decrease in the sales amount of GOGLA affiliated products is broadly attributed to the increase in competition from generic, copycat and counterfeit products in East Africa.[132]

[131] GOGLA. 2018. "Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data, January-June 2018".

[132] GOGLA. 2017. "Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data, July-December 2017".

Figure 1.2

Solar Products Sold by Major Companies in Uganda[133]



Given the overall growth of the sector, it is not surprising to observe that the number of private companies providing stand-alone solar services in Uganda has grown from a handful in the mid-2000s to many dozens of companies at present.[134] [135] A diverse supplier landscape provides a wide range of products that include both Lighting Global quality-verified[136] and non-quality verified lanterns, plug and play solar kits and larger component-based systems. Consumer credit from the private sector is driving distribution, with the highest volume of sales being driven by a mix of international PAYG companies. These businesses provide stand-alone solar systems ranging from individual lanterns and small multi-point lighting systems to larger systems capable of charging a television, a radio, a battery, and other household appliances, serving as an effective replacement for the grid.[137] Consumer financing via mobile money payments, including PAYG technology, has also accelerated market growth, minimizing the upfront cost for the consumer and dramatically increasing the addressable market for off-grid electricity as a service. The pie chart above summarizes sales of some of the key companies up to 2018.

Many international development partners are supporting a wide range of programs to advance energy access through stand-alone solar solutions, cultivating market growth and stimulating capital investment, as noted in the Uganda Off-Grid Energy Market Accelerator's 2018 market map.[138] Programs of key development partners that are actively supporting off-grid solar (OGS) are outlined in Table 1.1.

[133] Uganda Off-grid Energy Market Accelerator. 2018. "Mapping the Ugandan off-grid energy market".
[134] Uganda Off-grid Energy Market Accelerator. 2018. "Annual Impact Report, 2018".
[135] Lighting Africa, 2014. "Market Assessment of Modern Off-Grid Lighting Systems in Uganda".
[136] Lighting Global conducts solar products quality testing. Products are tested for durability, system quality, lumen maintenance, availability of warranty and whether advertising materials reflect tested product performance.

[136] Based on market information gathering by UNCDF under its CleanStart program.
[137] Ibid.

Table 1.1

Major Development Partners and Their Main Programs[139]

Development Partners	Key Programs
European Union (EU)	Scaling-up Rural Electrification using Innovative Solar Photovoltaic distribution models Project
The World Bank	Lighting Africa Campaign
United Nations (UN)	UN Capital Development Fund CleanStart
United States Agency for International Development (USAID)	Power Africa Program
Shell Foundation	Market Development Program
Embassy of the Netherlands	Milking the Sun and Harvesting the Sun
The Federal Ministry for Economic Cooperation and Development (BMZ)	Promotion of Renewable Energy and Energy Efficiency Program
Agence Française de Développement (AFD)	Sustainable Use of Natural Resources and Energy Fi-nance in East Africa (SUNREF)
Department for International Development (DFID)	Energy Africa Campaign

While Uganda is one of the top five stand-alone solar markets globally, and the second biggest market for PAYG sales, trailing only Kenya, continued market growth will depend on increased consumer awareness, a rigorous quality assurance framework, financing to help companies access hard-to-reach rural areas and affordability gap financing. Households in the bottom third of the income pyramid will have particularly acute affordability issues without the introduction of affordability gap financing.[140] The affordability gap will be discussed in more detail later in this chapter.

Mini-Grids

Uganda's mini-grid sector is much less mature than the stand-alone solar sector. Uganda has 11 operational mini-grids that serve approximately 4,000 households and various commercial and small industrial customers. The bulk of these feature solar power generation and battery storage. Most have less than 50 kilowattpeak (kWp) of generating capacity and serve 100-200 customers each. The outlier, Kalangala Island's 1.6-megawatt peak (MWp) photovoltaic (PV)-diesel hybrid mini-grid that serves over 2,000 household consumers, could be deemed a 'small isolated grid' instead of a mini-grid. Only one of the eleven is private-sector owned and operated.[141]

[139] Uganda Off-grid Energy Market Accelerator. 2018. "Mapping the Ugandan off-grid energy market".
[140] Ministry of Energy and Mineral Development. 2015. "Uganda's Sustainable Energy for All (SE4ALL) Initiative Action Agenda".
[141] Uganda Off-Grid Energy Market Accelerator. 2019. "Market Map of Off-Grid Solar in Uganda: 2019 Edition".

Mini-grid growth has been constrained by an undefined policy and regulatory framework, which greatly undermines developer and investor confidence, and a lack of incentives to sufficiently de-risk the business model and bring down the price of power for consumers.[142] Additional issues that limit mini-grid investment include fears over grid intrusion in mini-grid service areas, lack of transparency around licensing and permitting, issues with technical and quality standards, a uniform tariff policy that requires regulatory approval to enact cost-reflective tariffs, and a shortage of grants to buy down the cost of mini-grid electricity and make it more affordable for poorer households.[143] As one interviewee observed, mini-grid strategy documents need to be streamlined and tariff uses resolved to create a more effective mini-grid policy environment and in turn build a more attractive mini-grid sector.[144]

Despite these challenges, several mini-grid sites are being evaluated in the north and south of Uganda, including hydropower sites. The REA master planning process has identified 320 mini-grid sites serving approximately 32,000 customers (including some 26,000 households) for development.[145]

Many international development partners are supporting a wide range of programs to advance energy access through mini-grids, cultivating market growth and stimulating capital investment.[146] Partners include the EU, the World Bank, the UN, USAID, AfDB, the Shell Foundation, Foundation Rural Energy Services, World Wide Fund for Nature, and development agencies in Austria, Finland, Germany, and the United Kingdom. BMZ is leading the way in support for mini-grid development in Uganda. The Promotion of Mini-Grids project, funded by BMZ and implemented by GIZ and Ugandan government partners, includes targeted support to the Ugandan Ministry of Energy and Mineral Development (MEMD) to further develop and improve the regulatory framework for mini-grids.

[142] Uganda Off-grid Energy Market Accelerator. 2018. "Mapping the Ugandan off-grid energy market".
[143] Based on in-country interviews; NARUC Practical Guide to the Regulatory Treatment of Mini-Grids, November 2017.
[144] Based on in-country interviews.
[145] Uganda Off-grid Energy Market Accelerator. 2018. "Mapping the Ugandan off-grid energy market".
[146] Ibid.

Anecdotes from stakeholders in Uganda demonstrate that the financing available for mini-grids outside of development partner grants is negligible. Developers for two projects totaling USD 3.2 million, indicated that one project used 100 percent grant financing while another used 74 percent grants and 26 percent equity. One mini-grid company was refused a loan from a commercial lender because the business model could not meet the bank's required seven- to ten-year debt repayment period. Support between grid, stand-alone solar, and mini-grid has also been highly inequitable. As one interviewee noted, mini-grids are the least supported electrification segment but require the most reform and support going forward to succeed.[147]

CURRENT STATE OF ENERGY ACCESS

Defining Energy Access

Taking the Pulse uses the globally accepted Multi-Tier Framework (MTF) to define energy access.[148] The MTF establishes five "tiers" of household electrification that are based on capacity, duration, reliability, quality, affordability, legality and health and safety impacts. The MTF is often referred to as the "energy access ladder," whereby households may graduate from one level of service to another depending on what sources of electrification they have access to, what they need, and what they can afford. Tier 0 represents a household that uses stopgap measures to meet their basic electrification needs, often using fuel-based lighting (e.g. kerosene lanterns, candles) or battery-operated flashlights for lighting needs, and relying on third-parties to power their devices (most notably cell phones). Tier 1 and 2 services are most often delivered by "stand-alone solar solutions", frequently in the form of single or multi-light point systems that derive their power via solar PV panels. Tiers 3 through 5 are most typically met by connections to a centralized or localized grid (i.e. a "mini-grid"). However, it is important to note that having a grid connection can also qualify as Tier 1 (or as low as Tier 0 if power is available for less than four hours

[147] Based on in-country interviews.
[148] Bhatia, M. & Angelou, N., 2015. Beyond Connections – Energy Access Redefined, Washington: Energy Sector Management Assistance Program.

per day) if the MTF duration criteria are not met. More details on the MTF can be found in the *Taking the Pulse* methodology chapter.

Tier 1 stipulates either a certain level of installed capacity (in terms of power and capacity) or a level of service, which is expressed in lumen hours. Lumen hours is the unit of measure for the brightness of light. *Taking the Pulse* establishes the minimum level of electricity service based on the MTF service metric in lumens. It stipulates that fractional Tier 1 access counts toward the SDG7 goals. This means a single-light-point solar lantern that has the functionality to charge phones (one of the MTF service criteria) counts toward access goals. However, since the output of most solar lanterns is less than the MTF Tier 1 requirement of 1,000 lumen hours per day, this contribution is "fractional" given that the lantern does not deliver full service to all members of a typical household. *Taking the Pulse* assumes in its modeling that a lantern delivers sufficient lumen output to provide access to 60 percent of household members—in line with the capabilities of the typical modern lantern. As such, households would need to have two lanterns in order to achieve full Tier 1 access.

This is a critical methodological point, as lanterns are often more affordable than multi-light point systems. As such, this impacts the overall financing needs required to achieve universal access in a given market. The methodology chapter discusses how levels of service are derived in the model, and the assumptions that underpin them.

State of Electricity Access in Uganda

As of the end of 2018, 38 percent of households in Uganda had electricity access.[149] As seen in Figure 1.3 below, Uganda has expanded grid access to 19 percent, almost doubling grid coverage since 2010. Nevertheless, Uganda's electrification rate lags behind its African peers.[150] Stand-alone solar access, which was negligible at the start of the decade, now accounts for nearly 19 percent of Uganda household connectivity. Mini-grid access in Uganda is currently limited to about 4,000 households. Given that the number of households in the country now exceeds 8 million, the mini-grid access rate currently stands at 0.04 percent.

[149] Bhatia, M. and Angelou, N. (2015). Beyond Connections: Energy Access Redefined. ESMAP Technical Report Washington, DC: World Bank. Available at: https://openknowledge.worldbank.org/handle/10986/24368
[150] Energy Sector Management Assistance Program (ESMAP). 2018. Tracking SDG7: The Energy Progress Report. https://trackingsdg7.esmap.org/time?country=Uganda

Figure 1.3

Historical Electricity Access in Uganda

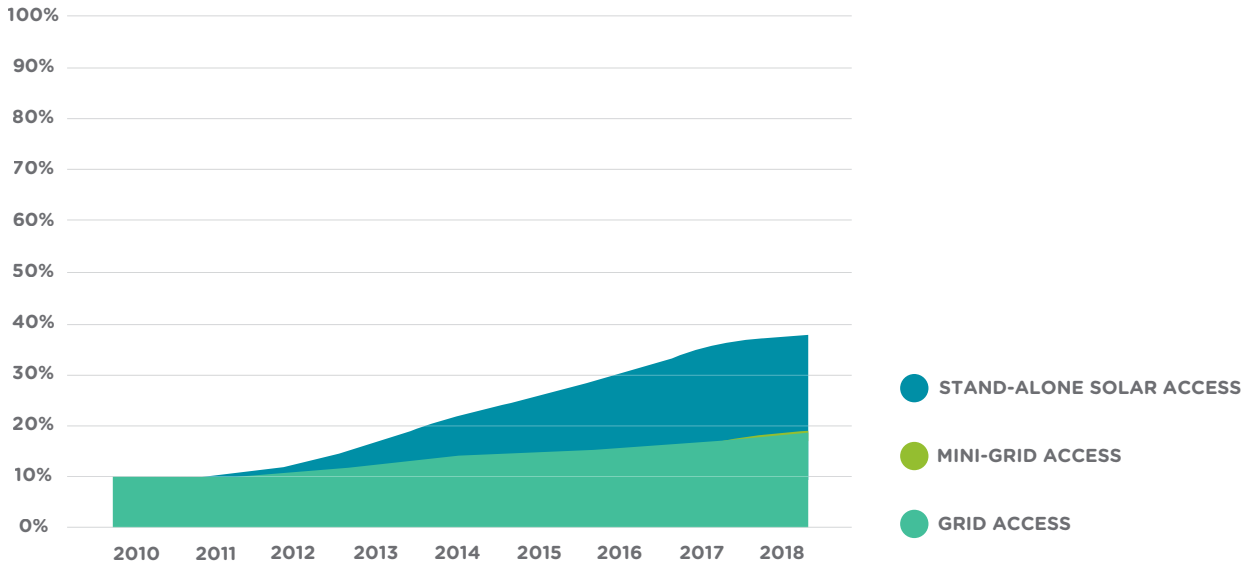
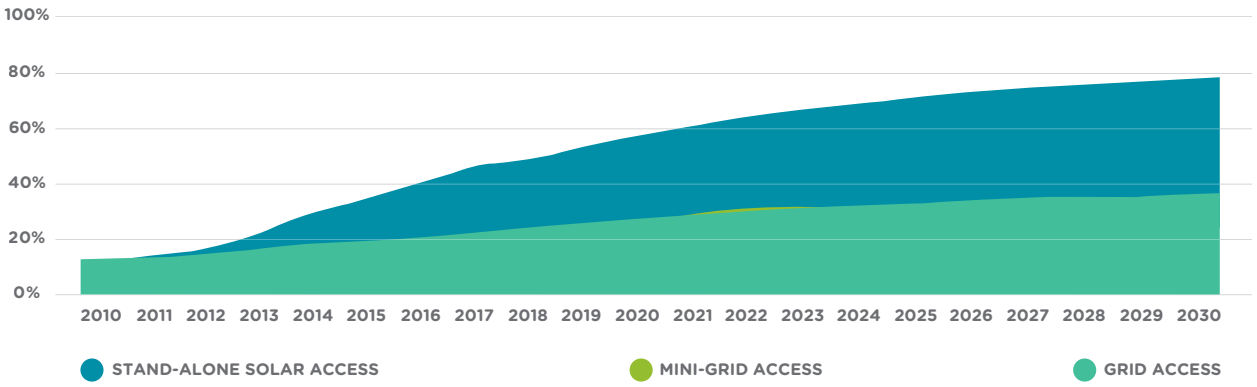


Figure 1.4

Uganda Business as Usual Electricity Access Scenario



As seen in Figure 1.4 above, the model outputs show that if Uganda continues to expand grid access at the pace seen in recent years, following a business as usual (BAU) scenario, grid coverage will reach just 28 percent in 2030. Stand-alone solar access, following its current trajectory, can be expected to reach 31 percent. This projection assumes an annual net increase of 200,000 to 250,000 households with 4.3 million households gaining access through 2030. This is slightly lower than the average net increase seen between 2014 and 2018 as it is projected that sales are likely to slow as stand-alone solar enterprises are forced to move into more rural, lower-density areas as the market becomes more saturated. They also need to move further afield to identify new customers. With the low number of current connections, extrapolating forward the BAU mini-grid scenario would be imperceptible (<0.1 percent, less than 10,000 households with access). In the aggregate, the BAU scenario shows that Uganda would provide energy access for 59 percent of households in 2030, leaving an access gap of 41 percent.

CLOSING UGANDA'S ELECTRIFICATION ACCESS GAP

Achieving universal energy access by 2030 in Uganda will require acceleration across both on-grid and off-grid technologies. The forecast projections modeled in Figure 1.5 below illustrate the targets for Uganda to achieve universal energy access by that time. The key assumptions driving this scenario are as follows:

- Grid connectivity would increase to 47 percent, yielding a total of 4.7 million new households connected to the grid between 2020 and 2030. The model outputs are based on a rather aggressive grid expansion scenario, whereby an average of 430,000 new household grid connections are added each year. This is in contrast to the past two years, wherein the number of new annual connections has averaged approximately 200,000. On balance then, the model foresees a 130 percent increase in grid connections under this scenario.[151]

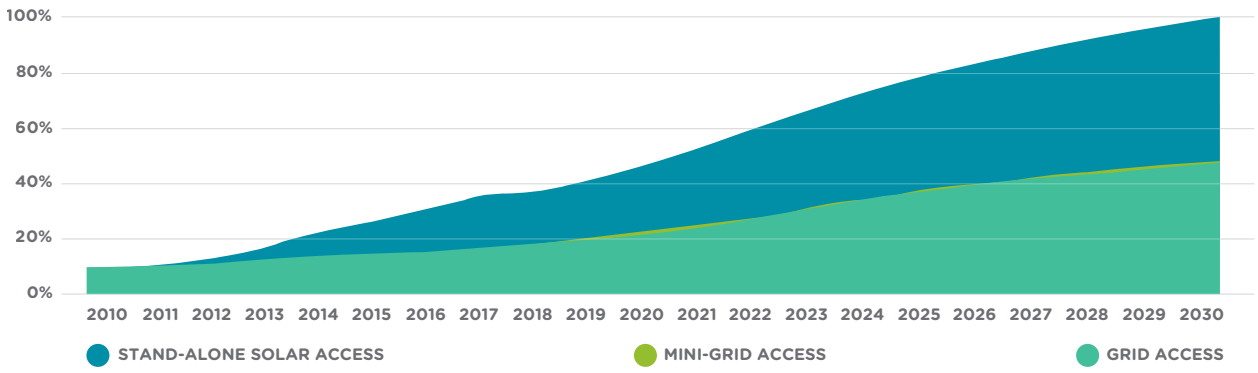
- The number of mini-grids will increase significantly under the forecast scenario (320 new mini-grids would be built, up from the current base of 11), though their contribution to the broader energy access deficit would remain modest. Mini-grids are expected to deliver access to approximately 70,000 additional households between 2020 and 2030.

- The electrification access deficit that remains from grid and mini-grid expansion will need to be filled by OGS. As a result, Uganda will be counting on stand-alone solar to deliver access to the remaining 52 percent of households—over 7 million—in order to achieve universal access by 2030.

[151] Despite the considerable increase in grid connections forecast in this scenario, it still falls short of the 600,000+ per year targeted in Uganda's 2015 Sustainable Energy for All Action Agenda. The authors chose a more conservative annual target that more closely reflects recent performance.

Figure 1.5

Uganda – Forecast Electricity Access (All Technologies)



Mini-Grid Contributions Toward Achieving SDG7

The forecast model projects that 320 new mini-grids will deliver approximately 70,000 new household connections over the period 2020-2030, through a concerted government mini-grid electrification program. This represents an approximate 1,600 percent increase in new connections via mini-grids, compared to the end of 2018. Though this is a substantial increase from the base case, it still means that mini-grid contributions to the SDG7 challenge will remain modest, at 0.5 percent of total connections.

Mini-Grid Financing Needs

Taking the Pulse establishes that mini-grids will deliver a minimum of Tier 3 electricity services.[152] The model therefore includes assumptions around the cost of delivering this level of service. This is a minimum and does not preclude the development of mini-grids that are capable of delivering Tier 4 or 5 access. However, if either of these levels of service were to be considered the minimum, the

[152] Based on the MTF; see the methodology chapter for additional detail on the MTF.

Figure 1.6

Uganda – Mini-Grid Electricity Access Forecast

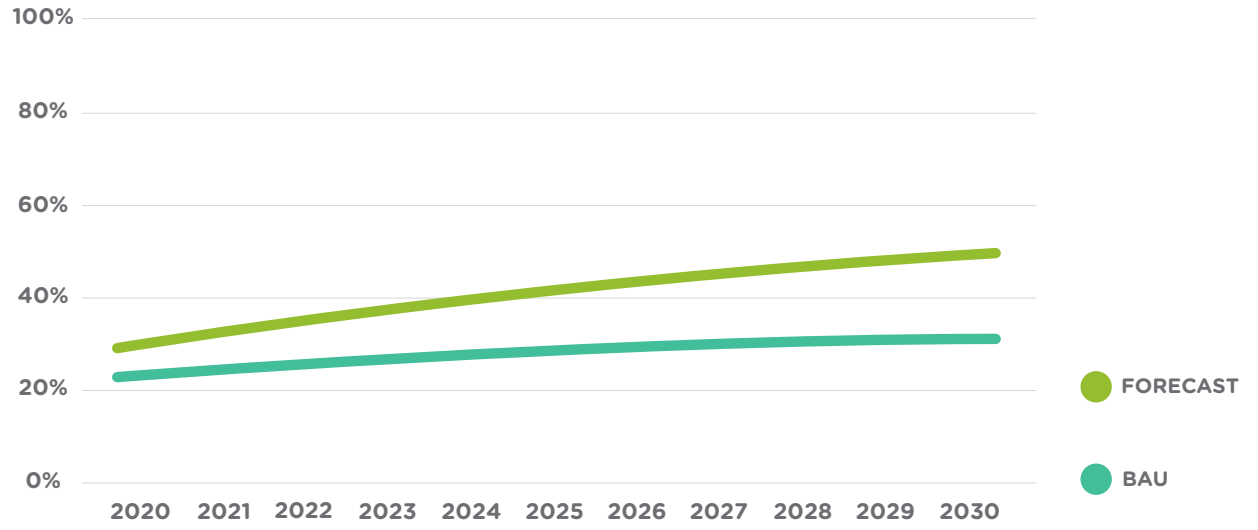
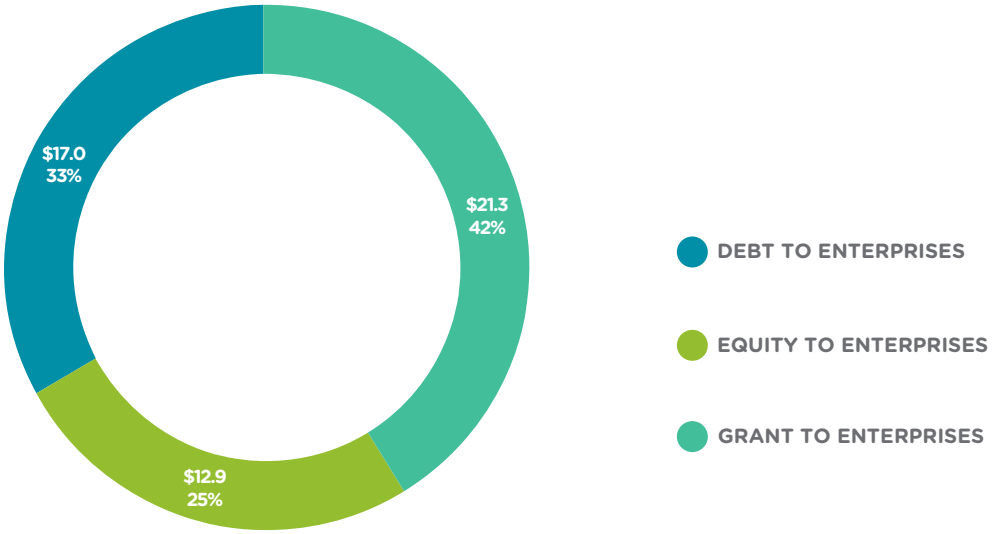


Figure 1.7

Cumulative Financing Needs for Ugandan Mini-Grid Enterprises (Million USD)



overall costs of delivering energy access via mini-grid solutions would increase considerably. To achieve the nearly 70,000 mini-grid connections envisaged in the forecast scenario outlined above, mini-grids will have a cumulative financing need of USD 51 million, averaging out to USD 4.6 million per year, as seen in Figure 1.7 above. The number of new mini-grids aligns with that of a government program designed in 2018 that specifically mapped villages where mini-grid deployment was appropriate. The *Taking the Pulse* model assumes that each mini-grid will support 200 households and two large anchor clients that consume at least one-third of the mini-grid's generated electricity, and that connections will cost between USD 650-1,050 per connection, depending on the maturity of the mini-grid developer. A mature developer, by virtue of experience deploying at least 25 mini-grids, is expected to be able to develop new mini-grids at lower upfront cost than its peers.[153] In reality, it is also more likely to ensure its mini-grids are efficiently exploited and thus more economically viable going forward. It is noteworthy that at this time, there are no mature developers operating in the Ugandan market.

[153] The methodology chapter provides details regarding the assumptions that underpin the mini-grid modeling outputs, including the enterprise level characteristics.

Table 1.2

Capital Blend by Mini-Grid Company Maturity

	Pilot	Validation	Scale-Up	Mature
Grant	75%	50%	40%	30%
Equity	25%	30%	30%	20%
Debt	0%	20%	30%	50%

Mini-grid projects rely on a blend of grants and equity to finance early-stage development and operational costs, and as leverage for the additional debt financing needed to build and maintain infrastructure, as illustrated in Figure 1.7. In the model, the blend of capital is directly tied to the companies' stage of growth, where pilot stage companies require closer to 75 percent grant funds and little to no debt, and mature companies require 30 percent grants and are much more reliant on debt.

Due to the early stage of mini-grid developers in Uganda and the early stage of the mini-grid market overall, the analysis of financing needs for mini-grid development in our forecast scenario assumes that international development agencies, local government agencies, trusts and foundations will provide grants to cover 42 percent of enterprise financing, while venture capital, private equity, and impact funders will contribute 25 percent in the form of equity. The remaining 33 percent of enterprise financing would come from debt provided by local and international investors. A main challenge will be to catalyze local sources of capital. To date, these actors have played a modest role in supporting energy access. As one interviewee remarked, "…most local investors don't understand the space and aren't very interested in learning."[154]

Affordability of Mini-Grids

Project developers have had difficulty setting cost-reflective tariffs in the current regulatory environment that recoup installation costs and operating expenses while staying within a rural household's willingness and ability to pay for electricity. Even with an anchor customer that has substantial energy needs, such as an agricultural facility, a cottage industry, or a mobile phone tower, mini-grid projects require subsidies to offset the tariff charged to energy users or buy down the connection cost. Therefore, the report model assumes a considerable contribution of grant financing (ranging from 30 to 75 percent) to make mini-grids economically viable. This financing would enable mini-grid operators to lower the cost of power to their customers to a level that would be affordable. This would also reflect the lowered risk profile of the business model as it matures, which would reduce the sector's dependency on concessional financing over time.

Key Challenges and Opportunities Relative to MGs Delivering on SDG7 Targets

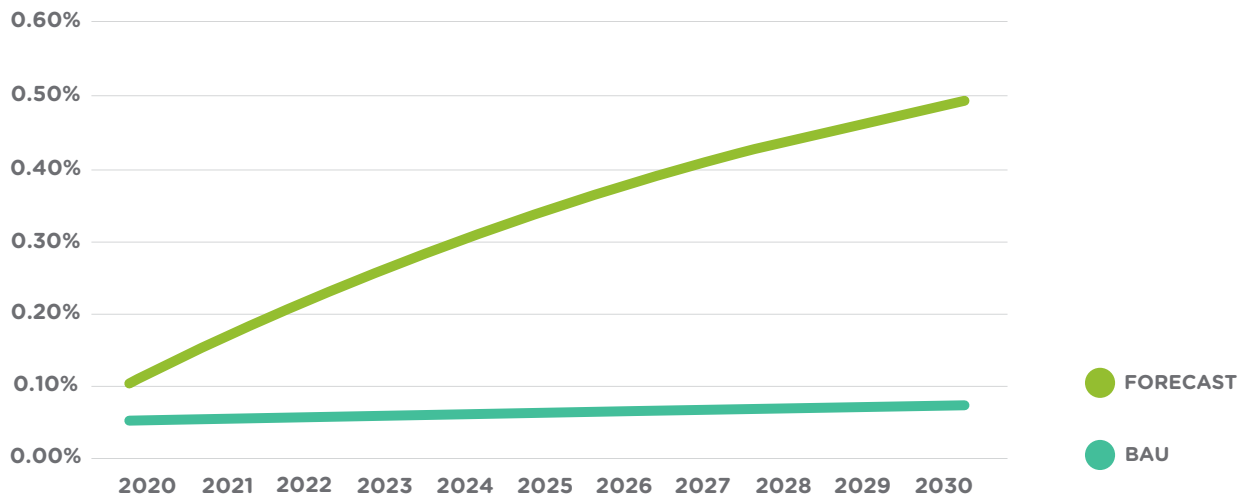
Fears over grid intrusion in mini-grid service areas, a lack of technical and quality standards, and uncertainty in the project review and approval process have been cited as key constraints for Ugandan mini-grids. Developers identifying project sites lack information on sites under consideration by competing developers, energy demand within a site, and whether the site is under consideration for grid extension. This can slow the site selection process significantly.[155] In addition, Uganda has not yet established mini-grid quality of service, interconnection policy, or equipment standards.[156] This can be difficult for developers whose mini-grids will eventually be reached by the grid and require transparency on integration standards and models for owning and operating the mini-grid, and the policy uncertainty can also deter medium- and long-term investors. Licensing for developers is time-consuming, sometimes exceeding a year. The government initially had little or no precedent for evaluating mini-grids separately from grid projects. As the project pipeline has grown, so has the need to build up human capacity. For example, a two- or three-person team at the Uganda Regulatory Authority performs technical evaluations for grid and off-grid projects. Grid projects generally take priority. Once evaluations are underway, they are characterized by a high degree of subjectivity. While reviewing a developer's business model and a project's balance sheet, evaluators use discretion to assess financial feasibility because there are no established criteria or clear guidelines for applicants to reference.[157]

[154] Based on in-country interviews.

[155] National Association of Regulatory Utility Commissioners (NARUC). 2017. "Practical guide to the treatment of Mini-grids".
[156] Uganda Off-grid Energy Market Accelerator. 2018. "Mapping the Ugandan off-grid energy market".
[157] Based on in-country interviews.

Figure 1.8

Uganda – Stand-Alone Solar Electricity Access



STAND-ALONE SOLAR CONTRIBUTIONS TOWARD SDG7

In a BAU scenario, stand-alone solar for households is expected to reach 31 percent, whereby net new connections (gross additions minus retirements) range from 200,000 to 250,000 Tier 1 equivalents per year through 2030. This scenario reflects the general slowdown in stand-alone solar product sales witnessed across many solar markets in recent years, including the slowing pace of sales referenced in Figure 1.1.

The forecast model, however, projects that new stand-alone solar will account for 5.3 million new household connections over the period 2020-2030 (52 percent of electrified households). This also means that stand-alone solar will deliver electricity access to nearly 7.2 million total households by 2030. This is a 66 percent increase from the BAU scenario and will require significant capital and private-sector absorptive capacity – and execution capability – to achieve. The challenges around delivering on these ambitious targets are discussed in more detail later in the chapter. The significant increase in solar uptake has already been observed by some interviewees. One noted that increasingly its new customers are second-generation users who are buying either improved or larger systems.[158] Another pointed to the growth of the stand-alone solar sector being manifested in the increasing awareness for solar as an alternative to the grid and being able to differentiate product quality.[159]

Financing Needs

To achieve the additional 5.3 million connections envisaged in the forecast scenario outlined above, stand-alone solar enterprises will have a cumulative financing need of approximately USD 1.43 billion, averaging to USD 130 million per year, as seen in Figure 1.9 below. The outputs depicted in this figure are based on three key assumptions:

- PAYG companies require long-term, up-front financing to accommodate the payment schedule of their customers—which is often 12 to 18 months but can extend to three years or more. This means that the initial financing challenge resides with the solar enterprises themselves. Debt is the most appropriate form for this financing to take, as it will enable stand-alone solar companies to import inventory, and in some cases, ex-

[158] Based on in-country interviews.
[159] Ibid.

tend loans to their customers. As those systems are purchased, loans can be repaid.[160]

- Stand-alone solar systems are assumed in the model to have a lifetime of four years and, as such, households purchasing a system in a given year are projected to require a new system to maintain access fully four years later.

- Uganda will also require a total of USD 329 million, an average of USD 29.9 million per year, in affordability gap financing to achieve universal electricity access. A more detailed explanation of consumer affordability is provided in Part 3 of this chapter.

The model assumes that OGS businesses are at different stages of maturity during the forecast period (pilot, validation, scale-up, mature)[161]. The blend of capital associated with these stages varies, as summarized in Table 1.3 below. Early-stage enterprises will be more reliant on grant financing and risk tolerant early equity, while more mature businesses will seek to leverage their equity financing to secure significant debt that will finance their consumer receivables and inventory finance needs.

Stand-alone solar enterprises benefit from increasing access to debt, limiting the need for grants in the financing mix. Through 2030, grants are expected to continue providing 15 percent of enterprise financing, largely due to the need to incentivize companies to establish sales channels in underserved rural areas. Equity finance covering 40 percent of enterprise needs will support ongoing operational activities and growth, while debt providers will contribute the remaining 45 percent of enterprise capital needs, accounting for low-cost funds to commercialize loans to solar service providers and first-loss guarantees against borrower defaults.

[160] Uganda Off-grid Energy Market Accelerator. 2018. "Mapping the Ugandan off-grid energy market".
[161] The report's methodology chapter provides more details regarding the assumptions underpinning these enterprise stages.

Figure 1.9

Cumulative Financing Needs to Achieve Stand-Alone Solar Targets in Uganda (Million USD)

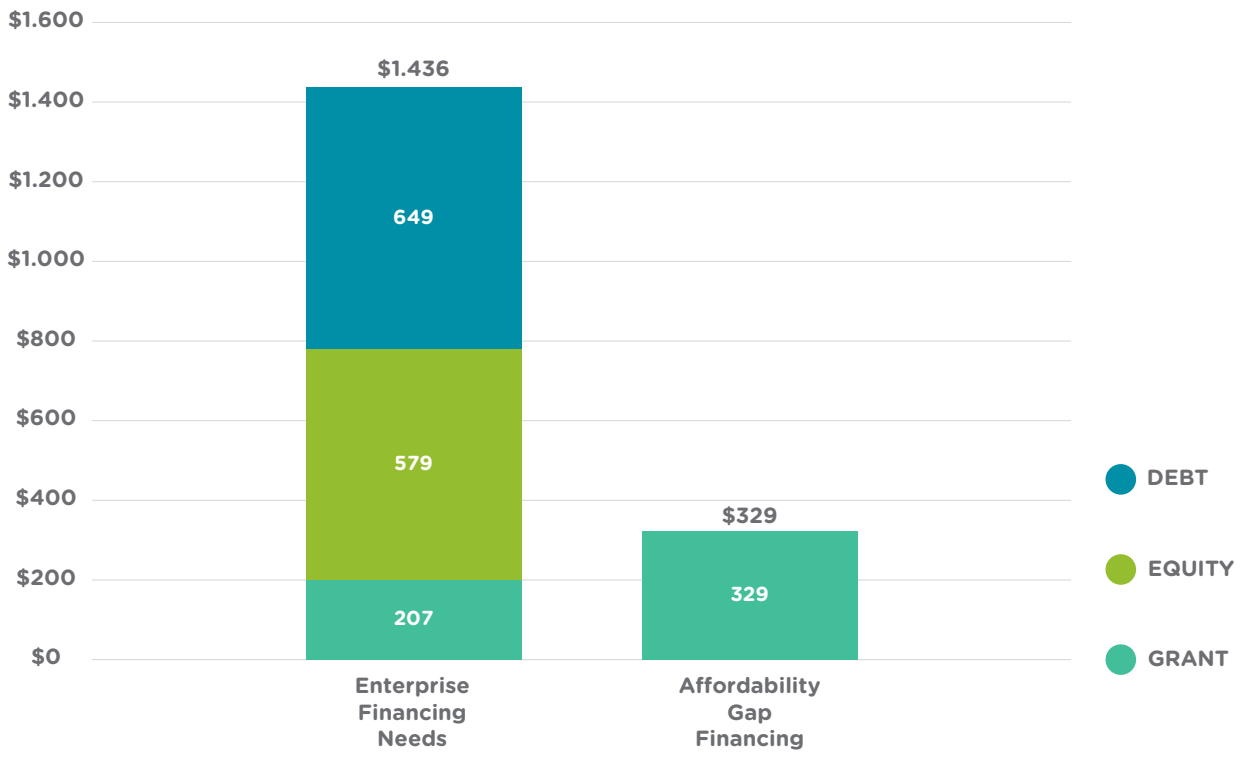


Table 1.3

Model Assumptions for Capital Blend by Stand-Alone Solar Company Maturity

	Pilot	Validation	Scale-Up	Mature
Grant	20%	30%	10%	5%
Equity	80%	55%	45%	15%
Debt	0%	15%	45%	80%

To date, many companies have struggled with accessing non-grant capital. As one interviewee highlighted, grants can be limiting in terms of purpose or application of funds. They mostly cannot finance inventory and the reimbursement structure means they must have funding to do the work before being reimbursed.[162] Another noted that there is a lot of buzz regarding investments into the renewable energy sector but companies, especially the small ones that have no fundraising teams, don't really know where to start to access this money or will not qualify for the money.[163]

Affordability of Stand-Alone Solar

A large proportion of Ugandans live under or near the poverty line[164] and, as such, it is likely they will have difficulty affording even basic stand-alone solar products. An estimated 13 percent of households are unable to afford the USD 3.3 per month[165] to buy a solar lantern on a PAYG basis. A further 44.5 percent are expected to be unable to afford a full Tier 1 solar home system at a cost of USD 7.5 per month[166], as illustrated in Figure 1.10 below. Interviews with private sector actors validated the affordability challenge that they face, with one player going so far as to lower its initial deposit requirement in order to boost sales.[167]

The estimated affordability constraints outlined above were determined by leveraging the World Bank poverty calculator (PovCal) to create Ugandan household consumption curves, i.e., charting the percentage of households with consumption at or below specific dollar amounts.[168] Then, by assuming that households are willing to allocate no more than 5 percent of their monthly consumption on electricity access (a threshold often used by practitioners to define electricity affordability), the model is able to estimate the percentage of households that cannot afford either the USD 3.3 a month for a PAYG lantern (marker "1" in Figure 1.10) or, separately, the USD 7.5 for a Tier 1 solar home system (marker "2" in Figure 1.10).

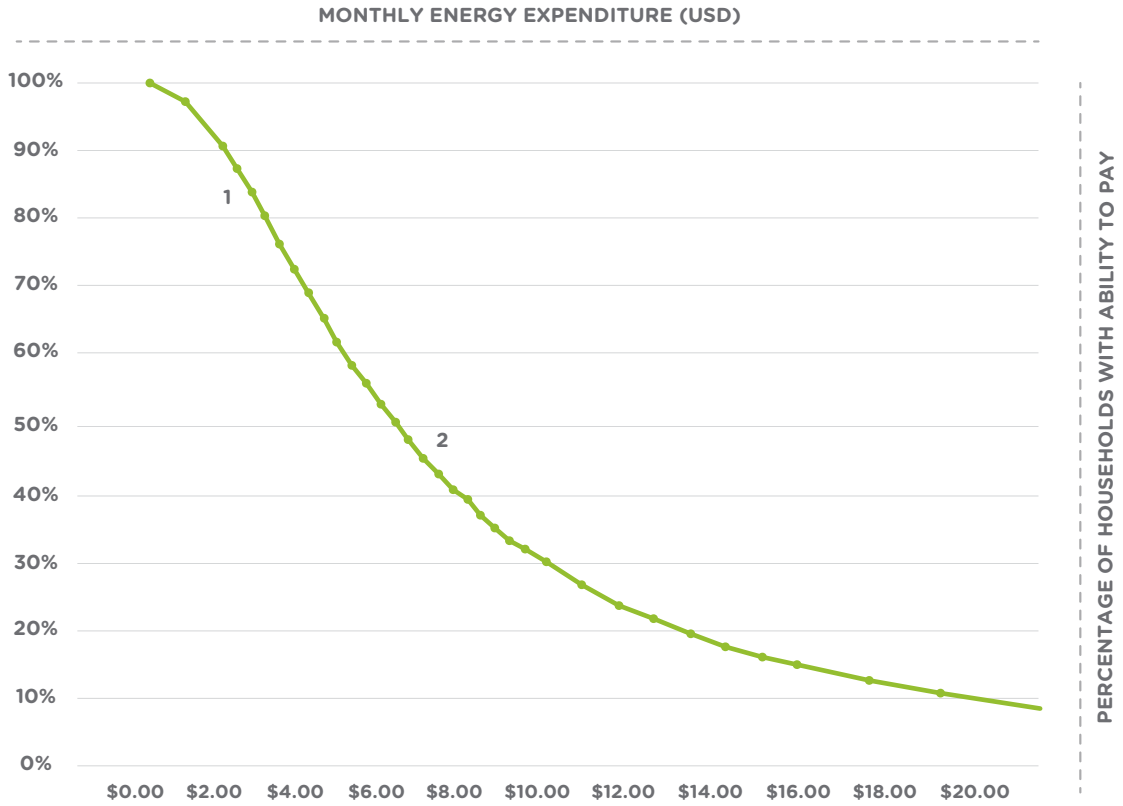
Key Challenges and Opportunities Relative to Stand-Alone Solar Delivering on SDG7 Targets

Although stand-alone solar has seen rapid expansion in Uganda and is expected to play a central role in electrification, there are still several major challenges to its advancement. First is a lack of access to resources to accelerate expansion, including capital, talent, and market knowledge. To overcome capital constraints, businesses will require technical assistance to improve investment readiness. To overcome gaps in market knowledge, companies will require higher-quality national data. This data could include in-depth, up-to-date market data on consumer af-

[162] Based on in-country interviews.
[163] Ibid.
[164] The international poverty line is set at USD 1.90 using 2011 prices by the World Bank. For additional information, see: https://www.worldbank.org/en/topic/poverty/brief/global-poverty-line-faq
[165] The model assumes this retail price point for a household to purchase a quality verified mid-range lantern, paid for in installments over 12 months.
[166] The model assumes this monthly cost for an entry-level multi-light point solar system, paid for in installments over 12 months.
[167] Based on in-country Interview.
[168] The methodology chapter discusses the approach to modeling affordability in detail.

Figure 1.10

Uganda's Ability to Pay at 5% of Monthly Consumption on Electricity Access

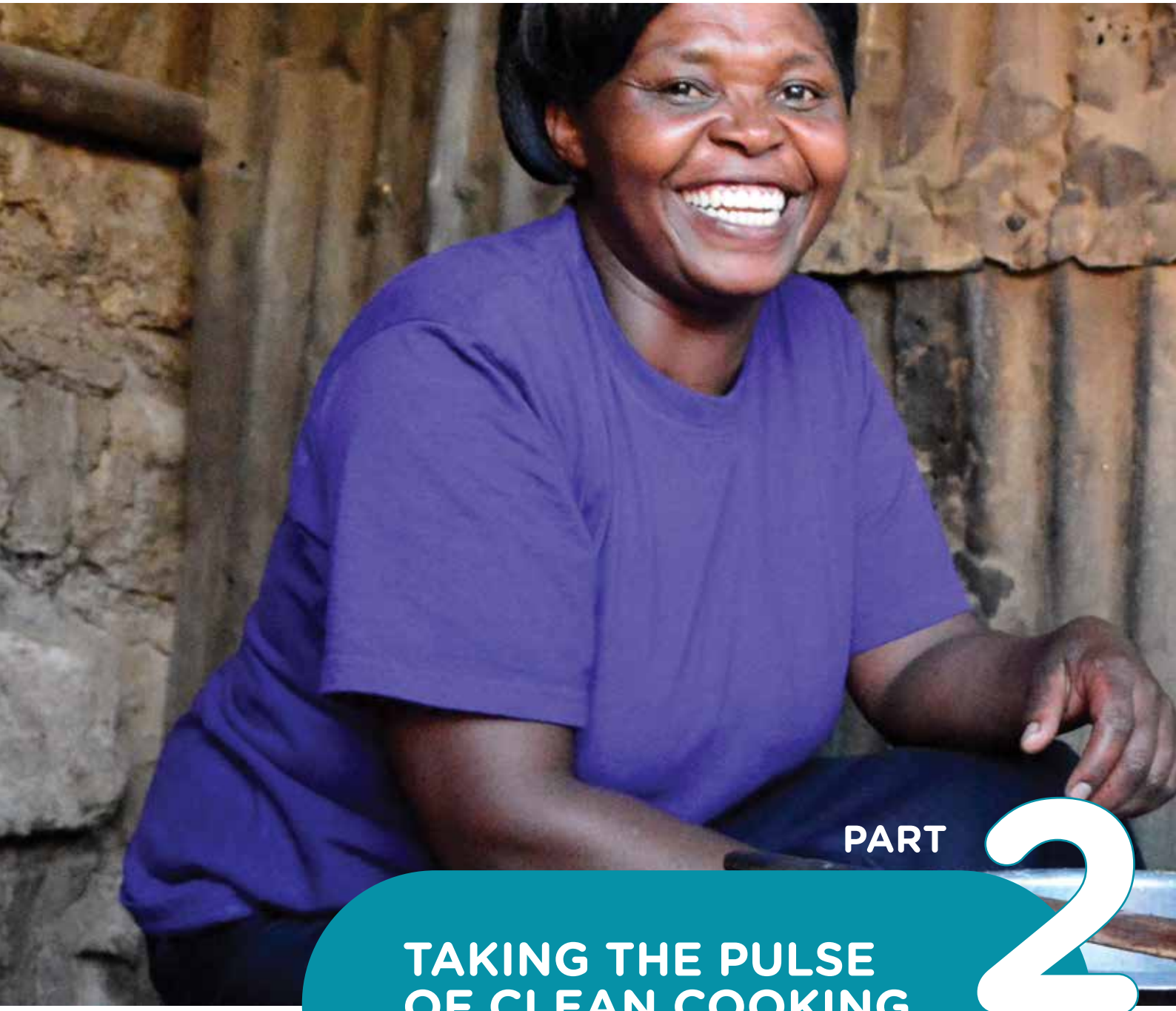


fordability, product availability, key policy initiatives impacting the off-grid sector, access to finance analysis for both companies and consumers, and a map of planned and existing electrification. Given the significance of this constraint, Uganda is already seeing increasing funding from development agencies to help businesses improve investment readiness and build up market data.

Second, the absence of quality standards is enabling low-quality products to flood the market and undermine consumer confidence in solar. Uganda has an opportunity to address quality assurance issues by adopting and enforcing the IEC/Lighting Global standards for Pico PV and stand-alone solar that set quality, durability, and truth-in-advertising requirements to protect consumers across different technologies. In addition to adopting national standards, the Government of Uganda can apply tariffs to non-quality verified products to improve affordability of quality products and lead consumer awareness campaigns to raise the visibility of quality brands with consumers. This would speed up sales and help reduce companies' customer acquisition costs.[169]

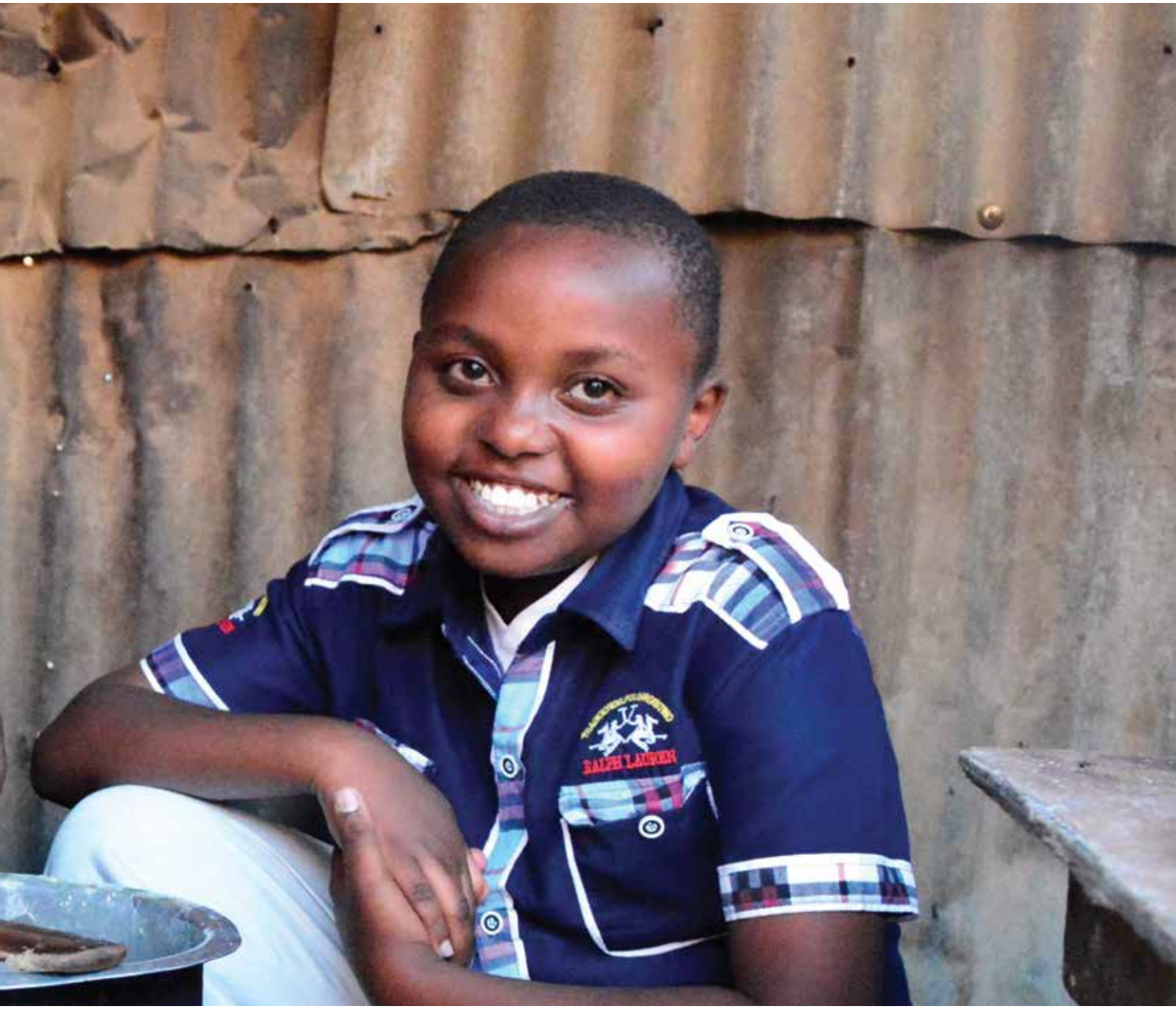
Finally, consumer affordability issues inhibit growth in connections. While PAYG solar companies have made great strides in improving affordability for many households, their price point is still not low enough to service the majority of rural Ugandans. For Uganda to reach 2030 access goals, affordability gap financing from government and development agencies will be an imperative. Agencies can direct funding to subsidize the cost of Tier 1 energy access for consumers with limited ability to pay, but this type of effort will take a great deal of planning and coordination among government, development partners, and the private sector to be effective.

[169] Uganda Off-grid Energy Market Accelerator. 2018. "Mapping the Ugandan off-grid energy market".



PART 2

TAKING THE PULSE OF CLEAN COOKING IN UGANDA



INTRODUCTION

Government Initiatives

The Government of Uganda through its 2007 Renewable Energy Policy set out to "increase access to energy in Uganda", including initiatives to significantly increase ICS adoption and incentivize consumers to switch to modern fuels, by setting a target of reaching approximately 4.3 million households by 2017 with "clean and efficient" cookstoves. The Uganda National Alliance for Clean Cookstoves (UNACC), a nonprofit national coordinating partner and implementation agency, works to create an enabling environment for equitable universal access to clean cooking solutions in Uganda. Established in 2014, UNACC facilitates increased innovation in design, testing, production, marketing, and use of clean cookstoves and fuels; government policies and increasing public awareness; downstream and upstream access to

finance; and producer and distributor technical capacity.[170] Through the Uganda National Bureau of Standards and the Ministry of Energy and Minerals Development, the government has been working with the UN Foundation's Clean Cooking Alliance to improve consumer awareness and stove quality through a standards and labeling process.[171] As of 2017, Uganda scored a 63 (out of 100) on the robustness of its clean cooking policy framework, according to a 2018 Regulatory Indicators for Sustainable Energy (RISE) report.[172] While the existence of a national cooking plan and improved availability of data are highlighted as strengths of the clean cooking sector in the country, lack of incentives and standards were identified as weaknesses.

CURRENT SECTOR ECOSYSTEM

Defining Clean Cooking

Taking the Pulse uses the MTF[173] to establish the minimum definition of "improved cooking" that counts toward the SDG7 goal of universal access. The MTF measures household access to cooking based on indoor air quality, cookstove efficiency, convenience, and safety, affordability, quality and availability of the primary fuel.

Taking the Pulse has two main ways in which it defines access to improved cooking solutions. The first, which is the primary focus of the report, centers on moving households away from traditional cooking solutions (typically using a three-stone fire or artisanal or semi-industrial cookstove) all of which do little to improve cooking efficiency and/or reduce emissions. As such, the report models out the cost of what it would take for these households to adopt improved "industrial" cookstoves, which typically entail centralized, large-scale production that uses quality components, manufactures with precision tools and employs considerable levels of automation. The focus is typically on rocket stoves, which have an insulated, L-shaped combustion chamber that improves combustion efficiency and reduces emissions. However, it is important to note that use of these stoves necessitates the continued use of either wood or charcoal as a fuel source. *Taking the Pulse* defines the minimum level of improved cooking access as ICS that meet International Workshop Agreement (IWA) minimum standards on fuel efficiency and emissions.

Related to clean fuels, the report focuses on three primary fuels considered to have significant potential. These are a sub-set of cooking solutions that deliver high performance in terms of reducing household air pollution—often (although not always) regardless of the type of cookstove used: biogas, LPG, electricity, ethanol[174], natural gas, and solar cookers, collectively called "BLEENS".[175] Given that *Taking the Pulse* only focuses on biogas, LPG, and ethanol, it adopts the term "clean fuels" in discussing them. The report forecasts the expected uptake of clean fuels over time, but does not cost out the financing that would be required to achieve these forecasts. This is because it was not in the scope of this report given the complexity surrounding the costing of delivering clean fuels for cooking.[176]

Clean Cooking in Uganda

Ninety-five percent of all Ugandan households rely on charcoal, wood, or other forms of biomass for their household cooking needs.[177] Despite this, ICS penetration in the market is low. As of 2012, only 3.7 percent of households in Eastern Uganda owned an ICS, compared to 8.7 percent in central Uganda.[178] A study conducted to measure customer behavior towards clean cooking found that the practice of stove stack-

[170] GVEP International. 2012. "Global Alliance for Clean Cookstoves: Uganda Market Assessment – Intervention Options."
[171] Ibid.
[172] The RISE scores highlight a country's policies and regulations in the energy sector organized by four pillars: energy access, energy efficiency, renewable energy and clean cooking. The scores are out of 100 and a lower score indicates poor performance whereas a high score indicates good performance.
[173] Bhatia, M. & Angelou, N., 2015. Beyond Connections – Energy Access Redefined, Washington: Energy Sector Management Assistance Program.
[174] As there is no active ethanol market for cooking in Uganda, it is not discussed in this chapter.
[175] Bhatia, M. & Angelou, N., 2015. Beyond Connections – Energy Access Redefined, Washington: Energy Sector Management Assistance Program.
[176] In addition to the financing needs for distribution and/or installation of the cooking hardware, scaling LPG and ethanol uptake requires the build-out of large-scale distribution infrastructure, particularly related to shipping, storage, and processing of fuels.
[177] Uganda Bureau of Statistics. 2017. "The Uganda National Household Survey 2016/17".
[178] GVEP International. 2012. "Global Alliance for Clean Cookstoves: Uganda Market Assessment – Intervention Options.".

ing[179] was commonplace in Uganda,[180] as it is throughout the African continent. The primary types of stoves available in the market are fixed 'rocket' stoves, mainly promoted by NGOs and installed by local artisans, a 6-brick stove, and several portable versions such as the improved ceramic, metal-clad stove. Many producers are centralized in Kampala, where the demand is likely to be higher for their product, and over 90 percent of urban households still cook with wood or charcoal. Most produce under 100 stoves per month and make local, portable models with varying levels of quality.[181] Many are struggling to get the necessary finance and marketing expertise to scale up and enter new, more disparate markets.

Internationally, a number of companies—such as Eco-Zoom, Burn Manufacturing, and Envirofit—are producing high-quality industrial stoves through scalable and centralized industrial production. They achieve this by sourcing quality components, manufacturing with precision tools, and employing considerable levels of automation in their processes. Their focus is typically on rocket stoves, which have an insulated, L-shaped combustion chamber that improves combustion efficiency and reduces emissions. The resulting stoves are considerably higher quality than what can typically be produced in local markets, and generally, achieve Tier 2 or higher on efficiency and Tier 1 or higher on emissions.[182] While these companies continue to improve their product designs and manufacturing processes, they have avoided investing heavily in the in-country retail distribution networks that are critical to driving sales and achieving the volumes required to meet SDG7. One main reason for this is the high cost of distribution to rural centers for those companies which are mostly located in Kampala. As such, they have rather limited market share and have often relied on substantial concessional financing in order to reach consumers.[183]

LPG Market

Despite the fact that less than 1 percent of households utilize LPG for cooking, there is a competitive market among LPG suppliers in Uganda, with over 10 medium-to-large sized companies operating. Shell Gas or Total are available in almost every region, mainly at petrol stations, along with a number of other local and regional players.[184] From a supply standpoint, Uganda has recently taken steps to begin exploiting its domestic oil resources.[185] Although much of this oil is expected to be refined into transportation fuels, it is anticipated that as much as 60,000 tons of LPG per year could be produced by 2023,[186] enough to meet the cooking needs of between 2.2 million and 2.6 million households (or 21-25 percent of all households in 2023).[187] [188] However, the country's planned oil refinery has been pushed off by two years until 2022, according to recent reports.[189]

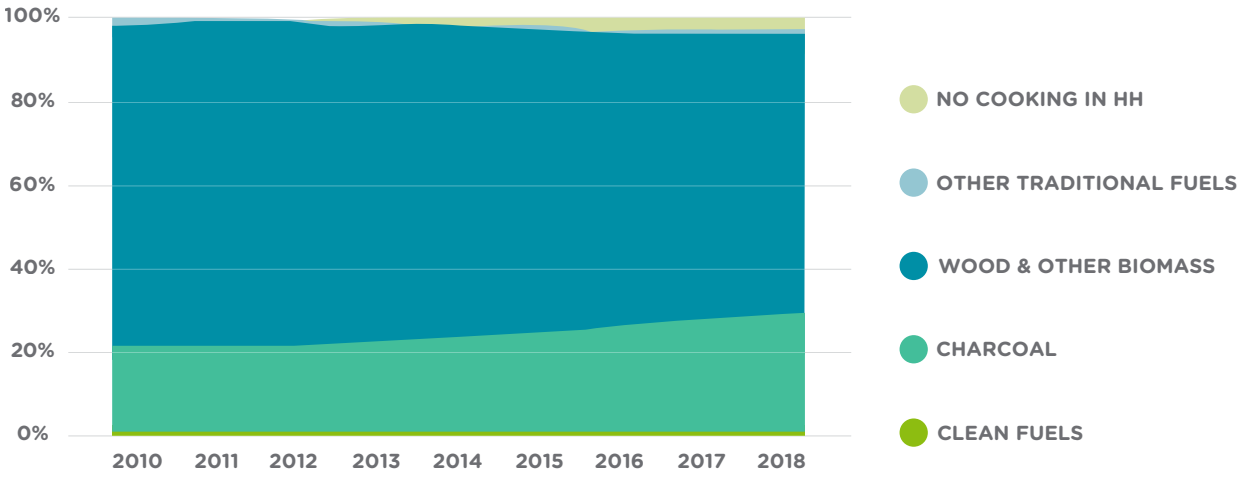
Currently, the larger LPG players are focusing mainly on the urban market and their existing distribution infrastructure (e.g., petrol stations), and not moving into rural and last-mile markets. The lack of economies of scale and comparatively lower income levels, in addition to the distribution costs and challenges, mean that the rural and remote market is broadly associated with higher risks and lower returns. To develop the market, efforts are being made to make the upfront costs of LPG more affordable and accessible in Uganda, notably on two fronts: i) by making smaller canisters available (e.g. 3-kilogram (kg) versus the standard 6kg or 12kg canisters); and ii) by piloting new pay-as-you-cook service delivery models. Anecdotal evidence from Uganda suggests that despite somewhat

[179] Stove stacking is the practice of using more than one stove or fire to carry out the cooking and other stove related tasks. It can be simultaneous use or at a separate time.
[180] The World Bank. 2015. "Willingness to Pay and Consumer Acceptance Assessment For Clean Cooking in Uganda".
[181] GVEP International. 2012. "Global Alliance for Clean Cookstoves: Uganda Market Assessment – Intervention Options".
[182] GVEP International. 2012. "Global Alliance for Clean Cookstoves: Uganda Market Assessment – Sector Mapping."
[183] Ibid.

[184] Other local and regional players include OilLybia, Lake Gas, Kobil, Wana Energy Solutions Gas (WesGas), Oryx Energies, Mpishi, Hashi, Mogas, Hass Gas, PET Gas, and RAMCO Gas.
[185] Export.gov. 2019. Uganda – Oil and Gas. 03 30. https://www.export.gov/article?id=Uganda-Oil-and-Gas
[186] Ssekika, Edward. 2016. Uganda targets 60,000 tonnes of LPG annually. 02 24. https://observer.ug/business/38-business/42758-uganda-targets-60-000-tonnes-of-lpg-annually.
[187] This is based on field research in Sub-Saharan Africa indicating annual household LPG consumption of between 22.6 and 27.3 kg.
[188] Economic Consulting Associates, The Global LPG Partnership. 2017. "Econometric analysis of potential LPG Household cooking market in Ghana".
[189] Mangula, George. 2018. Eagle . 09 20. https://eagle.co.ug/2018/09/20/plans-to-build-ugandas-oil-refinery-pushed-to-2022.html

Figure 2.1

Uganda's Historical Cooking Fuel Breakdown



higher per-unit (or per kg) costs, the 3kg cannisters are the highest in demand due to their lower initial cost.[190] However, reducing upfront costs is just one part of the problem. The bigger long-term barrier to higher LPG penetration remains its cost relative to alternatives. Even as households begin using LPG for small meals or elements of their meals, they are likely to continue using charcoal to limit their cooking fuel expenditure. Countries that have successfully boosted LPG uptake have done so by: i) subsidizing the cost of the fuel; and/or ii) successfully promoting economic growth and thus household purchasing power.

Biogas Market

SNV Netherlands Development Organisation (SNV) has been a major supporter of the biogas sector's growth in Uganda since 2009. At that time, a pre-feasibility analysis was conducted and found a market potential of 250,000 to 300,000 household biogas installations countrywide (equivalent to some 2 percent of the 2030 total). As of 2019, SNV estimates that there are approximately 10,000 biodigesters operating in Uganda. Several companies have been supported via Biogas Solutions Uganda (BSU), a company launched with the aim of providing training, management support, awareness raising activities, and other forms of technical assistance. The construction of the biodigesters is done by local companies, many of which are trained by BSU. It is estimated that there are approximately 20 biodigester construction companies in Uganda, over half of which work with the BSU.[191]

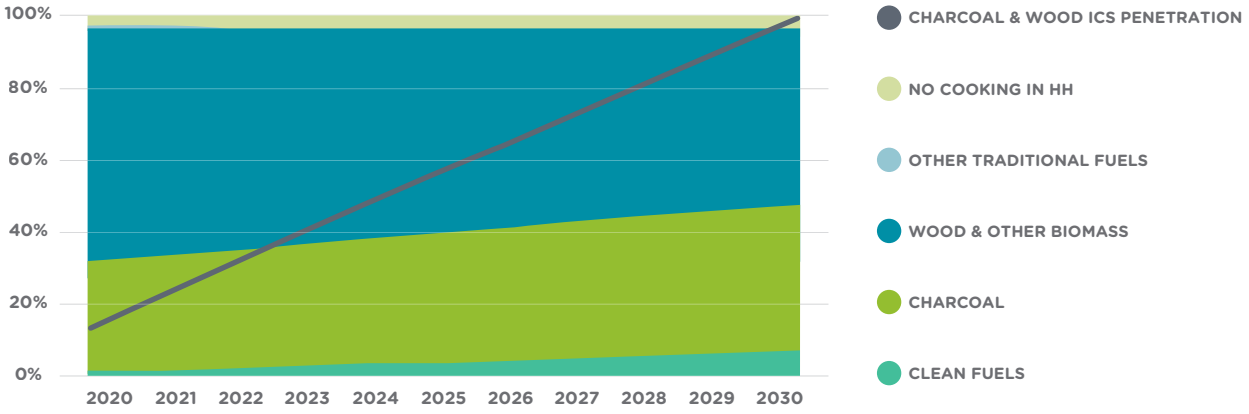
The biogas market is currently focused primarily on providing biodigesters to households with livestock, typically either cows or pigs. As a result, the customer base is predominantly rural. There are however some peri-urban biogas customers, typically households with two to three cows kept in a shed on small- to medium-sized plots. Given the high cost of borrowing from financial institutions in Uganda, much of the biogas market is based on cash sales. In an effort to bring down upfront costs, a form of results-based financing was available during an earlier phase of the SNV and Hivos' biogas initiative that provided up to 45 percent of the construction cost, a share that was reduced gradually down to 25 percent. There is also growing interest in Uganda from the institutional sector, particularly from institutions such as schools. For such larger installations with higher cooking demand, the economics of using food

[190] Based on in-country interviews.

[191] Based on in-country interviews.

Figure 2.2

Forecast Cooking Fuel Breakdown



waste rather than that from livestock can be quite attractive, particularly when compared to charcoal.

Another company trying to build a more commercially viable biogas business in Uganda is Green Heat International. The company has been successful in building larger projects, specifically for the institutional market segment. Awareness of the potential role of biogas is growing as familiarity with the technology grows, and as concerns around the depletion of forest resources and rising charcoal prices persist.

CURRENT STATE OF CLEAN COOKING ACCESS

By the end of 2018, just over 1 percent of Ugandan households were using clean fuel as their primary cooking energy source, typically LPG (0.7 percent) or electricity (0.5 percent). Approximately 95 percent of households still cook with wood or charcoal, as shown in Figure 2.1.

Based on outputs from the model developed as part of this report (see methodology chapter for details), at the end of 2018, only about 1 percent of households in Uganda were estimated to be cooking with charcoal or wood using a high-quality industrial ICS that meets international minimum standards on fuel efficiency and emissions. Fewer than 1 percent of households now cook with kerosene (the only other traditional fuel commonly used), though this share has dropped considerably over the years and is likely to continue to do so as better alternatives become available. The remaining households use a three-stone fire or an artisanal or semi-industrial cookstove that does not improve cooking efficiency and/or emissions enough to be deemed an ICS, with the exception of the 3.2 percent of households that do not cook at home, according to survey data.[192]

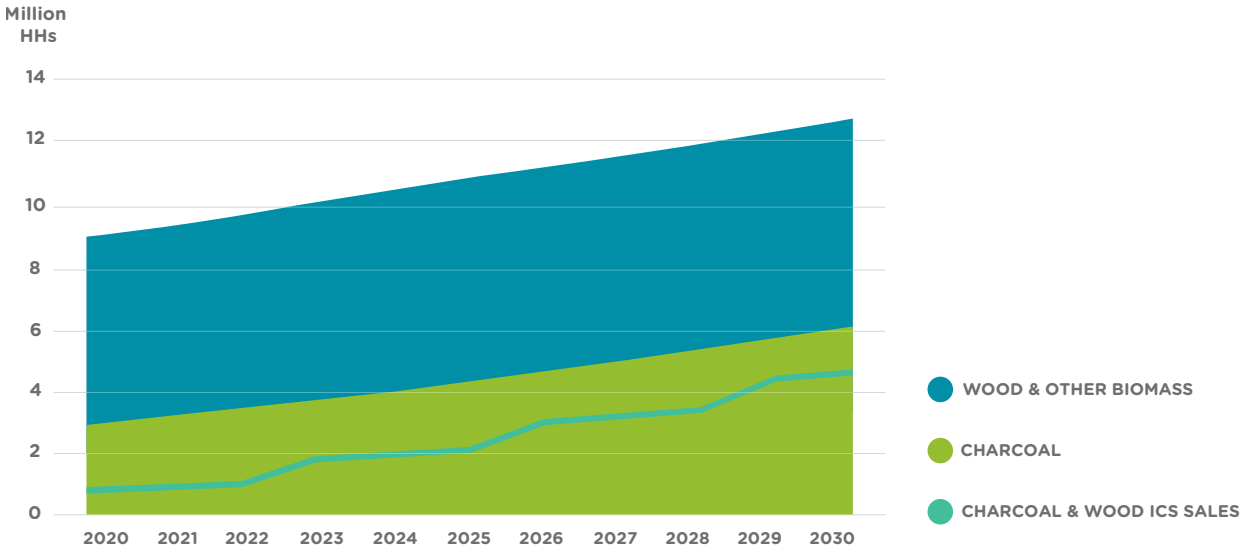
Closing the Clean Cooking Access Gaps in Uganda

Figure 2.2 illustrates the scope of the clean cooking challenge in Uganda. The model assumes that 3.2 percent of households will continue not to cook in the household. It also projects that households using clean fuels will increase to a total of 7.5 percent (just over 1 million households). This represents a seven-fold increase over the current situation. The remaining 12.2 million households (88.7 percent of the total) are expected to continue to cook with wood and charcoal. The challenge will be to shift all of these households away from traditional cooking technologies (namely three-stone fires and lower-quality semi-industrial stoves) and onto high-quality industrial improved wood and charcoal stoves, as illustrated by the blue line representing required penetration of ICS over the period 2020-2030.

[192] Uganda Bureau of Statistics. 2017. "Uganda National Household Survey 2016/17".

Figure 2.3

Forecast Traditional Cooking Fuel Use and ICS Sales



Wood and Charcoal ICS Contributions Toward Achieving SDG7

The analysis now focuses on the forward-looking projections through 2030 and, in particular, modeling what it would take for Uganda to achieve universal clean cooking access by that time. The figure above illustrates the model outputs through to 2030. The key assumptions that underpin the model are as follows:

- The minimum definition of access is high-quality industrial ICS that meets international minimum standards on fuel efficiency and emissions (namely Level 1 or higher in the MTF's multi-level matrix for access to cooking solutions).
- The assumed retail price is USD 25 for an industrial wood stove and USD 36 for an industrial charcoal stove.
- Population growth is factored in at 2.9 percent per annum, per Uganda Bureau of Statistics estimate.
- Stoves are assumed to be replaced at three-year intervals.

Based on these assumptions, the forecast model projects that 15 million industrial wood stoves and 11.9 million industrial charcoal stoves will be sold during the period 2020-2030.

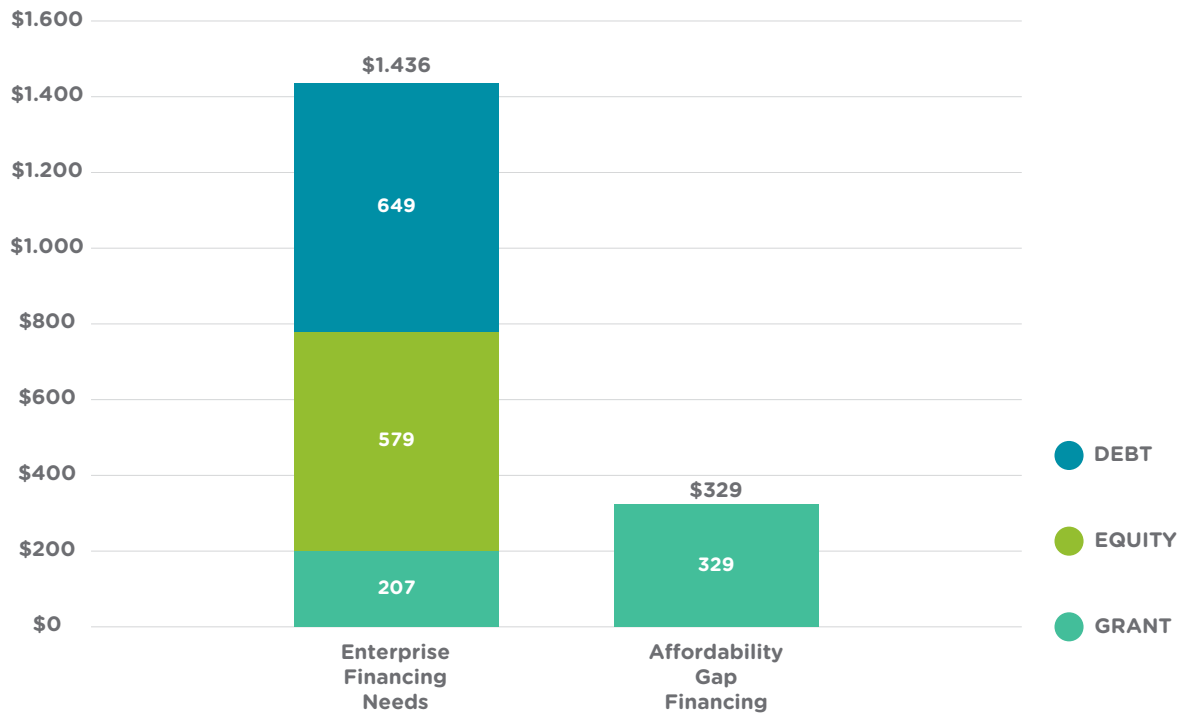
Financing Needs of ICS (Charcoal and Wood)

To achieve the aforementioned targets in Figure 2.4 above, ICS have a cumulative financing need of USD 193 million, averaging USD 17.5 million per year, for enterprises alone, as seen in Figure 2.5.

Grants to enterprises represent 17 percent of the capital mix (USD 32.6 million) used to lower costs associated with proving out the business model and displacing additional equity financing needs. Another 32 percent of financing needs will be in the form of equity investments (USD 61.7 million) in businesses that turn profitable at the scale-up phase. Debt financing accounts for 44 percent of the capital mix (USD 98.4 million). This is inventory finance to enable retailers to purchase stock of stoves and then repay those loans once sales are completed. The model assumes that all stoves are sold on a cash-sale basis.

Figure 2.4

Total ICS Finance Needs (Million USD)



Consumer Affordability

According to the forecast scenario, Uganda will require a cumulative USD 344 million, an average of USD 31.3 million per year, in affordability gap financing to help the 81 percent of households that cook with wood but cannot afford ICS. The model[193] assumes that households save an amount equivalent to two percent of total monthly household consumption for a period of three months in order to buy an ICS. The model also assumes that if a household can afford to buy charcoal, then there is no affordability gap in buying a stove. Since charcoal is expensive (nearing USD 0.50 per kilogram) relative to firewood and the charcoal stove enhances efficiency, reducing charcoal expenditures by purchasing the improved stove should be a selling proposition and compelling to consumers so long as they understand this benefit. Interviewees noted that consumers struggled to differentiate between high- and low-quality stoves and therefore would not justify paying a higher market price.[194] Therefore, priority must be given to efforts to understand what the customer wants in a cooking solution and in public awareness campaigns that provide information on the long-term benefits of adapting to cleaner cooking options.

With respect to clean fuels, the relatively high upfront cost of an initial LPG kit (including the cost of the cylinder, burner, hose, and regulator) remains one of the main barriers to scale-up in Uganda. However, the rising cost of charcoal has helped drive demand for LPG: a 50kg sack of charcoal currently sells for UGX 80,000 (USD 21.28), up from UGX 45,000 (USD 12.19) or UGX 50,000 (USD 13.55) two to three years ago. As a result, the economics of LPG are becoming increasingly attractive. That said, the refill cost of LPG would still need to drop by more than half before it becomes more affordable per useful unit of energy than charcoal. Table 2.1 below provides an overview of the current price range for LPG kit, broken down by component.

[193] The methodology chapter provides more details on how affordability was modeled.

[194] Based on in-country interviews.

Table 2.1[195]

LPG Price Range by Component (USD)

Cannister Size	Deposit Fee USD	Refill Cost USD	Grill in USD	Burner in USD	Hose in USD	Regulator in USD	Total LPG Start-up Cost
6kg	18.60 – 33.22	15.65	6.90	7.44	N/A	N/A	**48.59 – 63.21**
13kg	21.25 – 36.94	31.30	6.90	7.44	3.99	7.18 – 10.64	**78.06 – 97.21**
15kg	33.40 – 39.85	37.66	6.90	7.44	3.99	11.97 – 14.63	**101.36 – 101.47**

In a sign of the competitive nature of the country's current LPG market, one company has recently cut its upfront deposit *in half* to boost uptake.[196] Despite the high upfront costs, there are other peripheral factors contributing to fuel switching in Uganda. For instance, some landlords in Kampala are beginning to prohibit the usage of charcoal in their buildings. This leaves households with the option of either LPG, electricity or other non-charcoal alternatives. Much as with the LPG market, affordability remains the single biggest challenge to scaling up the biogas market. Current construction costs range between UGX 2.0-2.6 million (USD 530-700) per digester for a standard household, meaning that even with financing, such systems are out of reach to all but the wealthiest of households.[197]

An Energizing Development[198] program is currently providing results-based financing (RBF) to address the affordability challenge. The RBF is structured in two forms: The Credit Sanctioning Incentive, which is provided to financial institutions in the country to boost credit availability to the sector, and a Quality Plant Incentive, which is provided to so-called "Biogas Construction Enterprises" to encourage better after-sales services.[199]

KEY CHALLENGES AND OPPORTUNITIES: UGANDA'S SDG7 COOKING TARGETS

As outlined above, Uganda's clean cooking sector shows promise, but also requires a significant boost in order to achieve the SDG7 target. On the demand side, ICS operators struggle to sell to rural customers, where traditional cooking methods are preferred, and incomes are lower. Solutions include increased understanding of what drives household – and primarily women's – adoption of new cooking solutions and public awareness campaigns emphasizing savings in both time and money to influence household decision making around purchase and usage. On the supply side, operators must deliver cookstoves where the need is, in both urban and hard-to-reach rural areas. They will need to create supply chain and distribution channels along with the retail customer acquisition side of the business.

Regarding LPG, the Government of Uganda has recently committed to improving awareness of LPG fuels, as well as developing regulations to harmonize distribution, transportation, storage, and marketing.[200] The Uganda National Bureau of Standards has also been actively involved in developing safety standards for cylinders, and other key LPG system components. As a result, safety is becoming less of a concern among customers. De-

[195] Ibid.
[196] Ibid.
[197] The World Bank. 2018. The World Bank Data https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS?locations=UG
[198] Energizing Development. "Biogas Business Boost Benefitting Farmers (4B-F)" https://endev.info/content/Biogas_Business_Boost_Benefitting_Farmers_(4B-F)
[199] Ibid.
[200] Ssekika, Edward. 2016. Uganda targets 60,000 tonnes of LPG annually. 02 24. https://observer.ug/business/38-business/42758-uganda-targets-60-000-tonnes-of-lpg-annually

spite persistent concerns over affordability, the issue of introducing subsidies for LPG remains controversial, as many LPG players that would ultimately benefit are large, established companies. As a sign of the government's reluctance to give the LPG sector a free pass, it re-introduced a value-added tax on LPG in 2015, and LPG prices continue to remain unusually high at ~USD 2.50 per kg compared to neighboring countries such as Kenya where prices are closer to USD 1.50 per kg.[201]

With regard to biogas, the government has provided some credit to the SACCOs (local cooperative funds). It has also provided tax rebates for the importation of bio-digester components. There are also examples of RBF being made available by EnDev to support the construction and maintenance of biogas systems in the country. The national government is even currently in the process of re-drafting its renewable energy policy. This presents an opportunity to provide more strategic clarity on the future evolution of the clean cooking sector, particularly with regard to biogas and LPG, both of which benefit from relatively strong fundamentals.

[201] Based on in-country interviews.

The affordability challenge looms large for the improved cooking sector in Uganda. For ICS, fuel is less of a concern since most households collect wood themselves, though the cost of purchasing the stove remains a major obstacle. For clean fuel-based technologies, the affordability barriers to uptake are twofold. In addition to the upfront cost of the products themselves, the recurrent costs associated with fuel purchase constitute major hurdles for consumers. One solution is to further experiment with the PAYG model and mainstream its use in the clean cooking sector. Another way forward would be to eliminate the tax on cookstoves and their components. Stakeholders could also capitalize on the rapidly rising prices of charcoal which has already prompted some households to start using alternative fuels.[202] Helping consumers understand the economic benefits of adopting improved cooking solutions, in addition to their health, safety, and environmental benefits, could help accelerate adoption.

[202] The East African. 2018. The East African. 04 06. https://www.theeastafrican.co.ke/business/Uganda-bans-charcoal-exports-to-Kenya/2560-4375368-y8j06sz/index.html

REPORT METHODOLOGY

INTRODUCTION

This chapter provides a detailed description of the 2019 edition of the quantitative methodology for *Taking the Pulse*. The report's quantitative model was developed in Excel, and the purpose of this chapter is to provide a detailed description of its structure, assumptions, and outputs. The model identifies the associated volume and blend of financing required to achieve access to improved electrification and cooking in each of these countries. The outputs quantify the size of the energy access challenge in each of the three focus countries and, as such, they represent some of the most critical takeaways from the report. The quantitative methodology was complemented by comprehensive qualitative research for each of the focus countries. This consisted of extensive desk research to gather reports and analysis regarding each country and its electrification and cooking sectors. In addition, extensive key informant interviews were held in each country, targeting the private sector, development and other financing partners, and government officials. These interviews served two main purposes: to add additional flavor and context to the outputs derived from the quantitative analysis, and to ground-truth the assumptions used to populate the quantitative model for each country. They were conducted on background so that interviewees could speak with as much candor as possible; as such, insights from those interviews are not attributed to specific individuals or organizations.

Country Demographics

The demographic situations of each of the focus countries are dynamic; in modeling future scenarios through to 2030, it is essential that population growth be factored into the analysis. In addition, changes in settlement patterns are also important, particularly as urban areas become more densely populated and/or new urban centers emerge. The following are the core demographic elements that were included in the model, per country:

- In Uganda, the Uganda Bureau of Statistics (UBOS) is the source for all historical demographic data and certain projections. The model includes UBOS projections of population increases from 39.1 million in 2018 to 55.4 million in 2030. Using historical trends, the model projects that the future average household size will be reduced by 0.8 percent per year going forward (reaching 4.1 PAX/hh in 2030). In addition, rural population will decrease by 1.5 percentage points per year going forward, as per historical trend (reaching a 55:45 rural-urban split in 2030).

- In Madagascar, the *Institut National de la Statistique de Madagascar* is the source for all historical demographic data, while the United Nations Department of Economic and Social Affairs (UN DESA) is the source for population projections. UN DESA's projections show population increasing from 26.3 million in 2018 to 35.6 million in 2030. Using historical trends, the model projects that the average household size will be reduced by 0.8 percent per year going forward (reaching 3.8 PAX/hh in 2030). Rural population will decrease by 1.7 percentage points per year going forward, per historical trends (reaching a 54:46 rural-urban split in 2030).

- For the Philippines, the Philippines Statistical Authority is the source for all historical demographic data, while UN DESA is the source for population projections. On this basis, population is expected to increase from 108.1 million in 2018 to 125.4 million in 2030. As of 2015, 51 percent of the population was already living in urban areas, and this is forecast to increase by 0.5 percentage points per year going forward (reaching a 41:59 rural-urban split in 2030).

Defining Energy Access

Taking the Pulse uses the globally accepted Multi-Tier Framework (MTF) to define energy access.[203] The MTF establishes five "tiers" of household electrification that are based on capacity, duration, reliability, quality, affordability, legality

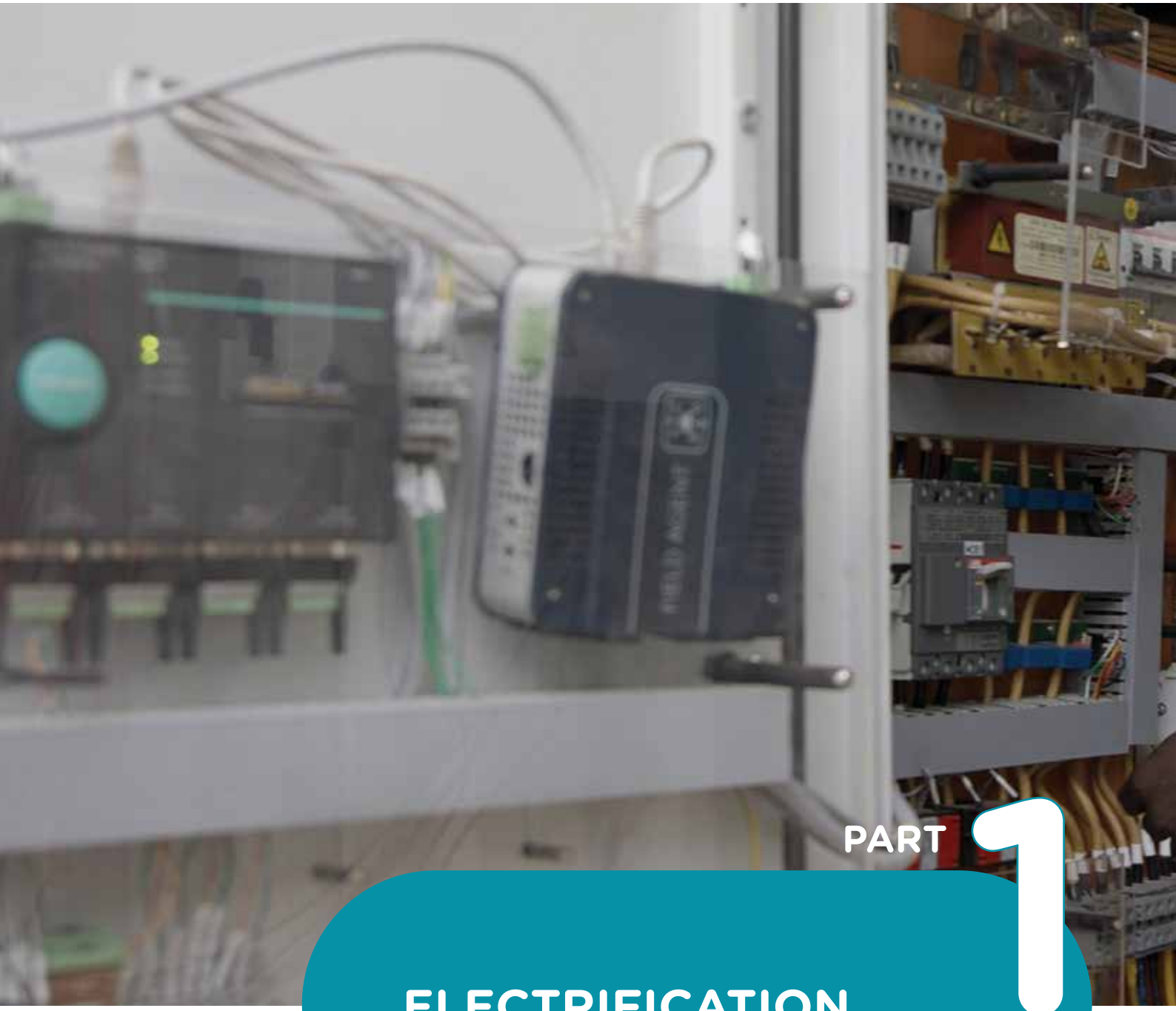
[203] Bhatia, M. & Angelou, N., 2015. Beyond Connections – Energy Access Redefined, Washington: Energy Sector Management Assistance Program.

and health and safety impacts. The MTF is often referred to as the "energy access ladder", whereby households may graduate from one level of service to another depending on what sources of electrification they have access to, what they need, and what they can afford. Tier 0 represents a household that uses stopgap measures to meet its basic electrification needs, often using fuel-based lighting (e.g. kerosene lanterns, candles) or battery-operated flashlights for lighting needs, and relying on third-parties to power their devices (most notably cell phones). Tier 1 and 2 services are most often delivered by stand-alone solar solutions, most frequently in the form of single or multi-light point systems that derive their power via solar photovoltaic panels. Tiers 3 through 5 are most typically met by connections to a centralized or localized grid (i.e a "mini-grid"). However, it is important to note that having a grid connection can also qualify as Tier 1 if the MTF duration criteria are not met.

Tier 1 stipulates either a certain level of installed capacity (in terms of power and capacity) or a level of service, which is expressed in lumen hours. Lumen hours is the unit of measure for the brightness of light. ***Taking the Pulse* establishes the minimum level of electricity service based on the MTF service metric in lumens. It stipulates that fractional Tier 1 access counts toward the Sustainable Development Goal 7 (SDG7).** This means a single light point solar lantern that has the functionality to charge phones (one of the MTF service criteria) counts toward access goals. However, since the lumen output of most solar lanterns is less than the MTF Tier 1 requirement of 1,000 lumen hours per day, this contribution is "fractional" given that the lantern does not deliver full service to all members of a typical household. *Taking the Pulse* assumes in its modeling that a lantern delivers sufficient lumen output to provide access to 60 percent of household members—in line with the capabilities of the typical modern lantern. As such, households would need to have two lanterns in order to achieve full Tier 1 access. This is a critical methodological point, as lanterns are often more affordable than multi-light point systems. As such, this impacts the overall financing needs required to achieve universal access in a given market.

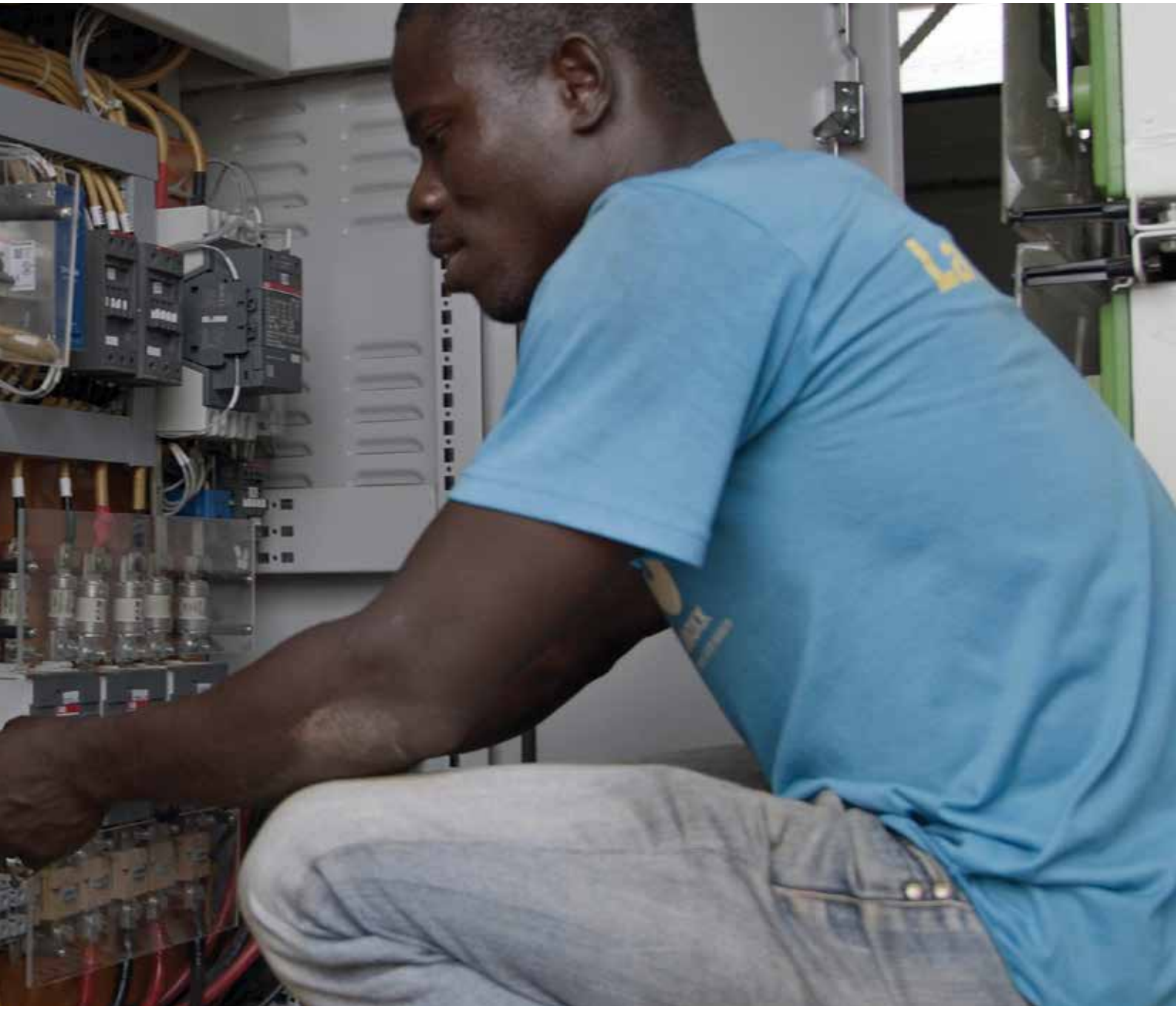
Taking the Pulse establishes that mini-grids will deliver a minimum of Tier 3 electricity services. The model therefore includes assumptions around the cost or delivering this level of service. This is a minimum and does not preclude the development of mini-grids capable of delivering Tier 4 or 5 access. However, if either of these levels of service were to be considered the minimum, the overall costs of delivering energy access via mini-grid solutions would increase considerably.

The remainder of this chapter is broken into three sections: electrification, improved cooking, and consumer affordability.



PART 1

ELECTRIFICATION



The model assumes that energy access will be delivered via three primary modalities:

1. The electricity grid is the interconnected network for delivering electricity from producers to consumers. This includes power generation, transmission lines, and distribution lines to connect individual customers.
2. A mini-grid is small-scale electricity distribution network that includes generation and distribution to a group of customers in a limited geographic area. The number of customers connected to these installations varies widely and typically depends on household settlement patterns and local enterprise presence and power needs in a given locality. Mini-grids are typically built when

there is a sufficient power load demand, either created by a critical mass of household demand and/or an anchor customer such as an industrial facility or installation that has substantial power needs.

3. Finally, stand-alone solar systems generate power via photovoltaic panels, store power via batteries (increasingly using lithium-ion battery chemistries), and deliver lighting and power for small devices and appliances. Particularly when coupled with the pay-as-you-go (PAYG) business model, they offer a cost-effective mode of supplying power for lighting and appliances to remote off-grid households. Importantly, this category also includes solar lanterns, which use the same basic components referenced above, but which are bundled into a single unit with a single light point.

UNDERSTANDING THE SCENARIOS

Grid Electrification

For grid electrification, the model is built around three distinct scenarios for each country:

- **Historical:** this looks back at the period 2010-2018, and compiles year-on-year information about net new grid connections over time.

- **Business as usual (BAU):** this is based on the historical trends that are developed in the first scenario. Using these trends, the average year-on-year electrification growth rate is projected forward. The model also builds in the demographic assumptions that are described above to account for the impacts of population growth on energy access targets over time.

- **Forecast:** This builds on the BAU scenario but also factors in government targets, policies, and new sector development programs. The forecast assumes that financing is available to achieve the target scenarios (through a government's own funds, provided by a development partner, or another source). This scenario also gives serious consideration to, and tests, the realism of targets. e.g., if a government's stated ambition for grid expansion necessitates an annual increase in new connections that vastly exceeds historical trends, this is discounted in the forecast scenario to ensure the projection is realistic. Such adjustments to official forecasts have only been conducted when supported by information gathered during the stakeholder interview process.

As referenced above, deriving the forecast scenarios for grid expansion in each country necessitates a reconciliation of historical trends with future ambitions. In Uganda, the government is targeting 6.5 million new grid connections between 2020 and 2030 (nearly 600,000 per year), while historical trends show an average of 120,000 new connections per year over the past eight years. As such, the report's forecast scenario projects 3.7 million new connections over the latter time period (an average of just under 340,000 new connections per year), which was deemed sufficiently ambitious yet realizable in light of previous experience in Uganda. In Madagascar, the government does not have an explicit grid connection target, though it is targeting 50 percent electricity access via all technologies by the end of 2023. Historical trends show that new connections averaged 17,000 per annum (including informal connections). In contrast, the forecast scenario more than triples this historical performance and projects an average of over 50,000 new grid connections per year. In the Philippines, the government does not have an explicit grid connection target, though it is targeting 100 percent electricity access via all technologies by the end of 2025. Historical trends show an average annual connection rate of 570,000 new connections over the past eight years, albeit with a marked slowdown to under 200,000 connections per year over the past three years. The forecast scenario projects 600,000 new connections per year between 2020 and 2030.

Mini-Grids

Mini-grids use a similar set of scenarios to those outlined above.

- The historical scenario gathers facts from various sources regarding connections via mini-grids.

- The BAU scenario utilizes the historical figures and projects these forward to 2030.

- The forecast scenario considers the two aforementioned scenarios but adjusts assumptions to a projection that best reflects the availability of suitable, cost-effective sites, and implementation capacity to develop and operate mini-grids in a given locality. In each case, these inputs and assumptions have been cross-checked with information from stakeholder interviews to arrive at realistic, market-tested assumptions.

The Uganda forecast scenario utilizes the government forecast for mini-grids from its national Off-Grid Strategy, which anticipates that 320 new mini-grids will be developed.[204] The *Taking the Pulse* model then optimistically assumes 200 households for the average number of household connections that will be derived from each of these grids. In the case of Madagascar, an equivalent government planning exercise has yet to be carried out. However, with

Table 1

Multi-Tier Matrix for Access to Household Electricity Supply[205]

ATTRIBUTES		TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Capacity	Power		At least 3 W	At least 50 W	At least 200 W	At least 800 W	At least 2 kW
	AND Daily capacity		At least 12 Wh	At least 200 Wh	At least 1 kWh	At least 3.4 kWh	At least 8.2 kWh
	Services		Lighting of 1,000 lmhr per day	Electrical lighting, air circulation, television, and phone charging are possible			
Duration	Hours per day		At least 4 hours		At least 8 hours	At least 16 hours	At least 23 hours
	Hours per evening					At least 4 hours	At least 4 hours
Reliability						At least 14 disruptions per week	At most 3 disruptions per week with a total duration of less than 2 hours
Quality						Voltage problems do not affect the use of desired appliances	
Affordability					Cost of a standard consumption package of 365 kWh per year is less than 5% of household income		
Legality						Bill is paid to the utility, pre-paid card seller, or authorized representative	
Health & Safety						Absence of past accidents and perception of high risk in the future	

[204] Catalyst Off-Grid Advisors was commissioned by NRECA and USAID to prepare the Uganda Off-Grid Strategy in 2017-2018.

[205] Bhatia, M. and Angelou, N. (2015). Beyond Connections: Energy Access Redefined. ESMAP Technical Report. Washington, DC: World Bank. Available at: https://openknowledge.worldbank.org/handle/10986/24368

relatively limited grid access growth expected in our forecast scenario, mini-grid opportunities remain more extensive, albeit tempered by policy and affordability constraints. In our forecast scenario, we anticipate the deployment of 530 new mini-grids in Madagascar, an increase in sites of roughly 350 percent relative to today. In the Philippines, mini-grids already provide electricity access to over 800,000 households, often through larger diesel-powered systems. In our forecast scenario, we project deployment of an additional 1,650 mini-grids serving a notable share of remaining unelectrified households.

Standard Mini-Grid Characteristics

The model assumes that each mini-grid is designed to deliver, on average, Tier 3 energy access. As explained earlier, the MTF seeks to understand electricity access not in binary on or off terms, but as a continuum of service levels that may be satisfied by a range of technologies. The MTF captures more robust granularity of electricity access including capacity, duration of supply, reliability, quality, affordability, legality, and safety.[206] Table 1 summarizes the MTF in more detail. **Tier 3 was deemed appropriate as the minimum level of service for the mini-grid modeling exercise,** given that the design characteristics of mini-grids capable of delivering Tier 4 or 5 levels of service would be prohibitively expensive and only justifiable in circumstances where a larger-scale industrial off-taker exists.

Table 2 below provides a detailed breakdown of the assumptions underpinning the four stages of growth used to characterize mini-grids (pilot; validation; scale-up; mature). This assumes a certain level of installed capacity, offtake, one-off construction costs, recurrent operating and maintenance costs, revenue needs, and capital needs per mini-grid site. Disaggregating the businesses into different stages of growth is a critical exercise in order to have a more nuanced understanding of the financing needs required to deliver energy access. As a business matures, so too does the blend and volume of capital it requires. As evidenced by the model extract below, the costs of delivering services via a mini-grid decrease with scale (see Prompt 1). Furthermore, more mature mini-grid developers rely less on grant capital as they scale, instead leveraging equity (and grants, which for financiers can substitute for equity) to borrow debt that will be used to pay off the assets over time (see Prompt 2 in Table 2). This financing structure is characteristic of infrastructure project finance, whereby a blend of capital is raised to pre-finance the assets, which is then paid off over time via cash flows generated by the assets.

Stand-Alone Solar for Households

As was the case with the grid and mini-grids, the model constructs three distinct scenarios for stand-alone solar, as follows:

1. **Historical:** this looks back at the period 2010-2018, and compiles information about off-grid solar connections over time. These figures are derived from Global Off-Grid Lighting Association sales data, and estimates of informal sales informed by various sources, including country market assessments, trade data, etc. This includes sales of Lighting Global quality-verified products and grey market sales of products that are not quality verified. The energy access rates factor in fractional access, whereby single light point lanterns deliver access to less than a full household. For modeling purposes, we assume lanterns provide access to 60 percent of a household.

2. **Business as usual (BAU):** using the historical figures, the average year-on-year stand-alone solar rate is projected forward. Since affordability considerations are factored in, the BAU scenarios do not necessarily assume that historical growth rates (when high) will be sustained.

3. **Forecast:** The model is structured in such a way that stand-alone solar is treated as the default access solution for households that do not directly benefit from grid extension or the installation or expansion of a mini-grid. In effect, stand-alone solar covers the remaining access deficit that is left once the grid and mini-grid forecast scenarios are combined. This is because the stand-alone solar model has demonstrated both its potential to scale

[206] Ibid.

Table 2

Mini-Grid Characterization Details

	Pilot	Validation	Scale-Up	Mature
Mini-Grids Deployed – EOP	1	6	25	100
Anchor Customers – per MG		2		
HH Customers – per MG		200		
Total HH Customers – EOP	200	1,200	5,000	20,000
MG Generation Capacity (kWp)		45		
Anchor Consumption – per Day (kWh)		75		
Upfront Cost – per Wp	$4.7	$3.8	$3.4	$2.9
Upfront Cost – per MG	209,250	171,225	153,900	130,500
of which CAPEX Costs – per MG	153,000	137,475	131,400	117,000
of which Soft Costs – per MG	56,250	33,750	22,500	13,500
Upfront Cost – per Cust.	$1,036	$848	$762	$646
Upfront Cost – Total **1**	$209,250	$856,125	$2,924,100	$9,787,500
Avg. Revenue – Anchors/m	$675	$675	$675	$675
Avg. Revenue – HH/m	$5.7	$5.7	$5.7	$7.2
Avg. Revenue – Cust./m	$9.1	$9.1	$9.1	$10.5
Annual Revenue – Total	$22,089	$132,532	$552,218	$2,556,563
Total Costs – Annual	$110,463	$301,368	$642,375	$2,502,080
Revenue – Total	$22,089	$132,532	$552,218	$2,556,563
Free Cash Flows – Annual	($88,374)	($168,835)	($90,158)	$54,482
Capital Needs – Total	$297,624	$1,024,960	$2,925,000	$9,788,000
of which Grant	75%	50%	40%	30%
of which Equity	25%	30%	30%	20%
of which Debt **2**	0%	20%	30%	50%
Capital Needs – per Cust.	$1,488	$1,025	$770	$653
of which Grant	$1,116	$512	$308	$196
of which Equity	$372	$307	$231	$131
of which Debt	$0	$205	$231	$326

(e.g., in Kenya, over 30 percent of households own a solar product) and that it is typically the most cost-effective, proven technology and business model to deliver basic access to modern electricity. The model assumes that the minimum definition of access is fractional (in other words, that solar lanterns count towards the SDG7 targets). However, since the target in the forecast scenario is full access for all, households with fractional access are assumed to purchase an additional lantern to 'top them up' to full access.

As was the case with mini-grids, disaggregating stand-alone solar businesses into different stages of growth is critical to obtain a nuanced understanding of the financing needs required to deliver energy access. As a business matures, so too does the blend and volume of capital it requires. As evidenced by the model extract below, while the cost of the systems decreases over time, the model assumes that the consumer-facing retail price remains the same (see Prompt 1 in Tables 3, 4, 5, and 6). The resulting improved profit margin on each sale is what enables enterprises to shift their financing blend away from grants and equity towards debt over time (Tables 3, 4, 5, and 6, Prompt 2).

Table 3

Fractional Tier 1 (Lantern) Costing: Model Extracts

		Pilot	Validation	Scale-Up	Mature
Total Customers – End of Phase		500	5,000	25,000	150,000
Loan Tenor (Years)		1	1	1	1
System CAPEX – per Cust.	1	$35.0	$32.5	$25.0	$20.0
System Retail Price – per Cust.		$44	$44	$44	$44
Down Payment – per Cust.		$4	$4	$4	$4
Default Rate		20.0%	15.0%	12.5%	10.0%
Revenue – per Cust.		$36	$38	$39	$40
Advertised Monthly Price		$3.3	$3.3	$3.3	$3.3
Revenue – Total		$18,040	$171,270	$776,563	$4,976,563
OPEX – Total		$132,000	$396,000	$656,250	$1,914,063
Margin – Total		($131,460)	($370,980)	($379,688)	$562,500
Capital Needs – Total		$150,000	$525,000	$985,000	$2,394,000
of which Grant	2	20%	30%	10%	5%
of which Equity		80%	55%	45%	15%
of which Debt		0%	15%	45%	80%
Capital Needs – per Cust.		$300	$117	$49	$19
of which Grant		$60	$35	$5	$1
of which Equity		$240	$64	$22	$3
of which Debt		$0	$18	$22	$15

Table 4

Tier 1 (Multi-Light Point System) Costing: Model Extracts

		Pilot	Validation	Scale-Up	Mature
Total Customers – End of Phase		250	5,000	25,000	150,000
Loan Tenor (Years)		1	1	1	1
System CAPEX – per Cust.	1	$75.0	$65.0	$52.5	$45.0
System Retail Price – per Cust.		$100	$100	$100	$100
Down Payment – per Cust.		$10	$10	$10	$10
Default Rate		20.0%	15.0%	12.5%	10.0%
Revenue – per Cust.		$82	$87	$89	$91
Advertised Monthly Price		$7.5	$7.5	$7.5	$7.5
Revenue – Total		$20,500	$410,875	$1,775,000	$11,375,000
OPEX – Total		$150,000	$950,000	$1,500,000	$4,375,000
Margin – Total		($148,250)	($847,875)	($775,000)	$1,375,000
Capital Needs – Total		$169,000	$1,239,000	$2,140,000	$5,382,000
of which Grant	2	20%	30%	10%	5%
of which Equity		80%	55%	45%	15%
of which Debt		0%	15%	45%	80%
Capital Needs – per Cust.		$676	$261	$107	$43
of which Grant		$135	$78	$11	$2
of which Equity		$541	$143	$48	$6
of which Debt		$0	$39	$48	$34

Table 5

Tier 2 (Multi-Light Point System) Costing: Model Extracts

		Pilot	Validation	Scale-Up	Mature
Total Customers – End of Phase		150	3,000	15,000	90,000
Loan Tenor (Years)		1.5	1.5	1.5	1.5
System CAPEX – per Cust.	1	$175.0	$150.0	$125.0	$100.0
System Retail Price – per Cust.		$250	$250	$250	$250
Down Payment – per Cust.		$25	$25	$25	$25
Default Rate		20.0%	15.0%	12.5%	10.0%
Revenue – per Cust.		$205	$216	$222	$228
Advertised Monthly Price		$12.5	$12.5	$12.5	$12.5
Revenue – Total		$30,750	$616,313	$2,662,500	$17,062,500
OPEX – Total		$225,000	$1,425,000	$2,250,000	$6,562,500
Margin – Total		($220,500)	($1,236,188)	($1,087,500)	$3,000,000
Capital Needs – Total		$252,000	$1,822,000	$3,134,000	$7,988,000
of which Grant		20%	30%	10%	5%
of which Equity	2	80%	55%	45%	15%
of which Debt		0%	15%	45%	80%
Capital Needs – per Cust.		$1,680	$639	$261	$107
of which Grant		$336	$192	$26	$5
of which Equity		$1,344	$352	$118	$16
of which Debt		$0	$96	$118	$85

Table 6

Tier 3 (Multi-Light Point System) Costing: Model Extracts

		Pilot	Validation	Scale-Up	Mature
Total Customers – End of Phase		100	1,000	5,000	30,000
Loan Tenor (Years)		3	3	3	3
System CAPEX – per Cust.	1	$750.0	$650.0	$600.0	550.0
System Retail Price – per Cust.		$1,000	$1,000	$1,000	$1,000
Down Payment – per Cust.		$100	$100	$100	$100
Default Rate		20.0%	15.0%	12.5%	10.0%
Revenue – per Cust.		$820	$865	$888	$910
Advertised Monthly Price		$25.0	$25.0	$25.0	$25.0
Revenue – Total		$82,000	$778,500	$3,550,000	$22,750,000
OPEX – Total		$600,000	$1,800,000	$3,000,000	$7,500,000
Margin – Total		($593,000)	($1,606,500)	($1,850,000)	$1,500,000
Capital Needs – Total		$675,000	$2,303,000	$4,622,000	$14,288,000
of which Grant		20%	30%	10%	5%
of which Equity	2	80%	55%	45%	15%
of which Debt		0%	15%	45%	80%
Capital Needs – per Cust.		$6,750	$2,559	$1,156	$572
of which Grant		$1,350	$768	$116	$29
of which Equity		$5,400	$1,407	$520	$86
of which Debt		$0	$384	$520	$457

Modeling Financing Needs

Table 7 below is an extract from the Madagascar model and is a simplified summary of the contributions made by each technology (grid, mini-grid, stand-alone solar) toward universal access targets over time to achieve the universal access target in 2030. As explained above, the contributions made by the electricity grid toward 2030 household electrification access targets are modeled. However, it is important to note that the financing needs of grid electrification are not costed as part of this report. This is because modeling grid expansion is a complex undertaking that was deemed beyond the scope of the report.

To derive the financing needs for the forecast scenario associated with mini-grids, the model inputted assumptions around the percent of connections each year that would either be made by pilot, validation, scale-up, or mature phase enterprises (see Prompt 1 in Table 8 below). From there, the number of new connections attributable to each stage of business was derived (Prompt 2 in Table 8). On that basis, the financing needs per customer and total capital needs were derived, drawing from the assumptions that were explained in the section above relative to mini-grid financing needs.

Table 7

Madagascar Model Extract Illustrating Access Contributions from Different Technologies

	Units	2018	2019	2020	2021	2022	2028	2029	2030
Forecast Scenario – Access									
Total Access	%HHs	21.2%	23.9%	33.6%	42.7%	51.1%	90.6%	95.5%	100.0%
Grid Access	%HHs	11.4%	11.4%	11.5%	11.7%	11.9%	13.4%	13.6%	13.8%
Mini-Grid Access	%HHs	0.4%	0.4%	0.5%	0.6%	0.7%	1.3%	1.3%	1.4%
Stand-Alone Solar Access	%HHs	9.4%	12.1%	21.6%	30.4%	38.6%	75.9%	80.6%	84.8%
of which Tier 3 OGS	*%HHs*	*0.1%*	*0.1%*	*0.1%*	*0.1%*	*0.1%*	*0.2%*	*0.2%*	*0.2%*
of which Tier 2 OGS	*%HHs*	*0.1%*	*0.2%*	*0.4%*	*0.6%*	*0.8%*	*1.5%*	*1.6%*	*1.7%*
of which Tier 1 OGS	*%HHs*	*4.1%*	*5.4%*	*6.6%*	*7.2%*	*8.0%*	*12.9%*	*13.6%*	*14.3%*
of which Frac. Tier 1 OGS	*%HHs*	*5.1%*	*6.4%*	*14.5%*	*22.5%*	*29.7%*	*61.3%*	*65.1%*	*68.6%*

In the case of stand-alone solar, the modeling exercise was more complicated. This is because the model assumed that households would purchase the highest level of service that they could afford. This assumption aligns with the experience that modern electricity services—particularly products that can power basic appliances such as radios and TVs—are aspirational. Households therefore exhibit a willingness to set aside a share of disposable income to move up the energy ladder and will typically 'graduate' from entry-level products such as lanterns to larger stand-alone solar over time. The model derived these percentages in the following manner:

- The affordability tool was leveraged to determine the share of unelectrified households that could afford to purchase different system types (see description in the affordability section below). Fractional Tier 1 systems (i.e., lanterns) and Tier 1 solar home systems breakdowns relied primarily on these projected affordability barriers. For Tier 2 and 3 solar home systems, historical sales breakdowns were also examined to calibrate future sales breakdowns for these system types. This is reflected in the forecasts summarized in Prompt 1 in Table 9 below.

Table 8

Madagascar Model Extracts Illustrating Mini-Grid Financing Need Calculations

	Units	2020	2021	2022	2028	2029	2030	Cumulative
New Mini-Grids Connections	Conns.	6,000	10,000	10,000	10,000	10,000	10,000	**106,000**
Implied Number of News Mini-Grids	Units	30	50	50	50	50	50	530
Share provided by Pilot-Phase Cos [1]	%	20%	15%	15%	5%	5%	5%	11%
Share provided by Validation-Phase Cos	%	80%	60%	40%	10%	5%	5%	26%
Share provided by Scale-Up-Phase Cos	%	0%	20%	25%	20%	15%	15%	22%
Share provided by Mature-Phase Cos	%	0%	5%	20%	65%	75%	75%	41%
#provided by Pilot-Phase Cos	Conns.	1,200	1,500	1,500	500	500	500	11,700
#provided by Validation-Phase Cos	Conns.	4,800	6,000	4,000	1,000	500	500	27,300
#provided by Scale-Up-Phase Cos [2]	Conns.	–	2,000	2,500	2,000	1,500	1,500	23,500
#provided by Mature-Phase Cos	Conns.	–	500	2,000	6,500	7,500	7,500	43,500
Total Capital Needs – Pilot-Phase Cos	Mn. USD	$1.8	$2.2	$2.2	$0.7	$0.7	$0.7	$17.4
of which Grant	*Mn. USD*	*$1.3*	*$1.7*	*$1.7*	*$0.6*	*$0.6*	*$0.6*	*$13.1*
of which Equity	*Mn. USD*	*$0.4*	*$0.6*	*$0.6*	*$0.2*	*$0.2*	*$0.2*	*$4.4*
of which Debt	*Mn. USD*	–	–	–	–	–	–	–
Total Capital Needs – Validation-Phase Cos	Mn. USD	$4.9	$6.1	$4.1	$1.0	$0.5	$0.5	$28.0
of which Grant	*Mn. USD*	*$2.5*	*$3.1*	*$2.0*	*$0.5*	*$0.3*	*$0.3*	*$14.0*
of which Equity	*Mn. USD*	*$1.5*	*$1.8*	*$1.2*	*$0.3*	*$0.2*	*$0.2*	*$8.4*
of which Debt	*Mn. USD*	*$1.0*	*$1.2*	*$0.8*	*$0.2*	*$0.1*	*$0.1*	*$5.6*
Total Capital Needs – Scale-Up-Phase Cos	Mn. USD	–	$1.5	$1.9	$1.5	$1.2	$1.2	$18.1
of which Grant	*Mn. USD*	–	*$0.6*	*$0.8*	*$0.6*	*$0.5*	*$0.5*	*$7.2*
of which Equity	*Mn. USD*	–	*$0.5*	*$0.6*	*$0.5*	*$0.3*	*$0.3*	*$5.4*
of which Debt	*Mn. USD*	–	*$0.5*	*$0.6*	*$0.5*	*$0.3*	*$0.3*	*$5.4*
Total Capital Needs – Mature-Phase Cos	Mn. USD	–	$0.3	$1.3	$4.2	$4.9	$4.9	$28.4
of which Grant [3]	*Mn. USD*	–	*$0.1*	*$0.4*	*$1.3*	*$1.5*	*$1.5*	*$8.5*
of which Equity	*Mn. USD*	–	*$0.1*	*$0.3*	*$0.8*	*$1.0*	*$1.0*	*$5.7*
of which Debt	*Mn. USD*	–	*$0.2*	*$0.7*	*$2.1*	*$2.4*	*$2.4*	*$14.2*
Total Capital Needs – All Companies	Mn. USD	$6.7	$10.2	$9.6	$7.5	$7.3	%7.3	**$91.9**
of which Grant	*Mn. USD*	*$3.8*	*$5.5*	*$4.9*	*$3.0*	*$2.7*	*$2.7*	***$42.8***
of which Equity	*Mn. USD*	*$1.9*	*$2.9*	*$2.6*	*$1.8*	*$1.7*	*$1.7*	***$23.9***
of which Debt	*Mn. USD*	*$1.0*	*$1.9*	*$2.0*	*$2.8*	*$2.9*	*$2.9*	***$25.2***

Table 9

Madagascar Model Extract Illustrating Stand-Alone Solar Forecast

	Units	2018	2019	2020	2021	2022	2028	2029	2030
At End of the Year									
Cum Tier 1+ Equiv OGS Deployed	mn.	0.58	0.78	1.44	2.10	2.76	6.72	7.38	8.04
of which Tier 3 OGS [1]	*mn.*	*0.00*	*0.00*	*0.01*	*0.01*	*0.01*	*0.02*	*0.02*	*0.02*
of which Tier 2 OGS	*mn.*	*0.01*	*0.01*	*0.03*	*0.04*	*0.06*	*0.14*	*0.15*	*0.16*
of which Tier 1 OGS	*mn.*	*0.25*	*0.35*	*0.44*	*0.50*	*0.57*	*1.14*	*1.25*	*1.35*
of which Frac. Tier 1 OGS equiv. OGS	*mn.*	*0.32*	*0.41*	*0.96*	*1.55*	*2.12*	*5.43*	*5.97*	*6.51*
Net New Tier 1 equiv. OGS Deployed	mn.	0.16	0.19	0.66	0.66	0.66	0.66	0.66	0.66
of which Tier 3 OGS	*mn.*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
of which Tier 2 OGS	*mn.*	*0.00*	*0.00*	*0.01*	*0.02*	*0.01*	*0.01*	*0.01*	*0.01*
of which Tier 1 OGS	*mn.*	*0.05*	*0.09*	*0.09*	*0.06*	*0.08*	*0.11*	*0.11*	*0.11*
of which Frac. Tier 1 OGS equiv. OGS	*mn.*	*0.05*	*0.09*	*0.55*	*0.59*	*0.57*	*0.54*	*0.54*	*0.54*
Total T1 + Equiv. OGS Retirements	mn.	0.04	0.1	0.1	0.2	0.1	1.4	1.5	1.5
of which Tier 3 OGS	*mn.*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
of which Tier 2 OGS	*mn.*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
of which Tier 1 OGS	*mn.*	*0.02*	*0.00*	*0.00*	*0.1*	*0.1*	*0.2*	*0.2*	*0.2*
of which Frac. Tier 1 OGS equiv. OGS	*mn.*	*0.03*	*0.04*	*0.06*	*0.13*	*0.08*	*1.16*	*1.26*	*1.19*
Gross New T1 + Equiv. OGS Deployed	mn.	0.15	0.25	0.76	0.88	0.79	2.08	2.20	2.12
of which Tier 3 OGS	*mn.* *%*	*0.00* *1%*	*0.00* *0%*	*0.00* *0.3%*	*0.00* *0.3%*	*0.00* *0.3%*	*0.01* *0.3%*	*0.01* *0.3%*	*0.01* *0.3%*
of which Tier 2 OGS	*mn.* *%*	*0.00* *1%*	*0.01* *2%*	*0.02* *2%*	*0.02* *2%*	*0.02* *2%*	*0.04* *2%*	*0.04* *2%*	*0.04* *2%*
of which Tier 1 OGS	*mn.* *%*	*0.05* *34%*	*0.11* *45%*	*0.12* *16%*	*0.14* *16%*	*0.13* *16%*	*0.34* *16%*	*0.36* *16%*	*0.34* *16%*
of which Frac. Tier 1 equiv. OGS	*mn.* *%* *mn. T1 equiv*	*0.13* *53%* *0.08*	*0.22* *53%* *0.13*	*1.03* *82%* *0.62*	*1.20* *82%* *0.72*	*1.08* *82%* *0.65*	*2.83* *82%* *1.70*	*3.00* *82%* *1.80*	*2.88* *82%* *1.73*
Cum Tier 1+ Equiv OGS Access Rate	%	9.4%	12.1%	21.6%	30.4%	38.6%	75.9%	80.6%	84.8%
of which Tier 3 OGS	*%*	*0.1%*	*0.1%*	*0.1%*	*0.1%*	*0.1%*	*0.2%*	*0.2%*	*0.2%*
of which Tier 2 OGS	*%*	*0.1%*	*0.2%*	*0.4%*	*0.6%*	*0.8%*	*1.5%*	*1.6%*	*1.7%*
of which Tier 1 OGS	*%*	*4.1%*	*5.4%*	*6.6%*	*7.2%*	*8.0%*	*12.9%*	*13.6%*	*14.3%*
of which Frac. Tier 1 equiv. OGS	*%*	*5.1%*	*6.4%*	*14.5%*	*22.5%*	*29.7%*	*61.3%*	*65.1%*	*68.6%*

Table 10

Madagascar Model Extract Summarizing Stand-Alone Financing Needs

		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Cum.	Cum. %
Forecast Scenario Financing Needs														
OGS – Total Enterprise Financing Needs	Mn $	$126.1	$99.3	$81.9	$82.4	$122.5	$123.0	$104.6	$102.6	$130.1	$132.1	$126.8	**$1,868.5**	**100%**
of which Grant Financing Needs	*Mn $*	*$18.4*	*$18.4*	*$15.4*	*$14.2*	*$20.9*	*$19.1*	*$15.8*	*$13.4*	*$17.0*	*$16.0*	*$15.3*	*$183.9*	*10%*
of which Equity Financing Needs	*Mn $*	*$47.2*	*$48.5*	*$38.9*	*$37.2*	*$54.2*	*$52.5*	*$42.2*	*$39.1*	*$48.1*	*$47.3*	*$45.4*	*$500.6*	*27%*
of which Debt Financing Needs	*Mn $*	*$28.4*	*$32.4*	*$27.7*	*$31.1*	*$47.4*	*$51.4*	*$46.6*	*$50.2*	*$65.0*	*$68.8*	*$66.1*	*$514.9*	*28%*

To derive the financing needs for the forecast scenario associated with stand-alone solar, the model inputted assumptions around the percent of connections each year that would either be made by pilot, validation, scale-up, or mature phase enterprises for each of the Tiers of access (fractional Tier 1, Tier 1, Tier 2, Tier 3). From there, the number of new connections attributable to each stage of business was derived for each Tier of access. On that basis, the financing needs per customer and total capital needs were derived (see Table 10 above), drawing from the assumptions that were explained in above relative to the financing needs of stand-alone solar businesses based on their stage of growth.

PART 2

COOKING

DEFINING IMPROVED COOKING ACCESS

Taking the Pulse uses the MTF[207] to establish the minimum definition of "improved cooking" that counts toward the SDG7 goal of universal access. The MTF measures access to energy for cooking based on seven attributes: health (based on household air pollution); convenience (based on fuel collection and stove preparation time); affordability (including expenditure on cookstove and fuel), safety, efficiency, quality, and availability. *Taking the Pulse* defines access to improved cooking solutions in two main ways. The first, which is the primary focus of the report, centers on moving households away from traditional cooking solutions (typically using a three stone fire or artis-

[207] Bhatia, M. & Angelou, N., 2015. Beyond Connections – Energy Access Redefined, Washington: Energy Sector Management Assistance Program.

anal or semi-industrial cookstove) all of which do little to improve cooking efficiency and/or emissions. As such, the report models out the cost of what would be required for these households to adopt improved "industrial" cookstoves. These stoves typically either burn wood or charcoal. Given that these two fuel sources tend to release a lot of carbon monoxide (CO), many improved charcoal stoves are designed with the goal of reducing CO emissions. Industrial stoves entail centralized, large-scale production that uses quality components, manufactures with precision tools and employs considerable levels of automation. The focus is typically on rocket stoves, which have an insulated, L-shaped combustion chamber that improves combustion efficiency and reduces emissions. The stoves are considerably higher quality than can typically be produced in local markets, and generally, achieve Tier 2 or higher on efficiency and Tier 1 or higher on emissions. *Taking the Pulse* defines the minimum level of improved cooking access as improved cookstoves (ICS) that meet International Workshop Agreement (IWA) minimum standards (Tier 1) on fuel efficiency and emissions[208] and, as such, it only includes industrial ICS (both charcoal and wood) in its analysis.

Related to clean fuels, the report focuses on three primary fuels considered to have significant potential. These are a sub-set of cooking solutions that deliver high performance in terms of reducing household air pollution—often (although not always) regardless of the type of cookstove used: biogas, liquefied petroleum gas (LPG), electricity, ethanol, natural gas, and solar cookers, collectively called BLEENS[209]. Given that *Taking the Pulse* only focuses on biogas, LPG, and ethanol, it adopts the term "clean fuels" in discussing them. Liquid and gas fuels tend to be efficient and clean-burning, even in conventional low-pressure gas burners and LPG is delivered to households in cylinders/canisters. Access to this clean-burning fuel type is increasing in the developing world, primarily in urban areas. To increase use of LPG, availability and affordability (stove, ongoing fuel requirements, and deposit for the gas cylinder) are challenges that need to be addressed. Biogas, produced from household- or community-level plants that convert organic waste material into combustible methane gas, is another clean fuel option for gas stoves. Ethanol is a liquid biofuel that can be made from a variety of feedstocks including sugary materials (e.g., sugar cane, molasses, sugar beet, or sweet sorghum), starchy materials (e.g., cassava (manioc), potatoes, or maize), or cellulosic materials (e.g., wood, grasses, and many agricultural residues) using a variety of conversion processes. Many new feedstocks are under development, such as algae, kelp, and other wild or non-cultivated crops.[210]

Though *Taking the Pulse* develops forecast scenarios in each of the focus countries related to clean fuels uptake, **it does not make projections around the cost of this uptake.**[211] This is because it was not within the scope of this report given the complexities associated with costing of delivering cooking solutions via clean fuels. We consider this to be an area ripe for further research.

UNDERSTANDING THE SCENARIOS

Clean Fuel Adoption

The model builds a clean fuel adoption (LPG, biogas, ethanol) scenario for each country based on historical trends and forecasted constraints to growth:

- **Historical:** this looks back at the period 2010-2018, and compiles year-on-year information about clean fuel adoption over time, relying predominantly on country household surveys. Since full surveys that include cooking-related data are

[208] Clean Cooking Alliance. "Voluntary Performance Targets". https://www.cleancookingalliance.org/technology-and-fuels/standards/iwa-tiers-of-performance.html
[209] Bhatia, M. & Angelou, N., 2015. Beyond Connections – Energy Access Redefined, Washington: Energy Sector Management Assistance Program.
[210] Clean Cooking Alliance. "Stoves". https://www.cleancookingalliance.org/technology-and-fuels/stoves/index.html
[211] This was also the case in the 2017 edition of *Taking the Pulse*.

infrequent in Madagascar and the Philippines, certain historical data are best estimates based on country trends.

- **Forecast:** This builds on the historical scenario but also factors in what is considered a realistic level of uptake for each fuel type given affordability and logistical constraints in each market. The uptake of electricity as a primary cooking 'fuel' was limited by its relatively high cost but also specifically the extent of grid electrification in a given country. While LPG is typically a more affordable cooking fuel than electricity, the forecast scenario assumed that its cost relative to alternatives would remain stable and thus uptake would be limited to households with sufficient consumption levels.

ICS – Charcoal and Wood

- The historical scenario gathers data from various sources regarding existing household ICS use. No household surveys conducted in the three countries specifically capture ICS uptake, thus data had to be sourced primarily from reports conducted by nongovernmental organizations and information gleaned from company interviews.

- The forecast scenario covers the remaining improved cooking gap that is left once clean fuels uptake is factored in. This includes households that use clean fuels but are also stacking, to ensure the scale of required interventions is appropriately captured. The model assumes that, for each market, fuel stacking continues to occur but that the percentage of households using a clean fuel alongside traditional fuel sources decreases over time.

Standard ICS Characteristics

The model assumes that each ICS sold in 2020 and beyond will meet IWA minimum standards on fuel efficiency and emissions. These are the most critical factors under which ICS can be judged given that they have affordability, environmental, and health impacts. The MTF for access to cooking solutions measures access to energy for cooking based on seven attributes: health (based on household air pollution), convenience (based on fuel collection and stove preparation time), affordability (including expenditure on cookstove and fuel), safety, efficiency, quality, and availability. Table 11 shows the matrix used to assess access to cooking solutions. Although distinct, the MTF for household access to energy for cooking has been defined to be consistent with the IWA tiers for measuring cookstove performance. To avoid any confusion with the IWA "tiers" for cookstoves, the framework uses the term "levels" for improving echelons of attributes of cooking access.[212]

Table 12 below provides a detailed breakdown of assumptions underpinning the four stages of growth used to characterize cookstove companies (pilot; validation; scale-up; mature). Disaggregating the businesses into different stages of growth is critical to a nuanced understanding of the financing needs required to deliver access to improved cooking solutions. As with electricity access businesses, the model assumes that as an ICS business matures, so too does the blend and volume of capital that it requires. As evidenced by the model extract below, while the cost of the systems decreases over time, the model assumes that the consumer-facing retail price remains this same (see Prompt 1 in Tables 12 and 13). This improved profit margin on each sale is what enables the enterprises to shift their financing blend away from grants and equity to debt over time (see Prompt 2 in Tables 12 and 13).

[212] Energypedia. 2019. "Global Tracking Framework for Measuring Energy Access" https://energypedia.info/wiki/Global_Tracking_Framework_for_Measuring_Energy_Access

Table 11

Multi-Level Matrix for Access to Cooking Solutions[213]

ATTRIBUTES		LEVEL 0	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
Indoor Air Quality	PM 2.5 ('µ'g/m³)		[To be specified by a competent agency, such as WHO, based on health risks]	[To be specified by a competent agency, such as WHO, based on health risks]	[To be specified by a competent agency, such as WHO, based on health risks]	< 35 (WHO, IT -1)	< 10 (WHO guideline)
	CO (mg/m³)					< 7 (WHO guideline)	< 7 (WHO guideline)
Cookstove Efficiency (not to be applied if cooking solution is also used for heating)			Primary solution meets Tier 1 efficiency requirements [To be specified by a competent agency consistent with local cooking requirements]	Primary solution meets Tier 2 efficiency requirements [To be specified by a competent agency consistent with local cooking requirements]	Primary solution meets Tier 3 efficiency requirements [To be specified by a competent agency consistent with local cooking requirements]	Primary solution meets Tier 4 efficiency requirements [To be specified by a competent agency consistent with local cooking requirements]	
Convenience	Stove preparation time (min/meal)			< 7	< 3	< 1.5	< 0.5
	Fuel acquisition and preparation time (hrs/week)			< 15	< 10	< 5	< 2
Safety of Primary Fuel	IWA safety tiers			Primary solution meets (provisional) ISO Tier 2	Primary solution meets (provisional) ISO Tier 3	Primary solution meets (provisional) ISO Tier 4	
	OR Past accidents (burns, unintended fires)					No accidents over the past year that required professional medical attendance	
Affordability						Levelized cost of cooking solution (including cooking fuel) < 5% of household income	
Quality of Primary Fuel: Variations in heat rate due to fuel quality that affect ease of cooking						No major effect	
Availability of Primary Fuel						Primary fuel is readily available for ≥ 80% of the year	Primary fuel is readily available throughout the year

[213] Bhatia, M. and Angelou, N. (2015). Beyond Connections: Energy Access Redefined. ESMAP Technical Report Washington, DC: World Bank. Available at: https://openknowledge.worldbank.org/handle/10986/24368

Table 12

ICS Characterization Details

		Industrial Wood ICS			
		Pilot	**Validation**	**Scale-Up**	**Mature**
Total Units Sold – End of Phase		500	5,000	20,000	100,000
System CAPEX – per Cust.		$21.3	$19.4	$17.6	$16.0
System Retail Price – per Cust.	1	$25	$25	$25	$25
Approximate Lifetime (Years)			3.0		
Lifetime Monthly Cost			0.7		
Revenue – Total		$12,500	$112,500	$375,000	$2,000,000
OPEX – Total		$12,500	$84,375	$93,750	$400,000
OPEX + CAPEX – Total		$23,148	$171,495	$357,750	$1,680,000
Profit – per Cust.		($21)	($13)	$1	$4
Profit – Total		($10,648)	($58,995)	$17,250	$320,000
Capital Needs – Total		$13,468	$77,213	$101,875	$346,667
of which Grant	2	*40%*	*30%*	*15%*	*10%*
of which Equity		*50%*	*55%*	*40%*	*20%*
of which Debt		*10%*	*15%*	*45%*	*70%*
Capital Needs – per Cust.		$26.9	$17.2	$6.8	$4.3
of which Grant		*$11*	*$5*	*$1*	*$0*
of which Equity		*$13*	*$9*	*$3*	*$1*
of which Debt		*$3*	*$3*	*$3*	*$3*

Table 13

Industrial Charcoal ICS Characterization Details

	Industrial Charcoal ICS			
	Pilot	**Validation**	**Scale-Up**	**Mature**
Total Units Sold – End of Phase	500	5,000	20,000	100,000
System CAPEX – per Cust.	$31.9	$29.0	$26.4	$24.0
System Retail Price – per Cust.	$36	$36	$36	$36
Approximate Lifetime (Years)		3.0		
Lifetime Monthly Cost		1.0		
Revenue – Total	$18,000	$162,000	$540,000	$2,880,000
OPEX – Total	$14,400	$97,200	$121,500	$576,000
OPEX + CAPEX – Total	$30,372	$227,880	$517,500	$2,496,000
Profit – per Cust.	($25)	($15)	$2	$5
Profit – Total	($12,372)	($65,880)	$22,500	$384,000
Capital Needs – Total	$16,288	$95,265	$143,250	$515,200
of which Grant	*40%*	*30%*	*15%*	*10%*
of which Equity **2**	*50%*	*50%*	*35%*	*20%*
of which Debt	*10%*	*20%*	*50%*	*70%*
Capital Needs – per Cust.	$32.6	$21.2	$9.6	$6.4
of which Grant	*$13*	*$6*	*$1*	*$1*
of which Equity	*$16*	*$11*	*$3*	*$1*
of which Debt	*$3*	*$4*	*$5*	*$5*

Modeling Financing Needs

Table 14 below is an extract from the Madagascar model and is a simplified summary of the contributions made by clean fuels and ICS toward universal access targets.

To derive the financing needs for the forecast scenario associated with ICS, the model inputted assumptions around the percent of sales each year that would either be made by pilot, validation, scale-up, or mature phase enterprises (see Prompt 1 in Table 15 below). From there, the number of new sales attributable to each stage of business was derived (Prompt 2 in Table 15). On that basis, the financing needs per customer and total capital needs were derived, drawing from the assumptions explained in the section above relative to ICS financing needs.

Table 14

Madagascar Model Extract Illustrating Access Contributions from Different Technologies

	Units	2018	2019	2020	2021	2022	2028	2029	2030
Forecast Scenario – Access									
BLEENS Access	%HHs	0.6%	0.7%	1.0%	1.3%	1.6%	4.2%	4.7%	5.2%
Charcoal	%HHs	38.1%	39.8%	41.5%	43.1%	44.6%	53.1%	54.3%	55.4%
Wood & Other Biomass	%HHs	61.3%	59.5%	57.5%	55.6%	53.7%	42.7%	41.0%	39.4%
Other Non-BLEENS Fuels	%HHs	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Charcoal & Wood ICS Penetration	%HHs	2.5%	2.4%	11.3%	20.2%	29.1%	82.3%	91.1%	100.0%

Table 15

Madagascar Model Extract Illustrating Charcoal ICS Financing Need Calculations[214]

	Units	2020	2021	2022	2028	2029	2030	Cumulative
Industrial Charcoal ICS Sales	Units	27,663	31,656	35,917	445,811	568,476	628,346	**2,549,657**
Share provided by Pilot-Phase Cos	%	3%	3%	2%	1%	1%	1%	1%
Share provided by Validation-Phase Cos	%	30%	25%	20%	5%	3%	3%	6%
Share provided by Scale-Up-Phase Cos	%	60%	50%	30%	10%	10%	10%	12%
Share provided by Mature-Phase Cos	%	7%	22%	48%	85%	87%	87%	81%
# provided by Pilot-Phase Cos	Conns.	830	950	718	2,229	2,842	3,142	21,904
# provided by Validation-Phase Cos	Conns.	8,299	7,914	7,183	22,291	17,054	18,850	159,723
# provided by Scale-Up-Phase Cos **1**	Conns.	16,598	15,828	10,775	44,581	56,848	62,835	311,021
# provided by Mature-Phase Cos	Conns.	1,936	6,964	17,240	376,710	491,731	543,520	2,057,009
Total Capital Needs – Pilot-Phase Cos	Mn. USD	$0.0	$0.0	$0.0	$0.1	$0.1	$0.1	$0.7
of which Grant	*Mn. USD*	*$0.0*	*$0.0*	*$0.0*	*$0.0*	*$0.0*	*$0.0*	*$0.3*
of which Equity	*Mn. USD*	*$0.0*	*$0.0*	*$0.0*	*$0.0*	*$0.0*	*$0.1*	*$0.4*
of which Debt	*Mn. USD*	*$0.0*	*$0.0*	*$0.0*	*$0.0*	*$0.0*	*$0.0*	*$0.1*
Total Capital Needs – Validation-Phase Cos **2**	Mn. USD	$0.2	$0.2	$0.2	$0.5	$0.4	$0.4	$3.4
of which Grant	*Mn. USD*	*$0.1*	*$0.1*	*$0.0*	*$0.1*	*$0.1*	*$0.1*	*$1.0*
of which Equity	*Mn. USD*	*$0.1*	*$0.1*	*$0.1*	*$0.2*	*$0.2*	*$0.2*	*$1.7*
of which Debt	*Mn. USD*	*$0.0*	*$0.0*	*$0.0*	*$0.1*	*$0.1*	*$0.1*	*$0.7*
Total Capital Needs – Scale-Up-Phase Cos	Mn. USD	$0.2	$0.2	$0.1	$0.4	$0.5	$0.6	$3.0
of which Grant	*Mn. USD*	*$0.0*	*$0.0*	*$0.0*	*$0.1*	*$0.1*	*$0.1*	*$0.4*
of which Equity	*Mn. USD*	*$0.1*	*$0.1*	*$0.0*	*$0.1*	*$0.2*	*$0.2*	*$1.0*
of which Debt	*Mn. USD*	*$0.1*	*$0.1*	*$0.1*	*$0.2*	*$0.3*	*$0.3*	*$1.5*
Total Capital Needs – Scale-Up-Phase Cos	Mn. USD	$0.0	$0.0	$0.1	$2.4	$3.2	$3.5	$13.2
of which Grant	*Mn. USD*	*$0.0*	*$0.0*	*$0.0*	*$0.2*	*$0.3*	*$0.4*	*$1.3*
of which Equity	*Mn. USD*	*$0.0*	*$0.0*	*$0.0*	*$0.5*	*$0.6*	*$0.7*	*$2.6*
of which Debt	*Mn. USD*	*$0.0*	*$0.0*	*$0.1*	*$1.7*	*$2.2*	*$2.5*	*$9.3*
Total Capital Needs – All Companies	Mn. USD	$0.4	$0.4	$0.4	$3.4	$4.2	$4.6	**$20.3**
of which Grant	*Mn. USD*	*$0.1*	*$0.1*	*$0.1*	*$0.5*	*$0.5*	*$0.6*	***$3.1***
of which Equity	*Mn. USD*	*$0.2*	*$0.2*	*$0.1*	*$0.9*	*$1.1*	*$1.2*	***$5.7***
of which Debt	*Mn. USD*	*$0.1*	*$0.1*	*$0.1*	*$2.0*	*$2.6*	*$2.8*	***$11.5***

[214] This table will be updated with revised figures in the next version.


14.2

PART 3

CONSUMER AFFORDABILITY

The Excel-based model derived the consumer affordability challenge in order to establish the affordability gap subsidy requirements to achieve SDG7 in a given country. For this analysis, the research team used PovcalNet,[215] an interactive computational tool that allows users to replicate calculations made by World Bank researchers in estimating the extent of absolute poverty in the world. PovcalNet also allows users to calculate poverty measures under different assumptions and to assemble estimates using alternative economy groupings or for any set of individual economies of the user's choosing. PovcalNet is self-contained; it has reliable built-in software that quickly does the relevant calculations from the built-

[215] The World Bank. "An Introduction to PovcalNet". http://iresearch.worldbank.org/PovcalNet/introduction.aspx

in database. It is critical to note that the approach to using the World Bank poverty calculator (PovCal) tool is by no means an authoritative rendering of household ability to pay for energy services. It is, however, a standardized tool that can be used across countries to establish reasonably well-informed extrapolations from existing datasets related to household consumption, including expenditures on electrification services.

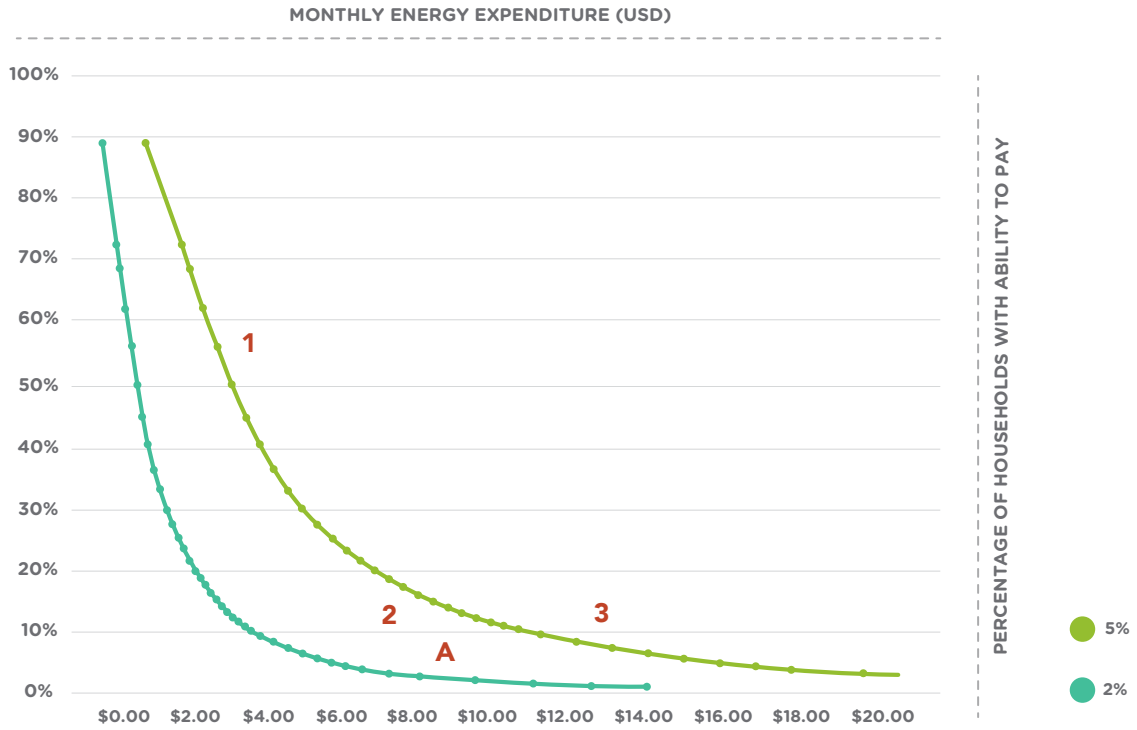
For each of the three focus countries, the PovCal tool was calibrated to depict the distribution of 5 percent of monthly consumption, which was determined to be an appropriate assumed level of household monthly expenditure on electrification services.[216] Figure 1 below illustrates the ability to pay curve for electrification and improved cooking services in Madagascar. With respect to electrification, the PovCal simulation shows the following:

- Point 1 shows the estimated percentage of households (approximately 58 percent) that could afford fractional Tier 1 access (a mid-range solar lantern, paid for in monthly installments, and which has an assumed cost of USD 3.30 per month, with a payoff period of 12 months).
- Point 2 illustrates the percentage of households that could afford full Tier 1 access (a multi-light-point stand-alone system, assumed to have a monthly cost of USD 7.50 over 12 months), which is approximately 18 percent of households.
- Point 3 shows a Tier 2 system (multi-light point, with the ability to power a fan or television, with an estimated monthly cost of USD 12.50 over 18 months) and illustrates that approximately 7 percent of households could afford a system of this size.

[216] This 5% figure was established based on extensive consultations with energy access economists, including at the Schatz Energy Research Center, Acumen, and the World Bank.

Figure 1

Madagascar Ability to Pay for Electricity Access and ICS



Based on these simulations, the report was able to establish two main things:

1. The percentage (and number) of systems that would be sold at various Tier levels, assuming that each household would purchase the highest level of energy services that it could afford.

2. The affordability gap, which represents the shortfall in ability to pay that the model estimates. This can then be used to derive the implied level of affordability-gap subsidy that would be required for this cohort of households to be able to afford the minimum acceptable level of energy services (fractional Tier 1).

With respect to improved cooking, the PovCal tool was calibrated to depict the distribution of 2 percent of monthly consumption. The model assumes that households would save that 2 percent of monthly consumption over a three-month period, and that this saved amount would be used to purchase an industrial ICS that uses wood as its fuel source. In the case of charcoal stoves, the model assumes these households have a higher purchasing power and can afford the cost of the stove (given that they are already foregoing the less expensive option of a wood-fired stove, and that an industrial charcoal ICS would result in considerable fuel cost savings). Figure 1 above illustrates the PovCal simulation around the 2 percent ability to pay assumption for improved cooking. Its findings are as follows:

- Point A shows the estimated percentage of households in Madagascar (approximately 2.5 percent) that could afford a wood ICS (with an assumed cost of USD 25, which is saved for over 3 months).

These outputs are used to establish the affordability gap for ICS, which is derived from the extrapolation of the number of households that are unable to afford the industrial wood ICS.

ANNEX

Key Terms Used in *Taking the Pulse*

TERM	DEFINITION
Access to electricity	Access to electricity was traditionally measured based on household connections to the national electric grid of their respective country. A recent shift, driven by the MTF for electricity access, seeks to understand electricity access not in binary terms, but as a continuum of service levels that may be satisfied by a range of technologies. The MTF captures more robust granularity of electricity access including capacity, duration of supply, reliability, quality, affordability, legality and safety.
Business as usual (BAU)	A forward-looking scenario that is based on historical trends. Using these trends, the average year-on-year growth rate is projected forward, factoring in demographic assumptions related to population growth over time.
Clean Cooking Alliance	A global network of partners established in 2010 to build an inclusive industry that makes clean cooking accessible to the approximately three billion people who live each day without it. The Alliance is driving consumer demand, mobilizing investment to build a pipeline of scalable businesses, and fostering an enabling environment that allows the clean cooking sector to thrive.
Fuel stacking	The parallel use of several fuels for the purpose of cooking.
High-impact countries	The 20 countries with the highest absolute gaps in access to electricity and/or clean fuels and technologies for cooking measured by population, as identified in the 2015 Global Tracking Framework (IEA and the World Bank, 2015). For electricity access the countries are: Afghanistan, Angola, Bangladesh, Burkina Faso, Congo (DR), Ethiopia, India, Kenya, Korea (DPR), Madagascar, Malawi, Mozambique, Myanmar, Niger, Nigeria, the Philippines, Sudan, Tanzania, Uganda and Yemen. For clean cooking access the countries are: Afghanistan, Bangladesh, China, Congo (DR), Ethiopia, India, Indonesia, Kenya, Korea (DPR), Madagascar, Mozambique, Myanmar, Nepal, Nigeria, Pakistan, the Philippines, Sudan, Tanzania, Uganda and Vietnam.

TERM	DEFINITION
Improved cookstoves	Cookstoves are commonly called "improved" if they are more efficient, emit less emissions or are safer than the traditional cook stoves or three-stone-fires. The term usually refers to stoves which are burning firewood, charcoal, agriculture residues or dung.
Clean fuels	This term refers to biogas, liquefied petroleum gas (LPG) and ethanol, which are the fuels that are featured in *Taking the Pulse*.
Lighting Global quality-verified products	Lighting Global supports the growing global market for modern off-grid energy with a widely applicable, rigorous Quality Assurance (QA) framework. The key QA activities include measuring, benchmarking, and communicating information about product quality and performance.
Mini-grids	Electricity generation and energy storage systems inter-connected to a distribution network that supplies electricity to a localized group of customers.
Multi-Tier Framework	A typology that monitors and evaluates energy access by following a multi-dimensional approach. It defines energy access as the ability to avail energy that is adequate, available when needed, reliable, of good quality, convenient, affordable, legal, healthy and safe for all required energy services. Energy access is measured in the tiered-spectrum, from Tier 0 (no access) to Tier 5 (the highest level of access).
Off-grid solar	Off-grid solar refers to products that generate energy from solar resources without a centralized infrastructure, such as an electric grid.
Pay-as-you-go (PAYG)	PAYG refers to a business model that allows users to pay for their product via installment payments over time. Customers are frequently required to make a down payment, followed by regular payments over a period of months or years. Payments are usually made via mobile money, and non-payment is frequently enforced by disabling the system until payments resume.
Semi-industrial stoves	Stoves typically involving local assembly of pre-fabricated components with basic tooling required for assembly.

TERM	DEFINITION
Stand-alone solar	Single (typically referred to as "solar lanterns") or multi-light point systems (often called "solar home systems") that generate power via photovoltaic panels, store power via batteries (increasingly using lithium-ion battery chemistries), and deliver lighting and power for small devices and appliances.

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