Poor people's energy outlook 2017

PRACTICAL ACTION
Technology challenging poverty

Poor people's energy outlook 2017

Financing national energy access: a bottom-up approach

Praise for PPEO 2017

'The energy access sector is in dire need of this kind of empirical analysis. Distributed renewable energy technologies have become a major player in the global energy equation. Yet, the trend to solely rely on grid extension and intensification continues in many parts of the Global South, against better reason. The *PPEO 2017* analysis takes this issue head on through a terrific decomposition of the energy for all scenario.'

Dr Sebastian Groh, Managing Director, ME SOLshare Ltd, and Assistant Professor, North South University, Bangladesh

'I appreciate that *PPEO 2017* is informed by consumer preferences and needs; not only the functional requirements of energy interventions and technologies, but also by consumers' lifestyles and aspirations. Practical Action's holistic view and its bottom-up approach ensure that the report considers the full range of energy needs and particularly highlight people's pressing desire for clean cooking solutions – something that is weaved into the report as a crucial priority as we all work toward achieving the Sustainable Development Goals and the Paris Agreement. This edition especially notes the importance of consumer affordability and the need to develop the right financial instruments that match the capacities of players along the entire energy access value chain, including consumers themselves.'

Radha Muthiah, CEO, Global Alliance for Clean Cookstoves

'*PPEO 2017* builds on the bottom-up energy planning approach recommended in the 2016 edition and enables us to see, clearly, that the costs of providing energy access are not prohibitive when recognizing real energy demands. The inclusion of productive use and community service energy demands within this bottom-up approach further differentiates Practical Action's analysis from the 'go to' modelling frameworks that underpin the discussions of global financial needs for access. I hope this *PPEO* accelerates the dialogue around why change is needed in looking at energy demand from the end user's perspective. This report shows us why the energy planning and global leadership sector needs to move past the business as usual approach, which uses top-down projections of future demand based on history or forecasts of future economic growth. The projections on the level of financing required for desired clean cooking solutions is a clear call to action for prioritization and innovation. Given the consensus on the urgency of delivering energy access, this *PPEO* must be digested by all who want to be part of the change required to meet SDG 7 goals.'

Christine Eibs Singer, Director of Global Advocacy, Power for All, and Special Advisor on Energy Access to SEforAll

'We welcome *PPEO 2017*'s analysis of gender and energy finance, and its specific recommendations on financing systems that promote gender equity and options for mainstreaming gender in financing mechanisms. We must continue to advocate for the critical role for women and women's organizations in bottom-up energy access planning processes and in influencing the policy, regulatory and financing environment. After reviewing *PPEO 2016* and *PPEO 2017* for Practical Action, we at ENERGIA look forward to reading the *PPEO 2018* on delivering energy access at scale.'

Sheila Oparaocha, International Coordinator and Programme Manager, ENERGIA

'Practical Action's *PPEO* series is very impressive and informative. The information and analysis found within *PPEO 2017* are robust and provide a more realistic basis of how we can achieve universal energy access and what needs to be done to achieve it in the three study countries covered. *PPEO 2017* has also rightly brought out the challenges of energy financing and how they can be addressed. Local contexts vary from one location to another and solutions must be developed adapting to the local contexts, which may be a combination of both bottom-up and top-down solutions rather than a one size fits all approach.'

Debajit Palit, Associate Director and Senior Fellow, Social Transformation Programme, The Energy & Resources Institute (TERI)

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About Practical Action

Practical Action is a development charity with a difference. We use technology to challenge poverty by building the capabilities of poor people, improving their access to technical options and knowledge. We work internationally from regional offices in Latin America, Africa, Asia, and the UK. Our vision is for a world where all people have access to the technologies that enable them to meet their basic needs and reach their potential, in a way that safeguards the planet today, and for future generations.
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Foreword

A global spotlight shines on the energy access space. To address energy poverty, we must rethink how we deliver affordable, reliable and clean energy services to the most marginalized people, especially women and children.

Extending energy services to the billions who still lack access to clean cooking and modern electricity will not only unleash their economic potential; it will increase access to nutrition, expand water security and improve health care. Moreover, this new-found economic prosperity will be supported by better climate mitigation and adaptation.

The Sustainable Development Goals and the Paris Agreement promise a future where we leave no one behind. Yet the 2017 Global Tracking Framework shows we are not on track to achieve sustainable energy for all. Business as usual has let the most marginalized down, so business as usual must change – and quickly.

Challenging the status quo has been central to the *Poor people's energy outlook* (*PPEO*) series since its inception in 2010. This edition builds on *PPEO 2016*, which unpacked the added value of a bottom-up approach to national energy planning. It showed national plans in energy-poor countries look completely different when energy customers' needs are put first, resulting in more reliable, quickly deployable energy systems at a similar cost to traditional ones – by using much more distributed energy than is used today. *PPEO 2017* focuses on the next piece of the puzzle: how to finance people-driven energy access infrastructure for all. Through national planning case studies in Bangladesh, Kenya and Togo, Practical Action highlights two important points: how imminently affordable universal access is, and that we already have most of the tools needed to finance a bottom-up renewable revolution.

Instead of typical calls for 'innovative business models' and 'innovative finance', *PPEO 2017* shows the need for inexpensive, quickly actionable work around mass capacity-building among entrepreneurs on finance, appropriate technologies, and business skills; and business literacy programmes for decision-makers and financiers at the global and national levels.

For these and other valuable contributions, particularly on the significance of including the energy poor's preferences in plans and financial systems that will, first and foremost, affect them, I welcome the *Poor people's energy outlook 2017*. Readers are encouraged to interrogate and incorporate its findings into their work, and follow future editions of the report to see how, building on the findings from *PPEO 2016* and *2017*, to deliver energy access at scale.

Rachel Kyte
Chief Executive Officer
Sustainable Energy for All (SEforAll)

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This edition of the report builds on *PPEO 2016,* which highlighted the integrated energy access plans that would more quickly, sustainably and meaningfully provide poor people in three countries (Bangladesh, Kenya and Togo) with the sorts of energy access they prioritize. Our first thanks therefore go to the women and men in Bangladesh, Kenya and Togo who participated in the *PPEO 2016* research, offering valuable insights into what energy access means to them and which solutions they prioritize and would be willing to pay for, on whose testimony *PPEO 2017* builds.

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Photo captions and credits

Front cover. The Kalawa Financial Services Association provides loans and financial advice to locals, enabling the rural poor to access a range of energy services (Credit: Practical Action / Edoardo Santangelo)

Back cover. See credits on page 36 and for Chapter 7 (below).

Executive summary. Sibinga resident and M-KOPA customer Elizabeth demonstrates how she uses her mobile phone to top up the energy meter connected to the solar home system installed on her roof. (Credit: Practical Action / Edoardo Santangelo)

Chapter 1. In Kenya, electricity lines run alongside the road that leads to Utumoni, Makueni County, one of the rural communities consulted in *PPEO 2016*. (Credit: Practical Action / Edoardo Santangelo)

Chapter 2. Inside the manager's office at the Kalawa Financial Services Association, which provides loans and financial advice to locals. (Credit: Practical Action / Edoardo Santangelo)

Chapter 3. A community focus group, similar to those undertaken for *PPEO 2016*, discussing the Kanyegaramire Solar Mini-Grid Project in Uganda, a project funded by Energy for Development (e4D) and the Rural Electrification Agency, Uganda. (Credit: Sustainable Energy Research Group (www.energy.soton.ac.uk) and Energy for Development (www.energyfordevelopment.net)).

Chapter 4. Togolese women transport goods back to their homes in Kamé. (Credit: Practical Action / Edoardo Santangelo)

Chapter 5. Lydia, a hairdressing business owner in Utumoni village, Makueni County, is one of only 5.9% of the population that is currently connected to the grid. (Credit: Practical Action / Edoardo Santangelo)

Chapter 6. Community members gather outside a local shop at which a rooftop solar panel generates electricity. (Credit: Practical Action / Edoardo Santangelo)

Chapter 7. A Bangladeshi woman sorts wheat while cooking on a basic, biomass stove. (Credit: Practical Action / Edoardo Santangelo)

Chapter 8. In Sibinga, Busia County, Kenya, communities have previously come together as part of table-top banking schemes to save money. (Credit: Practical Action / Edoardo Santangelo)

Chapter 9. Haho Prefecture, a seamstress in Kame, Togo, uses a manual sewing machine to create textiles to sell. (Credit: Practical Action / Edoardo Santangelo)

Executive summary

Investments in national energy systems have increased in recent years alongside growing awareness of the critical role of energy in a plethora of development objectives. While it is widely recognized that most of these investments should go into decentralized energy systems to have the fastest, most economical result, energy finance has not shifted or grown accordingly. As a result, the world is not on track to achieve universal, sustainable, and modern energy access by 2030.

The *Poor people's energy outlook (PPEO) 2017* uses national energy planning as an entry point into reframing energy finance discussions. Reframing energy planning using bottom-up integrated planning tools, we model the least-cost national technology mix – and financing required – to achieve Total Energy Access in Togo, Kenya, and Bangladesh. These case studies bring into stark relief the details of what previously abstract calls for increased investment into distributed energy should look like.

This PPEO offers a fresh perspective on what can be done today, at low cost, to direct finance to energy-poor areas

We discuss the important roles of civil society, the private and public sectors, and of course financiers in making this happen. Our finance discussion does not take the traditional look at flows, types of capital or business models. Instead we offer a fresh perspective on what can be done today, at low cost, to rapidly build up investment pipelines, reduce investor risk, and bring energy finance to where it is needed most urgently: energy-poor areas.

This *PPEO* is the second in a suite of three on energy access planning (2016), financing (2017), and delivery at scale (2018).

The finance gap: a bottom-up perspective

While sources disagree on how big the financing gap for energy in poor countries really is, everyone agrees it is enormous. *PPEO 2016* focused on how, in energy-poor countries, mainstream energy planning methods largely ignore the needs of the energy poor. We used our Total Energy Access approach to develop least-cost energy access plans with 12 communities in Togo, Kenya, and Bangladesh, based on their needs and preferences. Our results showed how radically different plans would look if governments used a technology-neutral approach aimed at meeting end-user needs.

In this 2017 edition, we scale these plans to the national level, defining the technology mix for cooking and electricity that would close the national access gap. We generate national financing estimates and use community figures on willingness to pay to calculate financing gaps.

Our methodology is the first to take an end-user needs approach to national rural energy planning and financing

Our analysis illustrates that getting additional finance to the right places on the right terms is a necessary, but not sufficient, condition for realizing these communities' energy aspirations. A range of other actions is required, but without the right finance, progress will remain stalled.

Our methodology is the first to take an end-user needs approach to national rural energy planning and financing. We match this with a review of barriers and potential opportunities for global and national energy financing. The results will help inform planners, donors, and concessional and commercial financiers about the appropriate technology mix, types of funding, and business and community support needed to create thriving markets for energy access services – and provide universal access to modern energy services.

Key findings and implications at the national level

Funding is out of sync with the most appropriate solutions

Informed by the needs and preferences of energy-poor communities, our detailed modelling finds distributed electricity systems (a mix of mini-grids and stand-alone systems) to be the least-cost solution for the majority of unconnected people: 66 per cent in Bangladesh, 68 per cent in Kenya, and nearly 100 per cent in Togo. Accordingly, we estimate that funding for distributed electricity should account for approximately 83 per cent of future electricity finance in Kenya, 82 per cent in Bangladesh, and 100 per cent in Togo. This does not reflect how expensive distributed solutions are, but how high the marginal cost of connecting dispersed users to the national grid really is.

Actual investments in grid versus distributed systems remain grossly disproportionate and out of sync with our findings and calls by other experts. In Kenya, despite new commitments, only 15 per cent of funding is going towards distributed energy, and in Togo only 5 per cent. In Bangladesh, investments in stand-alone systems are a quarter of total energy funding. Investments in all countries remain dramatically skewed towards electricity rather than clean cooking.

The clean cooking finance gap is more complicated and depends on the type of provision. While technology options vary widely, our case-study communities expressed strong preferences for clean fuels and technologies. Cooking finance must rise to levels near that of electricity, as our analysis shows.

To end energy poverty, clean cooking finance must rise to levels near that of electricity

Cumulative cost of provision of national energy access plans to 2030

	Electricity access		*Clean cooking (user choice)*		*Advanced biomass cookstoves*[1]	*Improved biomass cookstoves*[2]
	Total	*Per person/yr*	*Total*	*Per person/yr*		
Togo	$4.9 bn	$93	$2.1 bn	$20	$0.8 bn	$0.6 bn
Kenya	$26.0 bn	$72	$27.1 bn	$41	$8.4 bn	$3.4 bn
Bangladesh	$75.2 bn[3]	$134	$57.3 bn	$24	$77.4 bn	$37.0 bn

1 Tier 3 or above of the World Bank multi-tier framework.
2 Tier 2 of the World Bank multi-tier framework.
3 If electricity needs of small and medium-sized enterprises (SMEs) and smallholder farmers are excluded, the total is $37.7 bn, or $67 per person/year.

Productive activities and community services are finance opportunities

National financing strategies need to address and support not only productive energy but also productive activities. It is unacceptably rare to see financiers support a mini-grid company alongside longer term work with institutions to help boost uptake of energy-consuming productive activities and technologies. In such cases, both mini-grid developers and financiers are missing opportunities to help secure their future incomes.

Community uses of energy were very highly prioritized in our case studies but are rarely given the spotlight in planning or international conversations on energy. Our analysis shows that community services represent very small costs, but have significant potential for development impact. For instance, stand-alone street lighting amounts to less than 1 per cent of the electrification finance estimate in Bangladesh and Kenya, and 7 per cent in Togo.

Community uses were highly prioritized but are rarely given the spotlight in national planning

So what does it all mean?

A bottom-up, end-user driven approach to national planning radically influences the outlook in terms of the technology mix and finance required, and indicates dramatically shorter timeframes for achieving universal access. This approach also better meets the needs of both women and men, and ensures energy reaches community services as well as households and productive uses. A community-driven approach gives a clearer picture of the viability of particular technologies and the potential for decentralized solutions.

The actions most urgently needed are not expensive, difficult, or out of the ordinary

The finance gap between what is needed and what is happening is real and large. Energy-poor countries are largely pre-commercial spaces for most energy services and longer term, concessional-sector support will be needed to activate markets and to close the affordability gap. The inability to build energy markets in poor countries is the result of a number of 'chicken and egg' problems that can be resolved only with multiple, simultaneous actions. Good policies and a few successful companies will not solve this problem: it is time to get back to basics.

The actions most urgently needed are not expensive, difficult, or out of the ordinary. The problem, however, is no one is funding them at the scale required to end energy poverty. We urge you to join us in working together with donors, financiers, businesses, and civil society to build institutional support, human resources, and funding to undertake broad campaigns of:

1. **creating leadership commitment within concessional financiers** to update and align institutional practices to robustly support distributed energy;
2. **scaling up what already works by building up the skills and experience of energy SMEs and future leaders**, including supporting and empowering women at all levels within energy value chains;
3. **shifting development financier evaluation and reward metrics** to reflect development impacts in addition to, or rather than, deal size;
4. **building trust and understanding among local and international financiers** to support decentralized electricity and clean cooking;
5. **supporting gender-aware community energy training and financing** to promote access to productive end-use technologies;
6. **resourcing national market activation campaigns and partnerships in all energy-poor countries** to build demand, collaboration, positive peer pressure, and the policy and regulatory foundation for distributed energy markets to thrive.

1. Introduction

The fundamental role of energy in improving people's lives has garnered extraordinary attention over the past decade. Recognition of its centrality in mitigating climate change and improving economic opportunity, social welfare, and human wellbeing continues to grow, as evidenced in the 2015 Paris Climate Agreement and its inclusion as a dedicated goal in the UN 2030 Agenda for Sustainable Development, which highlights cooking and electricity as key to achieving universal energy access.

Nonetheless, an overwhelming number of people still live in energy poverty. Between 2012 and 2014 those living without an electricity connection fell by only a negligible amount, from 1.06 billion to 1.05 billion people (World Bank, 2017a), while in sub-Saharan Africa population growth meant numbers actually increased. In 2014, 3.04 billion people lacked access to clean cooking; again, progress remains painfully slow. At these rates we will fail to reach universal energy access by 2030 or to fulfil many of the other Sustainable Development Goals that rely on SDG7 (GACC, 2016a; IRENA, 2017). Purposeful and innovative ways to challenge 'business as usual' are needed, to ensure we deliver on the promises made to the world's poorest.

Multi-stakeholder planning with poor people at the centre

The *Poor people's energy outlook (PPEO) 2016* illustrated that the starting point is to revolutionize national energy access planning to include energy-poor populations as vital stakeholders in the process. This addresses the 'know your customer' deficit that has resulted in decades of governments and donors focusing almost exclusively on grid-based approaches to electricity generation and distribution which could never reach everyone logistically or economically.

To illustrate the value of prioritizing those at the bottom of the pyramid in energy decision-making, in *PPEO 2016* we created community-driven integrated energy access plans with 12 communities across Bangladesh, Kenya and Togo. These plans, with their unique insights for future energy planning initiatives, were based on the expressed needs and priorities of the energy poor and on the energy resources available in their given contexts.

The results were conclusive: the most appropriate, economical, reliable, and expedient technologies in almost all cases were distributed energy systems – *not* traditional, centralized energy infrastructure.

The most appropriate, economical, reliable, and expedient technologies are distributed energy systems

PPEO 2017 builds on this analysis by scaling these community insights to the national level. We model the technology mix needed to deliver universal energy access quickly and at least cost for electricity and clean cooking across entire countries. We model the total cost of achieving universal energy access in these countries, and examine the challenges faced by a range of stakeholders in accessing the finance they require. We explore the pattern of current investments and make recommendations for increasing the flow of finance.

The next edition of *PPEO* will illustrate a range of experiences of delivering decentralized energy access at scale, considering in more detail aspects of market activation and capacity-building of a range of stakeholders.

The financing gap for energy access

Many reports reference the International Energy Agency's modelling of the finance required to achieve universal energy access by 2030: US$979 billion (from 2011 to 2030), or $49 bn per year (IEA, 2012). Given existing and planned financing, IEA identified an annual shortfall of $34 bn from which $11 bn is needed for grid electricity, $19.5 bn for decentralized electricity access, and $3.5 bn for clean cooking (IEA, 2011). This represents an enormous and almost certainly unattainable increase over current investment levels, estimated at around $13 bn per year in 2013 (see Figure 1.1; IEA, 2015).

While the need for sizable increases in investment is widely accepted, the exact level of that investment is debated (Rai et al., 2016). Costs vary depending on the tiers, or levels, of energy service targeted, with estimates for electricity access ranging from $2 bn to $55 bn annually (IEA & World Bank, 2015). Falling prices, more efficient appliances, and a rethink of the consumption level needed to provide basic services and major development benefits could lower the maximum projected cost by as much as 71 per cent to $210 bn in total; or $14 bn annually (Craine et al., 2014).

A revival of official development assistance (ODA) financing and private investment to the energy sector since the mid-2000s has concentrated on grid electricity. The split between renewable and non-renewable sources has been fairly even, with private investment concentrating on generation and ODA increasingly spent on generation and transmission (Pueyo et al., 2015).

Despite this, the distributed electricity market holds enormous potential for growth, considering the energy poor already spend approximately $27 bn annually on lighting and mobile-phone charging (BNEF, 2016), and significant amounts on kerosene and charcoal for cooking. The distributed electricity market is growing exponentially, with a 10-fold increase in distributed renewable capacity in Africa since 2005. It now provides electricity access to about 60 million Africans: 10 per cent of the off-grid population (IRENA, 2016a). Private investment has similarly increased, with most flowing to pay-as-you-go (PAYGO) companies in a few countries. Over $223 million in private investment was announced in 2016 (BNEF, 2017), an exponential rise from just $3 m in 2012, raising concerns for some about the stability and maturity of the market (Neichin et al., 2017).

The distributed electricity market holds enormous potential for growth

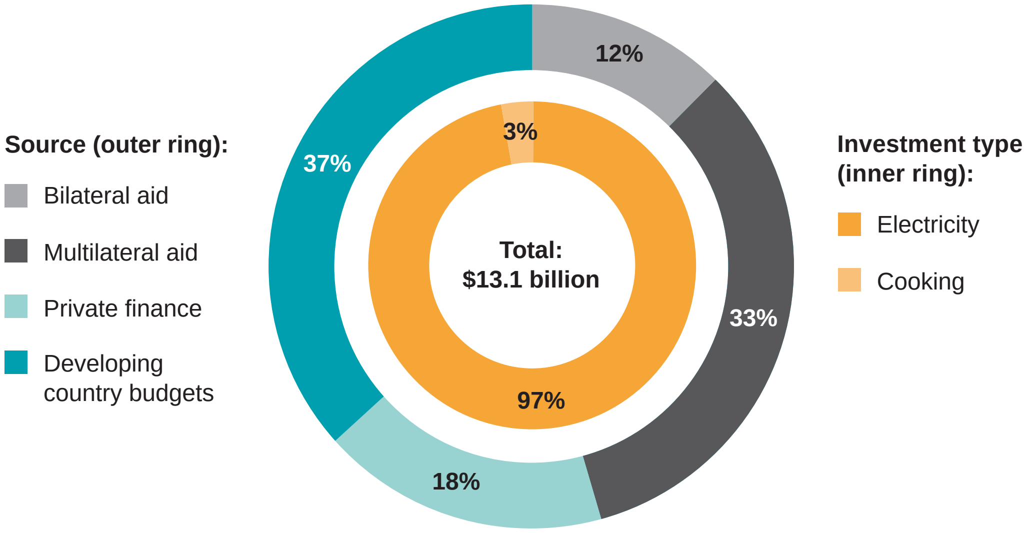


Figure 1.1 World energy access investment by type and source, 2013
Source: IEA, 2015

Levels of investment in clean cooking remain tiny in comparison. IEA estimates that in 2013 just 3 per cent (around $400 m) of world energy access investment went to clean cooking (IEA, 2015). The Global Alliance for Clean Cookstoves found private investment into cookstove companies was just $12 m in 2015 and nearly $60 m over the past five years (GACC, 2016b), a fraction of the $4.7 bn the IEA estimates is needed. Though the smoke from cooking fires causes 4.3 million deaths per year (WHO, 2016), investment in solutions is tiny compared to other significant health problems. Looking at premature deaths from household air pollution, global investment in clean cooking is between $30 and $250 per individual compared to $2,000–4,000 per death from Malaria or HIV/AIDS (Putti et al., 2015).

Levels of investment in clean cooking remain tiny compared to electricity

From analysis to action: financing integrated national energy plans

Following adoption of the SDGs and Paris Agreement, we urgently need to move from planning to implementation. Increasing numbers of countries are finalizing their Sustainable Energy for All (SEforAll) Action Agendas and Investment

Prospectuses with commitments to achieve defined access levels. Energy-sector actions also feature in many Nationally Determined Contributions under the Paris Agreement.

These plans cannot be achieved without increasing levels of finance. Financing on its own, however, is not sufficient for achieving global energy goals. Other conditions need to be in place to make financing effective, including supportive, transformative national planning, and activities that build the capacity of different actors in the sector (PwC, 2016; IRENA, 2017). At the same time, the finance that is available needs to be directed in new ways, shifting the balance away from supporting large-scale grid electricity and towards distributed solutions, clean fuels, and efficient stoves which will accelerate energy access for poor consumers.

In *PPEO 2017* we first outline some of the inadequacies of the current energy financing landscape such that money is not flowing where it is needed in the right forms and quantities. We outline the methodology for our national finance estimates and then report on the modelling exercises we carried out for Togo, Kenya, and Bangladesh. We also give a picture of each country's national energy finance and the specific barriers, challenges, and opportunities for accelerating energy access finance. In Chapter 7, we compare the results of our national-level technology and financing models across the three countries, highlighting the value of a bottom-up approach to create a more accurate picture of needs. In Chapter 8, we draw together the findings from the country chapters on how to address the key barriers to finance, and conclude with a set of clear recommendations for action.

2. The inadequacies of energy access finance

Energy financing in developing countries, like energy planning and energy utilities, remains overwhelmingly focused on large-scale, centralized, grid-based electricity systems. Our robust, community-based model in *Poor people's energy outlook (PPEO) 2016* illustrated that the best way to affordably and expediently deliver the services energy-poor people want is through a variety of distributed energy technologies. Yet, even if energy ministries and utilities changed their approaches to match these expressed needs, there are few examples of concessional or commercial financiers attempting to adapt financial tools and structures to the needs and technologies of today's energy landscape.

Development financing in the energy sector has traditionally been dominated by support for large projects: primarily the construction of power stations, new grids, and transmission lines. Politically this has also been driven by the perception that only grid power is 'real electricity' and that decentralized supply options are second best. The IEA coupled its quantification of the level of investment needed to reach universal access (US$49 billion per year) with an analysis showing that the majority would most economically be delivered through distributed systems (IEA, 2012). For some, this estimate reinforced the need for large projects; for others, it encouraged a greater focus on early-stage grant support for mini-grids and solar home system providers. Pressure quickly emerged, especially from bilateral donors, for the private sector to play a far larger role in financing and delivering energy access, recognising that ODA and national budgets alone would never deliver the levels of investment needed.

The forgotten origins of rural energy finance

US rural electric cooperatives proved the poor could pay for energy

For much of the 20th century, big industry drove growth in wealthy countries. Key development finance institutions that still dominate infrastructure support today were developed in the 1940s to back similar industries in poor countries. Their working methods have changed little, with institutional operations and processes remaining focused on large, multi-year government loans to undertake considerable infrastructure projects (Power for All, 2016).

The history of rural electrification in the United States paints a different picture, however, and is a story which is often overlooked. In the early 20th century, utilities in the USA were unwilling or unable to serve remote rural areas for the same reasons utilities in energy-poor countries cite today: high costs of grid extension combined with low perceived demand for energy and affordability in rural areas (Beall, 1940). Indeed, in 1934, only 10 per cent of US farms were electrified. In 1935, the Rural Electrification Administration (REA) was formed to provide subsidized loans and guarantees to private companies, public entities and rural energy generation cooperatives. By shifting the focus from supply alone to also supporting demand from end-users, the REA was able to spur radical changes in the energy and economic landscapes of America's countryside. In two years 350 cooperatives were set up providing energy to 1.5 million farms. Over the following 20 years, the REA became financially self-sustaining with default rates of only 1 per cent and all farms in the nation were essentially electrified (Malone, 2008). Rural electric cooperatives cut costs by 30–50 per cent compared to the existing large private and public utilities, and showed that the poor could pay.

Significantly, women's desire for home appliances drove the rural market and high load in the USA. Electric appliances lightened women's drudgery, enabling them to work more efficiently in their homes and participate in the formal economy (Matly, 2005). The parallels to the need and opportunity in energy- and capital-constrained regions of the world today are blindingly obvious.

The politicized nature of energy access financing

Large energy infrastructure projects are complicated and long in duration, with World Bank-funded power-sector projects averaging nine years from conception to service delivery (IEG, 2015). This means that every single large-scale project contributing to universal energy access by 2025 – which many, including Practical Action, are calling for to ensure other SDGs reliant on energy can be achieved by 2030 – must already be in the works today. While some projects are in the pipeline, these are nowhere near adequate to achieve timely universal access. Indeed, based on current trends, it will take until 2080 to achieve universal electricity access and the mid-22nd century for access to clean energy for cooking (Africa Progress Panel, 2015).

Transforming energy finance and energy delivery systems is, however, fraught with difficulties due to the politicized nature of the energy sector. Currently, energy financing is primarily channelled through governments via concessional loans from international financial institutions. Additional finance comes from bilateral donors, which subsidize many utilities (that remain mostly state-run) in energy-poor countries at a rate of hundreds of dollars (often more than $500) per new connection (Kojima and Trimble, 2016). Even with this grant support, many utilities in energy-poor countries run deficits and are basically bankrupt. The lending community's extreme focus on supply-side support without robust efforts to increase consumer demand and ability to pay has left many utilities, unsurprisingly, losing money on every new connection.

The norm of lending to suppliers without supporting demand means many utilities lose money on every new connection

Dependent on subsidies to stay afloat, grant support to flagging and/or mismanaged utilities is a major barrier to reforming energy systems. Yet, removing support is often politically unpopular and risks disintegration of already fragile power systems and severe impacts on local economies. There are powerful vested interests in business as usual. Retaining these subsidies, however, ensures continuation of inefficiencies and other unhelpful practices, including top-down planning and associated inappropriate technology choice, that have left billions under-electrified or with no electricity at all.

Additionally, in many energy-poor countries the energy sector is heavily regulated. Often these regulatory regimes have semi-altruistic origins, aiming, for instance, to prevent price exploitation of impoverished populations through uniform national tariff regulations. They also often restrict independent power producers (IPPs) from operating; similarly, because of concern that IPPs would either exploit or provide poor service to customers. Both uniform national tariffs and restrictions around IPPs are increasingly seen as political tools and are coming under scrutiny. For loss-making but politically powerful state-run utilities, IPPs are risky as they may be more cost-effective than the utility. Moving away from heavily subsidized uniform national tariffs and towards potentially higher, but cost-reflective, tariffs would improve the business propositions for IPPs undertaking rural electrification work and could be used as ammunition against politicians presiding over end-user price increases. There is some recognition that these issues must be addressed to successfully increase energy access. In Kenya, for example, there is discussion of subsidizing IPP costs to bring tariff levels in line with those of the utility. This would be a break from the norm where it is only grid power tariffs that are subsidized.

Fossil fuel subsidies are a final example of energy's politicized nature. They are not only used for power generation (hundreds of millions of mostly diesel generators are used as primary or back-up power in energy-poor countries), but also for the kerosene lighting or cooking fuel used by billions of the poorest people around the world. Because of the direct impact of these subsidies on the most economically vulnerable, attempts to remove them have often led to unrest and even violence (for example in Egypt and India). Recent research and fieldwork, particularly in Indonesia, however, has shown that smart reforms of fossil fuel subsidies can be accomplished even in highly politicized and subsidized contexts (ADB, 2015).

At times, the politicized nature of the energy sector can be turned to advantage. For example, the pressure to recognize energy access as the 'missing Millennium Development Goal' (Brew-Hammond, 2012) due to its centrality in achieving other development objectives, including health, gender equality, education, and economic development. With acceptance of energy's role in development comes increasing recognition that integrated, cross-sectoral planning and coordination is required to address our world's environment and

With acceptance of energy's role in development comes increasing recognition that integrated, cross-sectoral planning is required

The energy uses of poor communities are routinely overlooked in energy plans, projects, and finance

development challenges simultaneously. Coordination is particularly pertinent in cooking. Energy-poor households' primary energy consumption is in cooking using biomass – something not controlled by energy ministries but by those responsible for forestry, which could be ministries of agriculture or environment. Thus, for the vast majority of energy-poor communities, their main household energy source is overlooked in energy plans, projects, and finance.

Such gaps are seen across many other important energy 'nexus' sectors. In many countries, ministries of health, education, water, agriculture, and energy rarely engage with one another. These same 'silos' are often true for donor governments, development financiers, and even non-government organizations, and further limit cross-sectoral planning and funding.

What kind of finance and for what types of energy?

Private-sector finance for grid electrification has increased rapidly in the last 10 years, to the point where it now vastly exceeds ODA financing (Pueyo et al., 2015). This is the result of 'blended finance' leveraging private-sector investment, for example through concessional financiers providing various support mechanisms to reduce real or perceived risks/barriers. This private investment has been concentrated in a few emerging, particularly middle-income, economies, with Brazil, India, and China having captured about half globally.

The amount of finance supporting energy access in more remote areas compared to centralized power generation or transmission remains small (Sierra Club and Oil Change International, 2016). IEA (2011) estimated that between 5 and 20 per cent of total private energy investment went to energy access, encompassing grid-based systems, distributed systems, and clean cooking. While this allocation has certainly improved in recent years, the sea change in types and sizes of technologies required to end energy poverty (IEA identifies approximately 55 per cent will need to be distributed systems) still lacks the government leadership it needs to become a reality.

Types of finance

Financing needs for expanding decentralized, renewable energy access are extremely varied

The financing needs for expanding decentralized, renewable energy access are extremely varied, with a range of actors requiring different types and amounts of finance and for whom different financial instruments are relevant (see Figure 2.1).

- Energy producers normally require both debt and equity investments (and often grant or technical and business support to become viable pipeline companies for debt and equity investors).
- Energy consumers often require debt or subsidies to afford connection costs (including purchase of clean cooking products).
- Financial institutions and funds require credit guarantees and other risk mitigation tools to lend and invest in new technologies / business models and new, uncertain markets.
- Governments require finance to support any role it has in the project as well as for linking it to broader infrastructure and/or undertaking required regulatory or policy work (Rai et al., 2016).

UNEP's guide to private financing of renewable energy (Justice, 2009) provides useful explanations of financing terms.

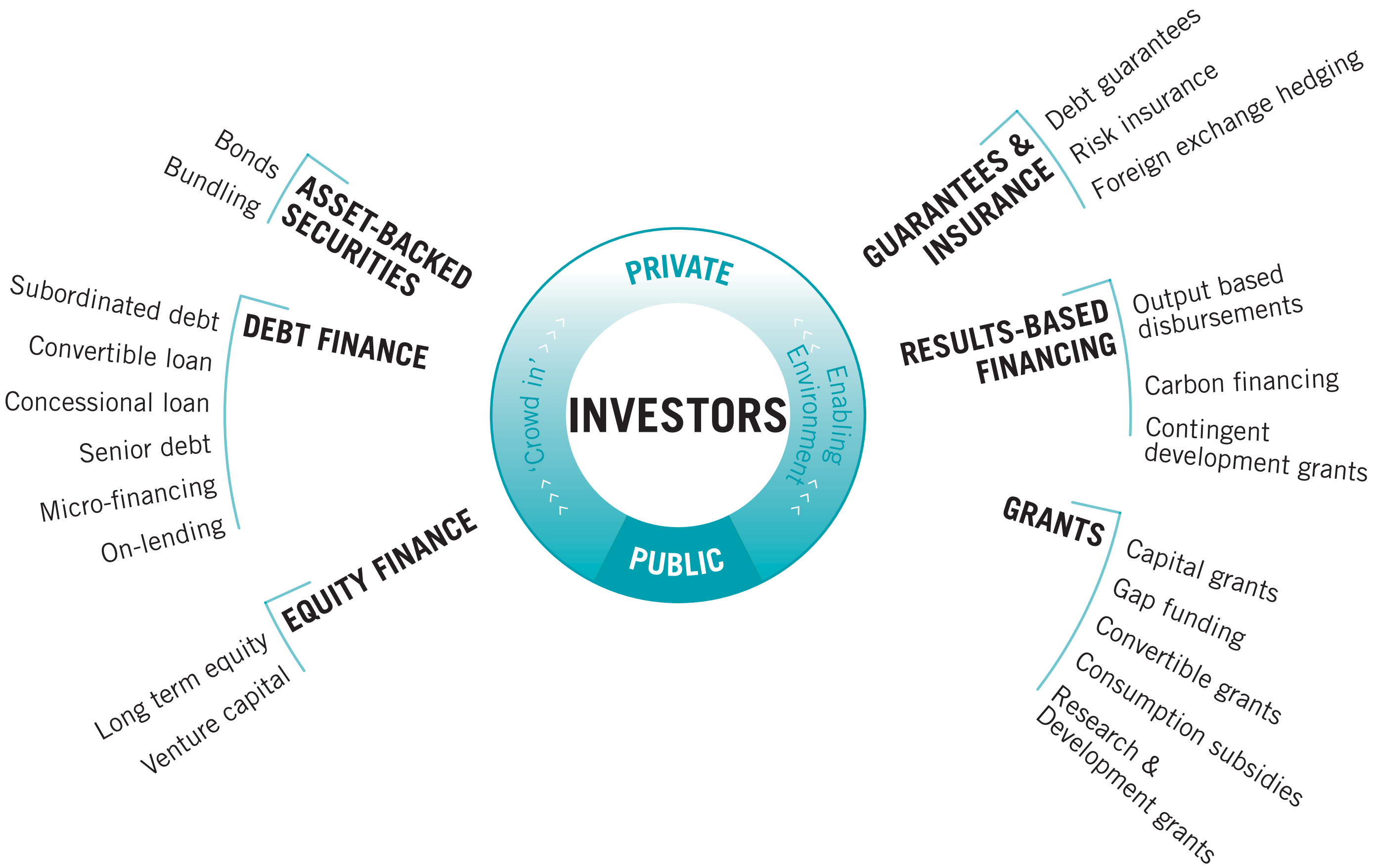


Figure 2.1 The energy access finance ecosystem
Source: based on World Bank, 2013; IRENA, 2016b

It was hoped that the carbon finance market could play an important role in energy access, and it has helped to increase the affordability of clean cookstoves. At its peak in 2012, of the 8.2 million stoves sold that year, approximately half received some support from carbon finance (Putti et al., 2015). Since then carbon finance flows have dwindled as demand and pricing of cookstoves carbon credits have fallen.

Decentralized energy service companies (DESCOs), such as mini-grid or solar home system (SHS) businesses, or cookstove and clean fuel producers and distributors, may appear to have similar financing needs because they operate in the same sector. A closer look at their business models, however, reveals divergent needs.

For established SHS companies, shorter term working capital is a major concern as their model relies heavily on buying and selling hundreds or thousands of SHS units per month. Companies that offer PAYGO are in the lending business, as customers pay for the system over a period of a few years in the form of weekly payments. For consumers, small solar products save households on average $205, so far putting $3.4 bn back in the hands of poor customers in Asia and Africa (GOGLA, 2016). The question of affordability is more one of limited disposable income and the need to spread payments over time (Desjardins et al., 2014).

Mini-grids, on the other hand, are essentially small infrastructure projects offering higher levels of power with much higher up-front and connection costs. Mini-grid developers therefore require longer term capital that is repaid slowly over longer periods – often up to a decade. This type of 'patient' capital

Companies need faster moving financing models with fewer delays and administrative burdens

is hard to find for DESCOs serving economically poor customers due to the opportunity costs involved for the lender. If other investment opportunities could repay a lender more securely, quickly or at a higher rate of interest, why would they choose the comparatively slow, less profitable and riskier mini-grid?

There are also differences in terms of the size and maturity of companies. Smaller companies are looking for concessional loans, equity finance or convertible debt. They may need grants and technical assistance to refine products and business models. Working capital is needed to scale up operations to a level more likely to achieve profitability. Larger companies are looking for debt at reasonable rates and, sometimes, longer pay-back periods. All are looking for faster moving models with fewer delays and administrative burdens.

Barriers to increasing energy access finance

Current methods of financing energy are unable to meet the challenges of investing in most energy-poor countries

While investment decisions are based on a range of factors, influenced by the financiers' motivations and the type of finance they are providing, in purely financial terms, an investor wants to ensure the money lent or invested is returned and has grown. For this reason, energy financing in developing countries is rarely directed outside areas of high population density or industrial areas where companies can grow and reach new markets more quickly.

There has been considerable analysis in the last few years of the barriers to financing renewable energy (UNEP, 2012), decentralized, off-grid energy access and clean cooking (Bhattacharyya, 2013; AT Kearney and GOGLA, 2014; Wilson et al., 2014; SEforAll, 2015a; EAPN, 2016; Rai et al., 2016). Box 2.1 gives an overview of these barriers. Some barriers relate to underdeveloped financial markets, 'making it difficult or impossible to obtain the types of financing required at reasonable costs' or in local currencies, and are common to 'most infrastructure projects in low income countries' (Hussain, 2013). Other barriers relate to risks specific to the energy access sector, such as policy and regulatory uncertainties,

Box 2.1 Barriers to energy access finance

- **High risks (actual and perceived):** including "political instability, regulatory uncertainty, currency risk, low investor returns, an unproven business model and unreliable cash flows". Perceptions of risk are heightened by a lack of knowledge, highlighted as an important factor among investors surveyed by EAPN (2016).
- **Shortage of proven business models and good quality business plans:** highlighted as the most significant barrier by investors in the EAPN (2016) survey.
- **Investor returns and short-termism:** with competing investments offering faster or more secure returns, there is a lack of 'patient' forms of capital.
- **Investment size and transaction costs:** a particular problem for enterprises in their start-up phase. Sub-critical deal sizes were the biggest barrier to financing clean cookstoves in the EAPN (2016) survey.
- **National banking systems:** industry players surveyed by EAPN identified the lack of support from local banks in local currencies as the primary barrier to financing (EAPN 2016).
- **Policy and regulatory environment:** including a lack of clear regulatory frameworks and difficult processes for e.g. permits and licences (EAPN, 2016); and a "lack of clarity on grid extension plans, and… tax and subsidy regimes favouring large-scale or fossil fuels". Clean cookstove industry players highlighted the lack of national strategies for the sector (EAPN 2016).

Source: Rai et al., 2016: 28–29

or slower pay-back times especially for mini-grids. In the clean cooking sector, multiple barriers apply. In comparison with more established electricity access markets, business models are perceived as less mature, markets riskier, profit margins lower, and pathways to scale more difficult.

In terms of access to finance from multinational development banks, Power for All concludes that there is a mismatch between the 'wholesale capital' available from MDBs and the 'retail capital' required at the national level to support decentralized renewable energy: 'There is a mismatch between the traditional expertise and incentives within development banks (a small number of large projects with extensive due diligence) and the new opportunities that will quickly reach the poor with DRE access solutions (via numerous small transactions with limited information and high perceptions of risk)' (Power for All, 2016: 5).

Gender and energy access finance

There are important gendered dimensions of the barriers to energy access finance. This relates to women's access to finance as both consumers and as entrepreneurs. Part of the difficulty lies in the assumption that, where traditional grid-based solutions to energy access are proposed, men and women will benefit equally. There is little or no consideration of the use of grid-based energy beyond the household or of how to achieve a more equitable gender balance in energy enterprises or employment (Winther et al., 2016).

Important gendered barriers exist to women's access to finance both as consumers and entrepreneurs

A UN Women and UNDP review of seven barriers and risks to energy access finance evaluated their impact on women and men, and if women faced additional barriers (Glemarec et al., 2016). Some of the findings were promising, confirming research by others (Alstone et al., 2011; Dutta, 2013) that women entrepreneurs have enormous potential 'to manage the supply chain and acquire new creditworthy customers in rural areas' (Glemarec et al., 2016: 146). In a cookstove sector example, women entrepreneurs sold three times as many stoves as their male peers given the same training and support (GACC, 2016c). In another project women entrepreneurs demonstrated over twice the business capacity of men (wPOWER Hub, 2014). Moreover, women borrowers are generally considered a lower credit risk than men.

Socio-economic and cultural barriers outweigh these positive factors, however. Women are less likely to own the collateral required to secure loans or to have had the chance to save and build up their own assets to invest. Because of occupational gender gaps they may have had less opportunity to develop technical, entrepreneurial, and financial skills. Their mobility may be constrained by domestic responsibilities and the risks of violence, which can make it harder for them to access bank branches or other financial institutions. Women may have less social capital to ensure compliance on contracts and less access to justice. They can also be bound by stereotypes that result in discriminatory business practices (Glemarec et al., 2016; GACC, 2017a). Figure 2.2 shows the many roles that women play across the energy access value chain, and the importance of appropriate finance in enabling this. Until these barriers are addressed, the energy access sector will continue to be constrained in terms of its effectiveness and potential to impact the lives of both men and women. Dissolving these barriers opens up even greater opportunities to catalyse energy markets for electricity and clean cooking.

Until gendered barriers are addressed, the sector will not realize its full potential

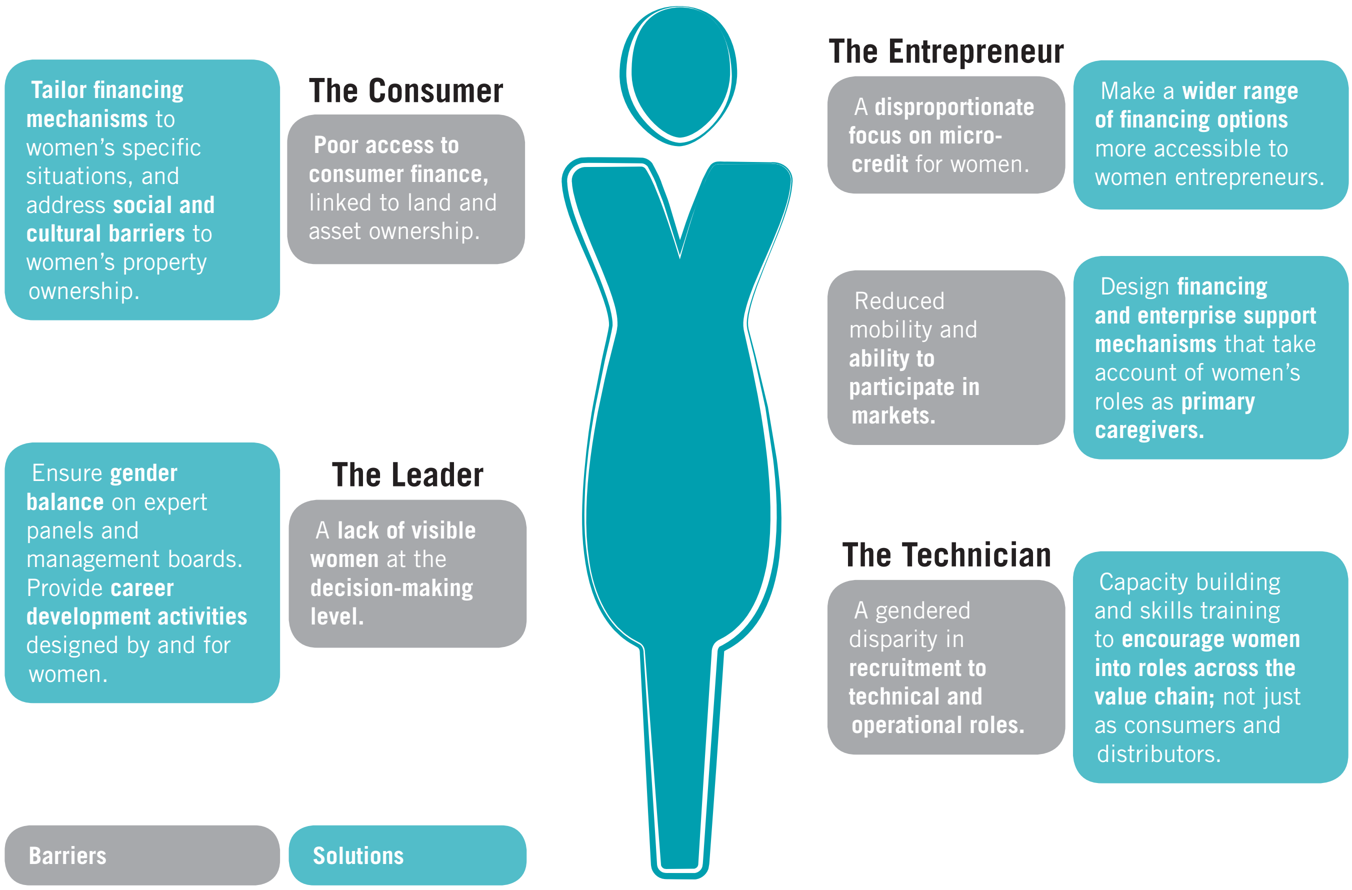


Figure 2.2 Barriers and solutions to women's participation in energy access markets

Conclusion

Adequate finance must flow to the programmes, sectors, and businesses that will accelerate energy access quickly enough to reach universal energy access by 2030. Progress is being made in some areas (such as off-grid lighting and SHSs), but small companies trying to expand their businesses in clean cooking and decentralized renewables still face significant barriers. The finance available needs to be of the right type to be accessible to these stakeholders. Barriers are multiplied for women entrepreneurs, and many current strategies do not address gender issues adequately. While leveraging private finance is important, a key role remains for grant money and public investments, which can in part be used to strengthen capacities to absorb this finance. In Chapter 8 we explore potential solutions, but it is clear that additional money needs to come in a variety of scales and from a variety of donors, at global and national levels.

3. A bottom-up approach to estimating national technology mix and financing requirements

In this edition of the *Poor people's energy outlook (PPEO)* we take a bottom-up approach to estimating the technology mix and financing requirements for achieving universal energy access by 2030. Our work is unique in that it is based on the needs, priorities, and preferences expressed by energy-poor communities in the community energy plans developed for *PPEO 2016*. We consider all households within a community, comprising those clustered near the centre as well as those scattered further away, and we adopt a Total Energy Access framework, which considers energy needs across households, productive activities, and community services.

Methodology for scaling community-based results to the national level

Creating a nationally representative sample

Our model is based on a spatially and demographically representative sample of 95 settlements in each of our case study countries: Togo, Kenya, and Bangladesh. This number of data points allows us to scale up the results to within 5 per cent accuracy. Working with the most recent census data for each country, stratified sampling was used to build the dataset. Countries were divided into regions and again into urban and rural locations, with locations selected randomly within these groups. Locations were the smallest government-recognized area: Union Councils in Bangladesh, sub-locations in Kenya, and cantons in Togo.

For each location, spatial characteristics were investigated and defined. Among these characteristics were village areas, household numbers, and household density. Values were often available from country censuses and, where this was not the case, primary research was undertaken. Population data for Kenya (sub-locations) and Bangladesh (Union Councils) were collected using publicly available information, combined with analysis using online mapping. We reviewed satellite imagery to understand the clustered or dispersed natures of dwellings in these areas, which is a key variable in our economic modelling. For Togo, the case was the other way around, with village data available but data for the Canton level very difficult to find. We therefore manually reviewed satellite imagery to define the sizes, populations, and population densities of the Cantons.

We used geographical information systems (GIS) and a range of publicly available data sets to analyse resource and infrastructure availability for the 95 locations. The most current data available was collected for the following variables: administrative boundaries (level 2, level 3, and level 4); land elevation; electricity grid; major roads; wind speed; solar insolation; waterbodies; biomass land cover type; density of cattle and pigs; production capacity of energy crops. The representative data set was uploaded to a GIS programme, QGIS, and each of the 95 locations was analysed in the context of each of the layers (see Figure 3.1 for an example of a GIS layer). This provided values for each of the variables at the given locations. These values were recorded along with the data on household numbers and density already collected. In some cases the GIS data gave only a proxy, so further work was required to estimate the real nature of that characteristic. For example, cattle heads per square kilometre was used as a proxy for biogas potential.

Our economic model gives technology and financial outputs based on the community characteristics and their demand profiles

Modelling energy demands and least cost of provision

Our analysis involved a demand model and an economic model in a two-step process (see Figure 3.2). The demand model uses profiles of energy demand based on energy service needs for households, agricultural uses, enterprises, and community facilities.[1] The demand profiles also reflect people's technology preferences. The economic model gives technology and financial outputs based on the demand profiles and the characteristics of the communities. The models interact through an iterative process calculating the least-cost means of providing the level and type of energy access required.

There was no scope to create new demand profiles; instead we used the profiles from the four communities per country established for *PPEO 2016* and attributed them to the set of representative locations on a random basis. The four profiles per country cover a

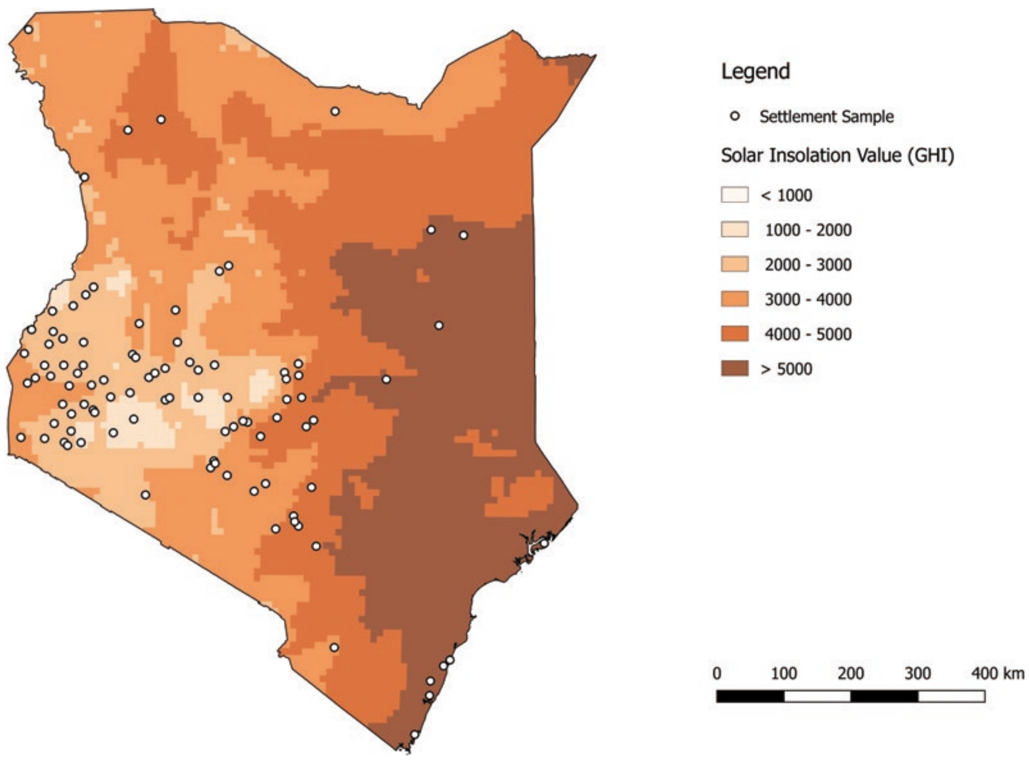


Figure 3.1 Example of a GIS layer – solar insolation in Kenya
Source: SWERA database (UNEP, n.d.)

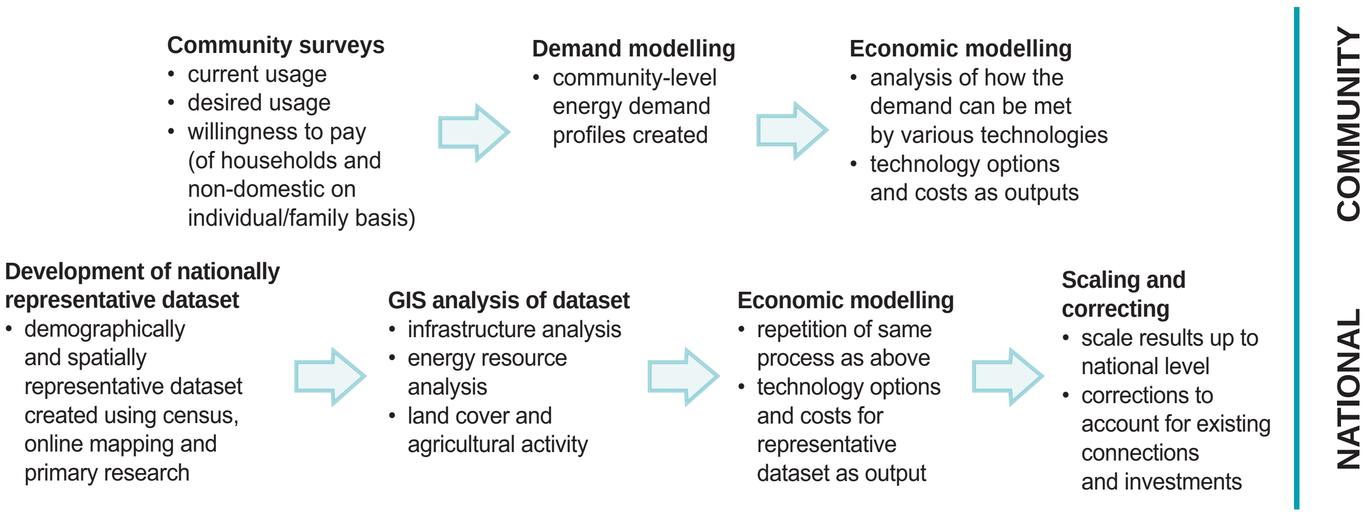


Figure 3.2 Flow chart of PPEO 2017 analysis

variety of demand scenarios, but certainly do not cover the magnitude of variety that exists within each country. As we discovered in *PPEO 2016*, requirements vary considerably from one individual to the next, resulting in a mix of technology preferences and provision required that ranges in quantity and quality (tiers), and in type (distributed or distribution system). We initially assumed a 0 per cent electrification rate from both on-grid and distributed technologies. A correction was then applied to the model to account for existing rates of connectivity.

It is important to note that the modelling exercise does not factor in predictions about the falling price of solar and other distributed technologies, or the improving performance and decreasing price of batteries. Nor does it consider estimates of efficiency gains in energy appliances. These have the potential to make a significant difference to the size of systems required to provide the desired level of energy service. All these factors will drive down the overall cost of provision and favour decentralized energy over grid extension in a higher proportion of cases. On the other hand, our modelling does not account for population growth rates or changing patterns of population distribution, which would drive up the overall cost of provision.

In terms of cooking, models were based on people's preferences of fuels and technologies, but with certain restrictions. Where people chose a traditional fire, we based our analysis on their preferred choice for a Tier 2 or higher solution. Where people chose electricity, we included this only where the cost would be within 10 per cent of liquefied petroleum gas. We compare the costs for these choices, with standardized cooking technologies for all. Our modelling included the cost of fuel. Our finance estimates are for the entire population, without correcting for the numbers already using Tier 2 or above stoves. This is to account for people's preferences, which were often for fully clean solutions.

As a final step, the outputs were analysed and tested. Several scenarios were created which imagined greater and lesser financial contributions from energy users, different attribution of demand profiles, and different starting point electrification rates. User contributions were calculated based on the willingness to pay data collected from the case-study locations in *PPEO 2016*.

Sensitivity of financial results for electricity access

Our model is sensitive to the assumptions on which it is built. One in particular is the proportion of the country already connected to grid electricity and our assumption that this meets their needs. Although some figures for connectivity rates are available, these are not always reliable, as discussed in the country chapters. New national studies applying the multi-tier framework in Kenya and Bangladesh will show the extent to which grid-based energy is in fact meeting people's needs. If large proportions are underelectrified even when they are grid connected, this is likely to have financial and technical implications which will need to be addressed in future studies. Secondly, we needed to make assumptions about the number of SHS and mini-grid connections available in the country for people who are otherwise off-grid, the extent to which they are operational, and the amount of power they supply.

The financial results we report are sensitive to the discount rate applied. This reduces the current value of future money (based on predictions about inflation and other uncertainties). We applied a 10 per cent discount rate for all countries, but reducing this to 5 per cent would increase our financial estimates by a third. We also accounted for savings that can be made in the cost of mini-grids by using diesel–solar hybrid models. Exact figures are difficult to calculate at scale so we therefore applied an average figure of 15 per cent cost savings compared to diesel mini-grids (which are generally cheaper than fully solar systems) because hybridizing both reduces the upfront solar costs and the ongoing costs of buying diesel.

Comparison with other models

A range of models is used by global organizations to predict the least-cost technology mix and to estimate financial requirements for universal energy access. This includes projections in the World Energy Outlook (IEA, 2016a), the World Bank's Access Investment Model tool (IEA & World Bank, 2015), which helps model scenarios according to tiers of electricity access, and the universal electrification access model (UN-DESA, 2017).

Our model includes for differences which have implications for the resulting technology mix and financing requirements. The differences are outlined here, and the implications are discussed in Chapter 7. These differences are all aimed at making energy supply planning more realistic and better matched to the energy demands of the people and communities they are intended to serve.

Bottom-up model of energy demand

The IEA's World Energy Model assumes a uniform energy consumption rate for rural households of 250 kWh per year. The UN-DESA model allows for a choice of energy consumption rates across the five multi-tier framework tiers: 224 kWh per household per year for Tier 2, or 696 kWh for Tier 3, for example.

Our model, on the other hand, relies on the energy demands of communities based on the energy services they would like to use and the efficiency of the appliances available to them. These demand profiles are not based on everyone having the same electricity usage, but on a range of usage across the community, affecting the viability of different technology options. For household uses, our estimates were close to UN-DESA's Tier 3 figure, at an average of 607 kWh/hh/year.

PPEO 2017 is based on the needs, priorities, and preferences expressed by energy-poor communities

Inclusion of productive and community uses of energy

A second important inclusion in our model is energy demand for productive and community uses, which is not part of the UN-DESA model. Energy for productive uses brings significant additional demand, accounting on average for 39 per cent of total electricity demand in Bangladesh, 21 per cent in Kenya, and 11 per cent in Togo. The higher demand in Bangladesh is explained partly by the desire for irrigation pumping (not often a possibility in the communities we surveyed in Kenya and Togo) and by a greater presence of existing rural small industries requiring high-powered machinery.

Sensitivity to geographic spread of communities

Our model is more sensitive to geographic spread in that it recognizes, and accounts for, the fact that a particular geography may have households clustered around village centres, with others more dispersed. Other models do not account for this to the same extent.

Kenya has the most clustered rural settlement pattern, lending itself economically to mini-grids or national grid connections to a greater extent than the other countries. Indeed, in Togo and Bangladesh, more than half the households in off-grid districts are beyond the economic reach of a distribution network (see Table 3.1). Here, the role of solar home systems remains significant.

In Togo and Bangladesh, more than half the households in off-grid districts are beyond the economic reach of a distribution network

Table 3.1 Percentage of unelectrified districts where half or more households are best served with a solar home system

	Togo	*Kenya*	*Bangladesh*
Percentage of unelectrified districts	89%	29%	73%

Inclusion of demand for overlapping products

A fourth unique aspect of our model is its inclusion of people's wish to have solar lanterns as a secondary system alongside connection to a larger SHS, grid electricity, or a mini-grid. These products are relatively cheap, but it is useful to understand the levels of demand and therefore the size of the potential solar

Table 3.2 Solar lantern market size for unelectrified populations

	Togo	*Kenya*	*Bangladesh*
Total no. of lanterns required	0.12 m	2.86 m	1.44 m
Demand per no. of households	1 per 6 HH	1 per 2 HH	1 per 5 HH

lantern market. Demand is greatest in Kenya, with one in every two unelectrified households choosing solar lanterns in addition to other solutions (see Table 3.2). Our analysis focused on districts where people are currently off-grid; however, it is a safe assumption that those who are grid-connected but have unreliable supplies will also likely want solar lanterns, further boosting the market.

Interviews and workshops

Qualitative data were collected through interviews with international and national stakeholders and in-country workshops

Along with the modelling and the quantitative analysis, qualitative data were collected through interviews with international and national (Kenya, Togo, and Bangladesh) stakeholders and in-country workshops. The ultimate objective of this broad consultation exercise was to gather real and credible experiences of energy access financing from key national and international actors.

Approximately 20 prominent international organizations were selected and interviewed, including The World Bank, DFID, Acumen, GACC, UNDP, BMZ, and Shell Foundation. In addition, face-to-face interviews were conducted with government agencies, commercial and cooperative banks, microfinance institutions, small and medium-sized enterprises, NGOs, and private-sector organizations/implementers at the national level. The objective of the interviews was to identify the main challenges and opportunities faced by national players in the energy finance sector, including major risks and possible solutions.

Finally, in each country we held a multi-stakeholder workshop inviting representatives from the government, implementing agencies, the private sector, development banks, and energy researchers and advocates to explore the issues around financing national energy access and to get a realistic picture of the local context. The workshops focused on funding requirements, the main challenges and proposed solutions, and the role of public and private finance in accelerating energy access.

Conclusion

The unique features of our modelling process are that it takes the demand profiles of real communities as its starting point and it encompasses energy needs across households, productive uses, and community services. As with all modelling exercises, it has limitations and is based on a range of assumptions that can have a significant impact on the results. Yet, we are confident that our results are broadly in line with those produced by other, similar, geospatial models (discussed further in Chapter 7). The quantitative results are contextualized by the qualitative assessments of the current energy access scenario at the national level for each country, allowing us to draw robust conclusions about where existing gaps lie and the opportunities to address them.

4. Togo

National context

The energy sector in Togo, particularly for decentralized energy or improved cookstoves, is thin. Even to power its existing grid network, the country is dependent on neighbouring Ghana and Nigeria, importing 79 per cent of its electricity in 2010 (SEforAll, 2012; Bertelsmann Stiftung, 2016). With a population of about 7.8 million, Togo is sparsely populated and the poorest of the three case-study countries. Its gross domestic product per capita in 2016 was $1,500 compared to $3,400 in Kenya and $3,900 in Bangladesh (CIA, 2016). Two-thirds of the population lives in rural areas and food and cash crop production accounts for 47 per cent of GDP and 65 per cent of employment. There is a strong rural–urban divide in energy access in Togo. Densely populated and growing urban areas tend to be connected to the national grid, which runs the length of the country. Rural areas, however, have very low levels of grid electrification and very limited penetration of stand-alone solar systems.

The energy sector in Togo is thin, particularly for decentralized energy and improved cookstoves

Rates of grid connectivity are not clear. At the end of 2015, the electricity distribution company CEET was reportedly serving 294,000 domestic customers (18% of 1.6 million households), with an installed capacity of 1,777 MW (ARSE, 2015; USAID, 2017). In the 2013 demographic and household survey, however, 46 per cent said they had electricity at home (MPDAT et al., 2015). The African Development Bank describes high levels of informal connections from a single meter. We are therefore assuming an effective household electrification rate of 50 per cent.

> Behind each connected household lies at least one other non-declared household. For this reason, the country estimates its rate of access to electricity at 27.62%, despite that those who pay the electricity bills only represent an access rate of 17%. (AFDB, 2015:9)

Around 91 per cent of the population relies on traditional biomass for cooking: firewood accounting for 48 per cent and charcoal for 42 per cent. The health of over 7.3 million Togolese is therefore impacted by exposure to air pollution. An estimated 7 per cent of the population uses LPG as cooking fuel (MPDAT et al., 2015) and some NGO programmes have promoted the local construction of basic mud cookstoves.

National energy policy focuses on the development of renewable energy sources and on increasing the nation's energy security (African Union, 2016). Togo's natural resources are virtually untapped and the impressive solar potential, at 4.6–5.7 kWh/m^2/day, has not yet been harnessed (USAID, 2017).

Modelling national energy access and financing needs

Access to electricity: mix of technologies and costs

It is not cost-effective to extend the national grid

We modelled the least-cost means of delivering electricity access to the 779,000 households that currently have no grid connection (whether formally or informally) or access to a stand-alone solar system delivering at least Tier 2 supply. Many rural communities consist of fairly widely dispersed homesteads and are far from existing grid lines. Our findings suggest it is not cost-effective to extend the national grid further than it currently reaches. It is better to concentrate entirely on decentralized systems and, in particular, on stand-alone solar. Mini-grids would mostly be powered by solar–diesel hybrid systems. There is demand for additional solar lanterns and a high demand for stand-alone solar street lighting, which was prioritized by communities and accounts for only about 7 per cent of the modelled budget (see Figure 4.1).

In our representative sample of cantons, a distribution system would not be viable at all in nearly 40 per cent of cases and all households would be better served with stand-alone systems (see Figure 4.2). Only two sample cantons (4%) would be best connected to the national grid, while in the rest a mini-grid is the least-cost choice. However, these distribution systems (grid or mini-grid) would serve only some of the households in a canton: less than half in most (87%) cases. This highlights the high costs of extending the national grid and of installing distribution systems of any sort in Togo.

The cumulative cost of delivering the energy access plan for Togo to 2030 is $4.9 billion, or $350 million per year (see Table 4.1). Based on people's expressed willingness to pay, we expect user contributions of $1.2 bn, or $89 m per year.

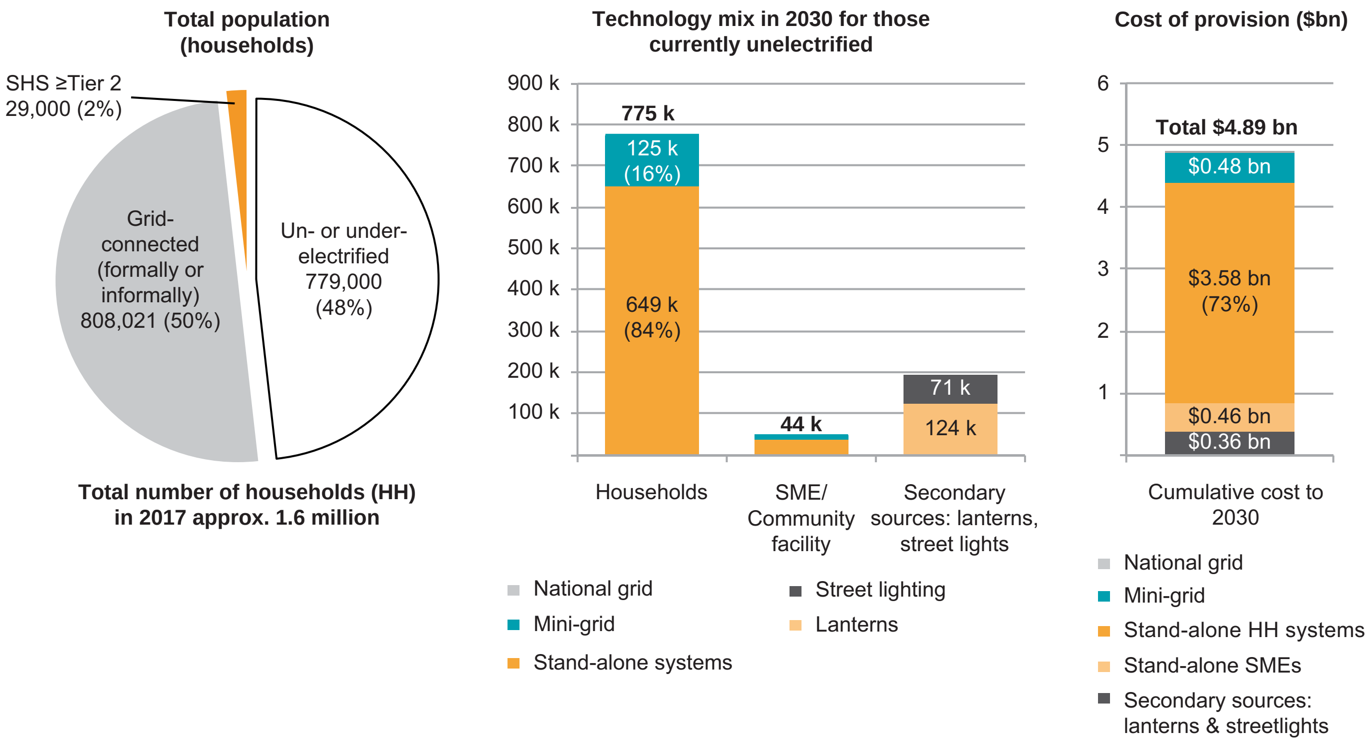


Figure 4.1 Current and future electricity access technologies and breakdown of costs, Togo

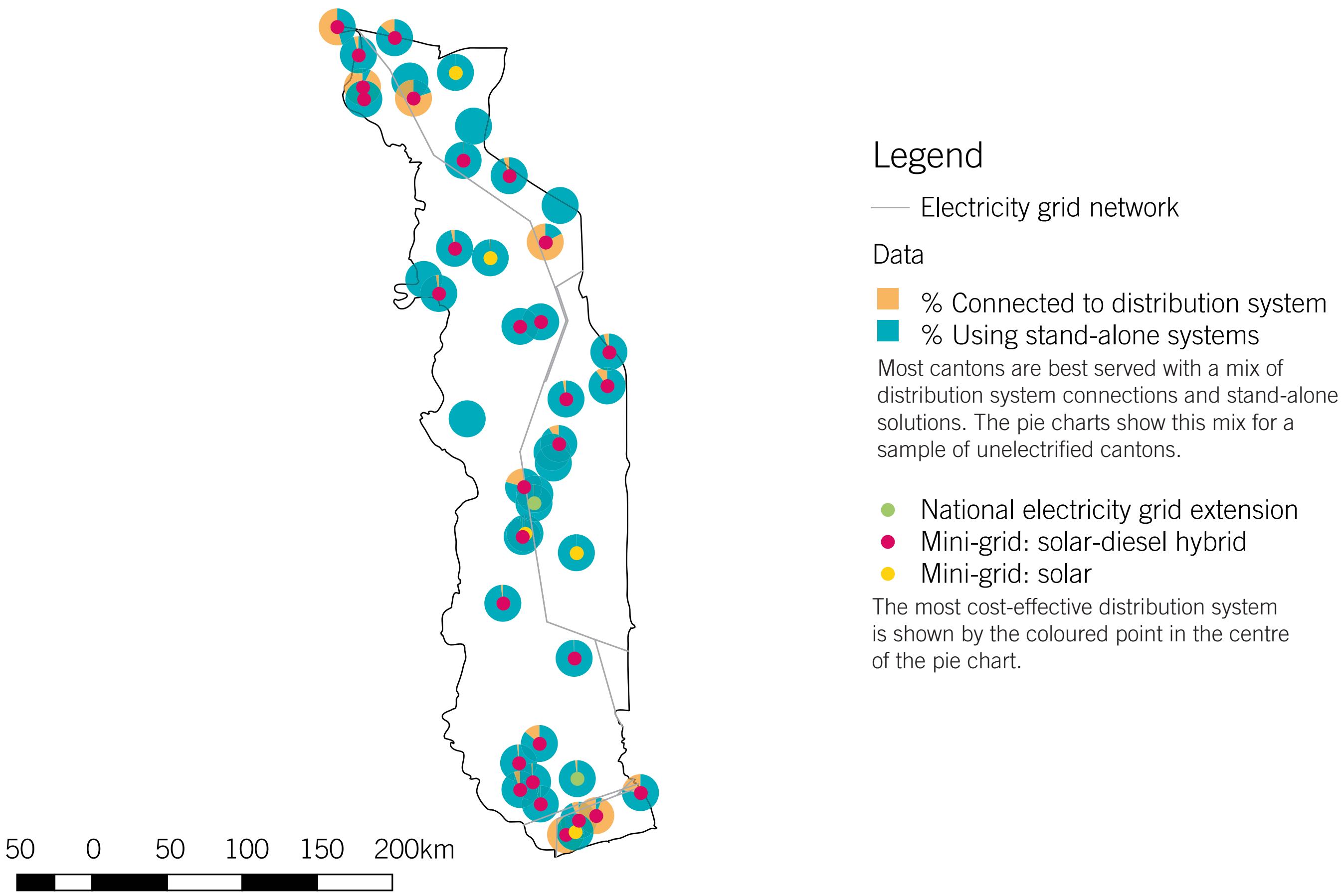


Figure 4.2 Togo forecast of stand-alone and distribution system connections
Note: The locations shown are a representative sample.

Table 4.1 Electrification costs for Togo

Scenario	*Cumulative cost*	*Annual cost*	*Cumulative cost per person currently unelectrified*	*Annual cost per person currently unelectrified*
Without user contributions	$4.9 bn	$0.35 bn	$1,308	$93
With user contributions	$3.6 bn	$0.26 bn	$974	$70

This amounts to $23 per person ($114 per household) per year for those currently without electricity or underelectrified. The remaining financing gap is large, at about $70 per person per year, or $3.6 bn between now and 2030.

Clean cooking: mix of technologies and costs

In Togo, the vast majority of the population cooks using a traditional three-stone stove or a simple mud stove, with just 7 per cent of people using LPG stoves (not necessarily as their primary stove) and very small proportions using electric stoves or solar cookers (see Figure 4.3).

Our *PPEO 2016* analysis found a strong preference for quicker, cleaner cooking solutions. There was a geographic split in our findings with northerly communities more likely to opt for biomass solutions, and those in the centre and south more likely to choose clean-fuel solutions.[1] Forty-seven per cent of the population would ideally like to switch to LPG and over a quarter (28%) would choose an improved charcoal stove. The *PPEO 2016* findings suggested biogas would also be a viable option in some cases and could be cheaper than LPG.

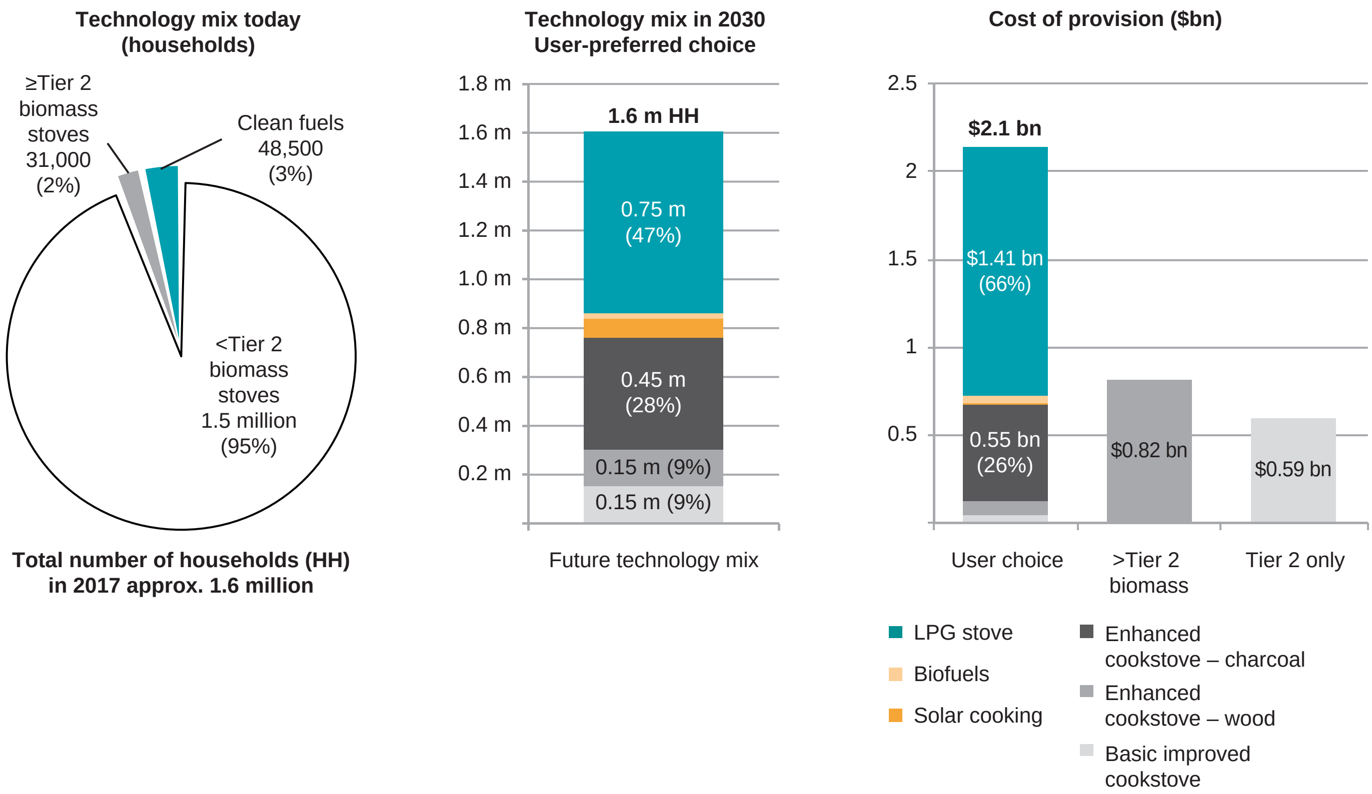


Figure 4.3 Current and future cooking and fuel technologies and costs in Togo

Table 4.2 Clean cooking costs for Togo

Scenario	*Cumulative cost*	*Annual cost*	*Cumulative cost per person*	*Annual cost per person*
Without user contributions	$2.1 bn	$0.15 bn	$275	$20
With user contributions	$0.87 bn	$0.06 bn	$112	$8

The choice of a shift to LPG accounts for 65 per cent of the budget for cleaner cooking. The cumulative cost is $2.1 bn, with an annual required expenditure of $153 m (see Table 4.2). Once user contributions are included, the cumulative cost to 2030 decreases to $869 m with an annual required expenditure of $62 m. Based on willingness to pay figures from *PPEO 2016*, we expect user contributions of $1.3 bn, or $12 pp/year. This is more than the cost of improved biomass solutions for all.

A shift away from traditional cooking methods translates into a significant saving in women's time. People's preferred cooking scenarios would reduce the overall time spent largely by women on cooking, collecting, and preparing fuel by roughly 51 per cent: from 6 hours, 43 minutes per day on average to 3 hours, 15 minutes. Nationally, this adds up to more than 1.86 billion hours annually that could be better spent in other ways.

Energy access financing

Funding for energy access in Togo has been limited, and the majority has been for large-scale grid extension projects. The largest current planned investments ($734 m, approximately 80% of all planned investments) are for new power plants in an attempt to reduce reliance on imported electricity. The balance may begin to change, however, with the recently announced CIZO Presidential Initiative which aims to roll out 300,000 solar home systems over the next five years at a cost of around $117 m. Only very small amounts (less than $0.25 m) have been committed for clean cooking – mostly biogas. To date, most clean cooking programmes have promoted locally made stoves.

> Funding for energy access in Togo has been limited, and the majority has been for grid extension

Few private pico-solar companies operate in Togo and, as yet, no mini-grid company has become established. The situation is largely pre-commercial. Micro-credit is available and some household energy loan programmes exist. Rural households and enterprises struggle to meet the down-payments for more expensive items. Pay-as-you-go systems have recently begun to operate on a small scale.

For community projects, grant funding has dominated, often paying for facilities such as street lighting and energy for churches and schools. Town-twinning schemes have provided some of this. Village elites also contribute their own money and seek donor support to match their contributions.

Challenges and recommendations

Energy access markets in Togo are thin, with few companies operating successfully. Our workshop and interviews highlighted particular challenges in this context, especially in relation to an insufficient supply of finance from either domestic or foreign sources. The local banking sector is not familiar with energy access projects and is not experienced in assessing their viability. Financiers

Box 4.1 The struggle to break through to commercial profitability – EBP-ESL

EBP-ESL is a commercial research centre based in Kara, specializing in different renewable energy technologies including solar PV, wind, and biomass. It runs a solar energy laboratory and manufactures high-efficiency cookstoves, pellets, and briquettes. The EBP-ESL centre has installed over 500 solar systems and completed energy audits for different buildings and various industrial companies.

Since 2014, EBP-ESL has been seeking funding to scale up its operations. An investment of around $600,000 would support the growth needed to see it achieve profitability and move away from reliance on grant funding within five years. Beyond this, the company will be looking for long-term bank loans (patient capital) with concessional interest rates (ideally around 2%). Having struggled to raise this external finance, EBP-ESL lacks the capacity to build the technical and financial viability of its projects.

generally lack awareness of the potential of the market, particularly for clean cooking where willingness to pay compared to costs is strong (especially for cheaper biomass stoves or biogas in some cases). Many small companies still require grant-funded inputs in the first instance. In this pre-commercial situation, enterprises do not have the track record required by lenders.

Regulatory barriers create an atmosphere where investing in the best technologies and approaches is fundamentally unattractive

In terms of consumer finance, microfinance institutions are well represented in the country, but few are involved in loans for energy access. Concerns exist about repayments for purchases which are not seen as 'directly productive', despite experiences in other countries of very good repayment rates. Where financial schemes have been introduced, they have not been well publicized and have had low uptake. The need for collateral for household-level loans, and other barriers for small enterprises, are likely to be even larger hurdles for women seeking finance, although there is very limited research on gender and energy financing in Togo.

To address this situation, the government must take greater action to create an enabling environment to support investments in energy access. This will require explicit targets for decentralized renewable energy, which have been proven to have positive impacts on market potential and growth, in the national renewable energy plan that isbeing developed (Power for All, 2017). A dedicated renewable energy department or agency can spearhead efforts to develop and activate a market for distributed renewable energy in particular. This will involve not only creating energy policy and regulation, but also working with private-sector energy companies, local financial institutions, civil society, and others to jointly build up supply, finance, and demand. Another important action is to standardize and streamline the procedures and practices required for establishing new energy access programmes, which will encourage donors and development banks to support these efforts.

A specific regulatory barrier in Togo is that independent power producers must be authorized by the national regulator and must charge *lower* tariffs than the national tariff. Given that cost-reflective tariffs for any mini-grid company are initially higher than the already subsidized national tariff, this creates an atmosphere where investing in the best technologies and approaches to achieve universal access is fundamentally unattractive. While solar panels are tax exempted, distributed/mini-grid systems still bear high import taxes and value-added tax. Reform is clearly necessary if Togo is to have any hope of universalizing energy access and achieving the dozen SDGs whose success depends on energy access.

In addition to supporting these reforms and the multi-stakeholder market activation work, the Togolese government and donors must fund feasibility studies and start-up grants, and provide training on energy access to government and financiers, and business training to entrepreneurs in the space. Beyond that, some form of subsidy targeting the rural poor is likely needed given willingness-to-pay gaps.

The private sector must also play its part by engaging actively with government to build an appropriate enabling environment for its own work and by supporting government objectives on electrification planning. The private sector can develop and run training initiatives, and can work with existing organizations active in rural areas (most likely NGOs) on energy literacy campaigns. This will build awareness of and potential markets for their products and services outside cities and peri-urban areas.

Collaboration between the government and the private sector is needed to build an appropriate enabling environment

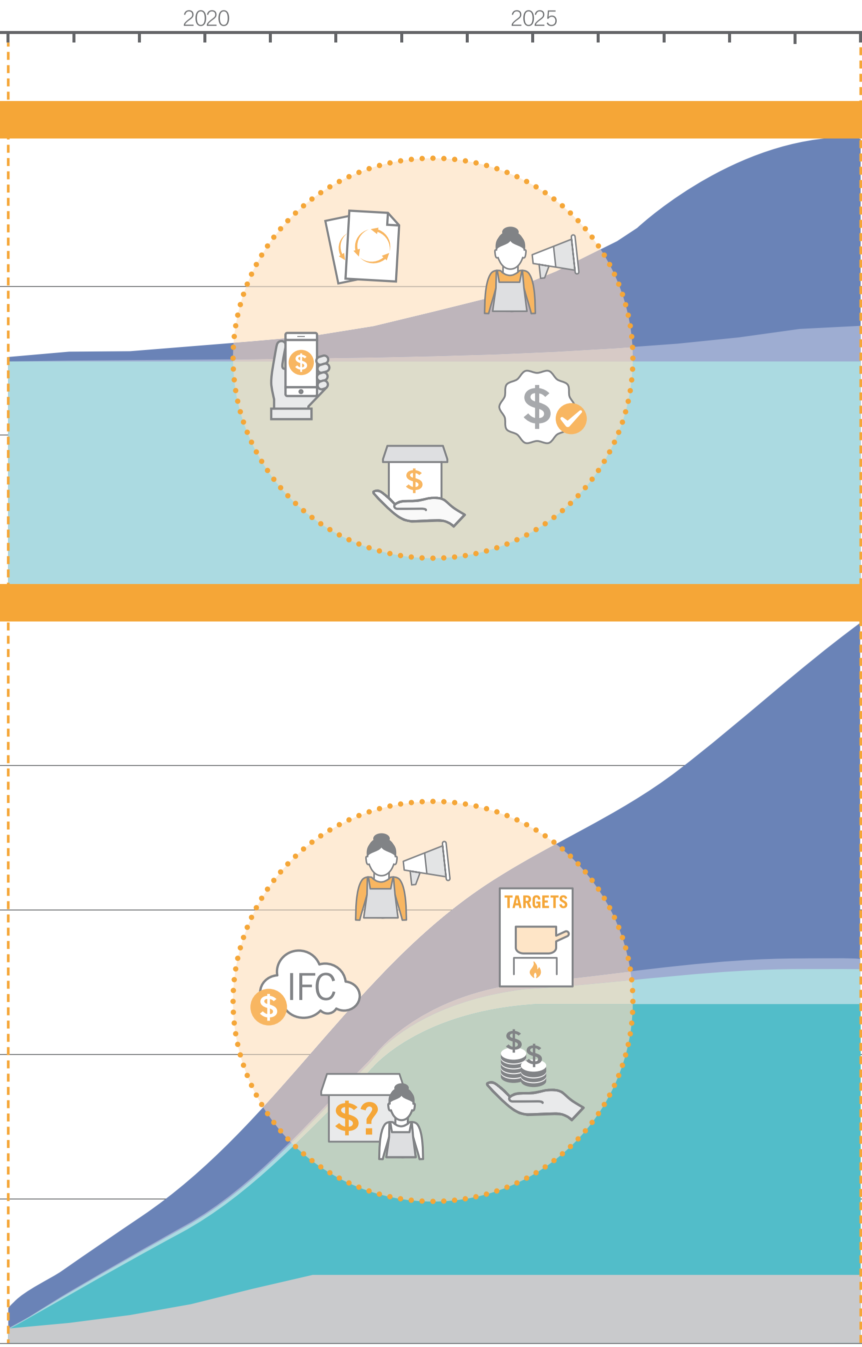
Conclusion: kickstarting energy access financing in pre-commercial markets

Togo is typical of many energy-poor countries in that energy access markets are pre-commercial and levels of affordability are low. The need for smart planning and significant support from the international community cannot be emphasized enough. The new CIZO solar initiative appears to address some of the concerns and challenges raised above by, for example, offering credit guarantees to local banks for the first 10,000 solar kits sold, as well as grant support to help energy enterprises test their business models.

Among our three case-study countries, Togo illustrates most dramatically how taking a customer-based planning perspective will create radically different results than business-as-usual planning. The geography and existing grid system mean all energy solutions are relatively expensive; but nearly universally, decentralized options are the least cost, fastest, and best address the government's concerns for greater national energy security. In terms of clean cooking, the needs are equally immense and the environmental pressures on wood fuel are severe. Initial investments must be made in awareness-raising campaigns and grant funding to kickstart market development in electricity and in clean cooking, leading to a greater pipeline of enterprises that can be nurtured as the enabling environment evolves.

Togo: Energy Access Journey | Recommendations to address and accelerate energy access finance flows

	2017 Household market share	2030 Household market share	Cumulative cost to 2030*
ELECTRICITY GENERATION			
Stand-alone systems	1%	42%	$4.41 billion
Renewable mini-grid	0%	8%	$0.48 billion
Grid extension	50%	50%	$0.002 billion
COOKING METHODS: USER-PREFERRED CHOICE			
LPG cooking	3%	47%	$1.41 billion
Biogas cooking	0%	1%	$0.04 billion
Solar or equivalent technology	0%	5%	$0.01 billion
Advanced biomass cookstoves **wood/charcoal**	0%	38%	$0.62 billion
Basic improved biomass cookstoves **wood/charcoal**	2%	9%	$0.05 billion



FINANCING RECOMMENDATIONS

- Focus on gender mainstreaming and empowerment
- Reduce taxes and charges for DRE products
- Encourage more flexible loan requirements for DRE enterprises
- Promote PAYGO
- Facilitate bundling of projects

- Include national targets for clean cooking
- Introduce targeted subsidies for the rural poor
- Reform collateral requirements for enterprises and consumers
- Facilitate carbon credits and alternative financing mechanisms

Pre-commercial markets need market activation initiatives to encourage private investment and foster opportunities for last mile service delivery.

*including for SMEs, productive uses, street lighting and secondary lanterns

5. Kenya

National context

Kenya's energy access sector is dynamic, with aggressive grid extension plans, a vibrant solar market, and a history of innovation in basic improved biomass stoves which has seen new companies expand their production and sales. Kenya's equatorial location offers exceptional solar power potential with year-round solar insolation at 4–6 kWh/m^2/day (SREP, 2011). In 2015, approximately 470,000 rural households owned solar home systems (IREK, n.d.), this figure increasing by well over a hundred thousand the following year (The Economist, 2016). The 2014 national demographic and health survey found 14 per cent of rural households owned a solar panel (KNBS & GoK, 2015). Large upfront costs for consumers have been eased with innovative financial schemes linked to mobile phone payment systems. Kenya is also one of very few countries to have set energy access targets based on the Global Tracking Frameworks tiered system.

Kenya's growing, dispersed population presents challenges for electrification. While keen to support the burgeoning distributed solar sector, the government's central strategy has been to increase grid connectivity, increasing from 23 per cent in 2012 (1.8 million domestic customers) to 70 per cent in 2017. The subsidised Last Mile Connectivity Project of the Kenya Power and Lighting Company (KPLC) reduces household connection fees and allows for payment in instalments. This programme has achieved significant increases in connections, with 3,138,000 customers added since 2011/12, of which 1,253,000 were connected in 2015/16 (KPLC, 2016).

Recent government policy revisions have improved the clean cooking landscape in Kenya

Comprehensive clean cooking figures have not been recently collected, though in 2014, 56 per cent of households relied on firewood and 17 per cent on charcoal as their primary fuel (KNBS, 2015). The health of well over 36 million Kenyans is therefore affected by exposure to household air pollution and more than 15,000 deaths are attributed to it each year. An estimated 2.25 million households own an improved cookstove (GVEP & ADP, 2012) and LPG is gaining popularity in urban settings (used by 25% of urban households in 2014, KNBS, 2015). Kenya is targeting the uptake of 5 million improved cookstoves meeting a minimum of ISO Tier 3 for air quality standards (ISO, 2012; SEforAll & MEP, 2016) and an increase in clean fuel use to 42 per cent, all by 2020. Recent government policy revisions have changed the clean cooking landscape: removing 16 per cent VAT on LPG and efficient biomass stoves; increasing kerosene costs; reducing import duties on fuel-efficient stoves from 25 per cent to 10 per cent; and removing excise duty on ethanol for cooking and heating (GACC, 2016d).

Children tend to a basic cookstove in their home in Utumoni village, Makueni County
Credit: Practical Action / Edoardo Santangelo

Modelling national energy access and financing needs

Access to electricity: mix of technologies and costs

As of June 2016, KPLC had 4.6 million domestic customers, representing approximately 43 per cent of households (KPLC, 2016).[1] Another 135,000 households (1%) are beyond the grid but use an SHS achieving Tier 2 or higher access (Practical Action, 2016),[2] leaving 5.9 million households (56%) without electricity or under-electrified. Based on Kenyan household and community preferences given in *PPEO 2016*, and the technology mix that would best meet these needs, 27 per cent of those still unelectrified would most economically be served by the national grid (1.6 million households) (see Figure 5.1). Distributed solutions (mostly solar or diesel–solar hybrids) would best serve the remaining 4.3 million households, with 2.3 million through mini-grids and 2.0 million with stand-alone solutions.

An additional 629,000 small enterprises and community facilities need electricity, 57 per cent of which would be best served by the grid. Substantial proportions of households want solar lanterns as well as a connection to a mini-grid or grid electricity. Modelled across the 5.9 million underelectrified households, 2.9 million solar lanterns and 85,000 stand-alone solar street lights are required.

The comparatively densely populated Central and South-Western zones of Kenya are already served by, or are relatively close to, the national grid and hence grid extension is viable for most of these areas. Elsewhere, mini-grids are more economical (see Figure 5.2), especially in densely clustered communities. Stand-alone systems are needed to reach more dispersed households and communities; in 29 per cent of currently off-grid sub-locations, over half the households need SHS.

Table 5.1 shows the cumulative cost to 2030 of universalizing electricity access in Kenya is $26.0 billion, or $1.9 bn per year, with the majority ($15.2 bn) needed for stand-alone systems. Based on people's expressed willingness to pay, we expect

Distributed solutions would best serve 73% of Kenyans who are unelectrified

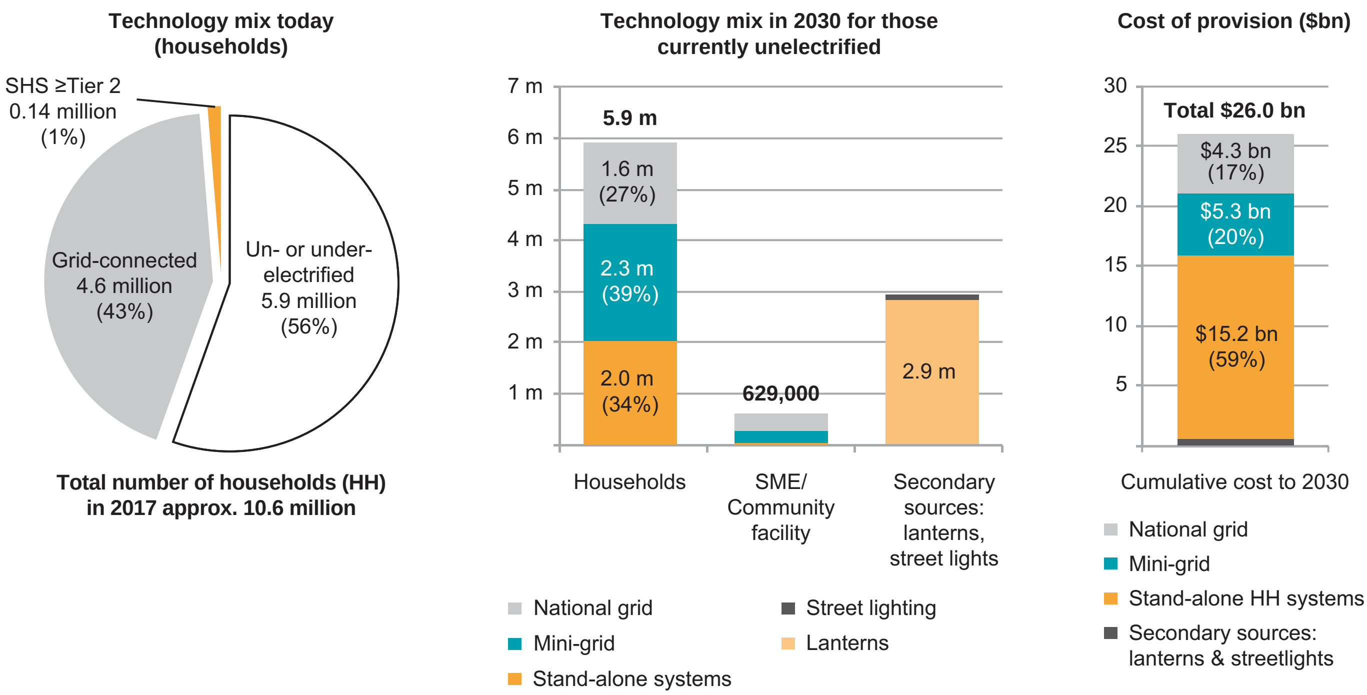


Figure 5.1 Current and future electricity access technologies and breakdown of costs, Kenya

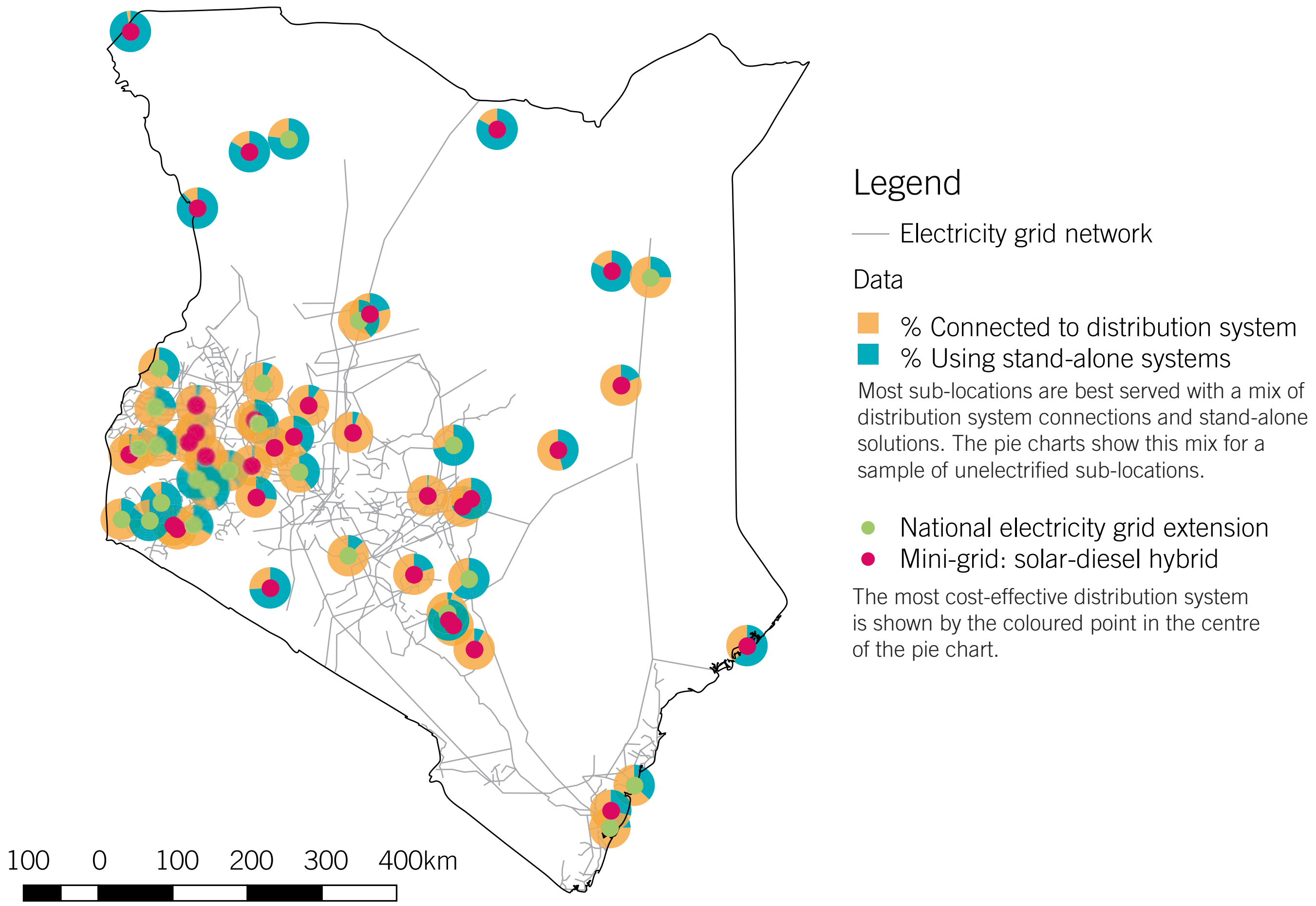


Figure 5.2 Kenya forecast of stand-alone and distribution system connections
Note: The locations shown are a representative sample.

Table 5.1 Electrification costs for Kenya

Scenario	*Cumulative cost*	*Annual cost*	*Cumulative cost per person currently unelectrified*	*Annual cost per person currently unelectrified*
Without user contributions	$26.0 bn	$1.9 bn	$1,011	$72
With user contributions	$17.6 bn	$1.3 bn	$683	$49

user contributions of $8.4 bn, amounting to $23 per person (£103 per household) annually. This leaves a gap of $17.6 bn, or $49 pp/year.

Clean cooking: mix of technologies and costs

Recent figures for cooking fuels and technologies are unavailable, but *PPEO 2016* revealed widespread use of *jiko* charcoal stoves, estimated at 30–40 per cent of households nationally (Winrock International et al., 2011). LPG's popularity is growing in urban areas with wider availability of 6 kg cylinders, but national uptake remains low (12% in 2014, KNBS, 2015) due to high upfront costs. The majority of Kenyans still primarily use basic wood-burning stoves.

The future technology mix is complex with people using a variety of stoves and fuels, depending on the cooking task, availability, and fuel costs (real and perceived) (see Figure 5.3). Our estimates, based on people's preferred choices, highlight the demand for clean fuels, with 47 per cent preferring electricity or

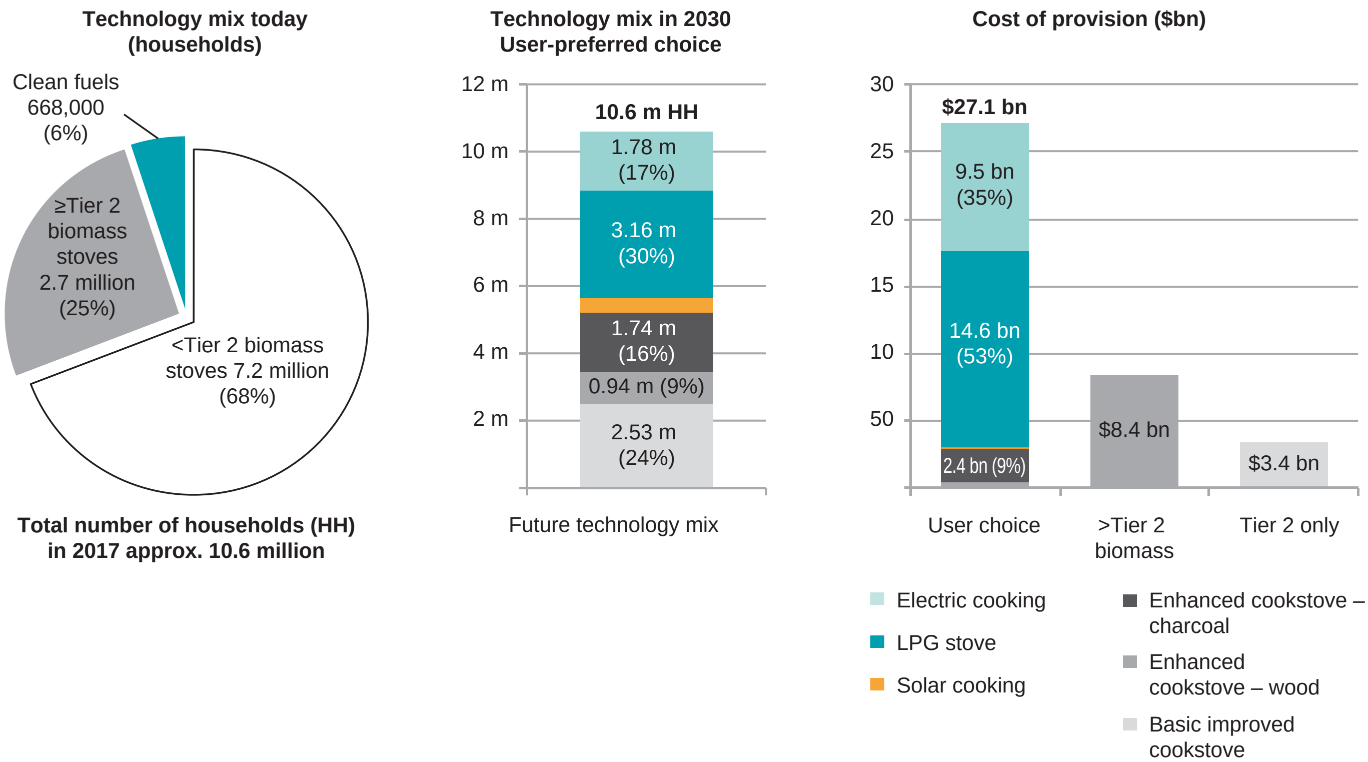


Figure 5.3 Current and future cooking and fuel technologies and costs in Kenya

Table 5.2 Clean cooking costs for Kenya

Scenario	*Cumulative cost*	*Annual cost*	*Cumulative cost per person*	*Annual cost per person*
Without user contributions	$27.1 bn	$1.9 bn	$581	$41
With user contributions	$19.9 bn	$1.4 bn	$427	$31

LPG[3] – relatively expensive choices, with a cumulative cost to 2030 of $27.1 bn (see Table 5.2). Based on figures from *PPEO 2016*, we expect user contributions of $7.2 bn in total, or $11 pp/year.

Biomass solutions cost substantially less: at $8.4 bn for Tier 3 or higher solutions, or $3.4 bn for Tier 2. In both cases, the amount people are potentially willing to pay ($7.2 bn) is near to or exceeds delivery costs, suggesting the best use of public money is to leverage additional private-sector investment targeting clean cooking solutions for rural populations.

A shift away from traditional cooking methods will significantly save women's time. *PPEO 2016* found that adopting people's preferred cooking scenarios would reduce the time households spent on cooking, collecting, and preparing fuel by 45 per cent: from 6 hours per day on average to 3 hours and 18 minutes. Nationally, this adds up to more than 7.6 billion hours annually which could be better spent in other ways.

Energy access financing

Energy access finance in Kenya is dominated by grid improvement and extension, with KPLC recently announcing $2.17 bn of investments over five years (Mutegi, 2016). Grid-connected renewable energy projects have been encouraged through a feed-in tariff and national Green Energy Fund (ERC, 2012). Kenya has also

Energy access finance in Kenya is still dominated by grid improvements and extension

D.light's affordable solar-energy solutions are transforming the way people use and pay for energy in Kenya, and elsewhere
Credit: Practical Action / Edoardo Santangelo

received concessional loans from the Scaling up Renewable Energy in Low Income Countries Programme (SREP), including $25 million for geothermal power generation (CFU, 2016).

Decentralized energy financing has increased, particularly with a $150 m World Bank loan under development for decentralized renewables (the first of its kind) and DFID's £30 m green mini-grids support facility (DFID, 2017). SREP funding has also supported mini-grids[4] and the Kenya Tea Development Agency has secured $55 m from the International Finance Corporation (IFC) for seven micro-hydro plants. Overall, however, committed mini-grid investment probably constitutes no more than $280 m and planned clean cooking investment around just $60 m, both of which are a small fraction of what is needed.

In terms of consumer access to financial services, 11.5 million Kenyans use mobile phone financial services compared to only 5.4 million using the banking sector (SEforAll & MEP, 2016). The ubiquity of mobile money in Kenya has played a central role in the rise of the SHS sector there and is seen as an example to be replicated globally. Indeed, repayment levels for solar product loans are so positive that a large Kenyan bank is planning to make hundreds of millions more dollars available for this type of credit (interview, March 2017).

Challenges and recommendations

The challenges and issues in accessing this finance in Kenya differ from the pre-commercial context of Togo. That said, participants in our stakeholder workshop and the experts we interviewed[5] highlighted many issues common to energy-poor countries: the affordability gap, high perceptions of financial risk, and a local financial system that could do much more for energy access companies and the communities they serve.

Affordability gap

A significant gap remains between energy delivery costs in rural areas and communities' ability to use enough energy and pay sufficiently high tariffs for mini-grid viability. Indeed, even the PAYGO successes have been seen mostly in and near urban and peri-urban areas, with few reaching remote areas.

For mini-grids, project preparation costs can be supported by public investment in, among other things, site identification and prefeasibility studies. The large, planned World Bank investment is a unique opportunity to support this type of work as well as test how to bundle projects together to reduce management and administration costs.

Furthermore, national dialogue is needed on how subsidies can be more equitable, while not distorting markets. Currently, grid expansion and connections are subsidized at significantly higher levels than decentralized energy, including connection and usage subsidies which DRE does not enjoy. Imported generation and storage technologies are not taxed at the moment, but there are suggestions this could be reversed, which would make DRE more expensive still against the heavily subsidized grid.

In the cookstoves sector, carbon credits can reduce product costs at the margin and their administration can be made simpler through companies such as Impact Carbon in Uganda.

National dialogue is required on how subsidies can be more equitable, while not distorting markets

Perception of risks

National sector experts highlighted a range of financial risks not unfamiliar to those involved in the energy access space (political, macro-economic, operational), but noted that even in Kenya – which is seen as a growing success story – a lack of understanding of the sector by financiers means their perceptions of these risks remain higher than is perhaps justified.

The perception of risk varies between the cooking, pico-solar and mini-grid sectors. Mini-grids are capital intensive with high upfront expenditures, taking time to reach profitability as energy use increases. Cookstove companies, on the other hand, which can be seen as simple consumer goods SMEs, are perceived by finance providers as informal, disorganized, and lacking sufficient accounting records. The sector as a whole is regarded as nascent and underdeveloped, resulting in high collateral requirements and interest rates (a problem still encountered by some PAYGO pico-solar companies) (Hewitt et al., n.d.). That said, some cookstove companies are beginning to operate at a different scale and level of professionalism, and have been successful in raising commercial finance.

The perception of risk varies between the cooking, pico-solar and mini-grid sectors

In light of these challenges, local stakeholders recommended greater certainty be provided in the regulatory environment by, for example, revising the feed-in tariff policy to incorporate mini-grids and their potential future grid integration. The lack of transparency about grid expansion plans must be addressed for any investor to have faith their money will not be made worthless when the grid unexpectedly arrives. Streamlined licensing and contracting processes, which are currently time-consuming and onerous, is also urgently required. These are all issues highlighted in the African Development Bank's Green Mini-Grids Strategy for Africa (AFDB, 2017). Similarly, for cookstoves, legitimizing value-chain actors through an accreditation process will improve trust and reduce barriers to finance for quality-certified companies.

Box 5.1 Local finance challenges – Livelyhoods Social Enterprise

Livelyhoods works with youth from slum communities, creating jobs in the distribution of life-changing products – primarily clean cookstoves. The social enterprise seeks grant funding rather than credit, not wanting to accrue further debt until it reaches profitability (within two to three years) and focusing on profitability with sustainability, avoiding aggressive expansion for expansion's sake. It has found debt easier to secure, however, having secured concessional loans (2% interest) averaging $50,000 with a payback period of one year to help cover cash flow.

Among the biggest barriers in attracting further investment is its commitment to employing local talent, perceived as risky by international funders. As a social enterprise, Livelyhoods' objectives go beyond promoting clean energy to encompass youth empowerment and job creation, which can make presenting a coherent strategy and identity challenging. Livelyhoods has found there is little money for distribution, as most funders focus on product or business model innovation. Competition is strong for limited grant funding and Kenya is perceived to be well served already. Each grant funding application drains time and resources.

Barriers in the domestic financial system

Barriers also relate to an insufficient supply of appropriate finance. The pico solar, solar home system and clean cooking sectors have high demands for local currency working capital. With only isolated instances of local currency transactions, local stakeholders reported that the problem was not the cost of capital, but the fact that they could not get it 'at any price'. Companies complain of complex loan processing systems, unrealistically strict criteria, and long delays in assessing loan applications (up to six months). This applies in particular to small companies and is common for improved cookstove companies seeking loans of up to $1 m (Hewitt et al., n.d.). Some have turned to crowdfunding, which works for small sums but cannot provide the necessary capital for scaling.

Consumer finance for small solar products through mobile-enabled PAYGO has been hugely successful in Kenya. The availability of consumer finance for cookstoves, however, is more limited, likely because loan sizes are too low for MFIs and banks but too high for cash purchases (at a maximum of around $15). Scope exists for partnerships and follow-on loans between small-scale solar and cookstove companies. There is clearly a role for government intervention here in building awareness of the availability of credit and PAYGO among consumers in remote areas, as well as supporting access to microfinance for clean cooking options.

Gendered barriers to finance

As in many countries, women as both consumers and entrepreneurs face additional problems accessing finance due to a range of factors, including a lack of credit history and collateral. Recent research indicates that because more women are present at lower levels of cookstove value chains, they are more likely to face difficulties accessing finance (Hewitt et al., n.d.).

In Kenya, a number of programmes have worked to address this and organizations such as wPOWER Hub are gathering evidence across the cookstove and decentralized electricity sectors. Research indicates achieving gender empowerment and accelerated energy access will require greater engagement of women throughout the value chain, not just in last-mile sales (Hewitt et al., n.d.). The government and KPLC have made progress in mainstreaming gender concerns. The government has launched initiatives to support women's empowerment in general, such as the Women's Enterprise Development Fund and the Uwezo Fund for Women and Youth Empowerment. Ensuring a consistent voice for women in energy decision-making is critical and this must be linked to the design of financial instruments.

Box 5.2 Gender mainstreaming in Kenya Power and Lighting Company

In 2010, ENERGIA assisted KPLC to develop a gender mainstreaming plan (Kenya Power, 2010). This included commitments to ensure that women and small businesses are able to obtain electrical connections. Women were included on all decision-making panels, gender training was provided for all staff, progress was made towards a target of 30% women in senior management, and all offices and depots now include safe and hygienic facilities for both women and men. The plan is still being implemented and its impact has yet to be evaluated.

Conclusion: need for long-term investments in mini-grids and clean cooking

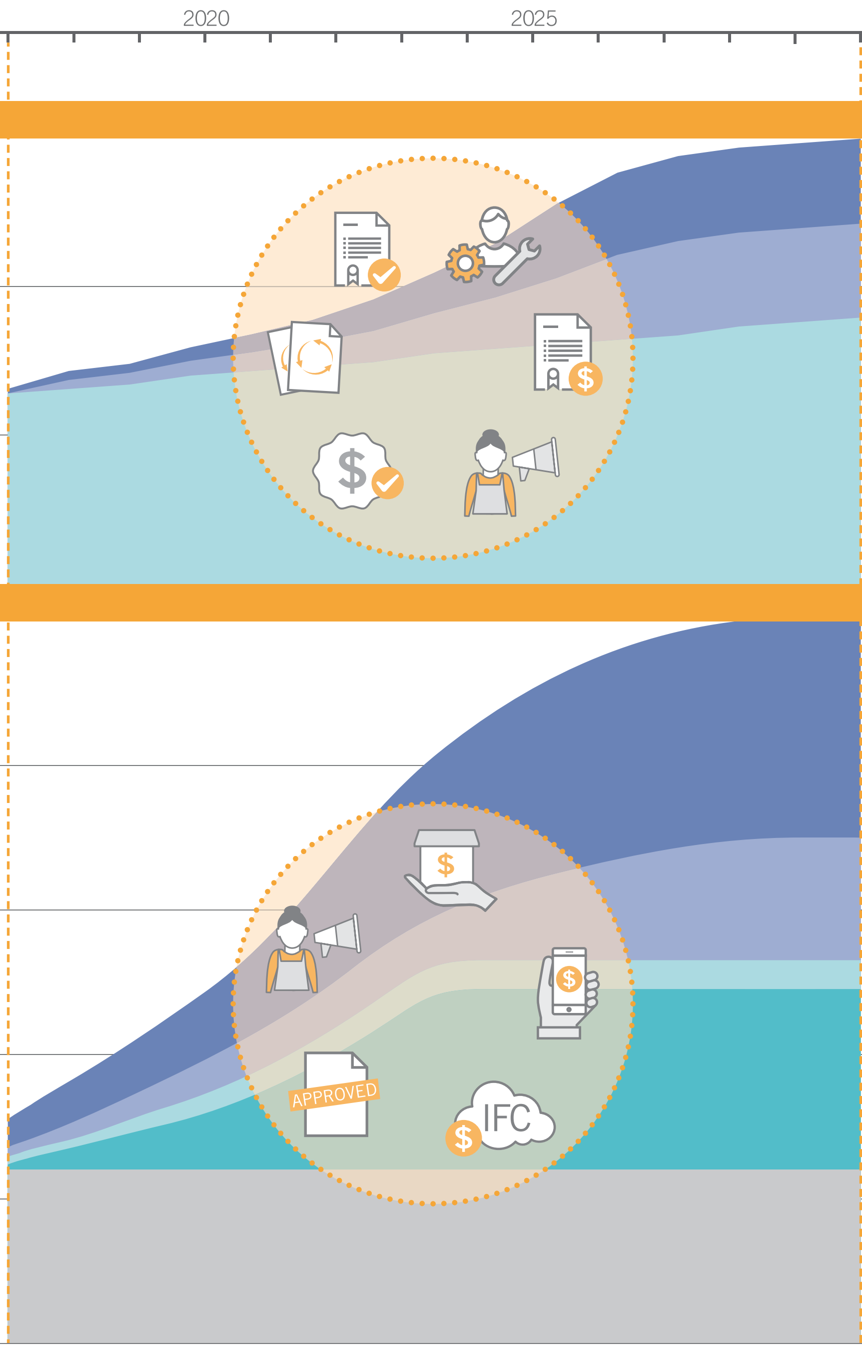
Kenya is renowned for its vibrant household solar market matched with mobile money facilitating consumer credit. Its economy is growing and the government has ambitious plans for energy access. This progress has yet to be matched with significant, long-term investments in mini-grid expansion and the acceleration of markets for clean cooking fuels and biomass stoves. Even the pending first-of-a-kind World Bank loan for decentralized renewable energy represents only a tiny fraction of what will be needed to universalize access in Kenya, but perhaps will be the first step towards that.

Despite the greater focus on gender and energy in Kenya than in many other countries, gendered inequalities in energy access and finance is another hurdle. Finally, despite the recent strong progress and commitments made in grid-based electrification, stand-alone solar products will still make up a large proportion of future energy delivery even where there is a grid connection due to affordability and reliability issues. Working further to ensure these decentralized technologies are affordable and available for the poorest must remain high on the government's and donors' priority lists.

Kenya: Energy Access Journey

Recommendations to address and accelerate energy access finance flows

	2017 Household market share	2030 Household market share	Cumulative cost to 2030*
ELECTRICITY GENERATION			
Stand-alone systems	1%	20%	$16.4 billion
Renewable mini-grid	0%	22%	$5.3 billion
Grid extension	43%	58%	$4.3 billion
COOKING METHODS: USER-PREFERRED CHOICE			
LPG cooking	5%	30%	$14.6 billion
Electric cooking	1%	17%	$9.5 billion
Solar or equivalent technology	1%	4%	$0.08 billion
Advanced biomass cookstoves **wood/charcoal**	1%	25%	$2.9 billion
Basic improved biomass cookstoves **wood/charcoal**	24%	24%	$0 billion



FINANCING RECOMMENDATIONS

- Support project development
- Reform tariff policies for DRE products
- Focus on gender mainstreaming and empowerment
- Reduce taxes and charges for DRE products
- Facilitate bundling of projects
- Standardize project requirements

- Encourage more flexible loan requirements for fuel and stove enterprises
- Expand consumer finance/PAYGO
- Facilitate carbon credits and alternative financing mechanisms
- Streamline accreditation for stove and fuel companies

Ensuring women's participation in energy decision-making and the design of financial instruments will accelerate women's empowerment and energy access for all.

*including for SMEs, productive uses, street lighting and secondary lanterns

6. Bangladesh

National context

Bangladesh is a world leader in the promotion of solar home systems through its Infrastructure Development Company Limited (IDCOL), which has facilitated the purchase of 4.1 million SHSs in rural areas of Bangladesh since 2003. Yet, an aggressive grid expansion programme is putting the future of the distributed energy sector in question.

Government figures estimate that electricity access reached 80 per cent by March 2017 (Power Cell, 2017).[1] Installed generation capacity has increased from 13.5 GW in 2015 to 15.3 GW in 2017 (BPDB, 2017), but this may well not be enough to cater for the demand from new customers. The seventh national five-year plan aims for electricity for all by 2021: the 50th anniversary of independence. Electricity tariffs are low at just 3.8 taka/kWh (US 5 cents) for the first 75 kWh, which is partially subsidized through fuel generation subsidies. The Bangladesh Power Development Board (BPDB) also incurs consistent losses that are covered by the government (Mujeri et al., 2014).

The role the government has envisaged for distributed renewable energy appears to be changing in Bangladesh

The IDCOL programme grew steadily since its inception, peaking in 2013. The programme works by providing low-cost financing to partner organizations (POs), primarily SHS companies, which then offer affordable payment-by-instalment to customers. IDCOL also provides a small subsidy to its POs for systems below 30-watt peak, which is transferred to customers (IDCOL, 2017).

Recently, however, the role the government has envisaged for distributed renewable energy appears to be changing. The IDCOL programme is facing threats from rapid grid expansion, competition from unregulated operators, and the government's social security *Kabikha* (food-for-work) programme, which has begun free SHS giveaways, undermining the SHS market. SHS installation rates under IDCOL fell to 8,000 per month in late 2016 from a monthly peak of 85,000 in November 2013. Repayment rates have plummeted and employment in the sector is decreasing with reports of POs laying off up to half their staff. To address these risks, IDCOL has tasked its POs with disseminating SHSs under the *Kabikha* programme and introduced PAYGO nationwide from March 2017 (Groh, 2017). This change is daunting, requiring a large shift in longstanding operations and user behaviour.

More than 90 per cent of Bangladeshis use solid fuels for cooking (SEforAll, 2015b), meaning that household air pollution affects the health of more than 137 million people and has led directly to an estimated 78,000 deaths annually. Improved biomass stove penetration is very low, with just over 510,000 thought to be in use. Biomass is the dominant cooking fuel, with rural populations mainly using crop residues (45.6%) and wood (44.3%) (MPEMR, 2013). The clean cooking Country Action Plan targets 100 per cent improved cookstove use by 2030, requiring the dissemination of at least 30 million stoves (MPEMR, 2013). There have recently been calls to bring this forward to 2022.

In our PPEO 2016 research, just one in 253 households surveyed in Bangladesh had a manufactured stove
Credit: Practical Action / Edoardo Santangelo

Modelling national energy access and financing needs

Access to electricity: mix of technologies and costs

Due to discrepancies among sources, for our model we assumed 21.7 million households are grid connected (72%) and that, of the 4.1 million SHSs, approximately 35 per cent reach Tier 2 in terms of their capacity (around 1.3 million)[2] and 10 per cent are non-functional (based on the *PPEO 2016* survey). This leaves 24 per cent of the population, or 7.2 million households, without electricity at all or underelectrified.[3]

Based on household preferences and the technology mix modelled for *PPEO 2016*, we estimated 34 per cent of those unelectrified or underelectrified can most economically be electrified via the national grid (2.4 million households). Grid expansion for the remaining 4.8 million is uneconomical and they will be best served with distributed solutions. Our modelling found 95 per cent of these (or 4.4 million households) will be best served through stand-alone solutions and 5 per cent through mini-grids.

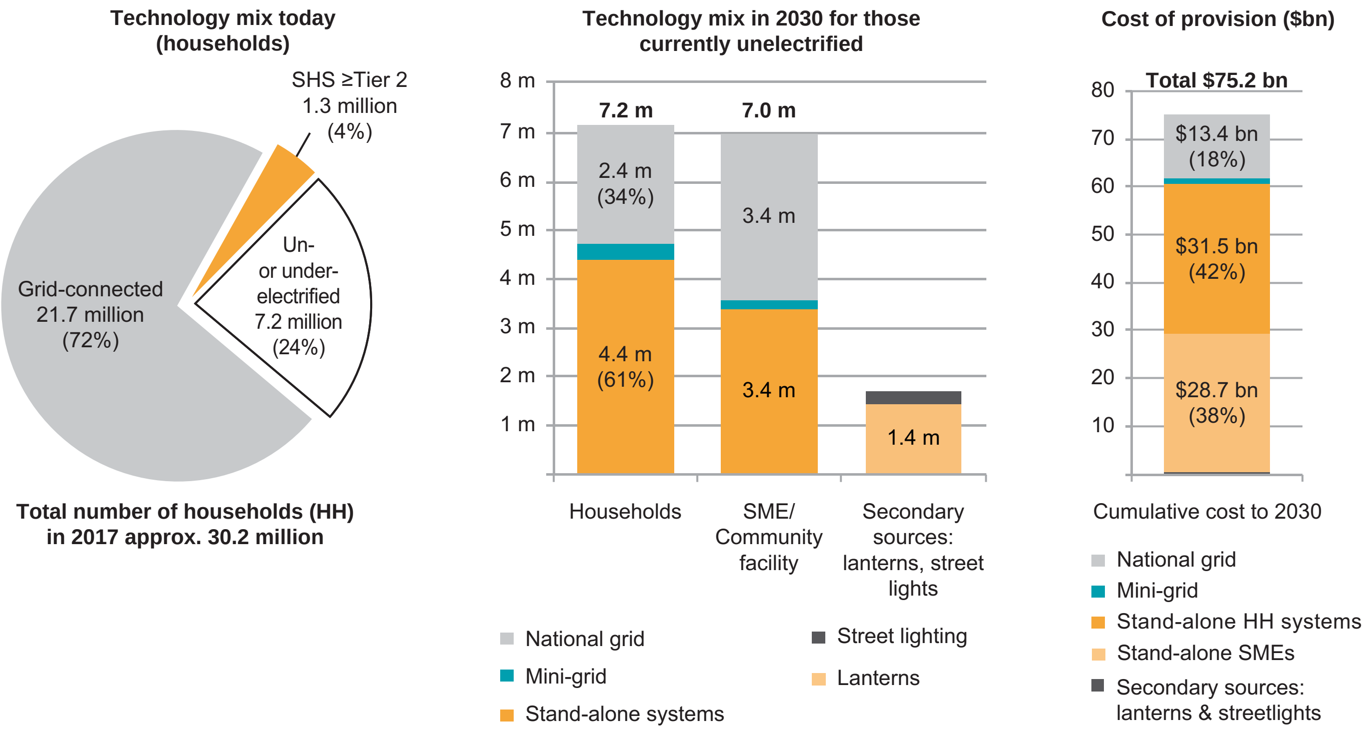


Figure 6.1 Current and future electricity access technologies and breakdown of costs, Bangladesh

Table 6.1 Electrification costs for Bangladesh

Scenario	*Cumulative cost*	*Annual cost*	*Cumulative cost per person currently unelectrified*	*Annual cost per person currently unelectrified*
Without user contributions	$75.2 bn ($37.7 bn excluding SMEs)	$5.4 bn ($2.7 bn excluding SMEs)	$1,874 ($940 excluding SMEs)	$134 ($67 excluding SMEs)
With user contributions	$62.1 bn ($31.2 bn excluding SMEs)	$4.4 bn	$1,548	$111

Many households choose to own stand-alone systems despite having a grid connection

In addition, we found that there is demand for almost as many connections for other uses as for households – for powering small businesses, agricultural appliances, and community facilities (7 million),[4] and for stand-alone solar street lights (238,000). This is significantly higher than in Togo or Kenya.

Moreover, numerous households choose to own stand-alone systems despite having a grid connection, probably linked to inadequacies of the grid as it is today. Power shortfalls on the grid are expected to continue as generation capacity fails to keep pace with new grid connections. Nationally this would mean an additional market for an impressive 1.4 million solar home systems.

Bangladesh has a population of around 169 million people (30.2 million households) – the highest population density of any non-island nation (World Bank, 2017b). Despite this overall density, rural villages tend to have a less clustered settlement pattern than in many other nations. All our sampled off-grid locations could viably use a distribution system with 85 per cent most economically connecting to the national grid (see Figure 6.2). However, dispersed settlement patterns mean that in the majority of cases (73%), only half the households would connect to the grid or mini-grid and the other half would most viably use SHSs.

The total cost of this provision on a cumulative basis to 2030 is $75.2 billion, or $5.4 bn per year (see Table 6.1). Nearly half of this comes from higher powered stand-alone systems for rural enterprises and productive uses. Based on people's expressed willingness to pay, we expect user contributions of $13.1 billion, amounting to $23 pp/year ($134 per household). A large financing gap remains of

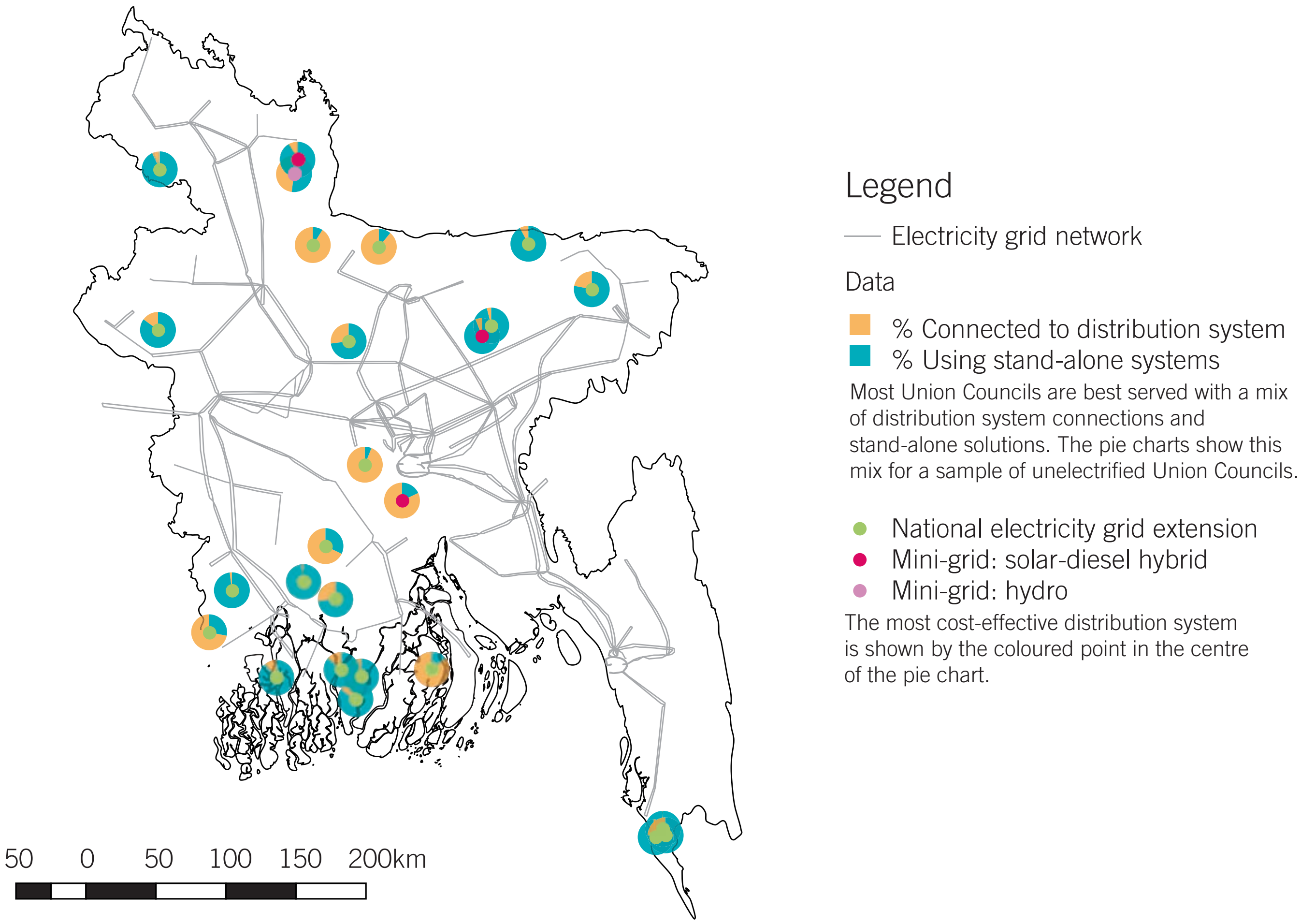


Figure 6.2 Bangladesh forecast of stand-alone and distribution system connections
Note: The locations shown are a representative sample.

about $111 pp/year, or $62.1 billion to 2030. Even excluding the costs of supplying SMEs, the gap is $31.2 billion.

Clean cooking: mix of technologies and costs

An estimated 27 million households in Bangladesh still primarily use poorly performing biomass stoves to cook. The use of LPG has grown, with 9 per cent of households using it as a primary fuel.[5]

Our *PPEO 2016* analysis found a low awareness of the benefits of clean cooking, with nearly half the respondents in two of the communities preferring to stick with their current (unimproved) stove. Our model, however, calls for an improvement to at least Tier 2 biomass stoves. In some locations, preferred choices were not feasible because of resource constraints, such as lack of access to LPG or insufficient livestock (cattle) ownership for biogas (van Nes et al., 2005).[6]

The preference for clean fuels is reflected in a very high cumulative cost for cooking energy access at $57.3 bn with an annual required expenditure of $4.1 bn (see Table 6.2). Willingness to pay for clean cooking is very low, at only $2 pp/year, compared to $23 for electricity.

A shift away from traditional cooking methods allows a significant saving in women's time. Moving to people's preferred cooking scenarios will reduce the time spent largely by women on cooking, collecting, and preparing fuel by roughly 47 per cent each week, from 5 hours, 40 minutes to 2 hours, 45 minutes. Nationally, this adds up to more than 22.6 billion hours annually that could be better spent in other ways.

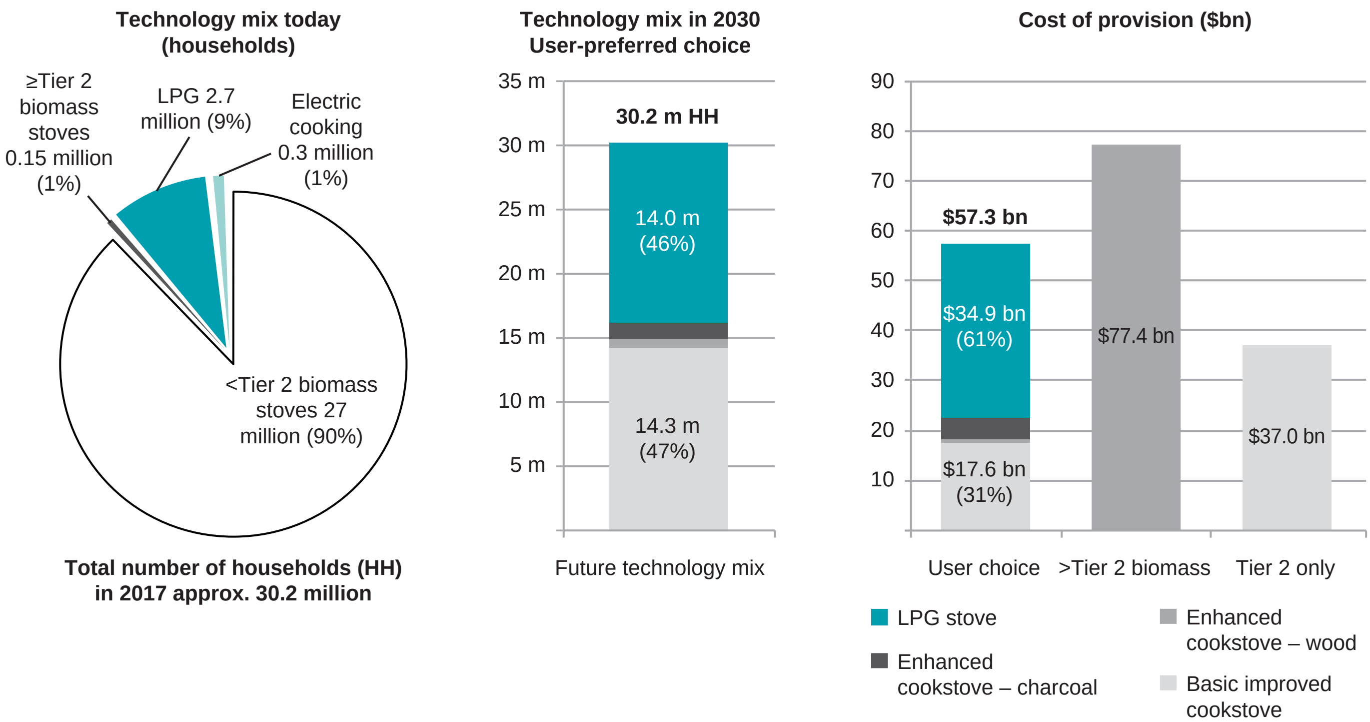


Figure 6.3 Current and future cooking and fuel technologies and costs in Bangladesh

Table 6.2 Clean cooking costs for Bangladesh

Scenario	*Cumulative cost*	*Annual cost*	*Cumulative cost per person*	*Annual cost per person*
Without user contributions	$57.3 bn	$4.1 bn	$339	$24
With user contributions	$51.6 bn	$3.7 bn	$305	$22

Energy access financing

In the last decade, the energy access sector in Bangladesh has gained a tremendous amount of attention, attracting new initiatives and additional funding. Coordination and harmonization remains a challenge. Our review of existing funding programmes indicates huge investments in grid expansion (some $1.2 bn planned). Investments in SHS programmes total around $340 m, largely from the World Bank under the RERED II project 2013–2018, which includes a $46 m component to disseminate 1 million improved cookstoves. Only around $4.5 m is planned for mini-grid investment.

Challenges and recommendations

Solar home systems

Supply of finance is seen as less of a problem in Bangladesh than in other countries

Bangladesh has one of the largest small-scale solar markets in the world, but there are still challenges restricting greater private-sector investment. Our engagement with sector stakeholders suggests these relate primarily to the unattractiveness of investments due to low and slow returns coupled with high capital costs, with the overall supply of finance surprisingly seen as less of a problem than in other countries. Finance in the SHS market is largely controlled by IDCOL and competition among partner organizations has historically kept customer interest rates down. This system is now being threatened as customers see others paying less for cheaper, lower quality systems, and receiving systems for free through the *Kabikha* programme.

The stakeholders we consulted strongly urged the government to reconsider its vision for the SHS industry. Given the well-established status of the SHS sector in Bangladesh, the avenue for achieving the best results is for the industry and government, informed by consultations with rural communities on their wants and needs, to consider how to affordably and quickly achieve their joint objective of bringing affordable and reliable energy services to all Bangladeshis. Linking this more closely with the off-grid energy needs of rural small industries and agriculture is a vital component of this vision.

Mini-grids

While many tea plantations and other established rural commercial entities own captive mini-grids for their own consumption, only a handful of mini-grids serving the public exist. For potential rural electrification mini-grid developers, financial risks are perceived as high, making unrealistically short repayment rates and high interest rates impassable barriers. Furthermore, there is essentially zero appetite to invest while the current grid expansion programme continues. Simultaneously, the very low but highly subsidized grid electricity tariffs mean consumers are unlikely to be willing to pay cost-reflective tariffs for mini-grid power.

Highly subsidized grid tariffs have led to an unwillingness to pay cost-reflective tariffs for mini-grids

For the few mini-grid developers that have entered this market, most have struggled to find skilled personnel for installation, operation, and maintenance tasks. This is not the case for SHSs, where robust technician training programmes exist. The largest, Grameen Shakti, has taken a leading role in training women technicians to install and repair SHSs as well as other accessories and appliances through its 'Grameen technology centres' (Khandker et al., 2014).

In relation to mini-grids, key local stakeholders we consulted recommended:

- simplified licensing and permitting systems as part of an overall streamlining of the regulatory framework;
- de-risking tools, such as loan guarantees and political risk insurance, offered by donors and concessional financiers;
- transparent and realistic plans for grid expansion;
- support of local financial institutions to lend more to off-grid energy products beyond SHSs, particularly by raising awareness of the sector's potential and market; training local financiers on how to structure deals for energy SMEs; bundling of productive tools and appliances (e.g. solar water pumps, grinding mills) as part of broader agricultural loans; and introducing interest rate subsidies similar to those offered for SHSs.

Clean cooking

Energy access policy and financing attention has been overwhelmingly focused on SHSs in Bangladesh. The cookstoves sector is small, though there are now a handful of local companies manufacturing higher tier biomass stoves, the largest of which has a monthly production capacity of 3,000 stoves. Some cookstoves programmes have been able to access carbon finance, but this has not been a major financial contributor thus far. GACC notes that small manufacturers' challenges overwhelmingly are around working capital and marketing investments required to build consumer awareness and demand for their products – an area where many SMEs lack experience and expertise (Accenture, 2012).

Entrepreneurs feel the government should invest in market activation strategies to help boost demand and support the growth of emerging businesses throughout the value chain in clean cooking. This could involve raising consumer awareness and demand through energy literacy programmes, while also building the business skills and capacities of companies. Working capital is a priority for existing producers, as well as grant and equity capital, and will pave the way for the hundreds of additional small businesses needed to create a thriving market of financially viable clean cooking companies.

Entrepreneurs are urging the government to invest in market activation strategies to boost demand for clean cooking

Box 6.1 Struggling to diversify into the mini-grid sector – Rahimafrooz Renewable Energy Limited

Rahimafrooz Renewable Energy Limited is a leading SHS installer and a key partner organization for IDCOL. As well as supplying over 100,000 domestic installations, RREL provides systems for agriculture, health care, education, telecommunication, rural streets, marketplaces, and government and private institutions.

The company has a strategy of diversifying its customers and products and is a pioneer in providing solar-hybrid solutions for telecom operators' BTS towers and for solar-powered irrigation systems. It is also expanding its operations in mini-grids and biomass and solar-powered cookstoves. It wants to develop and improve its solar manufacturing and assembly plant.

The company is facing a range of financing challenges. For mini-grids, it is struggling to access finance at affordable rates and with a long enough payback period. Even in its established SHS business it feels there is an insufficient rate of return, compounded by low ability (or willingness) of rural populations to pay for energy services.

RREL would like a better subsidy system, clearer policies for mini-grids, and support for charging cost-reflective tariffs. Their costs could be reduced by, for example, reduced taxes, loan guarantees, and a reduction in the interest rate charged to IDCOL partners.

Gender and energy access finance

Energy access policy remains gender blind

Segregated, gendered household roles in rural areas are the norm in Bangladesh and are likely to remain relatively static, meaning differentiated energy access needs between men and women will be the norm in the foreseeable future. Overall energy access policy remains gender blind (Winther et al., 2016), however, with no specific governmental efforts to mainstream gender concerns. While much of Bangladesh's microfinance sector focuses on women (Esty, 2014), who constitute the majority of borrowers, SHS loan agreements through IDCOL are made with household heads, who are mostly men. While this removes an element of control from women in regards to energy, there is evidence that introducing an SHS reduces household expenditure on other items, such as kerosene (Khandker et al., 2014), potentially leaving women with additional disposable income.

This complex picture is simply more reason to better understand, target, and address the gendered dimensions of energy in Bangladesh. Donor support is required to push for gender audits of energy policies and regulations, which must be not only gender aware but also explicitly address inequalities and the differentiated needs and priorities of women and men. This is particularly important for investments in productive uses of energy and for accelerated progress on clean cooking fuels and technologies.

In Bangladesh women require different energy services than men, according to their differing productive roles
Source: Practical Action / Edoardo Santangelo

Conclusion: ongoing focus needed to maintain successes

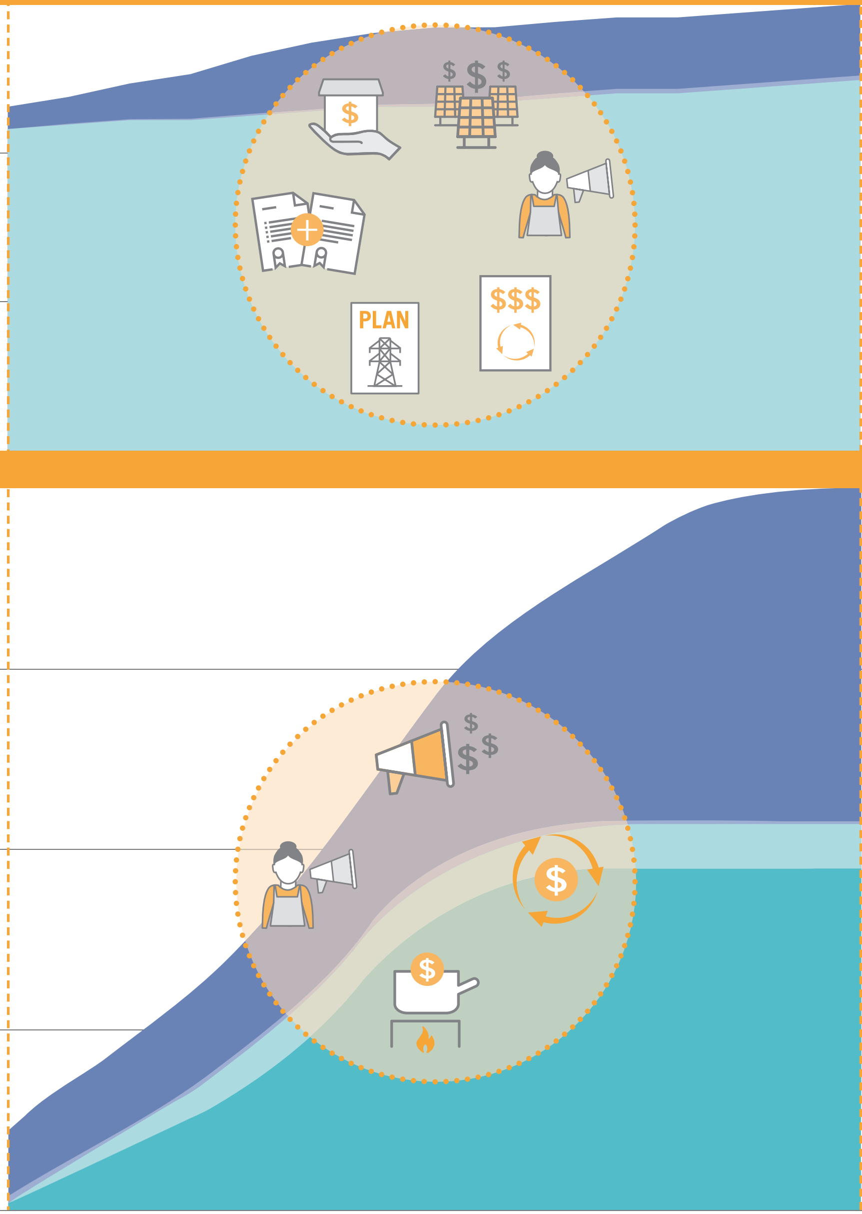
Bangladesh is a pioneer in its efforts to improve energy access, and other countries have been keen to learn from, and indeed replicate, the success of the IDCOL SHS programme. However, while the government and donors still support IDCOL, they are simultaneously, and counterintuitively, undermining it by supporting giveaways and universal grid electrification plans that are neither realistic nor economic for millions of people in remote areas, and furthermore will overstretch already heavily burdened generation capacity. Bangladesh's laudable goal of achieving meaningful universal access by the 50th anniversary of its independence is possible. But it will require a mix of technologies and approaches, with decentralized renewable energy, in particular SHSs, being the most economical and fastest way to reach many households even in the context of an extensive national grid. A renewed national discussion and vision for the off-grid electrification sector is needed, clarifying the regulatory framework for mini-grids and integrating more closely with the agricultural sector and the needs of small rural industries.

The government and donors are undermining IDCOL by supporting giveaways and uneconomic grid plans

Access to grid electricity will not change dangerous and time-wasting cooking practices. Nor will it provide the opportunities for women's empowerment that are possible by thinking carefully about the gendered aspects of energy and embedding the bottom-up needs of energy-poor communities in energy planning. To meet people's needs and aspirations for clean cooking, an investment of a similar magnitude to that of electricity is required, and the lack of attention and finance to date on this issue must be urgently reversed. Radical increases in government, donor, and impact investor support is required to activate the enormous clean cooking market potential in Bangladesh which, if successful, will also unlock tens of millions of hours of women's time to undertake further, potentially economically productive, activities.

Bangladesh: Energy Access Journey | Recommendations to address and accelerate energy access finance flows

	2017 Household market share	2030 Household market share	Cumulative cost to 2030*
ELECTRICITY GENERATION			
Stand-alone systems	5%	19%	$60.8 billion
Renewable mini-grid	0%	1%	$1.0 billion
Grid extension	72%	80%	$13.4 billion
COOKING METHODS: USER-PREFERRED CHOICE			
LPG cooking	9%	46%	$34.9 billion
Electric cooking	1%	0%	$0 billion
Advanced biomass cookstoves **wood/charcoal**	0%	6%	$4.9 billion
Basic improved biomass cookstoves **wood/charcoal**	1%	47%	$17.6 billion



FINANCING RECOMMENDATIONS

- Reform financing system for mini-grids
- Focus on gender mainstreaming and empowerment
- Integrate energy and agriculture financing
- Devise a clearer grid extension plan
- Reduce policy conflicts on energy-for-work
- Increase government loan guarantees

- Fund awareness campaigns for clean cooking
- Facilitate working capital finance for stove enterprises
- Encourage microfinance for clean cooking

Reviewing market support mechanisms will encourage greater innovation as the sector continues to evolve.

*including for SMEs, productive uses, street lighting and secondary lanterns

7. National implications of community-driven planning

Energy planning based on the needs and priorities of rural communities, rather than standard planning approaches, results in a different, more appropriate mix of technologies. In this chapter we explore the added value of community-driven planning and the fresh insights it gives across the very different contexts of Togo, Kenya, and Bangladesh.

Unique aspects of the PPEO model

Our approach to modelling energy access at the national level differs in fundamental ways from approaches such as the IEA's World Energy Model and UN-DESA's Electrification Modelling tools (IEA, 2016b; UN-DESA, 2017). Four key differences were outlined in Chapter 3, including: a bottom-up approach to understanding energy demand; the inclusion of energy for productive and community uses;

sensitivity to geographic spread; and the inclusion of demand for additional stand-alone products alongside connection to a larger SHS, grid electricity, or mini-grid. These differences have important implications for the national technology mix and how well it responds to the needs and aspirations of rural communities.

Resulting technology mix

While in our modelling, the average level of electricity consumption is nearer to Tier 3, our results in terms of technology mix are nearer to the Tier 2 service levels modelled by UN-DESA, resulting in a cost estimate lower than UN-DESA's Tier 3 estimates. This is the result of the geographic granularity of our model that accounts for dispersed households, giving a higher proportion of stand-alone systems. At higher levels of consumption, the UN-DESA model finds that it is worthwhile to extend the national grid, while our cost estimates (which included solar–diesel hybrid mini-grids not modelled by UN-DESA) found mini-grids to be cost-competitive (see Figure 7.1).

Our more realistic demand assessments, factoring in productive uses, also boost the viability of these electricity access choices. The potential for productive uses to boost incomes, which in turn can pay for electricity, is critical in planning for future national energy systems. Higher electricity usage helps to bring down the average cost per kWh on mini-grids to lower than the cost of stand-alone systems per kWh. Our model illustrates the fundamental importance of paying detailed attention to energy demand, to appropriately inform technology mix.

> The potential for productive uses to boost incomes, which in turn can pay for electricity, is critical in planning for future national energy systems

Technological advances in decentralized renewable energy mean that people could have electricity access now if the enabling conditions were right for such technologies to be financed, delivered, and appropriately operated and maintained. Due to radical increases in appliance efficiencies and DC product development, even limited amounts of power can now deliver more high-quality energy services, including for many rural productive activities. At the same time, there is growing potential for multiple SHSs to be interconnected and to extend this power to unelectrified neighbouring households. These 'swarm' electrification systems make smarter use of all the power generated, allowing SHS owners to use and sell electricity at the micro-level and even potentially feed into the national grid

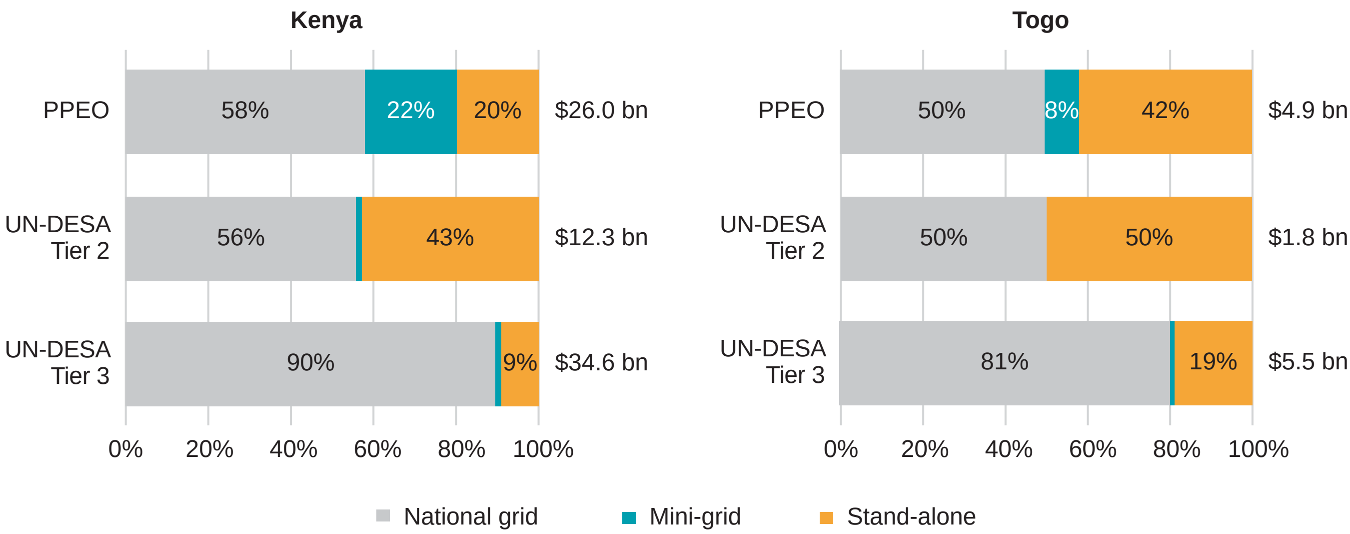


Figure 7.1 Technology mix: PPEO compared to UN-DESA model
Note: UN-DESA has not modelled the technology mix for Asian countries.

in the future (SolShare cited in UNFCCC, 2014). The challenge is to make these advances more widely available.

Technology and fuels for cooking

As established in *PPEO 2016*, there is high demand in all countries for clean cooking solutions. Hundreds of thousands of people in our three case-study countries die from unsafe cooking each year.

It is essential that governments and donors react more meaningfully to the growing demand for clean cooking and work to build up demand in places where it is lagging, such as Bangladesh. Illustrative of this demand is that more than 50 countries made clean cooking commitments in their Nationally Determined Contribution to the Paris Climate Agreement (GACC, 2017b). Climate finance, health finance, gender finance, and concessional energy financing must be targeted in ramping up opportunities for truly clean cooking with either gas (LPG, biogas, bioethanol, etc.) or electricity where possible.[1]

> Climate finance, health finance, gender finance, and concessional energy financing must target opportunities for truly clean cooking

For many, however, necessity dictates that biomass fuels will continue to be their primary fuel for the foreseeable future. *PPEO 2016* showed that in some communities there is reluctance to move away from traditional stoves. This is likely influenced by experiences with improved stoves that have not delivered the utility users wanted. Common problems raised by users were the types and size of fuel used in stoves; the frequency of needing to tend the fire; or the extent to which stoves catered for a variety of cooking needs and pot sizes. Today there are some high-performing stoves where designs have focused far more on the needs of the cook. Governments now have an urgent task to raise awareness of the product range available in order to address users' concerns.

When cooking technology options widen, there will likely be a corresponding increase in the range of fuels and stoves people use for different tasks, at different times of the year. Fuel and stove stacking are a rational user response but where polluting fuels dominate, governments must set targets and policies encouraging shifts to cleaner stoves and fuels. To support these policies and activate markets, consumer-awareness campaigns are essential to build demand. Further support must be brought to microfinance institutions, to enable microloans for cooking products; entrepreneurship mentoring programmes; and access to seed and working capital for small businesses targeting rural households.

Implications for financing

The least-cost technology mix for each country has important implications for the financing required. A range of factors affects the cost of a mix of technologies and determines which technologies are prioritized as least cost for each community.

Varying costs of technologies

The costs of extending the national grid and boosting generation capacity to accommodate new connections vary widely between the three countries. This is largely related to the distances to be covered, the extent of the existing grid, and the size of the community at the end of the line. In Togo, we estimate that the average price per kWh for grid extension is $0.60, compared to $0.36 in Kenya and $0.24 in Bangladesh.[2]

Table 7.3 Comparative price of cooking with LPG

	Togo	*Kenya*	*Bangladesh*
Refilling a 12 kg LPG cylinder	$10	$27	$30
LPG cost/hh/day	$0.69	$1.86	$1.08

WRI (Sanyal et al., 2016) analysed price differences of SHSs from the largest suppliers in Kenya and Bangladesh, and found similar-sized systems to be more than twice as expensive in Kenya. For example, entry-level 10 W systems in Bangladesh cost $99 compared to $208 for an 8 W system in Kenya. This probably relates to the role of IDCOL in coordinating the sector and offering financing at low interest rates, as well as the greater scale of the industry and competition between partner organizations in Bangladesh. There are fewer suppliers in Togo, hence we were unable to get a robust understanding of average costs there, but in nearby Ghana, costs are comparable or slightly lower than in Kenya.

Price variances for electrification and clean cooking mean a different pattern of investment is needed for each country

The price of diesel in rural areas also varies, from around $0.87 per litre in Kenya to $1.11 per litre in Bangladesh.[3] The diesel price affects the cost of solar–diesel hybrid mini-grids, which were often the cheapest mini-grid solutions.

For cooking technologies and fuels, there are important differences in costs. LPG makes up the biggest share of future costs and the price of LPG varies considerably between the three countries (see Table 7.3). Similarly, the price and availability of different biomass fuels varies, with wood fuel being more expensive in Bangladesh, though it is rarely purchased, and a wide range of other fuels being used, including crop residues, leaves, and cow dung. Charcoal prices are similar in Kenya and Togo, and it is hardly used in Bangladesh.

Price variances for electrification and clean cooking combine to create a different pattern of investment needs for each country. In Togo, where LPG is cheapest, it is the preferred cooking solution for 47 per cent of households and accounts for 66 per cent of future estimated cooking finance required. In Kenya, LPG is the choice of 30 per cent of households and accounts for 53 per cent of the costs. Charcoal cooking was preferred by 16% in Kenya and 28% in Togo but accounts for a far higher proportion of the finance required than wood-based solutions.

For people whose needs are best served by an SHS, it is the cheapest solution

For electrification, we found that SHSs should make up 34 per cent of the future technology mix in Kenya, though it accounts for 59 per cent of future costs. For households in Bangladesh, SHSs will make up 53 per cent of the technology mix but account for 83 per cent of the costs (because of the lower cost of grid extension in densely populated Bangladesh). Importantly, for those whose electricity needs are best served by an SHS, it is the *cheapest* solution. That is, reaching 53 per cent of currently unelectrified households in Bangladesh will require 83 per cent of the finance; for the government to reach them through national grid extension, the total finance required will be significantly higher than our estimates, the electrification process will take significantly longer and, due to generation constraints, the quality of connections is likely to be questionable.

Overall financing required

The total electricity finance required for each country clearly varies according to the population to be served, with the largest budget required in Bangladesh (see Table 7.4). Costs per person per year are also highest in Bangladesh because of demand for higher levels of productive power. Stripping this out, Bangladesh is in fact the cheapest (at $67 per person/year) and Togo the most expensive. These amounts

Table 7.4 Cumulative cost of provision of national electricity access plans to 2030

	Finance required		*Average WTP pp/yr*	*Finance gap pp/yr*
	Total to 2030	*Per person/yr*		
Togo	\$4.9 bn	\$93	\$23.80	\$70
Kenya	\$26.0 bn	\$72	\$23.40	\$49
Bangladesh	\$75.2 bn[1]	\$134	\$23.30	\$111
Bangladesh (households only)	\$37.7 bn	\$67	\$23.30	\$44

[1] A large proportion of this figure (\$37.5 bn) is for energy for productive uses.

are small given the opportunities electricity access brings, particularly in light of the fundamental role of energy in achieving 12 of the 17 SDGs.

Despite the variety in levels of poverty, the average willingness to pay (WTP) for electricity is very similar across all countries. This reflects less than half the real cost of provision, however, underlining the role for public funding and appropriate consumer finance products. Increasing rural incomes from powering agricultural livelihoods will also help fund electricity provision.

Increasing rural incomes by powering agricultural livelihoods will help fund electricity provision

While the IEA estimates the global cost of clean cooking is only 10 per cent that of electricity access, our estimates – taking into account people's preferences for cleaner solutions and fuel costs – find considerably more finance is required. In Kenya, financing needs for cooking are similar to electricity access, and are more than the total for household electricity access in Bangladesh. In Togo, the cost of clean cooking is a much lower 37 per cent of that needed for electricity access, due to a more people preferring to continue to use biomass fuels. Costs per person/year are lower than for electricity, but the national totals are similar because so many more people need to be reached.

Average willingness to pay for clean cooking solutions is lower than for electricity and is particularly low in Bangladesh (see Table 7.5). This emphasizes the need for public financing for more effective and consistent demand-generation campaigns. More positively, in both Kenya and Togo the cost of a switch to better-performing biomass stoves could be covered by people's willingness to pay. At the same time, there is a need to continue to explore cost-effective, truly clean-fuel cooking options (biogas, bioethanol or other technologies) to help bring prices down and close the affordability gap for clean, healthy, climate-friendly cooking.

An integrated approach including productive and community uses of energy affects the resulting technology mix and financing required. It underlines the need for more cross-sectoral discussion of financing and delivery plans across a range of responsible ministries (such as agriculture, education, health, and water).

More cross-sectoral discussion of financing and delivery plans across a range of responsible ministries is needed

For productive uses, our estimates are driven by existing energy demand from enterprises and mainstream livelihoods (such as agriculture and fishing). A more accurate and comprehensive picture is likely to emerge from the planned multi-tier framework surveys of productive uses. Our results, especially for Bangladesh, emphasize the importance of factoring this demand into national energy planning.

Table 7.5 Cumulative cost of provision of national clean cooking plans to 2030

	Finance required		*Average WTP pp/yr*	*Gap pp/yr*
	Total to 2030	*Per person/yr*		
Togo	\$2.1 bn	\$20	\$12	\$8
Kenya	\$27.1 bn	\$41	\$11	\$31
Bangladesh	\$57.3 bn	\$24	\$2	\$22

Equally, in all countries, energy for street lighting and community facilities, such as schools or for pumping drinking water, were high priorities. Our financing estimates highlight these are not significant additions to overall household financing needs, but provide much-needed energy services. Providing stand-alone solar street lighting represents 0.5 per cent of the electrification cost in Bangladesh and Kenya and 7 per cent in Togo (where more communities would be off-grid).

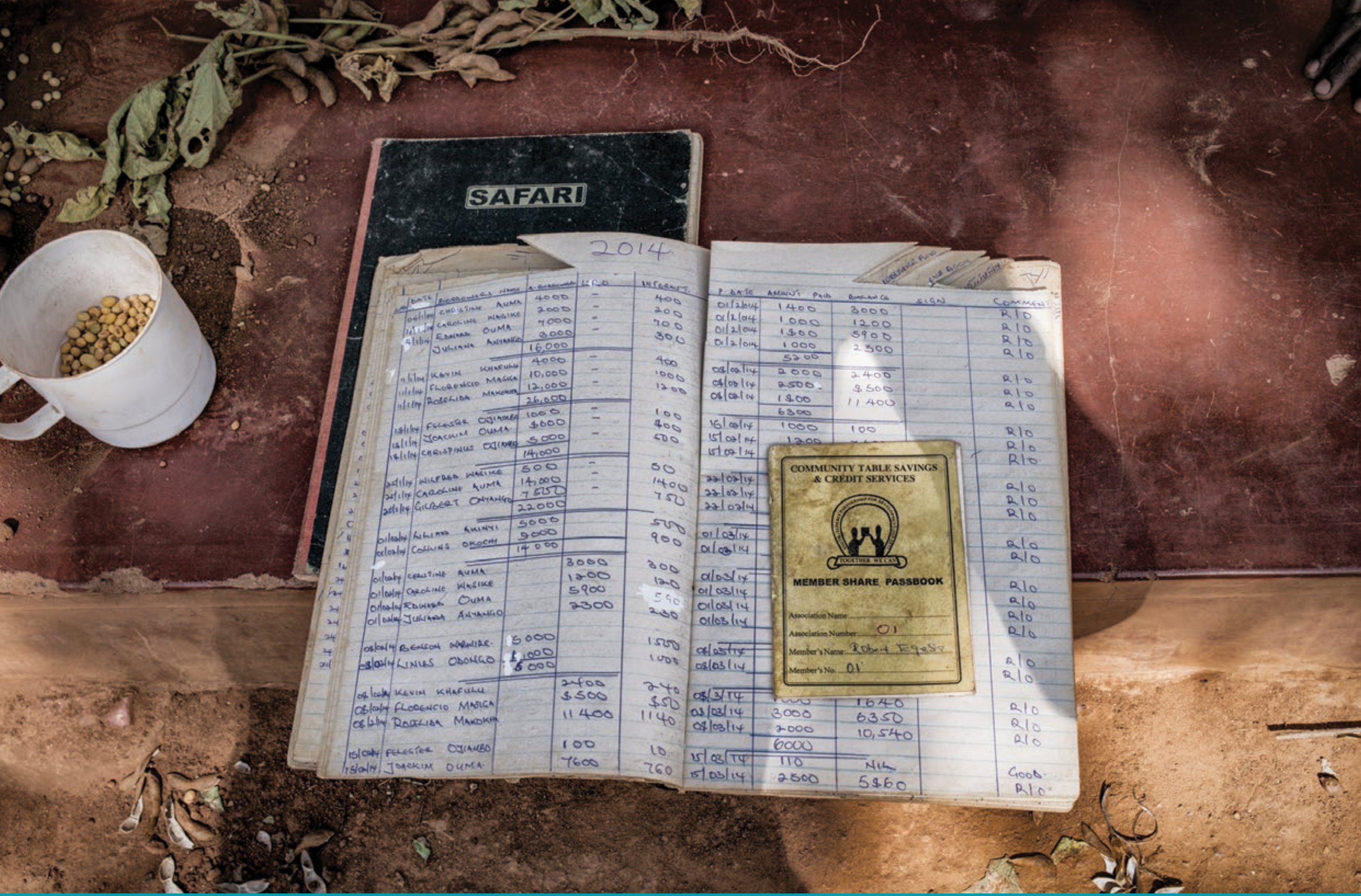
Conclusion: bottom-up planning makes 2030 targets achievable

If we are to meet our 2030 goals for universal energy access, we need to invest limited resources more in line with needs and demand

Applying a bottom-up approach to national planning influences national estimates of the technology mix and finance required. It also dramatically shortens the timeframe for achieving universal access by matching the most appropriate technology to each location. Bottom-up integrated approaches will also better meet the needs of both women and men, and ensure energy reaches community services as well as households and productive uses.

More accurate demand profiles, inclusion of productive and community uses, and a more granular geographic analysis help provide a better picture of particular technologies' viability and the potential for decentralized solutions. To meet our 2030 goals for universal energy access, we need to invest limited resources wisely. Our analysis highlights the need for a radical change in how energy planning is undertaken so energy financing and delivery can be targeted and more efficient.

Incorporating significantly larger proportions of decentralized renewables than is currently the case will reduce costs for national electrification by billions in our case-study countries. The billions saved here, however, must be allocated to the disastrously underfunded area of clean cooking.



8. A how-to guide for quickly and sustainably scaling energy finance and delivery

Beginning with the IEA in 2012, analysts have repeatedly shown that distributed energy is the most economical choice for the majority of new energy access investments. Yet, this will not be achieved without rapid and seismic shifts in policy, programmes, and finance. Finance remains inadequate for electricity and terrifyingly low for clean cooking where inaction costs millions of lives, wastes billions of hours of labour, and decimates millions of hectares of forest, annually.

In this chapter we discuss what can be done to radically hasten progress on energy access – and equally climate finance, which mostly remains siloed outside energy discussions and inappropriately focused on large projects rather than large local impacts (Rai et al., 2016). Business models, financial tools, and regulatory and policy changes have been extensively detailed elsewhere (Desjardins et al., 2014; GOGLA, 2015; Manetsgruber et al., 2015; SEforAll, 2015a; UNEP, 2015;

AEEP, 2016; Power for All, 2017). Here, we focus on some of the fundamentals that these detail-oriented approaches and tools miss, inhibiting their move from paper to practice. Getting these fundamentals right will help the world move away from financing one-off projects and businesses, and towards building the energy access markets we need to stand a chance of delivering universal access by 2030.

Waiting for innovation or building on existing success?

While innovation is still needed, we already know a lot about what works and how to deliver it

A decade ago, as the solar revolution began to take off, the international community's calls for 'innovative finance' and 'innovative business models' were helpful in pushing businesses, governments, and financiers outside their comfort zones. Today, however, as business models and technologies have matured, these two phrases have become something of a crutch. While innovation is of course still needed (particularly on the cooking side), in 2017 we actually know a lot about what works and how to deliver it.

Donors and concessional financiers focus too much on individual business success stories, diverting attention from building broader local and national markets. Instead of waiting for tomorrow's innovation, we need to work today to support thousands more of the businesses that we already know work. Some of these companies will incrementally innovate new best practices – and some will fail – but taken together, they will begin to solve the access problem at scale.

At the same time, given the gap between willingness to pay and the actual cost of delivering energy, there needs to be a wider conversation about how companies can be appropriately supported in the context of market-based approaches. The IFC and World Bank recently noted that, particularly during phases of fast growth, even SHS companies 'may need to rely on external sources of funding for 8–15 years, before generating cash' (Bardouille et al., 2017). For clean cooking, the World Bank (2014: 14) acknowledges that many providers 'will need to subsidise the upfront cost of their stoves … to see adoption at scale'.

This should hardly come as a surprise. Highly profitable, publicly traded global energy companies remain some of the largest recipients of government subsidies on earth. Duke Energy, EDP, E.ON and General Electric together have received over $4.4 billion in subsidies since 2007 in the United States alone (Good Jobs First, 2015). It is both unrealistic and incoherent for companies serving the world's poorest to be held to commercial profitability standards so early in the sector's history.

Public money has always been recognized as necessary to plug gaps in essential services for the poorest. Social protection schemes are well understood in other areas of development. Box 8.1 illustrates how clean cookstoves are distributed under a social protection scheme in Malawi. Non-market distorting public support for SHSs and cookstoves can help poor families to access clean, sustainable, and affordable energy. In clean cooking, there is potential to develop markets for 'health credits' or design results-based financing around health outcomes.

Energy investments in poor countries are long-term, change-making opportunities

It is time for national governments, concessional lenders, and donors to rebalance expectations away from short term commercial profits and see energy investments in poor countries as long-term, change-making opportunities.

Box 8.1 Funding energy access through social protection schemes: Malawi

In Malawi, the delivery of sustainable energy services has been linked to a targeted social protection scheme, the Social Cash Transfer (SCT) programme, which identifies ultra-poor, labour-constrained households and provides a monthly electronic cash transfer. The programme currently reaches 170,000 households (UNICEF, 2017). These households are also being given a voucher for a clay stove (the locally made Chitetezo Mbaula) which can be redeemed through a network of local distributors. The programme recovers some costs through carbon finance accessed through close monitoring of stove use.

The initiative delivers wider benefits, including empowering local women through cooperative manufacturing of the cookstoves. For each stove given away through the SCT programme, distributors receive a second which they can sell, stimulating a parallel market for cookstoves among families not in receipt of the SCT.

The SCT programme aims to reach 320,000 beneficiaries, which means a total of 640,000 stoves will be distributed. It is hoped that this scale of operation will create the necessary conditions to allow the private sector to scale up, meeting the government's target to increase the number of energy-efficient stoves in use by 2 million by 2020.

Source: adapted from Mary Robinson Foundation, 2015

De-risking begins at home: building financier understanding, experience, and trust

While at the global level financing for sustainable energy is theoretically available, in energy-poor countries it is not reaching businesses (large or small) or governments in the forms they need or at affordable costs.

Financiers, public and especially private, are often sceptical about decentralized renewable energy investments due to the sector and its business-people's limited financial and operational track record, but also largely because of their own lack of familiarity with it. This problem extends from global institutions to the local level, as is particularly the case in Togo. Exacerbating this is a lack of incentives encouraging bank staff to tackle the new and sometimes complex transactions that distributed energy requires. Employees are measured and rewarded by the number of deals and volume of capital disbursed, favouring 'business as usual' (big projects, well understood, and quickly structured). There is a need to shift bank metrics for career advancement and bonuses to instead reward, for example:

- the number of lives touched per dollar invested, with a multiplier for rural or remote areas;
- the extent to which interventions and investments address gendered barriers to finance and empower women;
- the time taken for an investment to deliver energy services (the 'energy access dividend' (Power for All, 2017);
- attempts to structure new, or scale nascent, modes of financial support, such as:
  - aggregation/securitization;
  - access to local currencies;
  - guarantee funds, insurance, and other risk mitigants.

If development banks had empowered teams, however small, working explicitly on the key issues of aggregation, local currencies, and DRE risk mitigation, we would see rapid and meaningful increases in knowledge, acceptance, and support of DRE companies. These experiences could more easily be shared with others, in a coordinated way, which is not currently happening.

Banks rarely engage with distributed energy companies and offer unrealistic interest rates and repayment periods

Pipeline, pipeline, pipeline: building an investable base

Much of the work needed to facilitate rapid expansion of distributed energy is at the level of local and national banks, particularly to reduce foreign exchange risk. These institutions rarely engage with distributed energy companies and, when they do, they offer unrealistically high interest rates and short repayment periods. Furthermore, their procedures and requirements often make financing more difficult for women to access.

Gender-blind action on finance will only exacerbate the unacceptable inequalities facing women

Banks face significant real and perceived risks. Others have suggested strategies to reduce political, institutional, off-taker, operator, development, and other risks. We highlight three broad, universally recognized, underutilized actions that must be scaled to mitigate financial demand and supply constraints. All have to do with people, knowledge, and experience, and must be undertaken simultaneously. Within each, gender-specific barriers (to access, finance, entrepreneurship, etc.) and opportunities (to purchase, use, and participate) must be addressed. Gender-blind action on finance will only continue to exacerbate the unacceptable inequalities facing half the world's population.

Unlocking local lending

In OECD countries, what is routine renewable energy lending today was rare and seen as risky less than a decade ago. In addition to technologies maturing, government pressure and incentives for renewables lending played a major role in today's boom. In energy-poor countries, the lack of experience and trust in rural, distributed energy companies is profound – and even deeper for women-led enterprises. While some work is being done by the World Bank, IFC, the African Development Bank and others to shepherd SHS deals through local banks, it remains very small scale and needs to be urgently expanded. Furthermore, very limited work or research is being done on developing project financing opportunities for mini-grids, a well-established need.

Developing countries tend to have weak financial systems, with local capital markets lacking long-term financial products in domestic currencies and well-developed financial intermediation (Glemarec et al., 2015). Initiatives such as SunFunder's announcement of a partnership allowing it to make local currency loans are welcome and should be replicated and scaled. Along with low-cost but underutilized risk mitigation tools, such initiatives will help rapidly expand investment opportunities for local financial institutions.

Upskilling businesses

Technical and business skills development is needed to build credible businesses ready for investment by local banks

For local banks to want to lend to distributed energy companies, they need to have credible businesses waiting for investments. Technical and business skills of all sorts are thus desperately needed. While some countries could build such programmes into existing university and vocational training centres (for example, Strathmore University in Nairobi), in many less developed countries this is not the case and support for building such institutions is urgently required. Opportunities need to be built at all levels, from formal courses to shorter inputs for existing businesses, and must be designed to be equally accessible to women and men.

A second strategy not yet being widely pursued is to develop and promote standardized tools. Concessional financiers should collaborate to harmonize baseline financial models for evaluating energy access investments that could be adapted for different lenders' needs. This would lower transaction costs and speed up training of staff and local lenders. For businesses, costs could be lowered and skill barriers reduced by encouraging the use of standardized business planning tools, such as MyBusinessPlan (Embark Energy, 2017), designed to help early-stage energy access businesses put together business plans that make sense to financiers.

Getting serious about data collection

A new sector selling new technologies to new and unfamiliar customers in challenging contexts will remain risky, slow, and expensive for businesses and financiers alike until transparent and reliable business and market performance data is available.

Bloomberg New Energy Finance (BNEF) in collaboration with the Global Off-grid Lighting Association (GOGLA) have done excellent early work but more granularity is needed to play a de-risking role. For clean cooking, GACC similarly provides market data from its partner organizations, but many stove manufacturers are not formally organized or robustly tracking sales, with fuel-tracking being even more challenging.

For mini-grids, BNEF has made a commendable effort to create a market report (BNEF, 2017), but its reporting has remained necessarily vague because investments and business performance in this sector are notoriously difficult to track. The Alliance for Rural Electrification, a global industry association, is therefore calling for more support for mini-grid market sizing data, regular market trends reporting and, if possible, anonymized financial performance data to be shared via an independent third party. While business-level data is challenging due to intellectual property concerns, industry agreement to share metrics will provide huge collective value for the sector and help unlock, and lower the cost of, capital.

More effective data-sharing will provide tremendous collective value for the sector and help unlock capital

Empowering the grassroots: bankable businesses need viable customer bases

Energy is only useful, and worth paying for, if it enables access to productive, household, and community energy services. Hence the importance for global development objectives and for business viability of empowering men and women end-users with access to appliances, tools, and skills cannot be understated.

In the UK, until the latter half of the 20th century, energy utilities ran shops selling household appliances and tools to customers, helping them to access energy services they wanted and needed. Today, some of the larger SHS companies offer appliances alongside their larger systems, aiming to move their customers up the energy service ladder over time. While early progress by some SHS companies is promising, mini-grid companies offering levels of power with more potential for earning a living have been pushed to primarily focus on streamlining internal business mechanics and innovating energy system technologies to improve bankability.

It is indeed confusingly rare to see financiers support a mini-grid company alongside, or in coordination with, local microfinance institutions, farmer field schools, civil society organizations, and other national and local institutions that can help boost uptake of more energy-consuming productive activities and technologies. Supporting energy companies without working just as hard to pump capital into local economies is the equivalent of supporting a smartphone company without any apps. From a climate perspective, such support offers both mitigation and adaptation benefits (Leopold, 2014) as capacity-building and diversification opportunities increase the resilience of livelihoods.

Good development practices are also good for business

Given that these good development practices are also good for business, Practical Action is calling for broad-based support for community-level energy literacy work, training in productive uses of energy, and MFI and bank training on accompanying lending streams.

Getting outside the box: activating markets

To achieve universal access to modern energy services, business and investor champions will not be enough

To achieve universal access to modern energy services, business and investor champions will not be enough. Broad support of alternative ownership models is required to create opportunities for serving geographies where the economics will remain a challenge. Furthermore, national-level market-building work is fundamental to ensure investments are going into energy markets with the potential to self-scale.

Cooperation at the core

The Miller Center for Social Entrepreneurship (2015) estimates universalizing access will require 7,000–20,000 local energy enterprises: a manageable number when spread across all energy-poor countries. It found most will be at the local level, with a minority being larger companies and utilities. This is not unusual despite the current focus on picking winners for rapid growth. In Germany, for instance, there are over 850 community-owned energy cooperatives (DGRV, 2017).

Though dismissed because they are not aimed at significant growth, cooperatives are often the most appropriate models for small, rural energy loads. The success of local ownership models is evidenced by: the International Labour Organization (ILO, 2013; ILO & ICA, 2014); historical evidence from the USA (see Chapter 2); Germany's experience (Sridhar, 2016); and the practices of Practical Action and other established energy organizations (SNV and TTA among others). Planners, donors, and financiers must recognize and support cooperative approaches, particularly for the thousands of rural communities so remote that neither grids nor the private sector will arrive any time soon (Stevens & Gallagher, 2015).

Simple methods for complex systems

Holistic, system-wide approaches to create thriving distributed energy 'ecosystems' are needed

Throughout this report, we have noted how priority and planning mismatches, information and awareness gaps, policy and practice blockages, explicit and implicit biases, and other barriers are severely constraining progress on energy access delivery. To overcome these barriers, we need holistic, system-wide approaches, which seek to create thriving distributed energy 'ecosystems'. Examples include Power for All's national market activation work, SNV and Practical Action's local markets work, and the nascent SEforAll People-Centered Accelerator. These seek to address a range of priority market barriers simultaneously. They develop shared goals and trust, and an enabling policy, regulatory, and financing environment. A key feature is the fostering of partnerships between civil society, the private sector, and government: essential for building capacity and delivering energy services to the last mile. Such market activation efforts are low cost, high impact, and needed in all energy-poor countries, for both electricity and cooking.

The Power for All Campaign and Partnership (of which Practical Action is a part) has demonstrated successful initiatives for building national household solar markets in Zimbabwe, Nigeria, and Sierra Leone. In each, the campaign mobilized broad cross-sector alliances of companies, NGOs, aid agencies and investors. In all three, the partnership is widely credited with unifying the sector, accelerating the creation of an enabling environment, and thus driving market growth. Power for All's approach is as simple as it is powerful:

- Establish robust DRE industry associations with clear published policy recommendations and a 'seat at the table' in decision-making processes.
- Enhance civil society action in support of distributed energy, ensuring issues of equality are addressed.
- Raise government awareness and support policy reforms directed at DRE market growth.
- Enhance coordination and collaboration among stakeholders, including regular government–private sector dialogue.
- Increase public awareness, for example, through improved volume and tone of media coverage of the sector.

By focusing on knowledge sharing and collaboration these actions build understanding that universal access is achievable, even in challenging contexts; create an atmosphere of positive peer pressure; clarify what needs to be done, by whom and with what support. Built-in mechanisms for ongoing dialogue and engagement help hold people to account, creating momentum and champions.

These simple methods create constructive, locally owned voices for change, and a multi-stakeholder environment to build trust between actors. They also bring in other sectors and ministries, such as agriculture, health, and education. Importantly, these improvements increase the financial sector's confidence to invest.

Fostering partnerships between civil society, the private sector and governments is essential for delivering energy to the last mile

Conclusion: getting back to basics

Increasing energy access finance is not the end goal, but it is a crucial tool and indicator that changes in the sector are happening. Focus on foundational issues is needed, which are not comparatively expensive, difficult, or out of the ordinary. The problem is that no one is doing or funding these activities at the scale required to end energy poverty. In particular, public funds must be better used to help close the financing gap; for example through smarter subsidies, working alongside and in support of market-building initiatives. The incentives for, and skills of, those shaping such funding must evolve to be more people and development-centred.

We urge you to join us in working together with donors, financiers, businesses, and civil society to develop institutional support, human resources, and funding to undertake broad campaigns of:

1. creating leadership commitment within concessional financiers to update and align institutional practices to robustly support distributed energy;
2. scaling what is already working by building the skills and experience of energy SMEs and future leaders, including supporting and empowering women throughout energy value chains;
3. shifting development financier evaluation and reward metrics to reflect development impacts in addition to, or rather than, deal size;
4. building trust and understanding among local and international financiers to support decentralized electricity and clean cooking;
5. supporting gender-aware community energy training and financing to promote access to productive end-use technologies;
6. resourcing national market activation campaigns and partnerships in energy-poor countries to build demand, collaboration, positive peer pressure, and the policy and regulatory foundation for distributed energy markets to thrive.

Public funds must be better used to help close the financing gap

Financing Energy Access for All

Using financial flows to stimulate market development

Recommendations

- Create leadership commitment from concessional financiers
- Build skill and experience of energy SMEs, and male and female future leaders
- Shift financier evaluation and reward metrics
- Increase financiers' trust in energy access sector
- Provide gender-aware community training and financing for productive and community end-uses
- Fund national market activation campaigns

STEP 1: Market Activation

Activating markets starts with building government capacity and consumer awareness, while skilling-up businesses.

1. Target-setting
2. Tax incentives
3. Awareness-raising
4. SME–NGO partnerships
5. SME training
6. SME grant funding
7. Support to women's groups
8. Industry associations

Finance flows increase

Environment grows more supportive

STEP 2: Bridging Public and Private Capital

Creating links between public and private capital by building commercial financier understanding of rural energy access businesses, promoting MFI consumer energy finance, and training and financially supporting new rural enterprises.

1. Concessional local currency debt and equity
2. Consumer financing
3. Loan guarantees
4. Market intelligence
5. Sector coordination groups
6. Public–private partnerships

STEP 3: Scaling Private Capital

Rapidly expanding rural private-sector penetration and national business development with increased private capital through, for example, PPPs and bundling rural energy investments to test securitization.

1. Harmonized quality standards
2. Licensing and regulatory frameworks
3. Training institutions
4. Bundled project investments

Environment grows more supportive

Finance flows increase

STEP 4: Mature Ecosystem

Once rural energy and non-energy enterprises are thriving, with easy access to all forms of commercial and consumer finance, subsidies and guarantees can be reduced. Support will still be required for remote locations and poorest communities.

1. End-user price subsidies for the remote and vulnerable
2. Commercial local currency debt and equity

Key

- (x) Actions in each step. These will continue in subsequent steps, as appropriate.
- Companies within different energy access markets grow and are joined by new market entrants over time.
- Market size grows over time and relationships between market actors are strengthened.
- Enabling environment grows more supportive over time.

9. Conclusions and recommendations

The global energy community knows the gaps between what is needed and what is happening are real and monumental in size. As yet, there has been very little nuanced analysis around how to deliver meaningful change at a scale that delivers for all people, economically and in a timely manner.

Our bottom-up energy planning methodology – which we are keen to share and collaborate on – gives detailed insights into how this can be accomplished. By clearly identifying least cost, most appropriate technologies, it provides benchmarks for governments as they work together to develop policies, support packages and, in the end, deliver robust markets for energy access services.

Despite differences between countries in the levels of energy access, technological needs, and the maturity of markets, we have identified how to overcome three major obstacles to realizing global energy access financing at scale. These can immediately be acted on and will have significant impact.

Bottom-up planning for appropriate energy access finance

By not putting people at the centre of energy planning, too many will remain unreached

By not putting people at the centre of energy planning, too many will remain unreached, without the energy needed to achieve the majority of the SDGs or our global climate objectives.

Bottom-up, integrated planning provides the most accurate picture of technology needs across households, productive uses, and community services, meeting the different needs of women and men. By knowing the true scale of the distributed technologies needed, we can adopt the correct financial tools and bring in the right financiers, to end energy poverty in an appropriate, expedient, and economical way.

Market activation to encourage the private sector

The energy context in most low energy access countries is pre-commercial and the private sector cannot be expected to enter, or deliver, without significant support.

Broad-based market activation initiatives are required to build up knowledge, shared goals, trust, and a wide-ranging enabling environment. Partnerships between civil society, the private sector, and government will be fundamental in the many cases where there are complex geographies and low population densities.

Novel financial tools to facilitate new ways of working

With the signing of the Paris Climate Accord and SDGs we are moving from an era of global debate to global delivery. Development finance institutions, donors, philanthropists, impact investors, and other concessional financiers thus find themselves at the front line of opportunities for facilitating systemic change, at scale.

Delivering will require new ways of working, expanded and adapted skillsets, and different ways of measuring success. Development finance institutions and others must incentivize their staff to move away from old approaches to embrace smaller, but more appropriate, solutions and adapt them to the institutional and financial constraints under which they work. This will require aggregation tools, early-stage risk capital, and challenge fund development. Above all, work must address the fundamental, but often critically ignored, issues of cooking and the gender gaps and barriers within current tools.

Change is daunting. But the world is unified around a global agenda for change: to end the era of mass global inequalities – between geographies, between incomes, between women and men. 2030 is getting nearer every day, and every day without change is one day less for making that change.

History does not remember those who dutifully followed the rules. History remembers those who rewrite the rules. Please join us in leading the charge for putting people first in global action on development and climate, with energy at the core.

Notes

Chapter 1

1 Putti et al. (2015) estimate the figure could be higher, at around $0.5–1 billion from all public-sector programmes, the private sector and carbon finance markets.

Chapter 3

1 We worked in off-grid communities, within which some households had solar home systems, lanterns, or electricity from diesel generators. Respondents projected their future demand, which entailed making some assumptions but was based on knowledge of the energy services they would like to access.

Chapter 4

1 In scaling this to the national level, we allowed people's choice of electricity only where the cost was within 10 per cent of LPG.

Chapter 5

1 There is conflicting data about what proportion of households is represented by the 4,566,000 domestic connections reported. KPLC claims this is 60%, meaning there is a total of 7.6 million households in Kenya. However, the 2009 census found 8.77 million households and a population of 38.6 million. The population has grown considerably since then. We are therefore assuming a total population of 46.7 million and an average household size of 4.4 (as in the 2009 census), which means there are 10.6 million households and an electrification rate of 43%.

2 We estimate a total of around 250,000 solar home systems in Kenya. Based on our findings from *PPEO 2016*, we estimate that around 193,000 of these are operational and that 135,000 operate at Tier 2 or higher.

3 Electricity for cooking was allowed as a valid choice where the cost was within 10% of cooking with LPG.

4 Kenya's SREP (2011) investment plan envisages an investment of $68 m in mini-grids, but only a first phase has so far been approved.

5 This project was commissioned by SEforAll and carried out by Practical Action Consulting. It is due to report in September 2017.

Chapter 6

1 This figure includes 4.1 million solar home systems sold by the IDCOL programme and is therefore likely to be an overestimate. It does not factor in SHSs no longer in operation or account for double-counting where SHSs are installed in households that also have grid electricity or single households with multiple SHSs.

2 This is based on IDCOL records of sales of systems of different sizes and is borne out by our *PPEO 2016* findings. However, another study of the performance of systems found that between 58% and 80% of SHSs achieved Tier 2 (Groh et al., 2016).

3 There is likely to be some overlap between grid connectivity and SHS ownership which would increase the number of people unelectrified or underelectrified. Those grid connected may also be found to be underelectrified. Greater clarity will be achieved when the results of the World Bank's first set of multi-tier framework surveys becomes available towards the end of 2017.

4 This very large number could be an example of bias due to the particular selection of communities surveyed for *PPEO 2016* and the type of rural industries present there. It also potentially reflects some weaknesses in the surveying methods used with results based on only relatively few interviews with farmers (as compared to small enterprise owners). The needs of farmers for, for example, irrigation pumps, may therefore be an overestimate.

5 A higher proportion of households may have access to LPG. A recent GACC assessment in Southern Bangladesh with a sample of 800 households found that around 40% used LPG occasionally (personal communication Asna Towfiq, GACC Country Manager, Bangladesh, May 2017).

6 The SNV feasibility study (van Nes et al., 2005) concluded that biogas would only be suitable for households owning at least five cows. Smaller systems could work for households owning three or four cows but this would not generate enough gas to cover all cooking needs. The study estimated that fewer than half of rural households own this number of cows.

Chapter 7

1 Where the cost of electricity generation is relatively low and efficient electric cooking technologies, such as induction cookers (around 10% more efficient), are available.

2 These prices are the average generated by our model for the locations we sampled in each country.

3 Diesel is subsidized in Bangladesh (Kojima, 2016; Star Business Report, 2017) but prices are controlled. In Kenya, diesel is not subsidized but lower rates of tax are charged than for other fuels. These prices reflect the price at the nearest point of sale in the four communities surveyed for *PPEO 2016*, with data collected in 2015.

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Poor people's energy outlook 2017

Energy access sits at the heart of sustainable development, enabling progress in health, education and women's empowerment, among other things. Recognizing this, the global community committed to a dedicated energy access goal in the Sustainable Development Goals for 2030. To achieve this, investments in national energy systems have increased. Yet, while it is recognized that the majority of these investments should be directed towards decentralized energy systems to have the fastest, most economical result, energy access finance has not shifted or grown accordingly.

Poor people's energy outlook 2017 uses national energy planning as an entry point to reframe energy finance discussions. Having developed bottom-up integrated national energy access plans in Togo, Kenya, and Bangladesh in *PPEO 2016*, *PPEO 2017* models the least-cost national technology mix, and financing required, to achieve Total Energy Access in these countries and globally.

Achieving SDG7 will require us to challenge 'business as usual' models that have left over 1 billion people lacking electricity and 3 billion cooking on inadequate stoves. This means building capacity and cross-sectoral partnerships, and focusing on alternative technologies and financing mechanisms to facilitate new ways of working. Key to this will be development finance institutions, donors, philanthropists, impact investors, and other concessional financiers who can help facilitate systemic change using targeted subsidies, concessional loans, and other tools to reach those at the bottom of the pyramid.

PPEO 2017 is the second in a suite of three *PPEO*s which takes the Total Energy Access framework developed in previous editions and illustrates how to operationalize it in terms of planning (*PPEO 2016*), financing (this edition), and delivering at scale (*PPEO 2018*).

'The energy access sector is in dire need of this kind of empirical analysis.'
Dr Sebastian Groh, Managing Director, ME SOLshare, and Assistant Professor, North South University, Bangladesh

'This PPEO *must be digested by all who want to be part of the change required to meet SDG 7 goals.'*
Christine Eibs Singer, Director of Global Advocacy, Power for All, and Special Advisor on Energy Access, SEforAll

'PPEO 2017*'s bottom-up approach highlights people's pressing desire for clean cooking.'*
Radha Muthiah, CEO, Global Alliance for Clean Cookstoves

'We welcome PPEO 2017*'s analysis of gender and energy finance.'*
Sheila Oparaocha, International Coordinator and Programme Manager, ENERGIA

'Practical Action's PPEO series is very impressive and informative.'
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