Poor people's energy outlook 2016

Praise for this book

'We are really happy to see gender issues featured throughout the *PPEO 2016* and would like to congratulate Practical Action on how influential the *PPEO* series has been in setting the stage for SEforAll. This edition of the *PPEO* continues to emphasize the need to change the paradigm and put the last mile first in energy access planning.'

Sheila Oparaocha, International Coordinator and Programme Manager, ENERGIA

'National energy access planning is of vital relevance to achieving the vision of Universal Energy Access by 2030. The *PPEO 2016* offers an important contribution to the debate by offering suggestions of what a good plan entails, and by offering tangible recommendations on how to meaningfully include the voices of those who are ultimately affected by national energy access planning.'

Caspar Priesemann, Energy Access Advisor, GIZ

'Practical Action's *Poor people's energy outlook* series continues to impress. The evidence and guidance found within *PPEO 2016* shows why and how universal energy access targets can only be achieved on a 2030 timeline by flipping the mainstream perspective on who, and what, needs to be delivered. I strongly encourage utilities, ministries of energy and energy financiers to act on the case presented here to focus on distributed renewables and bottom-up approaches'.

Jim Rogers, former Chair and CEO of Duke Energy

'Once again the *PPEO* provides terrific insights on the dynamic topic of energy and development. As energy demand and investment in developing countries continues to grow rapidly, the *PPEO* is a critical resource for decision makers.'

Morgan Bazilian, Lead Energy Specialist, the World Bank

'This edition of the *PPEO* demonstrates the value of using a gender lens in national energy access planning. By exploring first-hand evidence of women's and men's diverse energy access priorities and needs, the *PPEO 2016* highlights that only by incorporating both women's and men's differentiated energy access requirements in energy planning initiatives can we achieve truly universal energy access by 2030'.

Dr Joy Clancy, Professor of Energy and Gender, CSTM, University of Twente

'This is timely as, despite the growing recognition of energy service delivery as key to achieving development objectives, current approaches to energy planning and financing are too frequently failing to meet poor people's energy access needs. This call for more emphasis on decentralized energy solutions and on the actual energy services provided reflects well DFID's own approach, including the Energy Africa household solar initiative. This *PPEO* on national planning makes a valuable contribution, and DFID is pleased that this will be the first of three guides that DFID is supporting reframing the energy access agenda.'

Alistair Wray, Senior Energy Advisor, DFID Research and Evidence Division

'It is very important and timely to underline that energy plans (and policies) should be about the energy needs of people, in particular the poor. There is a serious risk that, with all new commitments in the field of climate change and energy transition, the focus of planners, policy makers and financiers will be limited to large infrastructure projects; while billions of people will still lack proper access to electricity and clean cooking, and can only be served by decentralized solutions. Delivering on universal energy access requires people centered planning, based on bottom-up practices.'

Frank van der Vleuten, Energy Expert, Climate Team, Ministry of Foreign Affairs of the Netherlands & Climate Investment Funds

Poor people's energy outlook 2016

National energy access planning from the bottom up

PRACTICAL ACTION
Technology challenging poverty

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 of a sustainable world free of poverty and injustice in which technology is used for the benefit of all.
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Foreword

Energy access is enshrined as an important component of the Paris Agreement on climate change. In addition, recognition of its fundamental role in achieving other global imperatives, such as gender equality, economic empowerment, improved health status, and water and food security, has led to universal energy access being highlighted in the Sustainable Development Goals.

There is a long way to go to achieve universal energy access – just over one billion people still live without electricity, and nearly three billion rely on solid fuels like charcoal, wood, and animal dung for cooking and heating. Business as usual approaches are not making fast enough progress on energy access.

Over the past six years, Practical Action's *Poor people's energy outlook* has ensured that the voices of the energy-poor are heard. It has shown that measuring progress by the numbers of connections and megawatts available is insufficient, and actually shifts the focus away from providing the technologies and services which are most relevant to the energy-poor.

Expanding energy access for the poor and most vulnerable – particularly through decentralized energy options – is a key priority of UNDP's new sustainable energy strategy. We are committed to supporting countries to achieve universal access to affordable, reliable, and sustainable energy. Progress towards many other Sustainable Development Goals, such as poverty eradication, better health and education, women's empowerment, clean water, food security, and tackling climate change also depends on progressing the SDG on energy.

The *Poor people's energy outlook 2016* notes that bottom-up national energy planning is feasible, and that it is much more likely to deliver good results than are traditional top-down approaches to energy planning. Its finding that decentralized energy options are more cost-effective for rural energy delivery, and faster to deliver, is important.

I warmly welcome the *Poor people's energy outlook 2016*, and encourage readers to incorporate its findings into their work to improve energy access.

Helen Clark
Administrator
United Nations Development Programme

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This edition of the *PPEO* draws on fieldwork undertaken with households, enterprises and community services in selected communities in Bangladesh, Kenya and Togo. Our first thanks therefore go to the women and men in these countries who enriched the report both with their personal testimonies of what energy access means to them, and their valuable participation in community consultation processes on energy access priorities and solutions.

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Photo captions and credits

Front cover. Villagers in Kitonyoni, a rural, off-grid, market village in Makueni County, Kenya, gather to discuss LED lanterns. (Credit: Sustainable Energy Research Group (www.energy.soton.ac.uk) and Energy for Development (www.energyfordevelopment.net))

Back cover (and page 1). A linesman in Bondo village, Mulanje, Southern Malawi connects a house to the micro-hydro mini-grid supply. (Credit: Practical Action/ Drew Corbyn), and, A woman in Tengagri Chak, Bangladesh, cooks outside on a traditional stove. (Credit: Practical Action/ Anjum Islam)

Page 5. Transmission lines run overhead a bustling street in Shompole, a vibrant community in southern Kenya's Kajiado county. (Credit: Sustainable Energy Research Group (www.energy.soton.ac.uk) and Energy for Development (www.energyfordevelopment.net))

Page 9. In Bangladesh, a solar panel is installed on a roof to provide increased access to electricty. (Credit: Practical Action/ Taif Hossain Rocky)

Page 15. Women vote for their top energy priorities in a focus group discussion in Tegragri Chak, Barguna. (Credit: Practical Action/ Anjum Islam)

Page 21. Kenyan women manufacture jiko charcoal stoves out of clay, as part of a programme on improved biomass cooking technologies. (Credit: Practical Action East Africa)

Page 35. There is only a 2% market penetration of improved stoves in Bangladesh, with the vast majority of households using wood, crop residues or animal dung as a fuel. Here, two women cook outside using traditional stoves. (Credit: Practical Action/ Anjum Islam)

Page 49. In Kame, Togo, an entrepreneur sits in her store front, the textiles she produces hanging in the background. (Credit: Practical Action/ Billy Yarro)

Page 63. Solar-powered irrigation has helped to transform people's lives in Gwanda, Zimbabwe, providing smallholder farmers with the water they need to cultivate successful crops. (Credit: Practical Action/ Martha Munyoro Katsi)

Page 73. Energy for schools was highly prioritized across our case study communities, and would help to provide a brighter future for all. Here, children gather outside their school in Kame, Togo. (Credit: Practical Action/ Billy Yarro)

Executive summary

Ending the scourge of global energy poverty has rightly become an international priority – but governments and the international community still lack the tools and approaches necessary to deliver on this important objective. One major reason for this is that current approaches do not meaningfully consider or understand the realities of energy-poor people or the technologies most suited to addressing their needs.

This *Poor people's energy outlook* is the first volume of a three-part guide for re-writing how the world needs to think about, and act on, energy service delivery if we are to eradicate energy poverty by 2030 in line with global goals. This current edition focuses on robust energy planning and policymaking for universal access; the 2017 edition will focus on financing national energy access plans; and the 2018 edition will show how to deliver universal access in practice.

New solutions to old problems

Recent years have seen incredible progress in our collective understanding of the centrality of energy services to achieving broader development objectives. This has resulted in energy access being a central pillar of the UN Sustainable Development Goals, where the global community has committed to universalizing energy access by 2030.

Previous editions of the *Poor people's energy outlook* have shown how the needs of people living in energy poverty, who mostly reside in rural areas, are quite different from what conventional energy systems are set up to deliver. Despite this progress in global prioritization and empirical understanding, and the recent radical technical evolution of renewables and systems management, energy planning and policies have evolved very little to date. In most countries, they remain the same as those that have left over two billion people without adequate, safe, reliable, or affordable access to energy services, and over three billion people cooking on dirty and deadly open fires.

Much energy planning and donor support is out of touch with the needs of the energy-poor

It has repeatedly been shown that energy poverty in dozens of countries around the world is actually set to increase, not decrease, as we move towards 2030; and that in many other countries energy poverty will only be marginally reduced (IEA 2014; IEG 2015). Much current national energy planning and international donor support is disjointed and focuses disproportionately on large infrastructure that, as evidenced in this publication, is not aligned with the global 2030 timeline, does not make economic sense in most energy-poor contexts, and is out of touch with the needs of the energy-poor.

Putting people at the centre of energy planning

Energy planning often takes place far from those without energy access; leaving them unseen, unheard and under-represented. The community-driven energy access plans we created in Bangladesh, Kenya and Togo, use the UN Sustainable Energy for All (SEforAll) initiative's Multi-Tier Framework to measure existing and required levels of energy access. This Total Energy Access (TEA) approach encompasses:

- all spheres of energy access: households, productive uses and community facilities, differentiated by gender;
- all forms of energy access: electricity, cooking, heating and mechanical power; and
- all feasible and appropriate means of energy provision: grid-connected, mini-grid, and stand-alone.

We used this approach to identify the combination of energy access technologies which provide the best means of economically meeting all of people's energy access needs on the tight 2030 timeline.

Findings and implications for national planning

The countries and communities we selected illustrate a range of geographic, socio-economic, and political contexts, as well as existing energy access levels. Insights gathered across 12 communities provide detailed and tangible recommendations for rapidly achieving universal energy access. For this executive summary, we focus on the top-line messages and findings:

- The process we use – putting energy-poor people at the heart of rural energy planning – fundamentally changes the outlook of national energy plans in terms of technologies (smaller), timelines (faster), and economics (different financial support, more rural economic opportunity, more energy-sector jobs).
- Based on the energy services people said they needed, and the applications they prioritized, Tier 3 (of the five tier SEforAll Multi-Tier Framework) electricity was found to be the minimum level at which households should be considered as having 'access' in national plans. Energy for productive uses and community facilities often needs higher Tiers of access. Tier 4 cooking energy should be the minimum level for 'access', recognizing transitional targets for Tier 2 may also be needed.
- Prioritizing cooking is essential to achieving broader development aims. Cooking with dirty biomass kills millions of people, mostly women and children, and collecting and processing it drains millions of hours per year. Cleaning up cooking will free up not only time but billions of dollars in health care resources, save millions of hectares of forests, cost dramatically less than universalizing electricity, and massively reduce women's burdens.
- Despite the conservative nature of our cost modelling, decentralized mini-grids were found to be cost-competitive or cheaper than grid extension in almost all our case studies. These systems would provide more reliable power than the national grids currently do, and would be deployable in a fraction of the time, swinging the balance even further in their favour. We found that overly focusing on traditional grids is wasting both time and money in most cases. Global and national energy planning, technical assistance, energy literacy and financing efforts must be urgently re-balanced to reflect this.
- There is demand and willingness to pay for energy services in rural areas that is often above what is charged for national grid electricity. By perversely incentivizing grids (via sustained subsidies) while often requiring decentralized solutions to function without much or any public financial support, energy planners and donors are actively constraining the technologies and approaches best suited to fulfill global agreements on universalizing energy access.

The process we used fundamentally changes the outlook of national energy plans

Major obstacles, simple solutions

Our case studies and review of national planning systems highlighted three overarching obstacles to, and simple solutions for, realizing global energy access objectives – all of which can be implemented immediately, are inexpensive, and would have incredible impact.

1. **Obstacle**: Amongst many global and national decision-makers, there is a fundamental lack of understanding and acceptance of the technologies and approaches we evidence as best suited to achieving universal energy access.
   Solution: A broad and robust effort must be made to educate staff to be well-versed in both decentralized energy technologies and the service-focused approach required to deliver modern energy services across all relevant sectors (energy, health, water, agriculture, and education).

2. **Obstacle**: Meaningful efforts to include the energy-poor in discussions on energy poverty are lacking, despite that it is only by knowing one's customer that a service provider can ensure its product is relevant. The results of this

PPEO illustrate how different energy plans and policies would look if voices of the energy-poor were adequately included.
Solution: Significant effort must be made to encourage participation of the energy-poor and their representatives in energy planning, from the project level up through programmatic efforts and national policy-making.

3. **Obstacle**: Counting megawatts and connections is misleading. Most new megawatts go to other mega needs, such as factories and mines, which only provide jobs for a select few and whose outputs are often exported rather than benefiting those at home. Counting household connections masks how rural connections are loss-making for most utilities, and that the quality of these connections is also often inadequate.
Solution: Outputs and outcomes of energy projects should assess the energy services delivered, and go beyond that to consider the numbers of jobs created, agricultural productivity increased, children educated, patients served per megawatt, and so on. These are the development objectives of the global community, and we should measure our progress accordingly.

People at the heart of the energy access agenda

We are risking a catastrophic failure to deliver on globally agreed promises made to the world's poorest and most vulnerable populations. If universal energy access targets are to stand a chance of being achieved, a radical and swift shift in approaches to national energy access planning is needed.

Those living in energy poverty should no longer be on the periphery of energy programmes steered by energy security, infrastructure expansion, and economic growth. Instead they should be at the heart of the agenda, driving planning and policy.

We can achieve universal energy access by 2030 – but only by listening to the voices of those who have for too long been ignored.

1. Introduction

The urgent need for a paradigm shift

Global attention to the energy space has reached unprecedented levels in recent years, as its centrality to mitigating climate change and improving economic opportunity, social welfare, and human wellbeing receive increasing recognition. The 2015 passage of global climate and Sustainable Development Goal (SDG) agreements committing all countries to action means that extraordinary amounts of political, financial and human capital are set to be invested in renewable energy, energy efficiency and, of fundamental importance, energy access. Furthermore, through the SDGs, an enormous stride forward has been taken in recognizing that energy access covers both electricity and clean cooking, and this will provide new avenues for addressing the important gendered components of energy poverty.

However, despite these positive trends, unless radical shifts in energy access planning and delivery are made, the outlook is bleak for poor people and for global aspirations to universalize energy access by 2030 (IEA, 2014; IEG, 2015; Hogarth and Granoff, 2015; ODI, 2015; Sierra Club & Oil Change International, 2016). Indeed, energy planning in the 21st century is thus far little changed from that which has been unable to bring adequate, safe, reliable, and affordable access to energy services to over 2 billion people, and has left over 3 billion people cooking on dirty and deadly open fires. Much of current national energy planning, and international donor support, is disjointed and focusses disproportionately on large infrastructure that, as we evidence in this report, is out of step with the 2030 timeline, does not make economic sense in many energy-poor contexts, and is out of touch with the needs of the energy-poor.

We are risking catastrophic failure to deliver on promises to the world's poorest and most vulnerable

While global figures indicate access to electricity has improved recently, this has largely been the result of grid expansion to high population density urban and peri-urban areas in India. The vast majority of those living in energy poverty today will not be as easy to reach. Indeed, the International Energy Agency (IEA) has recently forecast that, due to population growth, energy poverty in Africa is set to only decrease from 620 million people today to 540 million by 2040 – ten years *after* the 2030 global target for universal energy access (IEA, 2014). The World Bank's Independent Evaluation Group (IEG) has subsequently found that, without significant improvements in energy access efforts, global population growth will actually lead to an *increase* in the absolute number of people lacking any form of modern energy services: from 1.1 billion today to 1.2 billion by 2030 (IEG, 2015).

It is no exaggeration to say we are risking a catastrophic failure to deliver on globally agreed promises made to the world's poorest and most vulnerable populations. International support and national planning for energy access in energy-poor countries *must* change – quickly and radically.

Moving from understanding to action

In 2010, Practical Action published the first in a our *Poor people's energy outlook* (*PPEO*) series, which helped to redefine how the energy sector and key policy stakeholders understand energy poverty and energy access (Practical Action, 2010, 2012, 2013, 2014). Those editions illustrated that the global focus on simply counting new grid connections gives an inaccurate picture of energy access progress. By focussing on what poor people actually want and need in terms of household, community, and productive energy services, these *PPEOs* helped governments, international institutions, and energy service companies around the world rethink their work and redefine how progress should be measured. This Total Energy Access (TEA) approach has formed the foundation for the new global benchmark in energy access measurement: the UN Secretary General's Sustainable Energy for All initiative's (SEforAll) Multi-tier Framework (MTF).

There is now a much better awareness that national government and donor emphasis on centralized grids was often misguided, not least because many energy-poor countries are overwhelmingly characterized by sparsely populated rural areas where grids are slow and extraordinarily expensive to deploy. Many utilities reliant on large hub-and-spoke infrastructure lose money on every rural connection. Due to supply-only approaches taken by providers and a lack of integrated rural planning from governments, rural communities connected to the grid are often ill-equipped to use enough energy to make connections economically viable in the foreseeable future. There is an urgent need for energy decision-makers around the world to focus on promoting productive and community uses of energy as well as household connections. Moreover, the continued advancement and reduced costs of decentralized energy technologies, technology innovations, and new business and financing models for electricity and cooking, means there is considerably more opportunity for providing energy access more quickly, affordably, and reliably.

Our work with decision-makers and financiers around the world has revealed two critical barriers to achieving meaningful and universal access to energy.

The first is that most decision-makers, be they in global development institutions or working at national or local levels, struggle to keep up-to-date with technological innovations in renewable energy, particularly small-scale decentralized renewables. A new set of opportunities to more quickly, efficiently, and cost-effectively deliver universal access exists, but it is largely disregarded due to misperceptions of the quality and appropriateness of these technologies.

Decision-makers have misperceptions of the quality and appropriateness of small-scale, decentralized, renewable energy technologies

The second, and more fundamental barrier, is that no clear and useable guidance exists for energy planners about how to meaningfully incorporate new technologies, the voices of the energy-poor, or a service-focussed understanding of energy access into energy planning in the donor community or at the national level. The SEforAll MTF is a step in this direction but does not provide energy decision-makers with concrete examples of what plans utilizing all available and relevant technologies would look like or how they can be achieved.

Lacking a holistic vision for inclusive decentralized renewables planning means that, while many stakeholders in the energy sector acknowledge the need for an 'all of the above' approach (i.e. utilizing all energy options available to a country), the reality is that decentralized energy technologies or clean cooking technologies are rarely mainstreamed into energy planning – despite widespread and long-held recognition among technical experts that they are fundamental to achieving global energy access objectives (IEA, 2010). By not including them more holistically in energy portfolios, donors and other financiers, international institutions, and energy ministries take an 'all we have done before' approach which means the IEA's and IEG's prediction of a global failure on energy access is essentially unavoidable.

Not having a holistic vision of how to meaningfully integrate poor people's voices in energy planning means governments and donors are designing policies, regulations, and infrastructure without a realistic understanding of the needs of those they intend to serve. Despite widespread recognition that stakeholder participation improves decision-making and planning, when it comes to major energy policies and infrastructure projects, donors and national governments alike generally fail to meaningfully include either the participation of end-users, or the specific market, finance, and policy requirements of holistic energy access service provision.

Not having a holistic vision for Total Energy Access delivery means that, despite recognition of the importance of measuring energy access on the basis of quality, affordability, appropriateness, reliability, and safety, governments and the international community still plan the vast majority of energy interventions around connections and megawatts – metrics we know are wholly inadequate. Only by planning and measuring progress more holistically will we ever ensure national energy work and international development spending delivers not only power, but also empowerment.

Planning and measuring progress holistically will ensure we deliver not only power, but also empowerment

In this context, Practical Action recognized that, without mainstreaming clear and helpful guidance on bringing these fundamental principles and opportunities into energy planning processes, the world will struggle to deliver on global commitments to universalize energy access by 2030. This new suite of *PPEOs* undertakes to provide this guidance.

In this, the first of three editions, we are taking a first step towards creating a vision of Total Energy Access (TEA) and how plans for its delivery can be developed. The second *PPEO* in this new suite will explore further the economics of TEA and its financing, while the third will outline key methods for effective national deployment of energy access technologies and services.

With these reports, we hope to spark a revolution in how decision-makers approach energy policy, regulation, financing, and programmatic and project work. We are also optimistic that the private sector will find value in the approaches presented here, as we illustrate how attention to productive uses of energy can positively impact the ability of communities, businesses, and individuals to progressively pay for increased energy and services. This, in turn, will improve the bottom line for companies and balance sheets for banks. Win–win–win.

Planning in action: the structure of this publication

This *PPEO* begins with a concise overview of what energy planning currently looks like in energy-poor countries, underscoring the need for new approaches if we are serious about eradicating energy poverty.

The core of the report follows, with bottom-up TEA planning case studies from Bangladesh, Kenya, and Togo. Four communities from each country are discussed, representing a great variety in terms of size, economics, location, and existing energy services. Planning exercises were undertaken with each community, these provide examples of how to plan for holistic energy access, and of the TEA plans which could emerge from such a process, highlighting some of the issues around energy access needs and affordability.

We conclude the report with recommendations for the international community and national governments about how to realize rapid and broad uptake of energy planning that is truly 'all of the above'.

2. The inadequacies of energy access plans today

Achieving universal energy access by 2030 in line with SDG7 on Energy requires a significant increase in the speed of delivery of new electricity and clean cooking services. It is critical to understand the role of national governments in setting targets, agreeing plans and policies, and allocating resources in order to identify where change is needed to remove barriers to more rapid progress. This chapter therefore reviews existing national planning processes, drawing on available literature and Practical Action's own country-based experience, and identifies key areas for improvement.

The national energy planning landscape

From an access perspective, national energy policy and planning landscapes are often complex and difficult to understand for a number of reasons. First, national energy policies, strategies, and plans are generally framed with multiple objectives in mind: including economic growth, energy security, and environmental issues in addition to access. Disentangling those elements of a plan that are aimed at access from those aimed at other objectives can be difficult. Adding generating capacity to a national grid, for example, could deliver additional energy for industry and stabilize and significantly improve supplies for domestic consumers already connected, and/or allow for new households to be connected.

Second, the tendency for economic growth and energy security to dominate policies and strategies leads to over-emphasis on sources of primary fuels, generating capacity, and extensions of transmission lines, and under-emphasis on targets and strategies to improve access even in extraordinarily energy-poor countries. Indeed, Kenya's National Energy Policy has just eight out of 140 pages devoted to access (MEP, 2014: 50–52); Bangladesh's current five-year plan mentions access on fewer than two of 41 pages devoted to energy (GoB, 2015: 355); and Togo's law No. 2000-012 on electricity has no provision whatsoever for rural electrification (MEF, 2014).

Responsibilities for electricity access are distributed across agencies, making co-ordination of holistic plans extremely complex

Third, responsibilities for electricity access are distributed across multiple agencies, making creation of holistic plans to meet all TEA needs, and to direct resources to those means of access which will achieve most impact, complex and difficult. Rural populations (where the vast majority of those without access live) may get electricity via grid extension from the national supplier, such as the Nepal Electricity Authority, or via a specialist government agency, like the Bangladesh Rural Electrification Board or the Kenya Rural Electrification Authority. Off-grid energy provision may be the responsibility of a different government-funded agency, such as the Infrastructure Development Company Ltd (IDCOL) in Bangladesh. Or it may be shared between more than one agency, as in Kenya where both the Rural Electrification Authority and the Directorate of Renewable Energy sponsor off-grid initiatives (see MEP, 2015a, 2015b). The private sector can also make substantial contributions that are not generally captured in national plans or reporting. A 2014 study estimated 14% of Kenya's population get their electricity from solar home systems (SHS), largely supplied by the private sector and not yet included in national coverage estimates (M-KOPA, 2015).

Fourth, responsibilities for improved cooking facilities are often further fragmented and may fall across multiple ministries or other government institutions. In Kenya, while the Directorate of Renewable Energy promotes improved cookstoves (ICS) through its energy centres, the Ministry of Agriculture also has a national ICS project. In Bangladesh, although the Ministry of Power, Energy and Mineral Resources (MPEMR) is nominally responsible for renewable energy policy, both the Department of Environment and IDCOL run their own national ICS programmes (MPEMR, 2013). National strategies and policies on clean cooking have historically been weak and consideration of cookstoves has often been excluded from important policies. For example, despite recognizing that traditional use of biomass for cooking accounts for 55% of Bangladesh's overall energy consumption, the national energy strategy purposefully excludes cooking (SREDA & MPEMR, 2015: 7). In sub-Saharan Africa biomass for cooking accounts for a staggering 80% of residential energy demand but, again, this is rarely included in energy policies or planning (IEA, 2014: 35).

This complexity results in key information being scattered across multiple agencies, making it difficult to obtain clear oversight of either the scale and nature of energy access issues or how needs can be met. Consequences can be significant and include conflicting estimates of national coverage and progress, as reflected in the 2012 figures for Kenya, which range from the Global Tracking Framework's estimate of 23% (SEforAll, 2015), through to the Ministry of Energy and Petroleum's estimate of 30% (MEP, 2013), to M-KOPA's figure of 44% (M-KOPA, 2015). Other issues arising from this fragmentation include competition and infighting among responsible agencies, duplication of effort, and assumptions that another agency is responsible for a region or topic when, in fact, no one is.

Levels of consultation on national energy plans also vary significantly. Countries with effective decentralized governance systems can have strong local engagement, meaning national plans are more likely to reflect local realities and priorities. Nepal, for example, has a 14-step annual national planning process, starting at Village Development Committee level and building up to the national scale. Local planning is supported by specialist government energy staff at district level. Kenya, which has recently devolved powers to county level, is just beginning to trial ways of supporting people to develop the necessary skills at a local level to make such engagement in planning meaningful. In most countries, however, decentralized systems are rare, and planning processes take place very far from the day-to-day reality of those without energy access.

In most countries, planning takes place far from those living in energy poverty

Understanding drivers of national policy

So what leads to energy-sector strategy, policy papers, and plans being written and revised? In many countries, one factor is public agitation over the state of energy infrastructure. The impact of rolling blackouts in countries where power demand outstrips supply is headline news (e.g. Khaleej Times, 2016; Nelson, 2016); however, protest is primarily from those who are already connected: urban domestic consumers, industry, small and medium-sized enterprises (SMEs), financial institutions, and key urban service providers, such as water utilities or hospitals. Pressure of this nature reinforces the sector's tendency to focus on improvements to large-scale generating capacity, transmission, and distribution infrastructure.

More recently, climate change concerns have also become a driver of energy-sector policy. International climate negotiations under the UN Framework Convention on Climate Change (UNFCCC), combined with a growing awareness of the impact climate change is already having, is influencing energy-sector planning. There are no less than three UNFCCC processes relevant to national planning for energy access: Technology Needs Assessments (TNAs), Technology Action Plans (TAPs), and Nationally Determined Contributions (NDCs). The Zimbabwean NDC, for example, commits to a greater use of renewables in the national energy mix, while at the same time recognizing the growing threat of water shortages on hydropower potential and the need to adapt (GoZ, 2015).

National policy change is often driven by public agitation, climate change concerns, and availability of finance

Availability of finance under these processes can further accelerate policy review. Togo's application under the Climate Investment Fund's Scaling Up Renewable Energy Program (SREP), for instance, commits the government to developing and adopting a comprehensive energy policy (MEF, 2014). It should be noted, however, that, as with more general public pressure drivers, these climate-change-related processes can still leave policy discussions and commitments focussed on issues of national generating capacity and primary energy mixes, rather than on energy access for those without.

Engaging diverse stakeholders

In reality the experience of national policy-making varies dramatically from country to country. In many energy-poor contexts, governments are under-resourced and rely heavily on externally funded (often international) consultants with traditional energy backgrounds to draft legislation and regulation. In the dozen or so countries in which Practical Action has been active in energy policy-making over the years, only recently have governments begun opening up these processes to consultation with non-state stakeholders. Even so, there is a danger of these remaining 'box-ticking' exercises with little impact on policy.

The SEforAll initiative has put energy access firmly on the table in energy sector policy debates

Given the relatively low profile of energy access issues in national policies, and the fragmentation of responsibilities, the advent of the UN SEforAll initiative has proved significant in two ways. First, it has put the issue of access firmly on the table in both international and national energy-sector policy discussions, insisting those debates move beyond counting megawatts of capacity and kilometres of transmission lines to take a proper look at who does and does not have access. Second, through the process of developing national Action Agendas (AAs) and Investment Prospectuses (IPs), much-needed comprehensive national views are emerging on the scale of the access challenge, the major players involved, and the relevant policy and regulatory environment, as well as actions needed in the future. These AAs may not necessarily add anything new to existing analyses but they do, often for the first time, provide a single national snapshot of the access challenge. They add transparency, bringing together documents (ranging from rural electrification master plans to departmental budgets) that are often not easily available in the public domain.

Indeed, transparency will continue to be an important issue. As has been illustrated, many of the existing drivers for national energy-sector policies and plans do not naturally put improving energy access at the centre of debates. To change this, the voices of those who do not have electricity supplies or clean cooking need to be heard more in policy discussions. Civil society organizations (CSOs) have an important role to play in helping facilitate these interactions. CSOs and SMEs themselves have valuable knowledge to offer as a result of their direct experience delivering energy access services, experience other sector players often lack.

Civil society has a vital role to play in helping facilitate interactions between consumers and decision-makers

A 2014 survey of CSOs in six countries suggested wider consultation was not well managed in the earlier stages of gaps analyses for AAs (Gallagher & Wykes, 2014). More recent experience from countries such as Kenya, Zimbabwe, and Nepal has shown that improved levels of consultation and participation in planning, involving civil society and private sector players, is not only possible but also highly desirable. It can result in improvements such as the inclusion of the MTF in Nepal and Kenya; a greatly improved AA and IP in Kenya, widely bought into by all stakeholders (Wandera-Odongo, 2016); and a more comprehensive consideration of gender and energy nexus issues (such as energy's relationship to water and food). SEforAll has published a guidance note on multi-stakeholder consultations (SEforAll, 2014) which, if it can be adhered to, will help ensure future national and international energy planning processes achieve similarly improved outcomes.

As government decentralization processes further localize responsibilities for the planning and delivery of services such as energy, it is important to ensure that voices from lower tiers of government (for example, District Development Committees in Nepal or County Authorities in Kenya) are also involved in national decision-making. This could extend to urban local authorities tackling the different needs and challenges of energy access in informal urban settlements (Castán Broto et al., 2015).

Reinforcing the status quo or pushing for change?

Beyond national policies and plans, the availability of finance is a central driver of progress towards achieving universal access to electricity and clean cooking. The latest estimates from the IEA show that, in 2013, US$12.7 billion was invested globally in electricity access and $400 million in improved cooking. Around 37% of this came from developing country budgets, while 45% came from multilateral and bilateral aid, and 18% from private finance, showing access to international sources of funding remains vital to progress (IEA, 2015). That said, the vast majority of recent success with clean with clean cookstoves and small-scale solar has relied on household expenditure and access to finance. This has been extraordinarily important in providing evidence that poor people are willing, able, and indeed often keen, to pay market prices for energy services – though, as we demonstrate later in this report, they are often unable to afford the full cost of the higher levels of access which would fully meet their needs.

Even when funding is directed to countries of greatest need, it often fails to reach the populations without access

While development assistance for energy is growing substantially (six-fold in Africa: from $750 million in 2003 to $4.7 billion in 2013 (Africa–EU Energy Partnership, 2016)), major financial hurdles remain. Current global investments are still just a fraction of the IEA estimate of the annual funding requirement needed to meet SDG7 by 2030 (Figure 2.1).

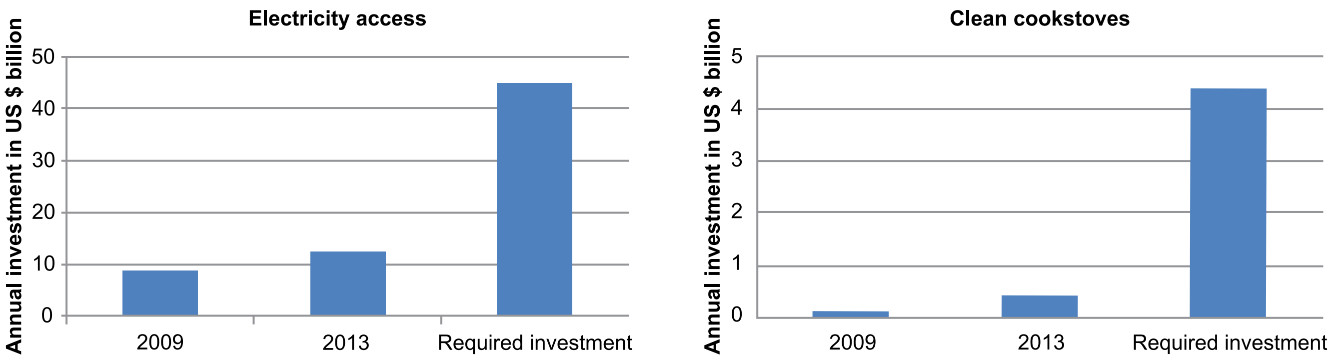


Figure 2.1 Estimates of actual and required global investment in energy access
Source: IEA, 2011, 2015

It should be noted, however, that many, including Practical Action, challenge the IEA's estimate of the cost of universal access. Falling prices, more efficient appliances, and a rethink of the level of consumption needed to provide basic services and major development benefits could lower the $45 billion annual cost of universal access by as much as 70% (Craine et al., 2014) or even 90% (Power for All, 2014). We will return to this topic in more depth in the next *PPEO*.

Even when funding is directed to countries of greatest need, it often fails to reach the populations without access. As the 2011 *World Energy Outlook* shows, because the vast majority of those without any access to electricity are scattered across rural communities where grid-based solutions are deemed uneconomic, around 65% of the additional funds required to provide universal electricity services will have to be invested in off-grid technologies, such as SHS or mini-grids (IEA, 2011). However, the World Bank's support for off-grid electrification has recently been described as 'low and sporadic', with an independent evaluation noting 'significant gaps in coverage of low-access countries, with low engagement and continuity mostly in sub-Saharan Africa, the region with the largest population without access' (IEG, 2015: 49).

Frustratingly, despite this evidence, neither the World Bank nor any other major development bank (all of whom are 'failing' in support to off-grid (Sierra Club & Oil Change International, 2016)) is investigating options to bring its energy investment portfolio in line with the recognized need to put a majority of financing into the decentralized energy space. Hence, continued pressure is required to ensure adequate financing is applied to the right mix of grid and off-grid investments. This will require significant improvements in transparency of financial flows, a change only likely to be adopted if this issue is kept relentlessly in the spotlight.[1] It will also require a new paradigm in energy planning for which many energy ministries, utilities and regulators are unprepared.

Keeping the needs of those without access at the centre of the policy and planning agenda

Approximately 3 billion people have inadequate access to modern, safe, affordable, and appropriate cooking and electricity services

Approximately 3 billion people have inadequate access to modern, safe, affordable, and appropriate cooking, electricity, or other energy services, yet national and international policy and financial drivers do not prioritize their needs. The SDG and SEforAll processes can play important roles in changing this. For the first time, in many countries, SEforAll AAs and IPs offer an easily accessible summary of national energy access contexts as well as a plan for action.[2] They can also point to new ways forward. The AA for Kenya and the draft for Nepal, for example, both adopt the SEforAll MTF to measure energy access and to set national targets (National Planning Commission, 2015). Despite these advances, further progress is required to ensure that the plans created through this process address all the aspects of Total Energy Access, look beyond the grid/off-grid dichotomy to identify concrete means by which TEA can be achieved, and reflect the interactions between different forms of access and real people's priorities and decisions.

Given the history of poor availability of information, the public availability of AAs and IPs is crucial and must be enhanced. It is encouraging to see the SEforAll Africa Hub is already publishing these documents online (SEforAll, 2016a; SEforAll, 2016b). This will enable a case to be made for more appropriate investments in access and will ensure governments and international development assistance providers can be held to account for delivering against the access plans agreed.

3. A bottom-up approach to national energy planning

Our approach aims to provide insights for national energy planning based on the holistic needs of rural communities, demonstrating that a TEA approach can be designed and delivered in practice, according to the real circumstances and perspectives of the energy-poor. Our community-level plans therefore encompass:

- all spheres of energy access: households, productive uses, and community facilities, noting the different needs of men and women;
- all forms of energy access: electricity, cooking, heating, and mechanical power; and
- all feasible and appropriate means of energy provision: grid-connected, mini-grid, and stand-alone.[1]

Our methodology is grounded in meaningful interaction with end-users. We shared realistic information about energy access options and sought community members' priorities and preferences, which we subsequently translated into access plans that provide valuable information on:

- technologies and approaches most likely to deliver improved energy access;
- aggregate costs of providing TEA holistically (instead of piecemeal delivery of different elements); and
- levels of access likely to be achieved if we base delivery solely on individuals' ability to pay, confirming the need for meaningful public support.

This draws on years of well-documented field-based experience in participatory energy planning at the village level (e.g. ITC, 1999, 2000; Practical Action, 2009; Energia, 2011) and, in particular, on experiences from the CHOICES project (Community and Household Options In Choosing Energy Services) led by the International Institute for Environment and Development (IIED) in South Africa, which involved participatory approaches to prioritizing energy service needs (Kar, 2014; Wilson, 2014), and earlier experiences in Sudan (Bakhiet, 2008).

Case-study approach

The plans we created were rooted in the realities of energy-poor people's lives

To ensure that our plans were rooted in the realities of people's lives we needed evidence from communities lacking access. We selected Bangladesh, Kenya and Togo for case studies because they illustrate different stages of energy access progress, and because Bangladesh and Kenya are high-impact countries (SEforAll, 2013) where rapid progress is needed if we are to meet global targets by 2030. In each country we identified four communities of different size, population density, and socio-economic profile that varied in terms of ease of access, topography, availability of energy resources, and livelihood activities, to illustrate the diverse situations of the rural energy-poor.

This inevitably means the plans developed are specific to these communities and we do not claim they form a statistically representative sample or encompass the full range of energy-poor community types. However, we strongly feel their diversity provides valuable insights to inform energy access planning and priorities.

We would not suggest that such detailed research be undertaken routinely, but a small number of similar exercises in selected representative communities would be valuable in any national planning process.

Evidence collection

Fieldwork teams visited each community to explain the exercise we proposed to carry out, what it would achieve, and the exercise's limitations (particularly that we could not commit to implement the plan). We did not carry out energy literacy campaigns which might have shifted preferences in desired energy services or technologies. We mapped each community and recorded numbers and locations of households, productive activities, community facilities, and energy resources.

This enabled us to identify which options were viable for each community and to establish potential electricity distribution system coverage areas. We also developed typical electrical usage profiles for households, enterprises, and community facilities for different tiers of energy access, based on the SEforAll MTF (Table 3.1).[2]

We collected costs and performance data on energy technologies and fuels, either locally or using published figures from product suppliers (Table 3.2). For more complex electrical technologies we used HOMER (Hybrid Optimization of Multiple Energy Resources) software. For cooking we considered solid-fuel stoves of a range of qualities (MTF Tiers 1–4) and clean-fuel options including solar cooking, biogas, liquid petroleum gas (LPG), bioethanol, and electricity (Table 3.2).

Using this data and our economic model, we estimated daily costs[3] of providing each access option at different tiers in each community[4]. These represented end-user

Table 3.1 Multi-tier matrix for access to household electricity

ATTRIBUTES		TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
1.Capacity	Power[1]		Very Low Power Min 3 W	Low Power Min 50W	Medium Power Min 200 W	High Power Min 800 W	Very High Power Min 2 kW
	AND Daily Capacity		Min 12 Wh	Min 200 Wh	Min 1.0 kWh	Min 3.4 kWh	Min 8.2 kWh
	OR Services		Lighting of 1,000 lmhrs per day and phone charging	Electrical lighting, air circulation, television, and phone charging are possible			
2.Duration	Hours per day		Min 4 hrs	Min 4 hrs	Min 8 hrs	Min 16 hrs	Min 23 hrs
	Hours per evening		Min 1 hrs	Min 2 hrs	Min 3 hrs	Min 4 hrs	Min 4 hrs
3.Reliability						Max 14 disruptions per week	Max 3 disruptions per week of total duration <2 hours
4.Quality						Voltage problems do not affect the use of desired appliances	
5.Affordability					Cost of a standard consumption package of 365 kWh per annum is less than 5% of household income		
6.Legality						Bill is paid to the utility, prepaid card seller, or authorized representative	
7.Health and Safety						Absence of past accidents and perception of high risk in the future	

[1] The minimum power capacity ratings in watts are indicative, particularly for Tier 1 and Tier 2, as the efficiency of end-user appliances is critical to determining the real level of capacity, and thus the type of electricity services that can be performed.

Source: ESMAP, 2015

Table 3.2 Electricity technologies considered

Appliances	*Household/enterprise systems*	*Distribution systems*
Kerosene lanterns Solar lanterns Solar streetlights	Solar Hydropower Wind Biomass Biogas Bioethanol Diesel	Mini-grid distribution systems covering different geographical ranges and powered as for household systems[1] Grid extension: transmission and distribution infrastructure and centralized generation

[1] Hybrid solutions were not modelled because of the complexity of optimizing hybrid generation combinations to match each community and case. However, they may offer financial and environmental benefits in comparison with single-fuel mini-grids.

costs of provision and did not account for externalities in several categories: environmental (carbon emissions, deforestation, land-use change), social (unpaid domestic work), or political (subsidies). The costs therefore remain approximate but are reasonably representative.

Using the results of this analysis, we consulted communities to understand energy needs, priorities, and willingness to pay for electricity, cooking, and street lighting. This consultation involved surveying a sample[5] of households, enterprises, and community facilities, and participatory activities with a focus group of community members in each location.

In the household surveys we asked about:

- household make-up, employment, and income;
- current energy access and expenditure;
- priorities for the community (between energy for households, productive uses, and community facilities) and for the household (between different forms of access); and
- preferences and willingness to pay[6] for solutions.

For each solution, an information card was shown describing briefly its costs and key attributes (Table 3.3 gives some of the information about cooking options). The costs presented were based on the means of providing the (technically viable) form and level of access which achieved lowest daily cost for users.

For enterprises and community facilities we asked about:

- the enterprise or community facility itself;
- use and need for various energy applications (lighting, ICT/entertainment, motive power, heating and cooling);
- current energy access and expenditure; and
- what appliances/equipment they needed to power and what they would be willing to pay for energy for these.

Table 3.3 Attributes of cooking solutions presented to survey and focus group participants

Stove type	*Smoke/cleanliness*	*Fuel requirements*	*Cooking*
Basic improved stove using wood, straw, or dung	Cleaner and less smoky	Uses a third less fuel than traditional stove	Saves 30 min cooking time/day
Enhanced wood fuel stove	Pollution greatly reduced, so kitchen and pots much cleaner	Uses two-thirds less fuel Fuel needs to be chopped into 5 cm pieces	Saves 45 min cooking time/day
Enhanced charcoal stove	Pollution almost zero	Uses two-thirds less fuel	Saves 45 min cooking time/day
LPG stove	Good for health: no smoke, very low pollution	Need to swap cylinders, and they are heavy (25 kg) Cylinder can run out during cooking	Lights instantly, good control of flame and heat
Solar cooker	Completely clean	No fuel required Can only be used in the daytime Needs to be realigned every hour or so	Heat can fry foods and can also cook slowly
Electric cooker	Completely clean	Only possible with a high-quality electricity connection	Good control over heat

Focus group discussions were held in each community using a range of participatory methodologies to get a more nuanced view of needs and priorities. As with the surveys, discussions focussed on:

- The energy access situation and how the need for and availability of energy varies across the day, the year, and geographically within the community.
- The community's needs for various energy services (such as household lighting, cooking, agri-processing, and education) and the relative importance of these needs.
- Views and preferences regarding possible means of energy provision (such as lanterns, home systems, or system connections).

In Thanchi, Bandarban district, community members engage in a focus group discussion on their energy access needs and priorities

Analysis and energy access plan development

Having mapped energy sources, technologies, and levels of access, we then modelled three scenarios for the mix of energy access to best meet the community's needs and priorities:

1. respondents' views of their needs based on the electrical applications and appliances they wished to use, and the cooking solution they ranked most highly;
2. a common standard of MTF Tier 3 for electricity[7] and Tier 2 or Tier 4 for cooking; and
3. the level and forms of access for which people were willing to pay the full cost.

Information from the focus groups was used to triangulate the plans and, in particular, to help identify productive uses of energy, beyond those put forward by existing enterprises, which would enable economic growth.

For each scenario, we identified the best means of providing the energy needed based on a combination of costs and preferences. For distribution systems, average and maximum daily electrical demands were calculated and aggregated[8] across the community, costs recalculated, and the selection process re-run using these costs. This iterative process[9] was repeated until the combination of electricity access provision (mix of system connection and stand-alone technologies), and the total cost of this combination could be established (Figure 3.1).

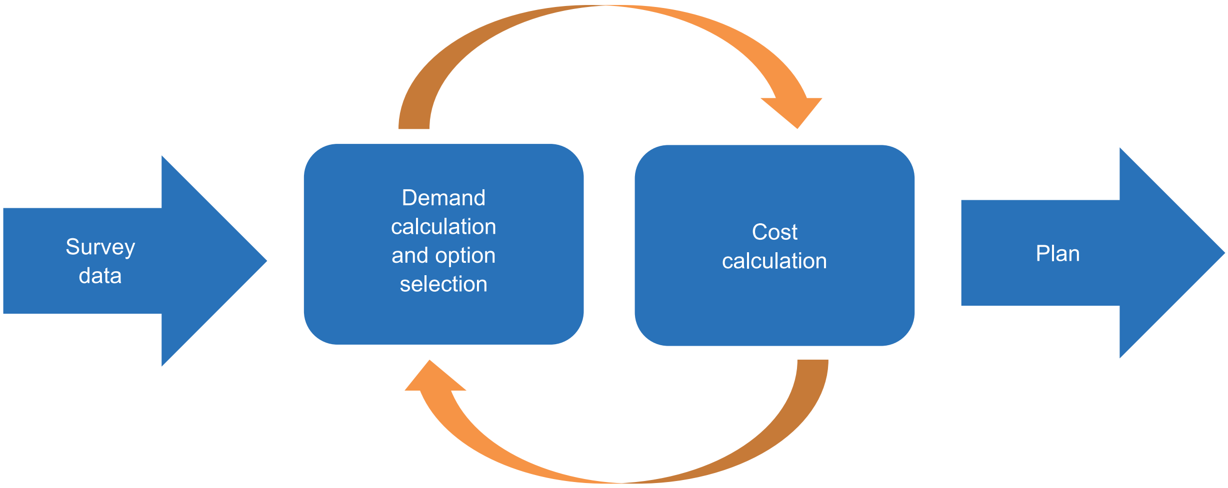


Figure 3.1 Electricity access modelling process

Our modelling aimed to produce the lowest cost for the community as a whole. Thus, for example, a larger distribution system might be chosen if it reduced the number of relatively expensive stand-alone systems, even if that meant increasing the cost for those connected to the system.

Finally, we compared costs of powering loads such as pumps and mills using electricity and mechanical power[10] and, if mechanical power could be provided at lower cost, the loads were removed from the electrical demand and the planning process repeated.

The process for arriving at plans for energy access for cooking was similar, but based on individual rather than community choices.[11] Again, three scenarios were modelled:

1. options respondents ranked highest;
2. a common standard of Tier 2 or 4, and the lowest cost means of achieving this (or a higher) level; and
3. respondents' willingness to pay, starting with their highest-ranked option.

The plans presented in the following case-study chapters provide snapshots of the combinations which together can address a variety of energy access needs in rural, off-grid communities, as well as the costs and affordability of these plans. The commonalities and differences between them give indications of the focus areas which may be most effective in achieving TEA, and the scale of effort needed if a meaningful level of universal access is to be reached by 2030.

4. Kenya

National context

Access to energy remains a significant challenge in Kenya, with its growing population and diverse socio-economic and geographic contexts. In 2012, electricity access (household connections to the national grid) was just 23%, with only 16% using non-solid fuels for cooking. This places Kenya seventh among the high-impact countries for electricity access and 14th for cooking (SEforAll, 2013). Kenya has set itself a 2022 target of 100% access to electricity.

There has been a significant uptake of solar lanterns and solar home systems (SHSs) in recent years, driven in part by innovative mobile phone-based payment systems. A recent value-added tax exemption on solar products has reduced the price of imported systems. The government estimates 'well over 200,000' have been installed (SEforAll & MEP, 2016a), while others put the figure at 320,000 (Ondraczek, 2014). The 2014 national demographic and health survey found 14% of rural households owned a solar panel (KNBS & GoK, 2015). Similarly, Lighting Africa estimates 700,000 solar lanterns had been sold, representing 8% market penetration, in 2013 (Lighting Africa, 2016). Despite this, the use of kerosene for lighting remains prevalent.

Over 84% of Kenyans rely on biomass as their primary energy source for cooking and heating

Over 84% of Kenyans rely on traditional biomass as their primary energy source for cooking and heating, with firewood contributing 69% and charcoal 13% (Ipsos & GACC, 2014). The health of over 36 million Kenyans is therefore impacted by exposure to household air pollution (HAP) annually, with over 15,000 deaths per year attributed to HAP. Kenya's cookstoves sector is active with, for example, ceramic *jiko* stoves widely used in urban and peri-urban areas (90% among better-off urban charcoal users). An estimated 2.25 million households own an improved stove and liquid petroleum gas (LPG) is gaining popularity for some urban residents. The major challenge, however, is among rural firewood users where only 2% own an improved stove (GVEP & GACC, 2012).

Overview of case-study communities

The four communities represent a range of the situations faced by millions of rural Kenyans. They are in some of the poorest counties, where electricity connections are around the national rural average (Table 4.1).

Table 4.1 Poverty rate and electricity connections by county

County (village)	*% below poverty line (2005–06)*	*% with electricity connection (2011)*
Turkana (Kalokol)	92.9%	2.4%
Makueni (Utumoni)	63.8%	5.9%
Busia (Sibinga)	66.0%	6.0%
Kwale (Mkwiro)	72.9%	10.6%
All rural Kenya	49.1%	6.7%

Source: CRA, 2011

Kalokol, Lake Turkana. Arid and semi-arid lands. Fishing. On the western shore of Lake Turkana, Kalokol (Turkana County) is in Kenya's arid and semi-arid lands. There are **890 households** across Kalokol town and two nearby settlements: Namukuse and Kalimapus. The livelihoods of most of the population depend on fishing or cattle-herding. The district's population density is low, and the nearest grid electricity is 55 km away.

Utumoni. Hilltop village. Smallholder farming. Female-headed households. Utumoni in Makueni County is a dispersed farming community of **110 households**. Along with traditional crops, avocados and mangoes are cultivated as cash crops and a fifth of families keep livestock. Labour migration is common. Half the adult male population is employed elsewhere and over half (52%) of households are female-headed (compared to 9–21% in the other settlements). The village suffers from water insecurity, relying on rainwater and natural springs located some distance away. Grid electricity reached the village in November 2015 but only one household is connected.

Sibinga, Western Kenya. Smallholder farming. Sibinga, a village of **754 households** grouped into about 300 homesteads in Busia County, is close to Lake Victoria and the Ugandan border, on a low hill surrounded by swampy land. Most people are smallholder farmers growing cassava and maize and keeping a few cows. Although not currently grid-connected, community facilities (at least) may be connected in the next three years. Average incomes are higher here than the other settlements.

Mkwiro, Wasini Island. Fishing. Mkwiro village, Kwale County, with **230 households**, is on the small island of Wasini in the Indian Ocean south of Mombasa. The main livelihood activity is fishing, but stocks are reducing. People also sell seashells, weeds, and rare sea animals. Some act as tour guides for very occasional tourists. Poverty levels are highest in this community.

Current levels of energy access

Household electricity

The penetration of solar lanterns and SHSs is evident in these villages, particularly in Kalokol and in Utumoni through its migrant labourers who have access to markets in Machakos or Nairobi (Figure 4.1).

The majority of those with electricity are at Tier 1, although there are some larger Tier 2 systems in Kalokol (Figure 4.2). The performance of some solar lanterns is so limited that people remain in Tier 0. Tier 1 access allows the use of a number of household appliances (phone chargers, radios, televisions, and a few fridges). Households without electricity have not invested in any of these appliances. Those without electricity are, on average, poorer and so probably cannot afford either solar products or the appliances to go with them.

In every case, households with electricity are able to use it for lighting; however, many (over two-thirds, except in Kalokol) continue to use additional energy sources for lighting, suggesting the lighting available from off-grid systems is insufficient. Some of those without electricity access have no source of lighting at all (Figure 4.4). Others rely on kerosene or batteries.

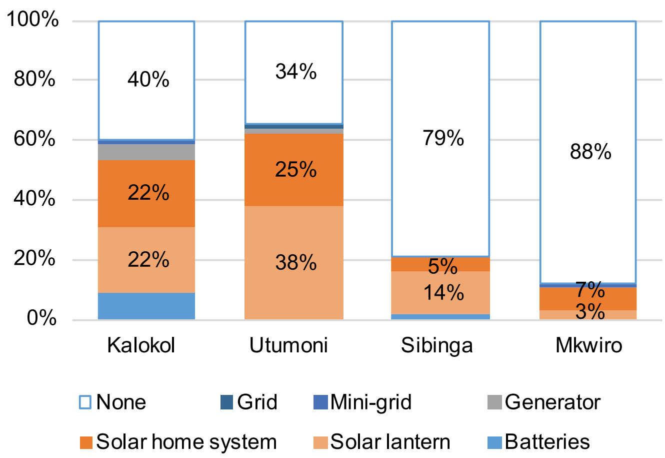


Figure 4.1 Primary source of household electricity in Kenyan case-study communities

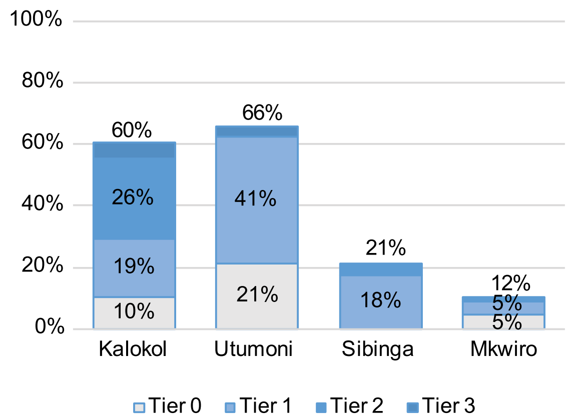


Figure 4.2 Level of electricity access (for those who have access)

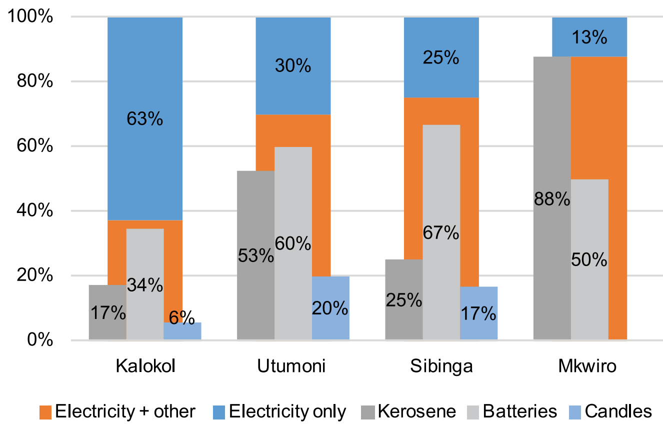


Figure 4.3 Source of lighting for those with electricity

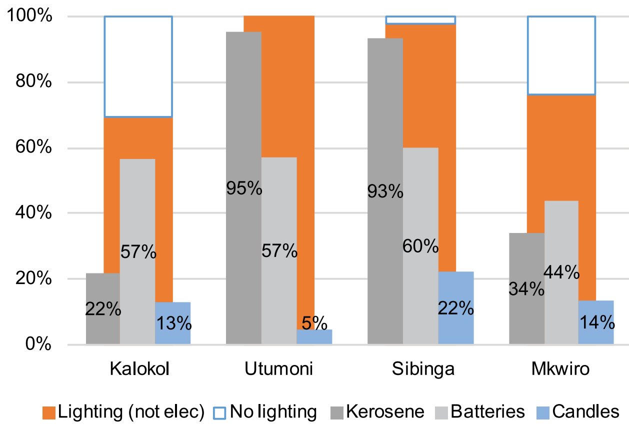


Figure 4.4 Source of lighting for those without electricity

Household cooking

People use a mixture of wood and charcoal, reflecting the national picture (Table 4.2). Fuel choice is reflected in primary cooking solutions (Figure 4.5).

'Fuel stacking', where households own and use more than one stove, is common: 14% in Kalokol, 21% in Sibinga, and a huge 84% in Utumoni had a secondary stove, with charcoal used for particular cooking tasks and at particular times of the year. This was partly related to seasonal fuel shortages, a challenge in all communities except Utumoni, where firewood is available on people's farms. The situation in Sibinga, especially during the wet season, is so difficult that people resort to burning plastic and spend more time collecting fuel (Table 4.3). Charcoal users are more likely to buy fuel, with 51% of all respondents in Kalokol and 64%

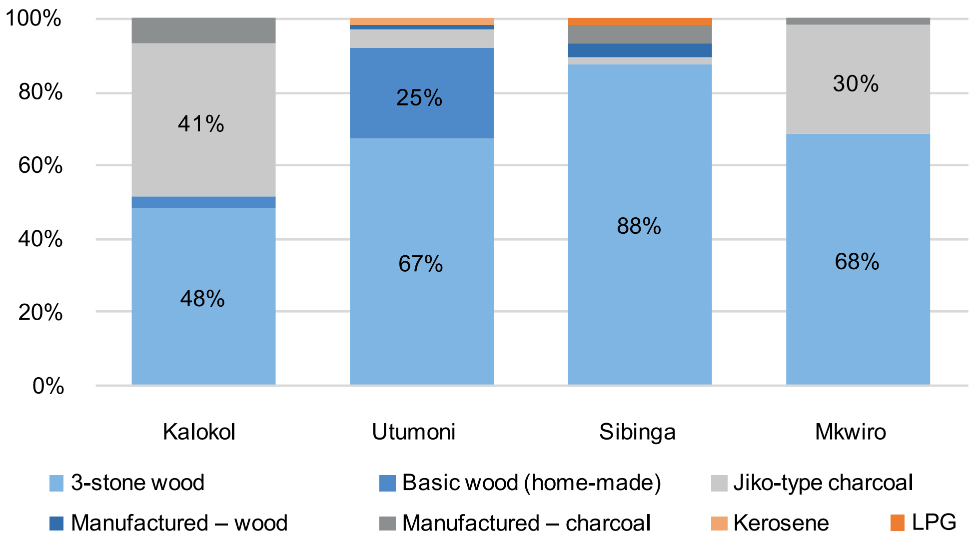


Figure 4.5 Primary cooking solution

Table 4.2 Primary fuel type

	Kalokol	*Utumoni*	*Sibinga*	*Mkwiro*
Wood	53%	95%	93%	68%
Charcoal	47%	5%	7%	32%

in Mkwiro spending money on fuel. Even in Utumoni two-thirds of respondents said they sometimes bought wood.

Improved cookstoves were almost all simple charcoal *jikos* (Figure 4.6). We found a handful of branded manufactured charcoal stoves, but only three manufactured wood-burning stoves. Uptake of LPG is very limited (Figure 4.5).

Cooking takes the greatest amount of time per week, with less time collecting or preparing fuel (tasks which are not required, or not reported, in all households, as indicated by the percentage answering the question) (Table 4.3).

Women generally cook and prepare fuel. Gathering fuel is more evenly shared between men and women; however, on average, men spend less time on this (Figure 4.7).

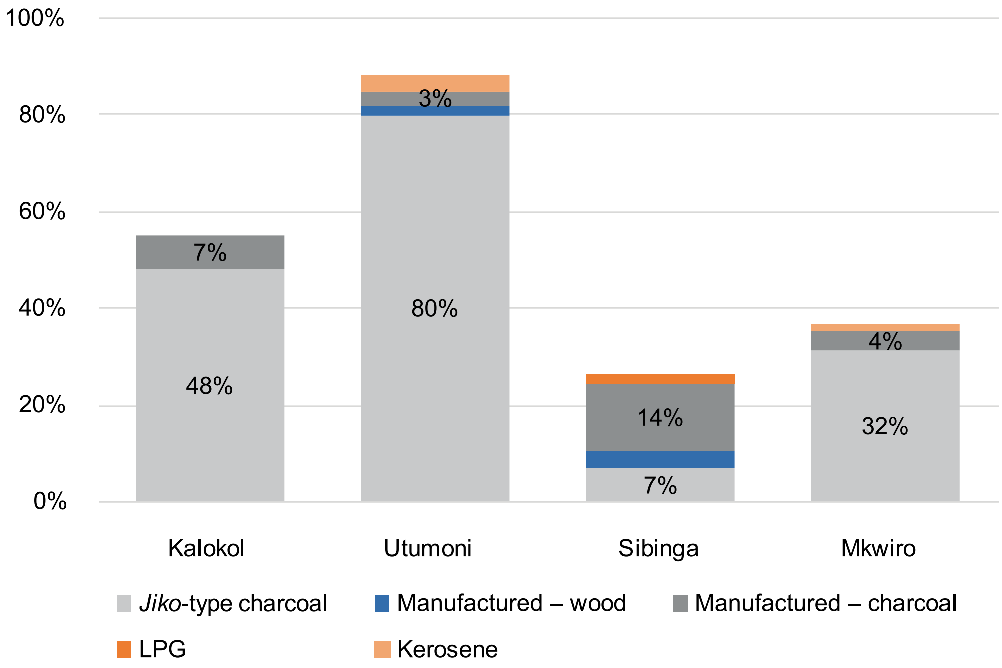


Figure 4.6 Ownership of manufactured stoves (as primary or secondary stove)

Table 4.3 Hours per week cooking, collecting fuel, and preparing fuel

	Kalokol	*Utumoni*	*Sibinga*	*Mkwiro*
Average hours cooking	26.8	27.7	41.4	27.1
Average hours collecting fuel (% answering)	7.0 (33%)	3.7 (87%)	11.3 (82%)	8.5 (33%)
Average hours preparing fuel (% answering)	5.9 (24%)	2.8 (90%)	5.0 (37%)	6.3 (22%)

Electricity for livelihoods

We interviewed all the small enterprises, and some farmers and fishers. Their electricity access rate is generally lower than that of households, but at a higher tier (Table 4.4). Enterprises require a wide range of energy services (lighting, ICT, cooling, heating, and motive power) and use a range of supplies to meet those needs (electricity, kerosene, batteries, wood, charcoal, diesel) (Table 4.5). Diesel generators are often used for electricity (five in Kalokol and one in Utumoni) or direct motive power (two maize mills in Sibinga). These are expensive to run because of the costs of transporting fuel long distances.

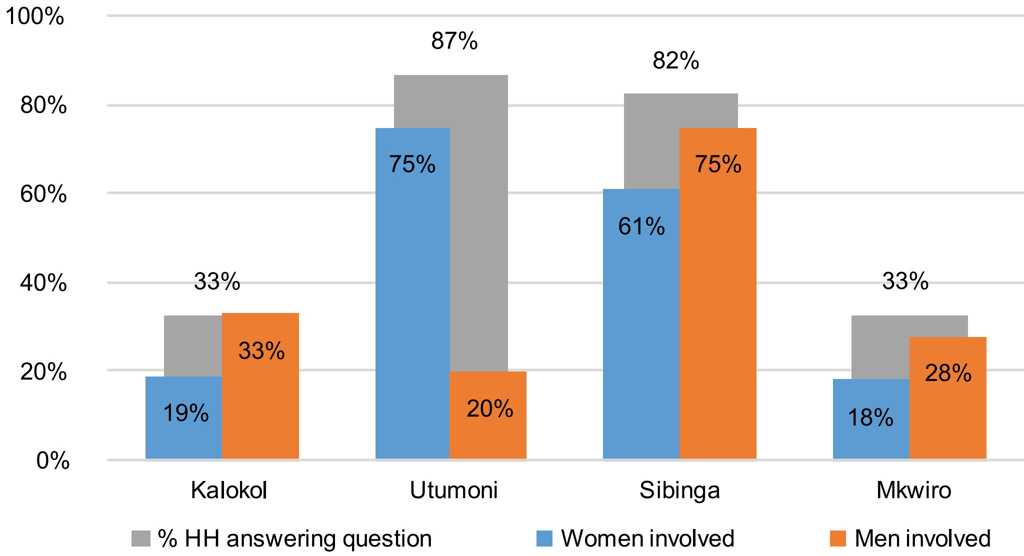


Figure 4.7 Gender division of labour for fuel gathering

Table 4.4 Level of electricity access and number of SMEs (those with access)

	Kalokol	*Utumoni*	*Sibinga*	*Mkwiro*
Tier 0		1		
Tier 1		2		1
Tier 2	2		1	
Tier 3	6	4		1

Table 4.5 Primary source of electricity for enterprises

	Kalokol	*Utumoni*	*Sibinga*	*Mkwiro*
None	8 (50%)	28 (85%)	18 (95%)	6 (75%)
Batteries			1 (5%)	
Solar lantern		4 (12%)		
Solar stand-alone system	3 (19%)			2 (25%)
Diesel generator	5 (31%)	1 (3%)		
Total	*16*	*33*	*19*	*8*

Electricity for community services

All the communities had schools and religious buildings. Kalokol and Mkwiro had health facilities. Mkwiro was the only place with street lighting (a single solar-powered light). Health facilities were most likely to have electricity (five out of six); in Kalokol, the facilities were larger and better equipped with electrical lighting, refrigerators, freezers, and ICT equipment. Religious facilities also used electricity. Churches in Utumoni had diesel-powered generators, with one at Tier 4, used for lighting and sound systems. Schools were the least likely to have electricity: of five schools surveyed, only one had any form of electricity (Table 4.6).

Table 4.6 Level of electricity access in community facilities

Type of facility	*Number surveyed*	*Number with electricity access*
Schools	5	1 (Tier 3)
Health facilities	6	5 (1 x Tier 1, 4 x Tier 3)
Religious centres	8	5 (1 x Tier 1, 2 x Tier 3, 1 x Tier 4)

Energy access priorities

It is energy services that matter to people, rather than supplies. We asked people to prioritize their most important energy services, to help guide the development of plans for energy access (Table 4.7).

Table 4.7 Prioritization of energy needs

	Kalokol	*Utumoni*	*Sibinga*	*Mkwiro*
1st priority	Health facilities (1st or 2nd for 94%)	Households (1st or 2nd for 82%)	Households (1st for 77%)	Households (1st for 82%)
2nd priority	Schools (1st or 2nd for 70%)	Schools (1st or 2nd for 74%)	Schools (1st or 2nd for 45%)	Businesses (2nd or 3rd for 79%)
3rd priority	Street lighting or Household energy	Businesses	Businesses	Health facilities

While men and women generally agreed on the first priority (energy for households), women were more likely to prioritize community services while men valued energy for businesses or agriculture more highly. Focus groups also highlighted that the difficulty accessing water severely drained women's time, and could be improved with new wells and pumps, as could energy for processing crops.

Women from Sibinga said: **'If we had a pump to draw water to our homes, this would reduce time and energy for going out to the river to fetch water. All this time can be diverted to other useful activities at home.'**

Energy for households. Household energy needs are, unsurprisingly, the top priority – except in Kalokol where levels of access are already quite good. To elaborate, respondents were asked: 'If adequate energy supplies were available, which applications of energy would be most important to you?'

The two common priorities are electric lighting and better cooking solutions (Table 4.8). Reducing the effort of collecting firewood and the time and smokiness of cooking were highlighted in focus groups, even when these did not come up

Women prioritized community services more highly, while men prioritized energy for businesses and agriculture

Table 4.8 Prioritization of household energy applications

	Kalokol	*Utumoni*	*Sibinga*	*Mkwiro*
1st priority	Electric lighting	Cooking food/hot drinks	Electric lighting	Cooking food/hot drinks
2nd priority	Refrigeration or preservation	Electric lighting	Making things/ doing work	Processing food or crops
3rd priority	Recreation & entertainment	Mobile phones & other electronics	Processing food or crops	Making things/ doing work
4th priority	Mobile phones & other electronics	Making things/ doing work	Pumping water	Mobile phones & other electronics

strongly during the survey. Almost all households said they needed lighting before sunrise and for 4–6 hours in the evening. People complained that when they used their solar systems during the day, there was not enough power in the evening.

Energy for businesses. In Mkwiro, the need to find alternative livelihoods which greater energy could support, and to reduce the wastage of precious fish catches with more refrigeration is urgent. Elsewhere agriculture-related energy needs include milling, and opportunities for new businesses such as barbering/hairdressing, cooking food, maize mills, welding and carpentry, and running general kiosks.

Energy for schools. This was a high priority even in Kalokol, where the schools have solar systems but still do not have all the energy services they would like. For students, the lack of adequate time to study comfortably with good lighting was the major problem (particularly in secondary boarding schools).

Energy for health facilities. Survey respondents felt their health centres could not offer some essential services because their energy supplies were still not adequate. This was the top priority in Kalokol, even though the health centres have electricity.

Energy for street lighting. This was the third priority in Kalokol, to extend business opening hours and to improve security after dark for motorbike taxi operators. Women tend to prioritize lighting outside at home instead, for improving security and going to the toilet more easily after dark.

Energy access plans

Across communities, electric lighting and improved cooking solutions were highly prioritized

Electricity access options

Households, enterprises, and those running community facilities were asked about the energy applications most important to them. We translated this into tiers of access. We triangulated and added information from the focus groups, factoring in a 50% increase in non-farm enterprise activity stimulated by greater energy access. (accounting for only 11% of demand on average, except in Utumoni where it was 51%). This community-defined level of need is therefore at the upper bounds of what people are likely to use in the coming few years.

The majority of households require Tier 2 or 3 access, with the average being 2.6–2.8: their existing Tier 1 systems are not meeting their needs. Tier 3 is highlighted in Figures 4.8 and 4.9 as a benchmark level for energy access. Figure 4.8 does not

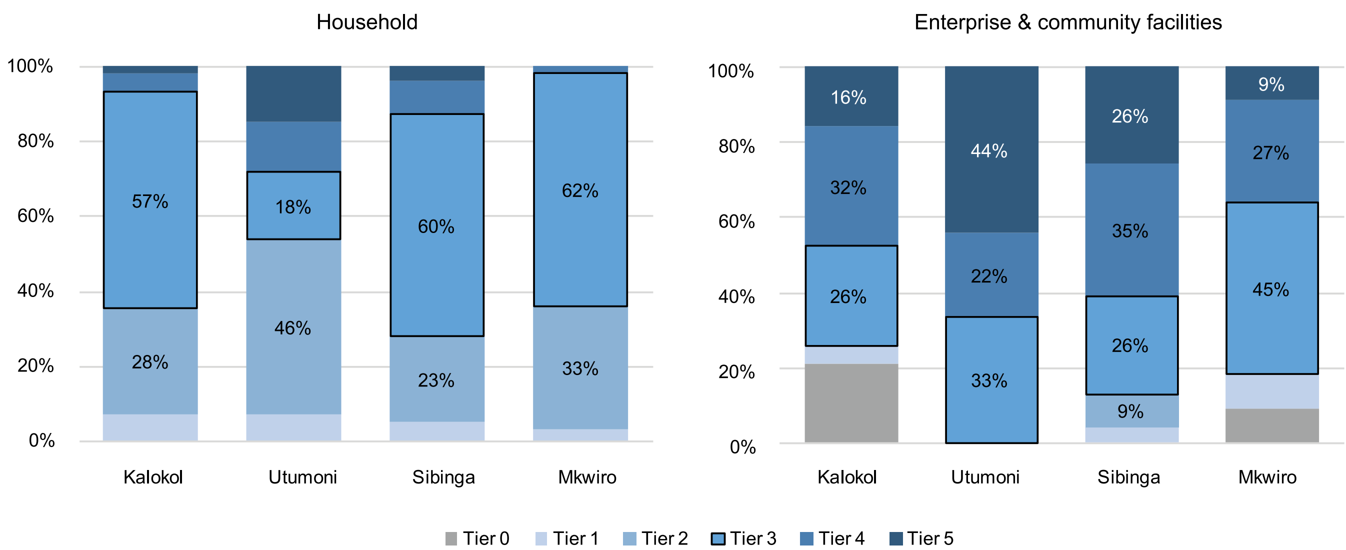


Figure 4.8 Electrictiy access needs for households by tier

Figure 4.9 Electricity access needs for enterprises and community facilities include people's aspiration to cook with electricity, which would increase the proportions in Tier 5. Enterprises and community facilities require higher levels of access, mostly driven by demand for medium-power appliances (refrigerators, stereos) or prolonged use of low-power appliances (multiple fans). Tier 4 or 5 was required for high-power appliances (welding and other workshop equipment) or prolonged use of multiple medium-power appliances (refrigerators[1], grain mills, water pumps, air conditioners). Based on this demand level, we calculated the least-cost means of delivering energy (Table 4.9).

Our analysis found that, first, above Tier 1–2, stand-alone systems are much more expensive per kWh than distribution systems. Our modelling therefore shows it would be cheaper, for the community as a whole, to supply needs through distribution systems covering all but a few dispersed households. In more dispersed communities (parts of Kalokol and most of Utumoni), a higher proportion of

Table 4.9 Determining the least-cost means of delivering community-defined level of energy access

	Kalokol		*Utumoni*		*Sibinga*		*Mkwiro*	
Total number HH	890		110		754		230	
Distance to grid	55km		National grid reached village November 2015		3km (but nearest sub-station 20km)		Island 3km from mainland	
Requirements: stand-alone systems								
SHS	266 HH (dispersed) 1 health centre		77 HH (70%)		28 HH		17 HH	
Solar lanterns[1]	668 HH		41 HH 5 SME		218 HH 25 SME/cmty facility		45 HH 11 SME/cmty facility	
Street lights	19 street lights		-		-		-	
Requirements: distribution system (grid/mini-grid)								
Connections[2]	535 HH (Kalokol and Namukuse) 21 SME/cmty facility 40 street lights		27 HH, 29 SME/cmty facility 23 street lights		679 HH All 32 SMEs and cmty facilities 14 street lights		213 HH All 20 SMEs and cmty facilities 3 street lights	
Peak demand[3] kW	266		35		337		99	
Total demand MWh/ year	502		65		685		152	
Least-cost means of electricity access provision								
Means of provision	2 diesel mini-grids	Stand-alone	Grid Extension + additional generation	Stand-alone	Grid Extension + additional generation	Stand-alone	Diesel mini-grid	Stand-alone
Capital $	1.18m	0.67m	0.33m	0.45m	1.45m	0.09m	0.23m	0.05m
Per unit $/kWh	0.73	1.29	1.05	1.26	0.41	1.48	0.64	1.3
Alternative means of powering distribution system (% difference from least-cost system)								
System type	Extension of national grid		Diesel mini-grid[4] (serving 5 HHs and 20 SMEs/cmty facilities)		Diesel mini-grid[5]		Solar mini-grid (serving 50 HH)	
Capital $	2.19m (+86%)		0.20m (-39%)		0.77m (-47%)		1.32m (+474%)	
Per unit $/kWh	0.80 (+10%)		1.33 (+27%)		0.48 (+17%)		2.04 (+219%)	

Notes:

[1] People often said they wanted and would pay towards both a distribution system and solar lanterns

[2] Abbreviations: HH (households), SME (small and medium enterprise), cmty (community)

[3] These figures include distribution and transmission losses

[4] A purely solar-powered mini-grid would be more expensive for users than stand-alone systems

[5] A mini-grid could also be powered by a biomass gasification plant, with a capital cost somewhere between that of a diesel mini-grid and a grid connection. But this results in a cost of energy about twice that of the grid extension because we assumed a relatively short lifespan of the equipment (~13,000 hours). If longer lifespans could be achieved, this solution would be much more competitive.

stand-alone systems would be needed. The geography and layout of Sibinga's settlements contributes to significantly lower costs there. Size matters and larger distribution systems (those based on levels of community demand from households and enterprises) provide electricity which is cheaper per kWh than smaller systems providing Tier 3 access only (Figure 4.10).

Second, unless costs per kWh are very high, it is cheaper to power productive loads through the distribution system and this makes the electricity cheaper for everyone. Third, diesel-powered mini-grids emerged as least-cost solutions in Kalokol and Mkwiro. However, wind-diesel or solar-diesel hybrid systems could further reduce costs and the difficulties associated with reliance on diesel. Even in Sibinga, very high diesel costs mean it would be worth investigating a hybrid system.

A clear gap remains between the access levels people want and what they can afford

In a final step, we looked at the viability of these systems according to people's willingness to pay (WTP). This varied according to the amount and type of electricity offered. Some were not willing to pay anything at all (as many as 80% in Kalokol and Mkwiro), and the average amounts in Figure 4.11 are for those who were. Costs are based on the least-cost distribution system price per kWh (Table 4.9).

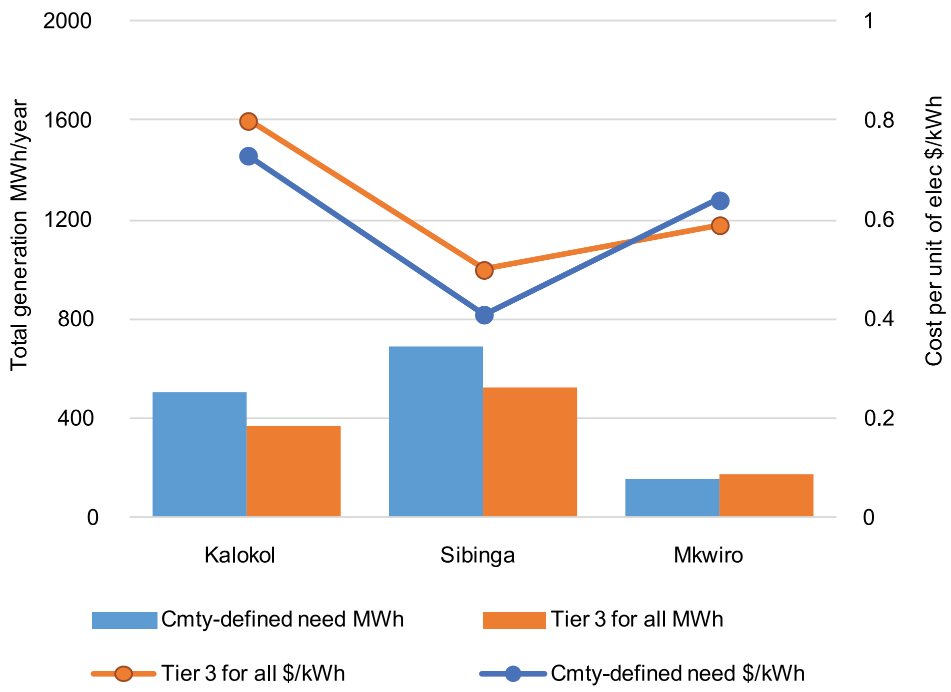


Figure 4.10 Costs per unit of electricity and generation capacity for universal Tier 3 access[5]

Note: Utumoni is not included because the size of distribution system required was too small to make comparisons meaningful.

There is clearly an affordability gap, especially when it comes to higher tiers of provision. On the other hand, the cost of Tier 2 level use of national grid electricity (excluding the connection fee ($150) and house wiring costs) is only $0.06 per day, and Tier 3 only $0.15 per day – well within people's willingness to pay. Our calculations suggest, however, that these tariffs are 2.2 to 5.8 times below the real costs of delivering grid extension in these communities.

We modelled the types of system that could be installed based on willingness to pay. In all communities except Utumoni, a distribution system would no longer be viable, leaving a limited number willing to pay for stand-alone systems. This applies even in Sibinga where the distribution system has the lowest costs. Inevitably, only richer households would be able to afford electricity access.

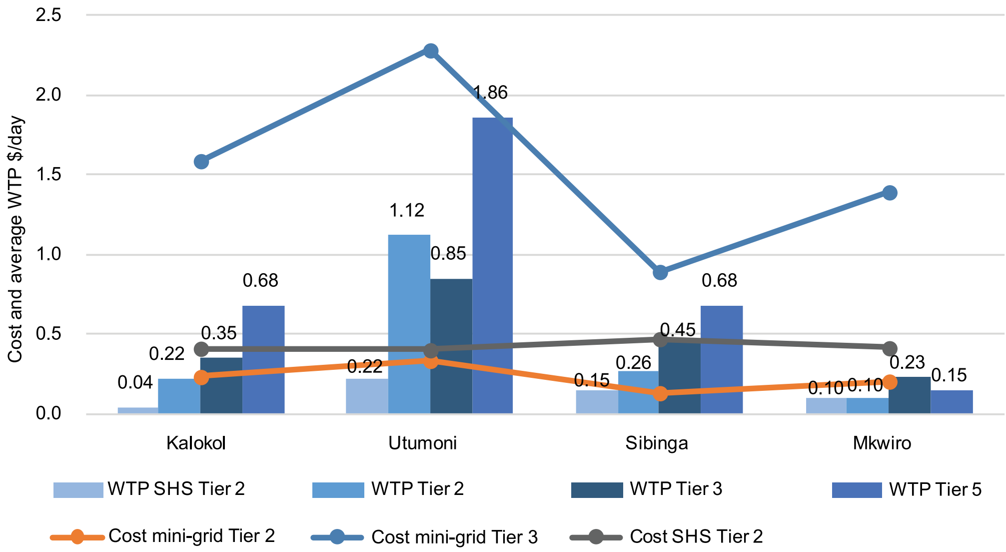


Figure 4.11 Cost and willingness to pay for different levels of electricity access

Options for access to improved cooking

What is important to cooks?

Two features stand out: fuel should be free, cheap, or easy to obtain; and cooking solutions should not cause health problems. Public awareness campaigns conveying this message have clearly begun to take effect, in particular among women, who mentioned this more than men. In terms of cooking needs, speed was most frequently mentioned. Women also mentioned the speed and ease of lighting fires. There was little concern about the ability to use more than one pot.

Which solutions do people prefer?

The cooking solutions offered included a range of biomass stoves. LPG was offered as the cheapest Tier 4 solution, but bioethanol could also be considered as an alternative, as a recently agreed tax exemption may bring prices in line with, or lower than, those of gas. Biogas was not considered a viable option due to a lack of readily available feedstock in these communities.

People felt fuel should be free, cheap, or easy to obtain

Respondents ranked solutions (including their current solution) in order of preference (Figure 4.12). This constitutes their community-defined plan. Apart from in Mkwiro, few chose traditional stoves. In Mkwiro and Utumoni, people preferred biomass-based solutions, while in Sibinga and Kalokol (where fuel is harder to obtain) there was a greater preference for cleaner fuels. The second choice of people who chose traditional stoves was generally a basic improved wood-burning stove.

The price of improved cooking

We compared the estimated costs of people's current solutions (monetizing fuel collection) with their improved choices in the community-defined plan, and with a benchmark of a basic improved wood-burning stove (Tier 2) or LPG (Tier 4) solution (Figure 4.13). The Tier 2 stove would actually save money, in terms of fuel costs or time spent gathering fuel. LPG, however, is as much as five times as expensive as people's current solution. The relatively low price at which electricity could be supplied in Sibinga brings the cost of electric cooking close to LPG.

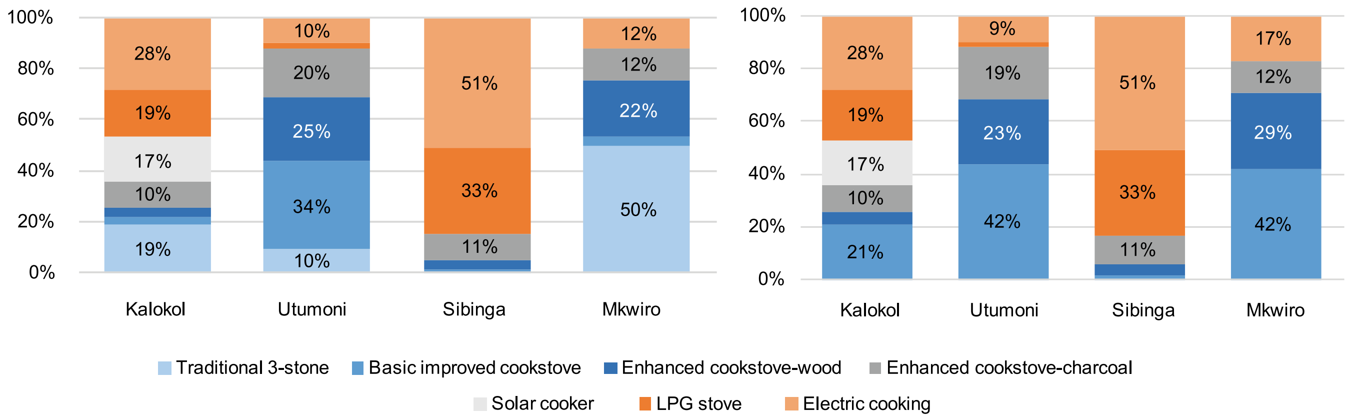


Figure 4.12 Preferred choice/community-defined plan for cooking solutions including three-stone fire (left) and excluding three-stone fire (right)

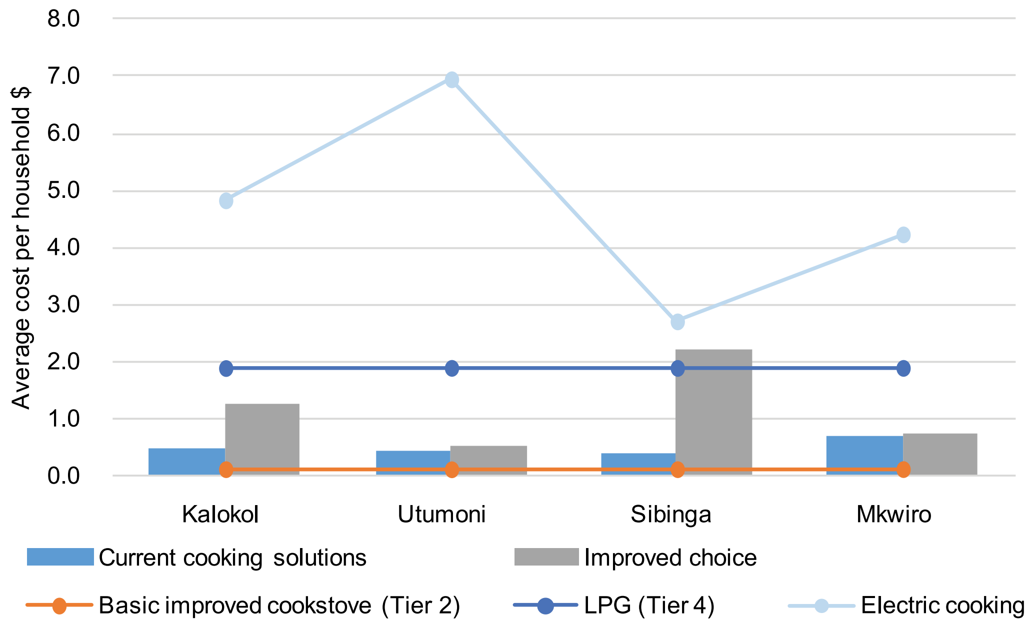


Figure 4.13 Cost of different cooking solutions

Willingness to pay for different solutions

If access progresses based purely on people's ability to pay, inequalities will grow

Respondents were asked about their willingness to pay for solutions they selected. Table 4.10 shows results only where more than 15% of respondents gave a figure. In Mkwiro only 9–10% of people were willing to pay anything at all for most options, compared to an average of 65% in Sibinga.

In Sibinga and Utumoni, the average willingness to pay was around the same as the full economic cost of basic wood-burning stoves. Although the least-cost wood-burning stove is affordable, and saves money compared to current solutions, it is only in Utumoni where there is much chance of uptake. Focus group participants negatively perceived stoves as complicated, taking too long to light, or only staying alight for a short time (this was also found by Ipsos & GACC, 2014). Enhanced wood stoves were less popular and people were not prepared to pay as much for fuel. Enhanced charcoal stoves were surprisingly unpopular in Kalokol and Mkwiro where higher proportions use charcoal.

Table 4.10 Willingness to pay for cooking solutions

Type of cooker	*Including or excluding fuel*	*Cost ($)*	*Average willingness to pay $/day*			
			Kalokol	*Utumoni*	*Sibinga*	*Mkwiro*
Wood ICS Basic (Tier 2)	Stove only	**0.01**	-	**0.01**	**0.01**	-
	Stove + wood	**0.10**	-	0.08	0.07	-
Wood ICS Enhanced	Stove only	**0.12**	-	0.07	0.07	-
	Stove + wood	**0.19**	-	0.11	0.10	-
Charcoal ICS Enhanced	Stove only	**0.05**	0.02	**0.05**	**0.05**	-
	Stove + charcoal	**0.28–0.57**	0.03	0.34	0.09	-
Solar cooker		**0.07**	-	-	0.05	-
LPG	Stove + gas	**1.86**	-	0.91	0.66	-
Electric cooker		**1.29–4.65**	-	1.34	1.02	0.08

There is a large affordability gap for clean fuels, despite enthusiasm for these solutions shown in. High proportions in Sibinga would pay something for LPG, but still on average only 35% of the full economic cost. However, three-quarters said they would pay for electric cooking at an average price that approaches the possible cost of electricity ($1.29/day).

Conclusion

Kenya is a large nation that is geographically and culturally diverse. It has some of the most vibrant cookstove and solar markets on the continent and good renewable-energy natural resources. Our research illustrates progress in the uptake of solar lanterns, SHS, and *jiko* stoves. However, some communities, and the poorest segments within communities, remain left behind and the levels of energy access achieved with these technologies fall short of people's needs. Our energy access plans illustrate the potential for reducing the cost of electricity provision through planning for all elements of energy access simultaneously. People are willing to pay something towards that provision, and towards cleaner fuels and stoves; however, an affordability gap remains. If access is to progress based purely on people's ability to pay, inequalities in provision will grow and universal access will remain elusive.

Kenya: findings and recommendations

- 23% nationally (2012), and just 7% in rural areas (2011), have electricity access.
- 14% of rural households own a Tier 1 level solar panel or lantern (2014).
- Only 2% of rural firewood users own an improved cookstove (2012).

	FINDINGS		RECOMMENDATIONS	
Grid or decentralized	**De-centralized**	In **all communities**, decentralized or stand-alone solutions were either the **least-cost** option to meet electricity needs, the **fastest** by many years, **or both**.	**Rebalance** (PLAN)	Review national plans to **increase focus** on decentralized solutions, providing needed levels of power **faster and at least-cost**.
Household affordability	**35-40%**	Despite a vibrant market, the poorest 35-40% **could not afford** a solar lantern or home system.	**Mini-grids**	**Expand** mini-grids programmes where feasible, **reducing the cost** of electricity per kWh compared to stand-alone solar.
Clean cooking	**58 hours**	In the most fuel-insecure communities, **women** spent on average **58 hours a week** collecting and preparing fuel and cooking.	**Time and attention**	Invest **more time and attention in rural cookstoves** and **clean fuels markets**, addressing challenges of acceptable stove designs, awareness, and affordability.
Community services	**Schools**	**Energy** for **schools** was the **second highest priority** after energy for households in almost **all communities**.	**School electricity**	**Expand** school electrification programme beyond government primary schools to **help all schools to be connected**.
Agriculture	**Benefits**	There is **significant potential to improve lives** and livelihoods through **linking** energy to agricultural production, post-harvest storage, and processing.	**Co-ordinate**	**Increase co-ordination** with Ministries of Water and Agriculture.

5. Bangladesh

National context

Bangladesh's large population and initially low levels of energy access placed it third on SEforAll's list of 20 high-impact countries for both electricity and clean cooking (SEforAll, 2013). The severity of the problem had already been recognized nationally. Under the sixth five-year plan (2011–2015), action was taken to boost grid-based electricity, aiming to reduce frequent power outages which were threatening the momentum of economic growth. Total installed generation capacity increased from 5,823MW in 2010 to 13,540MW in 2015. Electricity access (the number of household grid connections) increased from 48% to 72%. There was also a huge expansion in access to off-grid solar through some 4 million SHSs with 150MW of capacity (GoB, 2015). The country has now set a target of electricity for all by 2021.

Nationally, there is an improved cookstoves penetration rate of less than 2%

More than 90% of Bangladesh's population continue to use solid fuels for cooking (SEforAll, 2015). This means over 137 million people are affected by household air pollution, and an estimated 78,000 deaths annually can be attributed to the lack of clean cooking. Only 510,000 improved biomass stoves are in use in Bangladesh. Biomass is the dominant cooking fuel, with rural populations mainly using crop residues (45.6%) and wood (44.3%) (MPEMR, 2013).

Overview of case-study communities

The four communities represent a range of the situations faced by millions of rural Bangladeshis and rates of electricity connections in their districts are generally below the national rural average, although the electricity access situation has changed significantly since these figures were collected in 2010 (Table 5.1).

Table 5.1 Poverty rate and electricity connections by district (World Bank et al., 2014)

	% below upper poverty rate (2010)	*% electricity connections (2010)*
Bandarban (Thanchi)	40.1	49.1
Barguna (Tengagri Chak)	19.0	33.1
Sunamganj (Alamkhali)	26.0	29.6
Panchagarh (Sardar Para)	26.7	34.1
All rural Bangladesh	*35.2*	*42.5*

Thanchi, Chittagong hill tracts. Agriculture. Tribal communities. Thanchi, in Bandarban District, is in the Chittagong hill tracts region. The area includes the sub-district market centre of Thanchi Bazaar (population around 500) and an area of hilly, semi-wild land extending to 10 km from the centre, and containing approximately 20 dispersed villages and hamlets. There is a distinct difference between the more mixed population of the main village and the almost exclusively tribal communities beyond, who have their own language and culture. The whole area has 934 households. Agriculture is the main livelihood: forest is cleared to grow crops on a shifting basis. Men are also involved in transporting wood and bamboo via the Sanghu river while some women weave cloth for family use or sale. This is the poorest of the four settlements.

The construction of the Thanchi Bridge across the river in 2012 has brought development. Construction work started in 2015 to bring the grid (55 km away) to Thanchi Bazaar, the last sub-district centre to be reached.

Tengagri Chak. Coastal, cyclone affected. Fishing. Tengagri Chak in Barguna District is a coastal village spread along a narrow strip between the coast and the jungle, 10 km in length and containing **1,085 households**. The main livelihoods include fishing, fish processing, and agriculture. The region is prone to cyclones and super-cyclone Sidr caused a great deal of economic damage in 2007. Grid electricity has reached the west side of this area.

Alamkhali. High rainfall, seasonal flooding. Agriculture. Alamkhali in Sunamganj District has a tropical climate, receives significant rainfall across the year, and is subject to seasonal flooding. The village and surrounding area has **693 households**. The area is known for its *haors*: large, shallow lakes which accumulate water during the rainy months. Some places, including many roads, can remain under water for half the year. Alamkhali is 7 km from the nearest grid.

Sardar Para, northern Bangladesh. Rock-processing. Sardar Para in Panchagarh District, at the northernmost tip of Bangladesh, has **1,748 households in the village and surrounding area**. The main source of income is rock collection and processing for the construction industry. Tea cultivation also began in the district (although not in this village) in the last few years.

Current levels of energy access

Household electricity

The spread of SHS across Bangladesh is evident in these communities: it is used by two-thirds or more of households (except in Sardar Para) (Figure 5.1). In Thanchi, levels of access are 85% in the main village, but only 60% in surrounding tribal villages.

The level of electricity is mostly Tier 1, with low-capacity systems that can provide around 3 hours of evening power, with reliability being reported as excellent (Figure 5.2). This level of access allows households to use a number of appliances, in particular phone chargers (almost universal), fans (18–32%), and televisions. Households without electricity have not invested in any of these appliances, and earn about half the amount of households with electricity.

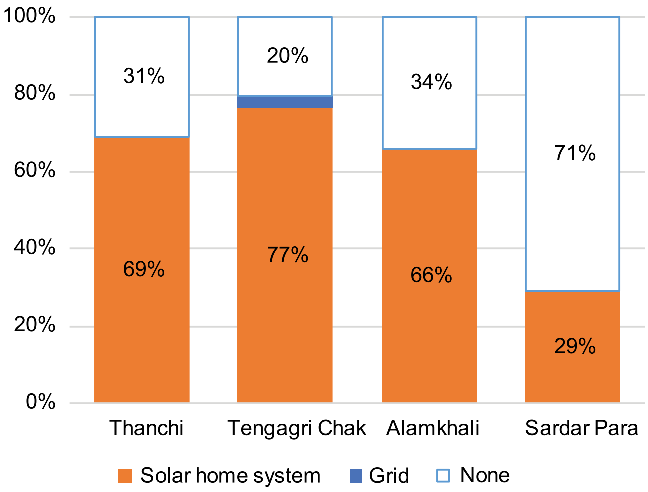


Figure 5.1 Primary source of household electricity

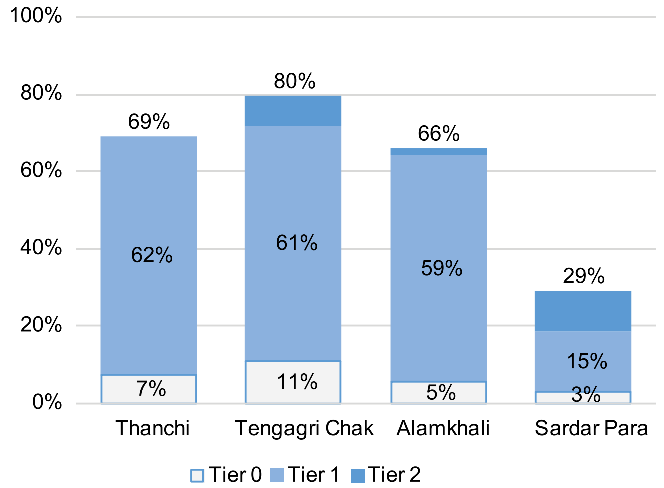


Figure 5.2 Level of electricity access (for those who have access)

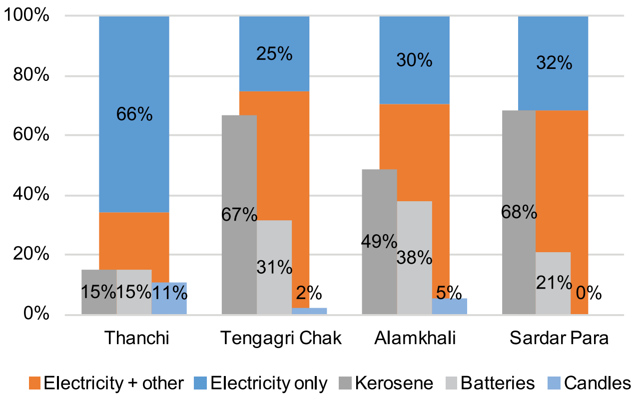


Figure 5.3 Source of lighting for those with electricity

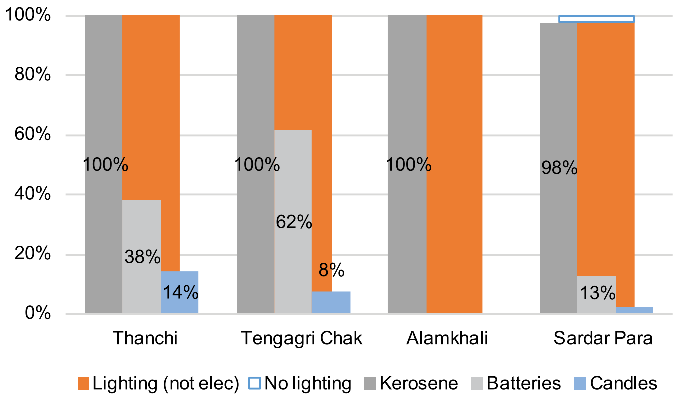


Figure 5.4 Source of lighting for those without electricity

In every case, households with electricity are able to use it for lighting but use of kerosene continues (Figure 5.3). It is also used universally for lighting in households without electricity, backed up by other sources of energy (Figure 5.4).

Household cooking

Wood is the primary fuel for all communities, although people also use crop residues and animal dung (applied to sticks and dried) as a secondary fuel (Table 5.2). Fuel is freely available in all the communities, but some households still reported buying wood, particularly during seasonal shortages. In Alamkhali (with its severe flooding) 21% of respondents reported buying fuel in the last year.

Table 5.2 Primary fuel type

	Thanchi	Tengagri Chak	Alamkhali	Sardar Para
Wood	100%	100%	86%	71%
Crop residues				25%
Leaves			14%	5%

Nationally there is a very low level of penetration of improved stoves. Among the 253 households surveyed, **all were using home-made stoves** (Tier 0), except for one with a low-grade manufactured stove. There was no evidence of fuel/stove stacking.

The division of labour is generally that women cook and prepare the fuel. Men and women share the task of gathering fuel, with men spending on average longer, except in Thanchi, particularly in the tribal area where women collect almost all fuel (Figure 5.5).

Overall, cooking takes the greatest amount of time per week (Table 5.3). A similar number of hours are spent preparing fuel (chopping wood or making fuel sticks) as collecting it (although not all households prepare fuel, as indicated by the percentage answering the question).

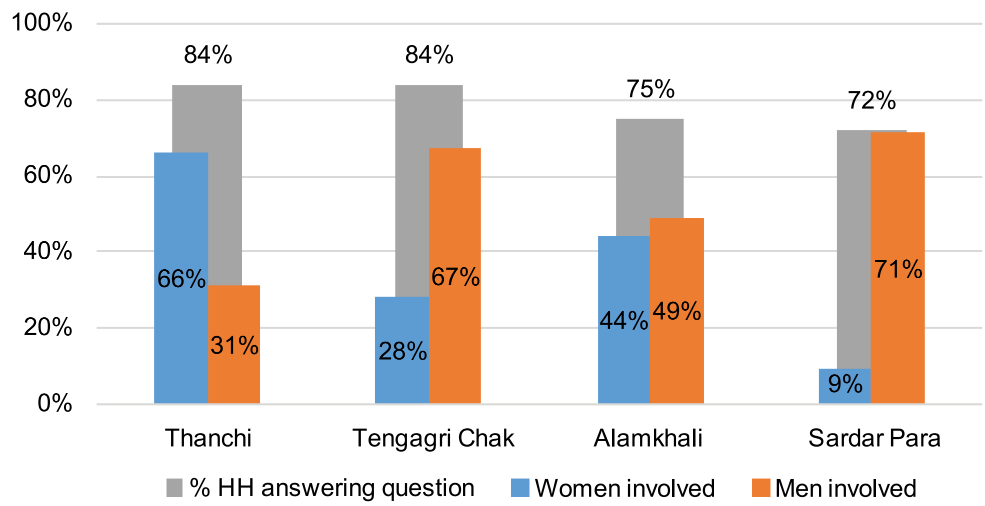


Figure 5.5 Gender division of labour for fuel gathering

Table 5.3 Hours per week cooking, collecting fuel, and preparing fuel

	Thanchi	*Tengagri Chak*	*Alamkhali*	*Sardar Para*
Average hours cooking	22.0	21.9	24.8	21.9
Average hours collecting fuel (% answering)	9.4 (84%)	7.5 (84%)	7.5 (75%)	11.2 (72%)
Average hours preparing fuel (% answering)	7.0 (49%)	9.1 (47%)	7.3 (38%)	9.0 (42%)

Electricity for livelihoods

We interviewed people from a sample of the many small enterprises present in these communities, as well as some involved in mainstream agriculture or fishing. Both the proportion with electricity access and the tier of access are slightly higher than for households (Figures 5.6 and 5.7). Far more enterprises than households in Tengagri Chak have opted for grid electricity; however, despite being grid-connected, these enterprises still only have Tier 3 access. In both Alamkhali and Sardar Para, rock-crushing is an important enterprise which relies on diesel engines. Electricity access varies considerably across different enterprise types, with service/retail enterprises being by far the most likely to have invested in electricity access.

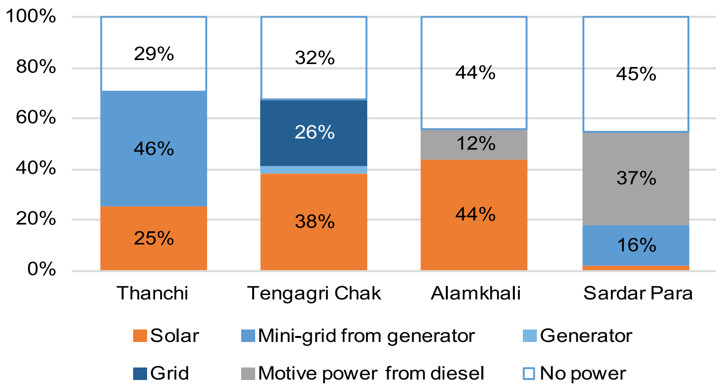


Figure 5.6 Primary source of electricity for enterprises

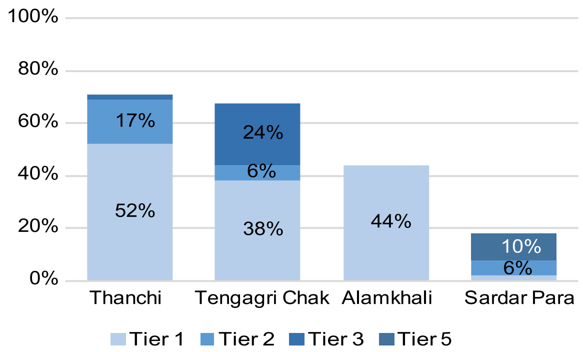


Figure 5.7 Level of electricity access for SMEs (those with access)

Electricity for community services

Since they are used after dark, religious buildings are most likely to have invested in solar systems for lighting (Table 5.4). There were health centres in only two of the communities – Tengagri Chak and Sardar Para – and both had electricity supplies.

Table 5.4 Electricity access for community facilities

Type of facility	*No. surveyed*	*No. with electricity access*	*Tier levels (for those with electricity)*		
			Tier 1	*Tier 2*	*Tier 3*
Religious centres	22	17 (77%)	9	4	4
Schools	17	5 (30%)	2	1	2
Health facilities	2	2 (100%)	1		1

Energy access priorities

It is energy services that matter to people, rather than supplies. We asked people to prioritize the energy services which were most important to them (Table 5.5), to help guide the development of energy access plans.

Table 5.5 Prioritization of energy needs

	Thanchi	*Tengagri Chak*	*Alamkhali*	*Sardar Para*
1st priority	Households (1st for 91%)	Households (1st for 84%)	Households (1st for 80%)	Households (1st for 100%)
2nd priority	Businesses (2nd for 41%)	Street lighting (1st or 2nd for 32%)	Schools (2nd for 45%)	Agricultural needs (2nd for 48%)
3rd priority	Street lighting	Schools	Health facilities	Schools

Street lighting was often ranked more highly by men than women

Women discussed the vital need for electricity for lighting and fans especially in the months before and after giving birth when they are less able to leave the house. They also valued lighting for cooking, doing household chores after dark, and so children can study. Power to pump drinking water, which can be a significant burden on women's time, especially during the dry season in Alamkhali and the tribal areas of Thanchi, was a priority. Women tended to be concerned about community facilities: in Thanchi and Sardar Para they prioritized energy for schools above energy for business or agriculture. Street lighting was often ranked more highly by men than women, with men feeling it may benefit their retail enterprises.

Energy for households. Respondents' prioritization of household energy needs above other spheres was most pronounced in Sardar Para, which currently has the lowest levels of electricity access. To find more information about their priorities, respondents were asked: 'If adequate energy supplies were available, which applications of energy would be most important to you?'

Priority household needs relate to electrical power for **lighting**, **mobile phones**, and **fans**; all of these require fairly low-capacity systems (Table 5.6). Indoor temperatures are uncomfortably hot for 16–18 hours a day, for 5–6 months a year (4 months in Thanchi). Cooking is not in the top four except in Tengagri Chak. Lighting, using reliable and long-lasting equipment, is needed for 4–6 hours after dark. In all communities the top reasons for needing lighting were working at home and moving around easily and safely at night, including to use the toilet.

Table 5.6 Prioritization of household energy applications

	Thanchi	*Tengagri Chak*	*Alamkhali*	*Sardar Para*
1st priority	Electric lighting	Electric lighting	Electric lighting	Electric lighting
2nd priority	Mobile phones and other electronics	Cooking food and making hot drinks	Mobile phones and other electronics	Mobile phones and other electronics
3rd priority	Fanning or cooling the living space	Mobile phones and other electronics	Fanning or cooling the living space	Fanning or cooling the living space
4th priority	Making things/doing work	Fanning or cooling the living space	Recreation and entertainment	Making things/ doing work

Energy for agricultural needs. This featured in the top three in only one community (Sardar Para). However, the focus group discussions revealed a consistent demand for energy for **irrigating crops**. In all cases, there was also a need for energy for **paddy threshing** and/or **pulse grinding** (predominantly a woman's task).

Energy for businesses. This was highlighted only in Thanchi, and mostly in the main village where there are shops and hotels. In all the other communities, agricultural needs were prioritized above business needs.

In Alamkhali, focus group participants said: **'Electricity should be agriculture-use based and for the general poor people. Not for just one or two persons.'**

Service enterprises prioritized a set of energy services and appliances very similar to household demands including lighting, fans, phone charging, colour television, and refrigerators. Focus group participants felt if greater electricity were available, a range of small businesses would grow. Electric-powered 'easy-bikes' are widespread in Tengagri Chak, and were mentioned as a need in both Alamkhali and Sardar Para. In Thanchi, women use handlooms for weaving and felt access to power and light would increase their output and incomes.

Diesel engines are used for high-power-demand tasks such as rock-processing. There is interest in reducing these costs and mechanizing further. In Sardar Para it was felt this would reduce the physical burden on women employees, but there were also fears of job losses.

People felt that increased electricity access would lead to growth in small businesses

Energy access plans

Options for electricity access

Households, enterprises, and those running community facilities were asked about the energy applications most important to them. We translated this into tiers of access. We triangulated and added information from the focus groups, factoring in a 50% increase in non-farm enterprise activity stimulated by greater energy access (amounting to 16-20% of power demand except in Sardar Para where it was 66%). This community-defined level of need is therefore at the upper bounds of what people are likely to use in the coming few years.

The majority of households required Tier 2 or 3 access, with the average being 2.6 or 2.7: their existing Tier 1 systems are not meeting all their needs. Tier 3 is highlighted in Figures 5.8 and 5.9 as a benchmark level for energy access suggested by Practical Action and others. Figure 5.8 does not include people's aspiration to cook with electricity which would increase the proportions in Tier 5. Enterprises and community facilities require higher levels of access, mostly driven by demand for medium-power appliances (audio-visual equipment, low-power water pumps) or for prolonged use of low-power appliances, such as multiple fans. Tier 4 or 5 access is needed for the use of high-power appliances (larger water pumps, rock-crushing machines in Alamkhali, workshop equipment, tea-processing equipment) or prolonged use of medium-power appliances (refrigerators[1] or workshop equipment). Based on this demand level, we calculated the least-cost means of delivering energy (Table 5.7).

People were willing to pay more for higher-powered systems, but an affordability gap remains

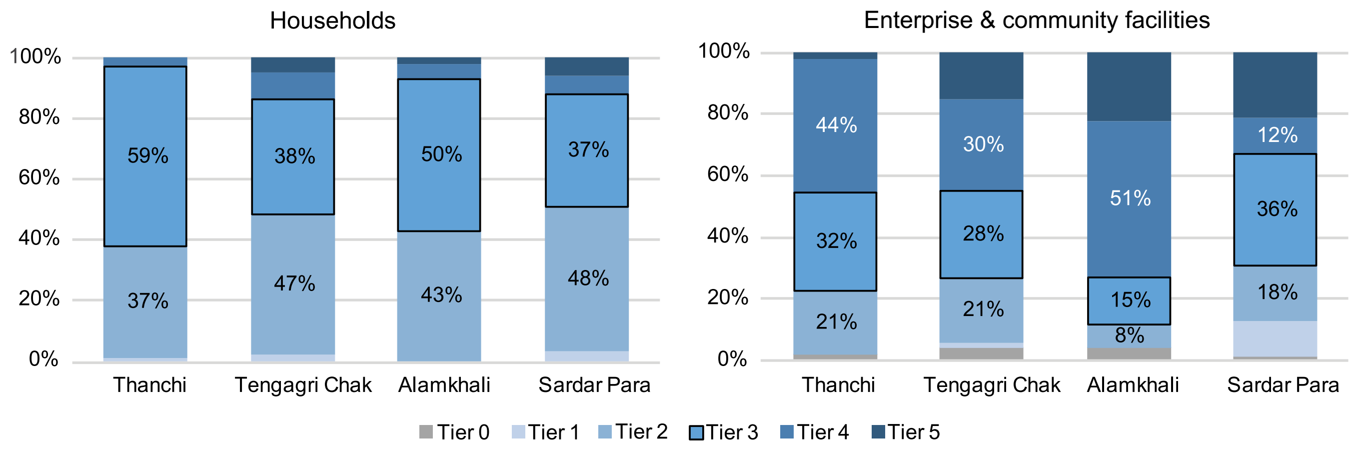


Figure 5.8 Electricity access needs for households

Figure 5.9 Electricity access needs for enterprises and community facilities

Our analysis found that, first, above Tier 1–2, SHSs are much more expensive per kWh than distribution systems – except in Thanchi where the dispersed settlement pattern means 60% of households would need an SHS. Size matters and larger distribution systems (those based on levels of community demand from households and enterprises) provide electricity which is cheaper per kWh than smaller systems providing Tier 3 access only (Figure 5.10). Second, in almost all cases it is cheaper to power productive loads through the distribution system and doing this makes the price of electricity lower for everyone. Third, in Thanchi, Sardar Para, and, potentially, Tengagri Chak, grid extension and diesel mini-grids are comparable in cost per kWh, with the capital costs for mini-grids being much lower (27-42%). However, diesel-solar hybrid systems could reduce costs further and would be worth investigating.

Table 5.7 Determining the least-cost means of delivering community-defined level of energy access

	Thanchi	*Tengagri Chak*	*Alamkhali*	*Sardar Para*
Total number HH	934 in 3 villages + dispersed HHs	1085	693	1748
Distance to grid	55 km	Already present at one end of the community	7km	5.5km
Requirements: stand-alone systems				
SHS	558 HH (60%) 104 SME/cmty facility	14 HH (259 HH already have elec which meets their requirements)	0 HH 3 SME/cmty facility	38 HH
Solar lanterns[1]	17 HH	170 HH 27 SME	141 HH 30 SME	54 HH 4 SME
Street lights	17	-	-	
Requirements: distribution system (grid/mini-grid)				
Connections[2]	376 HH served by 3 systems 349 SME/cmty facility 27 small irrigation pumps 14 street lights	729 HH 143 SME/cmty facility 542 small irrigation pumps 32 street lights	693 HH 311 SME/cmty facility 161 small irrigation pumps 26 street lights	1694 HH 80 SME/cmty facility 400 small irrigation pumps 87 street lights
Peak demand[3] kW	204 + 62 + 38 = 304	437	427	807

	Thanchi		*Tengagri Chak*		*Alamkhali*		*Sardar Para*	
Total demand MWh/year	700 + 106 + 63 = 869		1062		1,444		1,780	
Least-cost means of electricity access provision								
Means of provision	3 diesel mini-grids	Stand-alone	Grid Extension + additional generation	Stand-alone	Grid Extension + additional generation	Stand-alone	Grid Extension + additional generation	Stand-alone
Capital ($)	0.61m	1.91m	1.69m	0.09m	1.51m	0.01m	2.27m	0.20m
Per unit $/kWh	0.36	1.35	0.44	1.54	0.28	1.03	0.34	1.53
Alternative means of powering distribution system (% difference from least-cost system)								
System type	Grid extension + additional generation		Diesel mini-grid		Diesel mini-grid		Diesel mini-grid	
Capital ($)	1.46m (+240%)		1.24m (-27%)		0.97m (-36%)		1.33m (-42%)	
Per unit $/kWh	0.41 (+14%)		0.52 (+18%)		0.37 (+32%)		0.39 (+15%)	

Notes:

[1] People often said they wanted and would pay towards both a distribution system and solar lanterns

[2] Abbreviations: HH (households), SME (small and medium enterprise), cmty (community)

[3] These figures include distribution and transmission losses

Finally, we looked at the viability of these systems according to people's willingness to pay. On average, 40–54% were not willing to pay anything at all: the amounts in Figure 5.11 are for those who were. Costs are based on the least-cost distribution system price per kWh (shown in Table 5.7).

This highlights an affordability gap, especially at higher tiers of provision, but also a willingness to pay more for higher-powered distribution systems.

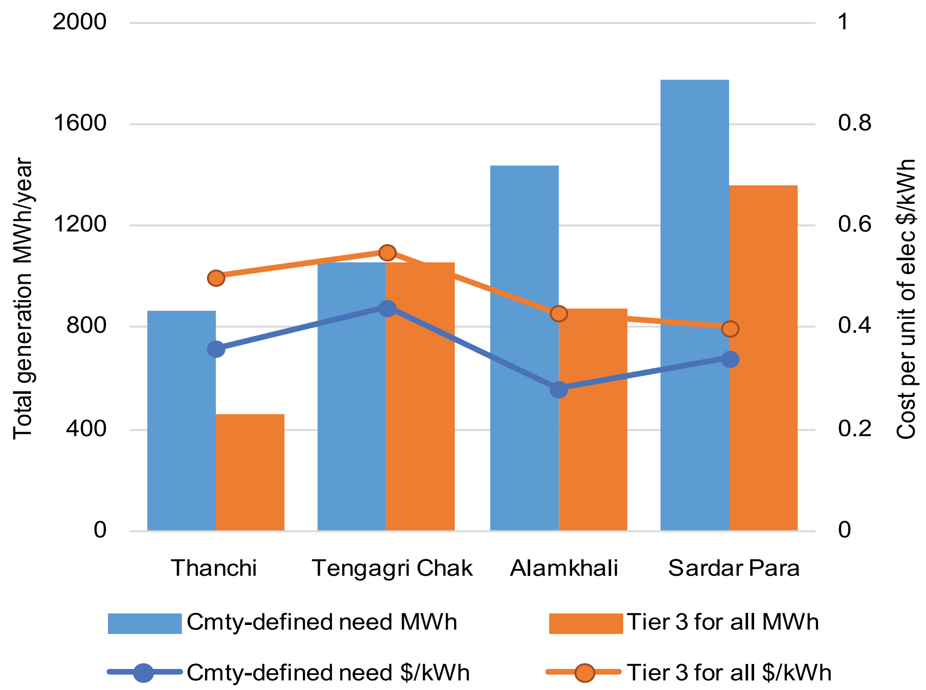


Figure 5.10 Costs per unit of electricity and generation capacity

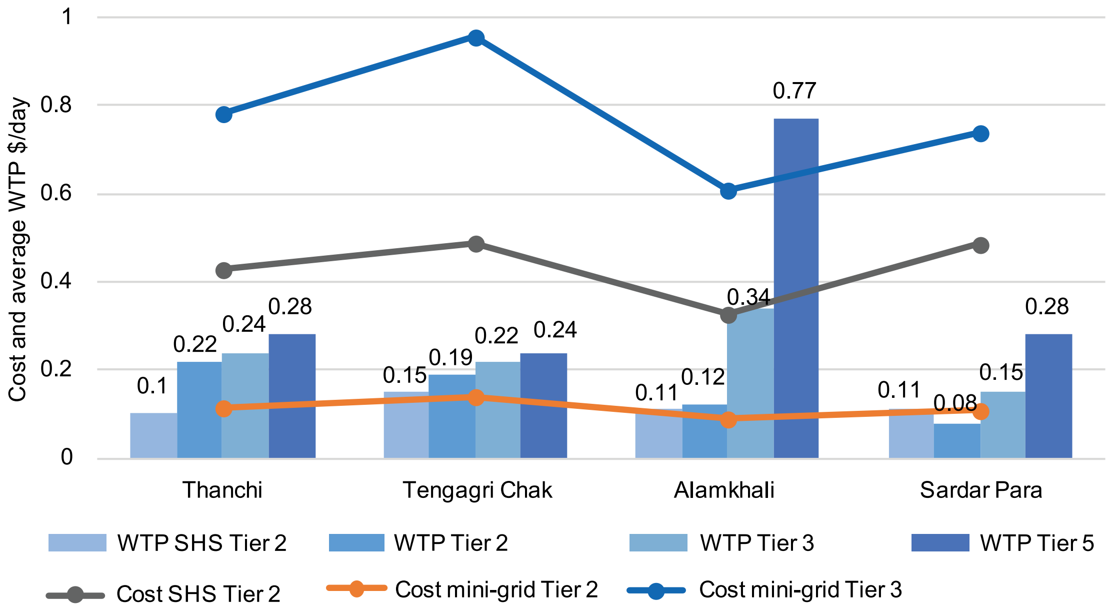


Figure 5.11 Cost and willingness to pay for different levels of electricity access

Focus group participants said: **'Even if grid [distribution system] electricity costs more, we need electricity supply'**, and **'Everybody wants to use electronic goods. A man can be poor, but his willingness to use electronic products crosses the boundary of being poor.'**

On the other hand, the cost of Tier 2 level use of national grid electricity (excluding the connection fee and house wiring costs, which are substantial) is only $0.015 per day, and Tier 3 only $0.1 per day - well within people's willingness to pay. Our calculations suggest, however, that these tariffs are 6-9 times below the real costs of delivering grid extension in these communities.

We modelled the systems that could be installed based on willingness to pay. A distribution system would no longer be viable in any community but Alamkhali (and even there the system would serve only 14 households and 40 SMEs or community facilities). The result would be greater inequality: with costs per kWh 3.5-4.5 times more than with a distribution system, they would be affordable only to richer households.

Options for improved access to cooking

What is important to cooks?

Women do not perceive significant health risks from the traditional stoves they use

The most important feature of ideal cooking solutions across communities was that **fuel should be free** or **cheap and easy to obtain**. In Alamkhali, focus group participants had been put off using *bondhu chula* (improved stoves) partly because of the time required to chop wood into small enough pieces (this was also found in other field tests, e.g. WASHPlus, 2014). Two other important factors were the **speed of cooking** (more important for men, and also found by GACC et al., 2015), and that the solution should not cause **health** problems (usually more important for women). Having said this, women do not perceive significant risks to health from their current stoves. They (and their husbands) also value the extent to which smoke helps to keep insects away.

Which solutions do respondents prefer?

The available cooking solutions offered included a range of biomass stoves. The prices we suggested were broadly similar to those reported by GACC et al. (2015). LPG was offered as the cheapest Tier 4 solution, but levels of LPG awareness are low: several respondents had never seen an LPG stove, and places where cylinders can be refilled are 20 km from Alamkhali and 80 km from Thanchi. Biogas was initially considered but, in these particular communities, geographical conditions made it unfeasible. Although although people keep cows, they would not provide enough material to successfully feed a domestic biogas plant and crop residues are used for other purposes.

Respondents ranked solutions (including their current solution) in order of preference. This constitutes their community-defined plan. Nearly half in Alamkhali and Thanchi, and over a third in Sardar Para, would keep their current home-made stove. After that, electricity or LPG were most popular. The second choice for people who chose traditional stoves was either a locally known *chula* model, or upgrading to an enhanced biomass stove (Figure 5.12).

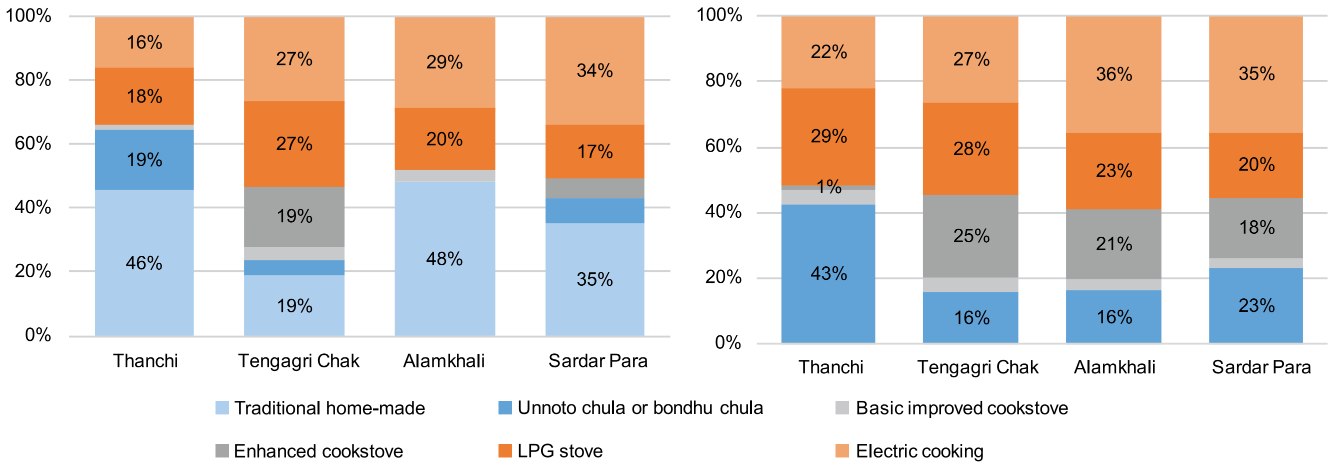


Figure 5.12 Preferred choice/community-defined plan for cooking solution including traditional stove (left) and excluding traditional stove (right)

The price of improved cooking

We compared the estimated costs of people's current solutions (monetizing fuel collection) with their improved choices, and with a benchmark of an enhanced biomass stove (Tier 2) or LPG (Tier 4). In all communities except Thanchi, a Tier 2 stove would represent a considerable saving and switching to LPG would only cost about 1.4 times as much as current solutions (Figure 5.13).

Willingness to pay for different solutions

Respondents were asked about their willingness to pay for solutions they deemed 'suitable'. Table 5.8 shows results only where more than 15% of respondents gave a figure.

Given people's preference for their current cooking solution and fuel, which is largely free of cost, it is not surprising there were low levels of willingness to pay for improved solutions. However, there was potential for people to pay for basic

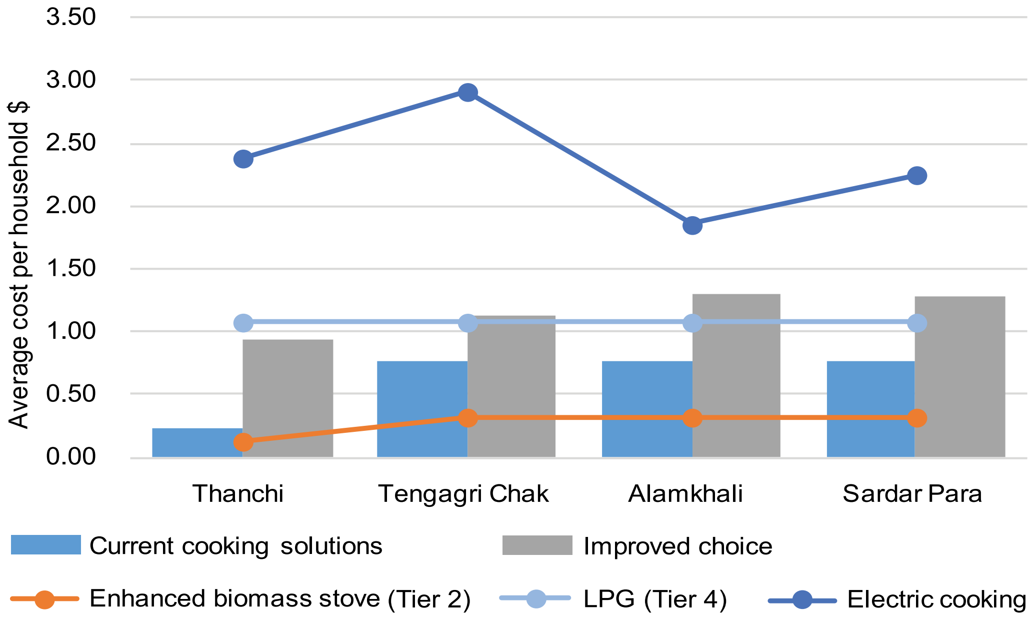


Figure 5.13 Cost of cooking solutions

Table 5.8 Willingness to pay for cooking solutions

Type of cooker	*Including or excluding fuel*	*Cost ($)*	*Average willingness to pay $/day*			
			Thanchi	*Tengagri Chak*	*Alamkhali*	*Sardar Para*
Wood ICS Basic	Stove only	**0.04**	0.04	0.03	-	-
	Stove+wood	**0.36**	0.10	0.14	-	-
Wood ICS Enhanced	Stove only	**0.13**	-	0.07	-	-
	Stove+wood	**0.18–0.32**	0.14	0.15	-	0.10
Solar cooker		**0.08–0.09**	-	-	-	-
LPG	Stove+gas	**1.08**	0.37	0.28	0.23	0.25
Electric cooker		**1.78–2.58**	-	0.23	0.53	0.32

Clean cooking plans need to tackle the lack of trust in improved biomass stoves

wood-burning stoves in Thanchi and Tengagri Chak (the cheapest option), or for an enhanced wood-stove plus fuel costs in Thanchi (where wood costs are lowest). Otherwise, despite some interest, there was low willingness to pay for these solutions. Similarly, with LPG and electricity, despite their popularity as preferred choices, there is a clear affordability gap. Across the whole sample, the average amount people were willing to pay for LPG ($0.28/day) represents only a quarter of the estimated cost.

Clean cooking plans for these communities would need to tackle the issues of trust in and awareness of improved biomass stoves, as also highlighted by GACC, et al. (2015). These stoves would also need to work better with the mix of available biomass fuels. There is an appetite for leapfrogging to fully clean fuels, which are beyond what people currently consider affordable.

Conclusion

Bangladesh is a large, populous nation. Its successes in the spread of SHSs have been applauded internationally, and our research demonstrates the impressive reach of these markets. However, some communities, and the poorer segments within communities, remain left behind and levels of energy access achieved using these technologies generally fall short of people's needs.

There is an urgent need to make significant progress on clean cooking, given the very low levels of awareness of and enthusiasm for available products. There are considerable enterprise and mainstream productive uses that could also benefit from higher tiers of electricity, and people are willing to pay something towards that provision. Indeed, they would pay more than is currently charged for grid-connected electricity. Such investments would have gender implications: irrigation pumping would benefit male farmers more, while energy to support threshing and domestic water pumping would likely lighten women's work. However, an affordability gap remains.

Bangladesh: findings and recommendations

- **Nationally, 72% have electricity access (2015).**
- **By 2015 over 4 million generally Tier 1 solar home systems had been sold.**
- **Only 2% of all households own an improved biomass cookstove.**

	FINDINGS		RECOMMENDATIONS	
Grid or decentralized	**De-centralized**	In **3 of 4 communities**, decentralized or stand-alone solutions were either the **least-cost option** to meet electricity needs, the **fastest** by many years, **or both**.	**Rebalance**	Review national plans to **increase focus** on decentralized solutions, providing needed levels of power **faster and at least-cost**.
Household affordability	**20-35%**	Despite huge promotion of solar home systems, **20-35%** still **could not afford one**.	**New products**	Promote **new products** and programmes to **reach the poorest**.
Clean cooking	**1/253**	Just 1/253 households surveyed had a **manufactured stove**.	**National campaign**	Implement a **national awareness-raising campaign** on the need for **clean cooking**. Develop biomass stoves better adapted to available fuels and cooking practices.
Community services	**2nd or 3rd priority**	**Energy for schools** and **street lighting** was ranked as the **2nd or 3rd priority** in all communities.	**Co-ordinate**	Include **plans for electrifying schools** in national plans in **co-ordination** with the Ministry of Education, and for **solar-powered street lighting**.
Agriculture	**Demand**	**Agricultural processing** and **irrigation** for small-holders was a **consistent demand** in focus groups in all communities.	**Co-ordinate**	**Increase focus** in national plans on the needs of **small-holder farmers** both for irrigation and crop processing, in co-ordination with the Ministry of Agriculture.

6. Togo

National context

Togo is the poorest of the three case-study countries. In 2011 the gross national income per capita was $1,228 compared to $2,762 in Kenya and $3,191 in Bangladesh. It also has the lowest human development index of the three: it is ranked at 162 whereas Kenya is ranked 145 and Bangladesh 142. The economy depends on agriculture and mining. Of the population of around 7 million, over half (55%) live below the poverty line (World Bank, 2015) and there are large rural–urban inequalities. While fragile, the country is enjoying a period of stability after two decades of economic and political turmoil. Energy access levels are low; in 2015 it was estimated that 50% of the population had an electricity connection, but only 16% in rural areas did (INSEED, 2016). The grid's performance has improved over the last four years, following investments in supply capacity, maintenance, and transmission. There is a very low penetration of off-grid electricity products, including mini-grids and household solar products.

More than 90% of the population cooks on traditional stoves

Biomass accounts for 75% of all energy use (SEforAll, 2012). More than 90% of the population cooks on traditional stoves using wood, crop residues, or charcoal. LPG is the main clean cooking fuel, but it is used by less than 5% of households, almost exclusively in urban areas.

There has been a programme to introduce 'multi-functional platforms' to provide energy for grain milling, oil pressing, and other forms of post-harvest processing. They are often powered by diesel engines. By 2012, 25 of these had been installed, although there is scope for over 1,700.

Overview of case-study communities

The four communities represent a range of situations faced by the rural Togolese, and poverty rates in their districts are generally below the national rural average (Table 6.1).

Kame. Flat land, not heavily forested. Strong church presence. This village in the Plateaux region towards the south of Togo is home to around 6,900 people; most live in one of **roughly 1,200 compounds** housing up to 50 people each.

Table 6.1 Poverty rate and electricity connections by district (UNDP and GoT, 2011)

Préfecture (village)	*below poverty line (2011)*	*electricity connections (2011)*
Haho (Kame)	72.1	14.2
Blitta (Assoukoko)	79.7	6.9
Tone (Koulmasi)	82.7	13.0
Tandjoare (Nandjoare)	94.0	1.3
All rural Togo	73.4	10.2

Much of the infrastructure (wells) and many community facilities (church, primary school, health centre) are provided by the Church of the Assemblies of God, which also has a theological college in the village. All the villagers are from the same ethnic background (Oyo – originally from Nigeria). People cultivate maize, rice, and sorghum. Cotton is grown as a cash crop, and women make soap from palm-nut oil.

Assoukoko. Central region. Mountainous, heavily forested. This village of **680 households** is in a mountainous area at the boundary between dry savannah to the north and forests to the south, close to the border with Ghana. The land is fertile and people cultivate cocoa, coffee, manioc, yams, maize, and other cereals. The community comprises three ethnic groups.

Koulmasi. Semi-desert, savannah. This village of **215 households** (1,432 people) is in the dry north of Togo and people live in compounds or large households, dispersed across a landscape of low hills. The villagers, all from the Tontetiéb tribe, cultivate a range of cereals and vegetables, grow cotton as a cash crop, and keep cattle and smaller livestock. Soils are poor and water scarce, with food security only seasonal. There is a shortage of wood for cooking. In 2014 the village was scheduled for grid extension, but the limited budget of the national electricity company has not allowed for this yet.

Nandjoare. Semi-desert, mountainous. This village is also in northern Togo, surrounded by a chain of mountains. The population of 814 people live **in 141 households** – which are quite widely dispersed – and from three different clans. The village has a more challenging geography than Koulmasi, and even less access to services. Average incomes are lower than in all the other communities. There is a severe water shortage, and the villagers struggle to produce enough food due to poor, stony soils and a lack of cultivable land. There is a shortage of wood for cooking. As with Koulmasi, although the energy company planned to extend the grid here, there was insufficient budget.

Current levels of energy access

Household electricity

Incomes in households without electricity are, on average, 30% lower than in those with electricity

The very low penetration of solar products in Togo is evident in these case-study villages. We found only 17 solar home systems and 4 solar lanterns in the 243 surveyed households. The performance of these is poor, sometimes worse than simple torch batteries, leaving over a third of users (37%) in Tier 0. Half (47%) provide Tier 1 electricity. The main appliances used are radios and phone chargers (more than 8 out of 10 households with electricity have these). Some own televisions, fans, and other appliances. A few people without electricity own radios and phone chargers, but no higher-powered appliances. Incomes in households without electricity are on average 30% lower than in those with electricity.

In every case, households with electricity are able to use it for lighting but the vast majority of households also use small, battery-powered torches. There is limited use of kerosene and candles (figures 6.3 and 6.4).

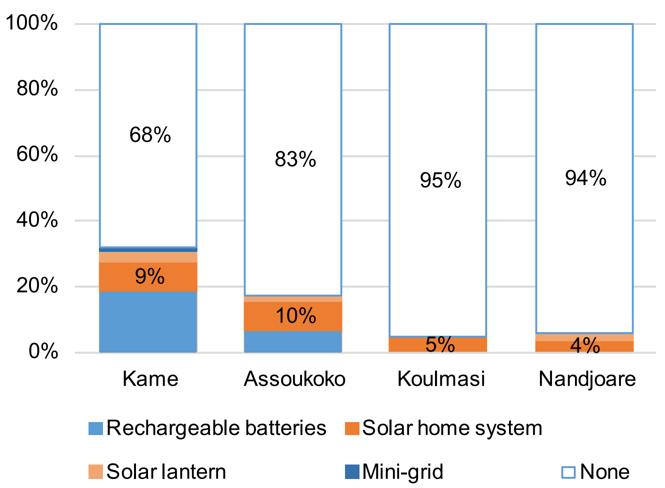


Figure 6.1 Primary source of household electricity

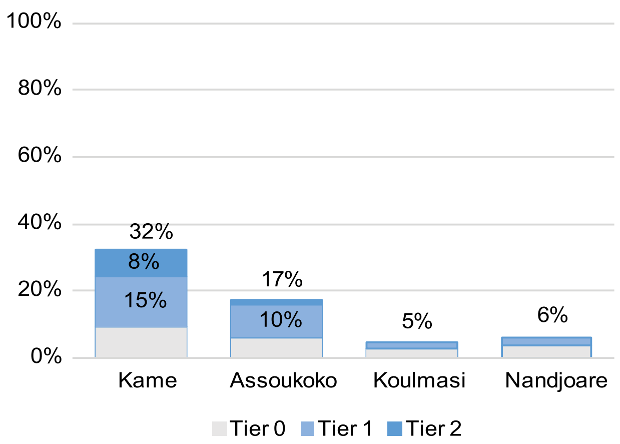


Figure 6.2 Level of electricity access (for those who have access)

Household cooking

Wood is the primary fuel for all communities, although in Kame a third of households use charcoal (Table 6.2). There is some use of crop residues as a secondary fuel. In Assoukoko, five families use LPG, probably sourced from Ghana. There is some stove stacking, more common in the south (Kame: 17%) and centre (Assoukoko: 10%) than in the north (2–3% in Nandjoare and Koulmasi).

Almost all the stoves are artisanal: made by the householder or another skilled person using local materials. Some stoves are simply three stones, while others are horseshoe-shaped and built with mud. Of the households burning charcoal, a few (14% in Kame) use locally made stoves similar to *jiko* stoves in Kenya. We only found three branded, manufactured stoves (all in Kame).

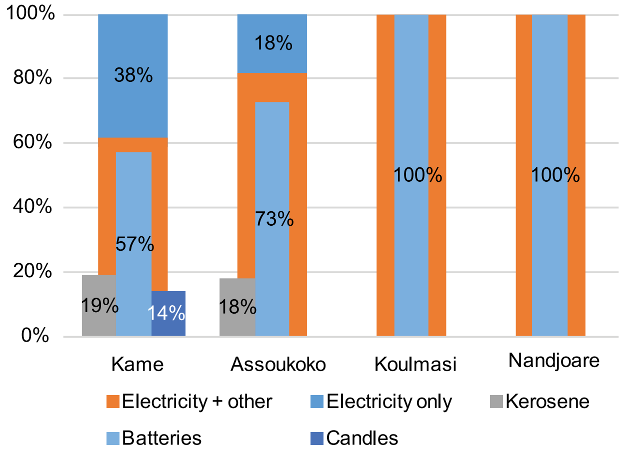


Figure 6.3 Source of lighting for those with electricity

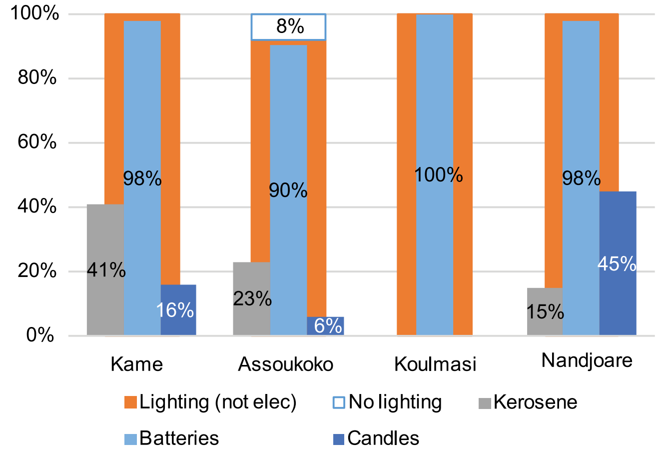


Figure 6.4 Source of lighting for those without electricity

Table 6.2 Primary fuel type

	Kame	*Assoukoko*	*Koulmasi*	*Nandjoare*
Wood	64%	83%	98%	98%
Charcoal	34%	9%		
Crop residues	2%		2%	2%
LPG		6%		
Kerosene		2%		

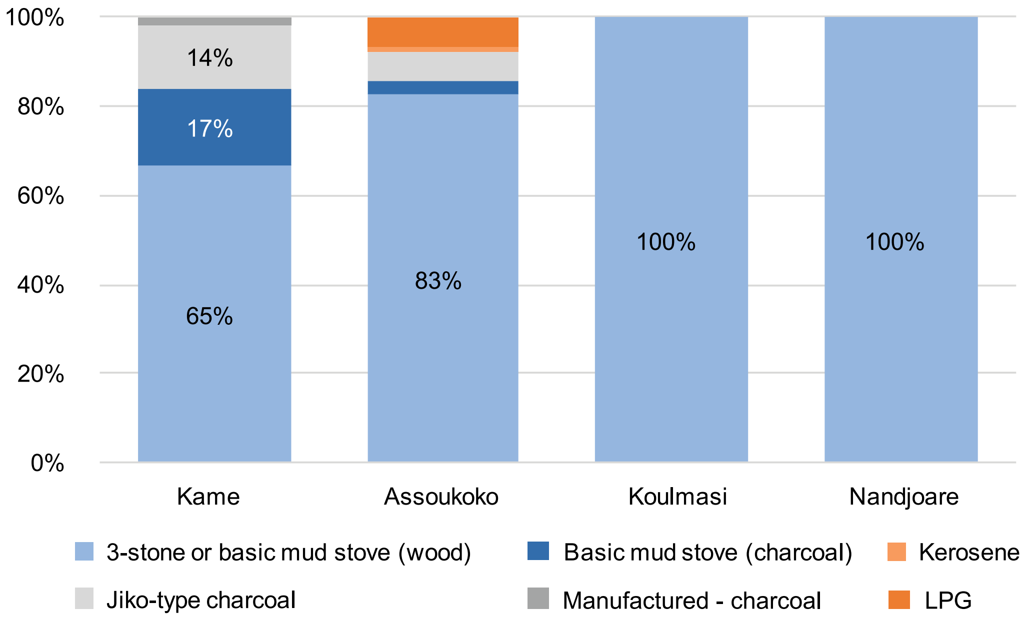


Figure 6.5 Primary cooking solution

Women bear the burden of almost all the tasks of gathering and preparing fuel and cooking. Only in Assoukoko are tasks of gathering and preparing fuel more evenly shared (Figure 6.6).

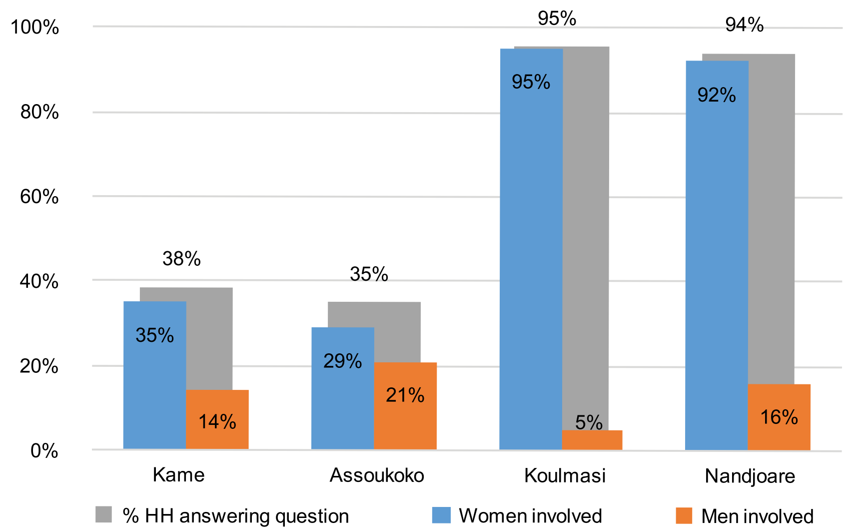


Figure 6.6 Gender division of labour for fuel gathering

Table 6.3 Hours per week cooking, collecting fuel, and preparing fuel

	Kame	*Assoukoko*	*Koulmasi*	*Nandjoare*
Average hours cooking	27	24	32	26
Average hours collecting fuel (% answering)	6 (35%)	8 (38%)	9 (95%)	9 (94%)
Average hours preparing fuel (% answering)	12 (37%)	14 (38%)	12 (51%)	9 (60%)

Cooking takes the greatest amount of time per week, particularly in Kame and Koulmasi where households are larger (the median sizes are 9 and 8.5 people respectively). Fuel preparation (chopping wood) takes considerable time, as does collecting wood in Koulmasi and Nandjoare where firewood is scarcer (Table 6.3).

Electricity for livelihoods

Even in the larger villages, there are few small enterprises. Farmers in these villages generally do not use any energy, even mechanical power. No enterprises in Koulmasi and Nandjoare have electrical power. In Kame and Assoukoko, only six enterprises have electricity: two lanterns (Tier 0), two SHSs, and two generators (one diesel and one wind-powered), providing power between Tiers 1 and 3.

Despite this, enterprises require a range of energy services and use a range of supplies to meet those needs. For lower-powered devices, this is usually batteries. For higher-powered needs, diesel, petrol, or kerosene is used (Table 6.4).

Electricity for community services

Religious establishments are the most likely to use electricity, generally from diesel-powered generators (one wind-powered in Assoukoko) (Table 6.5). The health facilities in Kame and Assoukoko are unelectrified. They use battery torches for lighting and kerosene-powered fridges, use of which is severely limited by the intermittent availability of fuel.

Table 6.4 Energy services used by enterprises

Energy Service	*Kame (n = 19)*	*Assoukoko (n = 16)*	*Koulmasi (n = 9)*	*Nandjoare (n = 12)*
Lighting	14: of which 8 are non-electrical, mostly using **batteries**	9: of which 2 use electricity; others use **batteries**	4: all use **batteries**	7: all use **batteries**
ICTs	Phone charging TV and radio Computer	Phone charging TV and cinema	Phone charging Satellite TV Radio	Phone charging
Cooling	1: fridge to chill drinks: **kerosene**	1: freezer to store smoked fish: **diesel**	–	–
Heating	1: **palm wine**	1: fish smoking 1: blacksmith: **charcoal**	–	1: iron for tailoring: **charcoal**
Motive power	2: milling: **diesel**	1: carpentry equipment: **petrol** 1: **manual** sewing machine	1: milling: **diesel** 1: manual sewing machine	2: milling: **diesel** 2: **manual** sewing machine

Table 6.5 Electricity access for community facilities

Type of facility	*Number surveyed*	*Number with electricity access*	*Tier levels (for those with electricity)*		
			Tier 1	Tier 2	Tier 3
Religious centres	16	9 (56%)	3	4	2
Schools	13	2 (15%)	1	1	
Health facilities	2	0 (0%)			

Energy access priorities

It is energy services that matter to people, rather than supplies. We asked people to prioritize the energy services which were most important to them, to help guide the development of energy access plans.

Table 6.6 Prioritization of energy needs

	Kame	*Assoukoko*	*Koulmasi*	*Nandjoare*
1st priority	Households (1st or 2nd for 62%)	Households (1st or 2nd for 75%)	Households (1st for 83%)	Households (1st for 66%)
2nd priority	Street lighting (2nd or 3rd for 48%)	Street lighting (2nd or 3rd for 44%)	Street lighting (2nd or 3rd for 74%)	Street lighting (2nd or 3rd for 70%)
3rd priority	Schools	Schools or businesses	Schools	Schools

The focus groups highlighted gendered differences in priorities. For women, street lighting and household lighting were important to improve security, reduce crime, and deter reptiles and snakes, while men and young people[1] talked about it 'revolutionizing their way of life'. Men were more likely to prioritize mobile-phone charging and heating water for washing. For women, 'pumping drinking water' and 'processing crops' (milling, threshing, and hulling) were high priorities, and were almost entirely their domain. Problems related to the scarcity of clean drinking water were particularly acute in Koulmasi and Nandjoare.

Energy for households. The focus group discussions generated a clear prioritization of needs from separate groups of women, men, and young people. This provided a more balanced picture of needs than the survey. The results in Table 6.7, therefore, reflect focus group findings.

Table 6.7 Prioritization of household energy applications

	Kame	*Assoukoko*	*Koulmasi*	*Nandjoare*
1st priority	Electric lighting	Electric lighting	Electric lighting	Electric lighting
2nd priority	Cooking food and making hot drinks	Cooking food and making hot drinks	Cooking food and making hot drinks	Pumping water
3rd priority	Milling grain	Pumping water	Recreation and entertainment	Cooking food and making hot drinks
4th priority	Pumping water	Recreation and entertainment	Pumping water	Recreation and entertainment

Electric lighting was the top priority from both the surveys and focus groups. In Kame, a focus group participant said: **'the lack of light is the source of many troubles: insecurity, isolation and ignorance'**. In Koulmasi, a participant said: **'in the darkness, you are almost dead'**. Most needed one to three hours of light before sunrise, and all needed evening light for at least two hours (in some cases up to eight hours). Large numbers would also like some light during the day. Fans for household cooling were not a priority.

The lack of light is the source of many troubles: insecurity, isolation and ignorance

Energy for schools. All communities prioritized this above energy for health facilities. People associated energy in schools with a brighter future and a better quality education, including having access to ICTs and being able to study in the evenings.

Energy for businesses. This was third or fourth priority in Kame and Assoukoko, and ranked below energy for schools and health facilities in Koulmasi and Nandjoare. There is a particular need for more grain mills, and threshing and hulling machinery. There are an insufficient number of mills, and the existing mills often break down or run out of fuel, with so many women spending long hours grinding crops manually. In Assoukoko women were aware of the potential of multi-functional platforms that can assist with these tasks. People also felt that energy access would enable new businesses to open, offering a wider range of goods and services.

Energy for health facilities. This was not prioritized in Koulmasi and Nandjoare, where there are no health centres. In Kame and Assoukoko, focus group participants recognized that energy access would allow their health centres to provide more and better services.

Energy for agricultural needs. Other aspects of energy access were prioritized above agricultural needs. However, people in Kame felt that irrigation would add value to their fertile land, while in Koulmasi the young people in the focus group wanted to 'modernize' their agricultural practices with motorized machinery.

Energy access plans

Options for electricity access

Households, enterprises, and those running community facilities were asked about the energy applications most important to them. We translated this into tiers of access by triangulating expressed priorities, adding information from the focus groups, and factoring in a 50% increase in non-farm enterprise activity stimulated by greater energy access (starting from a very low base, this only accounts for 11% of power demand on average). This community-defined level of need is therefore at the upper bounds of what people are likely to use in the coming years.

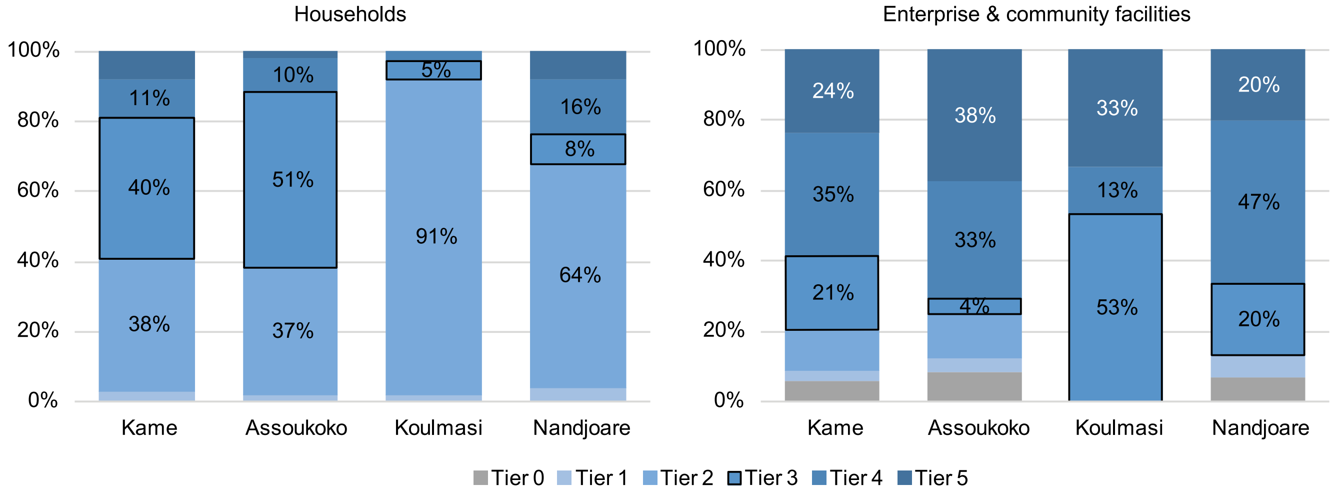


Figure 6.7 Electricity access needs for households by tier

Figure 6.8 Electricity access needs for enterprises and community facilities by tier

The majority of households required Tier 2 or 3 access, with averages from 2.1 in Koulmasi to 2.8 in Kame. This is based on people's aspirations to use, for example, electricity for lighting, phone charging, radios, colour televisions, and fans. It does not include people's aspiration to cook with electricity, which was significant in Assoukoko (43%) and Kame (31%). Enterprises and community facilities require higher levels of power, mostly driven by demand for medium-power appliances (audio-visual and computer equipment) or for prolonged use of low-power appliances, such as multiple fans. Tier 4 or 5 access is needed for the use of high-power appliances (mills, electric cooking) or prolonged use of medium-power appliances (air conditioning, refrigerators, or workshop equipment). Based on this demand level, we calculated the least-cost means of delivering energy (Table 6.8).

In Koulmasi and Nandjoare a distribution system would be more expensive than provision from stand-alone systems. The size of demand is not enough to achieve the economies of scale which would make a distribution system viable (Table 6.8).

Table 6.8 Determining the least-cost means of delivering community-defined level of energy access

	Kame		*Assoukoko*		*Koulmasi*		*Nandjoare*	
Total number HH	1,200		680		215		141	
Distance to grid	55 km		55 km		24 km		25 km	
Requirements: stand-alone systems								
SHSs	139 HH (9%) 4 SME/cmty facility		68 HH (10%)		215 HH (100%) 16 SME/cmty facility		136 HH (100%) 22 SME/cmty facility	
Solar lanterns[1]	344 HH		83 HH		129 HH		156 HH	
Street lights	2		7		43		70	
Requirements: distribution system (grid/mini-grid)								
Connections[2]	1033 HH 31 SME/cmty facility 46 street lights		612 HH 28 SME/cmty facility 61 street lights		n/a – distribution system more expensive in these communities than stand-alone systems			
Peak demand[3] kW	480		270		n/a		n/a	
Total demand MWh/year	975		500		n/a		n/a	
Least-cost means of energy access provision								
	Diesel mini-grid	Stand-alone	Small hydro mini-grid	Stand-alone	n/a	Stand-alone	n/a	Stand-alone
Capital $	1.52m	0.44m	1.79m	0.36m	-	0.51m	-	0.66m
Per unit $/kWh	0.51	1.3	0.62	1.3	-	1.4	-	1.4
Alternative means of powering distribution system (% difference from least-cost system)								
System type	Extension of national grid (combined-cycle gas turbine plant)		Extension of national grid (combined-cycle gas turbine plant)		Diesel mini-grid		2x diesel mini-grids (main village + hamlet)	
Capital ($)	2.20m (+45%)		0.81m (-55%)		0.43m (-16%)		0.53m (-20%)	
Per unit $/kWh	0.53 (+3%)		0.66 (+6%)		1.5 (+7%)		1.4 (+3%)	

Notes:

[1] People often said they wanted and would pay towards both a distribution system and solar lanterns

[2] Abbreviations: HH (households), SME (small and medium enterprise), cmty (community)

[3] These figures include distribution and transmission losses

The analysis found firstly that, in all cases, decentralized systems are cheaper than grid extension. Costs for the diesel mini-grid in Kame could be reduced further with a hybrid solution. Below a certain size, the cost per kWh from a distribution system rises quickly because of the extra infrastructure required (e.g. the poles and lines). So where overall demand is small, stand-alone solutions are the most economic. But these are still over three times more expensive per kWh than power from the distribution system in Kame. Secondly, size matters, and larger systems based on community demand are cheaper than smaller systems providing Tier 3 electricity for all, although only marginally so (Figure 6.9). Thirdly, in most cases it is cheaper to power motive loads using stand-alone diesel power.

In all cases, decentralized systems are cheaper than grid extension

Finally, we looked at the viability of these systems according to people's willingness to pay. Almost all respondents were willing to pay something. Costs in Figure 6.10 are based on the least-cost distribution or stand-alone system price per kWh from Table 6.8.

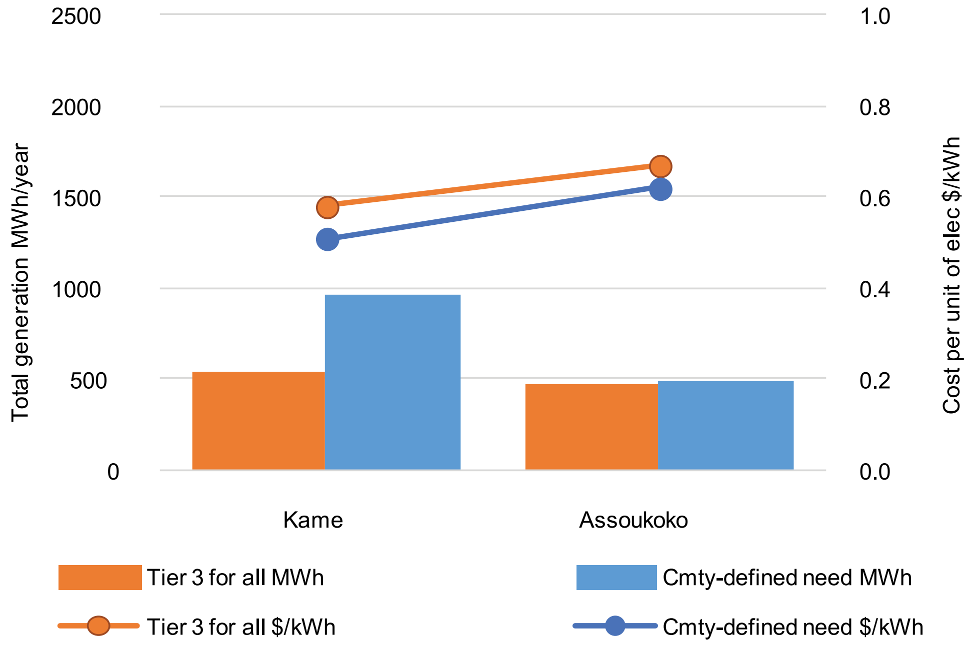


Figure 6.9 Costs per unit of electricity and generation capacity[2]

Note: The graph only shows figures for distribution systems, and therefore is only applicable in Kame and Assoukoko.

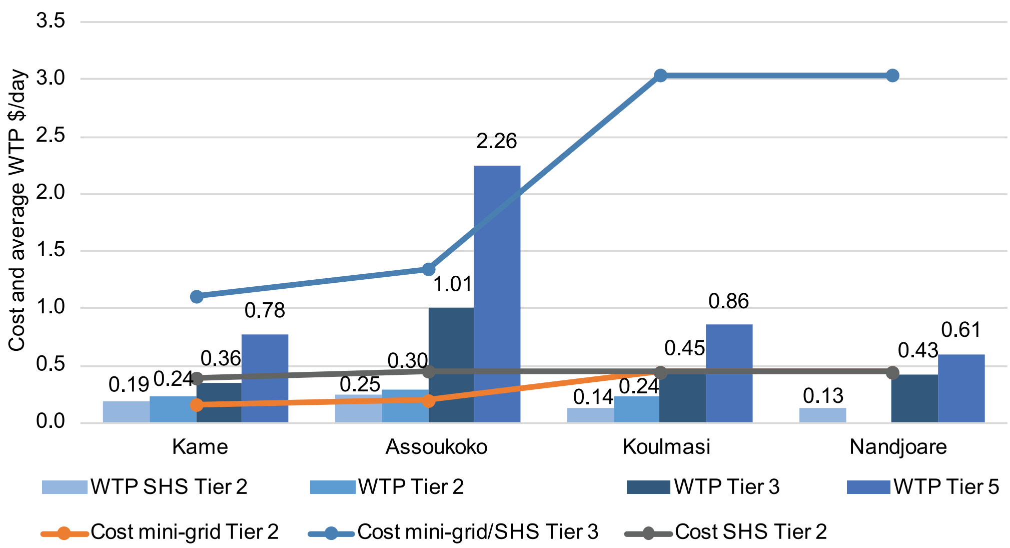


Figure 6.10 Cost and willingness to pay for different levels of electricity access

For a Tier 2 level of access, people were, on average, willing to pay more than the cost of provision in Kame and Assoukoko, but not in Koulmasi and Nandjoare (where costs are higher). However, even there, people were willing to pay near to the cost of a Tier 2 system when asked about Tier 3 provision. People still aspire to Tier 3 provision (particularly in Kame and Assoukoko, see Figure 6.7) so there is still an affordability gap for this level.

On the other hand, the price of Tier 2 level use of national grid electricity (excluding the connection fee and house wiring costs, which are substantial) falls within a 'social tariff' and is $0.14 per day. Tier 3 is only $0.37 per day, which lies within the range people are willing to pay.[2] Our calculations suggest that these tariffs are 1.2-1.5 times below the real costs of delivering grid extension in Kame and Assoukoko, and far more than that in Koulmasi and Nandjoare.

We modelled the systems that could be installed based on current willingness to pay. In Nandjoare and Koulmasi household access would be limited to 50–100 solar lanterns. In Kame a small distribution system serving around 10% of households would be viable, with around half the households buying solar lanterns. The costs per kWh would be twice that from a larger system. In Assoukoko, willingness to pay was much higher, and a hydro-powered distribution system serving 65% of households and all the community facilities and enterprises would be viable. Overall, basing provision on existing willingness to pay would result in a more expensive system affordable only to richer households.

Options for improved. access to cooking

What is important to cooks?

Improved cooking was prioritized strongly by women in the focus groups. The major issue was the time taken with cooking which could be used for more lucrative activities. In the surveys, fuel being free and easily obtained was one of the top priorities across communities. How long stoves took to light and heat up, and that they did not cause health problems, were also important factors.

Which solutions do people prefer?

Viable cooking solutions included basic and enhanced wood stoves, and an enhanced charcoal stove. Biogas is possible to generate and in most cases is the cheapest Tier 4 solution. LPG is being promoted, and the government is aiming for a tripling of its use by 2030 under SEforAll (albeit from a very low baseline). People were also offered the options of solar or electric cooking.

Respondents ranked solutions (including their current solution) in order of preference. This constitutes their community-defined plan. In reality, people are likely to choose whichever is the cheapest clean cooking solution: LPG, biogas, or electricity. The results demonstrate a clear dissatisfaction with the current situation. Only one respondent chose their existing stove as their preferred option. A large number of respondents in Kame and Assoukoko felt that wood was not suitable for them, and would like a ‘modern’ solution. However, in the north, where fuel is scarcest, 94% in Koulmasi and 73% in Nandjoare chose biomass-based solutions. Awareness of clean cooking and environmental messages is clearly not as great where it is needed the most.[3]

The price of improved cooking

We can compare the estimated costs of people’s current solutions (monetizing fuel collection) with their improved choices and with a benchmark of an enhanced wood-burning stove (Tier 2+)[4] or biogas/LPG (Tier 4) (Figure 6.12). In Kame, biogas is actually cheaper than current solutions, and in Koulmasi the cost is only 40% more. However, because it would rely on distribution from a central plant or several smaller plants, it would not reach everyone. For outlying households, LPG is the next-cheapest Tier 4 option. In all communities a Tier 2 stove would represent a considerable saving of 70–80%.

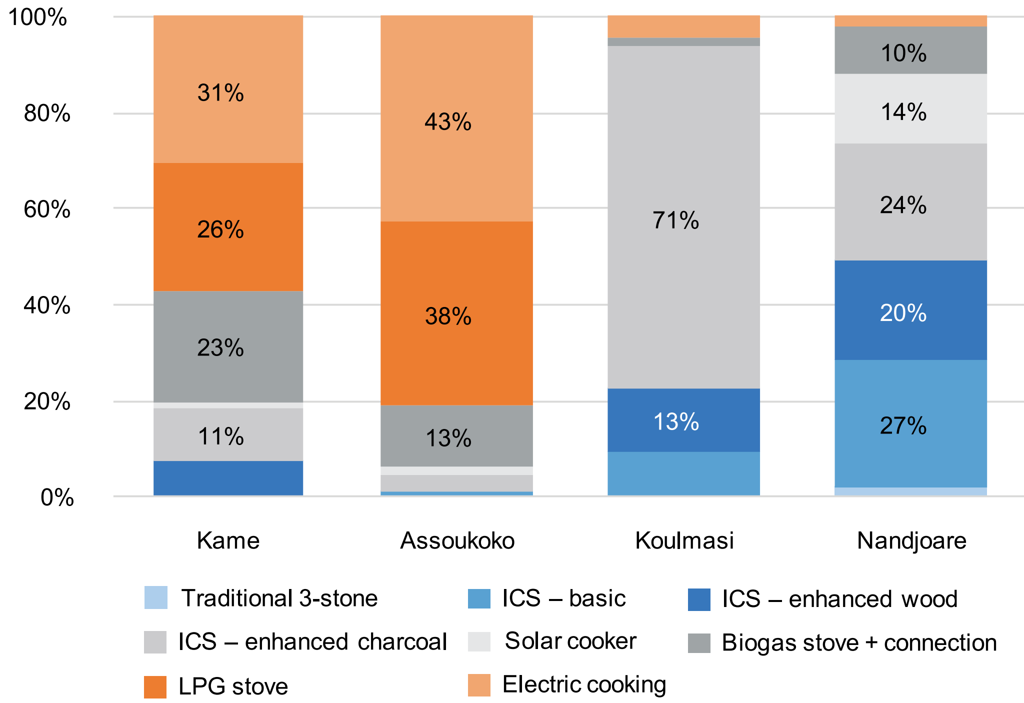


Figure 6.11 Preferred choice/community-defined plan for cooking solution

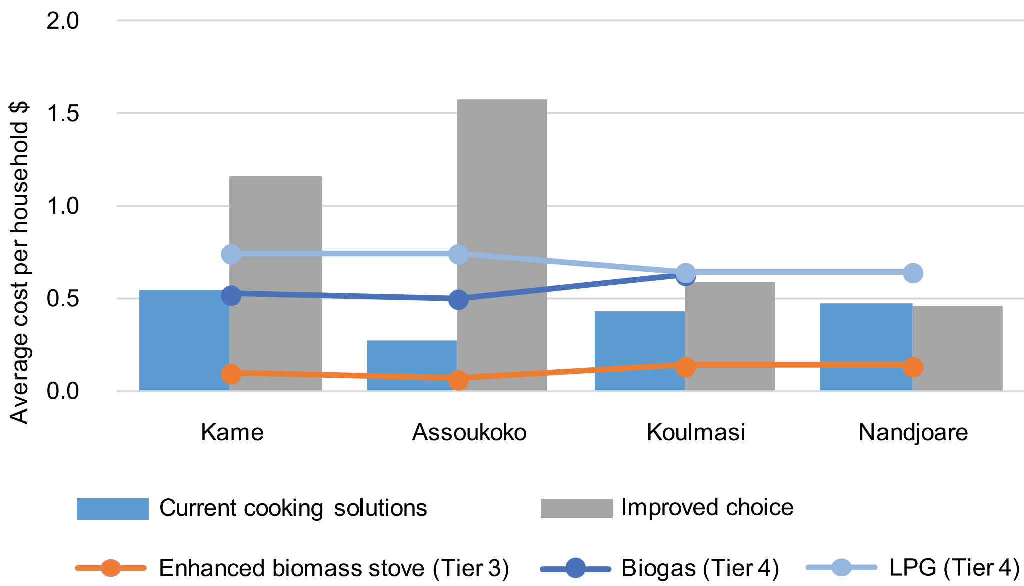


Figure 6.12 Cost of cooking solutions

Willingness to pay for different solutions

Respondents were asked about their willingness to pay for solutions they deemed 'suitable'. Although there is an affordability gap, there would be some uptake of improved solutions at these prices. A third of respondents were willing to pay the full levelized cost of their preferred option, and in Assoukoko and Nandjoare, two-thirds thought at least one of the improved options was both suitable and affordable. Among these, 37% of households in Assoukoko said biogas would be suitable and were willing to pay the full cost for it.

Table 6.9 Willingness to pay for cooking solutions

	Cooking Solution	*Cost ($)*	*Average willingness to pay $/day*			
			Kame	*Assoukoko*	*Koulmasi*	*Nandjoare*
Wood ICS basic (Tier 2)	Stove only	**0.01**	0.01	0.01	0.01	0.01
	Stove + wood	**0.07–0.17**	0.04	0.07	0.10	0.07
Wood ICS enhanced	Stove only	**0.03**	-	-	0.02	0.02
	Stove + wood	**0.06–0.14**	0.04	0.06	0.08	0.06
Charcoal ICS enhanced	Stove only	**0.05**	0.04	0.05	0.04	0.05
	Stove + charcoal	**0.42**	0.09	0.38	0.11	0.19
Solar cooker		**0.06**	-	-	-	0.05
Biogas	Stove + connection	**0.48–0.59**	0.19	0.41	0.25	0.18
LPG	Stove + gas	**0.64–0.75**	0.29	0.44	0.30	0.25
Electric cooker		**2.85–9.27**	-	0.65	0.92	0.85

Improving access to clean cooking in these communities is a question of both awareness and availability of technologies. There is, overall, a great dissatisfaction with current solutions and, among some, a desire to move away from biomass fuels altogether. There is some preference for charcoal as a fuel, but this is unlikely to help reduce the pace of deforestation. There would needs to be more attention paid to the design and performance of wood-burning stoves if they are to become a more attractive option.

Conclusion

Togo is a relatively small country with high levels of poverty and poor levels of energy access. It is nonetheless diverse culturally and geographically, with a range of potential sources of renewable energy. In all the different contexts we studied, it is cheaper to install decentralized electricity solutions and these would also meet people's needs more quickly than extending the national grid. In some cases, enthusiasm for these options is such that people are willing to pay amounts approaching the full cost. Equally, there is dissatisfaction with current cooking solutions, and therefore potential for uptake of high-quality biomass stoves or fully clean cooking solutions, with biogas being the best option in most cases.

The situation in Togo emphasizes the difficulties of energy access in small but dispersed communities in remote locations: any energy access solution will be expensive because the economies of scale of distribution systems cannot be realized.

Togo: findings and recommendations

- Nationally, electricity access was 50% in 2015 but only 16% in rural areas.
- Biomass represents 75% of all energy use and >90% cook on traditional stoves.
- 55% of the population is below the national poverty line.

	FINDINGS		RECOMMENDATIONS	
Grid or decentralized	De-centralized	Decentralized mini-grid or stand-alone solutions were the least-cost means of meeting electricity needs in all four communities.	Rebalance	Rebalance rural electrification plans in favour of mini-grids and stand-alone solutions.
Household affordability	Stand alone	Stand-alone household systems were the best solution in smaller, dispersed communities, but cost 8 x more than the grid for Tier 3 access.	Financing	Support financing packages to help the poorest households access good quality solar products.
Gender	Women's priorities	Women prioritized energy for lighting, cooking, pumping drinking water and processing crops.	Mainstream	Mainstream gender concerns in energy planning, and in energy co-ordination with Ministries of Water and Agriculture.
Clean cooking	Strong demand	There was strong demand for clean cooking solutions and biogas is potentially viable, costing only 40% more, on average, than current solutions.	Promote uptake	Promote the uptake of biogas alongside improved biomass stoves and LPG.
Community services	Street lighting	Street lighting was the second highest priority after household electricity in all four communities, for safety and security reasons.	Co-ordinate	Include street lighting in rural off-grid electrification plans.

7. Implications for national planning

Our case studies and modelling highlight key issues about current levels of energy access, what poor people prioritize in terms of improving access to energy, and the gap between real-world costs and people's expressed willingness to pay.

We have explored how to meet globally agreed targets by taking better account of the needs, priorities, and geographic realities of those currently beyond the grid. We found that, while extending the grid is sometimes the best option, more often it is not, and people would be best served by decentralized energy technologies. Viewing these needs from a holistic, gender aware, Total Energy Access perspective that encompasses household, productive, and community energy requirements, will create efficiencies and benefits beyond the energy sector.

In this chapter, we highlight themes emerging from the case studies and their implications for national energy planning, policy, and programme design.

What level of energy do people have and need?

The low levels of access we found were not delivering the energy services people wanted or needed

The SEforAll MTF is fundamental to comparably and accurately assessing levels of energy access and progress over time. But it does not address the question of what level of access is appropriate for national and global universal access objectives. Analysing what people want, and what types of technology enable development and produce significant health benefits, we argue that Tier 3 should be considered a global minimum standard for household electricity and Tier 4 for cooking (CAFOD et al., 2015). This should be central to the thinking of all programme, fund, and policy development which focusses on energy access interventions, financing, and policies.

In seven of the twelve communities we investigated, less than 30% of households had any form of electricity, and across the other five, while 60–80% had some form of electricity, this was almost always at an extremely low and unacceptable level (Tier 1). The cooking situation was consistently worse. Enterprises (in particular service and retail businesses) were more likely to have electricity than households in Bangladesh, but less likely in Kenya and Togo. The low levels of electricity access we found were *not* delivering the household energy services people wanted or needed. In nine out of twelve communities, over two-thirds of those *with* access to electricity also used an additional source of lighting (often kerosene or torch batteries in Togo) due to inadequacies in the modern options available to them.

In terms of the energy services people wanted, household electricity was consistently the top priority, and the needs were felt to be urgent. While people recognized the potential for productive technologies to enable them to make more money, they faced uncertainty around return on investment, among other things. What was certain to them was that their lives would be more comfortable (irrespective of income) with electricity at home. There were particular gender dimensions to this, with women benefitting more. Lighting, mobile-phone charging, and the ability to run a fan were the drivers for households needing Tier 2 or 3 electricity. Neither the newest small SHS nor the more efficient fans that can run on them were available in our case study communities. According to our analysis, Tier 3 access would satisfy 71% or more of household needs across these communities. However, this level of access would meet only 46% of enterprise and community needs alluding to the need for differentiated approaches for various energy uses.

According to our analysis, Tier 3 electricity access would satisfy 71% or more of household needs

In some communities there was significant interest in Tier 4–5 cooking solutions using clean fuels, yet more than half preferred to continue using traditional stoves or a basic biomass improved cookstove (ICS). Despite this, we would argue, in light of the need to reduce household air pollution to safe levels, a goal of Tier 4+ access should form the basis of energy access planning nationally and globally (with lower-tier cooking options being promoted as transitional solutions).

Targets in existing national plans

As noted in chapter 2, globally, the vast majority of energy planning is done without any consideration to potentially delivering different levels or tiers of energy access: it is ‘all or nothing’. Kenya’s SEforAll AA, finalized in 2016, is a welcome move away from this binary view of planning and includes targets referencing the MTF (Table 7.1).

Table 7.1 Targets for energy access in Kenya (SEforAll & MEP, 2016a: 9)

	Tier 1	*Tier 2*	*Tier 3*	*Tier 4*	*Tier 5*	*Total*
2022	20%	40%	25%	10%	5%	100%
2027	15%	35%	30%	12.5%	7.5%	100%
2030	10%	30%	35%	15%	10%	100%

While we welcome this broader approach to target-setting, the challenge is to translate this into collaboration between government, the private sector, and civil society to build markets for decentralized energy services, particularly for lower tiers of energy. It must also be noted that Kenya's AA still leaves 40% of people below Tier 3 in 2030. This is below both the suggested minimum global threshold of energy poverty and the self-identified needs of most households, communities, and enterprises in our case studies.

There is also a clear need to focus policies on improving product quality while ensuring affordability. As mentioned in Kenya's AA and underlined by our findings, many households owning solar lanterns or small solar home systems remain at Tier 0 due to poor system performance.

Box 7.1 Levels and targets: implications for planning

- Tier 3 should be the minimum level of electricity access that is targeted in national plans by 2030.
- Tier 4 access should be the minimum level targeted for cooking in national plans, recognizing that transitional targets for Tier 2 may also be needed.
- Policies must address product quality via standards or other tools.
- Policies must cater to a variety of levels of access, with higher levels for productive and community uses explicitly planned for.
- Lighting (inside and outside the house), cooking, fans, and mobile-phone charging would have significant gender benefits.

Clean cooking

In the past there has been a struggle to ensure cooking and clean fuels have equal priority with electricity in energy access debates. However, given the larger numbers involved and its serious health and environmental impacts, we argue that cooking must be prioritized at least at the same level as electricity access, if not higher. Universalizing clean cooking would be cheaper than universalizing electricity access, radically free up time that could be dedicated to other important household and productive tasks, improve a variety of health metrics, including mortality, and play an important role in reducing environmental degradation.

One significant challenge is that cooking is a silent killer, and often neither decision-makers nor communities recognize the profound effect it has on their countries and families on a day-to-day basis. It is therefore urgent and important that increased money and attention be brought to awareness-raising and education on these issues. The communities we surveyed in Kenya and to some extent Togo recognized the importance of clean cooking but levels of awareness in Bangladesh were much lower.

Cooking is a silent killer; its devastating effects often go unrecognized by decision-makers and communities

Table 7.2 Targets for clean cooking and fuels in Kenya (SEforAll & MEP, 2016a: 10)

	LPG	*Other clean fuels*	*Improved cookstoves with solid fuels*	*% with access to modern cooking*
2013	8.6	0.7	37.2	46.5
2022	18.6	3.4	52.7	74.7
2030	35.3	7.6	57.7	100.0

Note: numbers in final row do not add up to 100% due to an error in the original table.

The Kenyan SEforAll AA includes detailed sections on cooking and fuels, drawing on its Country Action Plan (CAP). The CAP targets the adoption of 5 million cookstoves by 2020 and predicts that, with the same level of progress, 58% of households will be using ICSs by 2030, and all households will be Tier 3 or above against International Standards Organisation air quality standards (ISO, 2012). Similarly, in Bangladesh, the country's CAP for cooking set a target of 100% ICS use, which would need the dissemination of at least 30 million improved stoves by 2030 (MPEMR, 2013). The SEforAll Action Agenda in Togo aims for 80% of the population with an ICS (MME nd).

Our findings suggest the least-cost option in all three countries for achieving clean cooking at a Tier 2 level would be the adoption of better-performing wood-fuel stoves. But people's experiences with these have not been encouraging.

Enthusiasm for completely clean fuels is hampered by a severe affordability gap

In Kenya, the absence of good wood-burning stoves means there is some preference for the convenience of charcoal. Given this, a strong clean-charcoal policy is needed alongside development and promotion of new types of wood-burning stoves. This need is recognized in Togo's Action Agenda. In all three countries we found encouraging enthusiasm for clean fuels (LPG or bioethanol) and electricity, but there remains an affordability gap. Even if prices come down significantly, only the better-off will be able to afford these solutions. It is only in Togo where biogas provides a more viable solution, which some could afford to adopt today in one of the communities.

To achieve Tier 2 cooking access would cost only 7% (in Kenya) and 22% (in Bangladesh) of the costs of Tier 3 electricity access for all. Tier 4 cooking (LPG) would be 37% more expensive than electricity in Kenya, and 86% of electricity costs in Bangladesh.

Box 7.2 Cooking energy: implications for planning

- All countries need to focus greater attention on clean cooking, and consider it on a par with electricity access: it is cheaper to achieve and provides enormous benefits.
- National plans need to consider a mix of clean fuels and biomass solutions even for rural communities which traditionally rely on biomass.
- Almost as much time can be spent processing fuel (women's task) as collecting it (a shared task). Stove designers and programme managers need to ensure they are not adding to women's time burden due to fuel requirements.
- In Bangladesh, barriers remain in terms of public perception of improved cookstoves, and the fit of existing solutions with fuel availability and cooking practices.

Delivering electricity for all: grid extension, mini-grids and stand-alone systems

Diverse renewable energy sources exist in our case-study communities and are almost always the least-cost choice for stand-alone electricity systems. Renewables are often on the cusp of fossil-fuel price parity for powering electricity networks, but are not quite there yet. Small decreases in capital or operating costs relative to those of conventional energy sources will favour these sources. While this exercise was not able to undertake such detailed analysis, had we included environmental (carbon emissions, deforestation, land-use change), social (unpaid domestic work), and political-economic (subsidies) externalities in our cost comparisons, these would have further strengthened the case for choosing renewables for rural electrification.

Renewable energy is almost always the least-cost option for stand-alone electricity systems

In our case studies, where fairly densely settled communities were located relatively close to the existing grid (four communities), our modelling unsurprisingly found the least-cost means of delivering required levels of electricity would be through grid extension. That said, while we modelled grid-based electricity as delivering Tier 5 access, our empirical findings confirmed how unreliable the grid is in our case-study communities, only reaching Tier 3 at most. If this is not improved, it clearly alters the best option to a different system type. Our estimates also did not factor in the costs of reinforcing the grid which would increase capital costs further.

Additionally, our estimates did not incorporate the fact that, despite progress on grid expansion in all three countries, it will likely be decades before grids reach 100% of communities similar to those we surveyed (see chapter 1). Hence, even where the economics point to the grid as least-cost, the realities of planning and delivering must utilize decentralized options that do not rely on making thousands of communities wait years for service. Smaller-scale SHSs, for instance, with a planned operational life of fewer than 10 years, would be one option; a mini-grid designed for later grid-tying would be another.

Looking deeper into grid extension, our model incorporated additional generation and distribution infrastructure, and found the true incremental costs per kWh to be significantly higher than that being charged by the utilities today. As the SREP Plan for Bangladesh highlights, most electricity in the country is sold at below cost-recovery tariffs (SREP, 2015), with substantial net operating losses for generation and distribution companies. The Kenyan and Togolese national utilities, despite charging higher tariffs, lose money on every connection under their current pricing structures. A survey of African utility companies found that the inability to charge cost-reflective tariffs was a major barrier to new investments (PwC, 2015). Interestingly, we found that people wanting an electricity connection were generally willing to pay more than grid electricity tariffs, but that they were not able to pay the full levelized cost of electricity from the network. There is clear rationale from supply and demand sides to revisit energy connection and tariff structures.

There is clear rationale from supply and demand sides to revisit energy connection and tariff structures

In five communities, local generation and distribution through mini-grids was the least-cost option, and in another three it was cost-competitive with grid extension. This was despite applying a 15% capital cost, where many others have used 10% (e.g. IRENA, 2015). It can also be delivered on a much shorter timescale. We priced this using diesel generators, factoring in replacement costs. The capital outlay was usually lower than grid extension, though running costs were higher and much more unpredictable.

Purely solar-powered mini-grids[1] were significantly more expensive in our simple model due to high capital costs of storage and the generation capacity

The realities of planning and delivering must utilize decentralized options to achieve universal access targets

needed to cover peak loads. In the one case where hydro-power was viable (Assoukoko in Togo) it was cheaper than diesel. However, using hybrid diesel-solar systems (which we did not incorporate into our models) can reduce costs by 12–16%, which would swing the balance back in favour of primarily solar-powered solutions (ARE, 2011; Frankfurt School-UNEP, 2015). Furthermore, as the price of solar cells and storage continue to fall, and economies of scale are created by national policy and programmes, we expect hybrid and purely renewable mini-grids to quickly become cost-competitive in a huge array of contexts.[2] Including the externalities we were unable to incorporate into economic modelling would strengthen the case for using hybrid or purely renewable systems over diesel.

Stand-alone household systems at Tier 2 were found to be extremely important for universalizing access in our case studies but are, compared to distribution systems, on average twice as expensive per kWh in Kenya and Togo and nearly four times more expensive in Bangladesh. Even so, because of the low population density in many energy-poor countries, such systems will be fundamental to universalizing access and must be incorporated into energy policy and programmatic planning globally. They were the most viable solution in two communities in Togo and for the majority of households in Utumoni in Kenya. One alternative Practical Action is experimenting with in Zimbabwe is the use of locally generated power to charge batteries for these households instead of them each having their own generation capacity.

The budgetary and planning mixes of the SREP and SEforAll plans remain fundamentally skewed in the wrong direction

Bangladesh's SREP programme gives a cautious welcome to mini-grids (14% of proposed budget) and recognizes the potential of solar-diesel hybrids. However, there are currently only four mini-grids in operation nationally, (albeit with an additional 33 approved), and the SREP report recognizes policy and regulatory barriers that make it challenging for those looking to build more. In Kenya, there are currently 22 mini-grids operated by the Kenya Power and Lighting Company, plus another 12 (at least) installed by the private sector and civil society. The country's SREP IP includes plans for 68 new sites and the SEforAll IP includes a proposal for 23 solar hybrid micro-grids at a cost of $85 million, and a further 24 off-grid solar and wind projects seeking funding, with a total budget of $33 million (SREP, 2011; SEforAll & MEP, 2016b). Togo plans for 9% of the population to be connected to mini-grids (MME nd).

While it is encouraging that all countries are planning further investments in the off-grid space, considering the vast majority of energy access needs in the three countries are in rural areas, which our case studies confirmed are often best served by off-grid technologies, the budgetary and planning mixes of the SREP and SEforAll plans remain fundamentally skewed in the wrong direction.

Box 7.3 Balance of mini-grids, grid extension, and stand-alone systems: implications for planning

- For most rural electrification, decentralized options are superior to the grid, and plans should reflect the need to balance mini-grids, stand-alone systems, and grid extension to achieve universal access in a timely manner and at least cost.
- Plans should consider clear trends in the energy sector where the falling price of solar is making diesel-solar hybrid mini-grids cost-competitive with grid connections, and are likely already the least-cost solution if externalities are included in estimating costs.
- Leaving energy provision in rural areas entirely based on individually purchased stand-alone systems is likely to be both more expensive and more unequal than plans involving mini-grids.

Affordability: inequalities and viability

The systems we modelled for electricity access were based either on stated needs or a fixed level of Tier 3 access (sufficient for most household needs, but not for most enterprises or farming applications). Yet, only a small proportion of those asked considered themselves to be in a position to pay for the level of access they felt they needed, or for the Tier 3 level we argue is appropriate as a global baseline of adequate access.

The uptake and reach of small-scale products has been encouraging in both Kenya and Bangladesh, and policies and programmes which focus on the lower end of the energy access ladder have clearly had an impact. Even in relatively well-developed markets, however, there are still hard-to-reach villages and people unable to afford even the smallest solar lanterns. Programmes and policies in these countries need to focus much more on reaching those beyond existing markets.

Indeed, if provision were to be based solely on ability to pay, that is, on market forces alone, energy access would be highly restricted across energy-poor communities. Universalizing higher-powered rural electrification will require longer-term public investment and subsidies, as was the case in electrifying Europe and the Americas. Such costs may seem prohibitive at first glance but dividends quickly accrue. In the case of energy access, they come in many forms including increased taxable incomes and more general economic growth, reduced healthcare costs (in both economic and wellbeing terms), and reduced costs associated with deforestation. As noted in chapter 2, with many ministries other than energy (education, health, agriculture) often responsible for energy infrastructure in their own areas, one way to reduce costs is to ensure a more integrated approach to planning and delivery.

Ensuring a more integrated approach to planning and delivery across ministries will reduce costs

Box 7.4 Affordability: implications for planning

- Despite demand and willingness to pay for electricity services in rural areas, longer-term public support will be required to bring higher levels of power to these areas.
- Planners (and donors) must consider the inequity of grid electricity being offered at prices well below costs, while off-grid solutions are expected to achieve full cost recovery.
- Integrated planning across ministries is key to reducing costs and realizing TEA.
- Products and programmes need to reach the poorest within communities who are currently unable to afford the products on offer.

Energy and earning a living

The sizing and viability of mini-grids is driven not only by the number and distribution of households, but by the demands of a smaller number of productive activities. Energy for production and businesses was among the top three priorities in six of twelve communities. In addition to demand levels, enterprises and community facilities support the economics of mini-grids because their loads peak at different times to those of households. Communities in our case studies see potential for new and/or expanded businesses. There is also potential for increasing agricultural production through irrigation, reducing the burden of manual agro-processing, and adding value to agricultural products.

In our models, we considered the possibility of a 50% growth in the number of non-farm enterprises, as well as factoring in productive loads from mainstream agricultural activities, making up a quarter of power demand on average. In half of the communities, we found it would be more economical to run large

Decision-makers must ensure women's differentiated energy needs are meaningfully incorporated into national plans

non-domestic loads, such as water pumps and rock crushers, using electricity rather than diesel motors. In more remote communities, electricity costs were matched or undercut by stand-alone diesel engines.

While recognizing a lack of coordination between ministries and of comprehensive planning, the Kenyan SEforAll AA notes the need for this to change, pointing to the need to cooperate with the Ministry of Water regarding water pumping and the benefits this could bring for women's time, and the Ministry of Agriculture regarding food security and processing of subsistence crops, again providing immense value to women in particular. In Bangladesh, the five-year plan addresses these issues but only through the intention to install approximately 15,000 for large farming operations, at sizes far larger than would be used in any of our case studies. (GoB, 2015). There is no reference to agricultural needs in the Togo Action Agenda.

If electricity access provision is not designed with sufficient flexibility to meet the needs of enterprises and community facilities, as well as the more modest requirements of households, the potential for mutual benefit and economic growth will be lost. There is also a need for energy literacy programmes and the creation of a market ecosystem to provide not only power, but also the productive technologies that will help increase productivity, which will in turn improve demand and therefore the economics of rural electrification. Exploratory mini-grids work in Zambia found that, if done well, increasing load factors over a nine-year demand development period can reduce costs per kWh by nearly 40% (ENEA & Practical Action, 2016).

Box 7.5 Energy, gender and earning a living: implications for planning

- Coordinated planning is needed with ministries responsible for water and agriculture.
- Planners need to ensure women's energy needs are valued.
- Building markets for energy access services must include energy literacy and productive uses capacity building, as well as concerted efforts to bring productive technologies to remote areas.

Energy for community facilities: schools and street lighting

In the communities we surveyed, energy for community facilities was a higher priority than livelihood needs, perhaps because it links to a better future for everyone in the community. Women in particular ranked the issue highly.

In our case studies, energy provision for schools lagged behind that for health centres and religious buildings. This may be because schools mostly operate during daylight hours, but lighting is not their only energy need. Fans and other electrical equipment were among the applications they would like to use. And, it is only with a computer that students can make the most of available information resources and prepare themselves for many 21st century employment opportunities. Household respondents clearly value good education, with improving energy in schools ranked above business or agricultural needs in eight of twelve communities, and above energy for health in ten of twelve communities.

In Kenya, one of the government's priority projects was for all government primary schools to be electrified by 2015 (SEforAll & MEP, 2016a). The existence of this goal is encouraging and clearly in tune with rural community desires. In contrast, Bangladesh and Togo are more out of sync with local priorities, having not yet developed clear plans or targets for the electrification of schools (SREDA & MPEMR, 2015).

While street lighting is often thought to be a priority for women, men prioritized it more highly in our surveys, while women prioritized lighting of the home and its environs. Street lighting increases safety and would help with extending the hours of small businesses, in particular retail shops. It was a high priority for both men and women in Togo.

Household respondents value quality education very highly; often above energy for businesses and health clinics

Box 7.6 Energy and community facilities: implications for planning

- Coordinated planning with ministries of education and health is a priority.
- Energy for schools is a high priority for community members, which should be reflected with clear plans and targets.
- Street lighting is easily affordable and valued by communities, and should be a priority for planners. Stand-alone solar street lighting could be installed now.

Conclusion

For remote rural electrification, decentralized options are superior to the grid.

Despite the conservative nature of our cost modelling, mini-grids or stand-alone solutions were found to be cost-competitive or cheaper than grid extension in eleven of twelve communities we investigated. The fact that these decentralized systems would also provide more reliable power than grids currently can, and would be deployable in a fraction of the time, swings the balance further in their favour. This should serve as a strong signal to donors, entrepreneurs, civil society, policy-makers, and regulators taking global goals to universalize energy access by 2030 seriously. The vast majority of energy poverty exists in rural areas where a focus on traditional grid electrification will waste both time and money. Global and national energy planning, technical assistance, energy literacy, and financing efforts must be urgently rebalanced to reflect this.

Energy poverty exists overwhelmingly in rural areas, where traditional grid extension wastes time and money

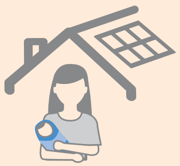
Our findings that household and community energy services were prioritized more highly than improving productive and cooking services is telling. On the one hand it indicates energy ministries and donors must ensure better integration of planning with other ministries, such as health, education, water and agriculture, that currently operate without much meaningful engagement with traditional energy players. This will lower overall electrification costs and provide maximum benefit to communities.

On the other hand, given the positive impact clean cooking and productive energy services will indeed have on lives and livelihoods in communities around the world, there is a need for donors and national governments to expand energy literacy programmes both at the community level and in governments themselves. There is also a need to focus more attention on issues that matter most to women, to reduce burdens and increase the potential for their full economic empowerment. That includes energy for pumping water and processing crops as well as for cooking, lighting and cooling at home. As we have noted throughout this chapter, national plans are often out of touch with end-user needs and aspirations. Energy literacy programmes are fundamental for ministries to bring them up to speed on the full range of energy access technologies available today as well as to inform them about the importance of productive and clean cooking technologies for incomes and health at the local level.

Bringing Energy to All

Implications of holistic local planning for national decision-making

FINDINGS



Decentralized solutions

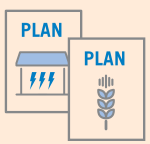
Decentralized options for rural electrification are overwhelmingly superior to the grid in terms of economics and speed. It is their unequal treatment and lack of subsidization that makes them appear otherwise.

Access targets

Just over 60% of households had no electricity at all, and Tier 3 access would satisfy almost three-quarters of household needs.

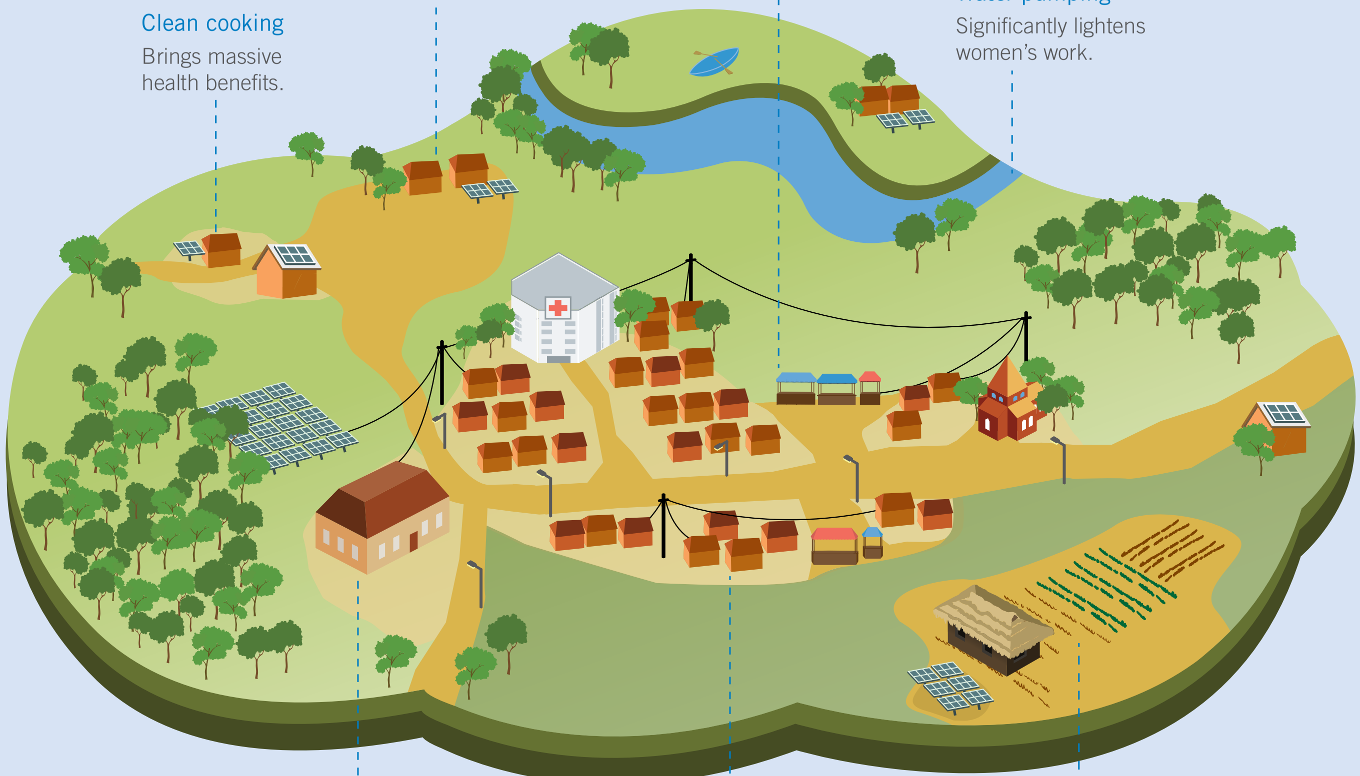
Unmet demand

There is strong unmet demand for clean-fuel cooking solutions, but a large affordability gap.



Co-ordination

Integrated planning across ministries is key to reducing costs and realizing Total Energy Access.



LEAST-COST SOLUTIONS FOR INTEGRATED RURAL ENERGY ACCESS

8. Recommendations and conclusions

The global imperative to do more and better work on energy access is clear. The energy poor do not deserve, and the world cannot afford, more time and money to be spent primarily on technologies and approaches that have been unable to deliver quality universal access to date. This edition of the Poor people's energy outlook has looked at how traditional energy policy-making has been ineffective in addressing energy-poor people's needs; shown through real-world examples how holistic, inclusive energy planning can be done; and demonstrated that, where there is rural energy poverty, decentralized options are superior to big grids for a variety of reasons. The bottom-up approaches illustrated in this report are much more likely to deliver lasting, empowering, viable, and sustainable results than traditional top-down, centralized approaches to energy planning.

There are three fundamental – but surmountable – obstacles to the rapid shift in ways of working that is required to achieve universal energy access using the methods outlined in this report.

Using decentralized technologies and approaches

Decision-makers often lack understanding of 21st century energy technologies and approaches

A lack of understanding and acceptance of 21st-century energy technologies and approaches exists among global and national decision-makers. Despite the centrality of energy access to delivering donor and national objectives on health, education, climate change, economic development, and other priorities, donors, international organizations, and national governments lack adequately energy-literate staff, particularly at the national level. Even fewer are knowledgeable about the decentralized energy technologies and approaches we have shown to be best suited to achieving universal energy access. This is true both for national governments, even within energy ministries and rural electrification agencies/authorities, and for key energy donors and international financiers, some of whom have no national-level staff knowledgeable in these areas at all, even in their energy-focus countries. This reality is not congruent with global aspirations to support energy-poor countries to achieve universal access on any timescale, let alone by 2030.

A broad and robust effort must be made to train and hire staff across different energy-relevant areas who are well-versed in both decentralized energy technologies and the service-focussed approach to delivering modern energy. One easy way to achieve this is to approach existing training institutions and stakeholders experienced in energy access technologies and market building to develop week-long courses for key staff, as well as to approach the same players and universities to develop longer training modules. Despite its challenges, understanding this sector is not overly complicated and massive progress could be made with this inexpensive and simple action.

Integrating the voices of the energy-poor in planning

A lack of meaningful efforts to include the voices of energy-poor end-users in policy and programmatic work impedes efforts to ensure energy solutions are adequate. Knowing one's customer is the only way to ensure a product or service is relevant to them and worth them paying for – but this is not being done in the energy access space. The well-established nature of the western energy sector provides a false sense of security around global energy expertise, which is often not directly transferable to the realities of energy poverty and approaches to overcoming it. Almost across the board, key universal development objectives, such as gender mainstreaming and local economic development (productive uses), are sidelined or completely absent from large energy projects and national energy policy and regulation.

Western energy expertise is often not directly transferable to the realities of energy poverty

Additionally, even with trained staff knowledgeable about technologies and approaches for overcoming energy poverty, the most comprehensive review of evidence to date clearly illustrates that creating economic benefit to communities via energy interventions cannot be guaranteed, regardless of the approach (PAC, 2015). Hence an in-depth understanding of, and active participation from, men and women from energy-poor communities is essential for energy access interventions to have the best chance of success. This point is only reinforced through our surveys where productive energy was often not prioritized by communities as highly as we had anticipated it would be, whereas community energy services were strongly desired but rarely adequately addressed in energy plans.

Significant effort must be made to encourage participation of the energy poor and their representatives in energy planning from the project level up through programmatic efforts and national policy-making. Not every person from every community must be involved, but meaningfully incorporating input from the energy poor and legitimate representatives of such communities is essential. Existing guidance on good practice for stakeholder inclusion in energy processes exists and is not complicated (Gallagher & Wykes, 2014). Simple things like ensuring vulnerable and marginalized communities are included in consultations, the timely announcements of meetings and sharing of preparatory materials, meeting with women and men separately as well as communally, and inexpensive funding for key stakeholders outside capital cities to attend important meetings are essential and easy to realize.

For interventions to succeed, the energy-poor must be included across the energy planning spectrum

Measuring and quantifying outputs holistically

We know counting megawatts and connections does not in and of itself deliver on global development objectives. For donors and national policy-makers alike, these remain attractive metrics because they are simple and impressive. However, they are misleading because megawatts more often than not go to other mega-projects such as factories and mines which provide jobs for only a select few and whose outputs often leave the country rather than benefit those at home. Household connections mask the fact that rural connections are often loss-making for centralized energy infrastructure, and the quality of these connections is poor in most cases.

Instead, we should be quantifying outputs, improved services and longer-term outcomes of energy projects holistically using numbers of jobs created, agricultural productivity increased, women's time saved, children educated, medical patients served per megawatt, and so on. These are the development objectives of the global community, and we should measure our progress in this enabling, 'nexus' sector accordingly and as a core delivery mechanism of SDG objectives. The world should use SEforAll's Multi-tier Framework to monitor the quality of energy access: the qualitative benefits of using it are an easy and politically appealing way to deliver on promises and the improvement of lives and livelihoods. Reframing progress on energy for regulators and ministries, and – of key importance – reorienting incentives (pay, career advancement, other benefits) to reflect these objectives is also important for donors, financiers, and national governments.

Conclusion

New global objectives and new technologies in the energy space necessitate that the work of the global energy community and national-level energy decision-makers evolves accordingly. The three essential changes presented here can be implemented immediately, are inexpensive, and would have incredible impact.

Let us empower the world, not just power it

Practical Action is an organization dedicated to finding solutions to overcome poverty using technology and to realize a technologically just world. We stand ready to work constructively with governments, financiers, the private sector, non-profits, and all others engaged in, and dedicated to, achieving universal energy access in order to implement the solutions we have outlined – and any others that might hasten progress on this central issue of human development.

Let us leave no one behind. Let us empower the world, not just power it.

Notes

Chapter 2

1 *PPEO* 2017 will explore this, providing analysis of the state of energy access financing and nuanced perspectives on what is needed and how to accomplish it.
2 For more information on these processes, see SEforAll, 2016a, 2016b.

Chapter 3

1 While we have sought to cover as wide a range of energy access provision options as possible within these categories, it is not possible to include every energy technology and the options given here have the widest applicability.
2 With the exception of the boundary between Tier 3 and Tier 4, which we set at 2kW power and 4kWh daily capacity based on an earlier draft of the Framework.
3 A 15% cost of capital, or discount rate, was used.
4 For mini-grid and distribution system based solutions, assumptions were also made regarding the proportion of households, enterprises, and community facilities which would connect.
5 Our sampling strategy sought to achieve a confidence interval of 10% and a confidence level of 90%. Interviews were spread geographically in line with population densities and took place at a variety of times of day.
6 Within the confines of the research we were not able to explore ability to pay.
7 For this purpose Tier 3 was set at between 0.2kW and 0.8kW and between 1.0kWh and 3.4kWh per day as in the most recent version of the MTF.
8 Aggregation was undertaken using a root-sum-square approach.
9 Iteration is needed because the cost of a distribution system plus generation capacity is driven by the number and level of demand of those connecting to it. This cost in turn affects the decision of whether a grid connection is still the best option, or a stand-alone solution would be preferable (or, in the willingness-to-pay scenario, whether someone would choose to go without).
10 This comparison was generally made against diesel-engine power, with the exception of pumping where a comparison with solar-pumping was also undertaken. We recognize that wind or hydro power may, depending on the specific context, be a preferable alternative.
11 It was not therefore necessary to iterate between demand and costs.

Chapter 4

1 We assumed commercial-size refrigerators, with loading patterns (e.g. quantities of goods to be chilled from ambient, frequency of door opening) in line with commercial, 24-hour use. This requires Tier 4. Tier 3 would suffice for some enterprises' refrigeration needs.

Chapter 5

1 We assumed commercial-size refrigerators, with loading patterns (e.g. quantities of goods to be chilled from ambient, frequency of door opening) in line with commercial, 24-hour use. This requires Tier 4. Tier 3 would suffice for some enterprises' refrigeration needs.

Chapter 6

1. This was a group of young men and women who did not yet have their own households.
2. There is less of a jump in costs per day for grid electricity between Tier 2 and 3 ($0.14 to $0.37) than for decentralized options (e.g. in Kame Tier 2 costs $0.16 per day and Tier 3 $1.11) because much of the cost of grid electricity is in the form of fixed charges: the unit cost is only a small proportion of the total.
3. These responses should be treated with caution as a high proportion of those interviewed in Koulmasi and Nandjoare were men. Women were not included even when it came to answering the questions about cooking. Hence these responses do not reflect the views of the cooks themselves.
4. In this case, a Tier 3 stove is cheaper than a Tier 2 stove because of the savings in fuel.

Chapter 7

1. Hydro generally provides a lower-cost option than solar; however, the lack of such resources in the communities we studied highlights the constraints on the current viability of renewables alone as a basis for energy access provision on a national scale. Diesel-renewables hybrids could significantly reduce dependence on fossil fuels while still being economically viable.
2. Indeed, the levelized cost of electricity from solar halved between 2010 and 2014, and solar PV module prices are expected to fall by 18–22% with every doubling of cumulative installed capacity (IRENA, 2015).

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