

Electricity beyond the grid

Accelerating access to sustainable power for all



PwC viewpoint informed by insights from industry participants in Africa and Asia.

A look at how standalone electricity and mini-grids can increase access to electricity.

What are the steps that can accelerate momentum for electrification?

We've spoken to sixteen movers and shapers involved in off-grid electrification projects in Africa and Asia to gain their perspective on the factors influencing the development of this solution to energy access. Interview participants included developers, technology providers, policy experts and government officials. The interviews covered organisations based in nine countries and with projects spanning a wider number of countries. Their insights were used to inform this report and, where appropriate, we include quotations from them to give a flavour of their perspective.

We use the term 'off-grid systems' as a collective term to refer to standalone systems and also to mini-grids that are not connected to a larger centralised grid. 'Standalone systems' refer to electrification systems for individual appliances/users that are not connected to any grid outside of the individual user premises. 'Mini-grids' are used to refer to small grid systems linking a number of users who are not connected to a larger main power grid. A fuller discussion of terminology is included in a glossary at the end of the report.

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Introduction

In Electricity Beyond the Grid we look at the opportunity to rapidly accelerate momentum towards universal energy access. Nearly one in five of the world's population don't have access to electricity. On current trends, two-thirds of them will remain without electricity by 2030¹, which is the target year to achieve the newly agreed post-2015 UN Sustainable Development Goal of universal access to energy.

Faster progress is needed and we believe it can be achieved if national energy policies adopt a more comprehensive approach to energy access, embracing the new starting points for energy provided by standalone renewable technology and mini-grids. We expect a broad transformation in the electricity sector in the coming years, due to these technological advances and the falling price of technology, both for grid-connected and beyond-the-grid customers. This will have a major impact on the future sustainability of incumbent generation, transmission and distribution utilities and these companies will need to adapt their business models accordingly.

For the millions of people who don't currently have access to electricity, the old assumption that they will have to wait for grid extensions is being turned on its head by new technological possibilities. Mobile payment infrastructure, customer-driven affordable payment systems and new entrant business models are all playing a part in a new bottom-up energy access that can complement the traditional top-down planning of national grid extensions.

In this report, we discuss these developments and look at what it will take for them to mushroom and fill the gaps in grid infrastructure. We look at the types of initiatives that are taking root, their strengths and weaknesses and the support they need to receive from national energy policies if they are to continue to flourish. We conclude by suggesting that a more integrated approach to energy policy could accelerate progress towards electricity for all.

Executive summary

Energy transformation means the time is right for policy-makers to reappraise their approach to energy access. Advances in technology are rapidly changing the options available beyond the grid. Falling solar technology costs have spurred the growth of standalone home systems and are changing the economics of mini-grid systems.

Other technological advances are set to also play an important role. Battery storage technology is fast evolving to the point where it is now playing a significant role in smaller-scale off-grid solutions and is beginning to feature in utility scale solar storage. Finally, technologies such as fuel cells are also beginning to come of age. Fuel cells are now becoming widespread as a source of power for telecoms towers in areas with uncertain grid reliability and are also beginning to penetrate consumer electronics.

An end to all or nothing

Most national energy policies have been built around the assumption that large-scale generation and centralised grid systems are the principal means for developing access to electricity. The result has been a tendency towards an 'all or nothing' approach. People within reach of the grid get electricity, subject to system reliability. Those out of reach are relatively neglected, with the exception of the piecemeal development of local mini-grids. The result is that 1.2 billion

people in the world remain without electricity, 95% of them in sub-Saharan Africa and developing countries in Asia. But 'all or nothing' approaches are increasingly out of step with what is now possible in power technology.

The advent of 'entry level' power

Technological change is turning the 'all or nothing' assumption on its head. 'Entry level technology' and service bundles have come into the world of electricity, in a way not dissimilar to other areas of technology such as mobile devices or computing. The advent of standalone solar systems, in particular, has introduced new choices for those without access to grid electricity. Standalone household systems are providing 'first rung of the energy ladder' access for an increasing number of people in many parts of Africa and Asia. And their growth is being driven by commercial business models that fit with household circumstances rather than the slower-moving progress of 'one size fits all' national energy policies. In Kenya and Tanzania, for example, low income customers are able to use mobile payment systems to obtain 'plug and play' solar and technology for very basic home electrification, with the potential option to scale up as income and/or technological development allows.

The new energy ladder

Standalone solar home systems are providing a bottom rung that was previously not easily accessible on the energy access ladder. They are able to provide a very basic level of power that is affordable for many and enhances quality of life significantly in key respects. Before, the lowest rung was usually some form of mini-grid system, typically based on diesel generation. But up-front capital costs, running costs and the need for project governance frameworks meant this wasn't an option for many people. Now the mini-grid rung is also becoming potentially more accessible with lower-cost renewable technologies enabling the development of hybrid (diesel and renewables) or renewables-only mini-grids, both of which bring down running costs. As we discuss later, mini-grid development remains difficult and hindered by policy and regulatory obstacles. But, if these can be overcome, then mini-grids have a logical role to play in providing

electricity access that is a step up from the 'entry level' access provided by standalone systems.

Modern energy frameworks to stimulate modern energy access

The time has come for national energy policies to broaden out and fully embrace off-grid solutions with better specific policies that can stimulate their further growth. Policies have traditionally depended on the single pillar of large-scale generation linked to the central grid. Now, three options are available for modern energy access – standalone systems, mini-grids and traditional extension of centralised grid systems. But off-grid solutions remain neglected in policy frameworks. We look at the success factors that have helped new energy access as well as the difficulties that need to be overcome and consider ways in which national energy policies in developing countries can be modified to accelerate electrification. We conclude by suggesting that a more integrated approach to energy policy could accelerate progress towards electricity for all. We make five broad recommendations:

Recommendations



1. Develop an integrated energy access plan and map.



2. Create an enabling environment for off-grid initiatives.



3. Recognise the value of and promote the growth of mobile infrastructure, microloans and payment solutions in supporting energy access.



4. Establish an off-grid innovation and development fund.



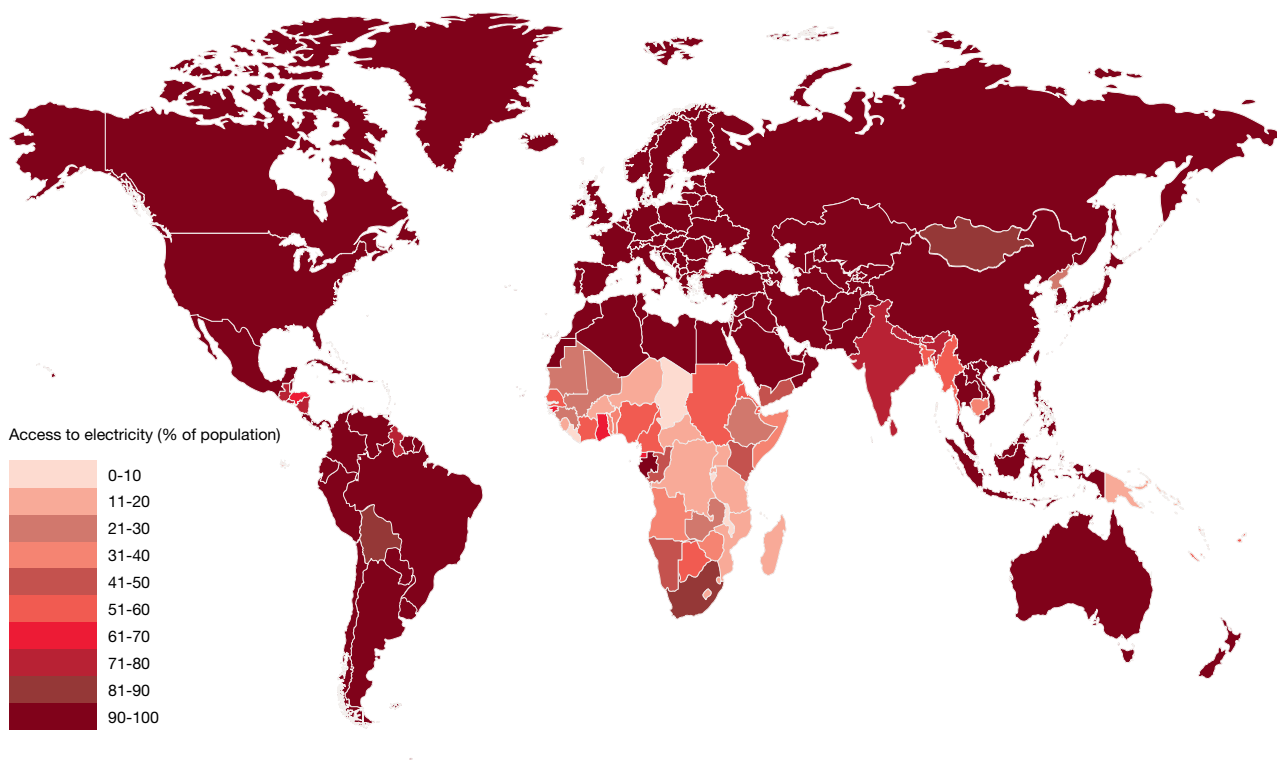
5. Have a high-level energy access champion who can drive results.

Challenges and opportunities

The 'beyond the grid' electrification challenge

Nearly one in five (18%) people in the world live without access to electricity, many of them living in locations that are beyond the reach of the current grid system. Ninety-five percent of these 1.2 billion people are in sub-Saharan Africa and developing countries in Asia.² In both Asia and Africa, electrification rates are lowest in rural areas although, in sub-Saharan Africa in particular, urban areas also contain a considerable number of those without electricity.

Figure 1: Access to electricity around the world



Source: World Bank data

² All data from International Energy Agency, database on electricity access, 2015.

Challenges and opportunities

Rates of electrification in sub-Saharan Africa have not kept pace with population growth. The region as a whole has now overtaken Asia as having the largest number of people lacking access to electricity. The countries with the largest populations currently without electricity are India, Nigeria, Ethiopia, Côte d'Ivoire, Democratic Republic of Congo and Bangladesh. In the developing countries of Asia, there are an estimated 526 million people without electricity.³ But demographic pressures and different rates of electrification are ensuring the problem is becoming more concentrated in Africa and will be even more so in future decades. Population growth has led the International Energy Agency (IEA) to revise upward its estimate for those without electricity in sub-Saharan Africa from 585 million back in 2009 to the latest estimate of 634 million.⁴ And it isn't until the mid-2020s that the IEA expects this trend of increasing numbers without energy access in sub-Saharan Africa to start to reverse.

For urban populations and others living within a reasonable distance of the grid, extension of the central power grid remains the most cost-effective solution. The cost of supplying grid-based electricity is less than the cost of alternative off-grid options in most situations where transmission and distribution lines are nearby. But beyond a certain distance, the cost of grid extensions becomes prohibitive and standalone systems and mini-grids offer cost advantages.

With an estimated 80% of those without access to electricity living in rural areas, many of them with no nearby grid, it is clear that grid extensions can't be seen as the sole, or even the primary, answer to provision of electricity for all. This is particularly the case in Africa, where grid extension is limited due to substantial distances across the continent and the cost and losses related to this. The distances in Africa can be put into perspective by comparing the continent's total area of 30.3 million sq. km. with that of China, the US, India, western Europe and Argentina combined (total 29.8 million sq. km.).

Indeed, the IEA concludes that “for the large rural population that is distant from power grids, mini-grid or off-grid systems provide the most viable means of access to electricity.”⁵ It goes on to anticipate, in its ‘new policies’ energy outlook, that 315 million people in rural areas will gain access to electricity by 2040, with most of this new electricity access coming from the development of mini-grids (80 million people) and off-grid systems (140 million).⁶

Of course, detailed local energy-sector mapping is required to identify the most cost-effective route in particular locations, but the importance of off-grid solutions is borne out by a study in Senegal that found that only 20% to at most 50% of the unconnected rural population could be most efficiently reached through grid extension investments.⁷ Off-grid electrification is the most realistic option for the remainder.

“The majority of new electricity access in rural areas will come from mini-grids and other off-grid systems”

3 Ibid.

4 2009 estimate from IEA, *Energy for All: financing access for the poor*, 2011; latest estimate (for 2013) from IEA, *database on electricity access*, 2015.

5 IEA, *World Energy Outlook*, 2014, p. 496.

6 Ibid.

7 Modi, V., Sanoh, H., Parshall, L., Kum, S. and Fall Sarr, O. (2012). *Local and National Electricity Planning in Senegal: Scenarios and Policies*. *Energy for Sustainable Development* 16:13–25. Accessed on 24 April, 2015, http://modi.mech.columbia.edu/wp-content/uploads/2013/09/Senegal_Aly-Energy-Policy-paper-4.20.10-JEPO-S-10-00600.pdf

The off-grid renewable generation opportunity

Off-grid electrification is nothing new. Diesel- or gasoline-fuelled mini-grid and standalone off-grid generation systems are well established in many locations. Many small islands, for example in Indonesia, the Philippines and China, rely on diesel generation for electricity. Some 108 isolated diesel grids, from 46 operators, are in operation in the Philippines alone. In Africa, Mali has had probably more success than any other African country in the development of isolated mini-grids, with more than 200 mostly small diesel mini-grids in operation. Increasingly, these diesel installations are being supplemented with renewable technologies to create hybrid mini-grids.

Renewable sources are being utilised more and more in mini-grid and standalone off-grid situations. A review of research by the International Renewable Energy Agency (IRENA) suggests that small-scale hydropower, for example, is currently the largest generation source for mini-grids.⁸ This is common in countries such as Nepal, where hydro availability provides a practical solution for remote rural communities. Mini-hydro is more prevalent in Asia than in Africa but has potential in hilly and mountainous location such as in Cameroon, the Democratic Republic of Congo, Ethiopia, Kenya, Rwanda, Tanzania, Uganda and Zimbabwe. There are a limited number of operational sites in some of these countries. Wind and biofuels are also present in some mini-grid situations where resources allow. But the biggest technological change in recent years has been a rapid rise in the use of solar photovoltaic generation in both standalone home energy systems and mini-grids.

Falling solar costs have led to solar playing a centre-stage role in providing many households with a first rung on the energy ladder with the spread of solar lanterns and small standalone solar home systems. New business models are emerging to support this development. For example, following the lead of mobile phone companies, solar developers are offering small basic home solar systems, sufficient for minimal LED lighting and device charging, on tariff terms that allow subscribers to keep the equipment once the contract term (typically twelve months) has expired.

Despite the rise of renewable sources, diesel remains an important fuel for off-grid generation. IRENA report that it is the second largest energy source for mini-grids.⁹ Diesel has the advantage, subject to fuel being available, of being able to generate electricity at all times when renewable

energy may not be on hand. For this reason, many installations are hybrid systems, combining renewable and diesel generation. A range of factors come into play in decisions about choice of technology – cost, availability and sustainability being foremost among them. Future developments in battery technology and pricing add another key variable in the ‘renewables versus diesel’ balance.

But the lower running costs of renewable systems give them an advantage over diesel. The cost of diesel can vary substantially. In oil-producing countries such as Nigeria and Angola, it is as low as US\$0.59-US\$0.74 a litre, but in countries such as Zambia and Zimbabwe it is closer to US\$1 a litre.¹⁰ These price variations shift the economics of different total system costs considerably, making the difference between diesel being more expensive or cheaper than renewables.

As we look to the future, the momentum is with renewable technologies. Already, it is often only fossil fuel subsidies that give diesel a cost advantage in some locations. In many isolated rural locations, the physical supply chain challenge of delivering diesel is a significant disadvantage. Unlike diesel, renewable generation involves no fuel cost to run. And with battery technologies rapidly evolving, renewable systems are beginning to overcome ‘always on’ availability challenges.

The important role the off-grid solutions can play is recognised by the power utilities industry in Africa. In our 2015 survey of leading executives and companies in the sector throughout the continent, 70% of our survey respondents believe there is a medium to high probability that advances and cost reductions in green renewable off-grid technology will deliver an exponential increase in rural electrification levels by 2025.¹²

The prospect of future local mini-grids and standalone generation being an important feature of the African power mix, alongside centralised generation, is an energy market vision that is viewed as likely or highly likely by 83% of survey participants. But many barriers remain. There are clear constraints to higher levels of rollout of mini-grids and off-grid systems. These include a shortage of proven business models, adequate and appropriate forms of financing, established supply chains and implementation capacity. We have explored these issues with industry participants in a number of African and Asian countries where off-grid systems have a major potential part to play, and we discuss our findings in the next section of this report.

Snapshot:

The benefits of basic energy access

The Government of Bangladesh and the World Bank's Rural Electrification and Renewable Energy Development II (RERED II) Project is a public-private partnership that is now installing over 70,000 solar home systems (SHS) every month, making it the fastest-growing SHS programme in the world. In total, three million systems have already been installed. Among the benefits, “a recent impact evaluation study on SHS [has] confirmed increased study time for children, increased mobility and sense of security for women, and increased use of contraceptives and fall in recent fertility in SHS households, thanks to awareness from watching TV.”¹¹

8 International Renewable Energy Agency, Off-grid renewable energy systems: status and methodological issues, 2015.

9 Ibid.

10 August 2015 diesel prices reported by globalpetrolprices.com.

11 World Bank, Lighting Up Rural Communities in Bangladesh, January 16, 2014.

12 PwC Africa Power & Utilities Sector Survey, A new Africa energy world, 2015.

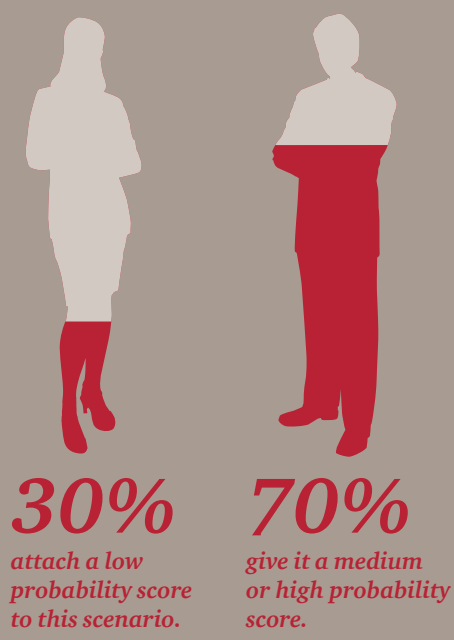
Challenges and opportunities



Future energy vision

Advances and cost reductions in green off-grid technology will deliver an exponential increase in rural electrification levels by 2025

The falling cost of and advances in standalone renewable generation are making survey participants optimistic about the potential for the technology to provide a solution for rural electrification. In a PwC survey of power sector viewpoints across Africa, a clear majority (70%) said there is a medium to high probability that these developments could lead to an exponential increase in rural electrification levels by 2025. Opinion is split evenly between the medium and high scores.



Source: PwC Africa Power & Utilities Sector Survey, A new Africa energy world, 2015.

Successes and constraints

Off-grid electrification takes two main forms – standalone home energy systems and mini-grids. Although mini-grids have been used for electrifying rural villages for at least two decades, it is standalone systems that are now far more common. We take a look at the part each has to play, who is doing what, the factors that are determining success or failure and the barriers that need to be overcome.

Standalone electrification solutions

Advances in technologies such as solar PV and LED lighting and falling prices have led to a surge in standalone electrification solutions in recent years. The International Renewable Energy Agency reports that there are more than six million pico and solar home systems (SHS) in operation worldwide, of which three million are installed in Bangladesh.¹³ In some locations, growth has been led by public initiatives such as the Rural Electrification and Renewable Energy Project in Bangladesh (see snapshot panel on page 7). In other places, growth has been more commercially-driven, with financing funded either by 100% upfront cash payment by customers or through pay-as-you-go (PAYG) schemes or long-term leases. The size of systems varies, from basic pico lighting systems to solar home system installations that can power devices such as phone charging systems, televisions, fans and fridges. They cover tiers 1-3 of the UN Sustainable Energy for All (UN SE4ALL) classification (see figure 2).

Part of the success of standalone home systems has been due to the strongly customer-centric focus of PAYG SHS companies. Their business model, in many respects, is not about selling electricity, such as would be the case with a traditional utility or, indeed, a mini-grid operator. Instead, the focus is on the needs of the customer – lighting, access to information and communications, solar TV etc. - and pricing is pitched accordingly.

Figure 2: The UN SE4ALL tier system

Energy Access	No	Basic	Advanced			
Attributes	Tier-0	Tier-1	Tier-2	Tier-3	Tier-4	Tier-5
Peak Available Capacity [Watts]	-	> 3 W	> 50 W	> 200 W	> 800 W	> 2000 W
Duration [hours]	-	> 4 h	> 4 h	> 8 h	> 16 h	> 23 h
Evening supply [hours]	-	> 1 h	> 2 h	> 3 h	> 4 h	> 4 h
Indicated Minimum Technology	-	Nano-grids/Micro-grids Pico-PV/Solar lantern	Rechargeable batteries, Solar home systems	Home systems	Mini-grids and Grid	Mini-grids and Grid

13 IRENA, Off-Grid Renewable Energy Systems: Status and Methodological Issues, 2015.

Successes and constraints

The spread of customer-financing business models such as pay-as-you-go (PAYG) for solar home systems in Africa has particularly caught the imagination. Companies such as M-Kopa and Mobisol have been in the forefront, using payment systems such as M-PESA and Airtel MTN. This combination of solar and mobile technology is bringing affordable solar technologies to off-grid villages. Mobisol reports that it has installed over 30,000 solar home systems for households in Tanzania and Rwanda since its creation in 2010. Customers pay off the monthly instalments using their mobile phones. After one to three years, they fully own their personal electricity source. Nairobi-based M-Kopa reported in January 2016 that it had reached the milestone of connecting over 300,000 homes to solar power.

As well as indigenous players such as Kenya's M-Kopa and Tanzania's Helvetic Solar, the market in Africa includes international companies such as Mobisol and solar panel manufacturers such as Canadian Solar, First Solar and Trina Solar. There are also niche NGO players such as Solar Aid, who describe their role as helping to "kickstart markets for solar lighting across the continent." There has been a dramatic shift towards PAYG in recent years. A Bloomberg analysis found that "pay-as-you-go companies attracted twice as much investment as cash-sales companies in half the time."¹⁴ The same study observed that the majority of pay-as-you-go firms offer home systems designed to power more than just a few lights and a phone charger. Companies such as BBOX and SolarNow, for example, offer 250W systems, capable of powering a radio and phone, twelve lights, a large TV, and a fridge.

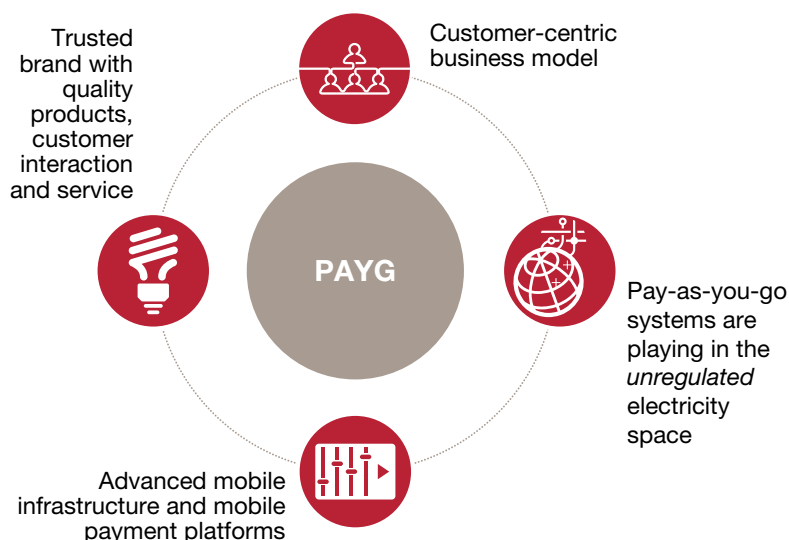
A key factor behind the growth of PAYG home electrification systems has been business models that are designed to respond to the needs of rural households and their ability to pay. Pricing propositions take account of existing energy expenditure on items such as kerosene. Further, the development of flexible credit facilities tailored to what customers can afford and their income patterns enables customers to scale up their solar solutions, products and services. Standalone home solar systems have also been able to develop in a relatively unregulated market context. Especially due to this unregulated market space, barriers to entering it are reduced and the business case for a profitable business is easier to establish.

In some respects, the energy landscape that is developing in parts of Africa, based on mobile connectivity and standalone electrification, has a level of customer and data interactivity that rivals the most advanced smart grid systems in developed markets. The mobile platform is able to link customers, equipment, support and payment in ways that benefit both the customer and the provider. Most systems have the ability to remotely turn off the equipment if monthly payments are not made and to switch them back on again once payments resume. Some systems allow superior customer service based on real-time data. For example, proactive alerts can be issued to customer service agents instantly to track problems before they evolve.

PAYG companies have invested in a strong brand and servicing, given the issues of trust and awareness in the market today. The emphasis has been on a clear customer promise and backup strategy. Affordability, simplicity of use, reliability and convenience are at the heart of both the product and payment arrangements. Individual company strategies to promote trust are reinforced by the Lighting Africa and Lighting Global quality assurance initiative for solar pico products which has been running since 2009. This was extended in 2015 to cover 'plug and play' kits up to 100W. The scheme's extension comes at a time when concern about the risks to the industry from generic products and counterfeiting is increasing.¹⁵

"Standalone home systems growth has been driven by a strong customer focus"

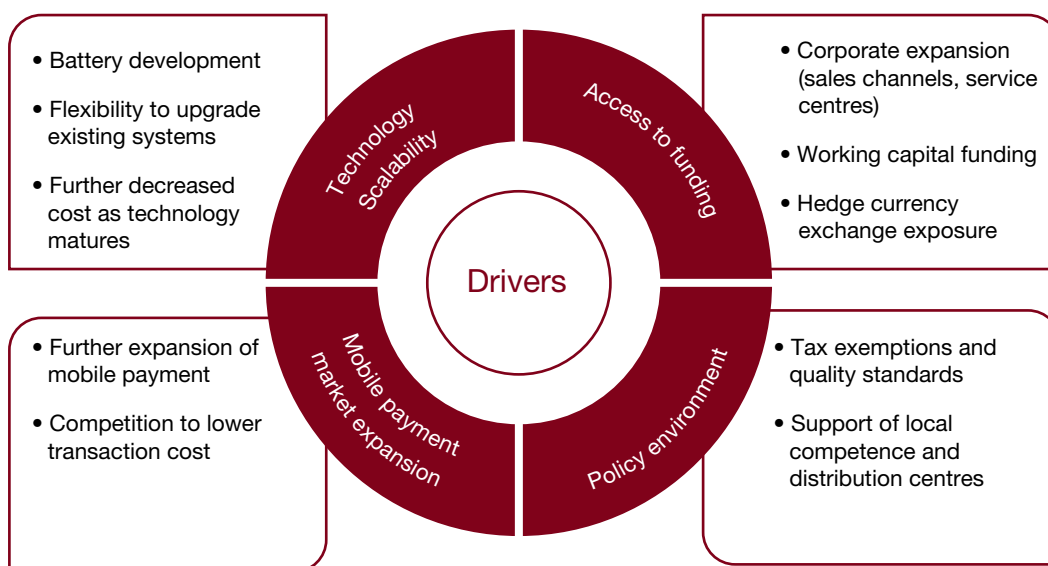
Figure 3: PAYG success factors



¹⁴ Bloomberg New Energy Finance, presentation to Fourth International Off-Grid Lighting Conference, 26 October 2015.

¹⁵ See for example: Off-grid Solar Market Trends Report 2016, Bloomberg New Energy Finance and Lighting Global in co-operation with the Global Off-Grid Lighting Association.

Figure 4: Four key factors are expected to drive the expansion of the standalone home systems market



Outlook for standalone home systems

We envisage the standalone home systems market will continue to expand significantly, driven by four key factors - technology, policy, mobile infrastructure, and funding (see figure 4).

Access to customer mobile payment services is an important prerequisite for such solutions, with countries offering the best developed payment infrastructure, and, ideally, interoperability between different mobile providers, being in the best position to increase uptake of standalone electrification. Where this is the case, companies have not had problems financing growth.

Technology development and scalability are important factors, although costs have reached a level where clearly viable sales models are possible and the choice of DC-operated home devices means that DC systems may prove sufficient. There is a substantial currency risk arising from the global technology supply chain. The policy environment is a key driving factor. For example, good minimum safety and quality standards, clear access plans and tax exemptions for clean technology products are enablers for the standalone home systems sector.



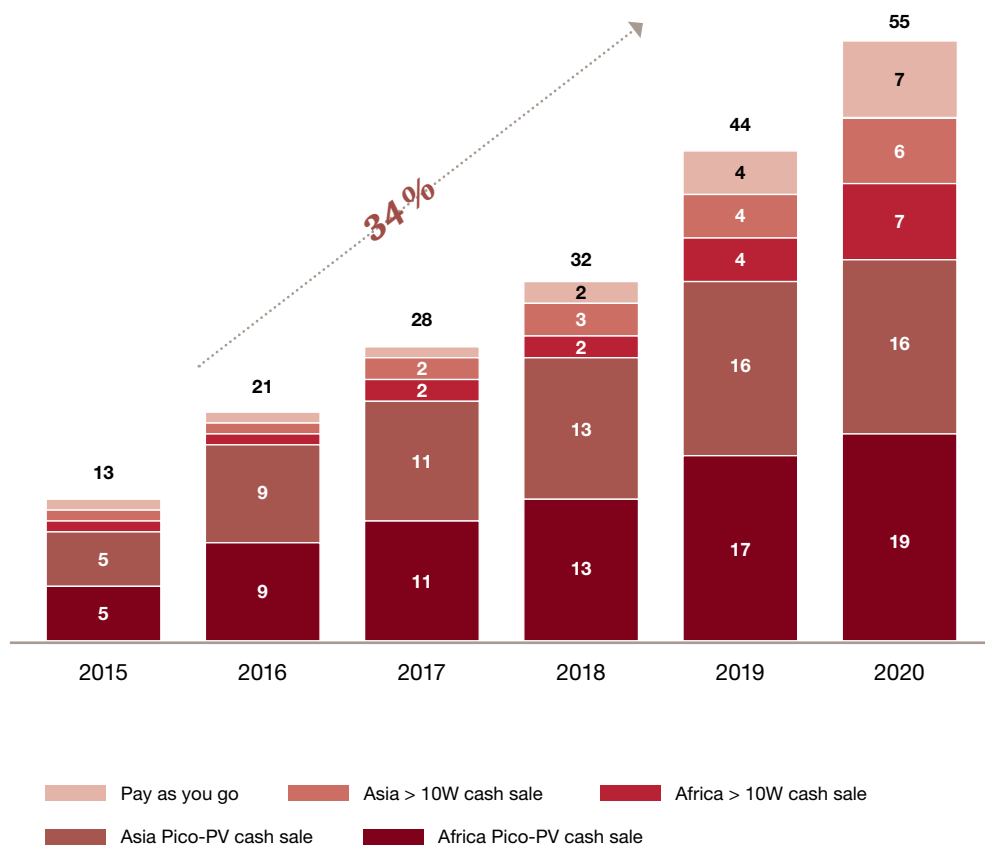
Successes and constraints

Standalone electrification for rural housing in the Eastern Cape

Off-grid solar home systems are being installed in 1700 rural households in the Eastern Cape region of South Africa. They comprise a 90W rooftop solar PV panel and storage battery to deliver enough energy to power six indoor LED lights for up to four hours per day and two external LED security lights for 12 hours. They are also capable of powering a DC 32-inch TV set for five hours as well as providing mobile phone charging for five hours via two 7A ‘cigarette-lighter-type’ sockets. The systems can be expanded, with additional solar panels and batteries, to cater for a DC refrigerator, washing machine and a sewing machine. Payment for the solar electrification project comes from a government-funded electricity grant previously earmarked to assist home owners in paying for Eskom-generated power. Grid expansion is not scheduled to reach these homes for at least three to five years. The project was commissioned by the Mbhashe municipality at Dutywa in conjunction with South Africa’s Department of Energy (DoE).

The customer relationship that lies at the heart of the PAYG model also has significant potential to add to economic momentum in rural areas. The customer is linked into a distribution channel and, after a year or two, they also build up a credit record which can be a foundation for more goods and services to be channelled to them. In this way, the PAYG SHS business model can become the starting point for a wider range of commercial relationships and activity, and will drive economic growth. However, as figure 5 shows, there is a large volume of cash sales and both cash and PAYG sales are expected to grow at a fast pace.

Figure 5: Baseline forecast off-grid solar annual sales (million units)



Source: Bloomberg New Energy Finance.

*“SHS systems market will help to lift rural electrification levels above 30% in sub-Saharan Africa by 2025”
 (SHS supplier in Tanzania)*

Mini-grid development

If customers have higher energy requirements than can be met by standalone home systems, then a renewables-fed mini-grid can be an option. Mini-grids have a longer history than standalone home systems as a solution for electrifying rural or remote island communities out of reach of the main grid. With the exception of those located next to local sources of hydropower, such as in Nepal, they have typically been powered by diesel generators. Diesel relies on fuel transport for operation and entails a higher running cost compared to renewable generation. Partly because of the disadvantages of diesel, mini-grid development has been limited, but the advent of cheaper renewable power technology has seen the emergence of hybrid mini-grids (combining diesel and renewable generation) and renewables-only mini-grids.

In contrast to the entrepreneurial impetus that is driving the growth of standalone home energy systems, mini-grids require more planning and institutional context. Because they serve a community of users, they rely on local governance frameworks or some other existing infrastructure that can provide a framework for their development. Sometimes the starting point might be an 'anchor client'. This might be a local business or a public service such as a health centre that has a power requirement. In such cases, a power installation can be designed that also serves neighbouring users through a mini-grid. In other cases, mini-grids might be community- or government-led. But in all cases, they require some framework to ensure agreement on planning, operating, pricing and maintenance.

Different models for mini-grid deployment exist. They can be classified into four categories - utility operated, privately operated, community operated or hybrids that combine a mix of the others. Due to the complex regulatory, process-related, technical, financial and commercial challenges, there is no one-size-fits-all approach. The best structure depends on local circumstances. Often, much of the momentum for mini-grid development depends on government- or donor-led initiatives and private sector involvement has been limited.



Snapshot:

Off-grid electrification trends in India

- The number of decentralised renewable energy (DRE) enterprises in India has grown from about ten in 2006 to over 40 in 2014.
- More than half of these entities use solar, while another third use biomass or hydro as their energy source.
- Only a few DRE enterprises employ wind or solar-wind hybrid technologies.
- Most DREs have plant capacities that are less than 10 kW.
- Biomass is more commonly used for larger plants of 30 kW or more.
- Investments in off-grid energy enterprises have begun to gain scale and range from US\$100,000 to US\$5 million. The need for investment and the growth potential of off-grid energy enterprises present a promising opportunity for private capital.

** The Climate Group in partnership with Goldman Sachs, The Business Case for Off-Grid Energy in India. 2015.*

Successes and constraints

Mali mini-grids: Reducing costs and overcoming barriers to scaling up

A decentralised rural electrification model managed by the Malian Agency for Development of Rural Electricity (AMADER) has been developed over the last decade. More than 60 private operators—mainly diesel mini-grids and Solar Home Systems (SHSs)—exist. But tariff costs are high and other barriers lie in the way of full scale-up. The Rural Electrification Hybrid System Project is designed to allow operators to improve their efficiency by selecting the lowest-cost off-grid access plan—mini-grid connection or SHSs. A donor note on the project observed: “Hybridisation of systems is crucial, as this reduces the volatility of operating costs for rural providers and contributes to more regular cashflows, creating incentives for investment in access expansion through off-grid solutions, while facilitating access to credit for operators.”¹⁶

Mali is often cited as the African country that has had probably most success in developing isolated mini-grids. The Africa-EU Renewable Energy Cooperation Programme’s mini-grid policy toolkit states there are “more than 200 mostly small diesel mini-grids in operation in the country, around 60 of those are privately run and a significant number are in the process of hybridisation.”¹⁷ But tariffs are considerably higher than for grid-connected customers and this has been a significant limiting factor in the development of mini-grids to date. Hybridisation with renewables has had positive impacts in reducing generation costs and falling technology prices will further ease cost issues, but other challenges remain.

Many mini-grids have been government- or donor-led and rely on some form of subsidy and the continuing commitment of the sponsoring agency. According to our market feedback, private sector involvement remains challenging, with many people we interviewed commenting on the lack of a clear framework for mini-grids in energy policies and plans, as well as general frustrations with delays and bureaucracy (see panel). There has been a lack of business focus and appreciation of the conditions needed to put mini-grids on a sound footing. And this echoes the findings of the Africa-EU Renewable Energy Cooperation Programme’s toolkit, which observes: “Many [mini-grid projects] have focused on technological and socio-economic aspects, leaving business-related aspects unconsidered.... However, other projects – in particular those with more business-driven approaches – have addressed these problems adequately and are potential sources for inspiration.”¹⁸

Where mini-grids have been successful, their role is likely to have been clearly identified in national energy plans, and the projects themselves are rooted in funding and governance models that are sustainable and able to cover repair and maintenance costs and processes. Where these conditions exist, private sector interest in mini-grids is likely to grow. In Kenya, for example, the Kenya Energy Regulatory Commission has licensed Powerhive East Africa Ltd., making it the first private company in Kenya’s history to receive a utility concession to generate, distribute and sell electricity to the Kenyan public.

Powerhive was granted the concession in 2015 after more than two years operating successful renewable energy microgrid pilot projects serving around 1,500 people in four villages in Kisii, Kenya. The company aims to scale up its operations in the region, beginning in the Kisii and Nyamira counties in western Kenya, and to deliver electricity directly to hundreds of rural communities that are beyond the reach of the national grid. The Kenyan government has a target of 100% electrification for the population by 2030. In early 2016, Powerhive closed a US\$20m financing round to enable it to expand into new markets in Africa and Asia Pacific, as well as to invest in continued growth in Kenya.

In India, Prime Minister Narendra Modi has said he wants electricity available in every home by 2022.¹⁹ A total of 125,000 Indian villages lack access to reliable power and the government has designated 18,000 of these villages as economically impossible to reach via conventional grid extension means. Activity is increasing in the mini-grid sector. For example, in just four years Husk Power Systems has installed 84 mini-power plants, using biomass from waste rice husks, to provide electricity to over 200,000 people spread across 300 villages, and employing 350 people. It runs its own Husk Power University, with the aim of taking unskilled people from rural communities and training them up to run the power plants and mini-grids themselves.

Outlook for mini-grid systems

Mini-grid systems have had a chequered history but have an important role to play in accelerating access to electricity for communities which cannot be reached by larger centralised grids. The availability of

“The lack of local technical skills remains a key barrier to sustainable mini-grid development and operations”

16 The Global Partnership on Output-Based Aid, Output-Based Aid in Mali Rural Electrification Hybrid System Project, June 2015.

17 Africa-EU Renewable Energy Cooperation Programme (RECP), Mini-grid Policy Toolkit: policy and business frameworks for successful mini-grid rollouts, 2014.

18 Ibid.

19 The Economic Times, PM Narendra Modi for 24-hour power supply in every village by 2022, 4 September 2015.

standalone home systems should be a key determining factor in the future development of mini-grids. There is little point in 'low power' mini-grids being developed that do no more than provide 'entry level' tier 1-3 access to power if this access is available at a more affordable cost through solar home systems. Instead, the logical role of mini-grids is to provide fuller tier four or tier five electricity access.

Historically, most mini-grids have been in the lower tiers, with a resultant high level of capital and overhead costs relative to power output. Mini-grids on this scale are unlikely to be as cost-effective for 'entry level' power compared to standalone home systems. But standalone home systems are not adequate for households, and particularly businesses, that need more power. For higher-consuming customers beyond the reach of the main grid, mini-grids provide a more feasible full electrification option.

We are seeing more private sector interest in mini-grids. And, like the private sector companies that are behind the growth of standalone home systems, an emphasis is being placed on market feasibility, affordability and site suitability. It is

important that mini-grids are designed with specific local circumstances in mind. Factors such as rural population density, affordability, the existence or otherwise of an 'anchor customer', maintenance and operational considerations and a sustainable revenue/financing model are all important considerations. But it is equally important that there is clarity at the level of national energy policies about the role that mini-grids can play, with governments and regulators being ready to develop the policy, planning, financing, technical skills and governance frameworks that can support them.

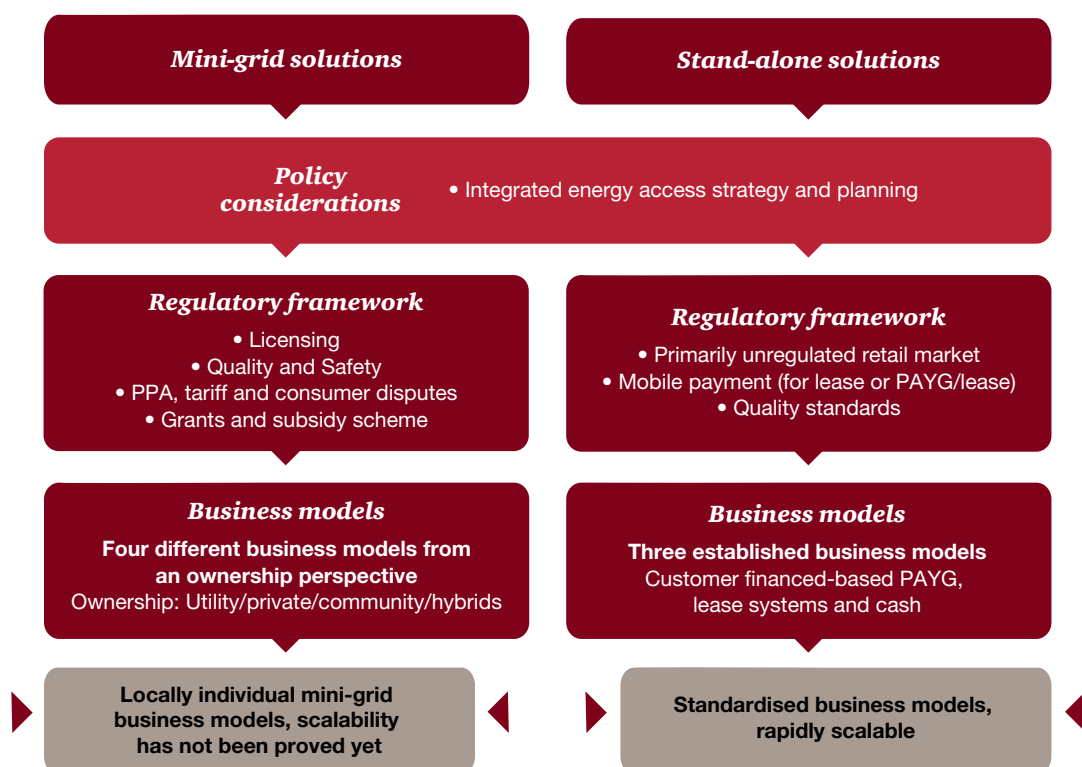
A key challenge for mini-grids is that, notwithstanding the possible presence of a main 'anchor customer', they need to serve very low-income customers, so system design must centre on affordability. Important lessons can be learnt from the commercially-led 'affordability-based' business models that have driven the growth of standalone solar home systems. Figure 6 highlights some of the other contrasts between the two approaches to electrification. Whereas standalone systems are proving themselves capable of growing to mass-market scale, mini-grid development has not yet demonstrated scalability.

Interview perspectives:

Mini-grids

- "Very often, public procurement procedures, evaluation and award are non-transparent."
- "Policy frameworks are unclear or do not exist."
- "Transaction times are too long and bureaucracy relatively high, which leads to significant transaction cost."
- "Discussions with REAs (rural electrification agencies) take very long and progress of project development remains very slow."

Figure 6: Contrasts between mini-grid and standalone solutions



Accelerating future momentum

How can energy access be accelerated? We conclude our report with a look at the future of energy access and make five recommendations that we believe would help accelerate electrification and contribute to wider rural development and prosperity.

Interview perspectives

Current electrification strategies

“Despite scalable business models in the standalone sector, governments still focus solely on national grid extension to electrify rural areas.”

“We could electrify African countries with half the budget of grid extension in less than five years.”



The future of energy access

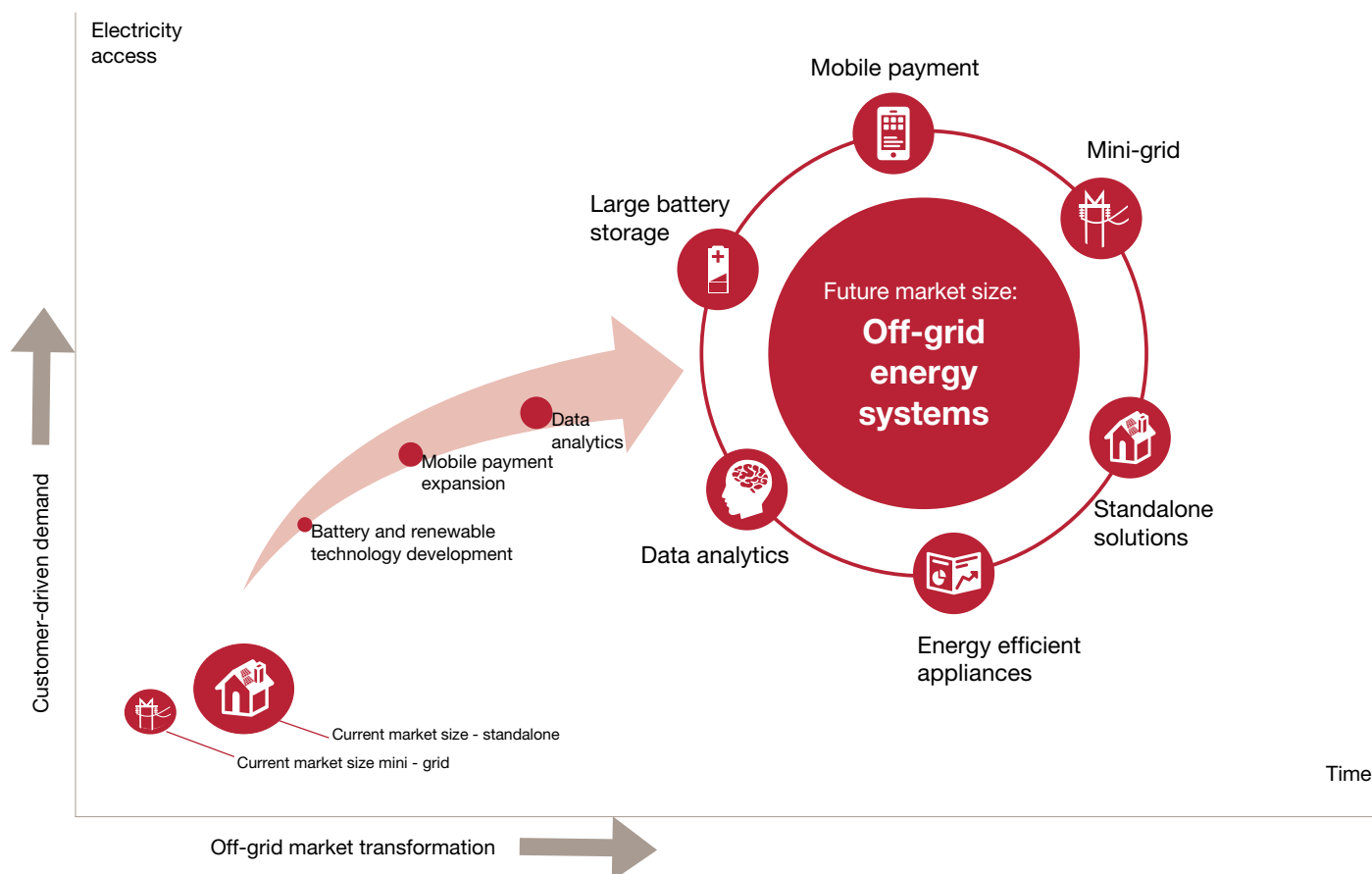
We see the growth of standalone home systems as just the first step in a potential transformation of energy access (see figure 7). Mobile technology, availability of microloans and falling solar module prices are already proving to be disruptive drivers of change. In the near- to medium-term future, we believe there is the prospect of further technological developments in small-scale power generation and large battery storage that could prove to be game changers.

The old assumption that electricity is something that has to wait for grid infrastructure development will be turned on its head by new commercial business models. Indeed, in countries with mobile payment systems, we are already seeing households being able to make their own electricity choices directly with technology providers. Bottom-up customer demand is proving as important as, and in some cases more important than, the traditional top-down planning of national grid extensions.

“Technology development in battery systems will be the next game changer for the off-grid market”

Data analytics is another game changer that is playing an increasingly significant role. PAYG companies are using real-time data feeds from installations to analyse usage and payment patterns. This data is also allowing them to anticipate repair and maintenance requirements. Using data analytics could further help in identifying the best sites for standalone solutions, mini-grids and national grid extension. We expect that existing standalone business models and mini-grid business models will transform into more connected smart off-grid energy systems with a substantial larger market size compared to those today. New business models driven by the development of mobile payment, data analytics and large battery systems will emerge and drive the transformation.

Figure 7: Transformation of rural electrification



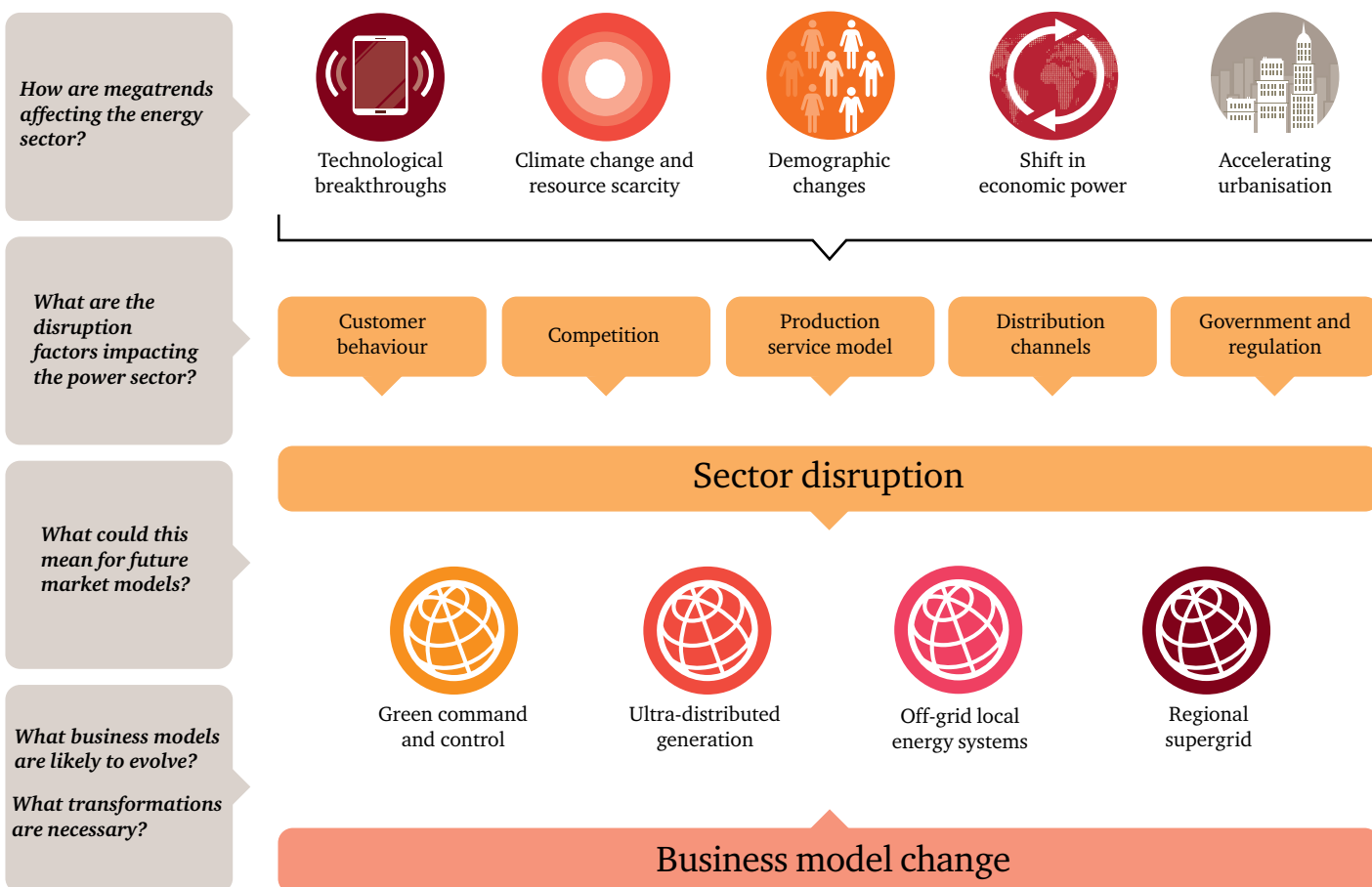
Time

Accelerating future momentum

Standalone home systems and mini-grids have the potential to fill the gaps in grid infrastructure smarter and faster. For those who are beyond the reach of the grid, these off-grid systems need to be recognised as the primary means of access to electricity. Yet many national energy policies do not give them this recognition, let alone go on to provide the appropriate policy, financing and regulatory frameworks that would enable them to develop and flourish.

Besides the use of standalone systems and mini-grids for customers who are not connected to the grid, we also see off-grid solutions becoming a financially viable option for grid-connected customers, especially where electricity supply is not reliable or not sufficient, or where electricity tariffs are high. We expect a broad transformation in the electricity sector in the coming years, both for grid-connected and ‘beyond the grid’ customers. This will have a major impact on the future sustainability of incumbent generation, transmission and distribution utilities and these companies will need to adapt their business models accordingly (see figure 8).

Figure 8: Off-grid growth is part of a wider energy transformation – existing power companies need to look at the implications for their business models



A five-point plan to accelerate electrification



1. Develop a national integrated energy access plan and map

Current electrification strategies tend to focus on national grid extension plans, whereas the challenge of rural electrification needs to be addressed with an integrated and holistic national approach. All three technologies – standalone, mini-grids and the national grid – need to form clearly recognised pillars of national energy policies. Instead of the tendency for mainly top-down grid extension centralised planning, policymakers should mix centralised top-down grid extension with decentralised demand-driven bottom-up strategies (mini-grids and standalone solutions).

Integrated energy access plans should contain a national energy access and opportunity map, including:

- Clear identification of territories where extensions to the national grid are a viable prospect, with realistic and binding timetables for grid rollout.
- For communities not included in grid rollout (and for those where grid rollout is not a near-term prospect or not cost-effective), mechanisms should be worked out to determine if they can be served by mini-grids or standalone solutions.
- Plans should include an understanding of the role of different stakeholders and the opportunities available for non-grid companies to deliver electrification solutions to non-grid areas.
- Clearly defined protocols should be agreed in advance, to avoid technology becoming stranded in cases where grid extensions become available to areas previously served by mini-grids.
- Plans should be reviewed on an annual basis to reflect changes in technology development, speed of grid extension and deployment of off-grid solutions.

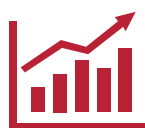
A clear energy access map and development plan would help provide a framework for a top-down planned electrification ‘push’ and a more commercially-driven bottom-up electrification ‘pull’. It would give more explicit recognition to the role of off-grid solutions in national energy policies and it would make it easier for companies to develop a viable business model and get access to finance.



2. Create an enabling environment for off-grid initiatives

A national energy access plan and map will help create greater awareness of and interest in off-grid initiatives, but if they are to take off, they will require a more enabling environment than currently exists in many countries. The most obvious enabler, in the case of standalone home systems, is the existence of a mobile payments infrastructure and access to microloans. Countries with such infrastructure are seeing the rapid growth of such systems. Those without are not. Indeed, this is so central that we single it out as a key recommendation on the next page. But other enablers are also important:

- Criteria for mini-grid development, such as the identification of anchor customers and minimum customer density, should be worked out, as these, in turn, would help clarify what is currently an unclear business model and rationale for mini-grids.
- Invest in skills and training for clean off-grid system installation, repairs and maintenance.
- Implement mechanisms for the qualification and training of locals, enabling community participation and increasing local awareness.
- Support the development and implementation of quality and safety standards, especially for mini-grid technologies.
- Develop supportive regulation with clear responsibilities to allow private players to unlock the off-grid market potential.
- Develop a supportive tax and customs framework with consideration given to import and tax exemptions for off-grid technologies.
- Promote local distribution- and off-grid expertise centres, with non-discriminatory access for all interested companies and clients to these centres.
- Support economies of scale by having planning mechanisms that enhance ticket size (project aggregation) and encourage process standardisation (e.g. with business plan templates).
- Facilitate interactions between stakeholders to improve understanding of off-grid economics.

Accelerating future momentum

3. Recognise the value of and promote the growth of mobile infrastructure

and payment platforms in supporting energy access

Dynamic and flourishing consumer payment mechanisms and customer loans can do a lot to enhance the ability of households to purchase basic electrification systems and enable companies to develop markets for their products. In turn, this increases uptake, creates economies of scale and brings down costs. For example, the micro-credit environment in Bangladesh and the mobile-enabled payment and credit infrastructure in parts of Africa has spurred the uptake of standalone home energy systems.

Mobile infrastructure is also crucial for facilitating 'smart' customer and home energy system interaction, giving providers a low-cost channel for customer relations and an ability to automatically manage non-payment. There are a number of measures that governments can consider to enhance the parallel development of mobile payments and financing systems to support the growth of off-grid electrification:

- A clear national policy framework to support the spread of mobile infrastructure and inclusive finance and payment systems.
- Exploration of opportunities for synergies between telecom grid and off-grid power developers, for example by examining the potential for mobile telephone masts to anchor clients for mini-grid systems.
- Expand mobile payment potential by measures that encourage interoperability between different mobile platforms.
- Reduce transaction costs for mobile payment solutions by the promotion of competition.



4. Establish an off-grid development and innovation fund

A highly visible development and innovation fund can play an important part in spurring off-grid growth in each country. At the moment there are many sources of possible grant funding, from multilateral institutions and from bilateral donors, but this can also result in a fragmented funding landscape and a scattergun approach to projects. A development and innovation fund, linked to the strategy established in the national energy access plan and map, can provide a more high-profile single focus for innovation finance, finance for pre-feasibility studies and for supporting local entrepreneurs. Among its functions, it can:

- Provide access to finance for entrepreneurs and local businesses in the off-grid industry.
- Develop a grant- and subsidy-funding mechanism for communities.
- Consider innovative financial mechanisms, such as convertible grants (that convert into subordinated debt, which qualifies as equity, helping fulfil equity requirements from senior debt lenders).
- Support feasibility studies for new business models, local entrepreneurs and technology implementation.

One approach can be for such a fund to have formal partnerships with commercial banks, in which the fund gives concession loans to local banks to administer. Loans can be released on a standard application that meets the requirements of the banks and also of the fund. Forging links between banks and project developers in this way can help commercial banks learn more about off-grid project economics and lead them to be more willing to lend from their own funds on market-based terms.



5. Have a high-level energy access champion who can drive results

A common challenge in many developing countries is difficulty in translating plans into effective delivery on the ground. There is a case for a high-level energy access champion, with their own project delivery oversight capability, who can cut across agencies and overcome obstacles and delays. Such an appointment might report direct to the president or prime minister, given the importance of energy access to the whole economy and society. The energy access champion would have a public duty to monitor and drive results, report annually on progress and have powers to remedy slippages.



Glossary

Access to electricity: The IEA definition of access to electricity is at the household level and includes a minimum level of electricity consumption, ranging from 250 kWh in rural areas to 500 kWh in urban settings per household per year. The electricity supplied must be affordable and reliable. The initial level of electricity consumption should increase over time, in line with economic development and income levels, reflecting the use of additional energy services.

Micro-grids and mini-grids: Some authors use the terms mini-grids and micro-grids interchangeably to cover smaller grids that are not connected to the main grid. Mini-grids are generally understood to be larger than micro-grids but there is no clear and consistent definition of the dividing line between them. Also, as noted in one study from which we borrow aspects of this terminological commentary²¹, there is no fixed definition of what constitutes the ‘main grid’. This becomes especially relevant in cases where the national grid is relatively small (e.g. small island states where the entire national grid has a generation capacity of less than 10 MW). Sometimes, a mini-grid is defined as a standalone AC grid (of undetermined size) while a micro-grid is a smaller standalone grid that deals exclusively with DC power. In this report we choose to use the term mini-grid to refer to any grid that is not linked to the main central grid in the country or territory in which it is located and we tend not to use the term micro-grid.

Mini-grids: A power source of a typical capacity ranging from a few kW to a few MWs, supplying electricity to consumers in a remote location through a local distribution grid justified by the population density in the concerned location. The power source could be a diesel-powered generator, a renewable energy power plant, or a hybrid between the two technologies.²⁰ ‘Micro-grid’, ‘nano-grid’ and ‘pico-grid’ are terms that are sometimes used to differentiate different kinds of mini-grids with size thresholds, capability and complexity as some of their defining characteristics.

Off-grid systems: A collective term to refer to standalone systems for individual appliances/users and also to mini-grids (serving multiple customers) that are not connected to a larger centralised grid.

Pico PV: A Pico PV system is a small PV system with a power output of 1 to 10W, mainly used for lighting and thus able to replace unhealthy and inefficient sources such as kerosene lamps and candles. Depending on the model, small ICT applications (e.g. mobile phone charger, radio) can also be added.

Standalone systems: Electrification systems for individual appliances/users that are not connected to any grid outside of the individual user premises.

²⁰ Definition taken from Sustainable Energy for All (SE4ALL) Energy Access Committee,

²¹ International Renewable Energy Association, Off-Grid Renewable Energy Systems: Status And Methodological Issues, Working Paper, 2015.

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