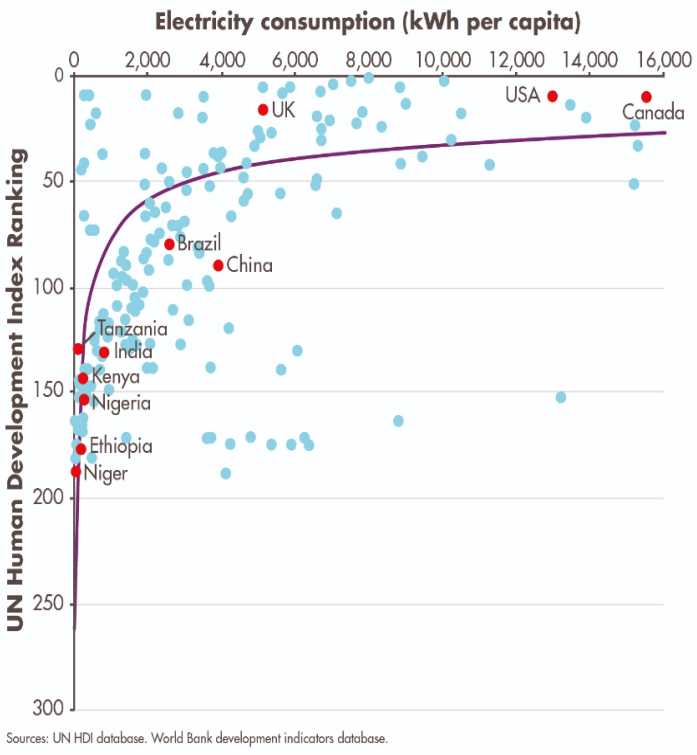
Decentralised Utilities:

Bridging the Rural Energy Gap in Emerging Markets

Over 1.1 billion people live without access to reliable and affordable access to energy.[1] While the wealthiest can find ways to circumvent infrastructure limitations in developing countries, the burden of this energy market failure falls hardest on the most economically vulnerable. At Shell Foundation, we have been working to address this access to energy gap for nearly two decades; more recently in partnership with structured co-funding from the Department for International Development (DFID) in the UK and United States Agency for International Development (USAID). Our commitment to accessible energy has led us to support various energy solutions, including solar home systems (SHS) biomass cookstoves, powered agricultural assets, mini-grids and various financing intermediaries, improving the lives of over 60 million low-income people across Africa and Asia.

Over the past decade, we have seen the mini-grid sector slowly evolve to enable a more mature, decentralised utility model, which we believe will be transformative for energy access in emerging markets. Through this article would like to share our learnings to our partners in the sector who share our commitment to energy access. This article is the first in a series to explore the potential for decentralised utilities and the interventions needed to scale the sector and help solve the energy gap in the developing world.

Meeting the complete energy needs of low-income consumers is essential to unlocking the development potential of emerging markets



The link between energy access and development has been well-documented – almost all countries with less than 2000 KWH per person are the bottom of the UN Human Development Index, reflecting the lowest composite life expectancy, education and per capita income indicators in the world.[2] The energy access gap is most acute in Africa, where 650 million people are without electricity[3], with the continent losing 2-4% of GDP growth per annum due to power losses alone[4].

Off-grid solar products are one of the most significant innovations starting to fill the gap, with an estimated 130 million products sold globally to date[5] (predominantly solar lanterns) .

We have supported four SHS pioneers and also supported the ecosystem through various market enablers, including financial intermediaries, last mile distribution and market associations.

Whilst the SHS industry has been revolutionary and will continue to play a leading role in meeting emerging market consumer energy needs, a SHS typically functions at loads up to 200W while local small businesses and commercial farms often require upwards of 500-1000W, respectively.

[1] Energy Access Outlook 2017. International Energy Agency, 2017.
[2] Internal analysis of World Bank and UN HDI statistics
[3] Electric Light Power, 2017.
[4] Electric Light Power, 2017.
[5] Dalberg Global Off-Grid Solar Market Trends Report, 2018.

Historically, only national grids have offered this level of wattage – and these currently only reach 40% market coverage in Africa.[6] Unfortunately, this phenomenon is partly why sub-Saharan Africa has not experienced the manufacturing and industrial growth that has lifted many Asian and Latin American countries into rapid economic development.

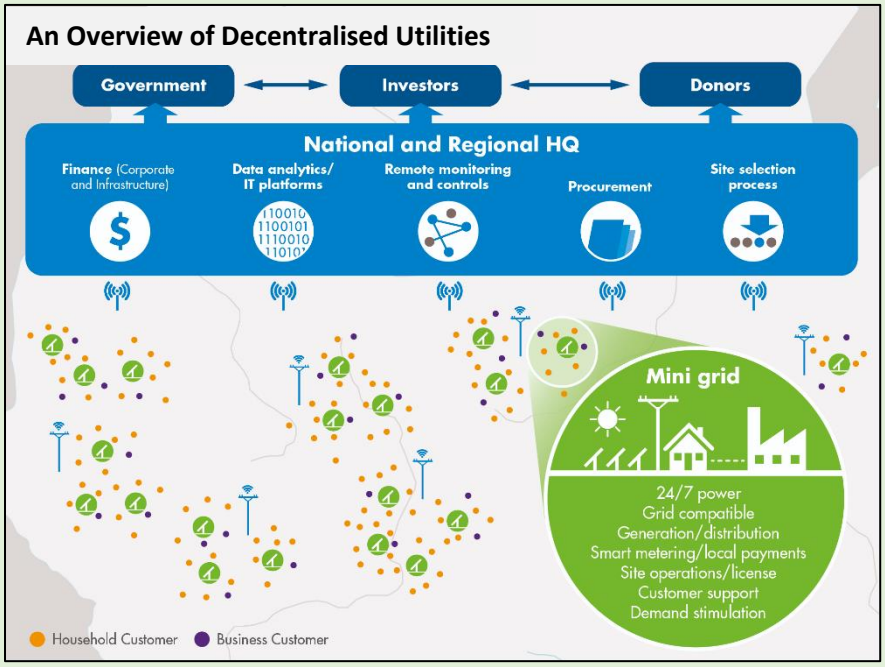
One nascent solution that is positioned to fill this productive use gap in rural areas is mini-grids. We believe the potential of mini-grids will be best realised if they are positioned and operated as professional utilities at scale. We expect decentralised utilities to play a vital role in enabling productive use energy, and along with that, the growth of micro-enterprises and small and medium sized enterprises (SMEs), which provide 70% of employment in OECD countries and only 45% of employment in emerging economies.[7]

We believe decentralised utilities can bring a new era in access to energy, with scale to help emerging markets to reach the SDGs

The evolution from the mini-grid model to a decentralised utility

Mini-grids are generation and distribution assets which can create and distribute energy to a localised group of customers.

Decentralised utilities are utility companies operating independently from large national utilities and typically use stand-alone mini-grids as their primary generation system, just as national utilities use turbines and power stations.



Decentralised utilities aim for a standard utility level service, providing 24-hour reliability, for both household and productive-use power. They are a long-term, professional solution, aligning with conventional utility standards, but tapping into latest technology such as sophisticated software platforms, strong data analytics through smart metering, innovative financing programmes, and high-quality customer service to reach the areas where it's more cost effective than extending the grid.

[6] "Off-grid power pioneers pour into West Africa" Reuters, 2018.
[7] Meeting of the OECD Council at Ministerial Level, 2017.

Our initial experience in mini-grids started in 2008 with Husk Power Systems, an off-grid power generation and distribution company. Husk pioneered the first 100% biomass gasification solution from rice husks in 2008 and reached over 10,000 low-income customers within five years of inception. Initially they were providing around 6-7 hours of energy a day in rural India, which was ground-breaking at the time. With Husk, we began to better understand the role of mini-grids in rural electrification and how the business model would need to evolve to utility standards to be successful long term.

We learned that the adoption of 24-hour residential and commercial service is critical for financial viability and social impact

First, we learned that 24/7 power is an unmistakable demand-driver, even with low-income consumers. 6-7 hours of guaranteed power was not enough to secure customer loyalty and market leadership over time*, especially given that the substitutes, diesel and kerosene, could be tapped on-demand at any time of day*. In addition, the economics of the model didn't work without daytime, productive-use demand, which needs reliable power. The productive-use/small business customers kept on using their own diesel solutions for productive-loads which stifled demand growth. In general, mini-grids rely on productive demand because daytime demand taps into the lower, fixed cost of solar, while night-time demand, primarily household/residential, use more expensive solutions, such as batteries. After receiving widespread customer feedback highlighting the importance of 24 hour energy, Husk pivoted the model and in late 2015, launched its revamped hybrid model: 24 hour household and productive use energy generated by seamless biomass and solar integration, with smart metering and highly focused customer care to increase sales and profitability. At the village level, Husk demand increased by 150% in the first nine months after they introduced 24/7power. *Husk Power evolved from mini-grids serving village households 6-7 hours day to a full-scale decentralised utility electrifying businesses and households at a utility standard.*

We learned how important demand stimulation and smart metering is to the decentralised utility model

In 2015, we partnered with Absolute Energy to build a utility level mini-grid in Bukasa on Lake Victoria. At 238 kWp, with 530 customers, the site is a test bed for demand stimulation initiatives. Realising the critical role that productive use energy plays in its business viability, Absolute created a small energy fund, which financed productive use energy assets for local micro, small and medium enterprises (MSMEs). These MSMEs purchased around 60 kWp of new productive-use assets, increasing energy demand and hence sales for the utility. The aggregate productive/household energy demand seemed to move in lock-step with broader local economic development on the island with new businesses springing up to harness the commercial potential of 100% electrification of the island. Soon, Absolute's local staff started getting more sign-up requests for electricity, even though all the households had already been powered. The local police chief confirmed that new people were relocating and when registering their homes, listed access to energy as their reason for moving to the island. This lesson further cemented the link between energy and productivity and the importance of building full-scale utility models capable of addressing both household and business customers.

Our journey towards a customer-centric utility model would have been impossible without smart metering technology which led us to work with SparkMeter in 2015 to develop an affordable, smart metering solution specifically designed for the remote off-grid sector. Customer level data and control is vital in the utility model to allow for remote management, flexible pricing models, theft detection and prevention, and demand data for investors.

The evolution from the mini-grid model to a decentralised utility model		
Differentiators	**Historical mini-grid model**	**Evolved distributed utility model**
Core business functions	Focus primarily on building the generation and distribution assets, usually one mini-grid at a time	A full-service company, complete with household level smart metering, IT platforms, payment systems and customer service, with a strong focus on technology to remotely manage and operate sites cost effectively.
Business model & ownership	No proven business model – sometimes community owned and difficult to scale	Managed as a commercially-viable business with many sites in operation, providing returns to shareholders (initially will need systematic, effective donor funding to attract commercial investors)
Scale	Implementation of the generation and distribution assets are a primary focus	Major focus on driving down costs on new implementation at scale and cost effectively managing a portfolio of mini-grids. Generation assets become standardised, key focus is on operation and customer care
Financing	Capital raised in small ticket sizes – generally enough to build 1-2 sites at a time	A large pipeline of sites that can absorb large financing ticket sizes, creating economies of scale to drive down costs and leveraging sufficient scale to secure adequate regulatory support for growth. Concessional capital becomes more systematic to allow the sector to scale.
Grid harmonisation	Generally, focused on site level implementation with no view to integrate with the grid eventually	Meets local technical standards for grid compatibility and integration with capacity to provide productive-use, 24/7 power. Building the grid from the outside in.

We believe decentralised utilities, solar home systems and grid power can combine efforts to unlock universal electrification faster

The role of decentralised utilities holds great promise as part of the energy mix, if harmonised with the expansion of state-owned utilities and solar home systems. Historically, rural electrification is characterised by unprofitable operations, high grid extension costs and low initial demand, which is a huge strain for national utilities to bear alone. A survey of 39 sub-Saharan African countries showed that only two countries have a financially viable power sector and only 19 of these utility companies were covering operating expenditures[8]. A *Power for All* analysis of World Bank-funded grid extension and power projects between 2000 and 2014 finds an average project cost of $2,500 per connection in Africa. For these cash-strapped state enterprises, who often have political pressure to charge very low tariffs, extending the grid to rural areas is typically a loss-making endeavour, if undertaken at all.

Decentralised utilities also struggle with the economics of rural electrification, but in many situations, it is the *least cost option* for providing electricity in rural areas, especially areas beyond 25 km from the grid. According to our partners, the cost of delivering decentralised utility provision is estimated to range from only $500 to $1,000 per connection for solar or biomass[9] with storage, depending on the village size and location. This is significantly cheaper than extending the grid to rural areas and we

[8] Making Power Affordable for Africa and Viable for Its Utilities. World Bank, 2016

[9] Internal Analysis from Shell Foundation and AMDA

believe in an attractive investment opportunity when matched with structured concessional financing, which we'll discuss in more detail in the next chapter.

In an ideal world, SHS, decentralised utilities and national grids can harmonise for universal electrification, serving the areas in which they are the least cost solution. For example, if a village is large enough that the combination of the cost of SHS would be higher than the cost of a decentralised utility, it would be served by a decentralised utility. While this is oversimplifying the complexity of rural electrification, it is a useful analysis when thinking of donor interventions. CrossBoundary Energy Access analysis below demonstrates how important all three solutions are for meeting energy needs.[10]

- *National grids:* National grids in sub-Saharan Africa are the main power source and will remain so. The least cost method analysis estimates that at least 210 million people, currently without energy access and residing within 25 km of existing grid, could be electrified at the lowest-cost by extending the grid.[11]
- *Solar home systems:* SHS bring the benefit of quick installation and instant electrification for low-income or rural consumers that don't have reliable grid coverage or any grid coverage at all. However, the average unit price of a SHS in Africa ranges from $7-30 per month, depending on type and number of products and approximately 40% of sub-Saharan Africans live on less than $1.25 per day, putting the cost out of reach of many rural consumers.[12] The affordability gap is part of why SHS usage tends to decline with distance from urban/peri-urban areas; the most rural populations are generally the poorest and often cannot afford SHS. At least 310 million people would be served at lowest cost by SHS, but they might need concessional capital to reach truly rural areas.
- *Decentralised utilities:* Decentralised utilities represent a good option for communities which are too far and too costly for immediate grid extension. It is estimated that **at least 100 million people, in low-income areas more than 25 km from the grid *where there is sufficient population density,* would be electrified at lowest cost using decentralised utilities powered by mini-grids.**[13] This is likely a conservative estimate as other research suggests the potential of mini-grids could be much greater. The African Mini-grid Developers Association expects mini-grids to have likely scale of 140 million in Africa alone[14], whereas the International Energy Agency has forecasted up to 290 million, globally.[15]

Please note, this analysis has left out pico PV (lanterns), as it is considering higher tiers of energy, but we also believe affordable lanterns have a big role to play in kerosene elimination in lighting, which is not reflected in this research. In addition, this view does not tackle the topic of customer affordability in decentralised utilities. Chapter 2 and 3 will discuss the economics and tariff levels/customer affordability respectively.

It is worth remembering that these solutions are not mutually exclusive – we believe future decentralised utility companies will use an array of solutions to meet their customer needs. It is also worth mentioning that SHS will continue to grow in capacity, appliances will become more efficient, decentralised utilities will continue to reduce in cost as will the grid as it continues to extend and the economics of rural electrification keep improving for all systems. And while neither system alone is sufficient to close the energy gap by 2030, we believe that all three can work synergistically for the most viable, timely and cost-effective electrification strategy.

[10] "Mini-grids are the cheapest way to bring electricity to 100 M Africans" CrossBoundary Energy Access Research, 2018.
[11] Internal research & analysis powered by CrossBoundary Energy Access
[12] Income Inequality Trends in sub-Saharan Africa: Divergence, Determinants and Consequences. UNDP, 2017.
[13] CrossBoundary Energy Access
[14] African Mini-Grid Developers Association, 2018.
[15] Energy Access Outlook 2017. OECD/ International Energy Agency, 2017.

To date, mini-grids and decentralised utilities are reaching only a fraction of a percent (0.2%) of households with energy access in sub-Saharan Africa

Even though there is vast emerging market demand for energy, decentralised utility developers have struggled for financial viability and access to finance that would enable scaling across rural markets in a country or region. Financiers have been reluctant to take a gamble on a sector with so many risks (ranging from macroeconomic to regulatory to commercial), especially in rural areas where there is rarely data to support demand forecasts. In addition, governments in many countries have either lacked a policy framework for decentralised utilities or simply don't have the data demonstrating that they are a long-term, reliable solution for rural customers.

Although these challenges remain, we believe the market landscape is starting to shift, unlocking enabling factors to support the industry's growth, long-term. Contributing to those market shifts has become core to Shell Foundation's strategy because we've seen tremendous progress at the technology and enterprise level, now we need to ensure the market enablers and service companies are in place to allow them to scale.

We have backed technology needed for the sector since 2014, such as our support for REDAVIA, which leases re-deployable modular solar farms, and SparkMeter, which provides remote metering to reduce energy losses and allows for household-level metering and data. Likewise, because the sector lacks a standardised method of valuing projects and aggregating data, we collaborated with Factor[e] (a tech VC based in Colorado, USA) to incubate Odyssey Energy Solutions, a web-based platform to allow financiers, donors and governments to compare projects in a standardised manner and allow for streamlined reporting and data aggregation. Finally, we believe that sector coordination is essential to align and advocate for policy and financing needs, so we've created and supported various market accelerators and worked closely with the decentralised utility companies in Kenya, Tanzania and Nigeria to create the African Mini-Grid Developers Association (AMDA), with the goal to become pan-African. With the progress in technological innovation, cost reduction and sector coordination, we believe it's time to scale the sector.

We believe various trends in the sector have created the opening for decentralised utilities to begin to scale

These have included:

- Expanded developer base: 20 years ago, mini-grids were a tiny niche in the energy landscape but today the quality and quantity of developers is expanding dramatically. Odyssey reports more than 50 project developers on their platform globally, whose pipelines total more than $500m worth of mini-grid projects being developed.
- Decreases in technology prices: As renewables have gained market share, their supply and cost base have become more competitive. For example, the cost of electricity from solar PV fell by almost three-quarters from 2010-2017 and continues to decline.[16] Batteries are positioned for a similar trajectory.
- Technology innovation: Technology advancement has made smart metering, remote monitoring and mobile payments possible, allowing for centralised control and management needed to operate these remote sites. Technological advancements such as these, along with the reduced input pricing, are continuing to advance the sector's profitability and attractiveness for investment.
- Private sector interest: Over the past 5 years, large energy corporates have increasingly entered the sector, either through their own teams or by directly investing into decentralised utility companies like Husk Power Systems and OMC, who recently raised $20m and $9m respectively.

[16] IRENA, 2018.

- Policy improvement: While policy is volatile and tends to change with election cycles, an increasing number of countries have created national mini-grid regulations that allow decentralised utilities the license to operate and provide frameworks on how to integrate with the grid.
- Donor engagement: Donors and development financiers can be major catalysts for policy and financing changes that shift the socio-economic landscape in developing countries. Some of the larger funders and financiers in the sector have started organising to co-ordinate and share learnings on their support to the mini-grid sector. The Mini-Grids Funders Group − currently co-chaired by DFID, AfDB and the World Bank − includes around 25 DFIs, funds and philanthropic institutions, which have collectively made in-principle commitments of over $1bn towards developing the mini-grid sector.

These trends have fuelled our optimism regarding the ability of decentralised utilities to electrify a critical mass in emerging markets.

Forward Look: Building Momentum for Decentralised utilities

We remain confident that the world can reach SDG7 with a combination of decentralised utilities, SHS and government utilities if certain conditions are met at both the enterprise and ecosystem level. For the decentralised utility industry to reach scale the **enterprises** will need to 1) continue evolving the business model with lower-cost CAPEX and operations; and 2) continue to find innovative ways to stimulate demand, including using complementary or adjacent services such as water or WIFI.

However, to allow the private sector the chance to truly drive down costs and increase demand, the sector will require a level of **ecosystem** support to: 1) ensure enterprises have the right regulatory frameworks and government support; and 2) enable access to capital to implement, reduce costs and increase energy demand, which can only be done successfully at scale.

It would take an estimated $7-11bn to extend the level of mini-grid coverage necessary for making SDG 7 a reality.[17] However, investors will need a certain level of confidence that there will be a financial return and many rural sites serving household customers are not financially viable without concessional capital. We believe systematic donor interventions will be the catalyst to allow the sector to attract commercial capital, implement sites at scale and reduce costs in a meaningful way. **Shell Foundation's outlook on the financing solutions required to propel the sector to the next level, will be explored in the next edition of this series.**

Improved collaboration between public and private sectors will be fundamental in creating the regulatory and business-enabling environments, and where appropriate, the smart subsidies that will attract the much-needed commercial capital into the sector. **The public-sector perspective and key elements of an enabling ecosystem will be unpacked in the third and final publication from this series which will also dive deeper into the topic of the customer. What do they use the energy for? What impact does it have on their lives? What do the customers need from the sector to use the power to its fullest, including access to appliances and productive-use assets?**

We hope that sharing our learnings and those of our partners within this series, will offer a meaningful contribution to the sector's knowledge. Realising the potential of decentralised utilities across emerging markets will require a concerted collaboration between government, financiers, practitioners and the private sector. The contribution of decentralised utilities in achieving SDG7 has just begun.

[17] Catalyst & Shell Foundation Proprietary research, 2018. CrossBoundary Energy Access Research, 2018.