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New Energy Finance

# POWERING LAST-MILE CONNECTIVITY

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# Summary

Nearly 4 billion people are not connected to the internet today, representing a significant opportunity for both socioeconomic development and business. Bridging this “digital divide” requires affordable and reliable access to electricity. Electricity will be essential to power and expand all stages of providing internet access, from backhaul and base stations to charging consumer devices.

Poor power supply across much of the developing world forces mobile network operators to spend an estimated \$3.8 billion annually on diesel fuel to power their infrastructure. For consumers in areas with poor electricity access, charging smartphone batteries is costly and time-consuming. This directly curbs the use of smart devices and online platforms. If current trends continue, the lack of electricity access will continue to act as a significant barrier to universal connectivity.

A combination of technological advances and innovative business models now provide alternative approaches to powering connectivity at the “last mile.” Partnerships between mobile network operators, energy companies and startups that focus on operational efficiency, new technology development, and innovative business and financing models can drive internet access and electrification for billions of people.



Source: Bloomberg

# Powering last-mile connectivity

Globally, some 3.8 billion people are unable to connect to the internet.<sup>1</sup> Known as the “digital divide,” this lack of access is most pressing in developing countries. While 80% of Europeans used the internet in 2016, only 25% of people in sub-Saharan Africa were online that year.<sup>2</sup> The gap is especially wide in rural areas, where new infrastructure is needed, service is operationally costly and telco revenues are low.

Closing this digital divide can create huge development and business opportunities. Access to the internet transforms lives by expanding access to education and health care, increasing civic participation, growing businesses and boosting gender equality.<sup>3,4,5</sup> Additionally, universal connectivity provides a massive business opportunity across industries, from mobile network operators (MNOs) to entertainment firms to fast-moving consumer goods companies to health care providers.

Cheaper and better smartphones are currently upending the way in which people access the internet

in developing countries. GSMA, which represents mobile operators globally, expects that Asia and Africa will add 1.3 billion new smartphone connections between 2016 and 2020.<sup>6</sup> Already, one in four mobile connections in Africa used a smartphone in 2016, while there was only one fixed broadband connection for every 200 residents.<sup>7</sup> Access to internet-connected smartphones enables economic opportunities by increasing access to apps that allow location-based services, payments, chats or photo and video sharing. Known broadly as rich interaction apps (RIA), such software has a positive socioeconomic impact, with one

study finding that for every 10% increase in global RIA use, GDP per capita increases by over 0.3%.<sup>8</sup>

With such a rapid rise in smartphone use, what prevents universal internet access? Availability and affordability are two of the main barriers, and both are exacerbated by unreliable, unaffordable or unavailable power.<sup>9</sup> Power is a crucial element at all stages of the connectivity value chain: from running network infrastructure to powering the devices that consumers use to get online. Yet, across much of the developing world, reliable electricity remains expensive and hard to get.



**Europe**

80% used the internet in 2016



**Sub-Saharan Africa**

25% used the internet in 2016

1, 2, 9 [Inclusive Internet Index](#)

3 [The Internet and Sustainable Development](#)

4 [Reaping Digital Dividends: Leveraging the Internet for Development in Europe and Central Asia](#)

5 [State of Connectivity: 2014](#)

6, 7 [The Mobile Economy 2016](#)

8 [The Economic and Societal Value of Rich Interaction Applications \(RIAs\)](#)

# Getting more people online requires more reliable electricity

Even with electrification continuing in the world's least developed countries, nearly 700 million people will still lack electricity in 2030.<sup>10</sup> Without a change in course, the expansion of the electricity grid will be limited by the same factors that have held it back in the past: infrastructure cost, low demand in rural areas and sometimes, a lack of political will.<sup>11</sup>

Without access to electricity in the home, connecting to internet services is a significant challenge, primarily due to the difficulty and cost of device charging. Even though people might live in communities covered by 3G networks, their smartphone use will be limited if they lack electricity at home.

Off-grid consumers travel up to 15 kilometers per week to charge their phones at small kiosks, often paying around \$0.10-\$0.30 per battery charge. Depending on the location, kiosk charging can constitute over a third of the total cost (\$2-\$7 per month) of owning an internet-capable device (Figure 1), and a significant portion of household income. Such conditions make daily charging prohibitive and curb smartphone ownership and use. Facebook research in Nigeria found that

over 60% of adult Facebook users reported not being able to charge their device regularly due to lack of electricity, limiting their use of the platform and other services.

Poor electricity supply also limits network reach and increases operational costs. Running base

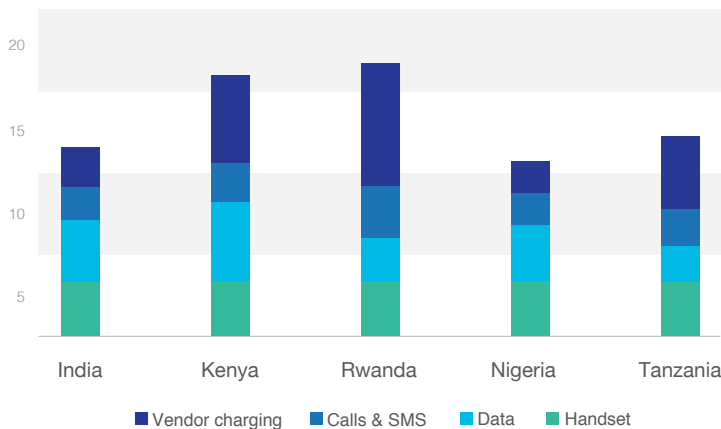
stations on diesel fuel instead of grid electricity is not just expensive, it also requires tower operators to run a complex fuel supply chain. Globally, mobile network operations (MNOs) and cellular tower operators spend \$3.8 billion for diesel fuel annually, according to Bloomberg New Energy Finance (BNEF) estimates.



<sup>10</sup> [Energy Access Outlook 2017](#)

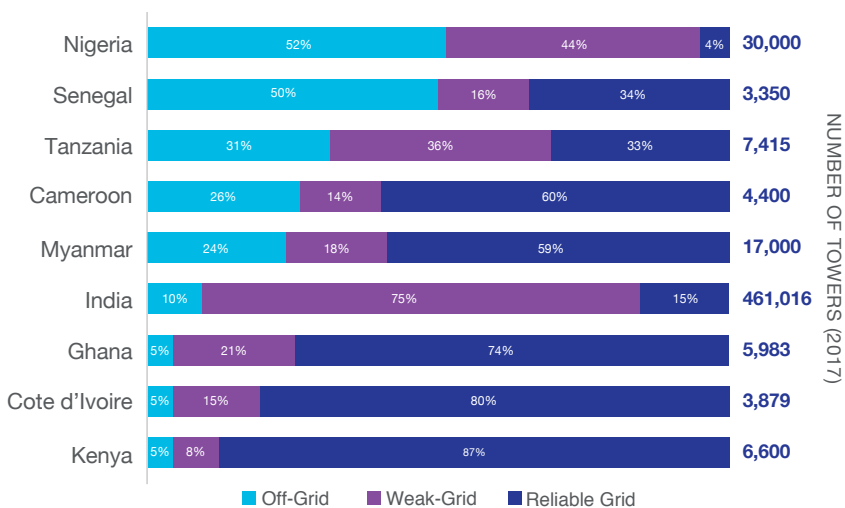
<sup>11</sup> [Decentralized energy systems for clean electricity access](#)

**Figure 1 | Estimated cost of off-grid smartphone ownership**  
Cost (\$/month)



Source: Bloomberg New Energy Finance, Research ICT Africa, Facebook. Assumes that handset costs are distributed over 36 months. Five battery charges per week.

**Figure 2 | Estimated status of power supply to telecom towers**



Source: Bloomberg New Energy Finance estimates compiled from various sources and company interviews. Note numbers on the right side of the bar chart are total tower counts.

## The Link Between Electrification and Connectivity

Use of the Facebook platform can often serve as a proxy for broader internet use,<sup>12</sup> and provide new insights into the barriers to universal connectivity.

Initial research from Facebook and the University of Massachusetts Amherst shows that household electricity access can have a strong causal effect on connectivity. The research teams analyzed two aggregated and anonymized datasets: internal Facebook app data for users in Kenya and data from the Kenya Power and Light Corporation.

Results show that households recently connected to the electricity grid show a significant and lasting increase in device utilization and new account creation on the Facebook platform.

### Key Results

Each new grid connection resulted in:<sup>13</sup>

- One additional smartphone connected to the platform
- 0.52 new users actively engaging on the platform within the first 12 months

To our knowledge, this is the first time that a causal relationship between better energy access and connectivity could be statistically shown.<sup>14</sup>

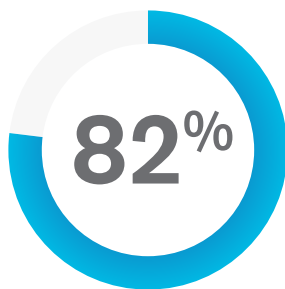
<sup>12</sup> Facebook research found that approximately 80% of Kenyan adults who were online in 2015 used Facebook

<sup>13</sup> The analysis focuses on the overlap between two consumer groups, limiting overall reach: (1) Facebook users with location services turned on and (2) KPLC customers with active/paying accounts in Jan-March of 2015.

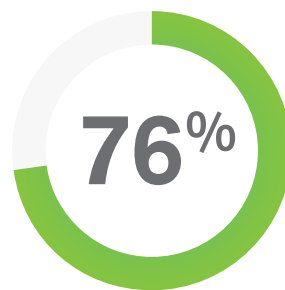
<sup>14</sup> Various other research highlights the correlation between energy and connectivity access. See for instance: [The centrality of electricity to ICT use in low-income countries.](#)

# Solar and battery storage are now cheap enough to play a key role

Small-scale photovoltaics (PV) and storage have started to gain traction as primary energy sources for remote infrastructure and communities, particularly when combined with innovative financing structures.<sup>15</sup> The critical components for such systems are rapidly becoming cheaper. Bloomberg New Energy Finance data show an 82% cost decline for PV modules and 76% for stationary Lithium Ion battery packs between 2010 and 2017.<sup>16</sup>



cost decline for solar since 2010



cost decline for Lithium Ion battery packs since 2010



Source: Bloomberg

<sup>15</sup> 5 Distributed Energy Trends in Emerging Markets

<sup>16</sup> Volume weighted average Lithium Ion battery pack prices in 2017 were \$209/kWh, primarily seen in the EV sector. Stationary storage developers can expect to pay a premium, with possible large volumes prices of \$240/kWh.

## Powering the consumers of new connectivity

Energy access companies are using these technologies to power connectivity with various business models, from small portable solar kits for individual households to village-scale microgrids that can power local businesses and cellular infrastructure (see Table 1).

**Table 1 | Solutions for powering connectivity**

Targets	Solutions	Notes
Households	Portable solar kits	Provides basic lighting and phone charging, from manufacturers like d.light, Greenlight Planet, Omnivoltaic, and <b>others</b> .
Households	Pay-as-you-go solar	Solar home systems sold with a financing plan, from actors like m-Kopa, Off-grid Electric, Mobisol, and others. Consumers often pay for use of the energy service via mobile money.
Communities	Microgrids	Community-scale power systems, often built and operated by startups like PowerGen, Electric Vine Industries or Husk Power, which supply electricity through a local distribution network. Consumers pay for the amount of electricity they use, often through prepay models.
Individuals	Phone charging kiosks	Mobile or stationary kiosks to provide more localized phone charging and other services, such as SolarKiosk or ARED, often powered by a battery, solar or other sources.
Households	Grid extension	Electricity distribution companies such as Tata Power Delhi or Kenya Power & Lighting Co have significantly boosted legal electricity connections and revenue collection in informal urban areas through targeted outreach or financing plans.

Source: Bloomberg New Energy Finance, Facebook.

## Powering connectivity infrastructure

Expanding a cellular network typically involves the construction of new towers for the base stations that connect mobile phones to the wider network. However, remote areas present unique challenges, including increased operating costs and lower customer density. A combination of cheaper, distributed solar-powered energy for conventional cellular infrastructure, and smaller, more efficient base stations designed to plug coverage gaps in the main network could reach more people at lower cost.

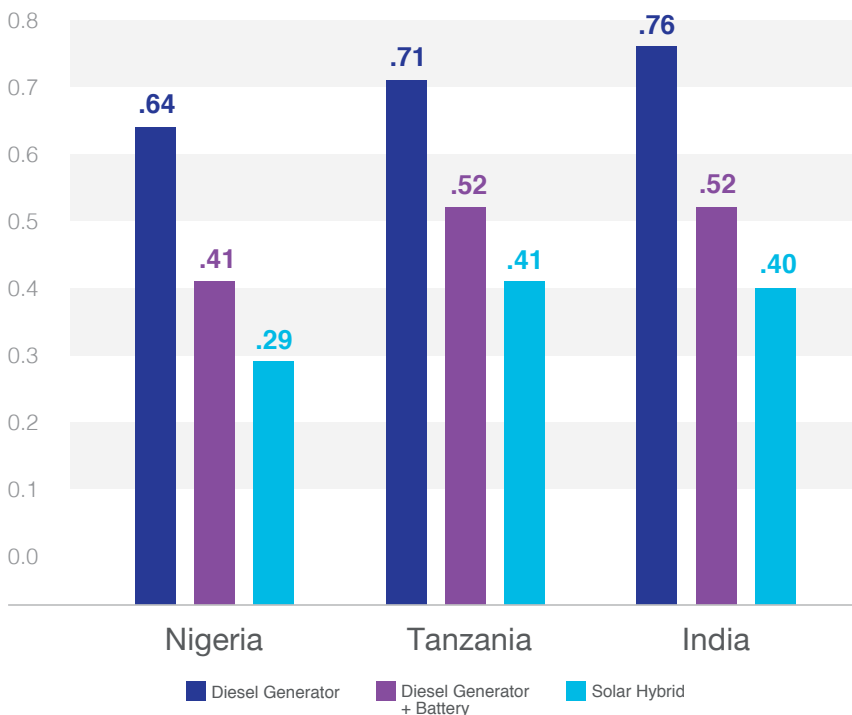
More than a million cellular towers in developing countries are off-grid or have at best extremely unreliable grid supply.<sup>17</sup> These towers typically rely on diesel generators for primary power during large parts of the day to avoid interruptions to the mobile network. Such generators, and the fuel they consume, can make up 40-50% of the operating costs of a tower.

One solution is already available in the market today. Composed of a mix of solar, diesel generator and

batteries, hybrid power systems can save MNOs or tower operators up to 54% of the energy cost for an off-grid tower that a conventional diesel generator would incur (Figure 3). Many tower operators nonetheless prefer to rely on established technologies or shy away from the far higher capital expenditure for solar. This opens an opportunity for specialized providers that can operate and finance solar energy for towers and help telecoms reduce the cost of serving remote areas.

**Figure 3 | Solar hybrids will be up to 54% cheaper than diesel for off-grid towers**

Cost of Electricity (\$/kWh)



**Source:** Bloomberg New Energy Finance based on company interviews, Homer Pro, Climatescope. **Note:** Diesel transport cost is not included.

<sup>17</sup> Green Power for Mobile



# Opportunities abound for partnerships and intervention

Innovators across the world are working to boost access to electricity and connectivity. However, to meet Sustainable Development Goals (SDGs) **7** and **9**, which call for universal access across both sectors, scale must be achieved faster. Without more entrepreneurs, more extensive distribution networks, easier access to capital and supportive enabling regulatory frameworks, there will be little traction. Partnerships between the connectivity and energy sector offer opportunities to accelerate progress toward both goals. MNOs, utilities and energy access startups can work together not just through investment, but also through operational collaboration and joint innovation.

## Collaborate

### Distribution and logistics

Mobile network operators are usually household brands with major distribution networks selling SIM cards, air time credit top-ups and other related products. These distribution channels can also serve as valuable routes to market for solar home system companies, leveraging existing MNO sales points, logistics hubs and brand association. Conversely, MNOs can enter into revenue share agreements for these services, as well as significantly boost customer loyalty by extending the range of services on offer.<sup>18</sup>

### Lumos Global and MTN partner in pay-as-you-go solar business

Lumos is a pay-as-you-go solar startup in Nigeria and the Ivory Coast. The company works in close collaboration with MTN, Africa's largest MNO. Lumos' service is co-branded and sold directly in MTN retail outlets.<sup>19</sup>

The partnership has enabled Lumos to ramp up its retail network quickly in new markets.

In addition to sharing retail points of presence and last-mile distribution infrastructure, MTN customer service staff can also address basic Lumos client requests. Co-branding increased consumer awareness and reduced quality concerns. Customers can also pay for the service directly via MTN.

<sup>18</sup> For more about collaboration for off-grid solar kits distribution, [read GSMA's report](#).

<sup>19</sup> [Lumos Mobile Electricity](#)

### Sharing data

MNOs and pay-as-you-go solar companies can also benefit from sharing consumer data, and thereby better understand customer characteristics and requirements. Better data and analytics can enhance customer acquisition, retention and upselling strategies for both parties. Each can also use the data to develop marketing campaigns, plan expansion, enhance customer service or even improve customer credit assessment when financing product purchases.

### Payments and mobile money

Most pay-as-you-go solar companies rely on mobile carriers to collect the large numbers of small payments from their customers, either through mobile money services or directly from a customer's balance. Both approaches boost MNO revenue.<sup>20</sup> Energy access could be expanded more rapidly if such partnerships and the necessary Application Programmer Interfaces (APIs)

to the telco's systems are more easily accessible. The IPN Hub, recently developed by GSMA, is a promising example of ways to ease mobile money adoption by the energy access sector, and accelerate deployment.<sup>21</sup>

### Deployment partnerships

MNOs struggle to source reliable low-cost power at the last mile, while local energy providers, particularly microgrid operators, require more stable sources of bankable revenue. Deployment partnerships present an opportunity, with both sides improving financial and operational performance. Through effective joint planning and co-deployment, specialized energy service companies can offer MNOs lower rates, while providing electricity to nearby households and businesses. One example, OMC Power, operates with this business model across India.

### Industry coalitions

In early stage technology markets, broad-based industry coalitions are a common means to accelerate

innovation, build consumer awareness and push for appropriate regulations. Alliances between energy access and connectivity companies can help to share best practices, explore partnership opportunities and collaboratively develop appropriate technology solutions. This kind of coalition also makes it easier for regulators to understand the common challenges that affect both energy and connectivity - such as licensing, customer identification or data privacy - and to create enabling environments through effective policy.

### The Telecom Infra Project (TIP)

is one example. Founded in 2016, TIP is an industry initiative focused on engineering solutions for network deployment, created by mobile network operators, equipment suppliers, project developers, integrators and startups. Within TIP, various working groups, like [OpenCellular](#) (see below), develop solutions to address barriers for improved connectivity.

<sup>20</sup> [The Symbiotic Relationship Between PAYG Solar and Mobile Money Ecosystems](#)

<sup>21</sup> [Mobile Money Instant Payment Notification Hub](#)

## Innovate

### Research, development and business model innovation

The basic technologies for most innovative energy and connectivity ventures, such as solar, batteries or smartphone components, are readily available today off the shelf. However, costs need to be reduced for these businesses to achieve scale, requiring innovation across the product chain, including standardization of key components and improved monitoring and remote management. Opportunities for innovative product development include smart meters and energy-efficient appliances, as well as software to reduce soft costs across payments, supply chain and customer service.

MNOs and other large corporations can support these efforts in various ways:

- Small research grants that allow new product testing (such as Microsoft's Affordable Access Initiative Grant Program)
- Startup accelerators and competitions that foster business model and process innovation (such as Fenix International's participation in the Orange Fab accelerator)
- Seed and early stage capital to build a business case for tested technologies (Orange later participated in Fenix International's Series B round)
- Sharing expertise by allowing employees to support partner startups in product development



### Small-cell networks and alternative infrastructure

Rural connectivity is primarily supplied by large cellular base stations with a range of over 20 kilometers that require at least one kilowatt of power (and often much more). While this infrastructure makes sense in dense areas, it often becomes operationally costly for rural areas with small, sparse population clusters. A network of smaller access nodes could potentially reach communities in a more targeted way while reducing overall power consumption.

A number of companies have been working on building such connectivity infrastructure. To help accelerate progress, Facebook launched the [OpenCellular](#) project under TIP to develop open source hardware and software for small-cell base stations. One of the project group members, [Nuran Wireless](#), is aiming for a complete

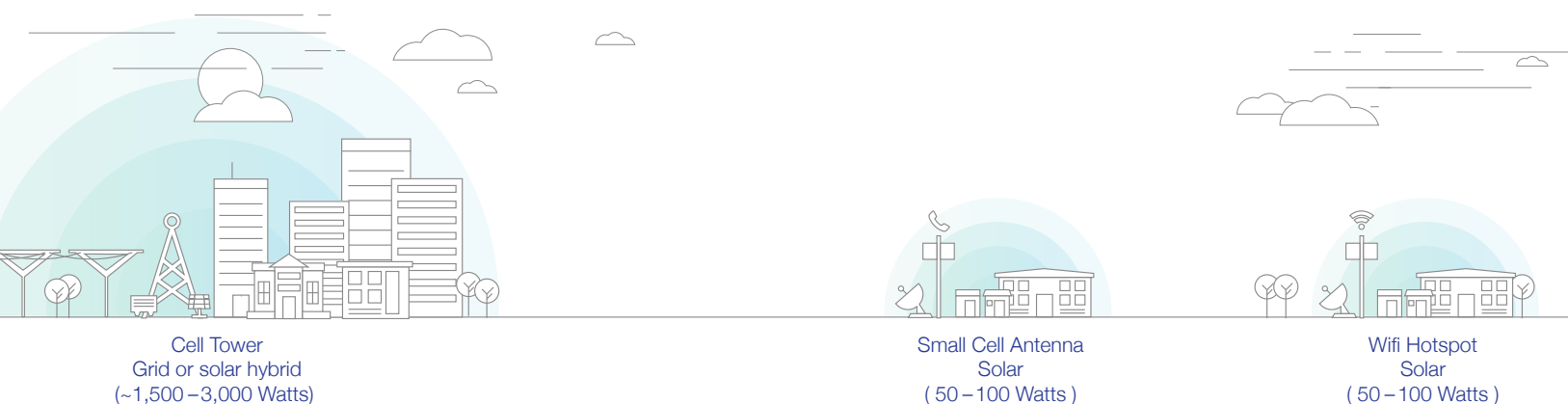
tower solution that costs \$7,000 with a 2G base station with a range of 1-2 kilometers. The power consumption of this base station is targeted for under 15 Watts, with the entire tower (including backhaul) consuming less than 50 Watts. The OpenCellular project is also working on an LTE base station with a power consumption of 55 Watts. Since the specifics of each site vary so much in population dispersion, revenue and terrain, the flexibility of small-cell infrastructure can enable network operators to optimize their deployments. Modeling using representative parameters from India showed that small-cell infrastructure could be more economical than diesel-powered macro towers even less than 10 kilometers outside of cities.<sup>22</sup>

Similar to the push for small cells, distributed rural access networks

using unlicensed spectrum, such as Wi-Fi and TV whitespace, have also begun to emerge. Initiatives like [Express Wi-Fi](#), [BRCK](#) and [Mawingu](#) are testing various network configurations to deliver broadband services to both urban and rural areas. The power requirements for these services are similar to that of small cells, and can provide additional opportunities for companies that can supply the appropriate equipment, software and services.

To realize the gains from more distributed infrastructure, power sources also need to be flexible and robust so they can be deployed and managed efficiently. As part of the OpenCellular project, Facebook has launched [OpenCellular Power](#), an open source project to support an ecosystem for power equipment specifically designed to support connectivity equipment.

**Figure 4 | Potential alternatives for last-mile connectivity**



Source: Bloomberg New Energy Finance, Facebook

<sup>22</sup> [ACM Digital Library](#)

## Invest

### Early stage equity

Venture and impact equity investment in startups remain one of the most popular ways for large companies to experiment with new approaches, get visibility into the market and benefit from the gains of early stage investment. Energy and equipment giants like GE and Shell are no longer strangers to the electricity access sector, and have participated in financing rounds worth as much as \$55 million.

While the majority of deals are still in early stage equity, some companies like [Off-Grid Electric](#), [M-Kopa](#), [OMC Power](#) or [Lumos](#) have gone far beyond the seed stage and raised tens of millions of dollars. Large companies can accompany new ventures as they mature. For instance,

the impact fund of French utility Engie invested in Fenix International's Series B round in 2015. A little under three years later, its Africa business unit acquired the company.

The most successful approaches could move beyond equity investment to operational partnerships, allowing startups to tap into their investors' networks and expertise. Engie's acquisition of Fenix International, for instance, is expected to make it easier for the startup to tap Engie's capital partners for debt to finance customer purchases.

### Debt capital

Debt, and local currency debt in particular, is one of the largest challenges to improved energy and

connectivity access. An increasing number of financial intermediaries are offering tailored products for energy access and off-grid solar companies, including [SunFunder](#), [responsAbility](#), [Lendable](#) and [SIMA](#). Many are starting to develop structured finance vehicles, which represent more commonly bankable structures for impact and commercial investors to participate in these markets. Many still employ blended finance structures, where affordable, risk-tolerant capital from development finance institutions and impact investors enables the participation of commercial investors. Boosting this pool of capital can accelerate the development of energy access debt markets that support innovative, but capital-heavy business models.



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