ELECTRIFYING ECONOMIES

DISTRIBUTED ENERGY REFERENCE SHEET

DEFINING DISTRIBUTED ENERGY

Distributed energy is the umbrella term used on this website to refer to systems that combine electricity generation, storage, and demand-side management at smaller scales (below 10MW, often much smaller) and close to final electricity demand.

Electricity generation is fully or primarily renewable, most often using solar photovoltaic (PV) systems. Storage systems are generally lead-acid or lithium-ion batteries, although other emerging technologies may become important over time. Demand-side management includes a range of activities related to energy efficiency and demand response, redistributing load to match supply or reduce infrastructure cost, for example through variable tariffs.

Importantly, these three components of distributed energy are not in isolation. Throughout the Electrifying Economies project, these resources are shown working together and complementing each other, as parts of a holistic electricity solution.

Two other terms are widely used, and are nearly synonymous with the approach to distributed energy described in this project:

- **Distributed Energy Resources (DERs)** are combinations of distributed generation, storage, and demand-side management, often shown from the perspective of value addition when taken together as clean energy portfolios. Although the name does not explicitly reference the renewable nature of the generation resources, they are generally understood to be dominated by renewables.
- **Distributed Renewable Energy (DRE)** refers to the generation systems used in distributed energy solutions, and is usually expanded to include a storage component. DRE is often used interchangeably with distributed energy or DERs.

BUILDING PORTFOLIOS OF DISTRIBUTED ENERGY

Distributed energy provides the greatest impact when integrated with traditional supply, working alongside distribution utilities. From the perspective of the utilities and government planners, there are great benefits to using portfolios of distributed energy. These can be bundled together in three main ways:

- **Extending energy access:**
  Using off-grid or undergrid minigrids to provide reliable power to areas that are too far for the main grid to reach cost-effectively, or where the distribution utility is unable to guarantee reliable power supply.

- **Non-wire alternatives:**
  Helping reduce loads on overstretched transmission and distribution via a set of distributed energy solutions, improving service throughout the system at a lower cost than building new infrastructure.

- **Clean energy portfolios:**
  Supporting the growth and adoption of a group (or portfolio) of distributed energy assets instead of building costly new centralized generation infrastructure, leading to lower cost energy services, and often lower carbon emissions.

COSTS OF DISTRIBUTED ENERGY

The cost of providing power using distributed energy is falling quickly. To track this cost reduction, we must follow three trends:

- **Global benchmarks:** the changing prices of distributed energy components, especially solar panels and batteries
- **Local realities:** the ability of local developers to access these hardware cost reductions and improve efficiency of operations
- **Cost of finance:** the perceived risks and maturity of the sector, which define the rates of return expected by local and international investors

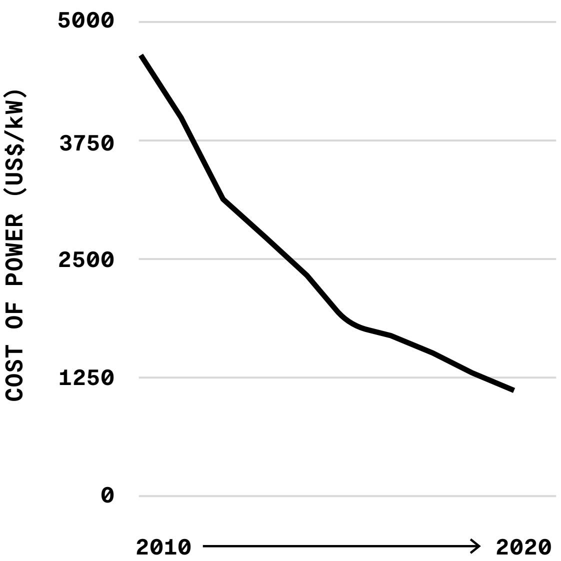
Global benchmark costs of solar panels and batteries are closely tracked and regularly published by institutions like IRENA and BNEF. The cost of distributed energy is often measured using the Levelized Cost of Electricity (LCOE), which is calculated as the annualized cost of producing energy (including capital and operational expenditures) divided by the annual electricity sales. It should be noted that the LCOE is sensitive to the discount rate applied and the internal rate of return sought by the investors.

A detailed explanation of the costs of minigrid components and approaches for calculating them was published by in RMI's "Minigrids in the Money" report (2018). At the time, best-in-class minigrids were able to provide electricity with an LCOE of US$0.60/kWh, and the report charted a route to reaching US$0.23/kWh within just a few years.

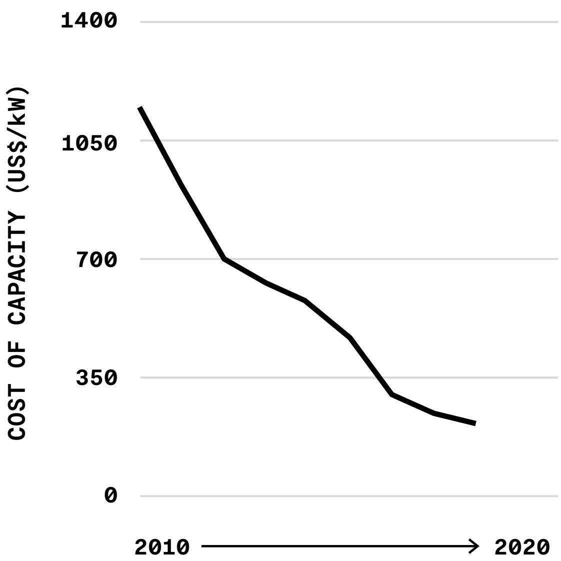
Benchmark costs have also been published in detail in ESMAP's "Mini-grids for Half a Billion People: Market Outlook and Handbook for Decision Makers" (2019), which suggests that LCOEs of $0.41/kWh are achievable in 2020. Falling component costs could drive overall costs down to $0.20/kWh by 2030, delivering power at a lower rate than most of sub-Saharan Africa's current utilities. Even more recent benchmarks are available in the Mini-Grids Partnership "State of the Global Mini-Grids Market Report 2020" and the Africa Minigrid Developers Association report on "Benchmarking Africa's Minigrids" (2020). Finance costs are highly dependent on the regulatory regime and the approaches adopted for subsidies or concessional finance as the sector scales; UNDP's "Derisking Renewable Energy Investment (DREI): Off-grid Electrification" (2018) looks at routes for reducing risk and hence finance costs.

Falling Cost of Installing Solar Panels and Batteries,
2010 to Present

Solar Panel Prices



Li-ion Battery Prices



DEVELOPMENT (WEIGHTED AVERAGE TOTAL INSTALLED COSTS)

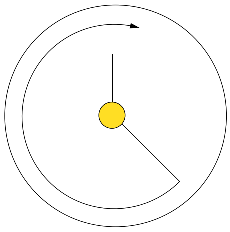
These reports agree that the cost of providing power via distributed energy is falling, and has the potential to fall much further, if the right actions are taken. In all cases, shaping demand is one of the single most important factors in reducing the cost of power: increasing total power usage and moving to more daytime loads through productive uses of electricity.

The development of the Electrifying Economies website involved additional modeling work to update costs and demonstrate the impacts of accelerating hardware cost reduction, by helping local developers buy solar panels and batteries at similar costs to major developers in more advanced markets. This simple measure can immediately reduce the LCOE by 15%, helping drive today's costs down as low as $0.34/kWh for well-designed projects.

Further detail on cost benchmarks and modeling approaches is given in the Detailed Cost Models and Benchmarks datasheet.

MULTIPLE BENEFITS OF DISTRIBUTED ENERGY

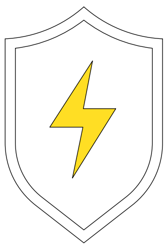
Faster to Deploy



It can take as little as two months to build and commission a new minigrid. While this is current best-practice by developers in India that depends greatly on the level of regulation and maturity of the market, the timeline for building a minigrid even in less mature markets today compares favorably with lead times for grid extension projects. One report notes that median project length for grid extension projects funded by the World Bank between 2000 and 2014 was nine years (cited in AMDA "Benchmarking Africa's Minigrids"). Literature examining electricity infrastructure development worldwide found that larger projects have greater risks of cost overruns and project delays, with greater impacts when they happen (see for example B.K. Sovacool et al, Energy 74 (2014) 906-917, which concludes that "small is beautiful" for decentralized energy projects).

The speed of deployment of distributed energy means the systems can offer financial savings, educational benefits, and climate benefits, as quantified in SEforALL and Power for All's "Why Wait? Seizing the Energy Access Dividend" (2017).

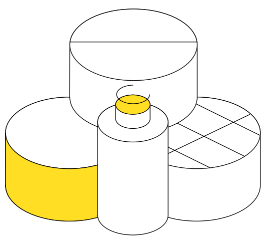
More Reliable



For rural customers, evidence points to levels of service and reliability that are far higher than national grid equivalents. AMDA's "Benchmarking Africa's Minigrids" provides a figure of 99% uptime for many minigrids (with the proviso that these figures are self-reported by developers).

Little research is available to estimate typical reliability of power in rural, grid-edge situations, but it is generally understood to be significantly worse than reliability in urban areas, which itself is already poor in most target markets. Anecdotal evidence from a number of sites suggests that figures of 40% power availability are not unusual.

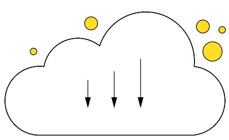
Resilient



Climate change is increasing the frequency of extreme weather events, with destructive effects on one-way power infrastructure. While storms cause power outages around the world, wildfires in California and hurricanes in the Caribbean have recently provided highly visible illustrations of the fragility of even highly developed energy infrastructure.

In recognition of this fragility, power systems are increasingly using distributed energy to power critical infrastructure and keep the lights on, as illustrated in RMI's "Solar Under Storm" studies. The increased resilience provides huge benefits for users in countries without universal electrification that have fewer resources to deploy and are often highly exposed to the impacts of climate change.

Low Carbon

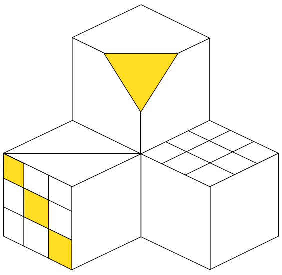


Distributed energy is dominated by renewable generation and can play an important role in avoiding future emissions from the power sector. Today, most new minigrids are solar hybrids that use back-up diesel supply for a small proportion of the time. However, as battery prices fall, and models for interconnected energy generation emerge, it may soon become cost-effective to eliminate the diesel back-up in many cases.

TECHNOLOGY DEVELOPMENTS IN DISTRIBUTED ENERGY

The falling costs of key hardware components for distributed energy are complemented by an increased availability of technology and software options that can improve planning, increase revenues, and reduce operational expenditures.

Modular Design

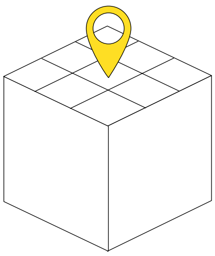


Minigrid loads take time to grow and reach their full potential. In communities where they are successful, incomes will increase, and demand will grow further. Building minigrids for future demand that may not materialize is risky and may leave the developer's assets stranded or underutilized for a long time.

In response to this challenge, there is an increased focus on modular minigrids. Modularity requires a little hardware innovation, especially in small inverters and interconnection of system components, but principally requires improved operational procedures. Developers are already expanding minigrid capacity over time, to keep track with demand and optimize the returns on the capital deployed.

Planning Tools

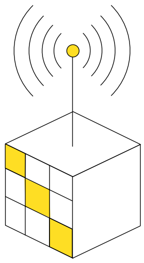
The use of geospatial analysis for identifying minigrid sites within national electrification plans has already become mainstream, using geographical information systems (GIS) and geospatial data. The **ESMAP Handbook** suggests that these tools can reduce site preparation costs from US$30,000 to just $2,300. More granular, regional analyses are also becoming common, drawing on a range of data sources to create detailed estimates of demand potential and ability to pay, helping developers prioritize sites and build portfolio. Technical design software takes these and additional inputs to cost the minigrid and develop initial system specifications.



Tools available for this type of analysis include the following:

- **Global Electrification Platform (World Bank, Google, and others) —** open access, interactive data platform that provides an overview of electrification investment scenarios for 59 countries; developed using the OnSSET model from KTH
- **Reference Electrification Model (MIT-Comillas)** — a model for producing least-cost system designs at a national or regional level
- **Energy Access Explorer (WRI)** — open source, interactive program using public datasets to visualize and prioritize energy access projects; beta version has data for Kenya, Uganda, and Tanzania
- **Homer (Homer Energy)** — design software for minigrids and other distributed energy resources
- **Energydata.info (World Bank Group)** — an open data platform for the energy sector, including links to several GIS datasets and analytics

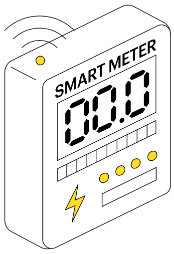
Digitalization



Remote operation, monitoring, and data collection are vital for efficient management of minigrids, and enable developers to reduce costs and provide additional services. Digital payments and solutions such as remote lockout technology enabled the growth of new business models for solar home systems and these technologies are being rapidly adopted in the minigrid sector. A detailed description of state-of-the-art digital solutions for energy access is provided in TFE Energy's "**Energy Access, Data, and Digital Solutions**" (2020).

Project aggregators such as **Odyssey Energy Solutions** provide platforms to manage portfolios, link to investors, and reduce transaction costs as developers seek additional finance options.

Demand Management



Several interventions can be used to shape the load curve and align demand with supply, reducing costs of providing power. Smart meters make it possible to control demand actively. Tariff innovation can be used to great effect, for example, by guaranteeing low-cost supply to productive users only during the day and cutting off power during the night, thus providing extra capacity for residential consumers.

Closely aligned productive use programs are also essential for distributed energy developers to have confidence that load will materialize over time. The provision of appropriate appliances and affordable finance should always be linked with the provision of power. A range of examples and business models are evolving in response to this need.

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The Electrifying Economies project demonstrates the role distributed energy will play in ending energy poverty and catalyzing a green and equitable recovery from the Covid-19 crisis. It draws on the latest data and research from around the world to show how distributed renewables can provide sustainable, affordable, and reliable power for all. The project provides information to support policy makers and investors in taking action today, to realize this potential.

#ElectrifyingEconomies
ElectrifyingEconomies.org