EXECUTIVE SUMMARY

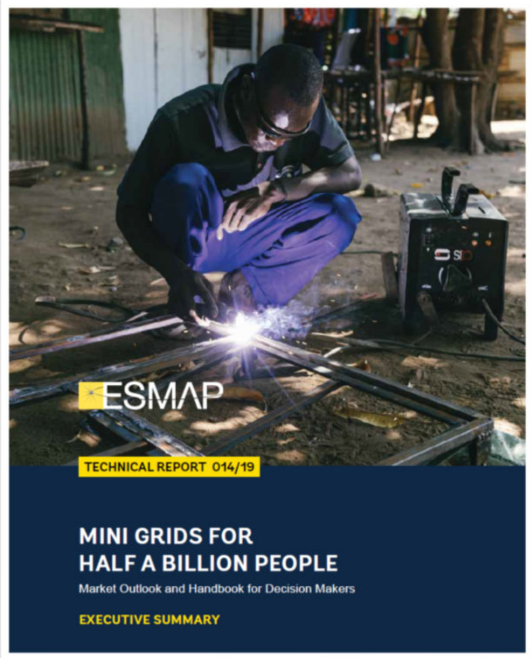
Mini Grids for Half a Billion People

WORLD BANK GROUP
Energy & Extractives

5th Mini Grid Action Learning Event and Summit

Global Technical Conference on Mini Grids

June 26, 2019



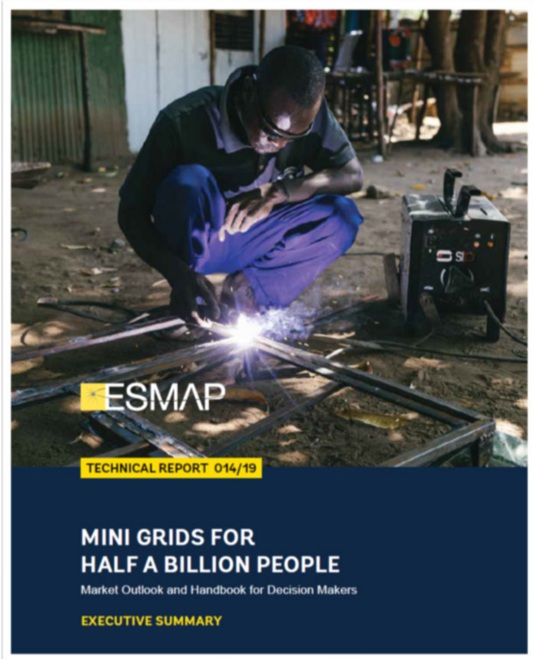
5 Action Learning Events with about 2,000 participants in total

10 knowledge frontiers researched in detail

Learning by doing through 37 World Bank mini grid operations for example Bangladesh, Myanmar, Kenya, Nigeria, Haiti possibly Ethiopia and Ghana

Roster of outstanding experts and magnificent team

Partnerships for example with:
industry: AMDA, companies
civil society: RMI, SNV
development partners: DFID, CIF, AfDB, GIZ
service providers: HOMER, Odyssey, Castalia, TTA, Inensus
research: NREL, MIT
host and client governments



Databases with:

- 26,000 mini grid projects
- 53 solar (hybrid) mini grids with detailed CAPEX costing
- 1,000+ operator surveys in 3 countries
- 37 World Bank mini grid investments in 33 countries

Executive report part of knowledge package with focus on implementation:

- 500 page main report, answering the 'how' question
- Volume with supporting annexes
- Volume with country and case studies
- Videos, animations, infographics
- More than dozen presentations

The **second generation of mini grids** can be found in modern developing countries. These systems are typically small and isolated, and generally built by local communities or local entrepreneurs to provide access to electricity in zones with low population densities and low demand, primarily in rural areas that have not yet been reached by the main grid or where it would be too prohibitively expensive to extend it.

Typically, such second-generation systems are built to supply electricity to single villages. The developers, whether public or private, are motivated by the overriding need to supply rural communities with a higher level of electricity service as soon as possible. When these mini grids are developed, little thought is given to the possibility of later interconnecting with the main grid, and many of them are simply abandoned when the main grid arrives. If they do not go out of existence, these mini grids often choose to become small power producers (particularly if using a more affordable renewable energy generation source rather than diesel); or small power distributors, converting to buying all of their electricity supply wholesale from the main grid and selling it to the local customers at retail prices.

Developers of such second generation mini grids almost always rely on standard existing technologies – such as diesel or mini hydro generation – as well as basic meters, on-site meter reading, and in-person bill collection. They also generally charge flat monthly tariffs or postpaid fees calculated and collected at the end of each month

based on the customers’ power consumption for that month.

As you have heard from James’ presentation, our (ESMAP’s) data indicates that the almost all of the 19,000 mini grids that we’ve identified across the world are 2nd generation systems.

A **mini grid** is
anything else than the main grid.

A **mini grid** is an electricity generation and distribution network that supplies electricity to a localized group of customers.

Mini grids can be isolated from and/or connected to the main grid.

Definition of a Mini Grid

Mini grids are electric power generation and distribution systems that provide electricity to just a few customers in a remote settlement or bring power to hundreds of thousands of customers in a town or city. They can be fully isolated from the main grid or connected to it but able to intentionally isolate ("island") themselves from the grid. Mini grids supply power to households, businesses, public institutions, and anchor clients, such as telecom towers and large agricultural processing facilities. They are designed to provide high-quality, reliable electricity. A new, third generation"of mini grids has recently emerged, which are solar hybrids, incorporate the latest technologies such as smart meters and remote monitoring systems, and are typically designed to interconnect with the main grid. The "Where Mini Grids Fit in the Electricity Sector" section provides a detailed description of 3rd generation mini grids.

But what is a mini grid? And why are they the best solution for such a large portion of the remaining unelectrified groups?

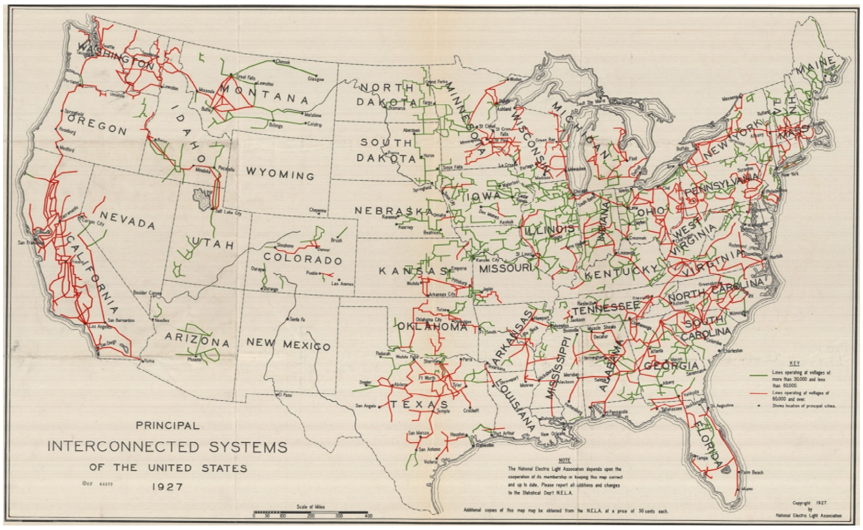
We at the ESMAP Global Facility on Mini Grids define them as electric power generation and distribution systems that supply electricity to a localized group of customers, and exist as a single controllable entity within clearly defined electrical boundaries. We intentionally do not define mini grids in terms of size – in our interpretation, they can provide electricity to just a few customers in a remote settlement, or bring power to tens or hundreds of thousands of customers in a town or a city. Nonetheless, in our detailed analysis of mini grid costs and in our global database of more than 26,000 mini grid projects – both of which are discussed in our Executive Summary report, and presented in detail in the main report - the vast majority (more than 99 percent) ranged from a few kW to several MW in installed capacity.

Mini grids can be fully isolated from the main grid, or connected to it. If they are grid-interconnected, mini grids must be able to intentionally isolate (or 'island') themselves from the main grid.

Mini Grids supply power to households, businesses, public institutions, as well as anchor clients, such as telecom towers and large agricultural processing facilities.

We at the ESMAP GFMG categorize them across three generations of systems.

1st Generation of Mini Grids

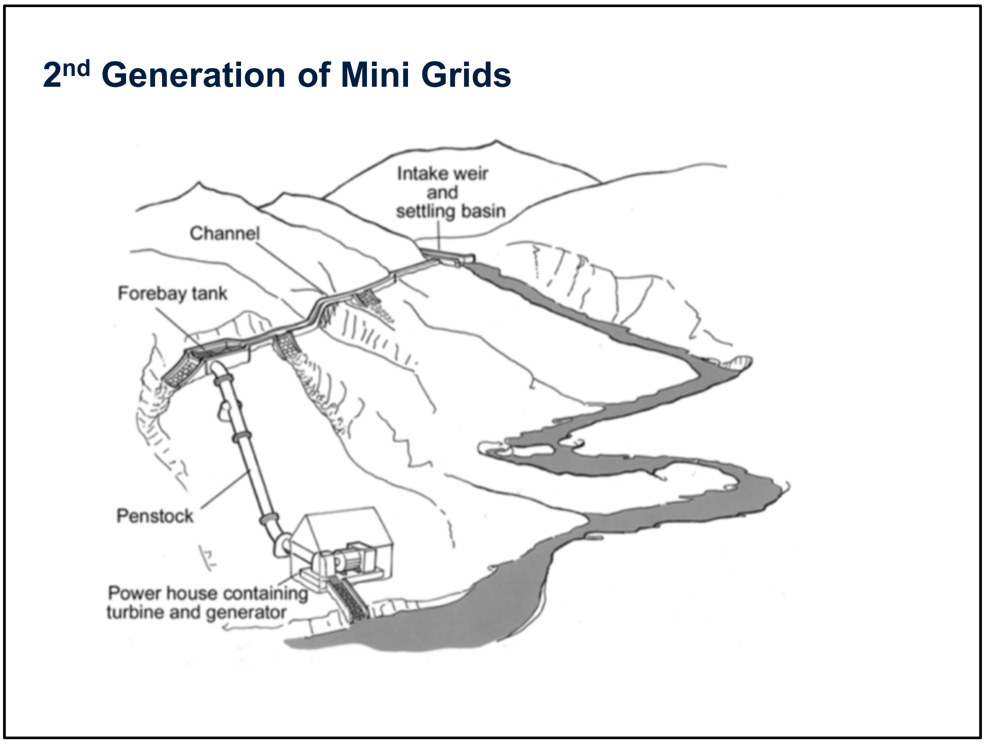


U.S. power system network in 1927

Mini grids are not a new phenomenon: all current centralized power grid systems started will small isolated power systems and mini grids.

These systems were the initiating “spark” of electricity uptake some 130 years ago, and were pivotal to the early development and industrialization of most modern economies, such as the United States, United Kingdom, Sweden, Spain, Ireland, China, etc. While these systems were initially few and scattered, their development was coupled with, and amplified by, the co-evolution of supply, demand, disruptive technology, and policy. As technologies improved, demand increased, and the policy and regulatory regimes stabilized, larger generators could be built, and electricity could be transmitted over longer distances. These factors resulted in the emergence of centralized utilities (either privately or publicly owned). Mini grids either became integrated with one another, forming the nucleus of a larger centralized system, or were absorbed by a larger grid system as it expanded. We describe these historical systems as the **first generation of mini grids**, which faced many of the same policy, regulatory and operational challenges experienced by mini grids in developing countries in Sub-Saharan Africa and Asia today.

One key note about these systems – which was already exemplified so eloquently during his Monday presentation by Mr. Jakab of the Steinbeis Consulting Centre: Private power companies would not or could not serve all of the population and provide power at large scales. The unelectrified areas were filled with small municipal public systems, rural cooperatives, and large federally owned power generation corporations—and supported through public and nonprofit entities, such as Rural Electrification Agencies and, in the United States, the National Rural Electric Cooperative Association (which was referred to by Mr. Jakab as the American AMDA).



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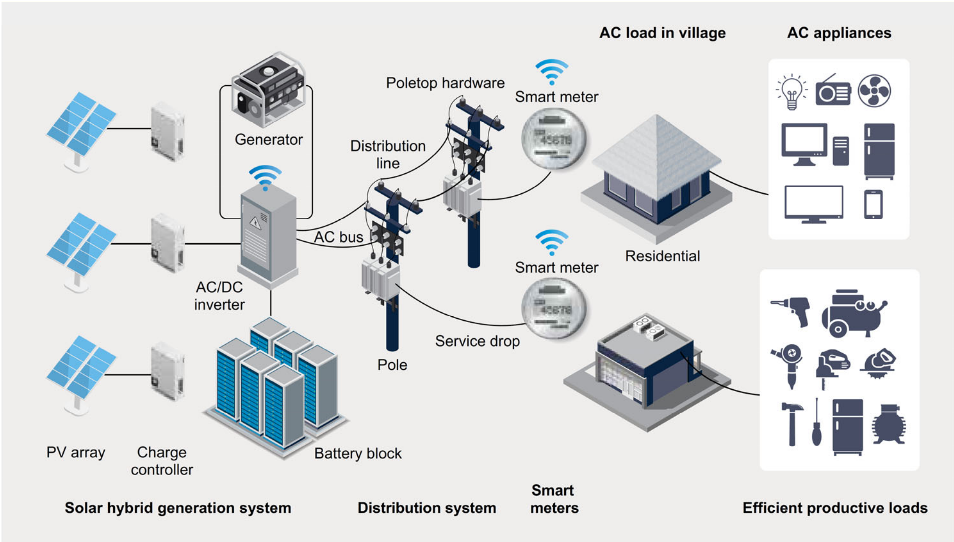
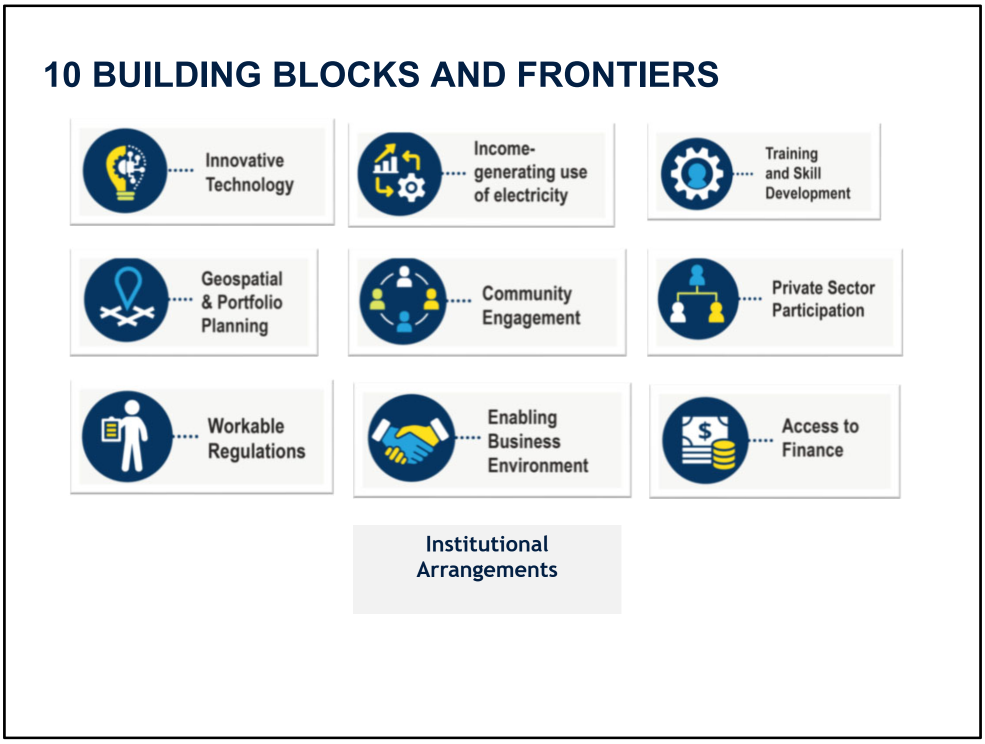
3RD GENERATION OF MINI GRIDS



Note: AC = alternating current; DC = direct current; PV = photovoltaic.



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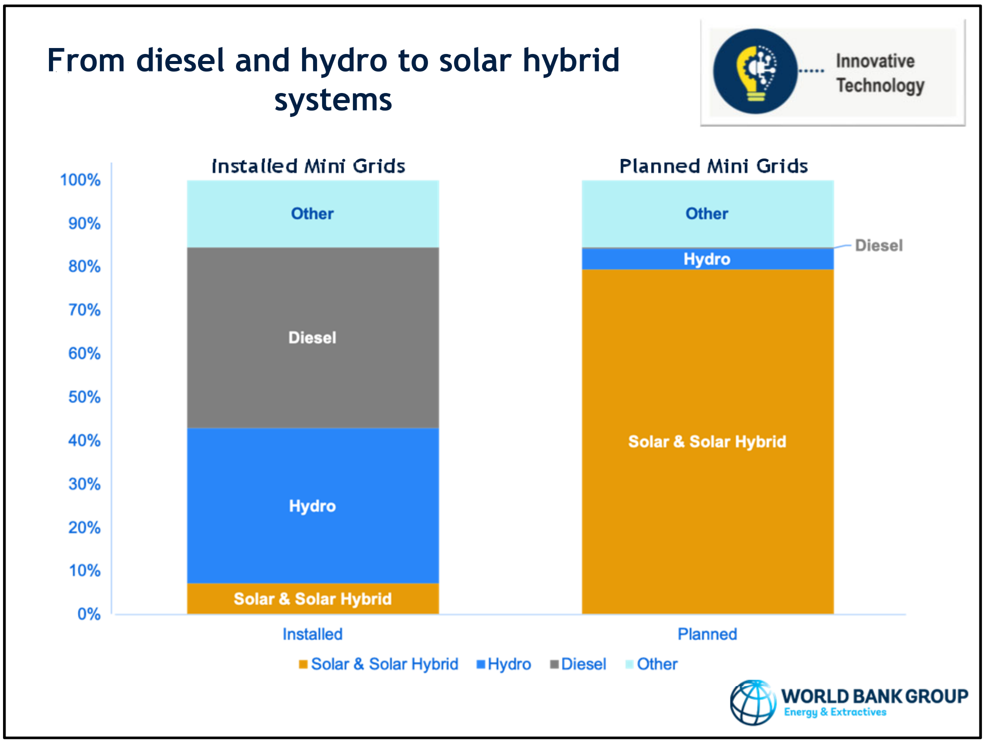
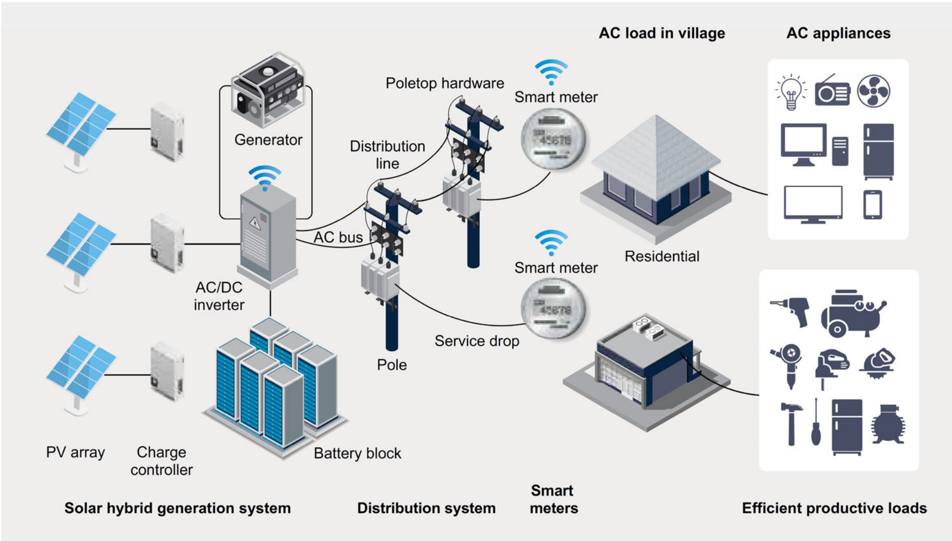


Finally, more than 80 percent of planned mini grids will use solar PV, while about half of existing mini grids run only on diesel generators. Other capacity in this chart includes primarily wind and biomass.

REMOTE CONTROLLED | SMART METER ENERGY EFFICIENT APPLIANCES | GRID INTERCONNECTION READY

Innovative Technology



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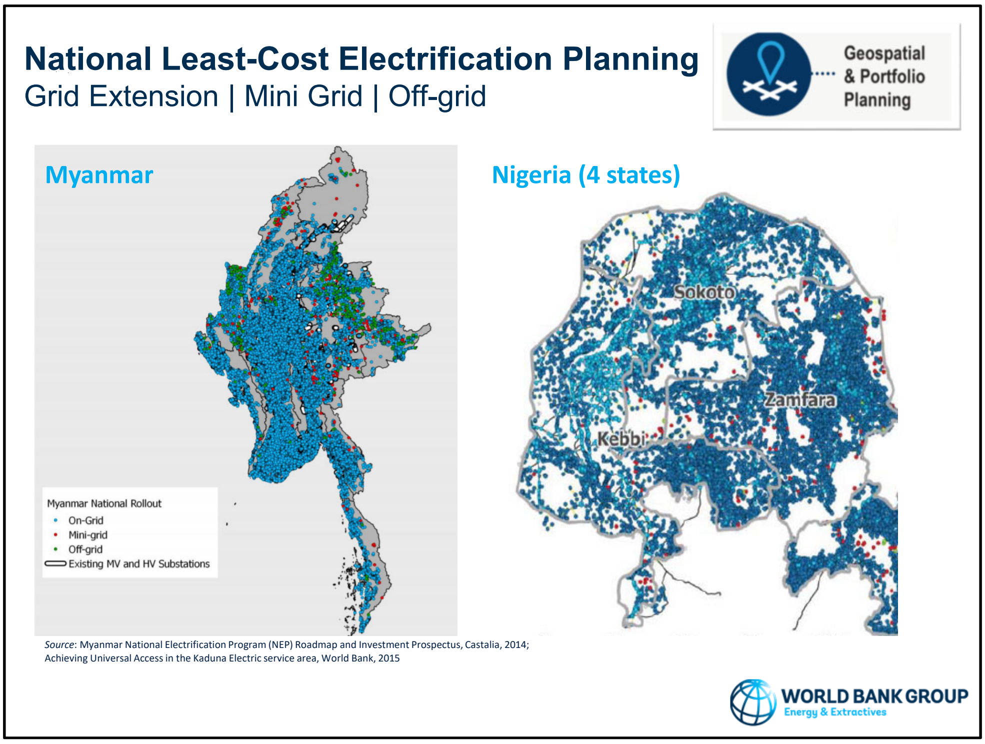
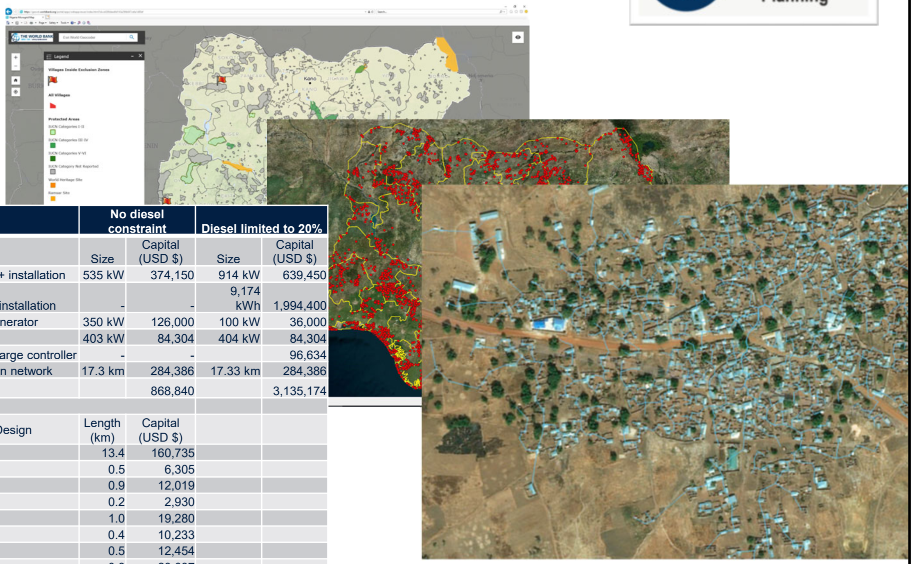


Countries are using geospatial analysis to develop national electrification plans that clearly delineate areas for mini grids (figure ES.5). Through a geospatial approach to national electrification planning, the existing grid network is mapped and its attributes are digitalized. The supply of and demand for electricity are geo-located and overlaid with supporting data, including demographic (population density and growth patterns); social infrastructure (schools, health centers, churches, administrative offices); and economic (household income, poverty, commercial activities, willingness to pay) data. Spatial modeling then delivers a least-cost plan that identifies the optimal grid or off-grid technology—technology that is tailored to local circumstances, technically feasible, and economically viable.

Mini Grid Portfolio Planning

Magnitude Change in Costing | $3,200 per site

Geospatial & Portfolio Planning



	No diesel constraint		Diesel limited to 20%	
	Size	Capital (USD $)	Size	Capital (USD $)
Solar PV + installation	535 kW	374,150	914 kW	639,450
Battery + installation	-	-	9,174 kWh	1,994,400
Diesel Generator	350 kW	126,000	100 kW	36,000
Inverter	403 kW	84,304	404 kW	84,304
MPPT Charge controller	-	-		96,634
Distribution network	17.3 km	284,386	17.33 km	284,386
Total		868,840		3,135,174
Network Design	Length (km)	Capital (USD $)		
Weasel	13.4	160,735		
Ferret	0.5	6,305		
Rabbit	0.9	12,019		
Horse	0.2	2,930		
Dog	1.0	19,280		
Dingo	0.4	10,233		
Panther	0.5	12,454		
Zebra	0.3	23,637		
Other	0.2	36,793		
Sub Total	17.3	284,386		

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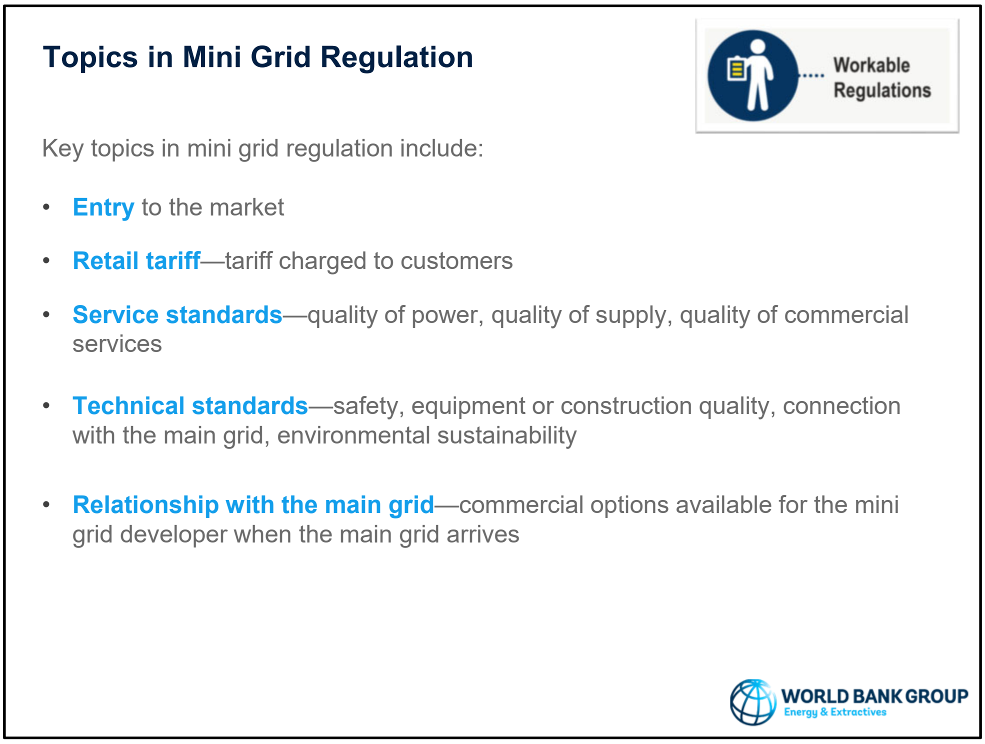
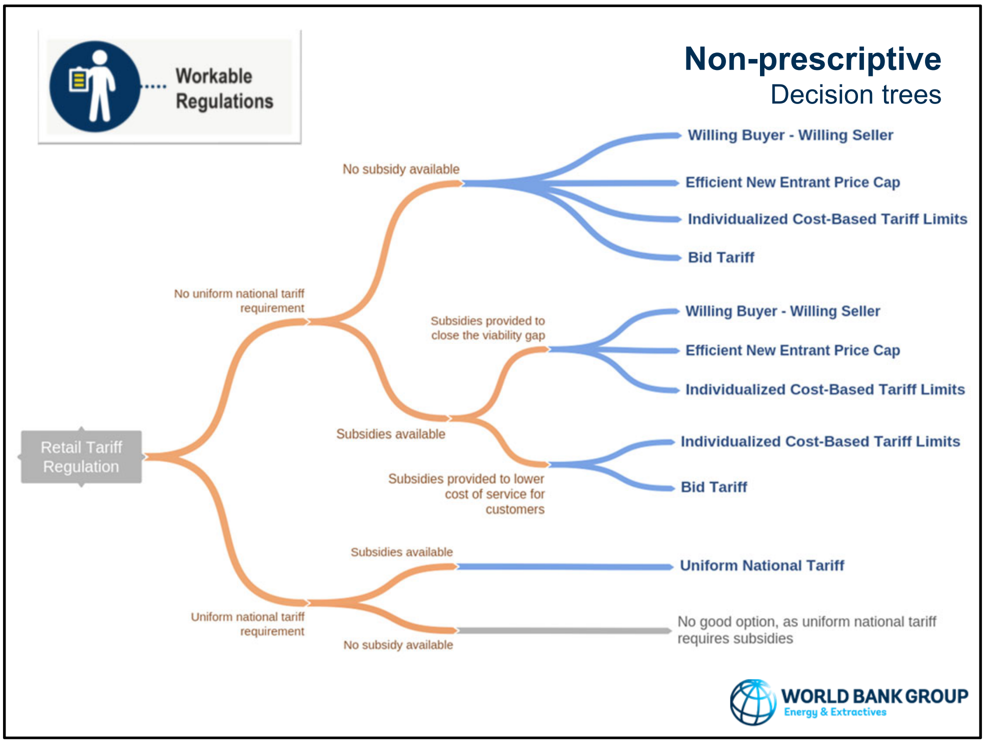


Service standards:

- Quality of power: e.g. voltage stability, frequency stability
- Quality of supply: e.g. hours of service, reliability,
- Quality of commercial services: e.g. customer service, accuracy in meter reading

Technical standards

- Safety: e.g. safety distances and protection corridors, pole height
- Equipment or construction quality: e.g. types of inverters, expected longevity of solar panels
- Connection with main grid (or between mini grids):
    - Distribution network poles, conductors, and insulators to ensure the network can handle the quantities of electricity that flow when energized by the main grid
    - Generation synchronization, to ensure safe and reliable operation of the grid when connected to the mini grid generator
- Environmental sustainability: e.g. toxic waste management

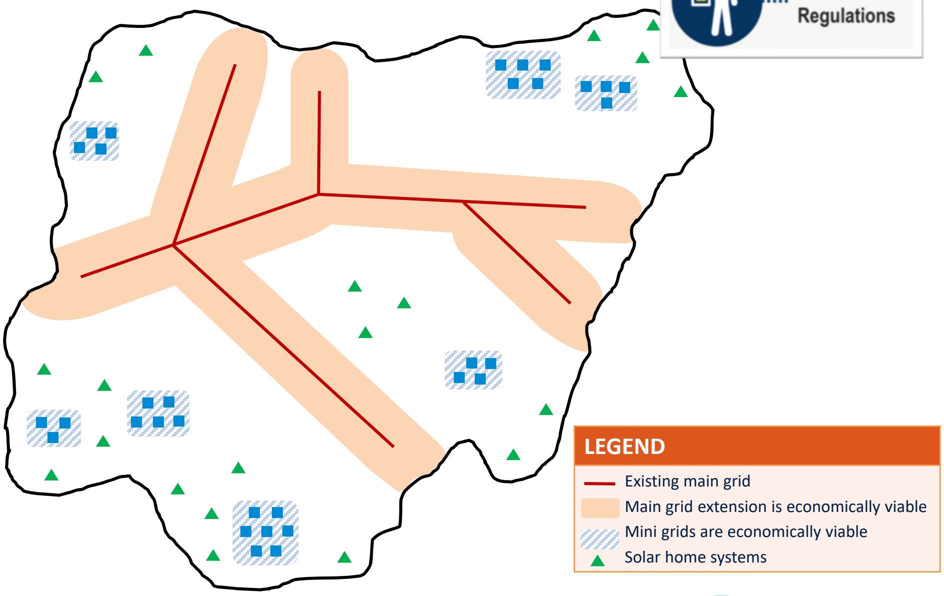


- **The decision tree provides guidance to regulators** on how to choose the regulatory approach that suits their objectives and context, and given legal and policy constraints. The decision tree is not exhaustive or prescriptive but does aim to indicate what might make sense in certain common scenarios
- **The key questions that will guide the regulator's choice are the following:**
  - Whether there is a policy requirement of uniform national tariff
  - Whether subsidies are available
  - If subsidies are available, what are the subsidies objectives: to expand access by closing the viability gap, or to ensure equity of affordability by lowering the cost of service for customers ?
    - If the goal is to close the viability gap to maximize access, efficient new entrant price cap and individualized cost-based tariffs are most appropriate. Willing buyer willing seller is an option but may be politically hard to implement (subsidies are provided but no tariff regulation). Bid tariff is not appropriate because subsidies may go to profits instead of expanding access.
    - If the goal is to reduce the cost of service below customers' willingness to pay, tariff regulation is warranted to ensure that subsidies do translate into lower tariffs
- **Other key criteria for regulators to evaluate their options are**:
  - **Tariff accuracy** (whether the tariffs set is cost-reflective): Individualized cost-based tariff limits ensure high tariff accuracy unlike a uniform national tariff.

If mini grids can set cost-reflective tariffs, this will increase the chances of attracting private investment.
  - **Risk of monopoly pricing**: willing buyer willing seller presents a high risk of monopoly pricing unlike individualized cost-based tariff limits
  - **Suitability to rapidly expand access:** a bid tariff approach is suitable given that it aims to rapidly scale up access in specific areas; while uniform national tariff may not be appropriate to scale up quickly, since this option primarily aims to ensure equity among customers in the country
  - **Regulatory capacity needed:** willing buyer-willing seller would require little to no regulatory capacity, while design of competitive tender or individual cost-based tariffs would require a lot.
  - **Compliance cost for the developer**: efficient new entrant price cap would impose little compliance costs while submitting a bid in a competitive tender would impose high costs on the developer
- **Regulators may opt for different options for retail tariff regulation between small and large mini grids**.
  - **Tiered-approach** as in Nigeria and Tanzania**:** willing buyer - willing seller option for smaller mini grids, and individualized cost-based tariff limits for larger mini grids
  - **Two-track electrification approach**, with two coexisting methods to set mini grid tariffs, as in Kenya: some mini grids in the North of the country will be developed under contract with the utility and charge the uniform national tariff, while in the rest of the country they develop spontaneously and are subject to individualized cost-based tariff limits

Mini Grids Evolve Over Time

Workable Regulations



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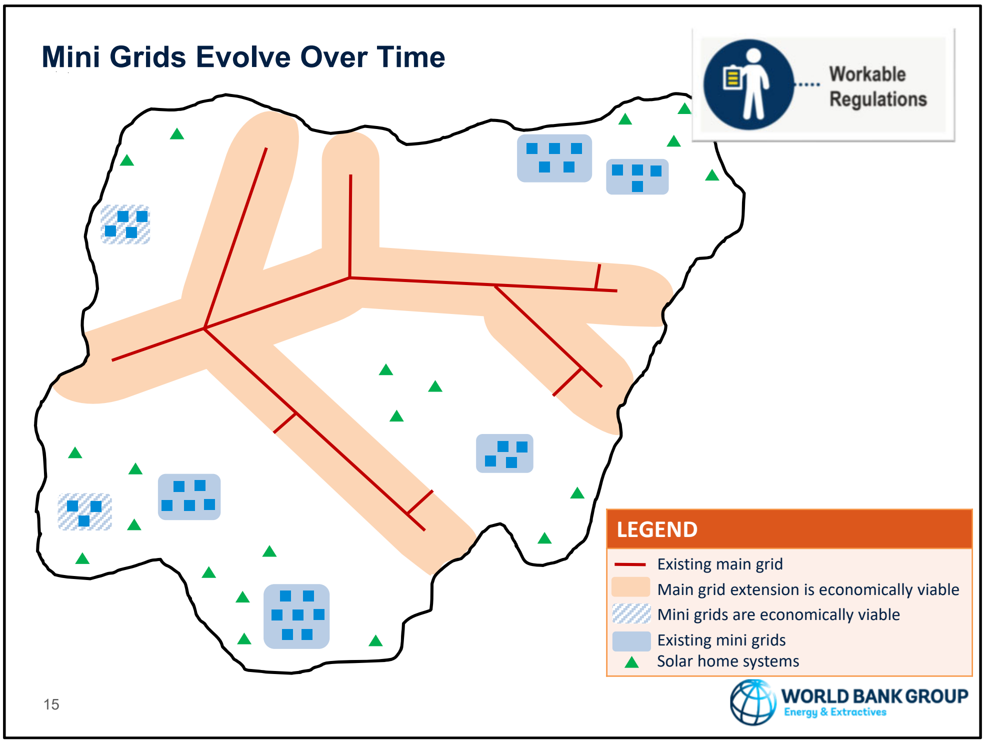
Mini Grids Evolve Over Time



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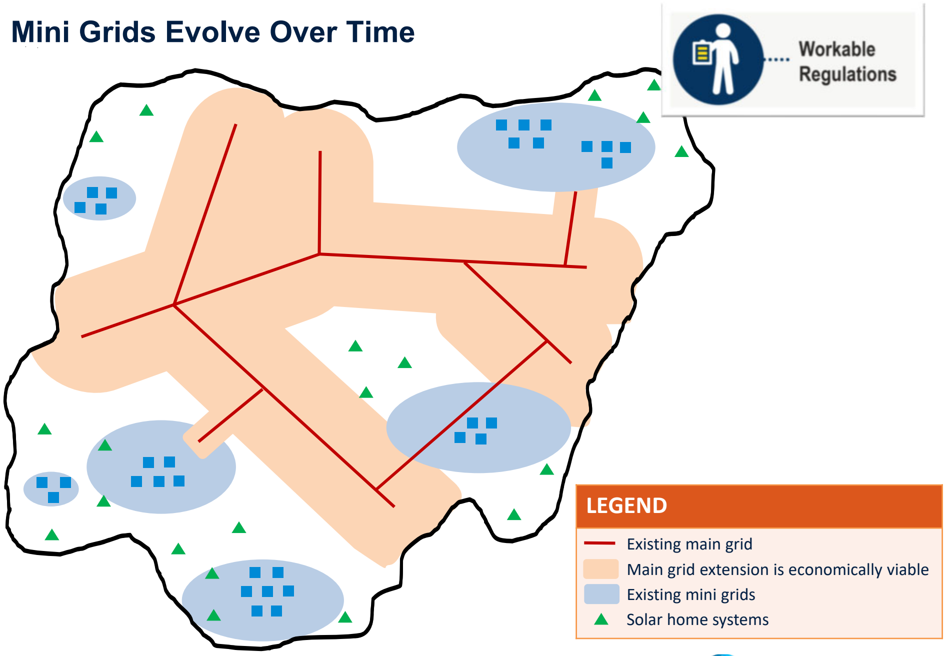

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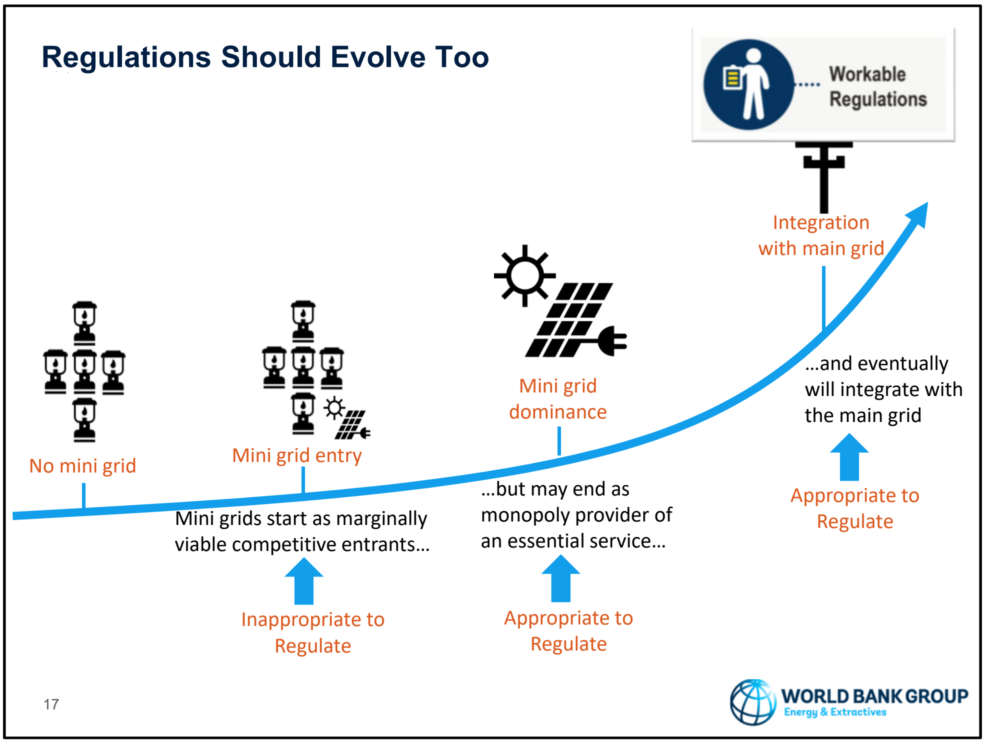
Regulations Should Evolve Too
Workable Regulations
Integration with main grid
Mini grid dominance
No mini grid
Mini grid entry
...and eventually will integrate with the main grid
...but may end as monopoly provider of an essential service...
Mini grids start as marginally viable competitive entrants...
Appropriate to Regulate
Inappropriate to Regulate
Appropriate to Regulate
17
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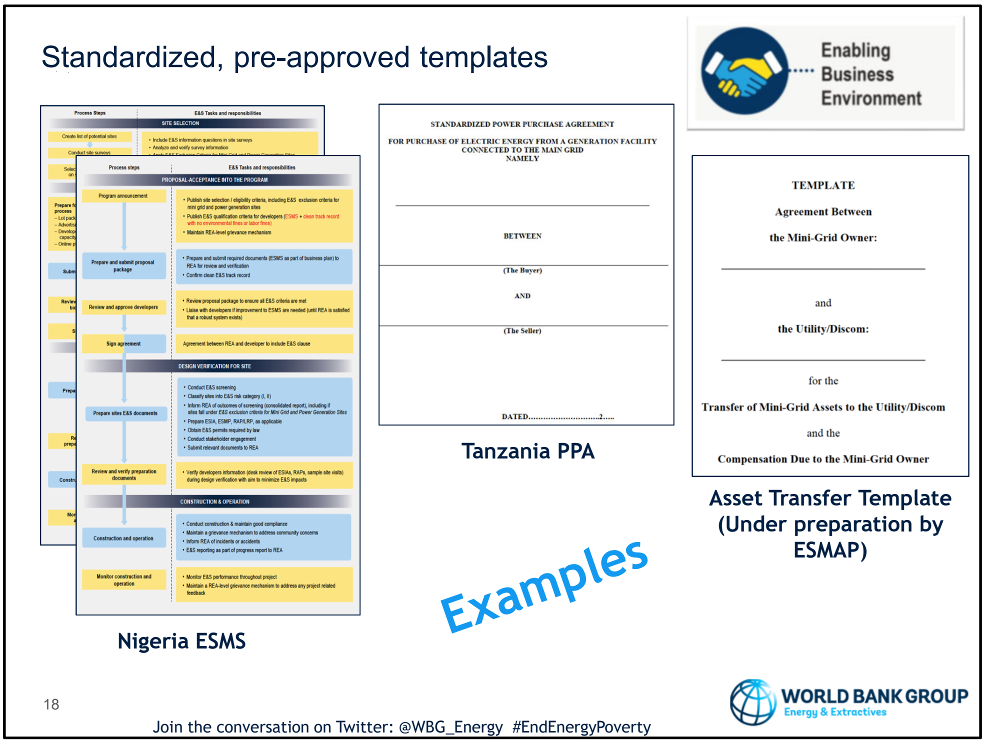
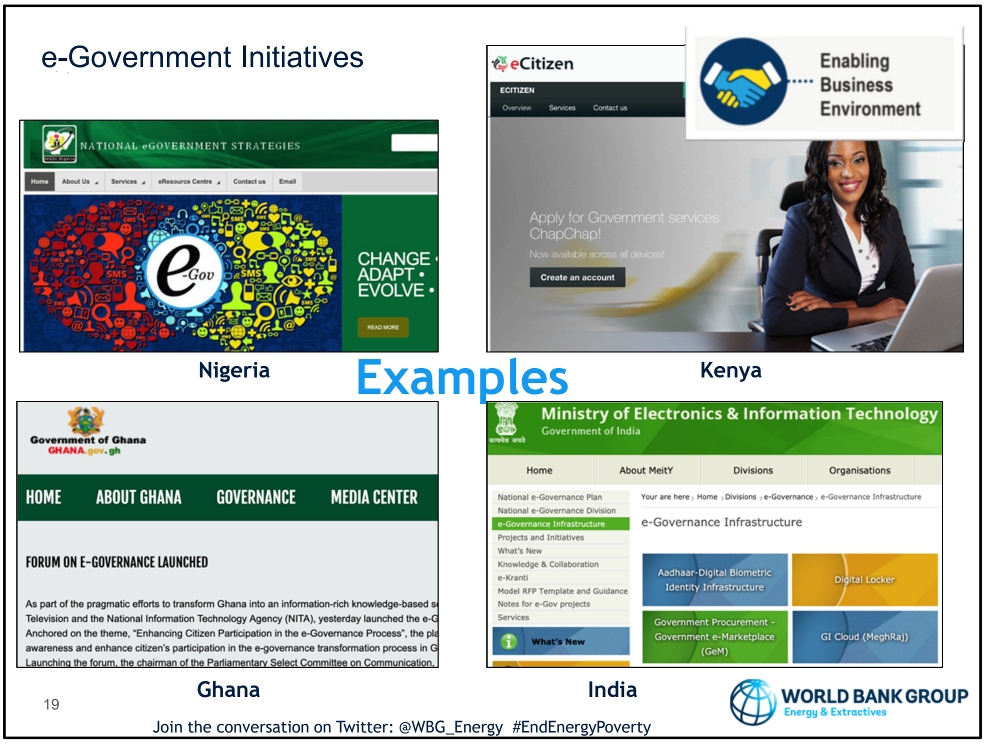


The first strategy to cut red tape is to develop pre-approved standardized templates. Three examples that we've come across are:

1. standardized environmental and social management system for when mini grid developers must obtain environmental approvals. This is currently being used in Nigeria.
2. standardized power purchase agreements for when mini grid developers intend to sell electricity to the main grid. This is currently in use in Tanzania.
3. standardized asset transfer agreements for when mini grid developers intend to sell their eligible assets to the main utility. This is currently being prepared by ESMAP.

The first template simplifies the process for obtaining approval of the developer's environmental and social management system – it reduces costs for the developer AND for government agencies that oversee environmental and social issues. The other two templates help mini grid developers negotiate with the national utility on more even and transparent terms.

All three templates should only be used after they been approved by the relevant government authority, and all three templates share the disadvantage that they are not tailored to the specific needs and characteristics of individual projects or deals.



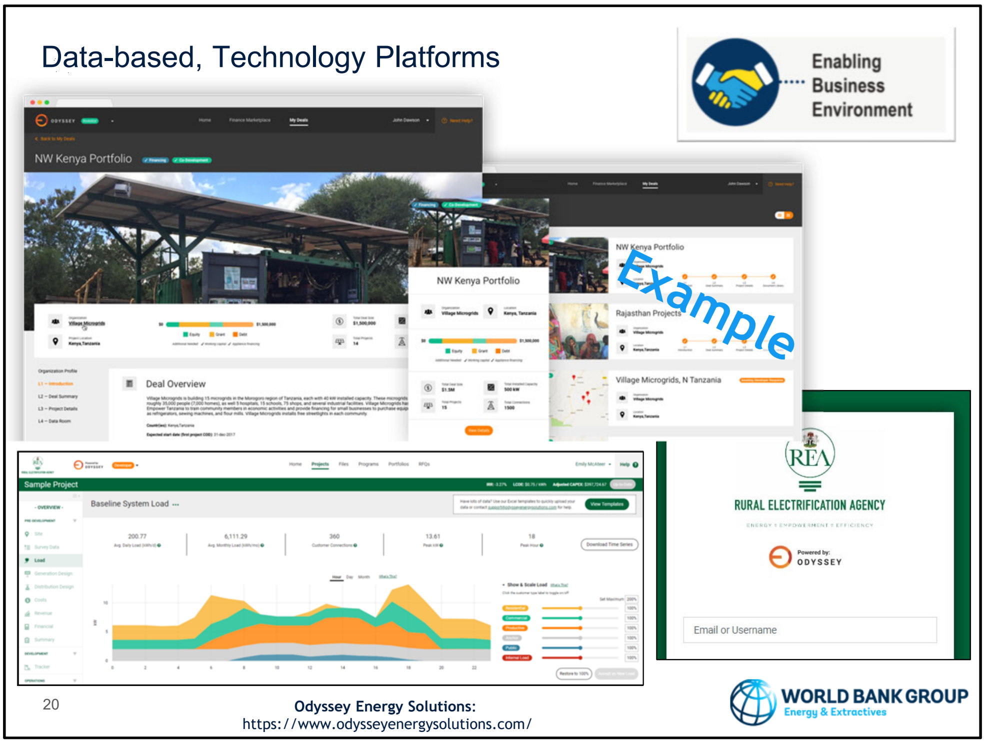
The last strategy that I wanted to talk about today is e-Government initiatives. These initiatives provide citizens and businesses with a way to interact with government agencies online.

Various e-Government tools are in use in many countries around the world. India, Kenya, and Nigeria are recent examples from countries where mini grids are expected to play an important role in reaching universal access to electricity. Earlier this month, Ghana launched its first public forum on e-Government.

For mini grid developers, the idea is to make it easy for them to find the latest forms, regulations, and policies online, apply for licenses, registrations, permits, etc., and receive the decision online. Ideally this would be done through a one-stop shop specific to mini grids.

The main advantage for developers is that it speeds up many processes that would normally take days or weeks to do in person.

The main disadvantage is that it requires security and data protection on both ends (government and citizen or business), and these may not (yet) be possible in some countries.

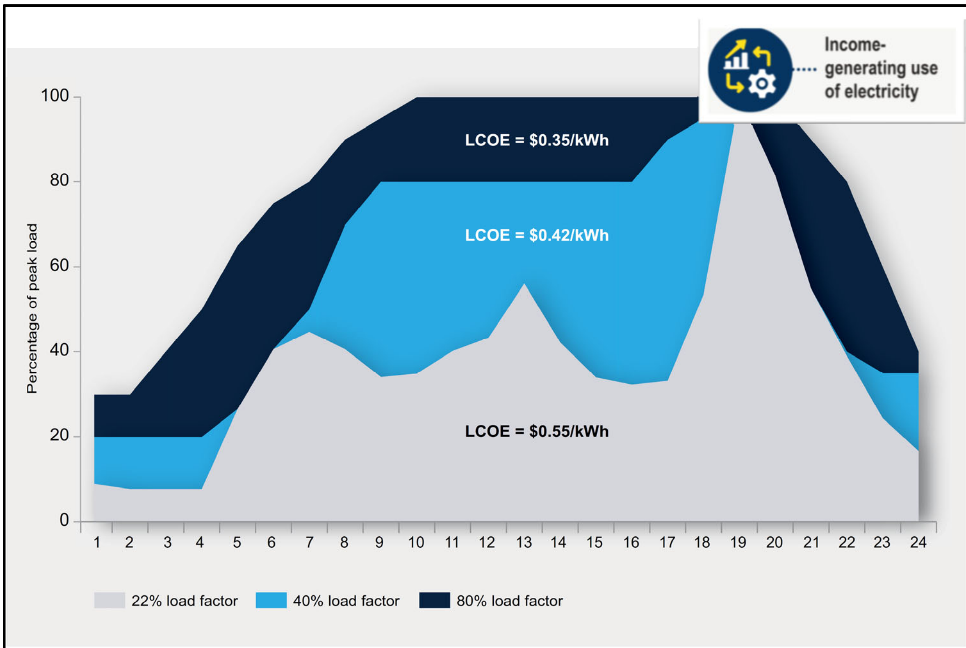


The second strategy for cutting red tape is to use technology platforms to connect developers with financiers and component suppliers. The goal is to help investors finance mini grid portfolios and to help developers secure financing and attractive deals from component suppliers. The platform can also be used for large-scale tenders of mini grids.

The best example of this type of platform that we've seen so far is Odyssey Energy Solutions, which is being used to run the mini grid tender for Nigeria Electrification Project implemented by Nigeria's Rural Electrification Agency, with support from the WB.

The main advantages of a platform like this is that it increases market efficiencies. It: 1) Reduces transaction costs for developers, suppliers, and financiers; and, 2) it Increases efficiency and transparency for large-scale tenders.

The main disadvantages of using an online platform is that it may pose privacy concerns for some developers and investors, and it may crowd out small-scale community-led projects.



Source: ESMAP analysis.

Note: kWh = kilowatt-hour.

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APPLIANCES WITH PAYBACK < 1 YEAR

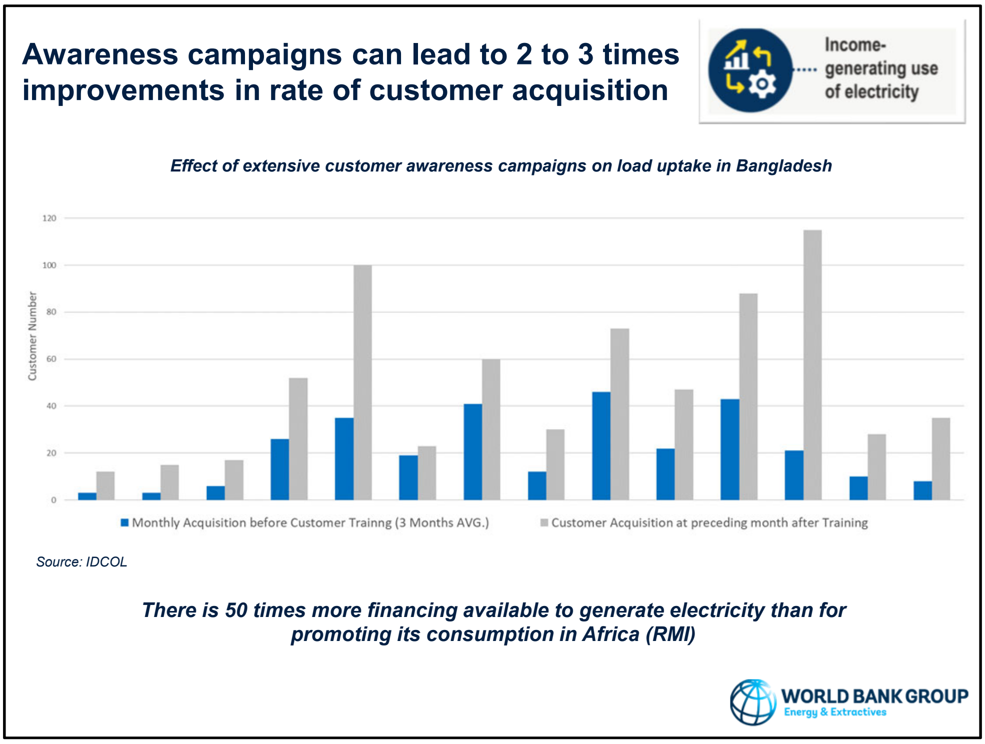
NEED SUPPLIERS AND MICRO-FINANCE

Income-generating use of electricity

Sector	Activities / Appliances	Power required (kW)	Cost from supplier ($)	Payback period (months)
Primary industries (agriculture, fishing)	Egg incubator	80 to 160W	$50 to $100	1 to 3
	Grinder for pulses and beans	5.2 kW	$1,500 to $4,000	6 to 12
	Water irrigation pump	3.7 to 22.4 kW	$200 to $1,000	3 to 6
	Sterilizer (for dairy processing)	3 to 6kW	$600 to $2,000	1 to 3
	Packager	250W to 3kW	$500 to $1,000	6 to 12
Light manufacturing	Electronic welding machine	3 to 7.5 kW	$200 to $300	6 to 12
	Jigsaw	400W	$100	3 to 6
	Electric drilling machine	400W	$20 to $50	3 to 6
	Popcorn maker	1.5 to 2.1 kW	$50	1 to 3
Commercial and retail activities	Computer	15 to 100W	$250 to $800	3 to 6
	Printer/scanner for stationery	0.5 to 2kW	$150 to $250	3 to 6
	Sewing machine	200W	$30 to $100	3 to 6
	Television for local cinemas and bars (including decoder)	50 to 200W	$100 to $200	1 to 3

Source: ESMAP, Alibaba, Inensus.

Note: Chapter 5 of the main report provides the full table of 37 income-generating machines and other equipment.
kW = kilowatt; W = watt.



Customer awareness campaigns can be effective as illustrated in the Bangladesh example.

IDCOL launched intensive customer awareness campaigns since October 2017 to address load uptake challenges. They combine customer training with public events such as folk song, shows and street drama. They have enabled significant improvements with increase in customer acquisition after customer training up to 500%.

What happened?
IDCOL organized three-day intensive sessions conducted by international experts and trainers from major equipment manufacturers. Simultaneously management skill development trainings were arranged for developers. It also tried to incentivize daytime loads via time-of-use packages and financing conversion packages ($120–$400 depending on industry and load).

Assessing profitability of operators

	ESCO 1	ESCO 2	ESCO 3	ESCO 4	ESCO 5	IPP		
Revenue	$46	$85,050	$1,564	$40	$145	$73.9 M	$43.7 M	$10.5 M
Gross Profit	-$251	$63,168	$985	$4	-$36	$32.1 M	$9.9 M	$2.5 M
Net Income	-$2,600	-$33,448	$672	-$11,100	-$148	$2.2 M	$4.8 M	-$148,000
Net Profit (% of Revenue)	-5454%	-39%	43%	-2744%	-102%	2%	10%	-11%
SG&A (% of Revenue)	2,700%	15%	16%	370%	88%	16%	8%	2%
Asset turnover	0.01	0.15	0.12	0.01	1.88	0.43	0.69	0.32
Return on Assets	-65%	-6%	5%	-32%	-191%	1%	7%	-4%
Current Ratio	7.14	0.81	1.82	0.32	0.04	1.06	1.12	1.06

- **Profitability remains challenged:** high personnel expense, other revenue (e.g. grants) key to offset more loss, need to incur CAPEX, should target 1-10% net profit
- **Cost containment:** SG&A high relative to comps … focus on hiring local resources, using digital tools to drive productivity
- **Low asset turnover / ROA:** driven by high investment needed over low revenue base; identify other monetization opportunities

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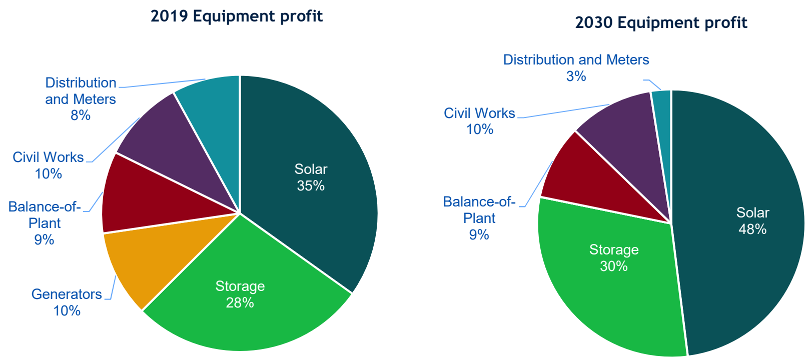
Equipment value chain profit potential

Private Sector Participation



Partnership among local and international industry

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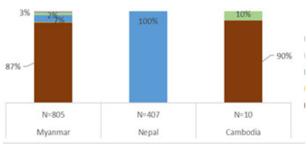
Results from first ever survey of operators

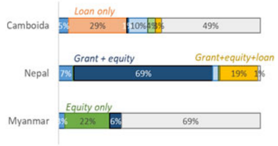
Select findings

Private Sector Participation

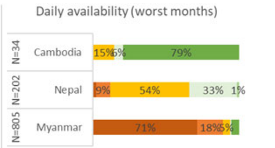
Majority of mini grids diesel-powered; all hydro powered in Nepal



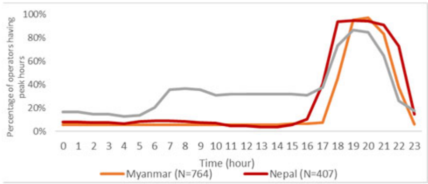
Most capitalized w/ grant & debt; use grant & equity in Nepal



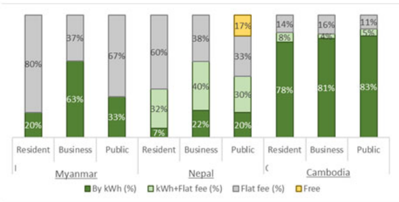
Cambodia: 24 hrs; Myanmar: 0-4 hrs., Nepal: <12 hrs.



Large evening peak, with some productive uses driving day load in Cambodia



Large portion of developers use flat fee in Myanmar & Nepal; volumetric in Cambodia



Full results available in "Mini grids for half a billion people" report

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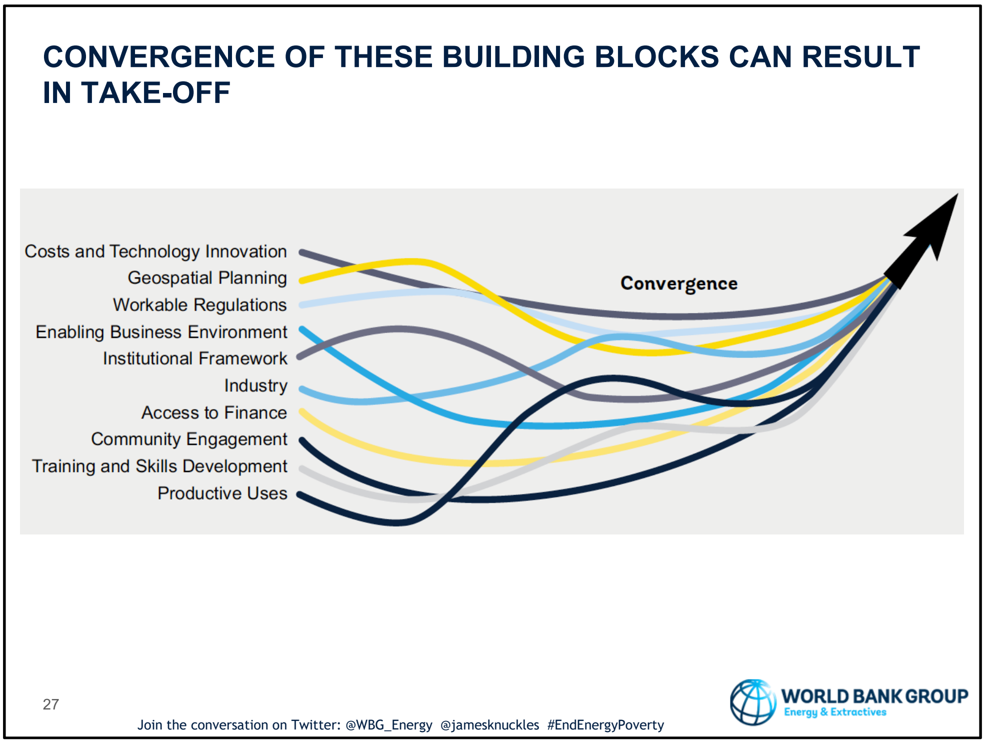

So, how do we get from where we are today – which is 47 million people connected to 19,000 mini grids – to where we want to be to reach universal access by 2030, which is 490 million people connected to 210,000 mini grids?

To be clear, this would represent a 2-orders of magnitude increase in the number of mini grids deployed in each of the 20 countries with the highest electricity access deficit per year – from 10 mini grids per country per year today to 500 per year by 2025 to 1,500 per country per year by 2030.

Achieving this scale will require 10 building blocks to be in place in each country in order to achieve this 2-orders of magnitude increase. These building blocks are: (i) solar-hybrid technology and costing, (ii) geospatial portfolio planning, (iii) income-generating uses of electricity, (iv) community engagement, (v) local and international industry, (vi) access to finance, (vii) training and skills building, (viii) institutional framework, (ix) workable regulations, and (x) enabling business environments.

KEY DRIVER FOR TAKE-OFF: COSTS

Cost of Solar-Hybrid Mini Grid Today . . .

$3,908/kW
Total Capital Expense

$690/kWp
Solar PV Module

$598/kWh
Lithium-ion Batteries

$264/kW
PV Inverter

. . . and by 2030

<$3,000/kW

$140/kWp

$62/kWh

$58/KW

Cost of Unsubsidized Solar Hybrid Mini Grid Electricity (LCOE) . . .

$0.55/kWh baseline today

$0.42/kWh with income-generating machines to achieve 40% load factor

$0.22/kWh with income-generating machines & expected 2030 costs

. . . Compared with Utilities in Africa

$0.27/kWh average across 39 utilities

2 of 39 utilities with cost-recovery tariffs

Load factor (percent)	Levelized cost of electricity ($/kWh) 2018	2030
22%	0.55	0.33
40%	0.42	0.22
80%	0.35	0.23[7]

Source: ESMAP analysis.
Note: LCOE data are for a well-designed 294kW_{firm} solar-hybrid mini grid in Bangladesh serving more than 1,000 customers (more than 5,000 people). A detailed description of the underlying analysis is provided in chapter 3 of the main book. kWh = kilowatt-hour.

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IMPACT OF PERFORMANCE BASED GRANTS ON LEVERLIZED COST OF ELECTRICITY

Load factor (percent)	Share of performance-based grants of CAPEX (percent)	2018 ($/kWh)	2030 ($/kWh)
22	0	0.55	0.33
22	40	0.43	0.23
22	60	0.37	0.19
40	0	0.42	0.22
40	40	0.34	0.15
40	60	0.31	0.12
80	0	0.35	0.23
80	40	0.31	0.19
80	60	0.29	0.17

Source: ESMAP analysis.

Note: Levelized cost of electricity data are for a well-designed solar-hybrid mini grid with 294 kilowatts of firm power output serving more than 5,000 people. A detailed discussion of the underlying analysis is presented in chapter 8 of the main book. CAPEX = capital expenses; kWh = kilowatt-hour.

40 - 60% of CAPEX Performance Based Grants is about $300 to $800 per connection

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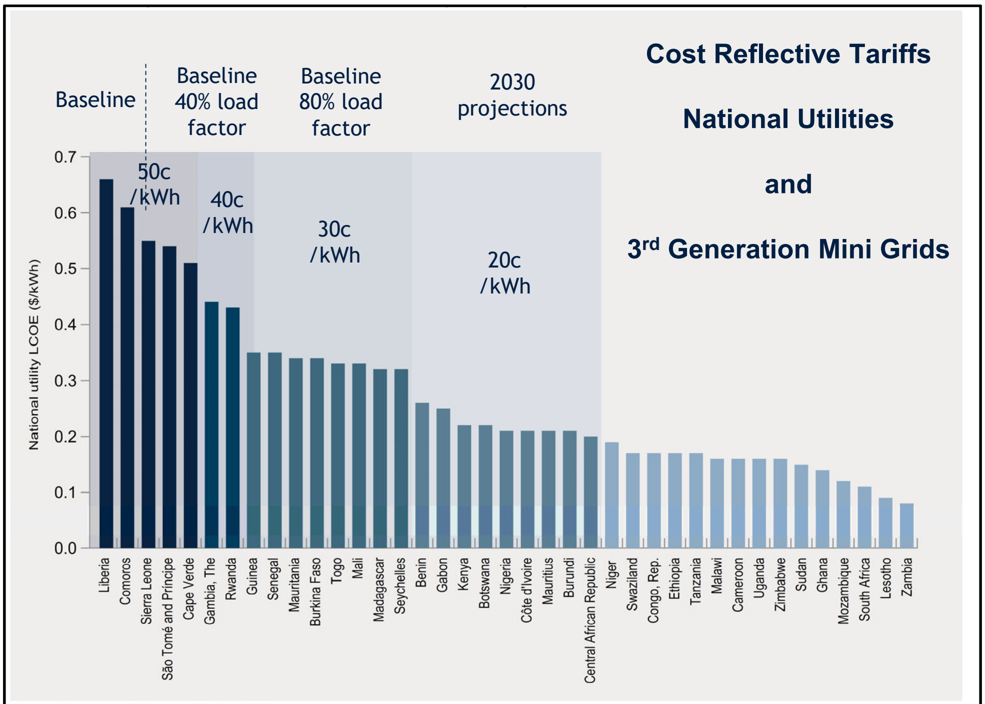


Source: Based on Kojima & Trimble 2016.
Note: kWh = kilowatt-hour; LCOE = Levelized cost of energy.

The **second generation of mini grids** can be found in modern developing countries. These systems are typically small and isolated, and generally built by local communities or local entrepreneurs to provide access to electricity in zones with low population densities and low demand, primarily in rural areas that have not yet been reached by the main grid or where it would be too prohibitively expensive to extend it.

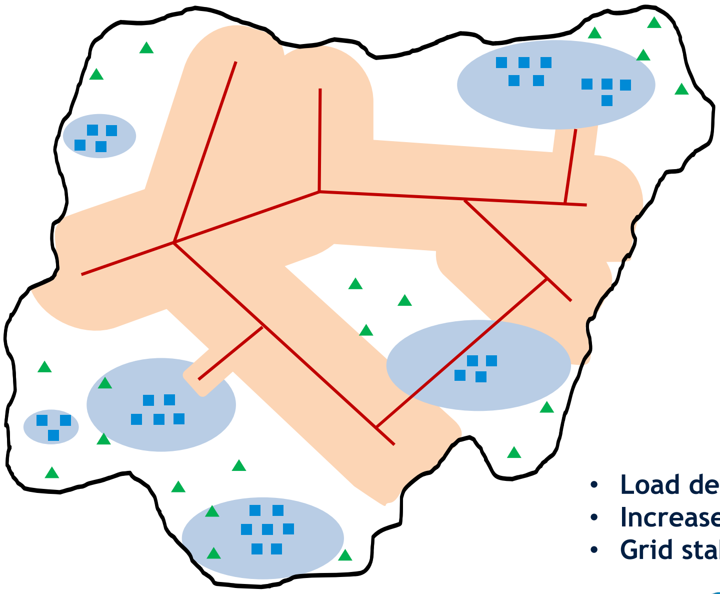
Typically, such second-generation systems are built to supply electricity to single villages. The developers, whether public or private, are motivated by the overriding need to supply rural communities with a higher level of electricity service as soon as possible. When these mini grids are developed, little thought is given to the possibility of later interconnecting with the main grid, and many of them are simply abandoned when the main grid arrives. If they do not go out of existence, these mini grids often choose to become small power producers (particularly if using a more affordable renewable energy generation source rather than diesel); or small power distributors, converting to buying all of their electricity supply wholesale from the main grid and selling it to the local customers at retail prices.

Developers of such second generation mini grids almost always rely on standard existing technologies – such as diesel or mini hydro generation – as well as basic meters, on-site meter reading, and in-person bill collection. They also generally charge flat monthly tariffs or postpaid fees calculated and collected at the end of each month

based on the customers' power consumption for that month.

As you have heard from James' presentation, our (ESMAP's) data indicates that the almost all of the 19,000 mini grids that we've identified across the world are 2nd generation systems.

Win-Win for Utility and Mini Grid Developer



- Load development
- Increase in affordability
- Grid stabilization

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MAKING IT HAPPEN

1. PACE

portfolio approach to around 1,500 projects per key access-deficit country per year by 2030.

2. QUALITY

keep quality of service at current 97% of up time, as well as increasing the industrywide average load factor to 45 percent

3. BUSINESS ENVIRONMENT

establishing enabling mini grid business environments to average RISE (Regulatory Indicators for Sustainable Energy) score in the top-20 access-deficit countries to 80 out of 100

4. FINANCE

Leveraging development partner funding to crowd in almost $220 billion of investment from private sector, donors, AND governments between 2019 and 2030

5. COST

Reducing the cost of solar-hybrid mini grids - which the other four market drivers will also support - to $0.20/kWh by 2030

			Target		
Objective/indicator	**What is measured**	**2018 Baseline**	**2020**	**2025**	**2030**
1. Increase pace of mini grid development					
Time from purchase order to commissioning (weeks)	Cohort of leading private sector developers	6–12	7	6	5
Time from goods arriving on site to commissioning (weeks)	Cohort of leading private sector developers	6–12	5	4	3
Mini grids per portfolio per year	Portfolios from rural electrification agencies, utilities, private developers, or industry associations	10–50	> 100	> 250	> 750
2. Provide superior-quality service					
Industry-wide standard for minimum technical specifications	Industry associations	Under preparation	Developed for solar hybrid mini grids	Developed for solar hybrid and hydro mini grids	Developed for all renewable energy mini grids
Industry-wide standard for reliability of electricity supply	Representative sample of mini grid developers	90–97 percent uptime	97 percent uptime during promised availability times	97 percent uptime for 24/7 electricity	99 percent uptime for 24/7 electricity
Customer satisfaction (percent)	Representative sample of mini grid customers	82–84	85	88	90
Average load factor across the industry (percent)	Representative sample of mini grid developers	22	25	35	45
3. Establish enabling mini grid business environment in key access deficit countries					
Average RISE score for mini grids framework in top 20 electricity access deficit countries	Top 20 electricity access deficit countries	59	60	70	80
Average Doing Business Score in top 20 electricity access deficit countries	Top 20 electricity access deficit countries	52	55	65	75
4. Crowd in government and private-sector funding					
Ratio of government and private funding to donor funding	Cohort of leading development partners	1.7: 1	2: 1	5: 1	10: 1
Ratio of developer investment to donor funding	Cohort of leading private sector developers	7: 1	8: 1	9: 1	10:1
Billions of dollars invested	Sum of all funding for mini grids in a country	28	40	93	217
5. Reduce cost of solar hybrid energy					
Levelized cost of energy ($/kWh)	Average across a cohort of leading mini grid developers	0.55	0.30	0.25	0.20

Note: A detailed discussion of the underlying analysis for each target is presented in the Introduction to Part II of the main book. kWh = kilowatt-hour; RISE = Regulatory Indicators for Sustainable Energy.

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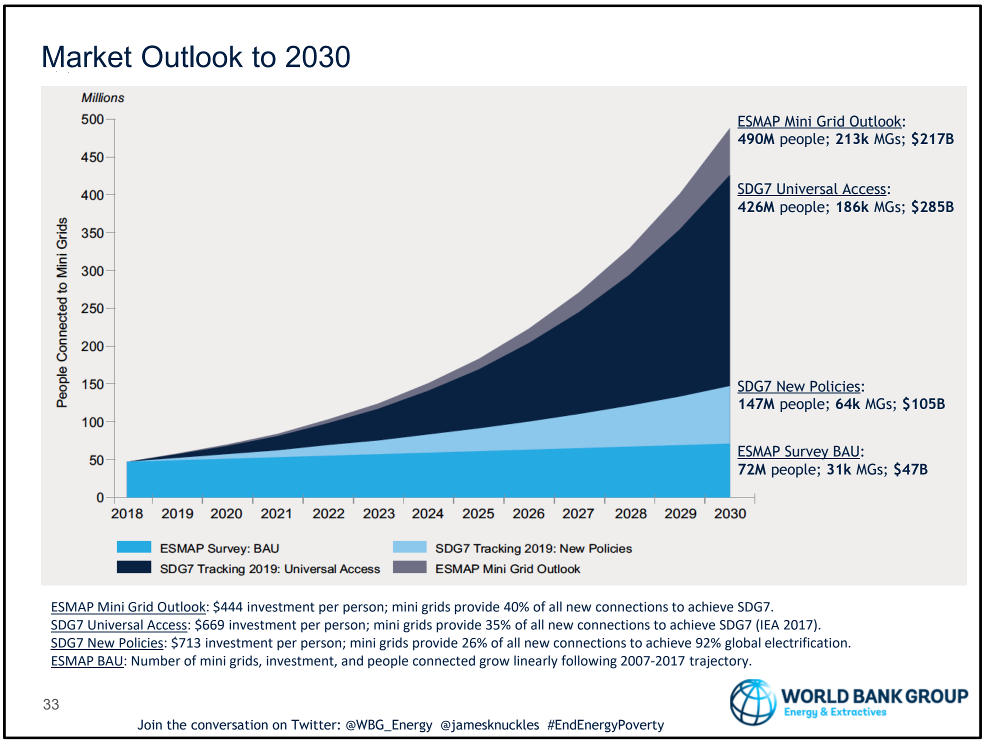
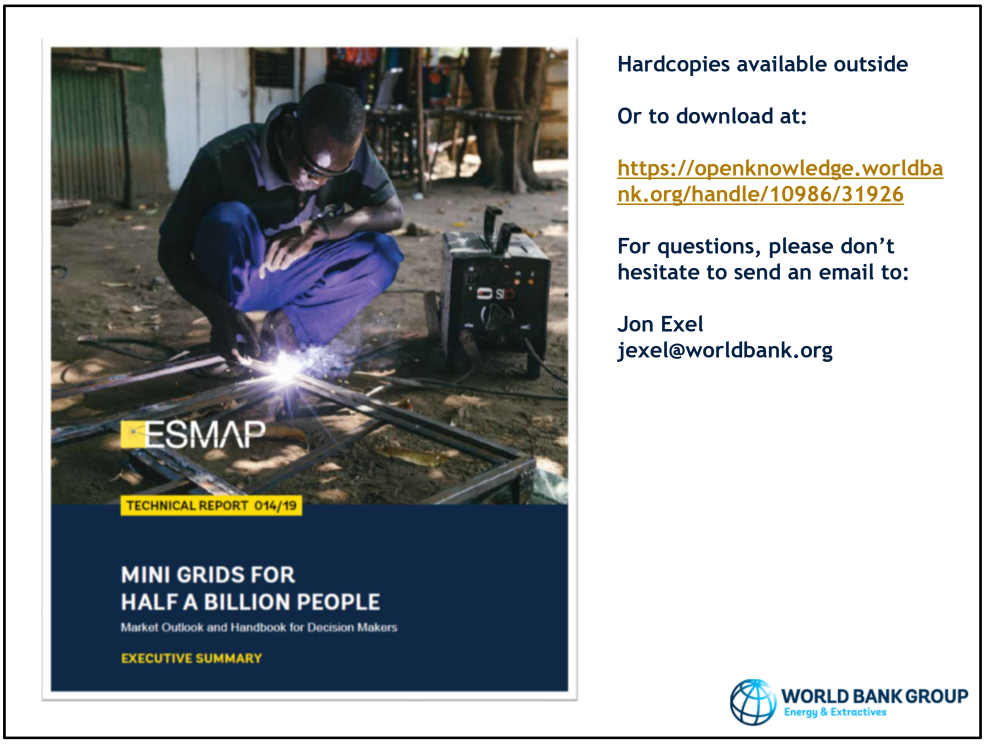


When we look ahead to 2030, we see mini grids as a core solution for reaching universal access. ESMAP estimates that achieving universal access by 2030 will require the construction of more than 210,000 mini grids, connecting 490 million people at an investment cost of almost $220 billion dollars. This is the grey area at the top of the graph.

For this scenario, we used the World Bank's latest estimate that reaching universal access will require 1.22 billion people gaining electricity access between 2019 and 2030. Due to cost declines for solar and solar hybrid mini grids, this scenario projects that mini grids will be the least cost option for **40 percent** of all new connections.

The SDG7 Universal Access scenario – which is the large dark area in the graph – uses the IEA's estimate that **35 percent** of all new connections will come from mini grids. The difference is that the IEA's estimate uses a higher per-customer cost than what we see in our database of planned mini grid projects.

ESMAP's business-as-usual scenario – the blue area at the bottom of the graph – assumes that the current pace of mini grid development continues unchanged. This scenario would see just over 31,000 mini grids serving 72 million people, at a total investment cost of $47 billion by 2030.



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ANNEXES

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ACCESS TO FINANCE

Environmental Impact by 2030

10–15 GW Solar PV installed by 2030

50–110 GWh Batteries mostly lithium-ion

60% Energy Savings from energy efficient appliances

1.5 billion Tons of CO_2 emissions avoided

Typical 3rd Generation Mini Grid

0.5–1.0 million US$ investment

200–800 Clients connected

800–4,000 People receiving electricity for the first time

50–100 kWp Solar PV installed

200–500 kWh Batteries installed

ACCESS TO FINANCE

Current Financing

$28 billion—Cumulative global investment in mini grids to date

$5 billion—Cumulative global investment in Africa and South Asia in mini grids to date

$1.3 billion—Development Partners committed including AFD, AfDB, DfiD, Islamic Development Bank, GIZ and WB.

$660 million—World Bank commitment to mini grids in 33 countries through 2025

$259 million—Private-sector investment in mini grid developers in low-income countries since 2013

25%—Average World Bank share of total mini grid investment (government, development partners, and private sector) in client countries

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REGULATIONS – NON PRESCRIPTIVE - DECISION TREES

Decision Tree Topic	Overview
Arrival of the main grid (see figure ES.6)	This decision tree provides options for what happens when the main grid arrives in the service area of a mini grid, including operating as a small power distributor (SPD) or small power producer (SPP).
Market entry	This decision tree provides options for regulating entry of mini grid developers into the market and indicates the conditions under which one of the four entry regulation options (registration, permitting, licensing, or no regulation of entry) would be most appropriate. The first branches of the tree are determined by what is legally required to operate as a mini grid business and how much control the regulator wishes to exert on who enters the market.
Retail tariffs	The options presented in this decision tree depend on the availability and type of subsidies and whether or not a uniform national tariff is required. The five options include willing buyer-willing seller tariff-setting schemes, efficient new entrant price caps, individualized cost-based tariff limits, bid tariffs, to uniform national tariffs.
Service standards	The first branches of this decision tree are determined by the maturity of the mini grid market (less stringent service standards may be more acceptable in more nascent markets) and the availability of subsidies. The options for regulating service standards orange from no service standards, to reporting standards, to differentiated standards, to uniform mini grid-specific standards, to grid-level standards.
Technical standards	This decision tree presents the options for regulating technical standards, and the first branches of the tree are determined by whether future integration of mini grids with the country's main grid is expected. The options for technical standards range from safety standards only, to mini grid-specific, to optional grid-compatible standards, to mandatory grid-compatible or main-grid standards.

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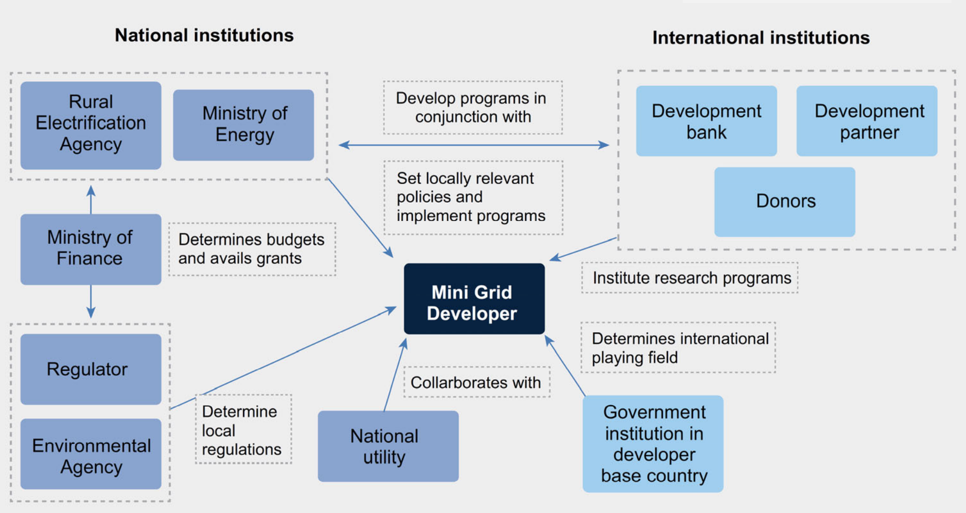
FROM A WEB OF INSTITUTIONS

Institutional Arrangements



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Delegating oversight to a single entity

Institutional Arrangements

Option	Advantages	Disadvantages	
Local government	• More accessible to developers and customers • Enforcement of regulation may be easier given the physical presence of the regulator in the community	• Potential lack of resources to be an effective regulator • Potential for different rules in different jurisdictions impedes large portfolios	Community agreements used in Haiti, Nigeria, and Myanmar
REA or grant-giving agency	Complex interfaces between agencies can be avoided if the subsidizing agency also acts as regulator (caveat: other gov. entities still may have authority over certain aspects)	• Potential lack of resources to be an effective regulator • May lead to conflict of interests	Bangladesh (IDCOL), Mali (AMADER)

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Mini grid developers risk facing multiple layers of government oversight, which slows their development and adds significant costs. This brings us to the third strategy for creating an enabling business environment: delegating oversight of mini grids to a single entity.

This strategy is relevant for countries where different government agencies have authority over mini grid regulatory issues like tariffs or service and technical standards. This situation often occurs in countries without a formal electricity regulator.

The two most common options are delegating authority to the local government, such as community agreements in use in Haiti, Nigeria, and Myanmar, and a government agency that provides grants or subsidies to mini grid developers (e.g., a Rural Electrification Agency), such as IDCOL in Bangladesh and AMADER in Mali.

For either of these options to be successful, there must be a clear legal delegation of authority to the government entity or local government, and the entity to whom authority has been delegated must explicitly state which laws and regulations will take precedence over its own authority.