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Ministry of Water, Irrigation and Electricity

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Solar and Wind Energy Resources for Off-Grid Electricity Access - Ethiopia

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Ethio Resource Group

Overview of the Off-Grid Energy Sector - Ethiopia

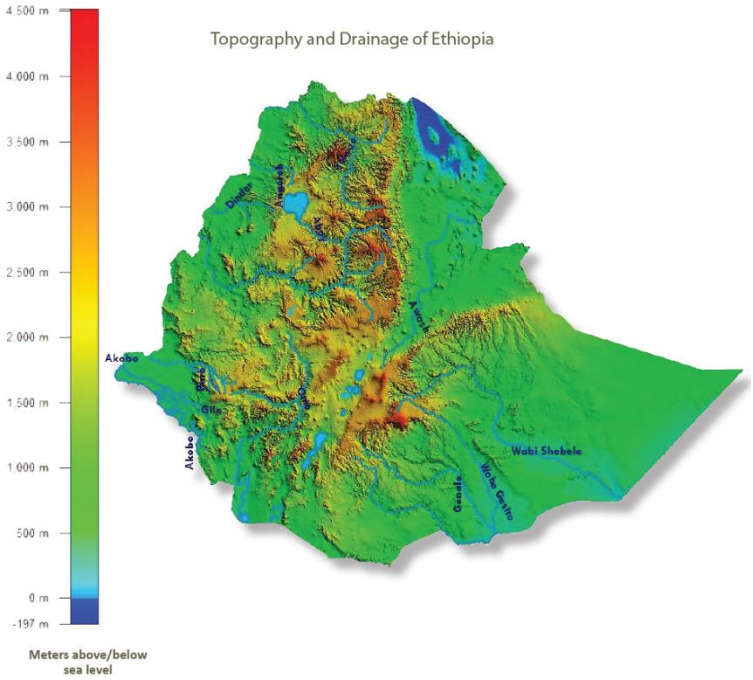
Ethiopia people, land

Population: 105 million (2.4% growth)

Surface area: 1.1 million km^2 (1/3 of area above 1500 masl)

Population density: 95/km^2 (2/3 live in 1/3 of area or highlands)

Urbanization: 20% (urban pop growth 4.7%, 80+ million live in rural areas)



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Energy supply

Energy consumed (2017): 39Mtoe

- **0.37 toe per capita**
- **85% in primary biomass** (wood, agri-residues) + **3% in derived biomass** (charcoal, ethanol)
- **9% petroleum, 1% coal**
- **2% electricity**

Biomass **consumed in homes for cooking**

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Energy use

Biomass:

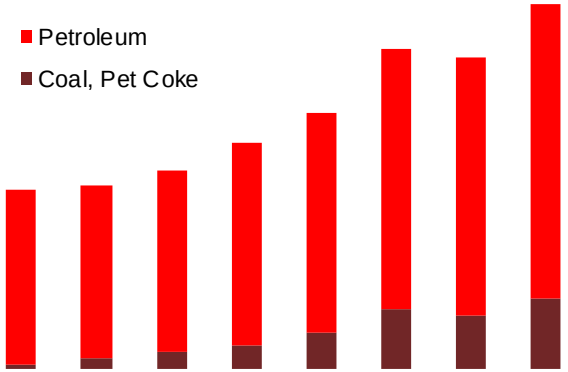
- **0.9 t biomass per capita** (grows as fast as food consumption)

Hydrocarbons:

- **Consumed in transport** (liquid petroleum) **and industry** (coal, pet coke)
- 8%/y growth for petroleum, 30%+ growth for coal /pet coke

Electricity:

- **Consumed 42% by homes, 36% industry, 22% services**
- **Exported 10% of production**



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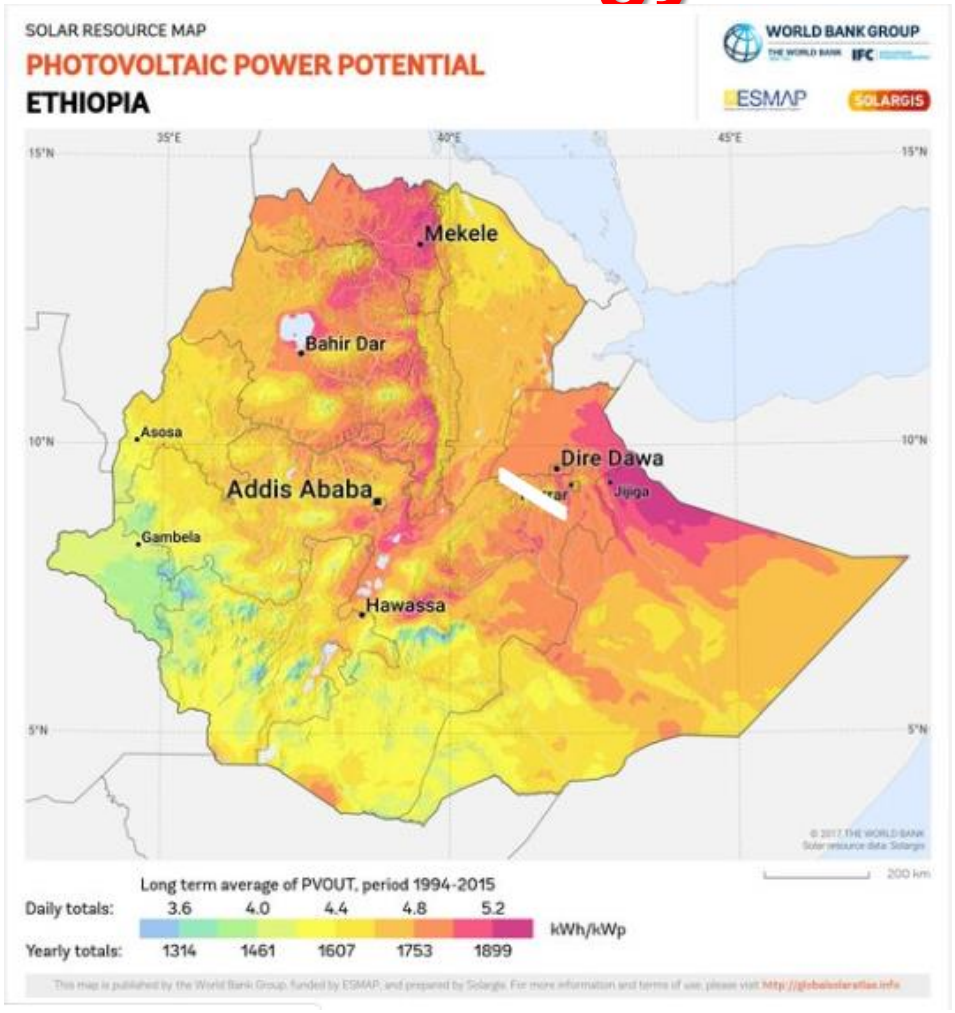
Solar and Wind Energy resources



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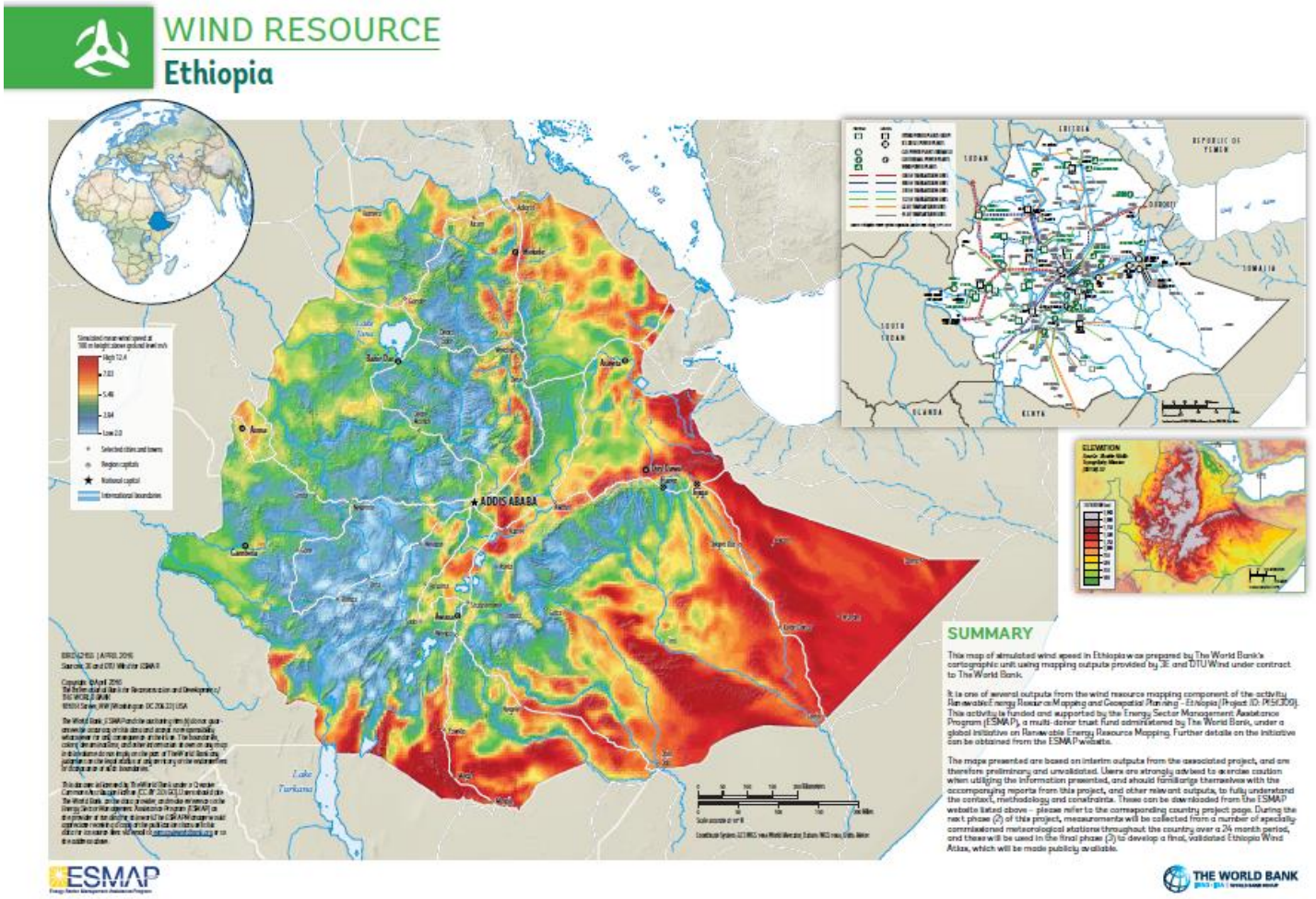

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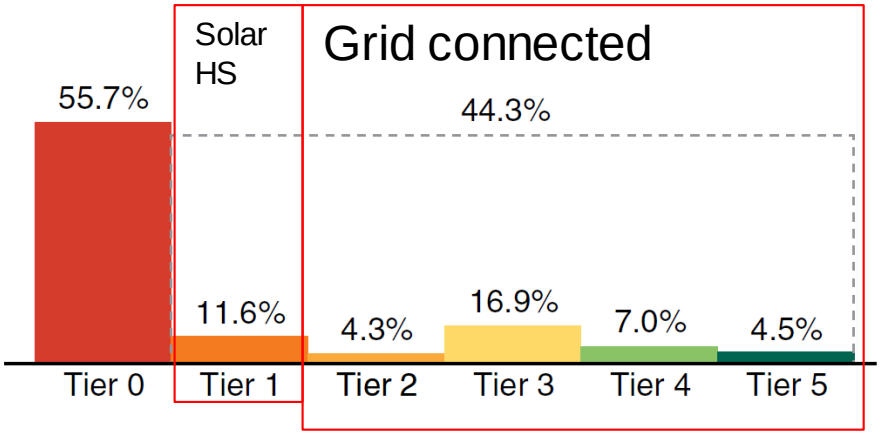
Electricity access

Access: 44% of households

- **33% connected to the grid**
- **11% served with off-grid** (mainly solar lanterns/home systems)

Electricity consumption level

- **86 kWh per capita (total)**
- **54 kWh per household (residential customers connected)**



Source: MoWIE, NEP 2, March 2019

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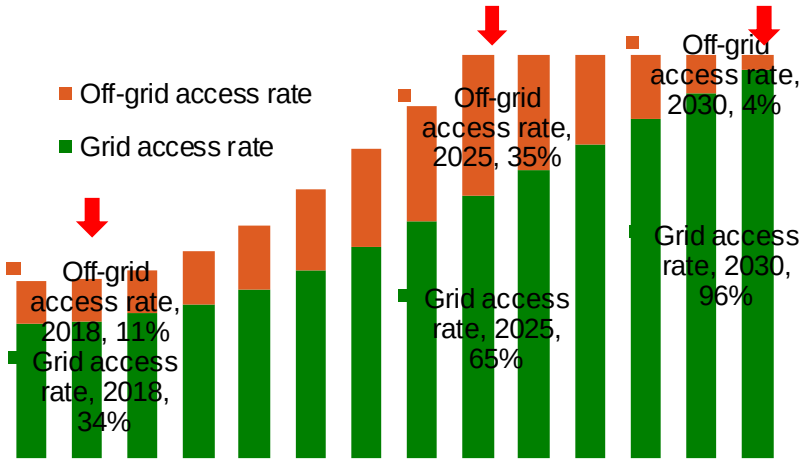
Electricity plan for access

- Plan for electricity access
- Reach 100% access in 2025
  (65% from grid, 35% off-grid)
- Reach 96% grid access in 2030
- 8.2M grid connections, 5.9M off-grid connections during 2019-2025



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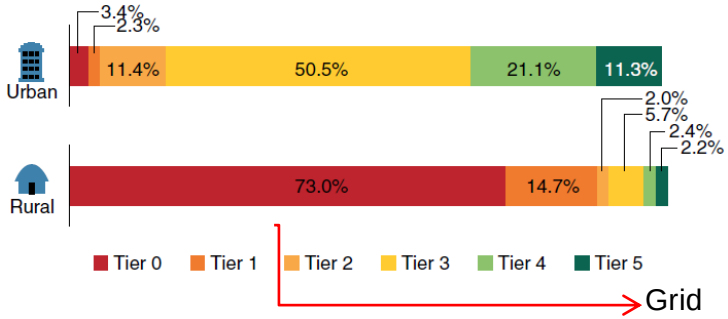
Rural electrification status

Rural households with access (2017) - 27% (12% from grid, 15% off-grid solar)

Those without access

- Households - 70M+
- MSEs - 100k+
- Social institutions (health, school) -1000s
- Smallholder agriculture



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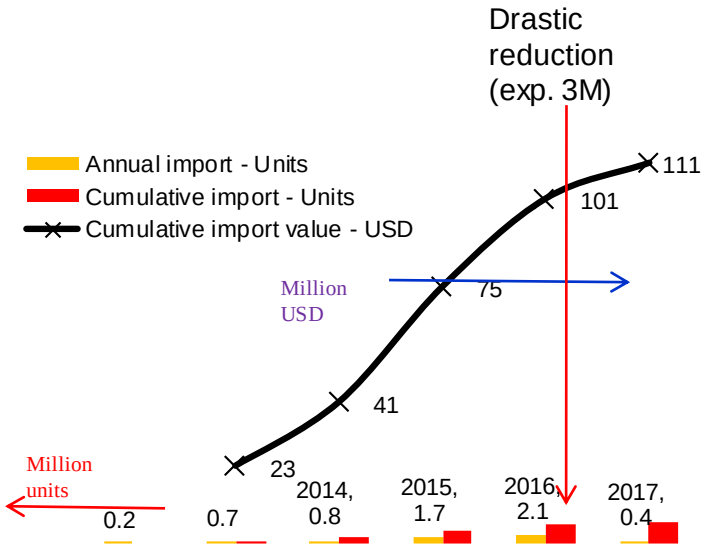
Rural electrification trends

Slow rate of rural customer connection (although relatively successful area coverage; >50% of sub-district centers are connected to the grid)

Very fast off-grid access through solar lanterns/HS (drastic fall in solar system sales in the past 2 years due to hard currency limitations, other factors)

Over the past five years, fuel based lighting has fast disappeared



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Rural electrification NEP

Investment required

- USD 4.6 billion (56% on grid, 44% off-grid) during 2019-2025
- USD 3.1 billion sought from external sources

Figure ES.14 Breakdown of grid and off-grid investments and syndication scenarios for universal access, 2025

	Investment (US$ million)	GoE contribution (US$million)	Syndication (US$million)
A. Grid program			
Grid total investments* ($370/connection)	3,200		
Customer contribution (—)	(1,100)		
Total	**2,100**	**480**	**1,620**
B. Off-grid program			
Access to finance (with a revolving fund)	1,760	530	1,240
End-user subsidy	72	72	-
Social institutions	230	70	160
MST off-grid solar	133	41	92
Mini-grids (MST and EPC)[a]	300	280	20
Off-grid total investment syndication	**~2,500**	**~1,000**	**~1,500**
C. Program implementation support (grid and off-grid)	**50**	20	30
Total investment syndication (A + B + C)	**4,650**	**~1,500**	**~3,150**

MTF=Multi Tier Framework
MST=Minimum Subsidy Tender

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Opportunities

Off grid energy

- Large off-grid pop (>70M), MSEs (100k?), social institutions
- Small agri, irrigation, preservation, processing
- Medium & Large Agri/Agri-Industry
- Imbedded generation (sale to the grid)
- Captive market (industries, refugee settlement, etc)

  - Technologies for management (control/monitor, payment)
  - Low off-grid system costs ($⇲) vs. high grid costs

Distributed systems

- Distributed resources (energy, capital, management); additional resources to grid, transport, thermal energy

  - S&M Hydro ≅ 50% of tech cap.
  - Biomass/waste/biofuels – forest waste, bamboo, agri-process waste, landfill, wastewater

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Rural electrification settlements

Amhara, East Gojam Zone, Baso ena Lisen Wereda, Yedege Kebele [10.0869019 37.7672966]

Oromia, West Shewa Zone, Jeldu/Gojo Wereda, Tulu Gura Kebele [9.164153 38.08337]

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Potential for Mini or Micro Grids

Settlement patterns determine potential for mini or micro grids:

- Mean number of households per kebele – 1035
- Housing density outside Kebele Centers – 30 to 250 households per square kilometer

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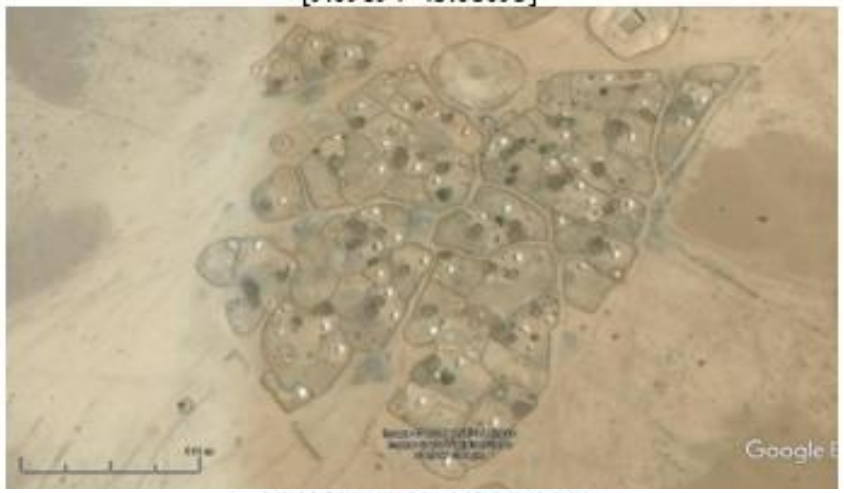
Somalie, Fafan Zone, Kebribeya Wereda
[9.09194 43.08093]



Afar, Zone 2, Berhale Wereda,
Degala Kebele [13.7528009 39.8849025]

Potential for Mini or Micro Grids

Sample settlement patterns:

1) Households in Kebele Centers – 10 to 20%

2) Clusters of households outside kebele centers – 10 to 20%

3) Scattered households – 60 to 80%

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Benefits of Mini or Micro Grids

1) Eliminate upfront investment commitment from consumers (fee for service)

2) May provide wider access for productive use (i.e. productive use need to be intentionally integrated with system development by developers)

3) Potential to optimize investment to power utilization

4) Better system monitoring and control, better quality service by a trained operator.

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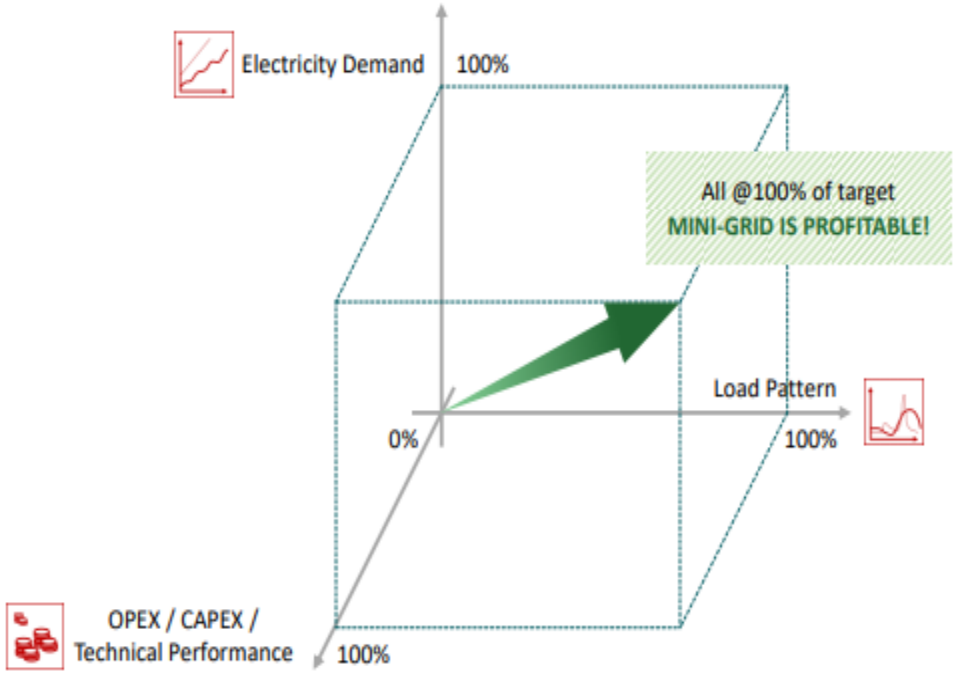

Source: Green Mini-grid Help Desk, Solar Mini-grid Policy 2, Nico Peterschmidt, Feb 2019

Operational Risks of Minigrids

1) Electricity Demand Risk
   - Expected demand development over time
   - Studies indicate growth is linear unless affected by external circumstances

2) Load Pattern Risk
   - Peak load, day time load
   - Battery size optimizes financial performance
   - Depreciation of battery CAPEX over time increases LCOE

3) Overspending and Technical Performance Risk
   - Increase capital and/or operating expenditure

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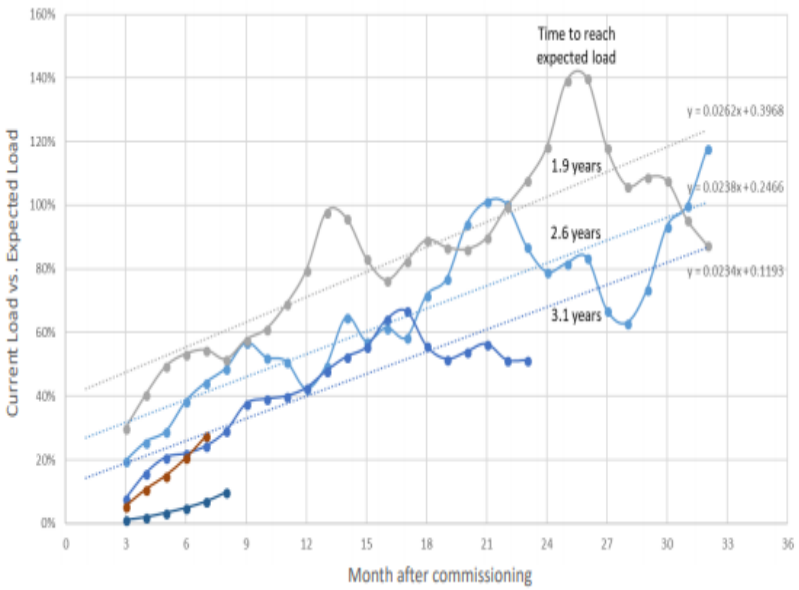

Operational Risks of Minigrids

1) Factors that affect Electricity Demand Growth

i. Trust of minigrid operator by the community as a basis for local investment into productive use of electricity

ii. Locally available microfinance for the establishment of micro-business;

iii. Creativity and education level of local business persons in making use of the new opportunities

iv. Availability of off-takers for locally manufactured goods (access to markets);

v. Availability of providers of electric machines and appliances, as well as repair-shops in the community;

vi. Success of electricity customers in remittances to increase the local standard of living;

vii. Degree to which additional income generated is converted into electricity expenditure (is subject to the degree of individual household risk-aversion)

viii. Availability of public funds to cover electricity expenses incurred by government institutions (i.e. social institutions, community eater supply systems, etc).

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Operational Risks of Minigrids

2) Load Pattern Risk Mitigation Strategy

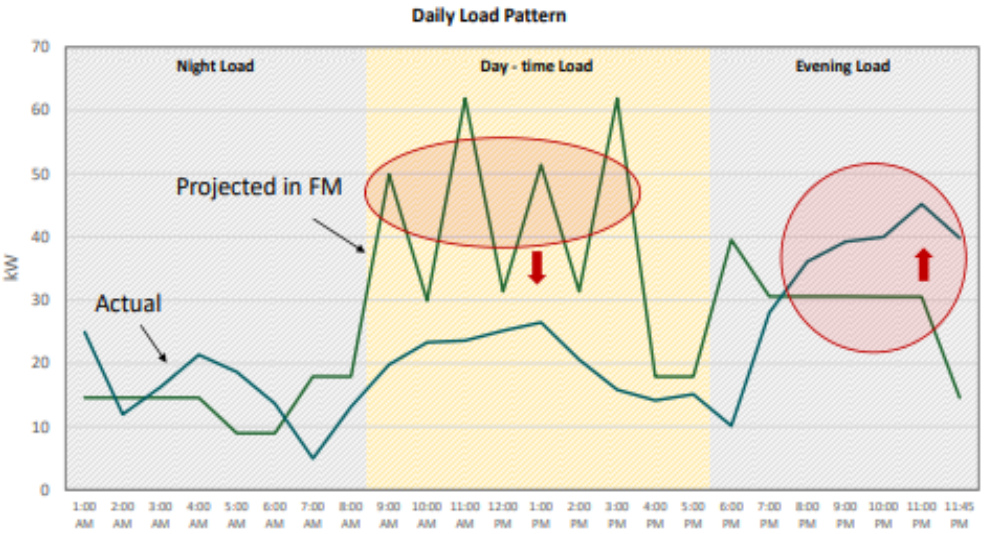

Figure 6: Comparison of projected vs. actual load patterns

i. Demand management through the application of Time of Use Tariffs(TOU) to shift/distribute electricity consumption to daytime

ii. Load management through switching so-called deferrable loads to increase daytime consumption (i.e. water pumps, grain milling, etc,

iii. Adjustment of system design through additional battery capacity

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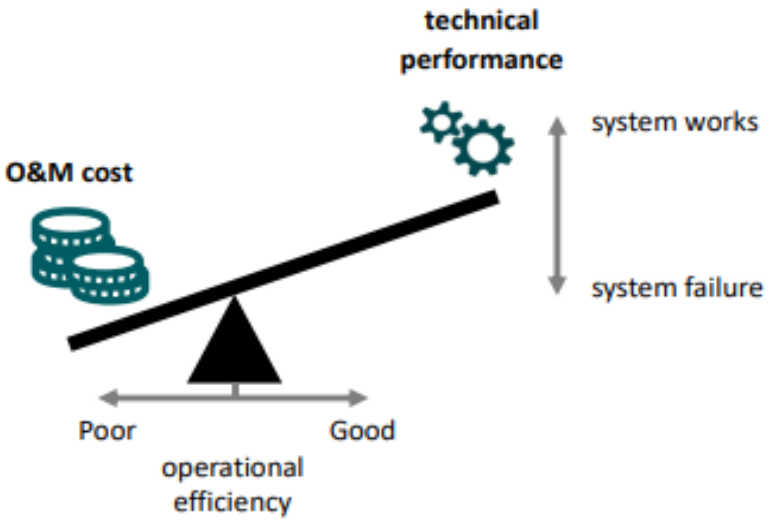
Operational Risks of Minigrids

3) Overspending and Technical Performance Risk



i. Increased capital expenditure can be avoided by efficient and effective project management

ii. Use of information technology help reduce operation costs and system failure (i.e. early warning systems for maintenance requirement)

iii. Operation efficiency determines system reliability

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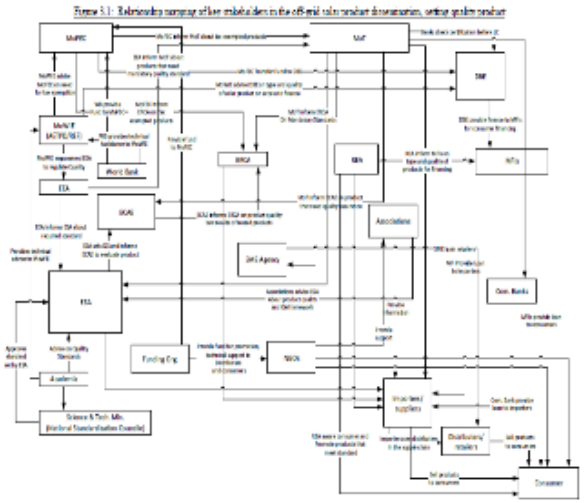
Current Challenges



- Limited access to finance (to businesses and consumers)
- Lack of guarantee for investment
- Unclear bureaucratic procedures (i.e., regulation)
- Undeveloped distribution chain
- Limited use of ICT
- Capacity limitation – 8.2M on grid, 5.9M off-grid connections in 6 years. Local technical and management capacity is low.
- Technology localization (i.e. policy, r
- Uncertainty because of changing directives
- Lack of clarity in implementation of regulations (what to regulate, how to regulate, when to regulate)

Thank You