



# Quality Assurance Framework for Mini-grids

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# A Quality Assurance Framework for Mini-Grids

To address the root challenges of providing quality power to remote consumers through financially viable mini-grids, the Global Lighting and Energy Access Partnership (Global LEAP) initiative of the Clean Energy Ministerial and the U.S. Department of Energy teamed with the National Renewable Energy Laboratory (NREL) and Power Africa to develop a Quality Assurance Framework (QAF) for isolated mini-grids. The framework addresses both alternating current (AC) and direct current (DC) mini-grids, and is applicable to renewable, fossil-fuel, and hybrid systems.



# Mini-grids Quality Assurance Framework

- **Purpose:** Provide structure and transparency for mini-grids sector, based on successful utility models, while reflecting the broad range of service levels required to meet the needs of various segments of the off-grid consumer base
- **Importance:** Lay the foundation for successful business models in the mini-grids space



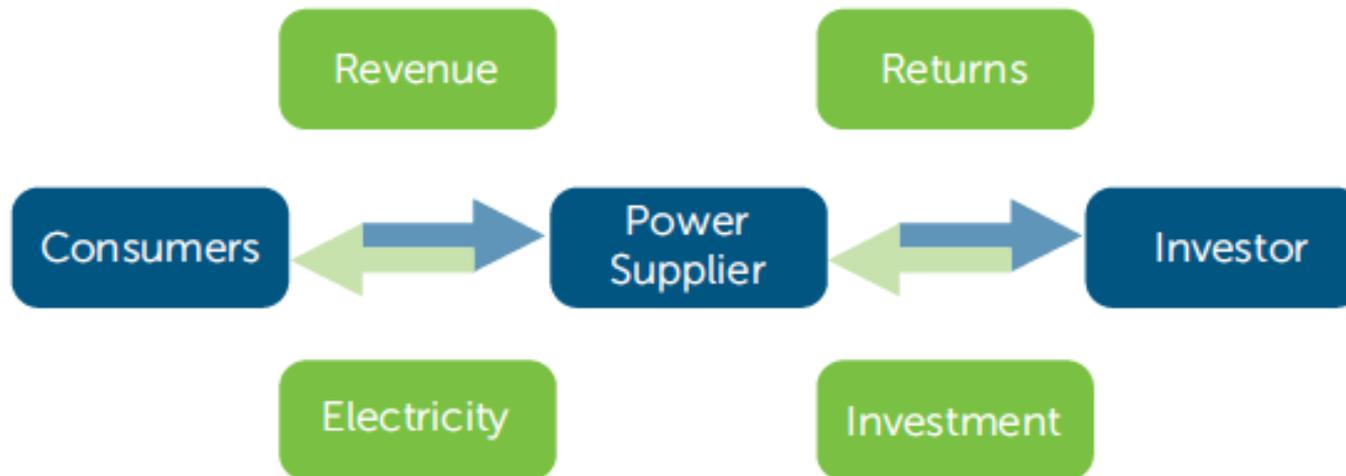
Source: Kari Burman, August 2007

A mini-grid is an aggregation of loads and one or more energy sources operating as a single system providing electric power, and possibly heat, isolated from a main power grid. A modern mini-grid may include renewable and fossil fuel-based generation, energy storage, and load control. Mini-grids are scalable so that additional generation capacity may be added to meet growing loads without compromising the stable operation of the existing mini-grid system.

# The Mini-grid Utility Model

Business models for commercially viable mini-grids must address the needs of the four key stakeholder groups:

- **Customer:** Need a guarantee of service that they can afford and are willing to pay for
- **Power Suppliers:** Need to be able to guarantee a rate of return to their investors
- **Investors:** Need to be confident of the risks they are taking
- **Regulators/Government:** Sets the rules, keeps the peace and may contribute funds



# Mini-Grids Quality Assurance: Unlocking Investment & Scale-up

- **Provide common technical standard for classifying service from mini-grids** based on well-defined system specifications for different levels of service
- **Strengthen revenue flows by optimizing system design** through more consistent system specifications that are better tailored to different tiers of consumer need and ability to pay
- **Facilitate aggregation, unlocking private investment** through adoption of uniform classification system coupled with accountability framework:
  - Bundle projects with similar attributes
  - Generate robust market information
- **Flexible and adaptable framework:** Which includes AC & DC mini-grids; applicable to renewable, fossil-fuel, and hybrid systems; capture basic to “grid-parity” service

# Elements of the Quality Assurance Framework

1. **Define levels of service** tailored to different tiers of consumers, including appropriate thresholds for:
  - Power quality
  - Power availability
  - Power reliability
  
2. **Define accountability framework**
  - Clear process for verification of power delivery through trusted information to consumers, funders, and/or regulators
  - Provides defined assessment and reporting protocol for operators

The Quality Assurance Framework **DOES NOT** mandate a standard level of service but provides a more detailed, common way to reference levels of service.

	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
<b>Peak Available Power (Watts)</b>	None	>1 W	>20 W	>200 W	>2,000 W	>2,000 W
<b>Consumption (kWh/year)</b>	< 3	3 - 66	67 - 321	322 - 1,319	1,319 - 2,121	> 2,123
<b>Duration of Supply (hours per day)</b>	None	> 4 hrs	> 4 hrs	> 8 hrs	> 16 hrs	> 22 hrs
<b>Evening Supply</b>	n/a	> 2 hrs	> 2 hrs	> 2 hrs	4 hrs	4 hrs
<b>Quality</b>	n/a	low	low	Adequate	Adequate	Adequate
<b>Typical Applications (Cumulative)</b>	None	Radio, Task lighting	General Lighting, fans, TV, light office needs	Air cooling, food processing, and task oriented food preparation	Refrigeration, water heating, pumps, expanded food preparation	Air conditioning, space heating and full food preparation

# Levels of Service for Isolated Mini-grids

**1. Power Quality** – Is the power provided of a reasonable or defined quality to safely provide the energy needs of the consumers?

- Voltage and frequency variations, distortion etc.

**2. Power Availability** – Is the power provided in the amount that meets expectations and available with the duration that has been specified?

- Hours of service, power and energy levels, etc.

**3. Power Reliability** – Is the power provided with enough reliability to meet consumer needs?



Source: Kari Burman, November 2016



Source: Solar Nigeria, 2014

# Mental Model – Rural Energy Needs



Source: NREL Pix #06954



Source: Creative Commons

- A heavy duty pick-up truck is a good mental model of “grid parity” power. It’s great to have but expensive to own and operate.
- Most people in rural communities don’t have the need for grid parity power supply, a scooter is more appropriate and much lower cost.

**Voltage Unbalance (AC)**

**Transients (AC & DC)**

**Short Duration Variations (AC & DC)**

**Long Duration Variations (AC & DC)**

**Waveform Distortion (AC & DC)**

**Voltage Fluctuations/Flicker (AC & DC)**

**Frequency Variations (AC)**

# What is Power Availability?

- The amount of energy services being provided to specific customers based on need and other factors. Three main criteria :
  1. **Power:** Maximum draw in Amps or Watts
  2. **Energy:** Total energy available (kWh) over a defined time period (month, year)
  3. **Time of day service:** For what hours of the day is power available (hours per day)
- Availability ties together the parameters that define how much energy service is to be provided to a specific customer based on their ability and willingness to pay for that service. Expected to change over the life of the utility/customer relationship
- Consistent with the World Bank Multi-Tier Framework but expands on the details taking a more power system focused approach

# Power Reliability

Represents how well the power system provides power during times when power should be provided.

- **Unplanned power outages**

- System Average Interruption Frequency Index (SAIFI)
- System Average Interruption Duration Index (SAIDI)

- **Planned power outages**

- Planned System Average Interruption Frequency Index (P-SAIFI)
- Planned System Average Interruption Duration Index (P-SAIDI)



Source: Canadian Pacific, flickr 2013

# Accountability Framework

- 1. Consumer Accountability** defines, demonstrates, and validates that a specific level of service is being provided to a customer
  - Level of Service verification
  - Service Agreement
- 2. Utility Accountability** allows funding or regulatory organizations to understand if the system is safe and providing contracted service
  - Technical reporting
  - Business reporting
  - Reporting template



Source: NREL PIX #07805



Source: Jake Lyell for the Millennium Challenge Corporation

## Level of Service Verification

- Ability to record energy consumption
- Ability to record hours of service at service drops
- Ability to check voltage levels at service drops
- Implementation of periodic, random, and documented voltage surveys to ensure proper quality of service

## Service Agreement

- Defines applicable power quality standards in place
- Identifies what type of investigation is warranted based on complaints
- Describes how to address power quality impacts caused by the customer vs. those caused by the power system (utility)

# Utility Accountability Framework

Provides a defined and secure methodology for utilities to provide relevant information to regulators and project financiers, essentially the information that will allow a good understanding of the utility business

## **Information about the performance of the utility**

- Technical Reporting: Measurements addressing system performance, energy usage, operational issues
- Business Reporting: Payment collection rates, electrification rates, customer characteristics, service calls and safety concerns, etc.

## **Reporting Template**

- Standard document or procedure that provides performance information to the funder/regulator, providing consistency across energy platforms and projects.

# A Quality Assurance Framework for Mini-Grids

Technical Report Available:

<https://cleanenergysolutions.org/qaf>

Implementation guide to be published shortly

QAF Fact Sheet: <https://cleanenergysolutions.org/sites/default/files/documents/qaf-fact-sheet-march-2017.pdf>

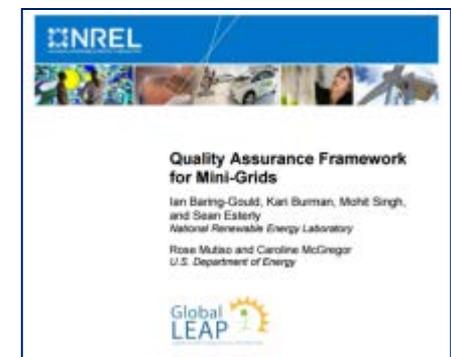
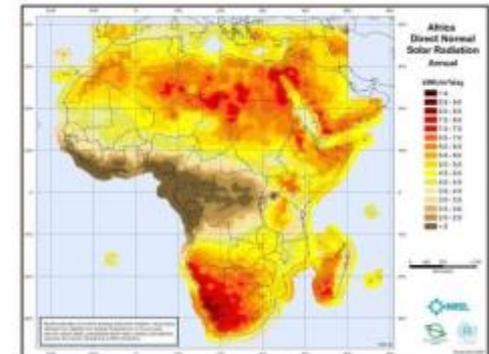
Supported by:

- Global Lighting and Energy Access Partnership (Global LEAP) initiative of the Clean Energy Ministerial
- U.S. Department of Energy
- National Renewable Energy Laboratory
- Power Africa



# Power Africa Beyond the Grid Program Support

- **Summary:** NREL is supporting Power Africa's Beyond the Grid Program with developing 8-10 million new electrical connections from mini and micro grids
- **Specific Support Areas**
  - Pilot projects to deploy the Mini-Grid Quality Assurance Framework
  - Technical assistance to developers
  - Support to governments, regulators, and utilities to develop policy and the enabling environment
  - Project modeling and assessment
  - Support is provided in coordination with other complementary programs such as the AfDB's Green Mini Grid Program



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# Thank You

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