Draft
MINI-GRID
TECHNICAL
REQUIREMENTS

For discussion with
mini grid stakeholders

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on behalf of RURA


DRD 2018. *Mini-grid technical guidelines*. Myanmar Department of Rural Development


  - Part 2a. Draft Standard for Application of Inverters to Mini-grids
  - Part 4a. Metering for Mini-Grids
Mini Grid Technical Requirements

1. Preamble
2. Introduction
3. General Requirements
4. Solar PV Generation System Components
5. Hydropower Generation System Components
6. Micro-hydropower generators and controls
7. Electricity supply stations
8. PV Array, generator, battery, and powerhouse wiring
9. Distribution Line
10. Metering
3 General Requirements

+ >50% renewable energy
+ Developer responsible for on-site warranty
+ Any mini grid that connects to National Grid must be in compliance with Rwanda Grid Code
3.1 Information

+ Information available from the mini-grid operator, and provided on-site at all times:

- Single-line diagram of the generating plant and distribution network
  - Generation, conversion, storage, monitoring/communication and isolation and protective devices. Connection Points clearly marked;
- As-built distribution network.
- Inventory showing quantities, sizes, manufacturers and technical specifications of equipment
- Customer database with names, connection type, meter number, etc.
3.2 Nominal voltage

+ Voltage

- **AC:**
  - Low voltage: 400/230 V ± 10%
  - Medium voltage: 15 kV or 30 kV ± 10%

- **DC:**
  - ≤48 V nominal
3.3 Nominal frequency

**Frequency:**

- 50 Hz
- If ±6% deviation then protection relay must operate within 500 ms.
4.1 Photovoltaic modules (1)

+ IEC certifications:

- IEC 61215 Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval.

- IEC 61730 Photovoltaic (PV) modules safety qualification – Requirements for construction and requirement for testing.
4.1 Photovoltaic modules (2)

PV warranty:

- Manufacturing warranty (material and workmanship): 10 years.

- Power output (performance) warranty:
  - 10 years 90% rated output
  - 25 years 80% rated output warranty.
4.1 Photovoltaic modules (2)

+ Bypass diodes in each module to prevent hot-spots.

+ Solar modules junction box:
  - Ingress protection: IP65

- ≥4 mm² cables.
**IP (Ingress Protection) Ratings Guide**

**SOLIDS**

1. Protected against a solid object greater than 30 mm such as a hand.

2. Protected against a solid object greater than 12.5 mm such as a finger.

3. Protected against a solid object greater than 2.5 mm such as a screwdriver.

4. Protected against a solid object greater than 1 mm such as a wire.

5. Dust Protected. Limited ingress of dust permitted. Will not interfere with operation of the equipment. Two to eight hours.

6. Dust tight. No ingress of dust. Two to eight hours.

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**WATER**

1. Protected against vertically falling drops of water. Limited ingress permitted.

2. Protected against vertically falling drops of water with enclosure tilted up to 15 degrees from the vertical. Limited ingress permitted.

3. Protected against sprays of water up to 60 degrees from the vertical. Limited ingress permitted for three minutes.

4. Protected against water splashed from all directions. Limited ingress permitted.

5. Protected against jets of water. Limited ingress permitted.

6. Water from heavy seas or water projected in powerful jets shall not enter the enclosure in harmful quantities.

7. Protection against the effects of immersion in water between 15 cm and 1 m for 30 minutes.

8. Protection against the effects of immersion in water under pressure for long periods.

**Rating Example:**

IP65

**INGRESS PROTECTION**
4.1 Photovoltaic modules (3)

Label of the PV module:

- Manufacturer
- Model number
- Serial number
- Short circuit current ($I_{sc}$)
- Open circuit voltage ($V_{oc}$)
- Current at maximum power ($I_{mp}$)
- Voltage at maximum power ($V_{mp}$),
- Power rating of panel at standard test condition (STC).
4.2 PV array rack (mounting structure)

- Made of corrosion-resistant material:
  - Aluminum alloy or hot dip galvanized steels. If hot dip galvanized, thickness of galvanization shall exceed 80 microns
- Earth mounted, top-of-pole, or roof-mounted type
- Structural material ≥2mm minimum thickness
- Bolts, nuts, fasteners, panel mounting clamps:
  - Galvanized, stainless-steel, or welding
- In case of a welding structure, galvanization should be done after the fabrication work.
- Any contact between unlike materials shall be avoided by using insulation between any aluminum and galvanized sections
4.3 Inverters (1)

+ Standards and certifications
  - IEC 62109-1 & 2; and
  - CE or UL 1741

+ Labeling
  - Manufacturer name and model
  - Serial number
  - Input and output voltage and rated power
4.3 Inverters (2)

+ **Warranty ≥5 years**

+ **Efficiency:**
  - PV inverters: 95% over 75% of range
  - Battery inverters: 90% over 75% of range
4.3 Inverters (3)

Protection:

- over-temperature and excessive DC voltage
- ≥ IP54 if outdoors
4.4 PV charge controllers (1)

+ **Type:**
  - Maximum Power Point Tracking (MPPT); or
  - Pulse Width Modulated (PWM)

+ **Efficiency ≥ 90% based on IEC 61683**

+ **Rated current at 50° C must be at minimum 120% of peak array current (Isc)**
4.4 PV Charge Controllers (2)

- ≥ IP55

- Certified (at least one)
  - CE or UL 1741 Marking
  - IEC 62509 (Battery charge controllers for photovoltaic systems - Performance and functioning)
  - IEC 62093 (Balance-of-system components for photovoltaic systems - Design qualification natural environments)
4.5 Batteries (1)

• Expected cycle life of the batteries ≥ 1,500 cycles when discharged to 60% DOD.
• warranted ≥ 2 years under the operational conditions on site, to 80% of original rated capacity.
### Battery labelling

- Each battery/cell shall be engraved with the date of manufacture.
- For each battery type, the battery must be labeled indicating at minimum:
  - Manufacturer
  - Model Number
  - Voltage
  - Capacity (Ampere hours – Ah)
4.5 Batteries (3)

**Overcurrent protection and disconnects**

- Positive cables between batteries and inverters shall be protected with DC-rated over-current protection and disconnect (either circuit breaker or fused disconnect) of appropriate rating to protect cables in the event of a short circuit.
4.5 Batteries (4)

Battery installations

- Space shall be provided for safe maintenance, testing, replacement, and inspection.

- Space shall be provided above the cells to allow for taking measurements, adding water (if cells are flooded type), and for lifting equipment.

- Accessible only to qualified persons.
4.5 Batteries (4)

Battery installations

- For flooded lead-acid batteries, the battery area shall be ventilated by a fan or natural ventilation system.
- Racks that support battery cells shall be firmly anchored.
- Racks made of metal shall be earthed.
- The floor material in battery areas shall be of a material that resists corrosion from electrolyte.
- Battery areas shall be provided with googles or face shield, acid-resistant gloves, and protective aprons.
5. Hydropower
5.1 Hydropower – powerhouse

- Powerhouse should be located above 25-year flood levels
- The floor area of the powerhouse should be sufficient to safely place equipment and carry out routine maintenance work conveniently.
- Window areas of the powerhouse shall be equivalent to at least 10% of the powerhouse floor area to ensure adequate ventilation.
5.1 Hydropower – powerhouse (2)

- The minimum height between floor and ceiling should be 3 meters.
- Roofing material should be made of fire-resistant materials.
- The roof should be watertight and should extend at least 1 meter over walls to prevent water for entering through window portals.
- The power house door shall be designed with adequate spacing for easy installation and removal of equipment. For safety reasons, the door should be outward-opening.
5.1 Hydropower – powerhouse (3)

+ Lifting mechanism (e.g. gantry crane) should be provided for the convenience of operation and maintenance in case the system components are unwieldy or otherwise difficult to access safely.

+ Workers’ quarters with basic facilities such as bathroom/washroom and essential living furniture should accompany the powerhouse design
5.1 Hydropower – powerhouse (4)

(inputs from REG)

- The Powerhouse must be painted with at least two top coats of durable washable paint both inside and outside for all plastered walls.

- The name of the plant displayed clearly on front of building.

- Electrical Danger warning signs at access points

- Fire extinguishers and all required safety equipment installed and maintained.

- Sufficient lighting to do safe work on any equipment.
Concrete grades

- For base (screed) concretes: grade 15
- For water-bearing structures such as the forebay tank, weir and channel of a hydropower facility: grade 25
- For foundations and other structures: grade 20

Tor steel or rebar used for construction

- comply with BS 4449-2005 and bends should comply with BS 8666.
5.3 Hydropower – Weir & intake
5.3 Hydropower – Weir & intake (1)

- **Weir should be:**
  - located at a river section with short width
  - exposed bedrock or where depth to the bedrock is minimum

- **Intake should be equipped with:**
  - trash rack;
  - control gate
  - flood barrier wall to make the control gate operations possible during high flow periods.
5.3 Hydropower – Weir & intake (2)

- Trash rack should have preferably iron rods or flat iron, rod orienting upward (vertical) direction without cross bars for ease of cleaning with a rake.
5.3 Hydropower – Weir & intake (3)

+ Environmental flow
  
  - A pipe without a valve to regulate flow of which diameter and location (height from the top of weir) determined by the National Environmental authority, must be placed to release environmental flow to safeguard the downstream ecosystem.

+ Sluice gate (flush gate)
  
  - Designed based on the maximum silt load of the stream.
  
  - Located at the lowest point of the weir.
5.4 Hydropower – Channel

**Channel velocity:**

- In case of silty water, minimum velocity of 0.3 m/s
- To limit erosion in the channel, maximum channel velocity (m/s):
  - Concrete: 2
  - Rubble and masonry with smooth plaster: 1.8
  - Clay: 1.5
  - Earthen: 0.7

**Channel freeboard:**

- Accommodate additional 30% of volume
5.5 Hydropower – Forebay & settling tank

- Settling tank should settle particles > 0.3 mm in diameter.
- A manually operated sluice gate and spillway in settling tank to flush silt.
- A second trash rack shall be included in the forebay section
5.6 Hydropower – Penstock and supports (1)

- **Penstock penetration through the forebay:**
  - Deep enough to avoid vortex formation, yet
  - Positioned at least 150mm above the forebay tank floor to prevent silt and small stones from entering the penstock.

- **A vent pipe with a sufficient diameter should be fixed to the penstock to prevent implosion of the penstock due to surge pressure.**
Penstock implosion (no vent pipe)
5.6 Hydropower – Penstock and supports (2)

- **Constant gradient** in each section is desired; i.e. straight from one anchor to the next.
- An **air release valve** shall be fitted to highest point if air is likely to be trapped due to the layout of the penstock.
- **Penstock strength**: normal operation & surges x 2.
- **Support blocks**: Penstocks above ground should be supported at every 6m intervals
- **Anchor blocks**: In all bends, an anchor block made of reinforced concrete
5.6 Hydropower – Penstock and supports (3)

- **Underground penstocks**: buried at least 30 cm beneath the ground and should be on a sand bed. No slide or support blocks apart from anchor blocks at the bends required.

- **Thermal expansion**: rubber sheets or tar sheets (graphite asbestos sheet) of minimum thickness of 3mm must be placed between penstock and supports to prevent abrasion due to thermal expansion and contraction.

- **Expansion joints** are required in steel penstocks just below anchor blocks and forebay tank to minimize the stress created due to thermal expansion and contraction.
6.1 Hydropower – turbine

- **Runaway speed (loss of load condition)** for two hours without mechanical failure.

- **Water flow** must be able to be **fully stopped** for turbine maintenance.

- **Valve** shall take at least **10 seconds to close** to prevent a pressure wave in the penstock pipe.

- **Bearings**: continuous operation and 2 year warranty.

- The turbine shall have a sealing mechanism to prevent water from entering the generator.

- **Flexible generator-turbine coupling** to avoid strain from misalignment.
6.2 Hydropower – generator

+ **Voltage and frequency limits** as per sections 3.2 and 3.3

+ **If the generator type is induction**, excitation capacitor banks should have an over-current device to stop the generation of excessive voltage and damage to the alternator in the case of turbine overspeed / runaway speed.
7 Electricity supply stations

+ Protective arrangements

- **Restricted access**: Spaces in which electric supply equipment are installed shall be protected from entrance of unauthorized persons.

- **Floors**: shall have even surfaces and secure footing.

- **Exits**: Each room with working electrical equipment shall have means of exit that is kept clear of obstructions.

- **Mechanical guards**: Mechanical parts such as pulleys, belts shall have guards installed to prevent injury.
7 Electricity Supply stations

On-site fuel storage

- Built in accordance with an approved standard (for example API STD 650).

- Storage facility shall incorporate spillage control such as remote impounding, impounding around tanks, bunding or by a combination.

- Impoundment area shall be protected by adequately designed systems to prevent the contamination of ground water.
8.1 General

- Outdoor wiring and junction boxes protected from UV
- Terminals protected against dust and moisture.
- Physically robust against bumping and tugging, and electrically robust.

8.2 Wiring losses

- PV array to battery circuit(s) ≤5% voltage drop at rated array current.
- Derated for climatic conditions.
8 PV Array, generator, battery, and powerhouse wiring (2)

+ **8.3 Wiring standards**
  - Cables may be copper or aluminum.
  - Cables shall **comply with IEC 60227** (Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V or appropriate standard.)

+ **8.4 Wiring installation**
  - Cables terminations **identifiable by color and/or lettering/numbering** unless there is no possibility of confusion
  - **Neatly installed** and secured by means of appropriate fasteners at regular intervals.
  - **Wiring lengths** long enough for connection and disconnection in the case of component maintenance.
8.51 Equipment earthing, including PV array frame

- Exposed metal parts bonded through an equipment earthing conductor connected to a ≤25 Ω earth rod.

- Earthing ampacities adequate for fault current over the operating time of the fault-protective device.
AC conductor earthing


- System electrical earthing shall only occur on the AC side of a system, where the AC neutral conductor is connected to the consumer earth conductor, at a single location at the generation facility site.

DC conductor earthing

- DC systems, or the DC portion of mini grids with AC may remain unearthed.
9 Distribution line (1)

Lines that developer intends to connect with the national grid

- MV lines and LV lines that the developer intends to possibly interconnect at a later time with the national grid shall be built in accordance with *REG standards: Reticulation Standards for Electricity Distribution Planning, Construction and Maintenance* available at: [http://www.reg.rw/fileadmin/user_upload/REG_Reticulation_Standards.pdf](http://www.reg.rw/fileadmin/user_upload/REG_Reticulation_Standards.pdf).
Lines that developer does not intend to connect with the national grid

- The maximum voltage at the customer not exceed ±5% and ±10%
- Poles supporting wires must be either rot resistant wood, concrete, or metal. Live trees shall not be permitted.
- Minimum height off the ground:
  - ≤3 meters (normal terrain)
  - ≤6 meters (crossing a road)
- Service connections must be attached to the house’s roof structure or walls by means of a suitable tension clamp that provides strain relief if wire is pulled.
9 Distribution line (3)

+ Lines that developer does not intend to connect with the national grid

- Service connections shall include a drip loop that prevents water from dripping onto the meter.

- Overhead conductor insulation UV & water resistant.

- All network wiring including service connections shall be built in such a way that protects against accidental contact with energized conductors.
Lines that developer does not intend to connect with the national grid (Inputs from REG)

- Each LV feeder must be protected with a circuit breaker rated for protection of the LV cable.
- LV feeders are not earthed at the transformer installation, but on the first pole away and on subsequent poles as described in the REG standards.
- The transformer LV side must be protected by a circuit breaker rated for the transformer protection.
- Heavy duty 10kA metal oxide LV Surge arresters must be installed on the LV side of the transformers (in the LV distribution box)
Meters used in mini grids that the developer intends to possibly interconnect at a later time with the national grid shall be in compliance with:

Suggestion: Pre-existing mini grids must comply with key safety requirements

- 3.1 Information
- 3.2 & 3.3 Nominal voltage & frequency
- 4.5.3 Battery overcurrent protection and disconnects
- 4.5.4 Battery installations
- 5.1 Hydropower Powerhouse (g,h,i,j)
- 6.2 Hydropower generator (6.2)
- 7.1 Protective arrangements
- 7.2 On-site fuel storage
- 8.1 PV array, generator, battery and powerhouse wiring
- 8.4 Wiring installation
- 8.5 Earthing
- 9 Distribution line
Thank you

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