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# ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN (ESMP) FOR CLEAN ENERGY MINI-GRID PROJECTS

TEMPLATE

# INTRODUCTION TO THE ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN (ESMP) TEMPLATE

## Notes:

This Environmental and Social Management Plan (ESMP) template has been created for the purpose of facilitating the assessment of environmental and social impact factors and the development of adequate mitigation strategies for prospective mini-grid project developers and operators. The approval of ESMPs by the applicable regulatory authorities are increasingly becoming a prerequisite to proceed with the construction of mini-grid projects. This template, thus, is intended to facilitate part of the project development work.

It is worth noting that the scope of environmental and social mitigation strategies that national environmental agencies will demand from prospective project proponents are directly dependent on the regulatory, geographic and demographic context where the future project is to be implemented. Maximum and minimum threshold limits of, for instance, pollution levels, are not homogeneous across countries and thus each Proponent must be familiar with the regulatory context where the project is to be implemented. Nevertheless, clean energy mini-grids *per se,* regardless of where they are located, imply a similar set of environmental and social risks, thus enabling the development of this standardized ESMP template.

## Instructions:

This template provides guidance for the preparation and implementation of Environmental and Social Mitigation Plans. The prospective Project proponent is expected to become familiar with the national regulatory framework and integrate those parameters of relevance to the template.

To adjust the Template to a specific context, the following is to be considered:

For each missing field, kindly fill in the blank space according to the associated instruction (as specified in brackets). In some cases, this implies the name of an institution; in others, it implies the maximum/minimum permitted thresholds as per national regulations.

Kindly attach all relevant environmental legislation under the section Reference

# CONTENTS



# LIST OF TABLES

# ACRONYMS

| | |
|---|---|
| **AC** | Alternating current |
| **CdTe** | Cadmium Telluride |
| **dB** | Decibels |
| **DC** | Direct current |
| **E&S** | Environmental and Social |
| **EIA** | Environmental Impact Assessment |
| **ESMP** | Environmental Social Management Plan |
| **Ft.** | feet |
| **GHG** | Greenhouse gas |
| **kW** | Kilowatt |
| **IEC** | International Electrotechnical Comission |
| **$m^3$** | Cubic meter |
| **NiCd** | Nickel-Cadmium |
| **NiMH** | Nickel-Metal Hydride |
| **$NO_2$** | Nitrogen dioxide |
| **PAP** | Project Affected Person |
| **PPE** | Personal Protective Equipment |
| **ppm** | Parts per Million |
| **PV** | Photovoltaic |
| **RAC** | Refrigeration and Air Conditioning Equipment |
| **$SO_2$** | Sulphur dioxide |

# DEFINITIONS

| | |
|---|---|
| Environmental Impact Assessment (EIA) | shall mean a decision-making tool or process of evaluating the likely environmental impacts of a proposed project or development on the immediate natural environment, both beneficial and adverse. |
| Environmental and Social Impact Assessment (ESIA) | additionally to Environmental Impact Assessment (EIA) above, shall mean a decision-making process of identifying and evaluating the socio-cultural impacts of a proposed project. |
| Environmental and Social Management Plan (ESMP) | shall mean a comprehensive document that directs effective and responsible implementation and management of environmental and social impacts mitigation and enhancement measures during the construction, operation and closure phases of a proposed project. |
| Power Generation Capacity | shall mean the guaranteed active power that a generation plant can supply to a load or network at any point in time under the given environmental constraints (temperature, humidity, etc.) for at least one hour under the assumption that the plant is well maintained and fully functional. |
| Project | shall mean the Mini-Grid to be developed by the Proponent requiring the ESMP Certificate. |
| Project Affected Person (PAP) | shall mean any person affected by the project activities directly and/or indirectly in the area of influence. |
| Proponent | shall mean a Project Proponent; that is an entity or individual, organising, proposing, designing, or advocating a Mini-Grid Project and may include the project designer(s), developer(s), investor(s) or any other party working on behalf of the Project. |
| Clean Energy Mini-Grid | shall mean any electricity supply system with its own power generation capacity from any of the following: solar photovoltaic, wind, hydro, biomass or geothermal energy together with any combination of battery storage and diesel generation of up to 1MW in total, and low voltage and/or medium voltage distribution system including electricity meters, supplying electricity to more than one customer and which can operate in isolation from or be connected to the network of a distribution company. In the context of this ESMP Template, the focus are solar hybrid mini-grids, given the predominance of this technology in SSA. |

# 1.) PURPOSE OF AN ESMP

An ESMP is a standalone management tool that details the set of mitigation, monitoring, and institutional measures to be taken during implementation, operation and decommissioning of a project to eliminate adverse environmental and social risks and impacts, offset them, or reduce them to acceptable levels. It is the document produced by the Project Proponent with input of all stakeholders highlighting the following:

1. identifies potential adverse and beneficial environmental and social impacts of the Project as well as the extent of short- and long-term effects
2. develops a set of mitigation and enhancement measures to potentially adverse and beneficial impacts and defines the roles and responsibilities of personnel in charge
3. determines requirements for ensuring that those responses (i.e. mitigations and enhancements) are made effectively and in a timely manner as well as reported adequately
4. describes the means for meeting those requirements in-line with regulatory/legal basis, if relevant.

# 2.) LEGAL AND POLICY FRAMEWORK

This section provides an overview of the most relevant policies and acts that are applicable to Clean Mini-grid Projects in ……………………… *(country to which ESMP applies).*

*(Kindly state relevant policies, national strategies, acts, guidelines, plans, international treaties/agreements and agencies involved on defining the national mini-grid framework and its implementation. Information in regards to date of issuance/creation, purpose of existence and achievements (if applicable) ought to be preferably mentioned).*

- ***………………………………………………………… (Name of Agency/Plan/Strategy, etc.)****:* ……………………………………………………………………………………………………… ……………………………………………………………………………………………………… ……………………………………… *(description, date, purpose and achievements, if applicable)*
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## 3.) ENVIRONMENTAL AND SOCIAL PARAMETERS

In defining the E&S parameters, it is expected that the Proponent will consider the environmental aspects emanating from the following minimum project activities:

1. Quantities and types of material needed during the construction and operation of the Mini-Grid Project;
2. Characteristics of the operational process;
3. Physical presence and appearance of completed development within the receiving environment
4. Geographical setting and use of the land for proposed development;
5. Estimated duration of the construction phase, operational phase and where appropriate, decommissioning phase;
6. Estimated numbers of workers and/or visitors entering the site during construction and operation and worker camps and/or transportation and access routes;
7. Power evacuation means;
8. Estimates, by type and quantity, of expected residues and emissions (heat, noise, vibration, light, radiation, air, water, and soil contaminants, etc.) during construction, operation and decommissioning phases of the proposed Mini-Grid Project;

The environmental and social impact of a Mini-Grid Project will depend to a large extent on the project's size (in kW of delivered power), on the project location in relation to its environmental and demographic context and the mini-grid's renewable energy fraction. Access to electricity at affordable tariffs is to imply direct improvements on the community's productivity, life comfort, health, education and possibilities to thrive.

The key power generation components of clean energy mini-grids are solar PV modules organized in arrays, battery banks (generally relying on lead-acid or lithium-ion batteries) and power electronic components such as inverters, charge controllers and combiner boxes. Often diesel or petrol generators are installed to complement the renewable energy components, given the fluctuating nature of renewable resources such as solar and wind energy as well as overall loads. Battery banks and inverters, combiner boxes and fuel gensets are located inside a power house. Transformers, low voltage distribution cables, poles and energy meters compose the power distribution network of a Mini-Grid Project. The higher the renewable energy fraction of a Mini-Grid, the lower its environmental impact in terms of air and acoustic pollution during the operational phase; nevertheless, particular attention ought to be placed on the correct disposal of large battery banks after the Project's operational phase comes to an end.

Thus, key environmental impacts to be considered during the ESMP process of a clean energy mini-grid and their corresponding risk assessment are:

**Table 1. Environmental impacts during life-cycle of a clean energy mini-grid**

| Impact | Relevant mini-grid component |
|---|---|
| **Construction Phase** | |
| Acoustic & air pollution from operating machinery (high probability/low impact) | Excavation works for power house foundation and distribution network poles as well as earth works for protection of power generation components |
| Soil erosion & sedimentation (medium probability/high impact) | |
| Water/ground pollution (low probability/low impact) | Improperly used or disposed paint, chemicals, sealants relied upon during construction process.<br>Improper closure of construction phase leading to unremoved construction materials (spare cables, connectors, etc.). |
| Solid waste generation (high probability/medium impact) | Packaging materials of PV panels, battery banks, combiner boxes, etc. |
| Oil/fuel spills (low probability/high impact) | Transport of equipment to remote site and operating of construction machinery. |
| Loss of natural assets (medium probability/low impact) | Need for tree cutting to construct the distribution network/power generation assets. |
| **Operation Phase** | |

| | |
|---|---|
| Water/ground pollution from spill overs (medium probability/high impact) | Improperly transported and stored fuel for genset operation.<br>Acid spillage (applicable for lead-acid battery banks relying on liquid sulphuric acid as electrolyte). |
| Acoustic pollution (low probability/medium impact) | Gensets strongly contribute to acoustic pollution. Power houses (where gensets are stored) should be built at sufficient distance from inhabitants' houses. |
| Air pollution (low-medium probability/medium impact) | Old genset filters prevent proper cleaning of exhaust air. Gensets' air and fuel filters have to be replaced frequently as part of generator servicing. Schemes are determined by genset's manufacturers.<br>Expulsion of toxic gas (thermal runaway) of improperly maintained or physically damaged lithium-ion batteries. |
| Fire/explosion (low probability/high impact) | Vegetation/trees falling on distribution network cables.<br>Applicable in case of large mini-grid systems with high current and voltage levels (inverters can be source of high magnetic fields).<br>Consequence of improperly stored/handled fuel.<br>Overheating of battery banks |
| Prevention of air/noise pollution and fires/explosions | Positive environmental impact associated with the reduction in genset use in favour of solar energy from PV arrays (applicable only where a solar mini-grid is deployed as a complement or replacement of an existing fuel generator).<br>Positive impact associated with use of electricity instead of kerosene for household lighting purposes. |
| Loss of physical assets (low probability/high impact) | Thunderstorms, floods and strong winds can lead to poles falling on community buildings (if not properly constructed) and short circuits. |

| **Closure/Disposal Phase** | |
|---|---|
| Water/ground pollution<br>(low probability/high impact) | Leachate generated on landfills of CdTe thin-film PV solar panels.<br>Battery banks have to be properly disposed of due to their composition/use of chemicals and heavy metals (especially lead-acid and nickel-cadmium batteries)<br>Refrigerants in air-conditioner units installed inside of power houses as part of battery coolant systems. |
| Landfill waste<br>(medium probability/medium impact) | Increased amounts of PV panel deployment worldwide. Priority for recycling. |
| Impact on landscape<br>(low probability/low impact) | Concrete foundations of powerhouse or PV panel arrays should be removed after Project life-time. |

Key social impacts to be considered during the ESMP process of a clean energy mini-grid and their corresponding risk assessment are:

**Table 2. Social impacts during life-cycle of a clean energy mini-grid**

| Impact | Relevant mini-grid component |
|---|---|
| **Construction Phase** | |
| Temporary access restrictions to properties/community buildings<br>(high probability/low impact) | Installation of poles and cables |
| Positive economic impact | Potential employment of local labour during the construction phase |
| **Operation Phase** | |
| Risk of burns/fire<br>(low probability/medium impact) | Fuel spill overs during refilling if proper systems are not used. |

| | |
|---|---|
| Negative health impact<br>(low probability/high impact) | Associated with genset fuel and battery bank acid leakages (for Lead-acid batteries). Nickel-Cadmium & Lead-acid batteries are partially composed of heavy metals, exposure to which can lead to headaches, brain and kidney damage, abdominal discomfort affect children's growth, cause sleep problems and in severe cases lead to comas. |
| Possible social exclusion<br>(medium probability/medium impact) | In case community interest to connect to the mini-grid is larger than the mini-grid size allows. |
| Positive health impact | Provision of electricity allows to power medical equipment as well as preserve food for longer periods of time.<br>Electrical bulbs are effective substitutes of kerosene lamps, which can be associated with multiple health issues (lung malfunction, infectious diseases and cancer). |
| Positive economic and social impact | Savings for households (provided affordable tariffs in relation to present expenditures on e.g. kerosene/diesel).<br>Creation of business opportunities.<br>Access to information (televisions, laptops, internet).<br>Community gatherings are facilitated during night-hours as well.<br>Potential employment of local personnel during the operation phase. |
| Increased security | Community/streets lighting during the night enforces security. |
| Women empowerment | Access to electricity is often associated with enabling women to become entrepreneurs. |
| **Closure/Disposal Phase** | |
| Negative health impact<br>(low probability/high impact) | Improver disposal of batteries after their life-time can potentially lead to health risks as described above. |

# 4.) MITIGATION MEASURES

## 4.1 PV PANELS

Solar modules are the source of conversion from solar energy to renewable electricity. They produce DC power, which is in turn fed into batteries through charge controllers or fed into the grid after being converted from DC to AC by inverters. PV panels are made of silicon, metal and glass. The key components of a PV module are the solar cells (heart of the component), a metal frame (typically aluminium), glass sheets for casing, wires and steel screws. PV panels are classified as monocrystalline, polycrystalline or amorphous thin-film modules. Solar panels are known for being an environmentally-friendly technology, free from noise and air pollution throughout their operational phase. For small-scale projects, PV panels are easily integrated into the environment without fundamentally changing the landscape.

90% of the modules in the market are made of silicon as a semiconductor material. Nevertheless, some thin-film PV modules use Cadmium Telluride (CdTe). Cadmium is a dangerous and highly poisonous heavy metal when inhaled or ingested, both for animals and humans, and should be properly disposed after the Project's lifetime. Furthermore, the PV manufacturing process is an energy-intensive one, and priority ought to be given to manufacturers implementing environmental and social mitigation measures in their processes. Other than the need to properly dispose PV panels as well as rely on environmentally-conscious PV panel suppliers, no other environmental requirements have to be fulfilled.

1. Mitigation measures:
    a. During construction and operation, no major considerations are required. It is nevertheless important to keep into account regular PV panel cleaning requirements, for which a nearby body of water will be necessary. While water access should be ensured, it must also be properly communicated to the recipient community during early stages of project design (especially in areas with water scarcity issues).
    b. Silicon-based PV panels present little concern during disposal. However, thin-film PV modules need to be handled carefully. Exposure to heavy metals such as Lead and Cadmium is a growing problem throughout the world. While the combination of Cadmium and Tellurium found in some thin-film PV panels reduce the toxicity of the former (with a concentration of only 0.04% on the entire panel), it is of paramount importance to develop a proper disposal plan of modules after the end of Project's lifetime.
    c. Emissions from Cadmium and Tellurium are assumed to be close to 0[1]. However, exposure of Cadmium on panels to rain water on landfills can lead to the formation of leachate in the mid-term. The landfill where PV panels would eventually be disposed of must ensure the treatment of its effluent. ………………… *(kindly state name of country)* environmental regulations set a Cadmium concentration limit on effluents of less than ………… *(kindly state maximum level of cadmium concentration levels on effluents as per national regulations)* mg/liter as per ………………… *(kindly state source of applicable national environmental regulation).* Minimization of exposure to water of the modules would

1 Okkenhaug, et.al., 2010.

significantly reduce the formation of leachate, and thus minimize the negative environmental impact in terms of direct soil and water pollution.

d. Furthermore, to minimize potential negative environmental and social impacts of the entire PV panel value chain from a life-cycle perspective, proper mitigation measures would include procurement provisions from suppliers regarding recycling and appropriate precaution practices throughout the manufacturing process. Operators and developers of mini-grid systems must subscribe to ……………………………… *(Kindly state, if applicable, name of national program regulating end-of-lifecycle equipment disposal).*

2. Monitoring of mitigation measures for PV panels:

   a. In order to ensure the recipient community's comfort with a developed clean energy Mini-Grid Project as well as the impact of the PV arrays on the environment, the system operator should hold meetings with the respective communities periodically to ensure continued acceptance and comfort with the Project. This is particularly the case when a scale up of the PV arrays is planned as the community's load grows.

   b. PV panel suppliers ought to be required to provide information on the source/origin of used raw materials.

## 4.2 BATTERY BANKS

In combination with the PV arrays, properly sized battery banks allow for a minimization of the dependence on fuel generators for power supply in Mini-Grid Projects. Mini-Grid batteries are operational on a daily basis and subject to varying states of charge. For this reason, deep-cycle industrial batteries are required for off-grid/mini-grid applications, given their high reliability and lower life-cycle cost to users. While Lead-acid batteries are the most commonly used technology (mainly due to economic reasons and proven in their application), Lithium-ion batteries are gaining traction in the market. Although less commonly used, other Nickel-based battery types, such as Nickel-Cadmium (NiCd) and Nickel-Metal Hydride (NiMH) batteries, are suitable for remote contexts with extreme environmental conditions (e.g. high temperatures), given their robustness and long use life.

1. Mitigation measures for Lead-acid batteries: Besides being heavy components (a single cell can weigh in the range of 100-200 kg), one of the down-sides of Lead-acid batteries is, as the name indicates, the presence of significantly more hazardous materials, namely the heavy metal lead present on the plates and the sulphuric acid. Batteries in mini-grids are generally organized in several banks, each of which can have a volume of a few $m^3$ to several $m^3$.

   a. During construction, special precaution in the transport and filling of the sulphuric acid serving as battery electrolyte has to be taken, given its highly corrosive nature. Personnel dealing with batteries should always wear protective personal equipment such as protective eyewear and gloves.

   b. During operation, battery banks should always be kept in an anti-corrosive container or sheltered in a well-ventilated room, protected from rain, water and heat. To avoid acid spillage, a basin should be placed underneath the battery cells.

   c. During operation, Lead-acid batteries have to be periodically refilled with distilled water (a process which should take place only when the batteries are charged and cooled). For this purpose, personal protective equipment (PPE) such as eyewear and gloves should always be worn.

d. During disposal, Lead-acid batteries should be transported to specialized collecting points, given the highly pollutant nature of Lead and as per ………………… *(kindly state name of country)* environmental regulations, which set a Lead concentration limit on effluents of less than …… *(kindly state lead concentration limit on effluents as per national regulations)* mg/liter as per ……… *(kindly state source of applicable regulation).*

2. Mitigation measures for Lithium-ion batteries: Although more expensive, this technology offers a much higher energy density (thus reducing the total weight of the battery banks) and contains significantly less hazardous materials than Lead-acid batteries. The battery cell's anode is generally made of Graphite, while the cathode is made of Iron Phosphate, Lithium Cobalt Oxide, Lithium Manganese Oxide or Lithium Nickel Manganese Cobalt Oxide. While Lithium does not present any major concerns from the pollution perspective, Cobalt and Manganese are examples of toxic heavy metals. The electrolyte is comprised of Lithium salt in an organic solution. While proper recycling of the battery maximizes the use of its components, its relative novelty leads to limited recycling methods until now.

    a. Adhering to IEC's international safety standards for the selection of Lithium-ion battery banks as well as their construction and operation should ensure Lithium-ion batteries' environmental and social impact is independent on the site and thus a more in-depth EIA would not be needed.

    b. If improperly maintained (not kept cooled and regularly exposed to complete discharging) or are physically damaged, Lithium-ion batteries can be subject to thermal runaway risk, which involves the rapid expulsion of a toxic gas that can eventually explode if ignited. It is thus of fundamental importance to keep the battery banks cool and operational as per manufacturer's guidelines.

3. Mitigation measures for Nickel-based batteries

    a. No major mitigation measures are required during construction and operation.

    b. Mitigation strategies for the disposal of Nickel-based batteries will ultimately depend on the specific compounds present on the battery cells. As previously discussed for PV panels, the Cadmium present in NiCd batteries is highly poisonous and requires a careful disposal plan. Alternatively, NiMH batteries can be disposed in properly managed waste landfills, given their significantly lower composition of poisonous materials.

4. Monitoring of mitigation measures for battery banks

    a. Existence/availability of battery recycling points must be ensured. Mini-grid operators shall subscribe to the ……………………………… *(Kindly state, if applicable, name of national program regulating end-of-lifecycle equipment disposal).*

    b. Battery manufacturers/suppliers ought to be required to provide information on the source/origin of used raw materials.

    c. Fire alarm systems must be set in place in case of an outbreak of fire due to the battery banks.

## 4.3 FUEL GENERATORS

The reliance on properly functioning diesel/petrol generators ensures mini-grid up-time throughout the day regardless of solar patterns (specially at night and during rainy seasons) while allowing to reduce initial capital investment in large battery banks and PV arrays. However, these components are the key contributor to negative environmental and social impacts throughout a Mini-Grid Project's operational phase. Gensets contribute to acoustic and air pollution during their operational hours. Furthermore, the transport of fuel and lubricant oil to remote locations poses in itself an environmental risk, given their highly hazardous nature. Fuel and oil leakages can significantly affect wildlife and ecosystems by make drinking water unusable as well as cause injuries and diseases to animals and human beings.

1. Mitigation measures for fuel generators:
   a. Generators have to be regularly and properly maintained/serviced as per manufacturer's guidelines to ensure genset emissions are under national emission standards. While servicing schedules differ across gensets, in-depth maintenance such as air, fuel and oil filter replacement must generally take place every 250-500 hours of operation. While genset servicing increases the operational costs of these components significantly (versus PV panels and battery banks), their negligence substantially increases the environmental and social impact of generators and shortens the genset's lifetime. Genset servicing must be undertaken by certified professionals wearing adequate PPE.
   b. Any genset is to be located on a separate and well-ventilated room in relation to the battery banks. Exhaust pipes should be directed far from PV panel arrays as well as other electronic equipment.
   c. Fuel is an extremely hazardous and flammable material. It must be stored in properly sealed tanks on-site, at a sufficient distance and separate room from the battery banks. Fire extinguishers must be available on-site and regularly maintained.
   d. A proper fuel refilling mechanism should be ensured (e.g. in the form of manual or automatic pumps) to pour the fuel from the transport drums to the tank on site, both to ensure the safety of the responsible personnel as well as avoid spills. Fuel spills must be cleared.
   e. Fuel theft is not uncommon and must be prevented under all circumstances, both for economic as well as environmental protection reasons.
   f. Noise derived from genset operation must remain below ………………… *(kindly state maximum limit of noise pollution levels as per national regulations during day-time)* dB (day-time[2]) and ………………… *(kindly state maximum limit of noise pollution levels as per national regulations during night-time)* dB (night-time) as per …………………………………… *(kindly state name and source of applicable regulation).*
   g. The Proponent will adhere to the ……………………………… *(Kindly state, if applicable, name of national program regulating end-of-lifecycle equipment disposal).*

2 Day-time: …………… *(kindly state time interval considered to fall during day-time hours as per national regulations)*; Night-time: …………… *(kindly state time interval considered to fall during day-time hours as per national regulations).*

2. Monitoring of mitigation measures:
   a. The genset and fuel tank room must be kept clean of oil and fuel leakages at all times to prevent risk of fire.
   b. The genset's operating hours must be constantly tracked to properly and timely plan servicing schedules. Emissions of $SO_2$, $NO_2$ and particulates must be kept below ………… *(kindly stated maximum limit of emitted $SO_2$ as per national regulations)* ppm, ………… *(kindly stated maximum limit of emitted $NO_2$ as per national regulations)* ppm and ………… *(kindly stated maximum limit of emitted particulates as per national regulations)* mg/m$^3$, respectively, as per national emission standards ……… *(kindly state source of applicable regulation)*. Emissions must be quantified and reported to ……………………… *(kindly state name of national environmental regulator, if applicable).*
   c. Genset exhaust gas must be colourless.
   d. Nearby water bodies ought to be tested periodically to ensure there is no contamination due to coolants/fuel.
   e. Cameras or guards must be based on-site to prevent fuel theft.
   f. Measurements on noise levels (both inside the facility as well as within the ambient environment) must be undertaken periodically with noise level meters and reported to ……………………… *(kindly state name of national environmental regulator, if applicable).*

## 4.4 POWER ELECTRONIC COMPONENTS

Power electronic components comprise those parts of the system controlling the flow of power as well as converting electricity from one form to another, such as inverters, charge controllers, circuit breakers, etc. While they imply no significant risk during the construction and operational phase, heavy metals may be present on their structures and thus disposal on adequately managed landfills/recycling points is required. As long as the electronic components are installed as per manufacturers' recommendations and international standards, these imply very low environmental and social risk, especially for smaller systems in the range of several kW.

1. Mitigation measures for power electronic components:
   a. No special treatment beyond adequate waste management plans is required. Mini-grid operators shall subscribe to the ……………………………… *(Kindly state, if applicable, name of national program regulating end-of-lifecycle equipment disposal).*

### 4.4.1. MINI-GRID POWER HOUSE, DISTRIBUTION NETWORK AND OVERALL SITE CONSTRUCTION AND OPERATION

Civil works of mini-grids involve mainly the construction of a power house for the storage of the battery banks, genset, battery inverters and combiner boxes as well as the erection of poles as part of the power distribution network. Power houses are constructed on-site next to the PV arrays, all of which must be gated to prevent theft of any of the components. For small-scale systems of up to 100 kW, power houses are usually not larger than 20 ft. containers, constructed on concrete foundations and usually covered with metal sheet roofs. In particularly warm climates, power houses may be equipped with air conditioners that serve as a cooling mechanism for the battery room.

A small-scale mini-grid requires the excavation and erection of several tens or hundreds of poles in order to connect all customers to the distribution network. Poles are often made of wood, but can also be made of steel or concrete. The proper excavation of holes for pole erection is of fundamental importance in order to prevent the risk from poles falling on household structures or other buildings when subject to strong winds or floods. Furthermore, wooden poles are treated with chemicals during manufacturing, which can lead to leaching and the formation of surface residues at the right-of-way, for which proper mitigation measures ought to be taken.

1. Mitigation measures for power house, distribution network and civil works include:
    a. During construction, dug plots/holes must be re-filled after excavation. Hazardous substances used during construction (such as paint and other chemicals) much be properly disposed. Construction works must be undertaken in a way to minimize generation of unnecessary amounts of dust, and noise levels must remain below ……… *(kindly state maximum noise levels during construction activities as per national regulations)* dB as per ………………………… *(kindly state name and source of applicable national regulations).*
    b. In line with sustainable development standards and as per ………………… *(kindly state name of national environmental regulatory agency)* regulations, every tree felled for the purpose of the Mini-Grid Project must be in conformity with the …………………… *(kindly state name and source of relevant environmental regulations, if applicable)*. The construction or installation activities must not interfere with the use of public space, land and airport facilities.
    c. During construction and operation, adequate litter bins must be provided on-site as per …………………………………… *(kindly state name and source of applicable waste control national regulation)*.
    d. During operation, wooden electric poles must be treated to ensure chemical fixation and prevent leaching as per ………………………… *(kindly state name and source of applicable national environmental regulation of the energy sector)*.
    e. During operation, right-of-way maintenance has to be undertaken to ensure events of trees and other vegetation falling on distribution cables do not take place.
    f. During decommissioning, concrete foundations must be removed and the landscape must be returned as close as possible to its pre-project state. Careful disposal of air conditioner units (if available) must be guaranteed, to prevent leakage of hazardous refrigerants on the surrounding environment.
    g. Proponent must adhere to …………………… *(Kindly state, if applicable, name of national program regulating end-of-lifecycle equipment disposal).*

# 5.) RESPONSIBLE ACTORS FOR MITIGATION PLAN IMPLEMENTATION AND MONITORING

As per ………………………… *(kindly state name and source of applicable national environmental regulation of the energy sector),* every mini-grid operator shall have an organisational system including a pollution control manager responsible for the internal environmental auditing of the facilities[3]. The pollution control management system has to include the improvement and operation of effective environmental management systems, the ability to know when a specific component is malfunctioning, control of environmental management procedures and records as well as serve as a contact point with ………………… *(kindly state the name of the national environmental regulatory agency).*

Every mini-grid operator must set up an emergency response plan to combat all types of pollution hazards, as well as submit to ………………… *(kindly state the name of the national environmental regulatory agency)* a list of chemicals used in the construction, operational and closure phases of the Mini-Grid Project.

3 Such organizational structure ought to be adjusted to the given national regulatory framework.

**Legend**

| | |
|---|---|
| **Required** | ✓ |
| **Not required** | ✗ |

**Table 3. Minimum Environmental and Social Parameters (indicators) for Clean Mini-Grid Projects.**

| Environmental Media | Parameters / Indicators | Pre-Construction | Construction | Operation | Decommis-sioning |
|---|---|---|---|---|---|
| **Climatic Information** | Climatic zone and extremes variability | ✓ | ✗ | ✗ | ✗ |
| | Climate change projections | ✓ | ✓ | ✓ | ✓ |
| | Solar Radiation and Temperature (air and land surface temperature) | ✗ | ✗ | ✓ | ✗ |
| | Rainfall – Pattern, amount, trend | ✓ | ✓ | ✓ | ✓ |
| | Prevailing wind – direction, speed | ✗ | ✗ | ✓ | ✗ |
| **Emissions and Noise** | Air Pollutant Gases | ✓ | ✓ | ✓ | ✓ |
| | Particulates | ✓ | ✓ | ✓ | ✓ |
| | Noise | ✓ | ✓ | ✓ | ✓ |
| | Vibrations | ✓ | ✓ | ✓ | ✓ |
| **Land Acquisition** | Voluntary and Involuntary land acquisitions | ✓ | ✗ | ✗ | ✗ |

| Environmental Media | Parameters / Indicators | Pre-Construction | Construction | Operation | Decommis-sioning |
|---|---|---|---|---|---|
| | Land use pattern – manmade features, economic use, public utilities, tourism site, etc | ✓ | ✗ | ✗ | ✗ |
| **Socio-economic Considerations** | Demography of PAPs and communities | ✓ | ✓ | ✓ | ✓ |
| | Economy and livelihood patterns | ✓ | ✓ | ✓ | ✓ |
| | Amenities and infrastructure | ✓ | ✓ | ✓ | ✓ |
| | Religion, cultures and traditions | ✓ | ✓ | ✓ | ✓ |
| | Public health, safety and security | ✓ | ✓ | ✓ | ✓ |
| | Traffic | ✓ | ✓ | ✗ | ✓ |
| **Surface water** | Hydrology, topography and flooding patterns | ✓ | ✓ | ✓ | ✓ |
| | Surface water quality | ✗ | [✓][4] | ✓ | ✓ |
| | Water volumes and sustainability | ✗ | ✗ | ✓ | ✗ |
| **Wastes Management** | Wastes (solid and liquid) | ✗ | ✓ | ✓ | ✓ |

[4] Surface water tests are often only applicable for projects located below a specified distance to surface water sources (minimum distance varies from country to country).

| Environmental Media | Parameters / Indicators | Pre-Construction | Construction | Operation | Decommis-sioning |
|---|---|---|---|---|---|
| **Occupations Health and Safety** | Workers health and safety | ✗ | ✓ | ✗ | ✓ |
| **Soil** | Soil quality | ✗ | ✓ | ✓ | ✓ |
| **Site Remediation and Restoration** | Landscape, drainage, community use | ✗ | ✗ | ✗ | ✓ |
| **Groundwater** | Water quality | ✗ | ✓ | ✓ | ✓ |
| | Water volumes and availability | ✗ | ✗ | ✓ | ✗ |
| **Biodiversity**[5] | Fauna and flora | ✗ | ✗ | ✗ | ✗ |
| | Habitat types | ✗ | ✗ | ✗ | ✗ |
| | Ecosystem services | ✗ | ✗ | ✗ | ✗ |

[5] It is expected that biodiversity will not be applicable for ESMP given that same is only applicable for projects in sensitive areas.

# 6.) REFERENCES

*(Kindly list all relevant national environmental regulations)*