Recommendation Brief

Sustainability Guidelines for Solar Mini-grids in Maluku

NZMATES has been working to accelerate renewable energy uptake in Maluku since 2018. Part of NZMATES assistance is conducting technical and socio-economic assessments for numerous solar PV mini grids. Up to 2019, NZMATES visited 15 installed solar PV mini-grids. However, most of the systems were broken or even shut down. Figure 1 summarizes the condition of the solar PV mini-grids at the time of NZMATES assessment.

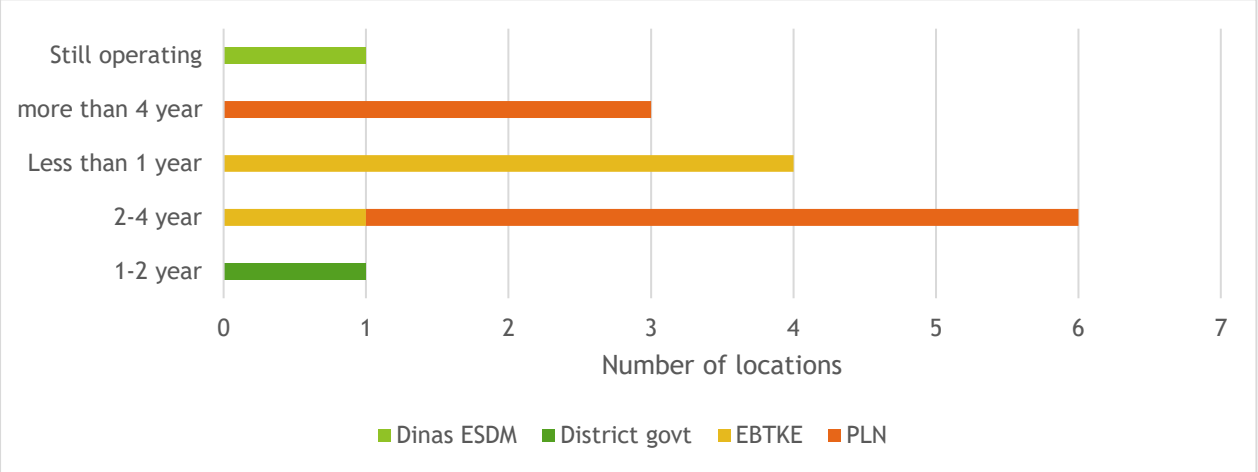


Figure 1. Condition of PLTS during NZMATES Assessment (disaggregated by operation time and system owner)

The challenges are mapped across various aspects, such as technical, institutional, economic, and others. A summary of these challenges is provided below[1]:

- **Technical factors**

  The main technical challenges are unsuitable/unresponsive system sizing, issues with batteries exposed to high temperature and high depth of discharge, poor component quality, configuration issues with inverters, and lack of technical support. Moreover sites lacked diesel genset for back-up power to keep batteries healthy. Some of the technical issues found in the field could have been easily solved by a technician with the right expertise and resources.

- **Institutional factors**

  Community-based institutions often lacked institutional and legal clarity, or even any formal status as an electricity provider. In most cases, one or more community members received training on basic maintenance tasks before the operation phase. Yet, division of responsibility and budget needs between the local institutions and

[1] The order of presentation does not represent order of importance.

the project owners was left unclear. This condition was aggravated by the lack of mechanisms for seeking support in the event of complex failures. Meanwhile, local communities had limited capability to reach out to maintenance providers or buy spare parts or other equipment. Lack of legal clarity for village management teams also made tariff collection challenging.

- **Economic factors**

  A key problem identified across all PLTS was a lack of lifetime economic planning. Community-operated projects are often developed considering only capital expenditure costs, and costs for replacing key components such as batteries were not accounted for ahead of time. Thus, communities were often left with the impression that operator salaries were the only ongoing cost. Electricity tariffs were usually set at a flat monthly rate for all users which, while accessible for all, was not enough to cover the costs of repairs, replacement of components, and other O&M work.

- **Other factors**

  Other factors that affect the sustainability of solar power plants in Maluku include weak social embeddedness, a lack of coordination between stakeholders, and health and safety risks that present a major hazard to communities and workers.

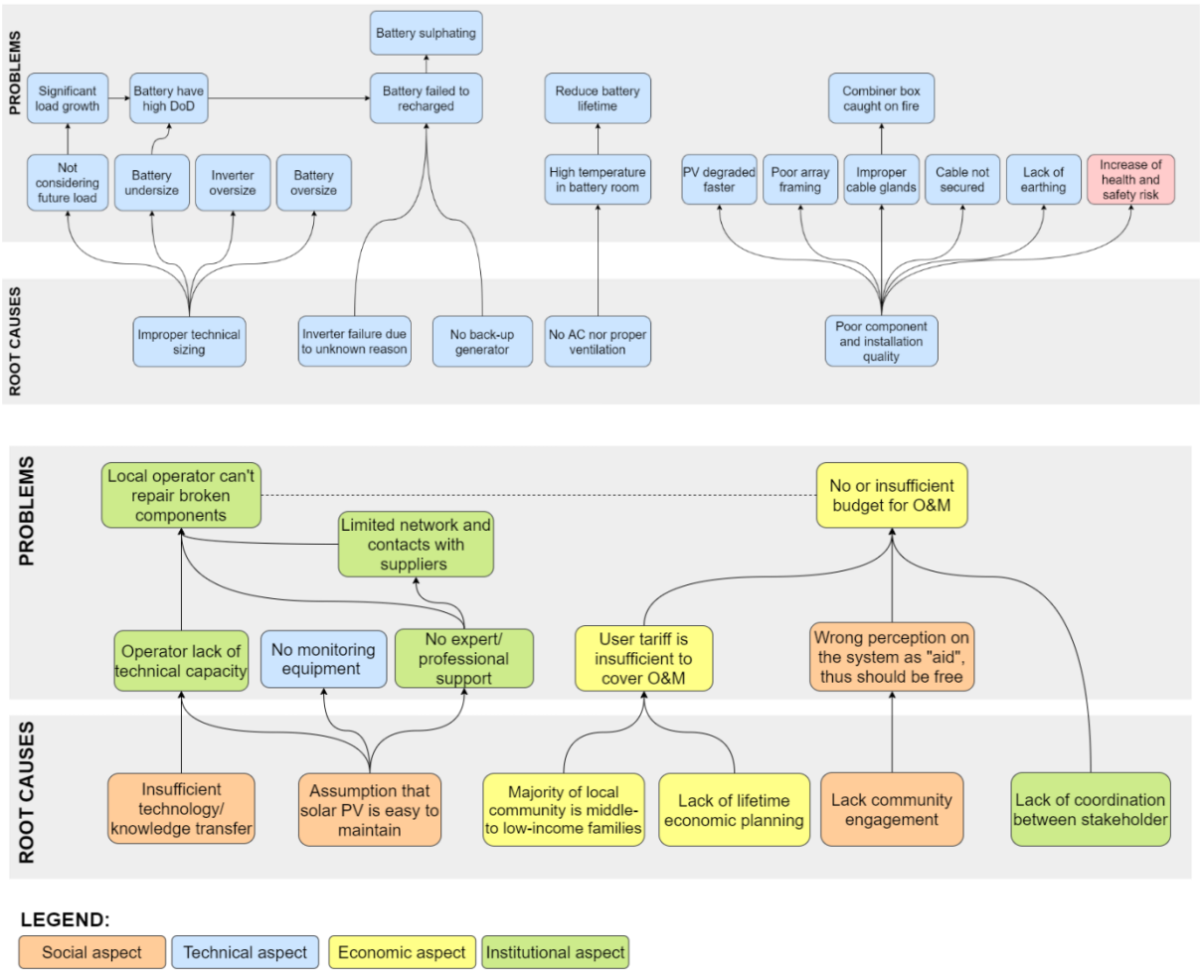


Figure 2. Mapping of Root Cause Analysis from NZMATES Assessments

From the assessment, NZMATES developed recommendations according to project phase, i.e., scoping, planning, installation, operation, and decommissioning.

1 SCOPING PHASE RECOMMENDATION

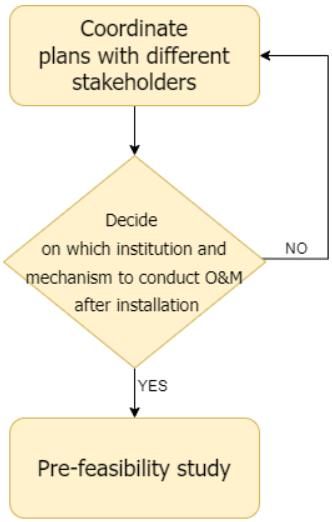


Figure 3. Scoping Phase Recommendation

During scoping phase, it is important to coordinate with different stakeholders since there are several institutions working with electrification in Indonesia. The objectives of coordination are:

- Synchronize data and development planning
- Decide on which institution will conduct O&M activities after installation?
- Discuss how the O&M activities will be fund?
- In case of community-based operation, develop mechanism on how the field operators get support to get spare parts or components that need to be replaced?

Unless the O&M institution and after installation mechanism decided, it is not advised to move the project forward.

In deciding O&M institution, it should be based on:

- The institution experience working with RE system
- The institution has engineers in place who have capability to perform regular O&M (preventive, routine, corrective and condition-based maintenance), performance testing, and troubleshooting.
- The institution has expert support in place in case system trouble cannot be handled by field engineers/operators
- The institution has plan and resources to procure spare-parts and components when it's needed
- The institution should have financial plans and resources to conduct O&M activities
- The institution should meet all legal requirements to conduct the O&M activities

During pre-feasibility study, project developers should prioritize projects that have the best value for money and greatest impact for all. These other factors might be number of households that will be affected by the project, emerging industry nearby, economic growth of the area, and many more.

2 PLANNING PHASE RECOMMENDATION

Once suitable locations and projects have been identified, details of the project will be developed during the planning phase. This phase will see detailed feasibility studies carried out, engagement with key stakeholders (including community leaders and members), detailed technical design of the proposed system, economic and financial planning, and development of an institutional plan for the entity that is to own and operate the system once built.

PLANNING PHASE CHECKLIST

TECHNICAL ASPECT

Section 4.2.2

☐ Conduct proper sizing and design
- ☐ Define load profile
  - !! Use direct measurement, or load profile for location with similar setting.
  - !! Best practice is to have load profile with 15-minutes time step for over one month, at least.
- ☐ Calculate annual energy production
  - !! Include PV derating factor and annual degradation throughout system lifetime (20 years).
- ☐ Conduct feasibility with other technology/fuel options to find optimum techno-economic configuration.

☐ Planning to extend battery lifetime
- ☐ Having back-up generation
- ☐ Battery management system (BMS)
- ☐ Choose battery operating temperature close to Maluku's ambient temperature and install air conditioning in battery room

☐ Ensure all components meet minimum standards.
☐ Develop planning for component end-of-life, especially for component that need replacement less than 20 years.

ECONOMIC ASPECT

Section 4.2.3

☐ Conduct long-term budget analysis for the whole system lifetime (20 years)
☐ Calculate appropriate electricity tariff
☐ Design a financial mechanism to collect tariff and good bookkeeping

SOCIAL ASPECT

Section 4.2.4

☐ Inclusive community engagement: local stakeholders and community should be informed regarding the project
☐ Stakeholder mapping
☐ Develop strategy for community engagement for during and after installation

INSTITUTIONAL ASPECT

Section 4.2.5

☐ Develop clear structure and responsibility of O&M institution
☐ For community-based system, the O&M institution should meet all legal requirements to conduct O&M, including to collect electricity tariff from the customers

3 IMPLEMENTATION PHASE RECOMMENDATION

IMPLEMENTATION PHASE CHECKLIST

PREPARATION

- ☐ Contractor develop project plan, including documents such as:
  - ☐ Installation milestones
  - ☐ Health and safety planning
  - ☐ Quality control
- ☐ Contractor submit regular progress report (at least monthly)
- ☐ Supervision conducted to check quality standard

INSTALLATION SUPERVISION

- ☐ Installation supervision
  - ☐ Identify location, designer, and project contractor information.
  - ☐ Check the arrival of equipment by using a checklist of goods or Bill of Quantity (BOQ).
- ☐ Document checking: Check if the following document is ready for implementation
  - ☐ Technical specifications of Solar PV, storage and mini-grid equipment
  - ☐ Certificates of main equipment
  - ☐ Lay out diagram/ equipment layout
  - ☐ Single line diagram
  - ☐ Fire extinguisher layout
  - ☐ Grounding layout
  - ☐ Operation and Maintenance Manual
  - ☐ Occupational Safety and Health-K3 Guidelines
- ☐ Regular inspections every 4-5 weeks to check progress, milestones, HSS good practice, etc.
- ☐ Visual inspection (name plate) of installed /newly installed equipment without conducting any real measurements.
- ☐ Contractors should submit regular progress reports to the supervising agency describing progress against schedule and milestones.
- ☐ Conduct certified inspection.
- ☐ Ensure certified testing and commissioning.
- ☐ O&M Training from the contractor to O&M entity.
- ☐ Internal report on supervision of installation activity is developed after the testing and commissioning over.

4 OPERATION PHASE RECOMMENDATION

OPERATION PHASE CHECKLIST

TECHNICAL ASPECT

- ☐ Ensure regular O&M (preventive, routine, corrective, and condition-based maintenance) conducted properly.
- ☐ Expert technical support is available.
- ☐ Ensure certain spare parts are ready on the site, such as spare parts for:
  - ☐ O&M modules
  - ☐ MCBs
  - ☐ Surge protection devices
  - ☐ Cables
  - ☐ Fuses
  - ☐ Inverters
- ☐ Conduct inspection and safety checks in year 7, year 10 and year 15.
- ☐ Ensure key supplies are on site, which are:
  - ☐ Warranty documents (in Bahasa Indonesia), including claim conditions and procedures, and contact details.
  - ☐ Operating manuals (in Bahasa Indonesia) for all components
  - ☐ Site inspection guide
  - ☐ Measurement devices

ECONOMIC ASPECT

- ☐ Maintain good bookkeeping.
- ☐ Perform annual budgeting practices properly.

INSTITUTIONAL ASPECT

- ☐ Maintain proper documentation of financial mechanism, including user payment, and O&M budget.
- ☐ Ensure all employees, including local staffs, get full-time employment and salary.

SOCIAL ASPECT

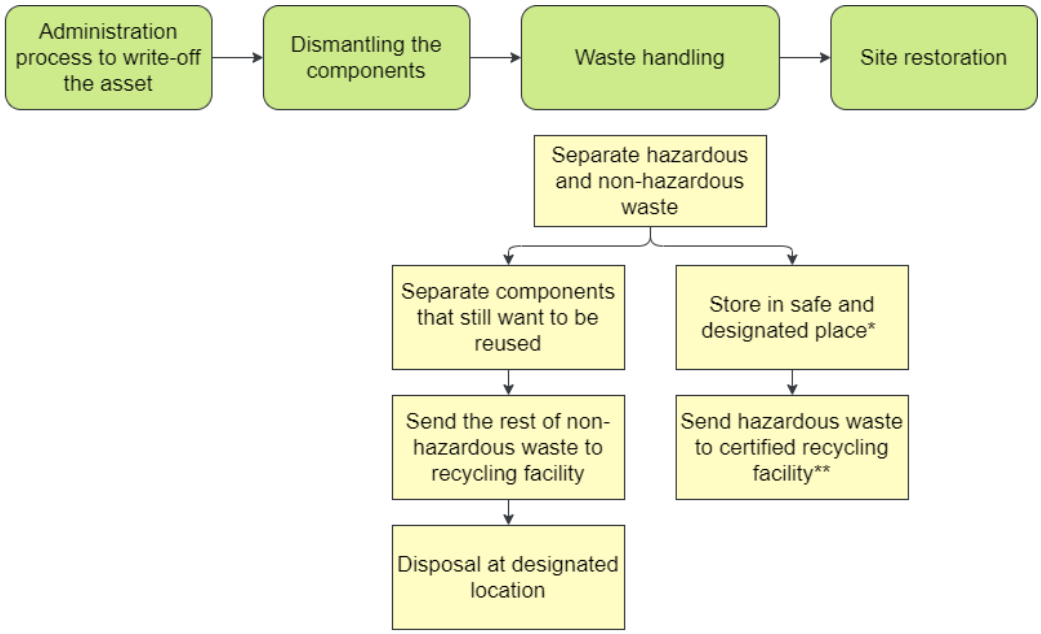
- ☐ Continue to engage with the community
- ☐ Ensure mechanisms in place to allow community to submit feedback regarding electricity service, and the O&M entity to respond to the community.
- ☐ Promote feedback mechanism so the community know how to submit feedback.

OTHER ASPECTS

- ☐ Operators and other staff are equipped with enough knowledge of hazards and H&S procedures to safely operate the plant.
- ☐ Ensuring environmental management procedures are in place and that all operators know what to do in the case of an environmental incident.

5 DECOMMISSIONING PHASE RECOMMENDATION

Decommissioning phase consists of several steps, i.e. administration process to write-off the asset, dismantling all components, waste handling, and site restoration. Figure 4 illustrates a summary of decommissioning process. All activities in the decommissioning process, including waste management, will be performed in accordance with all relevant regulations.



*) Storage for hazardous waste should comply with regional and national regulations
*) Hazardous waste transportation should comply with regional and national regulations

Figure 4. Summary of decommissioning process

6 CONCLUSION

Solar PV is widely implemented in Maluku as alternative source for electrification, especially in remote areas. However, its operationality face many challenges. NZMATES found solar PV mini grids in Maluku which operation stopped before its technical lifetime ended (20 years). NZMATES conducted root cause analysis to map failure causes into several aspects, such as technical, economic, social, institutional, and other. In all cases, system failure did not only cause by technical problems, but it is also exacerbated by other interlinked aspects. Finally, NZMATES developed recommendation how to sustain Solar PV Installation from scoping phase up until decommissioning and waste management.