EnDev2 Indonesia:

Inspection Guide for Photovoltaic Village Power (PVVP) Systems

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kerja sama jerman
DEUTSCHE ZUSAMMENARBEIT

Implemented by:
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Abbreviation

DGNREEC	Directorate General for New and Renewable Energy and Energy Conservation
EnDev	Energising Development (2009 - 2018)
GIZ	Gesellschaft für Internationale Zusammenarbeit (German Agency for International Cooperation)
GSM	Global System for Mobile Communications
KPI	Key Performance Indicators
kW	kilo Watt
LCD	Liquid crystal display
MHP	Micro/mini hydro power
PLTS	Pembangkit Listrik Tenaga Surya (solar power plant)
PVVP	Photovoltaic Village Power (mini-grid)
RMS	Remote monitoring system
VMT	Village management team

Glossary

This glossary briefly describes the interpretation of some terms used frequently in this document.

Coordination Office	Central office of the evaluator(s) and support staff for coordinating the work of the inspection teams, provides logistical support, updates instructions, and undertakes quality assurance of checklists and photographs submitted.
Evaluator	Senior expert(s) with experience in off-grid technologies, prepares the inspection teams, coordinates their deployment and performs final evaluation of data.
Handheld measuring device	A battery-operated stand-alone portable device, like a multi-meter, clamp meter or thermometer, used for spot measurements.
Insufficient	From workmanship scoring: describes an obvious shortcoming, deviating from common best practice.
Inspector/Inspection team	Two (2) persons field team conducting site visits and completing all checklists and questionnaires; comprising an experienced technician and an assistant.
LCD	Automatic data monitoring device integrated into key components like inverters or charge regulators.
RMS	Automatic data monitoring device extracting data from key components, like inverters; usually a computer permanently installed in the powerhouse.
Unsecure	Cable or material not connected or secured according to best practices.
Unfirm	Poles or materials not stable, but wobbly, with risk of collapse.

1. Introduction

Energising Development (EnDev) Indonesia's objective is to support sustainable access to modern energy services for rural communities in Indonesia. One key intervention is to support different rural electrification infrastructure projects under various public and private agencies in Indonesia.

EnDev conducted a technical review and baseline data survey for over two hundred (200) 15kW to 150kW solar mini-grid installations (photovoltaic village power/PVVP) across Indonesia, installed by local suppliers under contract with Directorate General for New and Renewable Energy and Energy Conservation (DGNREEC) in 2013 and 2014. Hereafter referred to as the *DGNREEC PVVP Technical Review*.

Specialist technical inspection teams, comprising one (1) experienced technician and one (1) assistant, were recruited for this programme to conduct 2-day site visits, complete prepared checklists and questionnaires and train the beneficiary communities on system operation, maintenance and administration. Findings of these inspections were summarised and submitted to DGNREEC for subsequent follow-up with contractors. In addition, baseline data (through the EnDev Key Performance Indicator/KPI survey methodology) was captured for a comprehensive database on EnDev-supported rural electrification projects.

This Inspection Guide present the checklists, measurements form, and KPI questionnaire, as well as explanatory documentation compiled during this programme and adapted to capture essential lessons learnt.

Figure 1 PV-VP site

All PVVP sites were provided with unique site codes ensuring that all collected technical and socio-economic data is correctly referenced.

Purpose of this Inspection Guide is to record the process and make templates available for future inspections by any interested third parties. First version of this guide was published in October 2013. This updated version includes the latest templates.

For any support regarding guidelines and updated templates for future inspections, third parties can enquire with:

Energising Development (EnDev) Indonesia
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH
Gedung De RITZ, Floor 3A
Jl. HOS Cokroaminoto No. 91
Menteng, Jakarta Pusat 10310
Indonesia
T + 62 21 391 5885
F + 62 21 391 5859
Website: http://endev-indonesia.org

2. Inspection Guide Overview

Inspection preparation - *conducted by inspector and evaluator prior to site visit*

Preparatory work to be done in order to conduct site survey effectively and efficiently. Described in **Section 3**.

Component compliance - *conducted on site by inspector*

Spread sheet-based checklist comparing all components (type, specifications, quantity, etc.) installed on site between tender specifications and contractor contract. Assessment is done on the basis of "Fulfilled" or "Not Fulfilled". Purpose is to determine whether contractors neglected to provide any components as legally required under the contract. Described in **Section 4.1**; template included in **Appendix 1**.

Performance verification - *conducted on site by inspector*

Spread sheet-based measurement sheets for spot-check measurements on the performance of key components (solar PV generation capacity, battery charging status, inverter output, and distribution network losses). Evaluation is based on quantitative data collected. Purpose is to determine whether the PV-VP system as a whole operates close to its optimal. Described in **Section 4.2**; template included in **Appendix 2**.

Workmanship checklist - *conducted on site by inspector*

Spread sheet-based checklist of workmanship indicators, clustered into different categories. Evaluation is done according to a scoring system using a rating of 1 to 5 (worst to best). Purpose is to assess whether quality of installation adheres to best practices, safety requirements and overall installation sustainability. Described in **Sections 4.3 and 4.4**; template included in **Appendix 3**.

Key Performance Indicator (KPI) survey - *conducted on site by inspector*

Questionnaire for assessing technical, social and economic aspects. Interviews involve different community stakeholders. Evaluation is based on qualitative and quantitative data. Purpose is to assess the overall sustainability of rural electricity infrastructure and to capture baseline data on technical and non-technical aspects in the community. Described in **Section 5**; template in **Appendix 4** and user manual in **Appendix 5**.

Technical summary sheet - *conducted by evaluator after site visits*

Document (5 to 7 pages) with assessment and scoring results of the technical review, with photographic evidence and recommendations for any corrective actions. Purpose is to provide objective and verifiable information regarding the PV-VP installation status, for possible follow-up with the relevant contractors. Described in **Section 6**; template with scoring guidelines included in **Appendix 6**.

3. Inspection Preparation

3.1. List of Equipment

The inspection visits would require meticulous logistical planning and preparation. Table 1 List of equipment below presents the equipment to be brought by the inspection team to each site, in order to fulfil the tasks at hand.

Table 1 List of equipment

General equipment	Measuring equipment	Survey forms and training tools
Introductory mandate letter (laminated)	Clamp meter (AC and DC)	Inspection guide for PVVP
GSM cell phone + charger	Digital multi-meter (*avometer*)	Technical checklist – Component Compliance
Handheld GPS device + charger/spare batteries	Digital thermometer (ambient air)	Technical checklist – Performance verification
Laptop (with MS Office)	5 m Measuring tape (for distance)	Technical checklist – Workmanship quality
Calculator		KPI PVVP questionnaire
Camera (with memory card, charger, spare battery, USB cable)		Any other awareness materials, which may include: • PVVP troubleshooting poster • SMS-gateway poster • 1 set of administration books (consists of 5 books) for VMT
Spare memory sticks (flash-disks)		Stencils for site code + spray paint
Pens and pencils		
Sturdy backpack		

3.2. Implementation Guide

1. Read the *Inspection Guide for PVVP* (this document).
2. Obtain an introductory letter (laminated to prevent damage) from the authority requesting the inspection, in order to ensure that the inspection teams have the mandate to carry out the site inspections. This introductory letter must be carried by the inspectors at all times.
3. Ensure that local authorities (Dinas/Pemda, village chief, and village management team/VMT) on site had been contacted and informed prior to departing for the sites.
4. Report to the local authority office when arriving in the area. As a minimum, this is a courtesy visit, while as a maximum, a local authority representative might accompany the inspection team.
5. Prepare all equipment (see Section 3.1) in advance before leaving the Coordination Office.
   - Keep all logistics in the car or lodging.
   - Carry equipment and supporting tools only one set per single site visit.
6. Buy spray-paint in the capital town.
7. Get info for Coordination Office where to collect documentation delivered via courier.
8. Make sure all electronic devices are fully charged at night before each site visit.
9. Travel to the site as early as possible in the morning ideally accompanied by the local authorities.
10. If you cannot find the site after maximum half day, please contact to head office for further instruction and decision.

11. Spray-paint the site code on the powerhouse door or wall using the provided stencils.
12. Allocate time wisely within 2-day visit to conduct: component compliance, performance verification, workmanship quality, on-site PVVP operator(s) training, KPI survey (through interview with relevant respondents), VMT training and taking photographs.
13. Conduct visual inspection of the civil structure and power house.
14. Conduct technical checks together with the operator. Let the operator do the check/measurements with inspector's guidance and supervision.
15. Do not adjust the system! If you see something is wrong, make notes, but do not attempt to fix or alter the system in any way.
16. Take numerous photos (see guidance in Chapter 4).
17. Conduct KPI survey based on the following components:
    - Interview and train the operator (KPI Part D)
    - Interview the VMT members (KPI Part A, B and C)
    - Interview the village chief or the most respected person related to village regulation
18. Ensure all parts of checklists, forms, and questionnaires are completed and all photos are taken BEFORE leaving the site.
19. Soon after you arrive at your lodging, type down the result to electronic format (Word document).
20. Send the electronic version to the Coordination Office via email once you have internet connection.
    - Coordination Office supervisor:
    - Email:
    - Mobile:
21. Send hard copies of checklists, forms, and questionnaires and uncompressed photos on a flash disk to the Coordination Office via courier as soon as possible.
    - Coordination Office physical address:
    - Coordination Office postal address:
    - Email:
    - Mobile:
22. Contact Coordination Office each morning (email or mobile/SMS) to communicate inspection status/problems and further proceedings.

Figure 2 EnDev site identification

All EnDev-supported sites are allocated a unique site code for easy future identification. The site code is spray painted to the powerhouse door or wall.

3.3. Inspection Process

The inspection process follows the flow as shown in Figure 3 Inspection flow diagram. In some instances, depending on the situation on site, the order of activities might be certainly modified.

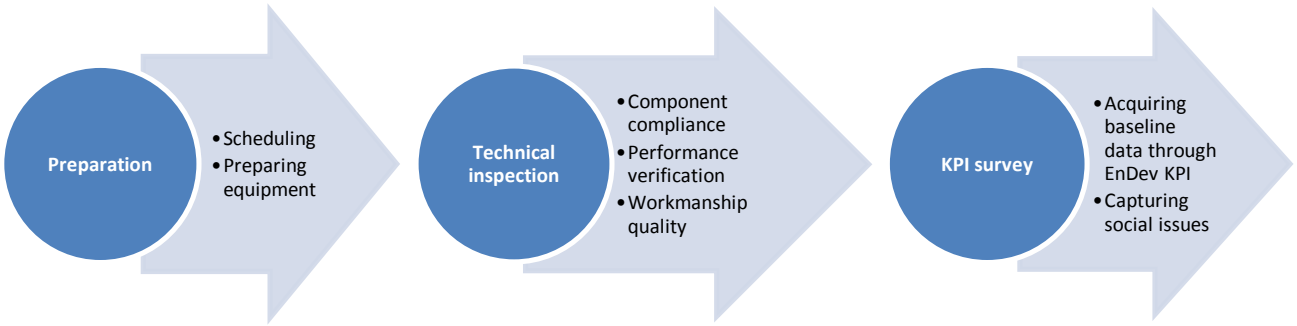


Figure 3 Inspection flow diagram

3.4. General Tips

Introductory pitch: Formulate a very brief 5 sentence statement that you learn off by heart as means of quickly introducing yourself to community members. This statement, or "pitch", ensures that you are consistent in your message and avoids you struggling for words. An example would be:

> *"Good morning. My name is ……. I am here on behalf of …… I was sent here to do a technical inspection of the PVVP installation and to provide this/your community with information on how best to take care of and manage this technology. Maybe you have some time so that I can ask you some questions? This will help me to understand your community better."*

Listen: Avoid offering advice and opinions, unless asked for them. Allow the community to express their observations, experiences by listening attentively. Ask clarifying questions and acknowledge the communities concerns seriously.

Detach: You are there for a very specific task. Do not get too distracted by side issues. Do not make any promises to the community, unless you yourself can keep them. Some communities might experience frustrations and share these with you. This demonstrates trust and respect for you. Be very cautious though and do not get involved. Remain detached, but friendly and sympathetic.

Respect: You are a stranger entering people's village and homes. Do not assume that they appreciate your presence. Always introduce yourself (see "pitch") and always ask permission before asking questions and taking photographs.

Buy from a local shop: Buy a drink or a snack, even if you might not need it. This sends a signal of inclusivity. It also offers an opportunity for ice breaking and small talk.

3.5. PVVP DC System

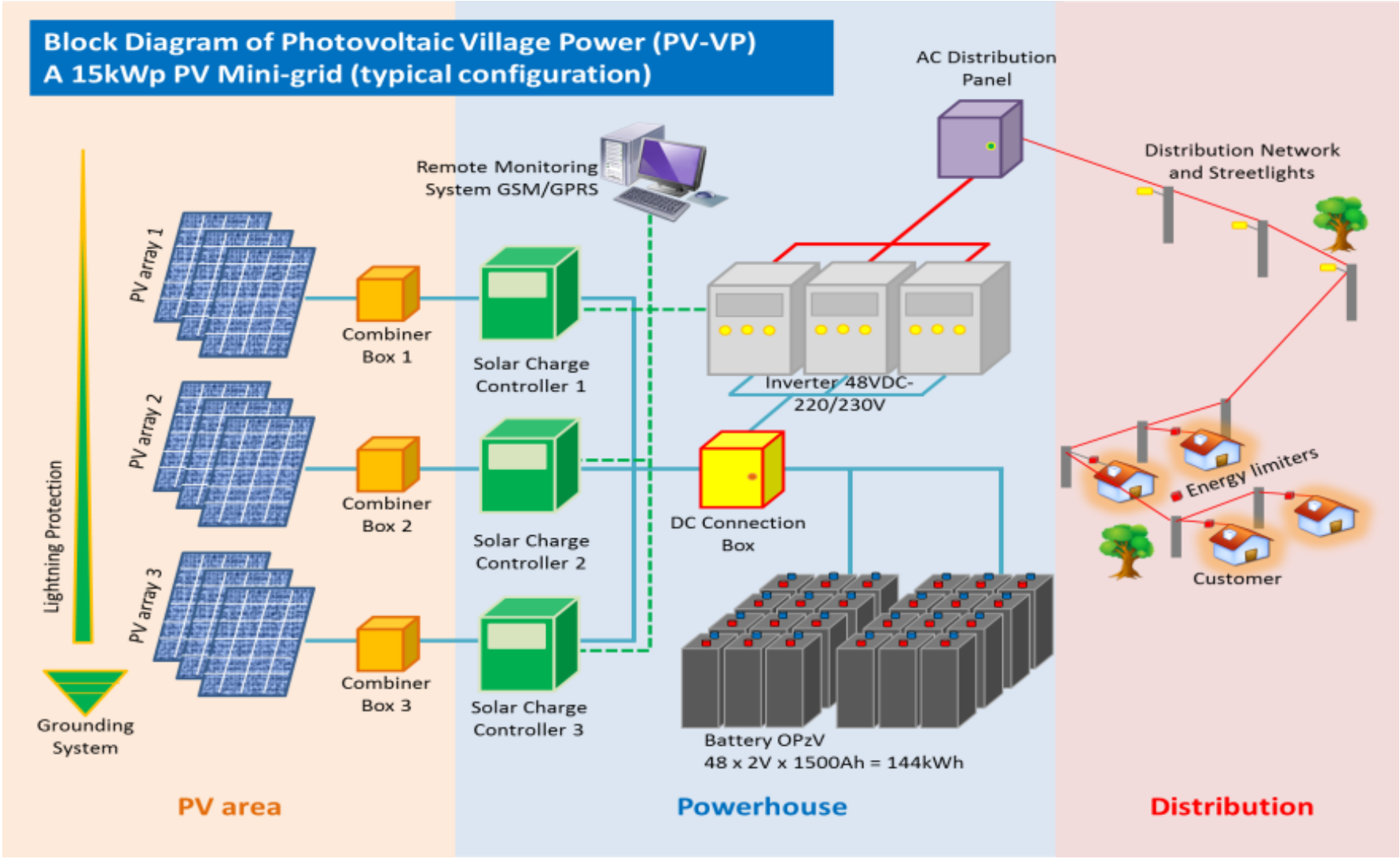


Figure 4 Block diagram of PVVP DC system

3.5. PVVP AC System

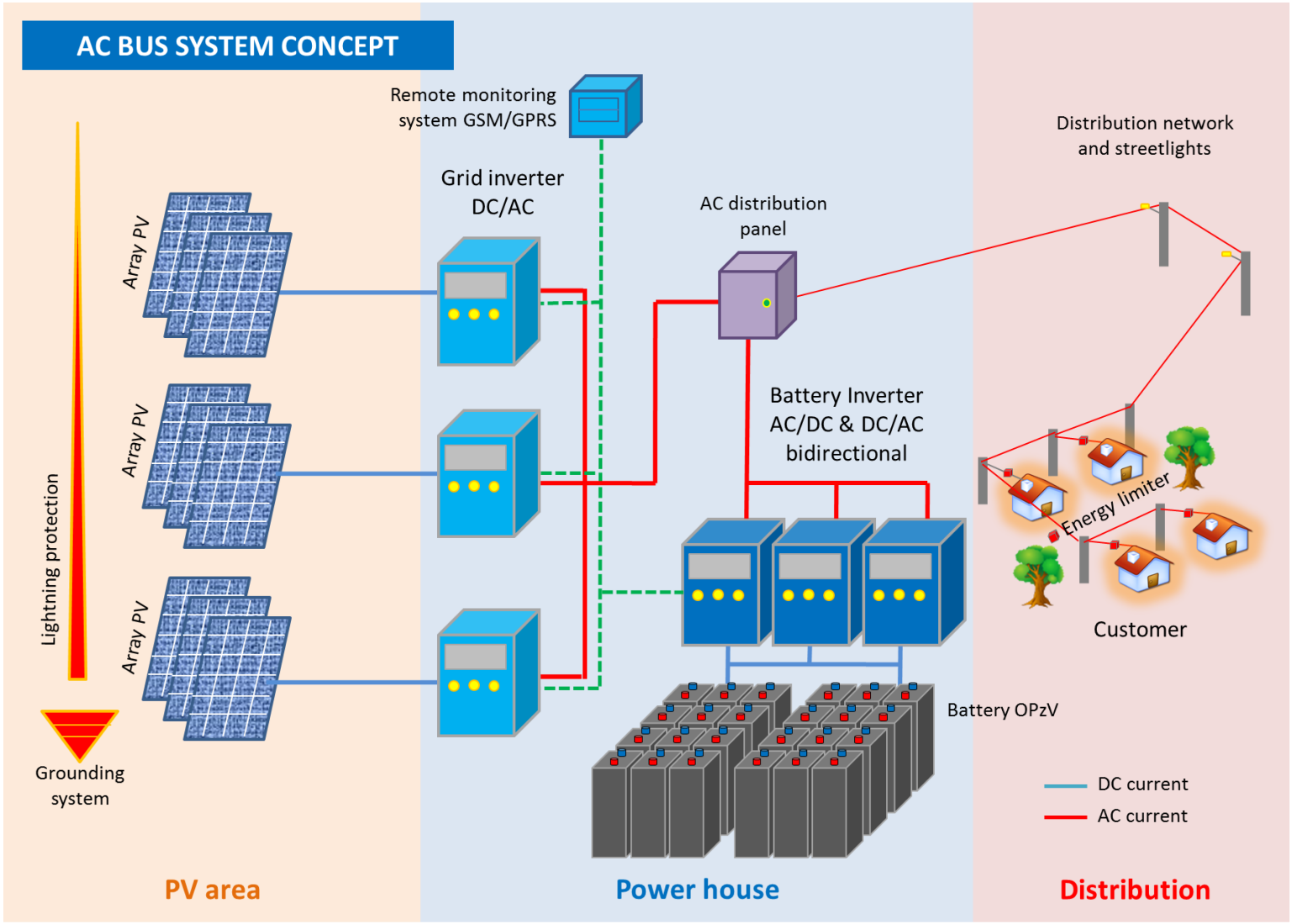


Figure 5 Block diagram of PVVP AC system

4. Technical and Workmanship Checklist

The checklists described in this chapter, along with their corresponding templates, were originally designed during the *DGNREEC PVVP Technical Review*. Several adjustments and refinements were subsequently done as a result of lessons learnt during the inspection and evaluation processes. This Inspection Guide reflects the version as of October 2013.

Before conducting the inspection and recording the findings fill in the site code, village name and date on all pages of the checklists and questionnaires.

4.1. Component Compliance

The component compliance part of PVVP Technical Checklist is a document comprising main components of the PVVP. This checklist is used to verify actually installed components at site against the contractual obligations as specified in the contract. This checklist thus requires a pre-review of the tender/contract document and adding the relevant technical specifications into the checklist template. The template is included in **Appendix 1 Technical checklist: component compliance** and specifications from the *DGNREEC PVVP Technical Review* are inserted as examples.

In the case of the *DGNREEC PVVP Technical Review,* the component compliance covered the technical specifications for:

1. Works conclusion
2. PV modules
3. PV array support
4. Grid inverter
5. Solar charge controller
6. Battery system
7. Battery inverters
8. Remote monitoring system
9. Power house
10. Power cables and grounding
11. Power house distribution panel
12. Distribution, connection and household installation
13. Streetlights
14. Sub-subsystem of household installation
15. Energy limiter - household
16. LED lamp - household
17. Lightning protection
18. TV and digital parabola
19. Commissioning and training

Inspection Tips	
General	▪ Make sure the column “Specification” has been filled-in in advance (before leaving Coordination Office). ▪ Fill in the date, name of surveyor and signature. ▪ Take photos (see Chapter 4.4).

Completing the checklist	▪ For some selected technical specifications, the brand, type, etc is filled in as ideally displayed on product labels. ▪ For most specifications, only the compliance needs to be verified with "Yes" (compliance) or "No" (non-compliance) by ticking (✓) the corresponding cell. ▪ Space is provided for "comments". Always provide "comments where "No" (non-compliance) is ticked as these greatly assist further evaluation.

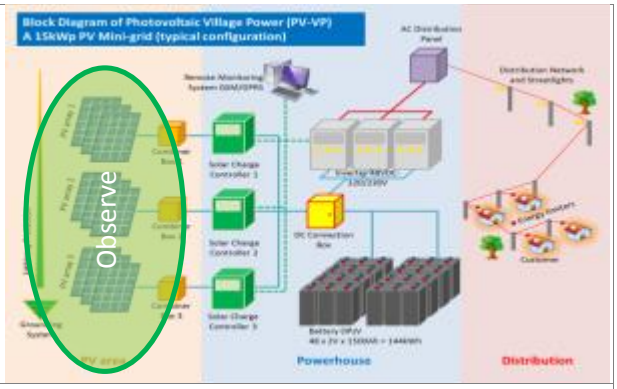
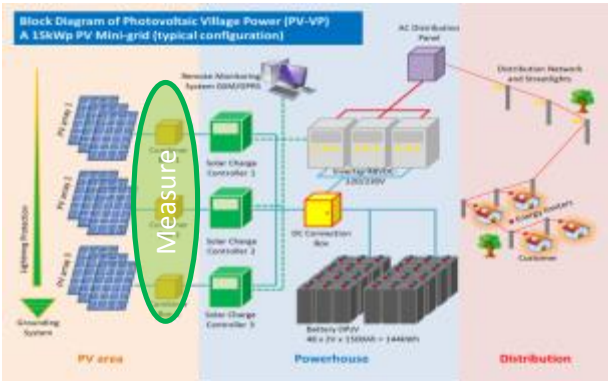
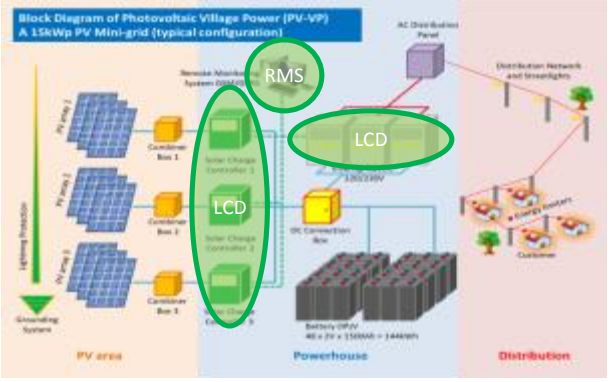
4.2. Performance Verification

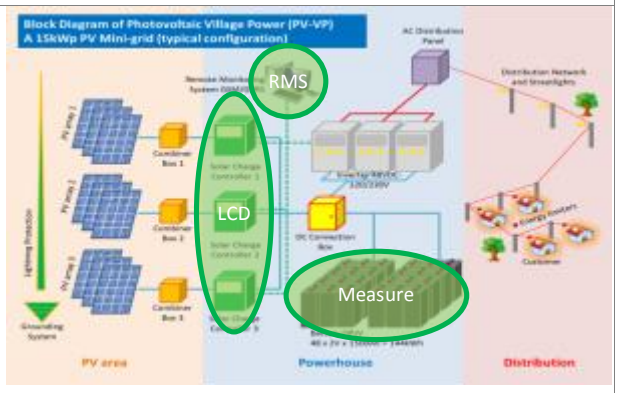
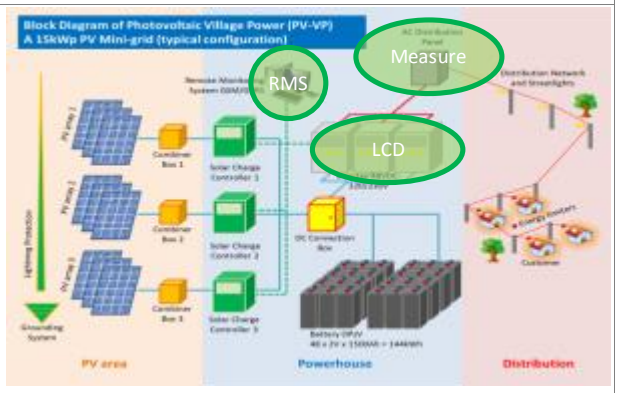
Verification of reliable system performance is essential and should be part of the final acceptance of the system. Performance verification is a very good indicator to demonstrate whether a system is functioning optimally and all components are installed and configured correctly. It is thus the combination of component quality and workmanship quality.

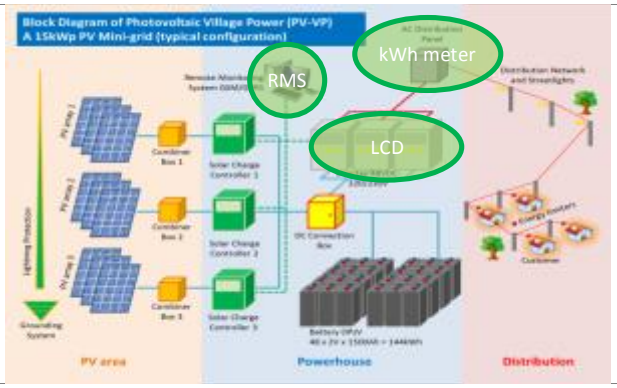
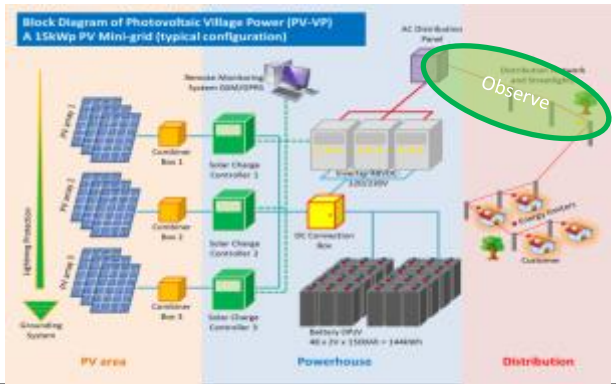
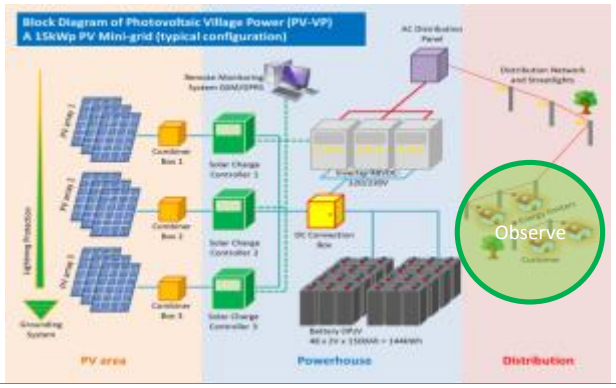
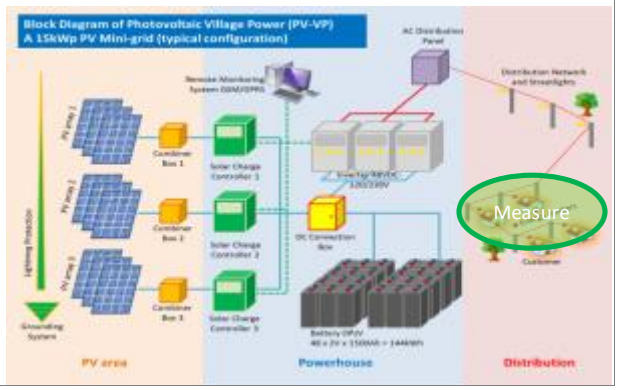
In the case of the *DGNREEC PVVP Technical Review,* the performance verification recorded electrical data of spot measurements to determine performance of key components, and the template is attached as **Appendix 2** Performance verification covered:

1. Time and weather conditions
2. PV performance
3. Charge controller recording
4. Battery status
5. Inverter performance
6. Total energy production
7. Remote monitoring system and pyranometer
8. Streetlights
9. Household connection
10. Distribution grid performance

Inspection Tips	
General	▪ Fill in the site code, village name, name of contractor, date, name of inspector and sign. ▪ Measurements (and opening of cabinets) shall ideally be carried out by the local operator, with guidance and supervision by the inspector. ▪ "Handheld measuring devices" refers to clamp meters, multi-meters and thermometers that the inspector carries along to site. ▪ "RMS/LCD" refers to monitoring displays installed at site. These could include the liquid crystal display (LCD) on inverters and charge controllers and/or the monitoring interface on a computer display for a remote monitoring system (RMS). ▪ Make comments on any faults or irregularities noticed. ▪ Take photos (see Chapter 4.4) of measurement displays. ▪ Ask operator to provide name, contact number and signature after measurement.
"Time and weather conditions"	▪ "Time and weather conditions" are recorded at time of measurement as these parameters influence subsequent measurements. ▪ Time is filled in using *hh:mm* format, while the weather condition is ticked (✓) in the appropriate cell.

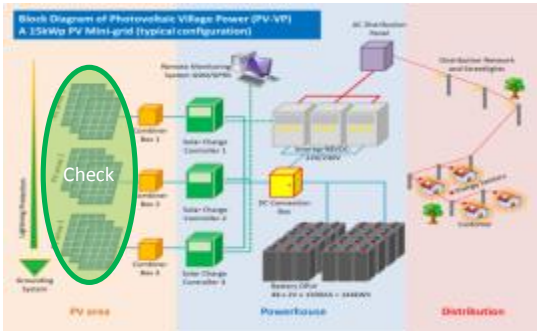
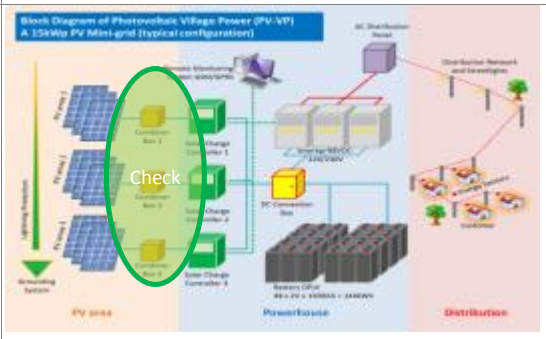
	▪ Only the morning times are recorded, since evening measurements are not generally affected by weather conditions (in the case of PVVP). 
"PV performance"	▪ "PV performance" is measured using a handheld measuring device in order to detect any deviations in electricity generation from the different solar PV module strings. ▪ The points of measurement are the different "Combiner Boxes", using handheld measuring device. ▪ Wait for stable light conditions until you take measurements per box. ▪ Do measurements in the morning (around 10:00 to 12:00) in order to have good light conditions, and to avoid a situation where the charge controller is switching off or regulating down the power of the panels because of full batteries.  ▪ Note: Each solar panel has two Voltage values (Vmp/Voltage at Maximum Power and Voc/Voltage at Open Circuit), while each solar charge controller has a voltage limit (typically 150-250VDC). Panels connected together in strings should not exceed Vmp and Voc limits of the solar charge controllers (e.g. if a panel produces 36VDC for Voc and the solar charge controller has a limit of 150VDC for Voc input, then only 4 panels can be strung together, producing 144VDC max). ▪ Measure the Voltage (V) between the positive and negative busbar in the combiner boxes. ▪ Measure the Current (Amp) with 3 or 4 strings together in order to see if the current of all strings are similar and note the values (number of strings measured and the Ampere). ▪ In case of different string currents, try to identify reasons (shading of modules, loose cables) and make comment. Be aware that when the light is changing rapidly due to clouds, the current will also change rapidly. ▪ If one or more strings have no current please check for broken, burnt or loose cables, broken panels or other irregularities and make comments.
"Charge controller recording"	▪ "Charge controller recording" records the accumulated solar energy production (kWh) since start of operation and the current charging voltage (VDC) from the solar PV array.  ▪ Points of reading are all charge controllers, through LCD on charge controller (or inverter or RMS if charge controller does not incorporate LCD). ▪ Recording time is during peak electricity generation (at 10:00 to 12:00 in the case of solar PV).

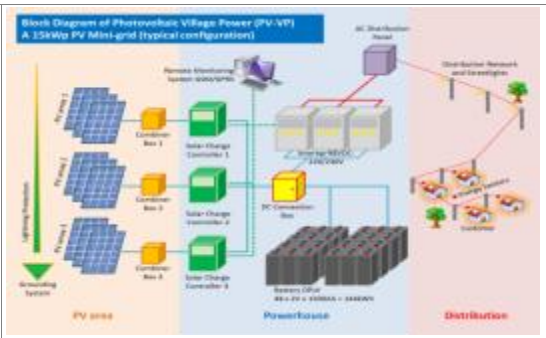
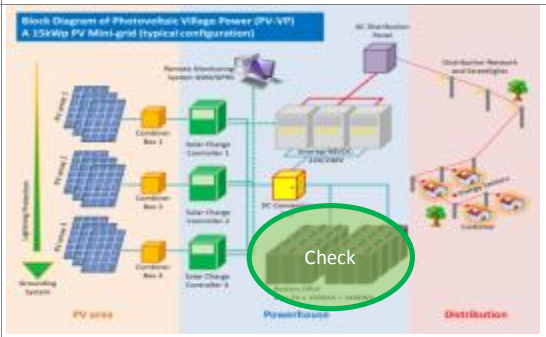
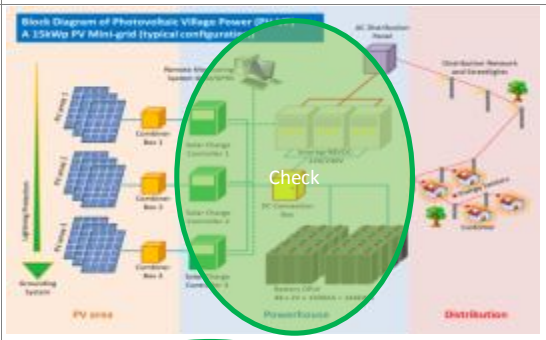
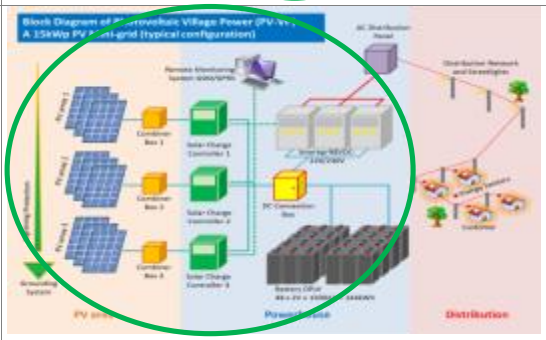
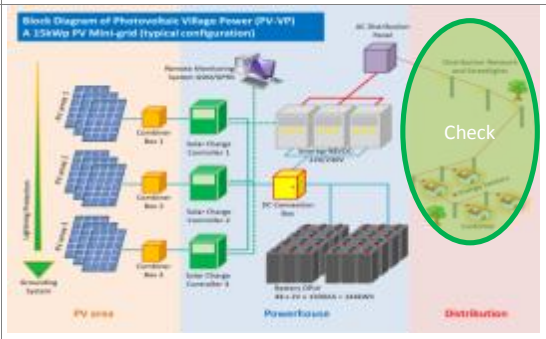
	▪ "Energy generated", when compared with date of commissioning (from KPI survey) and hence the theoretically maximum available sunshine hours, allows an assessment of the availability factor of the installation. ▪ "Energy generated", when compared with "total consumed energy" recording, allows an assessment of the balance between electricity generation and demand. ▪ "Solar PV voltage" (input to charge controller), when compared to "Measured Voltage on busbar" (output from PV) values, allows an assessment of losses between solar PV array and charge controllers. This might be indicative of the wiring quality.
"Battery status"	▪ "Battery status" measures the current state-of-charge of the battery as a means to gauge battery "health" and balance between electricity generation and demand. ▪ The point of measurement for voltage (VDC) and discharge current (Amp) is the main battery terminal, using a handheld measuring device and the reading on the Charge Controller LCD or RMS. Both values are recorded in the checklist.  ▪ Evening measurement: first battery measurement is done after sunset, or when no electricity is generated, and during time of peak load. Around 19:00 for a PVVP installation is likely optimal. This ensures values are not corrupted, caused by simultaneous charging of batteries. ▪ Morning measurement: second battery measurement is done the following morning, while sun intensity is still low. Around 07:00 for a PVVP installation is likely optimal. This value, compared with the evening record, allows for an assessment of the night time load. ▪ The point of measurement for battery room temperature (°C) is a thermometer or sensor placed between batteries in the battery bank during hot time of day (11:00 to 14:00). This allows an assessment whether high temperatures prevail in the battery room, which will reduce battery life expectancy. ▪ To check whether any batteries emit more heat than others, simply touch all batteries briefly. If any hot battery cells are detected, tick (✓) the cell. This is indicative that some batteries might have a high internal resistance.
"Inverter performance"	▪ "Inverter performance" measures and records the AC voltage (compared to nominal 220V or 230V), the current (Amp) being drawn at time of measurement (i.e. the load) and the total supplied energy (kWh) since installation. ▪ Point of measurement is the AC Distribution Board busbar using handheld measurement device.  ▪ Point of recording is the LCD on each inverter using the menu or navigation feature. ▪ Time of measurement and reading is evening (about 19:00 to 20:00) during peak demand and morning (about 07:00 to 08:00) during off-peak demand. ▪ Note: AC Distribution busbar Voltage and current measurement will likely be same for all inverters (regardless of whether all inverters is working or not). Only comparing the busbar Voltage and current with the recorded Voltage and Current from LCD or RMS will show inverter faults.

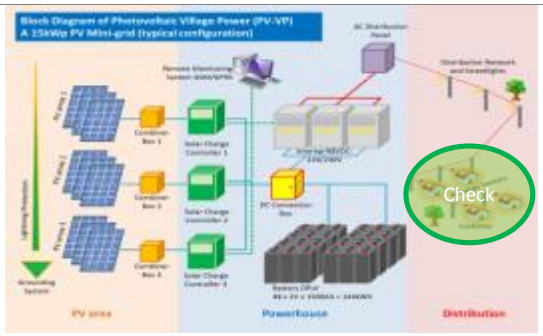
	▪ Record total supplied energy (kWh) at the kWh-meter(s) and/or LCD and/or RMS in the evening and the following morning. This shows approximate night-time load
"Total energy production"	▪ "Total energy production" takes a reading of the one (1) or more energy meters installed at numerous time intervals. ▪ This allows for comparison of day and night time loads/consumption, but also possible variations in the meters 
"Remote Monitoring System and Pyranometer"	▪ This is a simple verification that the systems are installed and operating ▪ Important: download any data stored on the devices for future analysis
"Streetlights"	▪ "Streetlights" confirm installed wattage of streetlights and the daily lighting duration (either checking for an installed timer or asking the operator) ▪ Time of assessing streetlights operating is evening (after 19:00) for a general visual inspection. Operator can also provide information (verify some examples). 
"Household connection"	▪ "Household connection" does **spot check** review on some household installations. ▪ Visually check the energy limiters and micro-circuit breakers installed at household level and records basic information ▪ Record any breakages through information from operator (and verify some examples) 
"Distribution grid performance"	▪ "Distribution grid performance" measures the voltage drop between power house and furthest household and furthest social institutions (community centre, clinic or other). ▪ Point of measurement is the household wiring (or connection box) at the household with the longest cable distance from the powerhouse (i.e. the longest stretch of AC distribution cable). 

4.3. Workmanship Quality

Quality of workmanship has a direct influence on system performance and sustainability, and poor workmanship can compromise even the best system components. The purpose is to assess whether quality of installation adheres to best practices, safety requirements and overall installation sustainability. In the case of the *DGNREEC PVVP Technical Review,* the workmanship checklist comprises various workmanship indicators clustered into different categories. The workmanship checklist is included under **Appendix 3** Workmanship checklist.

Inspection Tips	
General	▪ Fill in the date, name of surveyor and signature. ▪ Check each indicator and tick (✓) with "**True**" or "**False**". Note that an indicator marked with "True" shows that the indicator statement (e.g. "cracked glass of PV panels") applies and that there is indeed poor workmanship. ▪ **For indicators marked "True", provide additional comments and information.** This will show whether it is an isolated minor problem or an extensive major problem. ▪ **Categories 5a), 5b), 5c), 8, 13, 15 and 18 are highlighted in RED in the checklist.** This is because "True" indicators in these categories might pose a danger or safety risk to persons. **Inspectors shall alert the operator to these dangers**. ▪ Take photos of all indicators (regardless of "True" or "False"). ▪ For streetlights: check operational status during the evening to determine broken streetlights. ▪ For households: only spot check at 3-6 houses.
1. PV module quality 2. PV module array foundation 3. PV array mounting structure	
4. PV array combiner box and internal wiring	

5. a) PV module wiring, b) External wiring weather proofing c) Wiring to power house 6. Grounding and earthing	
7. Battery rack 8. Battery terminal connections	
9. Internal powerhouse wiring 10. Powerhouse foundation 11. Powerhouse general condition 12. Powerhouse ventilation 13. Powerhouse flooding prevention	
14. Fence and gate	
15. Distribution grid pole installation 16. Distribution grid wiring 17. Streetlight installation	

18. Household installation	

4.4. Photographs

Collecting photographic evidence of the inspection on site is vital. Photographs confirm the observations of the inspector and can also reveal issues that are not recorded in the checklists and questionnaires.

General Tips
▪ Set the camera to produce photographs with minimum size of 3 MB **or** around 3 megapixels (2048x1536) in JPEG format. This is important because it allows zooming into the picture for future analysis.
▪ Familiarise yourself with your camera. Take some practice shots at different settings of the same object and compare the results. Load practice pictures onto computer to check whether the file size is sufficient and format is correct.
▪ Be conscious of what photographs to take and how best to capture an object. Keeping in mind that others will view the photographs as well, and might not immediately notice what you wanted to show. ▪ Also take pictures that include technology and people in action to liven up the photograph. ▪ Be aware of opportunities to take interesting pictures, i.e. do not only stick to the picture list as included below. ▪ Try to include more than one object in the picture so that the photograph contains several messages and reveals more information.
Camera orientation: ▪ Take photos in landscape for wide shots (e.g. entire PV array area) ▪ Take photos in portrait for high shots (e.g. distribution pole) ▪ Take close-up photos of detailed views (e.g. to show faults or LCD display readings)
Lighting: ▪ Always ensure that a light source is shining onto the object. ▪ Take outside photographs with your back to the sun. ▪ Be aware that flash might cause blurry reflection, so take pictures at an angle to avoid this. ▪ Do not use flash if not necessary. It wastes battery life and can over-light to object. ▪ Do not take of an object with a brightly lit background. This will only show the silhouette of the object.
Contrasts: ▪ Be aware of contrasting colours around the object. Background colours that contrast with the object make the object appear clearer and better defined. This is especially true if the background is of a single colour.
Focus: ▪ Keep the camera steady. Blurry pictures are useless. ▪ Press the shutter button on digital camera half-way first, to allow the camera to focus. Blurry pictures are useless.
Dimensions: ▪ Use familiar objects or people to indicate size of the object.

Framing:

- Centre the object to ensure it is not cut in the picture.
- Avoid irrelevant side objects in the picture.
- Use different angles to take picture of an object to ensure that the picture clearly shows certain details.

The section below shows some examples of good and bad inspection photos. Photos with captions in green-font are the good examples, while captions in red-font are examples of the bad ones.

Good and bad of inspection photo

People in action, showing clearly what they are doing, liven up a photograph and make it more interesting.

Picture with more than one "object" (in this case: poor wiring, corrosion on steel frame, no conduits and bolts not equal length) reveal more information.

Close-up picture of measurement reading, BUT flash causes reflection, which covers numbers.

Picture taken too close, cutting off both person and technology. The context of the picture is compromised.

Good overview picture, BUT solar panels cut off. Slight increase of camera distance would have been better.

Object is not centred, with very poor focus and lighting, and several cut offs in the picture. The picture has very little information value.

Very interesting picture showing a home-made streetlight, with a standard streetlight, BUT the car behind the solar panels is disturbing.

Picture out of focus, too low picture resolution (only 90kB), too close and wrong angle. Angle from below, taken from opposite direction (i.e. showing underside of panels and unsealed conduit opening) would have been better.

Good picture of general interest, showing logistical challenges in reaching site. Main object (road) well-centred, with motorcycle as reference. Without motorcycle this picture would have less meaning.

Clear close-up picture with size reference (photographer's hand).

Main object (batteries) very well centred in the picture with correct orientation. Good lighting, sharp focus and picture shows other objects (ventilation openings, neat battery room, conduits).

Picture with too much backlight and wrong orientation (landscape orientation from slightly greater distance would show ground conduits and avoid backlight).

The photograph checklist is presented below.

Table 2 List of photographs

List of photographs to take		
1	First page of KPI questionnaire	This is the first photo should be taken (make sure the site code is written as it may help identifying what photos belong to what site)
2	Outside power house	▪ Highlight the distance to the solar array ▪ Foundation and apron condition ▪ General workmanship (i.e. plastering, painting)
3	Inside power house	▪ Overview of power house (with battery, inverter, and monitoring system visible) ▪ Overview of general condition (cleanliness, tidiness) ▪ Overview of ventilation ▪ Detail of windows and ventilation (glass and insect screen installed?)
4	Battery	▪ Plate showing brand and type ▪ Arrangement of batteries ▪ Battery terminal connection ▪ Measurement of battery room temperature
5	Charge controllers	▪ Plate showing brand and type ▪ General workmanship ▪ Controller interior
6	Inverter	▪ Plate showing brand and type ▪ General workmanship ▪ Measurements as shown on LCD
7	Details of cabling	It comprises both external and internal cabling, to highlight if the correct cables (in

		terms of type and size) are used as well as the quality of installation
8	Solar array	▪ Overview of solar array (TIP: take a higher land or climb the lightning rod to get the overall picture of the site, if possible) ▪ Foundation and struts ▪ Grounding ▪ Mounting (nuts and bolts)
9	Solar module	▪ Plate showing brand and type ▪ Junction box ▪ Randomly on some spots, be alert for damage/breakage!
10	Remote monitoring system (RMS)	▪ Location of computer set in the power house ▪ Display of monitoring software on screen
11	Connection and distribution box in the power house or in the panel box	▪ Ampere and Voltage measurement ▪ kWh-meter and hour-meter records
12	Existed administration books (if any)	With number of customers/household visible
13	Distribution pole and cables	▪ State of poles (showing distance between poles) ▪ State of cables
14	Streetlights	▪ Type of lamp and fixture (close-up) ▪ Installation and location
15	Energy limiter	▪ Close-up photo of energy limiter and its installation ▪ Overview showing where it is located in a house
16	Public television	Overview showing where it is located
17	HH connection	▪ Close-up of socket/plug and switch ▪ Close-up of lamps ▪ Cabling workmanship ▪ Overview of connection workmanship
18	People in actions	For example: ▪ Operator cleaning the PV module ▪ Inspector checking the installation ▪ Inspector training the operator ▪ Sensitization (sosialisi) of VMT and villagers
19	Surroundings of system	▪ Pathway to the power house ▪ Surrounding trees ▪ Fence and gate workmanship
20	Access road to the village	▪ Road condition ▪ Mode of transportation used ▪ Overview of village
21	Site overview	Shows the entire installation taken from a distance
22	Village chief (when agreed upon)	Ask kindly the village chief to be photographed
23	Detail photo if any installation looks wrong or unsure	Be observant and critical!
Photograph naming and filing		
1	Create individual folder for each site	Name the folder according to the site code with this format: **ProvinceSXX**, example: JaTimS01, MalS02, PapBarS12
2	General file and folder naming	Suitable folder naming should be designed and agreed prior to reporting. As a minimum, a filename should contain site code and component item.

5. KPI Questionnaire

The Key Performance Indicator (KPI) survey is conducted using a questionnaire and collects technical, social, economic, and environmental data. The data are vital as a baseline status of the PVVP installation, allowing for future comparison after subsequent surveys. The KPI survey was originally designed for capturing data on micro-hydro power (MHP) installations and has been used extensively by EnDev Indonesia since mid-2012 and comprises five main sections:

Part A: General information
Part B: Key performance indicators in target area
Part C: Administration and management
Part D: Operation and management

The KPI questionnaire considered several aspects during design, which include:

a. The question wording being simple enough to be understood by unskilled surveyor and asked to rural people.

b. The questions are arranged in logical order and working flow so that unskilled surveyor can naturally converse with the interviewee and complete all questions smoothly.

c. Tick boxes are used extensively. The advantages are: a) minimize narrative answers by pre-defining multiple answers beforehand, b) occurrence and frequency of set answers are more easily quantified (while unanticipated reasons can be addressed through "other" option), and c) easier to handle conditional questions effectively.

d. The question arrangement accommodates consistency verification of data surveyed.

Figure 6 KPI survey

In many cases KPI surveys comprise group interviews with members of the Village Management Team.

e. Anticipating most common and typical situation in the village that might potentially disturb survey processes and data integrity.

f. The questionnaire format must be flexible enough to allow for adjustments and customizations, depending on the technology deployed at site.

In order to help field surveyors to conduct the KPI Survey, a questionnaire manual was also compiled.

The KPI survey adjusted for the *DGNREEC PVVP Technical Review* is included in **Appendix 4** along with a detailed user manual in **Appendix 5**.

6. Technical Summary Sheet

The Technical Summary sheet is completed by an expert evaluator and/or a highly experienced PVVP inspector.

The expert evaluator needs to have extensive experience and expertise regarding off-grid electrification systems and the deployed technology (photovoltaic [PV] mini-grids in the case of the *DGNREEC PVVP Technical Review*). Naturally the evaluation can only be done well if the aforementioned checklists are thoroughly completed and numerous photographs are available.

The technical summary sheet is a resume of findings collected and concluded from the technical and workmanship checklist. It consists of 4 parts as follows:

- Part 1: Component compliance as verification between contract requirements and actual site installation. This part presented into 6 categories: solar module, inverter, charge controller, battery system, balance of system, and appliances.
- Part 2: Measurements to give insight of technical performance and electrical status of the system. This part is presented into 4 categories: PV module output consistency, battery storage acceptable, AC distribution board voltage acceptable, and distribution grid voltage acceptable.
- Part 3: Workmanship verification as a review of workmanship as per general quality, health and safety requirements.
- Part 4: Recommendations regarding any possible follow-up with contractor.
- Part 5: Pictures of poor quality workmanship as per 20-point "workmanship quality" checklist

Evaluation of Part 3 Workmanship is done according to a scoring system using a rating of 5 to 1 (best to worst):

5 = very good, meets required specification
4 = good, meets required specification with few faults
3 = fair, meets required specifications with several faults
2 = poor, below standard, some major faults
1 = safety risk, serious faults and shortcomings

Summarised workmanship scorings per PVVP site are converted into a percentage (%) serving to compare the scorings between different sites and different contractors. A contractor achieving a scoring of five (5) for each of the 20 workmanship categories would thus score 100% (complete success). The lowest possible score would be 20% (complete failure).

For any workmanship score of 1 and/or 2 the evaluator must include photographic evidence into the Summary Sheet.

The Technical Survey Summary template with its scoring guidance is included in **Appendix 6**.

APPENDIX

Appendix 1 Technical checklist: component compliance

PVVP Technical Checklist - Component Compliance (version 150615)

SITE CODE:		INSPECTOR:		DATE:	
VILLAGE/HAMLET:		CONTRACTOR:			
CAPACITY:		SIGNATURE:			

NO	COMPONENT	SPECIFICATION FROM CONTRACT	Qty / Size	Unit	Yes	No	REMARKS
1.0	**WORK CONCLUSION**						
1.1	Clean up location / work site		1	ls			
	NOTES:						
2.0	**SOLAR MODULES**						
2.1	Solar modules and its properties already on location			pc			
2.2	Solar modules are installed on its frame			ls			
2.3	Total capacity solar array (record in kWp)			kWp			
2.4	Solar module size (Wp per module)			Wp			
2.5	Type of solar module (mono/polycrystalline)						
2.6	Brand of solar module						
2.7	Model of solar module						
	NOTES:						
3.0	**PV ARRAY SUPPORT**						
3.1	Solar modules foundation structure		1	ls			
3.2	Frame material	galvanized iron/metal through hot deep galvanized treatment					
3.3	Module support	free standing above foundation		yes/no			
3.4	Foundation	concrete					
3.5	Mounting angle	between 10-15 degrees to ground level		yes/no			
3.6	Orientation	facing the equator					
	NOTES:						
4.0	**GRID INVERTERS (applicable only to AC Bus system types)**						
4.1	Grid (solar) inverters already on location			pc			
4.2	Grid inverters are installed			pc			
4.3	Grid inverter size (kW / kVA)			kWp			
4.4	Type of grid inverter (pure or modified sine wave)						
4.5	Brand of grid inverter						
4.6	Model of grid inverter						
	NOTES:						

NO	COMPONENT	SPECIFICATION FROM CONTRACT	Qty / Size	Unit	Yes	No	REMARKS
5.0	**SOLAR CHARGE CONTROLLER (SCR)**						
4.1	Solar charge controllers already on location			pc			Comment:
4.2	Solar charge controllers are installed			pc			
4.3	Solar charge controller (kW / kVA)			kWp			
4.4	Model of solar charge controller						
4.5	Type of solar charge controller (MPPT or not)						
4.6	Brand of solar charge controller						
	NOTES:						
6.0	**BATTERY SYSTEM**						
6.1	Batteries and its Properties already on location			pc			Comment:
6.2	Batteries are installed			ls			
6.3	Brand of battery						
6.4	Type of battery						
6.5	Nominal capacity (volts per cell)			Volts			
6.6	Battery capacity/cell (Ah)			Ah			
	NOTES:						
7.0	**BATTERY INVERTERS**						
7.1	Battery inverters already on location		0	pc			Comment:
7.2	Battery inverters are installed		1	pc			
7.3	Battery inverter size (kW / kVA)		5	kWp			
7.4	Type of grid inverter (pure or modified sine wave)						
7.5	Brand of inverter						
7.6	Model of inverter						
	NOTES:						
8.0	**REMOTE MONITORING SYSTEM**						
8.1	Remote monitoring system already on location		1	set			Comment:
8.2	Remote monitoring is installed		1	ls			
8.3	Data connection model (Webbox/Leonics/Schneider)			set			
8.4	Data storage - memory type						
8.5	Data storage - memory size			MB			
8.6	Pyranometer brand and model						
8.7	Pyranometer data logger brand and model						
8.8	External Memory on additional data logger						
	NOTES:						

NO	COMPONENT	SPECIFICATION FROM CONTRACT	Qty/Size	Unit	Yes	No	REMARKS
9.0	**POWER HOUSE**						
9.1	Power House is done		1	ls			Comment:
9.2	Type (permanent house/shelter)						
9.3	Shelter / building material (polyurethane and mild steel or brick)						
9.4	Room size			m2			
9.5	Walls (bricks or equal, neatly plastered and painted)						
9.6	Door (board/aluminum and equipped with lock)						
9.7	Floor (ceramics)						
9.8	Footpath (concrete or using con-block with 1 meter minimum width)						
9.9	Electricity installation for power house	5 points (3 lamps, 2 sockets), MCB 2 A					
9.10	Equipped surrounding with lightning rod system						
9.11	BRC fence is installed		1	ls			
9.12	Fence periphery	BRC type 120cm minimum height equipped with gate					
	NOTES:						
10.0	**POWER CABLES AND GROUNDING**						
10.1	Power cable from battery to inverter and/or battery to solar charge controller	minimum 1x70 mm2 (SPLN/SNI) to each string					Comment:
10.2	Power cable from inverter to distribution panel	type NYY 4 x 50 mm2 (SPLN/SNI)					
	NOTES:						
11.0	**POWER HOUSE DISTRIBUTION PANEL**						
11.1	Distribution panels already on location			set			Comment:
11.2	Distribution panels are Installed			ls			
11.3	Power capacity			kVA			
11.4	Number of feeder breakers			sets			
11.5	System voltage 220 or 230 VAC			VAC			
11.6	Monitoring device installed (volt meter)						
11.7	Monitoring device installed (current/amp meter)						
11.8	Monitoring device installed (frequency meter)						
11.9	Monitoring device installed (kWh meter)						
11.10	Positioning of distribution panel	as per safety standard and easy to monitor by the operator?					
	NOTES:						
12.0	**DISTRIBUTION, CONNECTION, AND HOUSEHOLD INSTALLATION**						
12.1	**General:**						
12.2	Pole network already on location			pc			Comment:
12.3	Network cabling for low voltage already on location			m			
12.4	Network cabling for medium voltage already on location			m			
12.5	Medium voltage transformers installed	using air network		pc			

NO	COMPONENT	SPECIFICATION FROM CONTRACT	Qty/Size	Unit	Yes	No	REMARKS
12.6	Distribution Network already on location			ls			
12.7	Type of network	using air network					
12.8	Distance between pole	maximum 40 m					
12.9	Type of poles	7 m, PLN standard (SPLN)					
12.10	installation depth	deep-seated with 1 meter depth					
12.11	installed equipment on poles	equipped with network accessories					
12.12	Inter-poles cable	NFA 2x35 mm2 + 1x25 mm2 (SPLN)					
12.13	Cables from pole to house	NFA 2x10 mm2 (SPLN)					
12.14	Cable deflection height between poles	4 m from ground surface					
	NOTES:						
13.0	**STREETLIGHTS**						
13.1	Number of streetlights already on location			pc			Comment:
13.2	Number of streetlights installed						
13.3	Control cabinet in power house grounded?						
	NOTES:						
14.0	**SUB-SYSTEM OF HOUSEHOLD INSTALLATION**						
14.1	LED Lamps already on location			pc			Comment:
14.2	Household Cabling already on location			m			
14.3	Household Installation are installed			pc			
14.4	Number of connections (households/buildings etc)			pc			
14.5	Protection system	current limiter (MCB) 1 A (including box and seal), 220 Volt					
14.6	Load per house	4 points (3 lamps and 1 socket)					
	NOTES:						
15.0	**ENERGY LIMITER - HOUSEHOLD**						
15.1	Number of *Energy Limiter* already on location			pc			Comment:
15.2	Number of energy limiters installed						
15.3	Input voltage	220 VAC, single phase, 50 Hz					
15.4	Cables in house installation	NYM 3x1.5 mm2 and 2x1.5 mm2. SPLN					
15.5	Grounding system			yes/no			
	NOTES:						
16.0	**LED LAMP - HOUSEHOLD**						
16.1	Lamp type	LED		pc			Comment:
16.2	Power consumption	maximum 5 W					
	NOTES:						

NO	COMPONENT	SPECIFICATION FROM CONTRACT	Qty/Size	Unit	Yes	No	REMARKS
17.0	**LIGHTNING PROTECTION**						
17.1	Tower and wire	tri-angle, guyed wire					Comment:
17.2	Lightning arresters already on location			set			
17.3	Lightning arresters are Installed			set			
17.4	Sky counter / strike counter installed			each			
17.5	Grounding system						
	NOTES:						
18.0	**TV AND DIGITAL PARABOLA**						Comment:
18.1	TV and antenna already on location			set			
18.2	LCD / LED TV model	32 inch, 100-240 VAC, 50/60 Hz LED/LCD					
18.3	Digital parabola type	solid dish (rusty-free) minimum 6 feet					
18.4	Accessories	including receiver, positioned, and actuator					
18.5	Pole	Iron pole 1.5 m					
18.6	Installation	public place, strongly recommended in village hall or other public places that are accessible					
	NOTES:						
19.0	**COMMISSIONING AND TRAINING**						
19.1	Comissioning is completed		1	ls			Comment:
19.2	Operator training is given		1	ls			
19.3	Village Management Team training is given		1	ls			
	NOTES:						

Appendix 2 Technical checklist: performance verification

PVVP Technical Checklist - Performance Verification (version 150615)

SITE CODE:		DATE:	
VILLAGE/HAMLET:		INSPECTOR:	
CONTRACTOR:		SIGNATURE:	

1. Time and Weather condition (during measurement):

PV performance measurement - Late Morning	Time:	hh:mm	Sunny	Cloudy	Rain
Battery status measurement - Evening (Just after dark)	Time:	hh:mm	Sunny	Cloudy	Rain
Battery status measurement - Early Morning (before sunrise)	Time:	hh:mm	Sunny	Cloudy	Rain
Inverter performance - Late Morning	Time:	hh:mm	Sunny	Cloudy	Rain

2. PV performance

At 10:30 - 11:00 Voltage and Current for PV string to check consistency - measure on the each combiner box - if feasible.
In case of different string currents, try to identify reasons (shading modules, loose cables) and make comment
Take photos of display readings

Combiner Box	1	2	3	4	5	6	7	8	9	10	Continue in new sheet
Number of strings:											Nr
Measured Voltage on busbars:											Volt
Measure current with 3 or 4 strings together:											Amp

Comments:

3. Charge controller recording

Record accumulated solar energy production since start of operation (reading from LCD on charge controller, inverter or RMS)
Recording at 10:00 to 12:00 during peak electricity generation

Charge controller	1	2	3	4	5	6	7	8	9	10	Continue in new sheet
Energy generated:											kWh
Solar PV voltage:											Volt

Comments:

4. Battery status

Battery measurements at evening (19.00-20:00) and morning (04:00-05:00) Has to be dark
Only over all measurement - not each individual batteries
Take photos of display readings (handheld measuring device, LCD and/or RMS)

Battery Voltage (from handheld measuring device) - Evening:		Volt	Battery Voltage (from handheld measuring device) - Morning:		Volt
Battery Voltage (from LCD or RMS) - Evening:		Volt	Battery Voltage (from LCD or RMS) - Morning:		Volt
Discharge Current (from handheld measuring device) - Evening:		Amp	Discharge Current (from handheld measuring device) - Morning:		Amp
Dircharge Current (from LCD or RMS) - Evening:		Amp	Dircharge Current (from LCD or RMS) - Morning:		Amp

Battery room temperature (measure point between batteries) between 11:00 and 15:00:		°C	
Are there hot battery cells (touch by hand each cell if there are temperature differences)?:	No / Yes	If Yes, provide details:	

Comments:

5. Inverter performance

Inverter measurements at evening (19.00-20:00) and morning (07:00-08:00)
Take photos of display readings (handheld measuring device, LCD and/or RMS)

	Inverter 1		Inverter 2		Inverter 3		Inverter 4		Inverter 5		
	Evening	Morning	Evening	Morning	Evening	Morning	Evening	Morning	Evening	Morning	
Inverter Voltage (measured with handheld device at AC distribution board):											Volt
Inverter Current (measured with handheld device at AC distribution board):											Amp
Inverter Voltage (reading from LCD or RMS):											Volt
Inverter Current (reading from LCD or RMS):											Amp
Total supplied energy since start of operation (reading from LCD or kWh-meter):											kWh

Comments:

6. Total energy production

Take kWh measurements throughout the time of visit
Take photos of display readings (kWh Energy Meter at Plant)

	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	Reading 6	Reading 7	Reading 8	Reading 9	Reading 10	
	time 00h00	time 00h00	time 00h00	time 00h00	time 00h00	time 00h00	time 00h00	time 00h00	time 00h00	time 00h00	
kWh Meter # 1 installed in AC distribution box (reading from meter or LCD or RMS):											kWh
kWh Meter # 2 installed in AC distribution box (reading from meter or LCD or RMS):											kWh
kWh Meter # 3 installed in AC distribution box (reading from meter or LCD or RMS):											kWh

Comments:

7. Remote Monitoring System and Pyranometer

Take photos of display readings
Copy card data

	System installed?		System recording?		Data copy succesful?		Data volume of copied data	
Remote Monitoring System (check PC or similar monitoring device):	Yes	No	Yes	No	Yes	No		MB
Pyranometer (check PC, pyranometer data logger or similar device):	Yes	No	Yes	No	Yes	No		MB

Comments:

8. Streetlights

Visual inspection after dark and verification with operator

Single streetlight power demand:		Watt	Lighting duration per day:		hrs/day
Number of streetlights installed:		units	Number of streetlights not operating:		units

Comments:

9. Household connection

Visual inspection and verification with operator

Energy limiters installed?	Yes	No	Mini Circuit Breaker (MCB) installed?	Yes	No
Energy limiter setting		Watts/day	Mini Circuit Breaker (MCB) rating:		Amp
Number of energy limiters installed:		units			
Number of energy limiters not operating:		units			

Comments:

10. Distribution grid performance

Measurement at furthest household from power house (i.e.with longest grid cable connection) at evening (19:00-20:00)
Measurement at furthest social institution at evening (19:00-20:00)
Take photos of display readings (of handheld measuring device)

Measure Voltage at furtherst social institution:		Volt
Measure Voltage at furthest household:		Volt

Comments:

Appendix 3 Workmanship checklist

PVVP Technical Checklist - Workmanship Quality (version 150615)					
Category	**Indicator**		**TRUE**	**FALSE**	**How many?/Comments?**
1. PV module quality:	1	Cracked glass of PV panels?			
	2	Twisted or broken PV panel frames?			
	3	White or brown spots under the glass?			
	4	Bubbles of air or moisture behind the glass?			
	5	Broken back sheeting (white EVA)?			
	6	Loose foils (delamination) at backside?			
	7	Browning under glass?			
	8	Junction boxes at backside loose or without cover?			
	9	Solar panels are partially shaded during the day?			
	10	Damaged cables from animals?			
2. PV module array foundation:	1	Broken or cracked concrete blocks?			
	2	Poor concrete mixture?			
	3	Insufficient foundation depth?			
	4	Anchor bolts too close to foundation edge or foundation too small?			
	5	Vulnerable to land slide?			
3. PV array mounting structure:	1	Overall array structure twisted or imbalanced?			
	2	PV module aluminium frames touch galvanised steel structure?			
	3	Height between lowest module and ground surface insufficient?			
	4	Distance between PV arrays too small?			
	5	Bad or loose panel clamps?			
	6	Loose anchor bolts into foundation?			
	7	Bad galvanizing on steel structure?			
	8	Insufficient support struts / cross members?			
	9	Rusting at structure or bolts?			
4. PV array combiner box and internal wiring:	1	Casing or housing is cracked?			
	2	No rain cover?			
	3	No rubber seals around door?			
	4	Mounted not correctly?			
	5	No lock or not lockable?			
	6	Door is not closing properly?			
	7	Water found inside the box?			
	8	Broken or burnt components inside?			
	9	Loose cable clamps inside?			
	10	Unbundled and disorganised cable layout?			
	11	Unsecure/unfirm connections or connectors?			
	12	Animals inside (or signs of animal like ants or mouse)?			
5. a) PV module wiring	1	Loose hanging cables between PV modules?			
	2	Cable conduits under PV modules not used?			
	3	Unsecure/unfirm connections or connectors?			
	4	Plug in connector socket missing?			
	5	Unsecure/unfirm junction box?			
	6	Burnt cables or connectors?			
	7	Wrong cable dimension used?			
5. b) External wiring weather proofing:	1	Any external cables exposed to direct sunlight or rain?			
	2	Any external cables with exposed copper wire?			
	3	Any external cables connections vulnerable to water entry?			
	4	Cable entries and exits not sealed with glands?			
	5	Cable conduits not sealed?			
5. c) Wiring to power house	1	Conduits not used properly from combiner box to power house?			
	2	Cables vulnerable to physical damage?			
	3	Cable entry point at power house wall not sealed?			
	4	Cables/conduits to power house not mounted securely?			

Category		Indicator	TRUE	FALSE	How many?/Comments?
6. Grounding and earthing:	1	No earthing of PV array structure?			
	2	No earthing of combiner box?			
	3	No earthing through lightning protection?			
	4	No earthing at charge controller?			
	5	No earthing at battery charger?			
	6	No earthing at inverter?			
	7	No earthing of battery protection box?			
	8	No earthing of AC distribution box			
	9	No earthing at all households?			
	10	No grounding connection in grounding pit/grounding rod?			
	11	Lightning mast not secure and unstable?			
	12	Wrong cable type/colour used?			
7. Battery rack:	1	Unstable battery rack?			
	2	Not strong enough? Risk of collapse?			
	3	Signs of corrosion or rust?			
	4	Signs of leaking batteries?			
	5	Wood or plastic pallet used?			
	6	No side bars to prevent batteries falling?			
8. Battery terminal connections:	1	No insulation around battery-to-battery cables?			
	2	Exposed battery terminals?			
	3	Exposed main battery bank combiner terminal?			
	4	Incorrect battery connections?			
	5	Main cables exposed to physical damage?			
	6	Signs of sulfide flakes at terminals?			
	7	Battery protection box fuses insufficient?			
	8	Battery protection box wiring insufficient?			
9. Internal power house wiring:	1	No conduits or cable trenches used?			
	2	No glands used at any cable entry points?			
	3	Unbundled and disorganised cable layout?			
	4	Cables with exposed copper wire?			
	5	Cables exposed to physical damage?			
	6	Unsecure/unfirm connections or connectors?			
	7	Incorrect grounding connections or connectors?			
10. Power house foundation:	1	Broken or cracked foundation?			
	2	Poor concrete mixture?			
	3	No concrete apron around power house?			
	4	Insufficient foundation depth?			
	5	Foundation too small for power house?			
	6	Gaps between foundation and power house walls?			
	7	Erosion or cavitation underneath foundation?			
11. Power house general condition:	1	Plaster, paint falling off walls?			
	2	Cracked, damaged walls?			
	3	Cracked, damaged floor?			
	4	Rust or corrosion on metal walls?			
	5	Doors are not closing?			
	6	Windows are not closing?			
	7	Waste materials left by contractor?			
	8	Untidy finishing?			
	9	Signs of animals entering?			
12. Power house ventilation:	1	Ventilation openings not on all power house walls?			
	2	Power house too hot inside? Note temperature (°C)			°C
	3	Ventilation openings dirty or blocked?			
	4	Ventilation openings do not stop insects to enter rooms?			
	5	Ventilation openings allow animals (e.g. snakes) to enter rooms?			
13. Power house flooding prevention:	1	Foundation height is insufficient to prevent water entry?			
	2	No external water diversion channels or aprons?			
	3	Roof is leaking?			
	4	Ventilation openings or windows are leaking?			
	5	Land slide risk at site?			
	6	Flooding risk at site?			

Category		Indicator	TRUE	FALSE	How many?/Comments?
14. Fence and gate:	1	Missing or broken fence sections?			
	2	Locks or keys for fence gate missing?			
	3	Much rust or corrosion on metal fence or gate?			
	4	Fence leaning?			
	5	Fence foundations poor, not existing or crumbling?			
	6	Fence too high thus do not prevent animals to enter?			
	7	No fence installed?			
15. Distribution grid pole installation:	1	Poor/inappropriate material used for poles?			
	2	No concrete foundations for poles?			
	3	Incorrect or broken cable bracket and tensioner?			
	4	Poles leaning or not securely anchored?			
	5	Poles inappropriately placed (e.g. in road, driveway)?			
	6	Poles spacing is incorrect (standard: max 40 m apart)?			
	7	Poles placed too close to trees?			
16. Distribution grid wiring:	1	Cables too slack and can be touched without ladder?			
	2	Cables not properly secured to pole brackets?			
	3	Incorrect cables used?			
	4	Exposed copper or aluminium wires?			
	5	Poor or exposed cable connections or connectors?			
	6	Poor grounding connections or connectors?			
	7	Cables touching sharp edges?			
	8	Cables crossing over and resting on other distribution cables?			
	9	Cables going through trees and resting on branches?			
	10	Cables resting on metal surfaces (e.g. building roofs)?			
	11	Cables vulnerable to physical damage?			
17. Streetlight installation:	1	Many streetlights not working?			
	2	Improper connection cable used?			
	3	Cables not protected or secured, but hanging loose?			
	4	Cable connection exposed to direct sunlight and rain?			
	5	Lamps are not covered or weather protected?			
	6	Unsuitable placing of streetlight (e.g. shining into trees)?			
18. Household installation:	1	Lamps, lights not working?			
	2	Outlets, sockets not working?			
	3	Cables not properly secured to the walls?			
	4	Household connection box exposed to weather?			
	5	AC distribution cable to household connection box not in conduit?			
	6	Energy limiter, meter, MCB damaged, tampered or broken?			
	7	Energy limiter, meter not resetting or recording properly?			
	8	Exposed copper wires in cable?			
	9	Poor or exposed cable connections or connectors?			
	10	Untidy cable layout?			
	11	No conduits or suitable surface cable (e.g. Surfix) used?			

Appendix 4 KPI questionnaire

KPI and Sustainability Survey for PVVP System (version 150430)

Location code:

Date	Name of surveyor	Signature

A. General Information

1. Location code
2. Village name/hamlet name
3. Closest city
4. Distance to closest city — km
5. GSM/GPRS — ☐ Yes ☐ No
6. GPS coordinate powerhouse (in decimal):
7. Distance to PLN grid: — km
8. Site accessibility by — ☐ Motorcycle ☐ Normal car ☐ 4x4 car ☐ Other
9. Date of commissioning:
10. Date of operation start:

	Manufacturer	Type	Capacity	Total number
11. PV modules			Wp	
12. Battery			Ah	
13. Charge regulator				
14. Inverter			kVA	

15a. Contractor company that build the PVVP
15b. Organisation that operates the PVVP
15c. Official owner of the PVVP
15d. Funder of the PVVP construction

B. Key Performance Indicators in Target Area

(Interview with Village Management Team/VMT)

B.1 Households (HH)

1. Enter the **number** of households and where they receive electricity from

	Connected to PVVP	Connected to PLN grid	Connected to other sources	No electricity
Households				

2. What is the **main reason** households have NOT been connected to PVVP?

- ☐ Location:
- ☐ Financial:
- ☐ Technical:
- ☐ Connected to PLN grid
- ☐ Energy supply from generator-set
- ☐ Other:
- ☐ Hand-operated appliances
- ☐ PVVP capacity too low
- ☐ PVVP operating hours not convenient
- ☐ Not allowed by PVVP management
- ☐ PVVP energy quality not satisfying

Comments:

B.2 Social institutions (SI)

1. Enter the **number** of each type of social institution and where they receive electricity from

		Connected to PVVP	Connected to PLN grid	Connected to other sources	No electricity
Social institutions	**Schools**				
	Health centre				
	Community centre				
	Religious buildings				
	Streetlights				

2. What is the **main reason** social institutions have NOT been connected to PVVP?

- ☐ Location:
- ☐ Financial:
- ☐ Technical:
- ☐ Connected to PLN grid
- ☐ Energy supply from generator-set
- ☐ Other:
- ☐ Hand-operated appliances
- ☐ PVVP capacity too low
- ☐ PVVP operating hours not convenient
- ☐ Not allowed by PVVP management
- ☐ PVVP energy quality not satisfying

Comments:

B.3. Rural businesses (productive use of energy/PUE)

1. Enter the **number** of warungs and other businesses and where they receive electricity from

	Connected to PVVP	Connected to PLN grid	Connected to other sources	No electricity
Warungs (electricity is used for lighting)				

Rural businesses (Productive Use of Energy)

List all businesses (other than warung) and specify the type (using the code below), number of employees and if it is owned/managed by the community or private, male or female, and tick the electricity source. Write each business in a separate row.

Code

- **(1) IT** – Communication and secretarial services (computer services, internet shop)
- **(2) AP** – Agricultural processing (rice huller, hatchery, butchery)
- **(3) FS** – Food production and catering (bakery, packaging and bottling, restaurant)
- **(4) CS** – Craft and souvenir (tailor, weaver, carpet making, toys production)
- **(5) HH** - Health care and hygiene (doctor, nurse, midwife, cleaning services, pest control)
- **(6) MR** - Maintenance and repair services (vehicle repair, electronics repair, plumbing)
- **(7) MA** - Manufacturing goods (carpentry, metal workshop)
- **(8) Ot** - Other

Business (list each one)	Type (Code)	Number of Employees or Members	Owned/managed by: 1: Community 2: Private 3: Group	Owned/managed by: M: Mostly male F: Mostly female	Source of electricity: PVVP	PLN grid	Other sources	None

2. What is the **main reason** PUE have NOT been connected to PVVP?

- ☐ Location:
- ☐ Financial:
- ☐ Technical:
- ☐ Connected to PLN grid
- ☐ Energy supply from generator-set
- ☐ Other:
- ☐ Hand-operated appliances
- ☐ PVVP capacity too low
- ☐ PVVP operating hours not convenient
- ☐ Not allowed by PVVP management
- ☐ PVVP energy quality not satisfying

Comments:

B.4 Energy supply in general

1. Is a kWh-meter installed in the powerhouse? ☐ No ☐ Yes — If yes, current reading: _____ kWh

2. Is an hour-meter installed in the powerhouse? ☐ No ☐ Yes — If yes, current reading: _____ hours

3. Is a remote monitoring system installed in the powerhouse? ☐ No ☐ Yes

4. Any problems with the kWh-meter? ☐ No ☐ Yes, _____

5. Any problems with the-hour meter? ☐ No ☐ Yes, _____

6. Any problems with the remote monitoring system? ☐ No ☐ Yes, _____

7. If "Yes" in 6: What are the reasons for the monitoring system giving problems?
   - ☐ Operator does not understand the messages
   - ☐ Operator does not know what to do
   - ☐ Computer is broken
   - ☐ Operator not familiar with computers
   - ☐ Only "Error" messages shown
   - ☐ Other: _____

8. Supply of electricity to community: ☐ 24 hours/day ☐ From: 00:00 to: 00:00

Days per week	S	M	T	W	T	F	S
Days per week	S	M	T	W	T	F	S

9. Is the PVVP operating at the moment? ☐ Yes, very well ☐ Yes, but with problems ☐ No, since _____

10. If "No" or "Yes, but with problems" in 9: What are the reasons that PVVP does not deliver energy?
   - ☐ Insufficient sunshine
   - ☐ Solar panels defect
   - ☐ Battery defect
   - ☐ Controller defect
   - ☐ Inverter broken
   - ☐ Outside solar cables damaged
   - ☐ Cables in powerhouse damaged
   - ☐ Grid cables damaged
   - ☐ Operator not available
   - ☐ Management not available
   - ☐ Lightning strike
   - ☐ Other: _____

11. If "No" in 9: When will electricity be available again?
   - ☐ Next few days
   - ☐ Next few weeks
   - ☐ Not sure

12. Do you know whom to contact when problems accoured? ☐ No ☐ Yes _____

B.5 Quality of energy (ask those who do not belong to VMT)

1. How satisfied are most customers with the quality of electricity provision? ☐ Very satisfied ☐ Satisfied ☐ Mostly satisfied ☐ Not satisfied
2. Do you have frequent blackouts? ☐ No ☐ Yes
3. Do you observe frequent light flickering? ☐ No ☐ Yes
4. Did appliances break due to insufficient quality of electricity? ☐ No ☐ Yes
5. Do customers complain about insufficient amount of energy per day?
   - ☐ Yes, most customers complain
   - ☐ Yes, but only businesses complain
   - ☐ Yes, a few customers complain
   - ☐ No
6. Are streetlights working?
   - ☐ Yes, all streetlights working
   - ☐ Only few streetlights working
   - ☐ Yes, most streetlights working
   - ☐ No streetlights working
7. What type of replacement lights is easily available for customers? ☐ LED ☐ CFL ☐ Incandescent ☐ None

(Interview with management chairperson and treasurer)

C.1 Village Management Team (VMT)

1. Salaries: ☐ Fixed amount ☐ Defined as % of revenue ☐ No salary

Function	2a. Name	2b. Phone number	2c. Age	2d. Gender		2e. Salary	2f. Period
				M	F	(IDR/month or % of revenue)	
Operator 1							
Operator 2							
Secretary							
Accountant							
Manager							
				Total salary:			

C.2 Condition of the administration books

1. Are there any administration books have been used by VMT? ☐ Yes ☐ No

	Not present	Not used	Used	Properly used
2a. Customer data book				
2b. Log book				
2c. Tariff and/or rule book				
2d. Budget book				
2e. Manual for operator				
2f. Other:				

3. Other bookkeeping system, please specify:

C.3 Team organisation

1. Are there any regular village meetings on PVVP? ☐ Yes ☐ No ☐ times since start of operation
2. Are there any regular elections or reorganisations? ☐ Yes ☐ No ☐ times since start of operation
3. Main reasons for irregular reorganisation (if any):
   - ☐ Only regular reorganisation
   - ☐ Members left the village
   - ☐ Members are too busy
   - ☐ Members are paid too little
   - ☐ Members are not interested
   - ☐ Members are not sufficiently skilled
   - ☐ Other:
   - ☐ Other:
4. Who provided trainings and/or introductions for the new staff?
   - ☐ No trainings
   - ☐ Old staff
   - ☐ Contractor staff
   - ☐ Other:
5. Do you exchange your experiences with management teams from other PVVPs?
   - ☐ No
   - ☐ Yes, with:

C.4 Tariff

1. What kind of **tariff system** is applied?
   - ☐ Flat rate depending on the number of appliances
   - ☐ Fixed rate
   - ☐ Rate per kWh
   - ☐ Other
2. Is there special **"social tariff"** for certain people? ☐ Yes ☐ No How:
3. Is there special tariff for **social institutions**? ☐ Yes ☐ No How:

4. Special tariff for **productive use of energy**? ☐ Yes ☐ No How:

5. Are **MCBs** in use? ☐ No ☐ Yes, size: ☐ 0.5A ☐ 1A ☐ 2A ☐ 3A

6. Different size MCB in different households? ☐ Yes ☐ No

7. Several households share MCB? ☐ Yes ☐ No

8. Are **energy limiters** in use? ☐ Yes, limit ____ Wh per day ☐ No

9. Different limiter setting for different customers? ☐ Yes ☐ No

10. If "Yes" in 9, please specify:

11. Did people pay a **connection fee**? ☐ Yes How much: IDR ____ ☐ No

12. Connection fee includes the household installation? ☐ Yes ☐ No

13. How many HH pay which tariff per **month** (current status of customers)?

	Number of HH	Tariff (IDR/month/HH)	Total expected amount (IDR/month)
Tariff 1			
Tariff 2			
Tariff 3			
Tariff 4			
Tariff 5			
		Total:	

14. How is the tariff collected?

☐ Staff walking from house to house ☐ People come to a specific place to pay ☐ Other method (specify)

Specify:

15. What happens if a customer does not pay the electricity fee?

☐ None ☐ Penalty fee of IDR

☐ Disconnection after 1 month ☐ Other:

☐ Disconnection after 6 month

16. How often the consequences of non-paying customers have been applied?

☐ Often ☐ Seldom ☐ Not yet applied

C.5 Financial administration (observe the book or ask VMT for data from the last three months)

1. Any financial records available? ☐ No ☐ Yes (If yes, complete the table below:)

	Month 1:	Month 2:	Month 3 (current):
2. Monthly **collected fee** (according to the book)			
3. Monthly **maintenance** cost (**no** cost for breakages)			
4. Total expense for VMT member **salary**			
5. Incidental expenses (repairment cost, etc.)			
6. Monthly **savings**			

7. Savings are kept in:

☐ PVVP dedicated bank account ☐ Treasurer cash box

☐ Cooperative saving account ☐ Other:

8. **Significant expenditures or repair works** happened so far, type and amount:

Type of repair/replacement	Total amount spent (IDR)	Date of repair

D. Operation and Maintenance
(Interview with operator)

D.1 General customer behaviour

1. Is there any abuse of electricity supply infrastructure by customers?

- ☐ No
- ☐ Yes, bypassing the circuit breaker (MCB)
- ☐ Yes, bypassing the energy limiter
- ☐ Yes, improper connection from grid to houses
- ☐ Yes, improper connections between houses
- ☐ Yes, vandalism of the PVVP system
- ☐ Inappropriate use of electrical appliances
- ☐ Other:

D.2 Periodic site check and supporting equipment availability

1. Is a tool box available on site? ☐ No ☐ Yes
2. Are manual books available on site? ☐ No ☐ Yes
3. Known spare parts vendor available? ☐ No ☐ Yes

   Name
   Location
   Phone number
4. Solar power technician available? ☐ No ☐ Yes

   Name
   Location
   Phone number
5. Log book filled regularly? ☐ No ☐ Yes

6. What repairs and maintenance had been conducted since commissioning and how regularly?

	Not yet	Once every 6 months	Once a month	Weekly	Daily
a. Solar panels replaced					
b. Solar panels cleaned					
c. Shading on solar panels removed					
d. Plant cutting to avoid shading					
e. Charge controller replaced					
f. Inverter replaced					
g. Batteries replaced					
h. Monitoring computer restarted					
i. Monitoring computer replaced					
j. Outside solar cables repaired					
k. Powerhouse power cables repaired					
l. Powerhouse sensor cables repaired					
m. Powerhouse maintenance					
n. Cleaning of power house					
o. Distribution grid cables repaired					
p. Customer energy limiter replaced					
q. Streetlights repaired					

List of photos to take

Save photos of each location in one folder!

Create sub folder consisting of:

- Photos of inside powerhouse
- Photos of outside powerhouse
- Photos of distribution network and connection
- Other

Name the photos according to this format: **Sitecode_Item.jpg** (use the automatic numbering on document explorer)

For example: the third photo of “Battery” at site SulBarS07 will be named: **SulBarS07_Battery (3).jpg**

Take photos as specified by the following list:

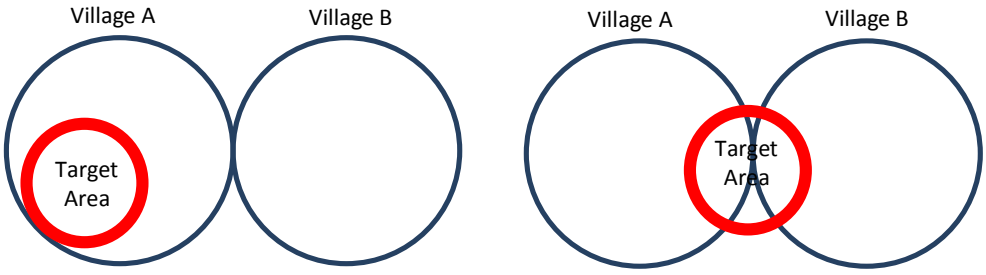
- Other		First page of KPI questionnaire **(with the site code written!)**
- Outside		Around the outside of the powerhouse
- Outside		Surroundings of system
- Outside		Solar array (landscape)
- Outside		Solar array orientation (compass reading overlay)
- Outside		Solar module (randomly on some spots, be alert for damage/breakage!)
- Outside		Details of cabling at solar array
- Inside		Inside powerhouse (with battery, inverter, and monitoring system visible)
- Inside		Battery
- Inside		Charge controllers
- Inside		Inverters
- Inside		Details of cabling inside the powerhouse
- Inside		Remote monitoring system (RMS)
- Inside		Connection and distribution box in the powerhouse or in the panel box
- Distribution		Distribution pole and cables
- Distribution		Streetlights
- Distribution		MCB and energy limiter
- Distribution		Public television
- Distribution		HH connection
- Other		Existed administration books (if any)
- Other		Examples of rural businesses including warung (with a person(s) demonstrates their activities)
- Other		People in actions (e.g. operator cleaning PV module, inspector checking the installation, operator training)
- Other		Access road to the village
- Other		Village chief (when agreed upon)
- *(Dependant)*		Detail photo if any installation looks wrong or unsure (put in sub folder depending on the topic)

Appendix 5 Manual for KPI questionnaire

A. General Information		
No.	**Question**	**Explanation**
1	Site code	**FILL IN before survey**, check in database
2	Village/hamlet name	**FILL** IN **before survey**, check in database
3	Closest city	What is the closest city to the site
4	Distance to closest city	Give the distance to the aforementioned closest city in km
5	GSM/GPRS	1. If GSM signal **is available** in location, then tick **Yes** 2. If GSM signal **is not available** in location, then tick **No** Check in PVVP location with a GSM cell-phone. If signal is present even though weak (one signal bar/strip), consider that the signal is available, then tick **Yes**
6	GPS coordinate powerhouse	1. If GPS coordinate is available in database, then **FILL IN** before survey 2. If GPS coordinate is not available in database, mark GPS coordinate at the PVVP powerhouse location using the handheld GPS device, then **FILL IN**. 3. Else, if none of that is possible or practical, leave it **EMPTY**.
7	Distance to PLN grid	1. If PLN grid is available in "TARGET AREA", **FILL IN** with 0 km 2. If PLN grid is not available in "TARGET AREA" but there is in certain distance from it, check by asking to locals or use car/motorcycle speedometer during travel, then **FILL IN**. 3. Else, if none of that is possible or practical, leave it **EMPTY**. *Explanation of TARGET AREA at Part B (key terminology)*
8	Accessibility by	**TICK** for all that might apply or available (can be more than one)
9	Date of commissioning	**FILL IN** with format day/month/year e.g. 25/07/2012 Date of commissioning is the time when commissioning process (civil structure check, electrical check, etc.) had been completed
10	Date of operation start	**FILL IN** with format date/month/year e.g. 30/08/2012 Date of starting operation is the time when first customer had received electricity from the PVVP
11	PV modules specification	Check from the PV module nameplate. Fill in the brand/manufacturer, type, capacity, and total number. *If no information is available from the nameplate, ask to the operator.*
12	Battery specification	Check from the battery nameplate. Fill in the brand/manufacturer, type, capacity, and total number. *If no information is available from the nameplate, ask to the operator.*
13	Charge regulator specification	Check from the charge regulator nameplate. Fill in the brand/manufacturer, type, capacity, and total number. *If no information is available from the nameplate, ask to the operator.*
14	Inverter specification	Check from the inverter nameplate. Fill in the brand/manufacturer, type, capacity, and total number. *If no information is available from the nameplate, ask to the operator.*
15	Name of contractor company	**FILL IN** with the company name of contractor as in database.

B. Key Performance Indicator in Target Area
Key Terminology: • **HH** is Household, a family life in one single building. • **SI** is Social Institution (i.e. school, community centre, health centre, religious building, streetlights etc.). • **PUE** is Productive Use of Energy application. It includes any kind of small enterprise that makes use of electricity: *i.e. a warung (kiosk), rice/coffee processing machine, workshop, hatchery, tailor, etc.* • **Customer** is any HH/SI/PUE inside the PVVP Target Area (explained below). • **Target Area** is a set of area consisted of HH, SI, and PUE that were intended to be connected according to the plan. It may

consist part of a village (left figure), or parts of two villages (right figure). It is the PVVP Target Area that will be the focus of KPI survey. This information is available from Village Chief or VMT.



GENERAL REMARK for PART B

In this part, you will need to fill the boxes with the number of HH, SI and PUE available inside Target Area.

This part of questionnaire absolutely needs to be filled!

Question 1 Further explanations for B.1 (Households), B.2 (Social Institutions), B.3 (Productive Use of Energy)

Connected to the PVVP	▪ Each customer is considered as connected to PVVP if they had connection devices/wires to PVVP and formally accepted as customer by the VMT *for at least one month ago* **(according to the last record of VMT or the last figure they remember if there is no record)**. ▪ If a customer had connection devices but it was disconnected by the VMT permanently due to sanction or lack of PVVP capacity then it is not counted toward the number. Illegal connection does not count. *Incidental use due to wedding celebration, funeral or other INCIDENTAL social event does not count.*
Connected to the PLN grid	Each customer considered as connected to PLN if they had legal or illegal (it does not matter) connection to PLN and not permanently disconnected by any reason. **Find this data by asking the VMT. Estimation is acceptable.** *Incidental use due to wedding celebration, funeral or other INCIDENTAL social event does not count.*
Connected to the other sources	Each customer is considered as connected to other sources if they had any **active and regularly used** electricity sources or generation devices e.g. genset. A backup generator-set does not count. **Find this data by asking the VMT. Estimation is acceptable.** *Incidental use due to wedding celebration, baby birth celebration, funeral or other INCIDENTAL social event does not count.*
Not connected	Considered not connected at all if they had no electricity source can be used in **daily basis**. **Find this data by asking the VMT.** **Estimation is acceptable.**

No.	Question	Explanation
2	What is the **main reason** HH/SI/PUE have **NOT** been connected to PVVP?	**TICK** all that apply. Try to focus on main reason(s). *Location:* e.g. houses are too far away *Financial*: e.g. no money for connection fee, no fund available for monthly fee, no money for appliances, etc. *Technical:* if the reasons is manly technical e.g. no technical equipment available, not enough capacity installed
3	What are **future prospects** for the connection rate of HH/SI/PUE?	**TICK** all that apply but try to focus on the most realistic prospect. This question intends to identify the potential of future PVVP customers.
B.2 Social Institution		
A	Schools	*PAUD, SD, SMP, SMA.*
B	Health centre	*Puskesmas, Posyandu, Hospital.* Doctor or midwife's house is not considered as health centre.
C	Community centre	Youth centre, community meeting building, village hall, etc.
D	Religious buildings	Mosque, *musholla*, church, etc.

E	Streetlights	The streetlights installed as part of the project.
B.3 PUE		
PUE		The *Business* table includes any PUE beside warungs. List one of each business existing.
B.4 Energy Supply in General		
No	**Question**	**Explanation**
1	Is a kWh meter installed?	If a kWh meter is installed and works properly, **TICK** the "Yes" box *Remember to take a picture of the total kWh recorded!* If a kWh meter is not installed, **TICK** the "No" box.
	(kWh meter) Current reading	▪ If and only if a kWh-meter is installed and working properly without recorded problems, **FILL IN** according to the meter. ▪ It is the kWh meter **inside powerhouse, and NOT in the household.** ▪ Be careful on meter reading; notice the decimal point display (no decimal point, one decimal point, two decimal points). Normally the decimal point of an analog kWh meter display will be coloured differently. ▪ Make sure you understand the kWh meter display before writing any number.
2	Is an hour meter installed?	If an hour meter is installed and worked properly **TICK** the "Yes" box *Remember to take a picture of the total hours recorded!* If an hour meter is not installed, **TICK** the "No" box.
	(hour meter) Current reading	Fill in the hour reading according to the meter.
3	Is solar monitoring system installed?	**TICK** "Yes" or "No" as applicable. This is the Remote Monitoring System (RMS) as specified in the specification document.
4	Have you ever had problems with the kWh meter?	If yes, specify the problems. Problems are the ones caused interruption in the measurement. This question is to identify if the kWh recorded can be compared to kWh records from other sites. Interruption of recording, i.e. PVVP running without metering it, can cause a bias within the analysis. **TICK** the "Yes" box if kWh-metering has been interrupted since installation of the meter. Otherwise, tick "No".
5	Have you ever had problems with the hour meter?	If yes, specify the problems. This question is to identify if the hours recorded can be compared to operational hour records from other sites. Interruption of recording, i.e. PVVP running without metering it, can cause a bias within the analysis. **TICK** the "Yes" box if hour meter has been interrupted since installation of the meter. Otherwise, tick "No".
6	Have you ever had problems with the monitoring system?	If yes, specify the problems e.g. error message, not connected, etc.
7	What are the reasons of monitoring system giving problems?	If yes on number 6, **TICK** all reasons that apply.
8	Supply of electricity to community	▪ **TICK** 24 hours/day and **CROSS** the days when PVVP works for 24 hours/day ▪ If there are days when PVVP does not work 24 hours/day, specify the time and **CROSS** the days when PVVP works on the specified time.
9	Is the PVVP operating at the moment?	▪ If PVVP still provides electricity regularly until the day of KPI Survey, **TICK** "Yes, very well". ▪ If PVVP is inactive for more than one month, **TICK** "No, since" and specify the date it stopped operating. ▪ If there are some problems that recently cause interrupt the regular operations, **TICK** "Yes, but with problems" *If PVVP is inactive during the survey due to maintenance, special day (Friday, Sunday), and not because of technical breakdown or non-functioning VMT, and there is clear evidence of regular PVVP use,* ***TICK*** *"Yes, very well"*
10	If "No" or "Yes, but with problems" in 9: What are the reasons?	If question 9 is answered as "no" or "yes, but with problems", **TICK** all reason(s) applied and write the reason on blank line if not in the list.
11	If "No" in 9: When will	If question 9 is answered as no, **TICK** one that applies.

	electricity be available again?	
12	Do you know whom to contact when problems occurred?	**TICK** one that applies. If "yes" specify the name/contact/workshop/etc.

B.5 Quality of Energy

No	Question	Explanation
1	How satisfied are most customers with the quality of electricity provision?	**TICK** one that applies.
2	Do you have frequent blackouts?	**TICK** "yes" if blackouts occur frequently e.g. more than once a week. **TICK** "no" if blackout does not occur, or only happens a few times within a month and do not affect the overall supply of electricity.
3	Do you observe frequent light flickering	**TICK** "yes" if light flickering occurs frequently e.g. each day, or each week. **TICK** "no" if light flickering does not occur, or only happens a few times that don't affect the overall supply of electricity.
4	Did appliances break due to insufficient quality of energy?	**TICK** "yes" if there had been appliances broken due to unstable energy supply.
5	Do customers complain about insufficient amount of energy per day?	**TICK** one that applies.
6	Are streetlights working?	**TICK** one that applies.
7	What type of replacement lamps is easily available for customers?	**TICK** all that apply.

C. Administration and Management (Interview with management chairperson and treasurer)

C.1 Village Management Team (VMT)

No	Question	Explanation
1	Salaries	**TICK** one answer and specify if the management team is paid and how.

2. Try to fill all the function of VMT being asked. Phone number and name of at least one person should be recorded for future means of communication.

If there is a person who have more than one function, write his/her name in every function s/he fulfils. **This is an example** of how it should be filled in this situation:

Function	2a. Name	2b. Phone number	2c. Age	2d. Gender		2e. Salary (IDR/month or % of revenue)	2f. Period (month)
				m	f		
Operator 1	Budi Rohman	0816XYZ123	40	x		Rp 400 000	2
Operator 2	Rahmat Wisnu	0815ABC246	50	x		Rp 600 000	8
Secretary	Vika Riana	0852BEF664	25		x	Rp 400 000	8
Accountant	Vika Riana	Look above	25		x	Look above	Look above
Manager	Rahmat Wisnu	Look above	50	x		Look above	Look above
					Total salary:	1,400,000	

By identifying two names which are identical (Rahmat Wisnu and Vika Riana), we can know that there are three persons in total in the VMT. In order to avoid time consuming repetition of phone number or salary writing, make a symbolic sign, for example Look above or === as long as it is consistent and understandable.

Try to identify since when they are accepted to the VMT in order to find out about the reorganisation, for example Budi Rohman recently joined the team as operator and has been working for 2 month. Sum up the total amount of salary that is spent for the management team, to cross check this data with the financial status in section C.5.

C.2 Condition of Administration Books

Firstly, ask if any administration books have been used by the VMT. Not all sites have books as indicated. If VMT has other books, but the function is more or less similar, you can say they have the books. If they have different book with different function from the list, specify what book it is.

Key terminology about the books:

1. **Customer Data Book**: book in which all customers are listed and accountant records fee collection.
2. **Log Book**: book in which operator record technical performance, trouble and maintenance schedule.
3. **Tariff and Rule Book**: book that explains the tariff system, rules/sanctions about illegal connection, late payment, connection application etc. This could only be a notebook and does not have a special format or design.
4. **Cash Book**: book that lists the income, maintenance and salary expense, spare part replacement expense etc.
5. **Manual for Operator**: book provided by the PVVP contractors regarding the solar power components.

Key terminology about the criteria:

- **Not Present:** the book **is not physically available** on the site during survey for some reason or excuse. As long as the VMT cannot show it, then **TICK** as **not present**.
- **Not Used:** the book is physically available in the location during KPI Survey and **can be photographed** but never used (completely blank or just filled for first month), **TICK** as **not used**.
- **Used:** the book is physically available in the location during KPI Survey and **can be photographed,** there is missing information, but **IMPORTANT DATA** (monthly expense, frequency of breakdown etc.) can be estimated roughly from the book, **TICK** as **USED.**
- **Properly Used:** the book is physically available in the location during KPI Survey and **can be photographed; IMPORTANT DATA** (monthly expense, frequency of breakdown etc.) can be estimated with good confidence from first month of operation until the day of survey.

C.3 Team Organisation		
No	**Question**	**Explanation**
1	Are there any regular meetings?	If there is scheduled meeting monthly, **TICK** "Yes", **FILL box** times since start of operation. If there is no scheduled meeting, **TICK** "No".
2	Are there any regular elections/reorganisations?	If reorganisation had been scheduled for certain years in the rule, **TICK** "Yes", **FILL box** times since start of operation. If there is no scheduled reorganizations, **TICK** "No".
3	Main reasons for reorganisation (if any)	**TICK** all that apply. (if one people already change, it count as reorganisation)
4	Who provided trainings and introductions for the new staff?	**TICK** all that apply. Any training whether formal or informal is accepted as training as long as they consist of (ask the VMT): 1. What to do in normal situation 2. What to do in problematic situation
5	Do you exchange your experiences with VMTs from other PVVPs?	If you exchange your experience about PVVP in official or informal way with other PVVP management teams **TICK** "Yes" and specify the name of the PVVP.
6	Any complaints/comments from costumers concerning management of PVVP?	**TICK** one that applies. Specify if there is any comment.
C.4 Tariff		
No	**Question**	**Explanation**
1	What **tariff system** applied?	**TICK** for one that most appropriate, choose the latest effective system used. Ask the VMT.
2	Special **"social tariff"** for poorer people?	If there is a special tariff for people who earn less than average, **TICK** "Yes" and specify the tariff.
3	Special tariff for **social institutions?**	If there is a special tariff for social institutions, **TICK** "Yes" and specify the tariff.
4	Special tariff for **productive use of energy?**	If there is a special tariff for productive use of energy (i.e. businesses), **TICK** "Yes" and specify the tariff.

5	Regular **tariff increase** (e.g. 5% per year)?	If there is a regular tariff increase, **TICK** "Yes" and specify the system/the increase.
6	Are MCBs in use?	If MCBs are installed in the HH, **TICK** "Yes" and choose all sizes installed.
7	Different MCB size in different HH?	If different sizes of MCBs are installed among the connected households, **TICK** "yes".
8	Several HH share an MCB?	If there are households share one MCB, **TICK** "Yes". For example this could apply on households that live in the same building.
9	Are the energy limiters in use?	**TICK** one that applies. If "Yes", specify the setting: ……. Wh/HH/day.
10	Different energy limiter settings for different customers?	**TICK** one that applies. If "Yes", specify the difference in No. 11.
12	Did people pay a connection fee?	If the customers paid a connection fee to use electricity from the PVVP, **TICK** "Yes" and specify the average amount of this connection fee.
13	Did connection fee include the household installation?	Household installation means the physical connection to the PVVP, i.e. wiring, switches, MCB, etc.
14	How many HH pay which tariff per **month** (current status of customers)?	According to the current status (which should be equivalent with the customer data book entries), give the number of households, tariff per month and total amount of payment from each tariff group. Sum up the expected amount of monthly tariff to cross check this data with the financial status in section C.5.
15	How is the tariff collected?	**TICK** one that applies or describe method of collecting the tariff.
16	What happens to the customer who does not pay the electricity fee?	**TICK** all that apply or specify sanctions on blank line if not in the list. Ask the VMT.
17	How many times the consequences have been applied?	**TICK** for one that most appropriate. Estimation is acceptable. Ask the VMT.

C.5 Financial Administration

Firstly ask if any financial records available. If "Yes", complete the table below.

Before entering the financial data, write the last three completed month. For example: If the date of survey is 15 May, the last three completed month are February, March and April and should be entered in the following order:

Month 1: February	Month 2: March	Month 3 (latest): April

No	Question	Explanation
1	Monthly expected fee	Calculate according to the rule or tariff book. Check how many customers exist in each of the 3 months and how much are they supposed to pay according to tariff book.
2	Incidental income (everything beyond monthly fee)	The total amount of income beyond monthly household fee for each of the 3 months.
3	Monthly **collected fee** (according to the book)	Real total fee collected for each of the three months. This only includes the income by monthly tariff and not the incidental income stated above.
4	Monthly **maintenance** cost (**no** cost for breakages)	Maintenance costs for each of the 3 months. This includes regular maintenance expenses or small reparations at civil construction but **NOT** the costs to fix major breakages!
5	Total monthly expenses for VMT **salary**	Get the data from section C.1!
6	Incidental expense at that month	Incidental expenses for each of three months. Those include any expense that is not included in the normal O&M costs (e.g. breakages, etc.)
7	Monthly **savings**	Monthly savings should equal to monthly income (tarif and incidental income) minus monthly expenses (maintenance, salary, and incidental expenses).
8	**Total** current savings	Ask the VMT or observe from cash book. This is the total amount of currently available money for PVVP.
9	Savings are placed in	**TICK** one that applies. If not in the list, specify the placement of savings on blank line.

10	Which **significant expenditures/repair** works happened so far, type and amount	Specify if there had been expenditures for reparation of major breakages or non-regular maintenances. For example breakages of powerhouse/PV modules/inverter/etc.
D. PVVP Operation and Maintenance (interview with operator)		
D.1 General Customer Attitude		
No	**Question**	**Explanation**
1	Is there any abuse of electricity supply infrastructure by customers?	**TICK** all that apply.
D.2 Periodic Site Check and Supporting Equipment Availability		
No	**Question**	**Explanation**
1	Is a tool box available on site?	Tool box does not necessarily a box, but any kind of container that neatly holds essential equipment like: screwdriver, plier, wrench etc. On site means either in the powerhouse or in the operator's house.
2	Manual books available on site?	[self-explanatory]
3	Known spare part vendor available?	Any kind of shop that can provide bolts, nuts, cables, MCBs, fuses etc. Note down the name, location, and phone number of the shop (if possible).
4	Known repair workshop available?	Specialised PVVP components repair workshop. Note down the name, location, and mobile phone number of the workshop/technician.
5	Log book filled regularly?	It is considered regular if at least all month are filled.
6	What repairs and maintenances had been conducted since commissioning and how regularly?	[self-explanatory] Quantify how often the system has experienced such occurrences within the last year. Fill in a number (estimation is possible). If no such occurrence was observed, please enter a "0".

Appendix 6 Technical summary sheet with scoring guideline

Mini-Grid Service Package for PVVP 2015
Technical Summary Sheet

Site code:	As per checklists/KPI	Survey date:	As per KPI
Village name:	As per KPI	Commissioning date:	As per KPI
District:	As per site list	Paket number:	As per site list
Province:	As per site list	Contractor name:	As per KPI
System size (kW):	As per checklists/KPI	**Total score (%):**	Average of scorings 1, 2 and 3

PV-VP system operational:	**Yes:**		**No:**		**Comment:** As per checklists/KPI

1. Component compliance

Verification between contract requirements and actual site installation

Solar PV Modules					
Installed capacity:		Fulfilled		Not fulfilled	Fulfilled if all are installed; state capacity (kWp) Additional comments in case of defects (e.g. spots and others)
PV module type / brand:		Fulfilled		Not fulfilled	State make and model as per KPI Fulfilled if as per specification
PV Array / Support					
Frame material:		Fulfilled		Not fulfilled	Fulfilled if planned material used/ installed; Additional comments in case of defects (e.g. rust etc.)
Mounting angle:		Fulfilled		Not fulfilled	Fulfilled if as per specification
Orientation / Azimuth:		Fulfilled		Not fulfilled	Fulfilled if facing North (Utara)
Grid Inverter (not applicable if Battery Inverter is used)					
Installed capacity:		Fulfilled		Not fulfilled	Fulfilled if installed even if defect; state capacity (kW0 In case of defects additional comment
Inverter type / brand:		Fulfilled		Not fulfilled	State make and model as per KPI Fulfilled if as per specification
Battery Inverter (not applicable if Grid Inverter is used)					
Installed capacity:		Fulfilled		Not fulfilled	Fulfilled if installed even if defect; state capacity (kW) In case of defects additional comment
Inverter type / brand:		Fulfilled		Not fulfilled	State make and model as per KPI Fulfilled if as per specification
Solar Charge Controller (not applicable if Grid Inverter is used)					
Installed capacity:		Fulfilled		Not fulfilled	Fulfilled if installed even if defect; state capacity (kW) In case of defects additional comment
Controller type / brand:		Fulfilled		Not fulfilled	State make and model as per KPI Fulfilled if as per specification
Battery System					
Installed capacity:		Fulfilled		Not fulfilled	Fulfilled: if battery voltage and capacity meets contract; state capacity (kWh)

Bank Voltage rating:		Fulfilled		Not fulfilled	Fulfilled: if battery bank voltage and capacity meets contract
Battery type / brand:		Fulfilled		Not fulfilled	State make and model as per KPI Fulfilled: if as per specification
Remote Monitoring System					
Data connection model:		Fulfilled		Not fulfilled	State make and model as per KPI Fulfilled: if as per specification
Data storage active:		Fulfilled		Not fulfilled	State type as per KPI Fulfilled: if data being stored on device or available on computer
Pyranometer installed:		Fulfilled		Not fulfilled	State make and model as per KPI Fulfilled: if as per specification
Pyranometer active:		Fulfilled		Not fulfilled	State type as per KPI Fulfilled: if data being stored on device or available on computer
Balance of System					
Power house:		Fulfilled		Not fulfilled	As per Technical Sheet Not fulfilled: In case of obvious deviations (incorrect building types or fittings)
Electric wiring as specified:		Fulfilled		Not fulfilled	As per Technical Sheet Not fulfilled: In case of obvious deviations (incorrect cables types)
Grounding as specified:		Fulfilled		Not fulfilled	As per Technical Sheet Fulfilled: in case that grounding had been done in the solar array yard and for all electrical cabinets and household connections Not fulfilled: in case that even grounding of one cabinet or of other equipment had not been done (serious risk of life and damage to equipment)
Combiner boxes as specified:		Fulfilled		Not fulfilled	As per Technical Sheet Fulfilled: if installed as specified In case of defects additional comment
Lightning protection as specified:		Fulfilled		Not fulfilled	As per Technical Sheet Fulfilled: if installed as specified Not fulfilled: missing sky counter
Distribution panel as specified:		Fulfilled		Not fulfilled	As per Technical Sheet Fulfilled: if installed as specified Not fulfilled: In case of major defects
kWh meter as specified and functioning:		Fulfilled		Not fulfilled	As per KPI and Technical Sheet Fulfilled: if installed Not fulfilled: In case of major defects
Appliances					
Energy limiters installed and functioning:		Fulfilled		Not fulfilled	State quantity as per KPI State Wh setting as per KPI Not fulfilled: if more than 10% defective
Customer (household and social institution) connections quantity:		Fulfilled		Not fulfilled	State Planned as per site list State Surveyed (HH & SI) as per KPI Not fulfilled: if surveyed is below planned

Streetlight installed and operating:		Fulfilled		Not fulfilled	State Planned as per contract State Surveyed as per KPI Fulfilled: if installed, even if improper streetlights are used (make additional comment) Not fulfilled: if surveyed is below planned, if more than 10% defective
LCD TV installed at community centre:		Fulfilled		Not fulfilled	Not fulfilled: if not installed, if installed in power house

2. Performance verification

Spot measurements for key components for consistency

PV module output consistency:		Fulfilled		Not fulfilled	In case of defects additional comment Not fulfilled: if inconsistency between different measurement points more than 50%
Battery storage acceptable:		Fulfilled		Not fulfilled	State voltage (V) and recorded time (hh:mm) as per Measurement Sheet Fulfilled: if >50VDC, if 48-50VDC (but with additional comments since voltage should be higher) Not fulfilled: if measurement <48VDC
Inverter output consistency:		Fulfilled		Not fulfilled	State voltage (V) as per Measurement Sheet In case of defects additional comment (e. g. check voltage at inverter LCD based on photos) Not fulfilled: if measurement of AC voltage is < 10%
Distribution grid voltage acceptable:		Fulfilled		Not fulfilled	State voltage (V) as per Measurement Sheet and voltage drop (%) Not fulfilled: >5% related to 220 or 230 V (measurement value: lowest value measured)

3. Workmanship quality

Review of workmanship as per general quality, health and safety requirements. ***Rated 1 (very poor quality/safety risk) – 5 (very good quality)***

General scoring guide:

5 = very good, meets required specification
4 = good, meets required specification with few faults
3 = fair, meets required specifications with several faults
2 = poor, below standard, some major faults
1 = safety risk, serious faults and shortcomings

1	PV module quality:	Rating:		1: if > 25% of modules with spots or other defects 2: if 10% to 25% of modules with spots or other defects 3-4: shading on modules, modules with minor defects
2	PV module array foundation:	Rating:		1-3: for eroded, partly not exiting foundations, cracked foundations, poor foundation size, insufficient depth
3	PV array mounting structure:	Rating:		1: wood or other non-standard material is used

				2-3: many loose modules, stays, base plates or mounting brackets; if stability concerns; twisted array 4: risk of galvanic corrosion
4	PV array combiner box wiring:	Rating:		1-3: If not properly fixed to the support structure and without sealed cable entries; if no glands are used or cable entries not sealed (animals inside) 1-2: if not weather resistant and mounted exposed to UV and rain
5	**External wiring (PV module to power house):**	Rating:		1-3: cables not protected in conduits, supported by channels or vulnerable to damage; in case of improper interconnection of module cable with string cable (e.g. with exposed terminal blocks) 1-2: if incorrect cable types, reduced cross sections or UV exposed cables
6	Grounding and earthing:	Rating:		1-2: if grounding of one or more equipment missing or poorly installed 3-4: if wrong cable colour is used, diameter too small
7	Battery rack:	Rating:		1: if nothing is provided 2-3: if vulnerable to corrosion (non-galvanised, non-primed metal frame) 3: if wooden or plastic pallets used; if no side bar
8	**Battery terminal connections:**	Rating:		1: if main terminals fully exposed 1-3: if some terminals not covered or just partly covered with plastic foil 4: if main cables not in conduit
9	**Internal power house wiring:**	Rating:		1-2: if exposed cables without insulation, faulty connections posing heat/fire hazard 1-3: if cables not protected in conduits, supported by channels or vulnerable to damage
10	Power house foundation:	Rating:		1-3: if extensive chipping, crumbling and cracking of foundation 4: if without apron
11	Power house general condition:	Rating:		1: if serious defects, such as broken walls, missing roof sections, unstable structure 2-3: if poor and sloppy finishing, doors and windows don't close, broken ceiling, broken floor, contractor waste materials left on site
12	Power house ventilation:	Rating:		1: if battery temperature > 40°C 2: if battery temperature > 35°C 3: if battery temperature > 30°C 3: if one or more walls without passive ventilation openings
13	**Power house flooding prevention:**	Rating:		1-3: if evidence of flooding, if high risk of flooding or land slide, with no precautions taken, foundation < 10cm above ground
14	Fence and gate:	Rating:		1-2: if sections missing, or large gaps 3: if strong rusting of bolts and fence; if fence leaning, fence too high from ground
15	**Distribution grid pole installation:**	Rating:		1-2: if not utility standard (or best practice) material and mounting brackets 2-3: if wrongly placed (blocking access routes, cause of potential accidents), if unstable poles, missing foundations and guy wires
16	**Distribution grid wiring:**	Rating:		1-2: if poor cable interconnection (cables just twisted together), insufficient cable height (can be touched without ladder), cable resting on other objects (e.g. house roofs) 1-3: if cables at power house and households not protected

17	Streetlight installation:	Rating:		1-3: in case of very poor cable interconnection (cables just twisted together) 3: if more than 50% not working 3: if non-weather-proof streetlights (e.g. under-roof flood lights) are used
18	**Household installation:**	Rating:		1-3: if cables not protected in conduits, supported by channels or vulnerable to damage; if energy limiters and MCB exposed to weather; if cable not properly interconnected (cables just twisted with poor insulation)

Items in RED, with very poor workmanship (scoring of 2 or less) pose significant health and safety risk!

Overall rating of Workmanship Quality: (Max. score = 90 ➔ 100%)	**%**

4. Recommendations

Recommendations regarding any possible follow-up with Contractor

Listed as per workmanship items above (state: Item #: …..recommendation…..) Recommendations relevant to contractor after-sales service or correctional work

5. Pictures

Pictures of poor quality workmanship as per "Workmanship quality" checklist

Caption to state "Item #" from workmanship list above Dimensions: 6x8 cm (if portrait), 8x6 cm (if landscape)	

Funded by:

Political partner:

Directorate General of New and Renewable Energy and Energy Conservation (DG NREEC)

Coordinated and implemented by: