EnDev2 Indonesia:

Inspection Guide for Photovoltaic Village Power (PV-VP) Systems

October 2013

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kerja sama jerman
DEUTSCHE ZUSAMMENARBEIT

Implemented by:
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Contents

List of Figures and Tables

Abbreviation

DGNREEC	Directorate General for New and Renewable Energy and Energy Conservation
EnDev	Energising Development 2 (2009 – 2014)
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)
PV-VP	Photovoltaic Village Power
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.

By way of example, EnDev conducted a technical review and baseline data survey for over one hundred (100) 15kW solar mini-grid installations (photovoltaic village power/PV-VP) across Indonesia, installed by local suppliers under contract with Directorate General for New and Renewable Energy and Energy Conservation (DGNREEC) during 2013. Hereafter referred to as the *DGNREEC PV-VP Technical Review 2013*.

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 PV-VP 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.

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

Deutsche Gesellschaft für Internationale
Zusammenarbeit (GIZ) GmbH
Energising Development (EnDev) Indonesia
Jalan Tebet Barat VIII No. 52
Jakarta Selatan
Jakarta 12810
INDONESIA
Tel : +62 21 830 9438
Fax: +62 21 830 9032
Website: http://endev-indonesia.or.id

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 121 workmanship indicators, clustered into 20 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 included in **Appendix 4** and user manual in **Appendix 5**.

Technical survey 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 PV-VP
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 PV-VP questionnaire
Camera (with memory card, charger, spare battery, USB cable)		Any other awareness materials, which may include: • PV-VP 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 PV-VP* (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 using the provided stencils.
12. Allocate time wisely within 2-day visit to conduct: component compliance, performance verification, workmanship quality, on-site PV-VP operator(s) training, KPI survey (through interview with relevant respondents), and 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.

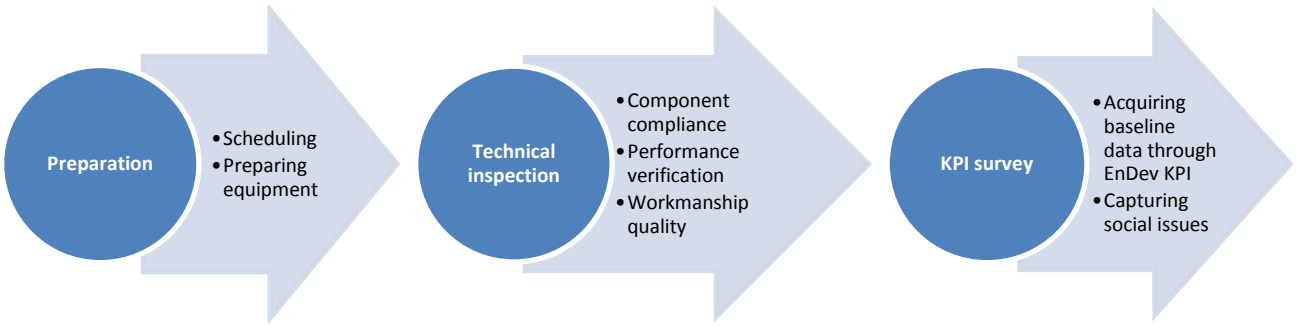


Figure 3 Inspection flow diagram

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 PV-VP 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. PV-VP Block Diagram

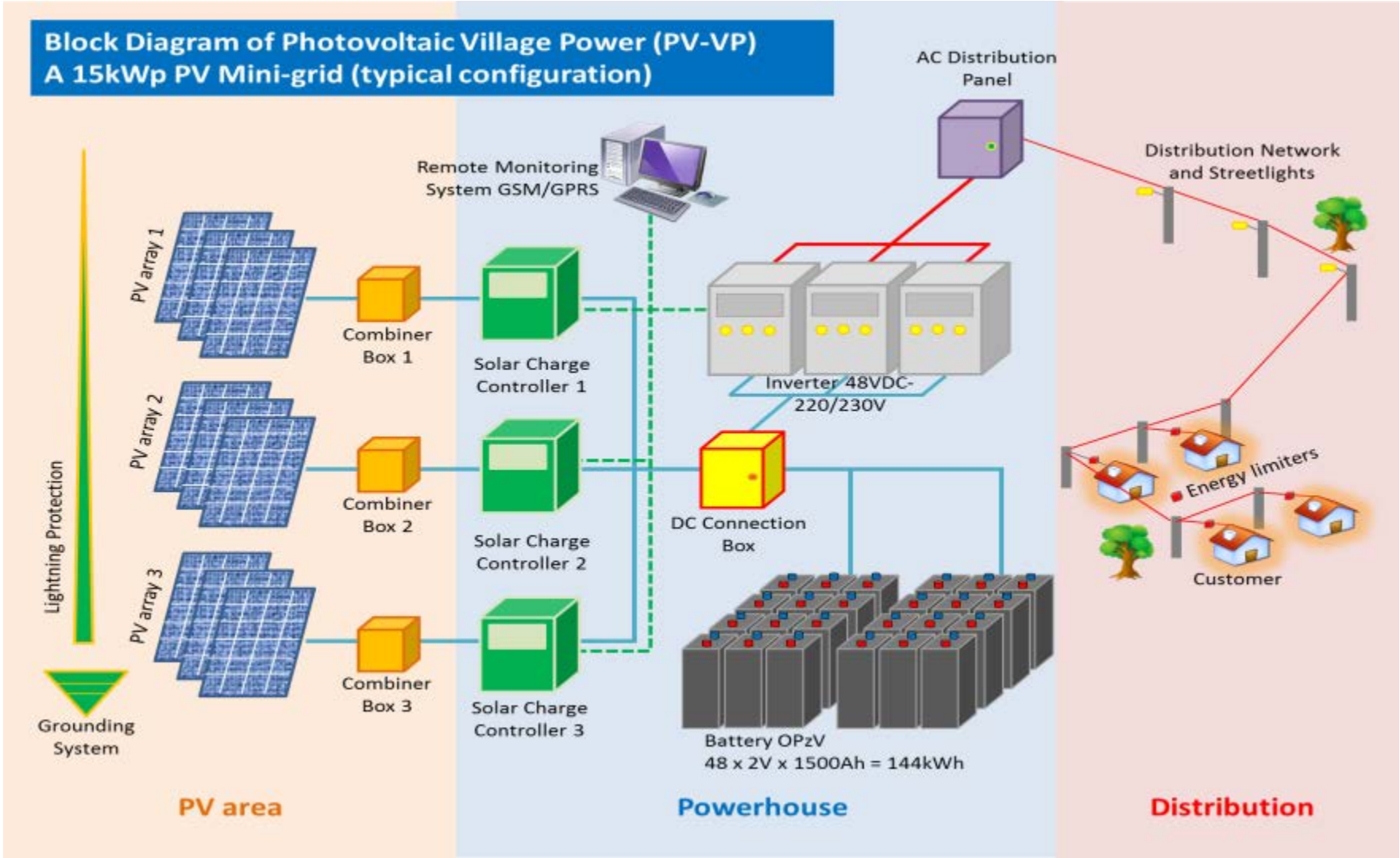


Figure 4 Block diagram of PV-VP

4. Technical and Workmanship Checklist

The checklists described in this chapter, along with their corresponding templates, were originally designed during the *DGNREEC PV-VP Technical Review 2013*. 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 PV-VP Technical Checklist is a 6-page document comprising 12 main components of the PV-VP. 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** and specifications from the *DGNREEC PV-VP Technical Review 2013* are inserted as examples.

In the case of the *DGNREEC PV-VP Technical Review 2013,* the component compliance covered the technical specifications for:

1. Solar PV modules
2. Inverter
3. Solar charge controller
4. Battery system
5. Remote monitoring system
6. Power cable and grounding
7. Distribution panel
8. PV array support
9. Power house
10. Distribution, streetlights and household connection and installation
11. Lightning protection
12. TV LCD and digital parabola

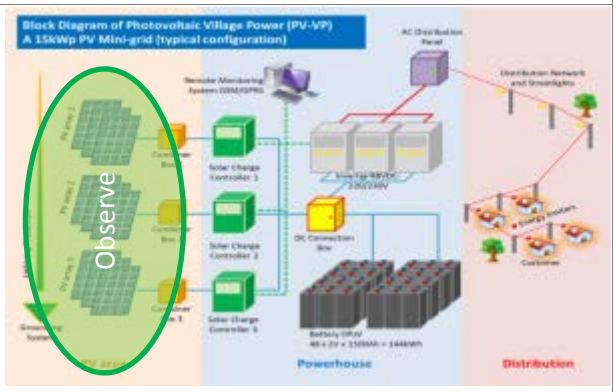
Inspection Tips	
General	▪ Make sure the column "Specification" has been filled-in in advance (before leaving Coordination Office). ▪ Fill in the date, name of surveyor and signature. ▪ Take photos (see Chapter 4.4).
Completing the checklist	▪ For some selected technical specifications, the brand, type, 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.

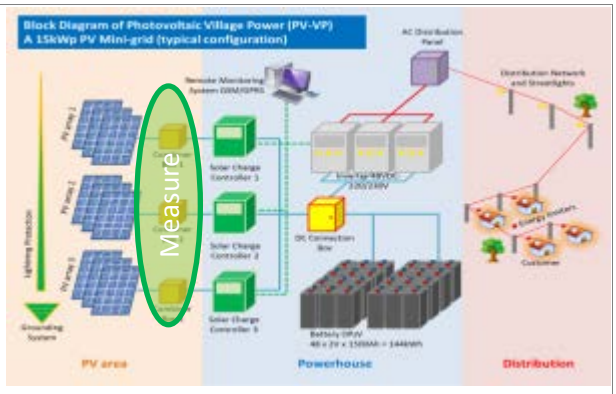
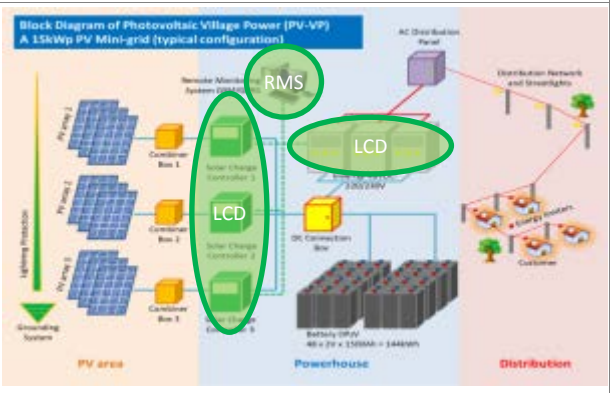
4.2. Performance Verification

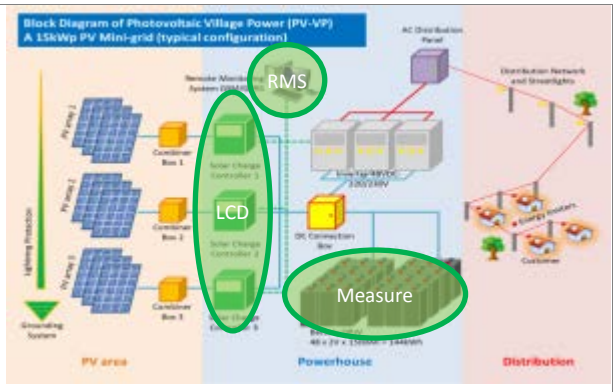
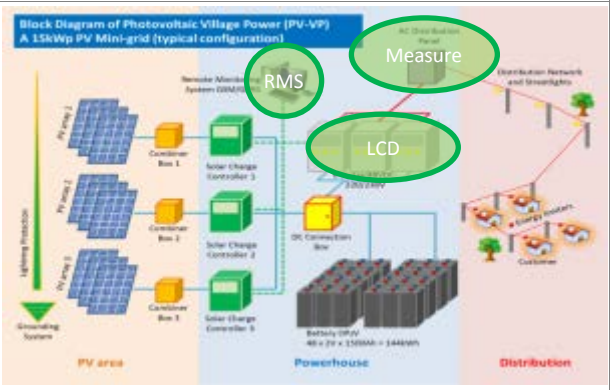
Verification of reliable system performance is essential and should be part of the final acceptance of the system. Performance verification is a very good indicator to demonstrate whether a system is functioning optimally and all components are installed and configured correctly. It is thus the combination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

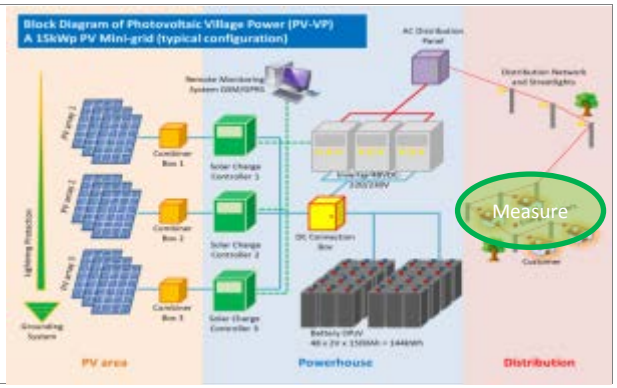
In the case of the *DGNREEC PV-VP Technical Review 2013,* the performance verification recorded electrical data of spot measurements to determine performance of key components, and the template is attached as **Appendix 2**. Performance verification covered:

1. Time and weather conditions
2. PV performance
3. Charge controller recording
4. Battery status
5. Inverter performance
6. 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.
Completing the checklist – "1. Time and weather conditions"	▪ "1. 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 PV-VP). 
Completing the checklist – "2. PV performance"	▪ "2. 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 2.2 Voltage (V) between the positive and negative busbar in the combiner boxes. ▪ Measure the 2.3 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.
Completing the checklist – "3. Charge controller recording"	▪ "3. 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). ▪ "3.1 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. ▪ "3.1 Energy generated", when compared with "total consumed energy" recording, allows an assessment of the balance between electricity generation and demand. ▪ "3.2 Solar PV voltage" (input to charge controller), when compared to "2.2 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.

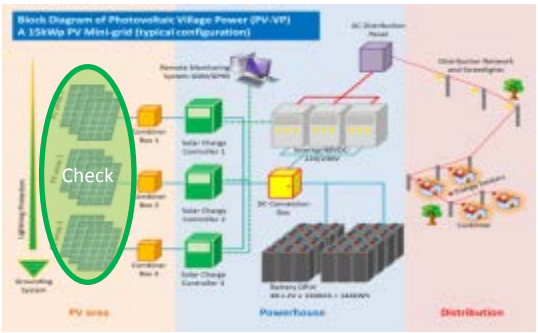
Completing the checklist – "4. Battery status"	 ▪ "4. Battery status" measures the current state-of-charge of the battery as a means to gauge battery "health" and balance between electricity generation and demand. ▪ The point of measurement for voltage (VDC) and discharge current (Amp) is the main battery 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 PV-VP 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 PV-VP 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 4.3 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.
Completing the checklist – "5. Inverter performance"	 ▪ "5. 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 (for 5.1 and 5.2) using handheld measurement device. ▪ Point of recording is the LCD on each inverter (for 5.3 and 5.4) 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 (for 5.5). This shows approximate night-time load
Completing the checklist – "6. Distribution grid performance"	▪ "6. Distribution grid performance" measures the voltage drop between power house and 6.2 furthest household and 6.1 furthest social institutions (community centre, clinic or other).

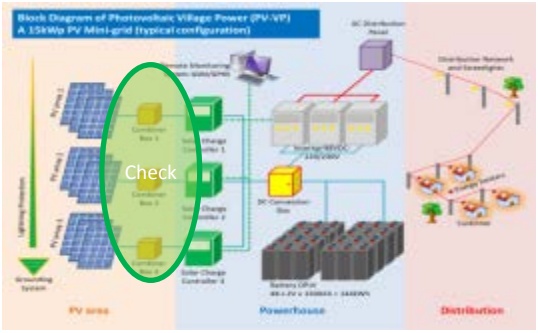
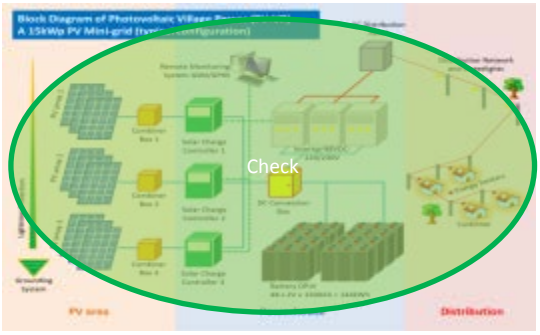
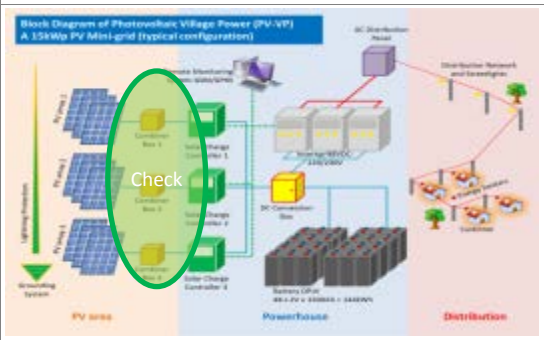
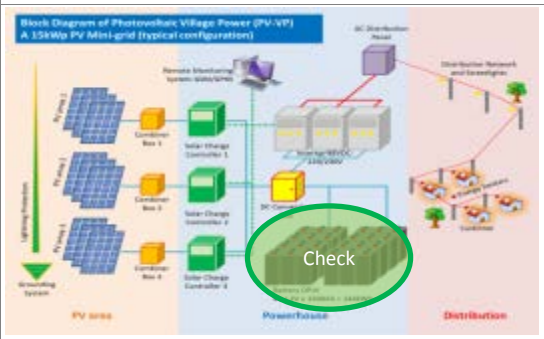
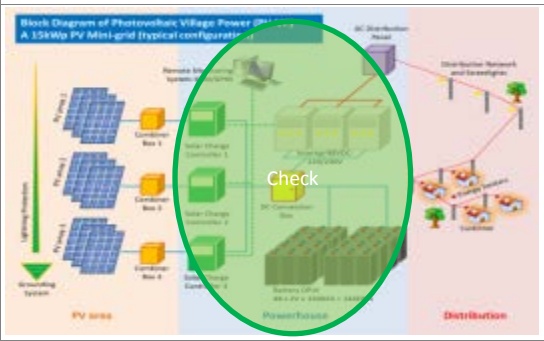
	▪ Point of measurement is the household wiring (or connection box) at the household with the longest cable distance from the powerhouse (i.e. the longest stretch of AC distribution cable).	

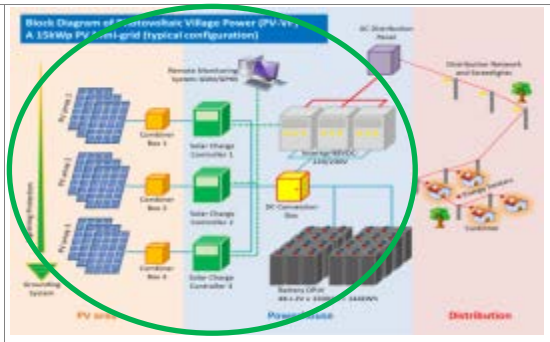
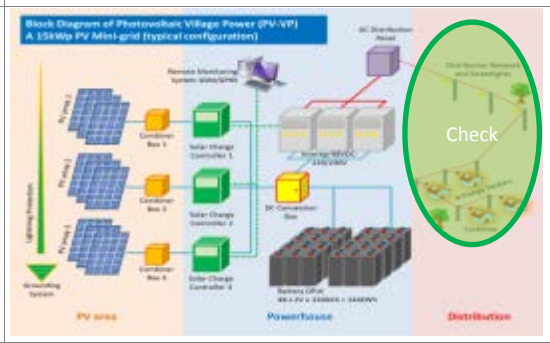
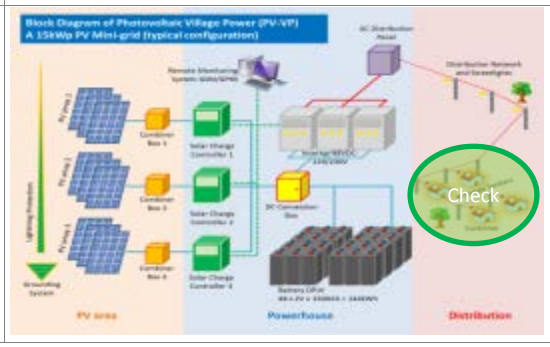
4.3. Workmanship Quality

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 PV-VP Technical Review 2013,* the workmanship checklist comprises 121 workmanship indicators clustered into 20 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 6, 10, 15, 17, 18 and 20 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 module wiring	

5. PV array combiner box wiring 6. External wiring weather proofing	
7. Grounding and earthing	
8. Wiring to powerhouse	
9. Battery rack 10. Battery terminal connections	
11. Internal powerhouse wiring 12. Powerhouse foundation 13. Powerhouse general condition 14. Powerhouse ventilation 15. Powerhouse flooding prevention	

16. Fence and gate	
17. Distribution grid pole installation 18. Distribution grid wiring 19. Streetlight installation	
20. 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 1 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	Village chief (when agreed upon)	Ask kindly the village chief to be photographed
22	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: **ProvinceS0X**, example: JaTimS01, MalS02, PapBarS03
2	Create individual sub-folder according to the categories: ▪ Solar array area ▪ Powerhouse ▪ Village ▪ Miscellaneous	Refer to the photos list above, put the relevant photos into relevant folder as follow: ▪ Solar array area: 7, 8, 9, 18, 19, 22 ▪ Power house: 2, 3, 4, 5, 6, 7, 10, 11, 18, 22 ▪ Village: 13, 14, 15, 17, 18, 19, 20, 22 ▪ Miscellaneous: 1, 12, 16, 21 *Note that an item could suit more than one category depending on the photo characteristics, e.g. cabling, people in actions*
3	Choose filename according to the format: **SiteCode_itemXX.jpg**	For example the third picture of "Battery" of site SulBarS07 will be named: **SulBarS07_Battery03.jpg**

5. KPI Questionnaire

The Key Performance Indicator (KPI) survey comprises an 8-page questionnaire and collects technical, social, economic, and environmental data. The data are vital as a baseline status of the PV-VP 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 5 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 PV-VP Technical Review 2013* 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 not by the PV-VP 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 PV-VP Technical Review 2013*). 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 PV-VP 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

PV-VP Technical Checklist - Component Compliance (version 131021)

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

NO	COMPONENT	SPECIFICATION FROM CONTRACT (Example)	CONTRACTOR SPECIFIC				QUANTITY	REMARK	
			TYPE	BRAND	COUNTRY	CAPACITY		YES	NO
1	**SOLAR MODULE**								
1.1	Type of solar module	mono/polycrystalline							
1.2	Output per unit	minimum 100 Wp	Comment:						
1.3	Total capacity Solar Array	minimum 15 kWp	Comment:						
1.4	Connection among solar modules	plug-in socket	Comment:						
	NOTES:								
2	**INVERTER**								
2.1	Type of inverter	minimum 5 kW each (3 units)							
2.2	Output voltage	220-230 VAC	Comment:						
2.3	Frequency/phase	50 Hz/1 phase	Comment:						
2.4	Input voltage	48 VDC	Comment:						
2.5	Indicator (LCD display)	inverter voltage & current?	Comment:						
2.6		inverter frequency?	Comment:						
2.7		battery voltage & current?	Comment:						
2.8		load voltage & current?	Comment:						
2.9	Inverter grounded?		Comment:						
	NOTES:								

3	**SOLAR CHARGE CONTROLLER (SCR)**								
3.1	Type of solar charge controller	minimum 3 units, 5 kWp each							
3.2	Charge controller grounded?		Comment:						
	NOTES:								
4	**BATTERY SYSTEM**								
4.1	Type of battery	VRLA Gel, OPZv stationary battery							
4.2	Battery capacity	Minimum 144 KWh	Comment:						
4.3	Nominal capacity	Minimum 2V/Cell	Comment:						
4.4	Battery capacity/cell	Minimum 800 Ah	Comment:						
4.5	Battery bank output	Nominal minimum 48 V DC	Comment:						
4.6	Battery connector	Made of copper covered with isolator	Comment:						
4.7	Battery protection	Minimum 144 KWh	Comment:						
4.8	Battery rack/holder	Resistant to corrosion	Comment:						
4.9	End terminals of battery blocks protected with non-conductive material		Comment:						
4.10	Battery protection box grounded?		Comment:						
	NOTES:								
5	**REMOTE MONITORING SYSTEM**								
5.1	Data connection	modem GPRS/GSM	Comment:						
5.2	Hardware and software	monitoring and data logging	Comment:						
5.3	Alarm	faults alarm	Comment:						
5.4	Display	user-interface	Comment:						
	NOTES:								

6	**POWER CABLE AND GROUNDING**				
6.1	Power cable from battery to inverter and/or battery to solar charge controller	NYAF 1x70 mm2 (SPLN/SNI)	Comment:		
6.2	Power cable from inverter to distribution panel	5kVA, type NYY 4 x 50 mm2 (SPLN/SNI)	Comment:		
6.3	Cable connector	equipped with suitable connector?	Comment:		
6.4	Installation materials and component grounding	adjusted with generator capacity?	Comment:		
6.5	Common grounding busbar existing (check also in cable trench in power house)		Comment:		
	NOTES:				
7	**DISTRIBUTION PANEL**				
7.1	Power capacity	minimum 5 kVA each	Comment:		
7.2	Number of feeder	3 feeder sets	Comment:		
7.3	System voltage	220 ~ 230 VAC, single phase	Comment:		
7.4	Monitoring	voltage?	Comment:		
7.5		current?	Comment:		
7.6		frequency?	Comment:		
7.7		kWh-meter?	Comment:		
7.8	Positioning	as per safety standard and easy to monitor by the operator?	Comment:		
7.9	Distribution panel grounded?		Comment:		
	NOTES:				
8	**PV ARRAY SUPPORT**				

8.1	Material	galvanized iron/metal through hot deep galvanized treatment	Comment:		
8.2	Module support	free standing above foundation	Comment:		
8.3	Frame	solid and easy to be assembled on to module support	Comment:		
8.4	Angle	between 10-15 degrees	Comment:		
8.5	Height between module and ground surface	minimum 70 cm	Measured height:		
8.6	Distance between PV array	properly designed so that no shades will fall on other PV array surface in the system	Measured distance:		
8.7	PV Array Support grounded?		Comment:		
	NOTES:				
9	**POWERHOUSE**				
9.1	Room size	minimum 36 m2	Comment:		
9.2	Type	permanent house/shelter	Comment:		
9.3	Shelter material	polyurethane and mild steel	Comment:		
9.4	Electricity installation	5 points (3 lamps, 2 sockets), MCB 2 A	Comment:		
9.5	Equipped surrounding with lightning rod system		Comment:		
9.6	**Permanent house specs:**				
9.7	Walls	bricks or equal, neatly plastered and painted	Comment:		
9.8	Door	board/aluminum and equipped with lock	Comment:		
9.9	Battery and control room floor	ceramics	Comment:		
9.10	Ventilation	sufficient for air circulation	Comment:		
9.11	Footpath	made from concrete or using con-block with 1 meter minimum width	Comment:		
9.12	Fenced in periphery	BRC type with 120 cm minimum height and equipped with gate	Comment:		

	NOTES:									
10	**Distribution, connection and house installation**									
	General:									
10.1	Type	using air network	Comment:							
10.2	Distance between pole	maximum 40 m	Comment:							
10.3	Poles	7 m, PLN standard (SPLN)	Comment:							
10.4	Poles installation	deep-seated with 1 meter depth	Comment:							
10.5		concrete foundation	Comment:							
10.6		equipped with network accessories	Comment:							
10.7	Inter-poles cable	NFA 2x35 mm2 + 1x25 mm2 (SPLN)	Comment:							
10.8	Cables from pole to house	NFA 2x10 mm2 (SPLN)	Comment:							
10.9	Cable deflection height between poles	4 m from ground surface	Comment:							
	Streetlights:									
10.10	Number of street lights installed	75 street lights								
10.11	LED lamp + cup	maximum 11 W	Comment:							
10.12	Lighting setting	maximum 5 hours/day	Comment:							
10.13	Control cabinet in power house grounded?		Comment:							
	Sub-system of house installation									
10.14	Number of connected households	according to location	Comment:							
10.15	Protection system	current limiter (MCB) 1 A (including box and seal), 220 Volt	Comment:							
10.16	Load per house	4 points (3 lamps and 1 socket)	Comment:							
10.17	Lamp	LED	Comment:							
10.18	Cables in house installation	NYM 3x1.5 mm2 and 2x1.5 mm2. SPLN	Comment:							
10.19	Grounding system	Available	Comment:							
	Energy limiter									
10.20	Number of energy limiters									

	installed								
10.21	Limit/quota	minium 160 Wh	Comment:						
10.22	Input voltage	220 VAC, single phase, 50 Hz	Comment:						
10.23	Maximum current load	1 Amp	Comment:						
	LED lamp								
10.24	Power consumption	maximum 5 W	Comment:						
	NOTES:								
11	**LIGHTNING PROTECTION**								
11.1	Tower and wire	tri-angle, guyed wire	Comment:						
11.2	Type	passive system, connection slave	Comment:						
11.3	Grounding system	available	Comment:						
11.4	System monitoring	equipped with system monitoring							
	NOTES:								
12	**TV LCD and Digital Parabola**								
12.1	LCD TV model	32 inch, 100-240 VAC, 50/60 Hz							
12.2	Digital parabola type	solid dish (rusty-free) minimum 6 feet	Comment:						
12.3	Accessories	including receiver, positioned, and actuator	Comment:						
12.4	Pole	Iron pole 1.5 m	Comment:						
12.5	Installation	public place, strongly recommended in village hall or other public places that are accessible	Comment:						
	NOTES:								

Appendix 2 Technical checklist – performance verification

PV-VP Technical Checklist - Performance Verification (version 131021)

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

1 Time and weather condition (during measurement):

1.1	PV performance measurement - Morning	Time:		Sunny	Cloudy	Rain
1.2	Battery status measurement - Morning	Time:		Sunny	Cloudy	Rain
1.3	Inverter performance - Morning	Time:		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, cables) and make comment
Take photos of display readings

		Combiner Box 1		Combiner Box 2		Combiner Box 3	
2.1	Number of strings:		Nr		Nr		Nr
2.2	Measure voltage on busbars:		Volt		Volt		Volt
2.3	Measure current with 3 or 4 strings together:		Amp		Amp		Amp

Comments:

3 Solar energy

Record accumulated solar energy production since start of operation (via display of charge controller if available)

3.1	Charge Controller 1 (kWh):		Charge Controller 2 (kWh):		Charge Controller 3 (kWh):	

Comments:

4 Battery status

Battery measurements at evening (19.00-20:00) and morning (07:00-08:00)
Only over all measurement - not each individual batteries
Take photos of display readings (handheld measuring device, LCD and/or RMS)

4.1.1	Battery Voltage (handheld measuring device) - Evening:		Volt	Battery Voltage (handheld measuring device) - Morning:	Volt
4.1.2	Battery Voltage (LCD or RMS) - Evening:		Volt	Battery Voltage (LCD or RMS) - Morning:	Volt
4.2.1	Discharge Current (handheld measuring device) - Evening:		Amp	Discharge Current (handheld measuring device) - Morning:	Amp
4.2.2	Dircharge Current (LCD or RMS) - Evening:		Amp	Dircharge Current (LCD or RMS) - Morning:	Amp
4.3	Battery room temperature (between batteries) - Evening:		°C	Battery room temperature (between batteries) - Morning:	°C

4.4 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	
5.1	Inverter Voltage (measured with handheld device at AC distribution board):		Volt		Volt		Volt
5.2	Inverter Current (measured with handheld device at AC distribution board):		Amp		Amp		Amp
5.3	Inverter Voltage (reading from LCD or RMS):		Volt		Volt		Volt
5.4	Inverter Current (reading from LCD or RMS):		Amp		Amp		Amp
5.5	Total consumed energy since start of operation (reading from LCD or kWh-meter):		kWh		kWh		kWh
5.6	Reading from solar PV Voltage from LCD or RMS:		Volt		Volt		Volt

Comments:

6 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 community centre at evening (19.00-20:00)
Take photos of display readings (handheld measuring device)

6.1	Measure Voltage at community centre:		Volt	Name of Operator: _____	Signature:
6.2	Measure Voltage at furthest household:		Volt		

Appendix 3 Workmanship checklist

PV-VP Workmanship Checklist (version 131021)					
			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	Is there browning under glass?			
	8	Junction boxes at backside loose or without cover?			
	9	Damaged cables from animals?			
2. PV module array foundation:	1	Broken or cracked concrete blocks?			
	2	Poor concrete mixture?			
	3	Insufficient foundation depth?			
	4	Vulnerable to land slide?			
3. PV array mounting structure:	1	Overall array structure twisted or imbalanced?			
	2	PV module aluminium frames touche galvanised steel structure?			
	3	Bad or loose panel clamps?			
	4	Loose anchor bolts into foundation?			
	5	Bad galvanizing on steel structure?			
	6	Rusting at structure or bolts?			
4. 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	Unsecure/unfirm junction box?			
	5	Wrong cable dimension used?			
5. 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 cables inside?			
	10	Unbundled and disorganised cable layout?			
	11	Unsecure/unfirm connections or connectors?			
	12	Animals inside (or signs of animal like ants or mouse)?			
6. 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?			
7. 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 battery charger?			
	5	No earthing of battery protection box?			
	6	No grounding connection in grounding pit/grounding rod?			
	7	Lightning mast not secure and stable?			
	8	Wrong cable type/colour used?			
8. Wiring to power house:	1	Conduits not used properly from combiner box to power house?			
	2	Trunk cables vulnerable to physical damage?			
	3	Cable entry point at power house wall not sealed?			
	4	Cables to power house mounted securely?			
9. Battery rack:	1	Unstable battery rack?			
	2	Signs of corrosion or rust?			
10. 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?			

			TRUE	FALSE	How many?/Comments?
11. 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	Any cables with exposed copper wire?			
	5	Cables exposed to physical damage?			
	6	Unsecure/unfirm connections or connectors?			
12. Power house foundation:	1	Broken or cracked foundation?			
	2	Poor concrete mixture?			
	3	Insufficient foundation depth?			
	4	Vulnerable to land slide?			
13. Power house general condition:	1	Plaster falling off walls?			
	2	Paint peeling off walls?			
	3	Rust or corrosion on metal walls?			
	4	Floor cement or tiles broken?			
	5	Doors are not closing?			
	6	Windows are not closing?			
	7	Rooms are dirty or untidy?			
	8	Poor finishing?			
	9	Signs of animals entering?			
14. Power house ventilation:	1	Ventilation openings or windows in some walls are missing?			
	2	Power house too hot inside?			
	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?			
15. 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?			
16. Fence and gate:	1	Bad and broken fencing?			
	2	Locks or keys for fence gate missing?			
	3	Rust or corrosion on metal fence or gate?			
	4	Fence too high thus do not prevent animals to enter?			
	5	No fencing installed?			
17. Distribution grid pole installation:	1	Poor/inappropriate material used for poles?			
	2	Incorrect cable bracket and tensioner used?			
	3	Poles unstable or not securely anchored?			
	4	Poles inappropriately placed (e.g. in road, driveway)?			
	5	Poles spacing is incorrect (PLN standard: max 40 m)?			
	6	Poles placed too close to trees?			
18. Distribution grid wiring:	1	Cables too slack?			
	2	Cables not properly secured to pole brackets?			
	3	Exposed copper or aluminium wires?			
	4	Poor or exposed cable connections or connectors?			
	5	Cables vulnerable to physical damage?			
19. Streetlight installation:	1	Streetlights not working?			
	2	Improper streetlights used?			
	3	Improper connection cable used?			
	4	Cable connection exposed to direct sunlight and rain?			
	5	Lamps are not covered or weather protected?			
	6	Unsuitable placing of streetlight?			
20. Household installation:	1	Lamps not working?			
	2	Outlet/socket 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 too low?			
	6	Energy limiter, meter and/or MCB damaged, tampered or broken?			
	7	Energy limiter and/or meter not resetting or recording properly?			
	8	Exposed copper wires in cable?			
	9	Poor or exposed cable connections or connectors?			
	10	No conduits or suitable surface cable used?			

Appendix 4 KPI questionnaire

KPI and Sustainability Survey for PV-VP System (version 131022)

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 power house (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	

15. Contractor company that built the plant

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 their electricity from

	Connected to	Connected to	Connected to	No
Households				

2. What is the main **reason** HH have **NOT** been connected to PV-VP?

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

3. What are **future prospects** for the connection rate of HH?

- ☐ More HH will be connected, that have not yet access to electricity
- ☐ More HH will be connected, that will switch from another source of energy to PV-VP
- ☐ Other:
- ☐ No HH will be connected because all HH already connected to electricity source
- ☐ No HH will be connected because capacity shortage or financial burden

Comments:

B.2 Social Institutions (SI)

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

		Connected to	Connected to	Connected to	No
Social institutions	**Schools**				
	Health centre				
	Community centre				
	Religious buildings				
	Streetlights				

2. What is the **main reason** SI have **NOT** been connected to PV-VP?

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

3. What are **future prospects** for the connection rate of SI?

- ☐ More SI will be connected, that have not yet access to electricity
- ☐ More SI will be connected, that will switch from another source of energy to PV-VP
- ☐ Other:
- ☐ No SI will be connected because all SI already connected to electricity source
- ☐ No SI will be connected because capacity shortage or financial burden

Comments:

B.3. Rural Businesses (Productive Use of Energy/PUE)

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

	Connected to	Connected	Connected to	No
Warungs (electricity for the lighting)				

List all businesses and tick the type of electricity source, number of employees and if it is owned/managed by the community or private, men or women. Write each business in a separate row. Specify the type of business, using the code below:

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 contr
- **(6) MR** - Maintenance and repair services (vehicle repair, electronics repair, plumbing
- **(7) MA** - Manufacturing goods (carpentry, metal workshop)
- **(8) Ot** - Other

Rural businesses (Productive Use of Energy - PUE)

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 men W: mostly women	Source of electricity: PV-VP	PLN Grid	Other sources	None

2. What is the **main reason** PUE have **NOT** been connected to **PV-VP**?

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

3. What are **future prospects** for the connection rate of PUE?

- ☐ More PUE will be connected, that have not yet access to electricity
- ☐ No PUE will be connected because all PUE already connected to electricity source
- ☐ More PUE will be connected, that will switch from another source of energy to PV-VP
- ☐ No PUE will be connected because capacity shortage or financial burden
- ☐ Other:

Comments:

B.4 Energy supply in general

1. Is a kWh-meter installed in the power house?	☐ No ☐ Yes	If yes, current reading:	kWh
2. Is an hour meter installed in the power house?	☐ No ☐ Yes	If yes, current reading:	hours
3. Is a solar monitoring system installed in the power house?	☐ 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 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 not familiar with computers
- ☐ Operator does not know what to do
- ☐ Only "Error" messages shown
- ☐ Computer is broken
- ☐ 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 PV-VP operating at the moment?

- ☐ Yes, very well
- ☐ Yes, but with problems
- ☐ No, since

10. If "No" or "with problems" in 9: What are the reasons that PV-VP does not deliver energy?

- ☐ Insufficient sunshine
- ☐ Inverter broken
- ☐ Operator not available
- ☐ Solar panels defect
- ☐ Outside solar cables damaged
- ☐ Management not available
- ☐ Battery defect
- ☐ Cables in power house damaged
- ☐ Lightning strike
- ☐ Controller defect
- ☐ Grid cables damaged
- ☐ 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 management team)

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 energy?	☐ No	☐ Yes		

5. Do customers complain about insufficient amount of energy per day?

☐ Yes, most customers complain ☐ Yes, a few customers complain

☐ Yes, but only businesses complain ☐ No

6. Are streetlights working?

☐ Yes, all streetlights working ☐ Yes, most streetlights working

☐ Only few streetlights working ☐ No streetlights working

7. What type of replacement lights is easily available for customers? ☐ CFL ☐ Incandescent ☐ LED ☐ None

C. Administration and Management

(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 (IDR/month or % of revenue)	2f. Period
				M	F		
Operator 1							
Operator 2							
Secretary							
Accountant							
Manager							
					Total salary:		

C.2 Condition of the administration books

1. Is there any administrion book 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 book keeping system, please specify:

C.3 Team organisation

1. Are there any regular village meetings on PV-VP? ☐ Yes ☐ times since start of operation ☐ No

2. Are there any regular elections reorganisations? ☐ Yes ☐ times since start of operation ☐ No

3. Main reasons for irregular reorganisation (if any)

☐ Only regular reorganisation ☐ Members are not interested

☐ Members left the village ☐ Members are not sufficiently skilled

☐ Members are too busy ☐ Other:

☐ Members are paid too little ☐ Other:

4. Who provided trainings and/or introductions for the new staff?

☐ No trainings ☐ Contractor staff

☐ Old staff ☐

5. Do you exchange your experiences with management teams from other PV-VPs?

☐ No ☐ Yes, with:

6. Any complaints/comments from customers concerning management of PV-VP?

☐ Yes ☐ No

Specify:

C.4 Tariff

1. What kind of **tariff system** is applied

☐ Flat rate depending on the number of appliances ☐ Per kWh

☐ Flat ☐ Other (specify below)

2. Special **"social tariff"** for poorer people? ☐ Yes ☐ No How:
3. Special tariff for **social institutions**? ☐ Yes ☐ No How:
4. Special tariff for **productive use of energy**? ☐ Yes ☐ No How:
5. Regular **tariff increase** (e.g. 5% per year) ☐ Yes ☐ No How:
6. Are **MCBs** in use? ☐ No ☐ Yes, size: ☐ 0.5A ☐ 1A ☐ 2A ☐ 3A
7. Different size MCB in different HH? ☐ Yes ☐ No
8. Several HH share MCB? ☐ Yes ☐ No
9. Are **energy limiters** in use? ☐ Yes, limit _____ Wh per day ☐ No
10. Different limiter setting for different customers? ☐ Yes ☐ No
11. If "Yes" in 10, please specify:
12. Did people pay a **connection fee**? ☐ Yes How much: IDR _____ ☐ No
13. Connection fee includes the household installation? ☐ Yes ☐ No
14. How many HH pay which tariff per **month** (current status of customers)?

	No. Of HH	Tariff (IDR/month/HH)	Total expected amount (IDR/month)
Tariff 1			
Tariff 2			
Tariff 3			
Tariff 4			
Tariff 5			
		Total:	

15. How is the tariff collected

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

Specify:

16. What happens to the customer who does not pay the electricity fee?

☐ None ☐ Penalty fee of IDR

☐ Disconnection after 1 month ☐ Other:

☐ Disconnection after 6 month

17. How many times the consequences of non-paying customers have been applied?

☐ Always ☐ Sometimes ☐ Not yet needed

☐ Mostly ☐ Usually never

C.5 Financial administration (observe in the book or ask VMT for data from the last three completed months at the time of the survey. Total monthly expenses for team salary is calculated in C.5.5)

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

	Month 1:	Month 2:	Month 3 (latest):
1. Monthly **expected fee from PV-VP** (calculated based on number of HH connected)			
2. Incidental income (everything beyond monthly fee)			
3. Monthly **collected fee** (according to the book)			
4. Monthly **maintenance** cost (**no** cost for breakages)			
5. Total monthly expenses for team **salary**:			
6. Incidental expense in the month			
7. Monthly **savings**			
8. **TOTAL current savings:**			

9. Savings are kept in:

☐ PV-VP dedicated Bank account ☐ Treasurer cash box
☐ Cooperative saving account ☐ Other:

10. **Significant expenditures/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 attitude

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

☐ No ☐ Yes, improper connections between houses
☐ Yes, bypassing the circuit breaker (MCB) ☐ Yes, vandalism of the solar system and power hous
☐ Yes, bypassing the energy limiter ☐ Inappropriate use of electrical appliances
☐ Yes, improper connection from grid to houses ☐ 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. PV-VP 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 month	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. Power house power cables repaire					
l. Power house sensor cables repair					
m. Power house 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 solar panel array
- Photos of power house
- Photos of the village
- Miscellaneous

Name the photos according to this form: **Sitecode_ItemXX.jpg**

For example the third photo of "Battery" of site SulBarS07 will be named: **SulBarS07_Battery03.jpg**

Take photos as specified by the following list:

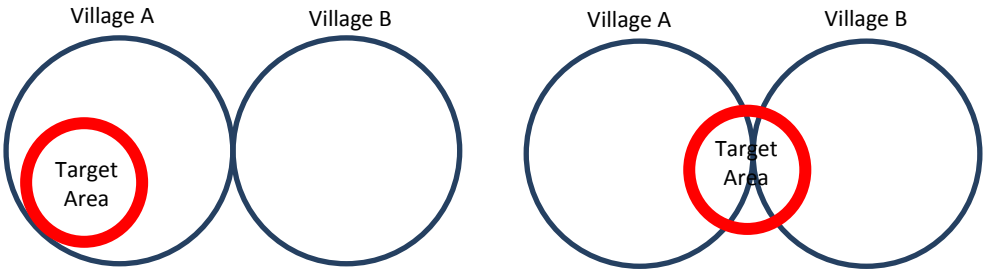
- First page of KPI questionnaire **(with the site code written!)**	
- Outside power house	
- Inside power house (with battery, inverter, and monitoring system visible)	
- Battery	
- Charge controllers	
- Inverters	
- Details of cabling	
- Solar array (landscape)	
- Solar module (randomly on some spots, be alert for damage/breakage!)	
- Remote monitoring system (RMS)	
- Connection and distribution box in the power house or in the panel box	
- Existed administration books (if any)	
- Distribution pole and cables	
- Streetlights	
- Energy limiter	
- Public television	
- HH connection	
- People in actions (e.g. operator cleaning the PV module, inspector checking the installation, operator training)	
- Surroundings of system	
- Access road to the village	
- Village chief (when agreed upon)	
- Detail photo if any installation looks wrong or unsure	

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 PV-VP 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 PV-VP 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 PV-VP
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 PV-VP 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 PV-VP 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 PV-VP		▪ Each customer is considered as connected to PV-VP if they had connection devices/wires to PV-VP 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 PV-VP 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 PV-VP?	**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 PV-VP 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. PV-VP 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. PV-VP 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 PV-VP works for 24 hours/day ▪ If there are days when PV-VP does not work 24 hours/day, specify the time and **CROSS** the days when PV-VP works on the specified time.
9	Is the PV-VP operating at the moment?	▪ If PV-VP still provides electricity regularly until the day of KPI Survey, **TICK** "Yes, very well". ▪ If PV-VP 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 PV-VP is inactive during the survey due to maintenance, special day (Friday, Sunday), and <u>not</u> because of technical breakdown or non-functioning VMT, and there is clear evidence of regular PV-VP use, **TICK** "Yes, very well"*
10	If "No" or "Yes, but with problems" in 9: What are	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.

	the reasons?	
11	If "No" in 9: When will electricity be available again?	If question 9 is answered as no, **TICK** one that applies.
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 PV-VP 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 PV-VPs?	If you exchange your experience about PV-VP in official or informal way with other PV-VP management teams **TICK** "Yes" and specify the name of the PV-VP.
6	Any complaints/comments from costumers concerning management of PV-VP?	**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 PV-VP, **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 PV-VP, 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 PV-VP.
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. PV-VP 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 PV-VP 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

Photovoltaic Village Power (PV-VP) Support Initiative

Technical Survey Checklist Summary – Scoring Guidelines

Location code:	As specified by EnDev	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

PV-VP system operational: status as per time of survey and/or operator feed-back prior to submission to DGNREEC	**Yes:**		**No:**	

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 *Additional comments in case of defects (e.g. spots and others)*
PV module type:		Fulfilled		Not fulfilled	State make and model as per KPI Fulfilled if as per specification
Inverter						
Installed capacity:		Fulfilled		Not fulfilled	Fulfilled if installed even if defect; state capacity *In case of defects: additional comment*
Inverter type:		Fulfilled		Not fulfilled	State make and model as per KPI Fulfilled if as per specification
Charge controller						
Installed capacity:		Fulfilled		Not fulfilled	Fulfilled: if installed even if defect *In case of defects: additional comment*
Controller type:		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 (total 48 V/3000 Ah specified)
Battery type:		Fulfilled		Not fulfilled	State make and model as per KPI Fulfilled: if as per specification
Balance of system						
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 Not fulfilled: in case that even grounding of one cabinet or of other equipment had not been done (serious risk of life and damage of equipment)
Array mounting as specified:		Fulfilled		Not fulfilled	As per Technical Sheet Not fulfilled: array materials not as specified

					or array dimensions and placing not as specified
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:		Fulfilled		Not fulfilled	As per KPI and Technical Sheet Fulfilled: if installed Not fulfilled: in case of major defects
Appliances					
Remote monitoring system installed and functioning:		Fulfilled		Not fulfilled	As per KPI and Technical Sheet Fulfilled: if installed and functioning Not fulfilled: In case of defects
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
Street light installed and operating:		Fulfilled		Not fulfilled	State *Planned* as per contract (75) 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 powerhouse

2. Performance verification

Spot measurements on 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
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
AC distribution board voltage acceptable:		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 <218V/228V
Distribution grid voltage acceptable:		Fulfilled		Not fulfilled	State voltage (V) as per Measurement Sheet and voltage drop (%) Not fulfilled: >3% related to 220V or 230V (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 more than 25% of modules with spots or other defects 2: if 10% to 25% of modules with spots or other defects 3: substantial shading on modules
2	PV module array foundation:	Rating:		2: for eroded, partly not exiting foundations
3	PV array mounting structure:	Rating:		1: wood used 2: several loose modules, stays or mounting brackets 3: risk of galvanic corrosion
4	PV module wiring:	Rating:		1: in case of improper interconnection of module cable with string cable (e.g. with exposed terminal blocks) 1: incorrect cable type, reduced cross-section or UV exposed cables
5	PV array combiner box wiring:	Rating:		1: if not properly fixed to the support structure and without sealed cable entries; if no glands are used and cable inlets not sealed 2: if not weather resistant and mounted exposed to UV and rain
6	**External wiring weather proofing:**	Rating:		1: cables not protected in conduits, not supported by channels or vulnerable to damage
7	Grounding and earthing:	Rating:		1: if grounding of one equipment had not been done 3: if wrong cable colour is used
8	Wiring to power house:	Rating:		1: cables not protected in conduits, not supported by channels or vulnerable to damage
9	Battery rack:	Rating:		1: if nothing is provided 2: if vulnerable to corrosion (non-galvanised, non-primed metal frame)
10	**Battery terminal connections:**	Rating:		1: if not covered or just partly covered with plastic foil
11	Internal power house wiring:	Rating:		1: cables not protected in conduits, supported by channels or vulnerable to damage
12	Power house foundation:	Rating:		2: if extensive chipping, crumbling and cracking of foundation
13	Power house general condition:	Rating:		2: poor and sloppy finishing, doors and windows do not close or no ceiling
14	Power house ventilation:	Rating:		2: if natural cross ventilation is not sufficient (battery temperature >30°C) 3: if two or more walls without passive ventilation openings
15	**Power house flooding prevention:**	Rating:		1: if evidence of flooding, if high risk of flooding
16	Fence and gate:	Rating:		1: if sections missing 3: if rusting of bolts and fence; if lock/keys are missing
17	**Distribution grid pole installation:**	Rating:		1: not PLN standard material and mounting brackets 2: wrongly placed (blocking access routes, cause of potential accidents)
18	**Distribution grid wiring:**	Rating:		1: poor cable interconnection (cables just twisted together), insufficient cable height, cable resting on other objects (e.g. house roofs)
19	Streetlight installation:	Rating:		1: in case of poor cable interconnection (cables just

				twisted together)
20	**Household installation:**	Rating:		1: 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: (maximal score = 100 ➔ 100%) sum of scoring from workmanship list above	**%**

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 20-point "Workmanship quality" checklist

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

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