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BIDDING DOCUMENTS

For

Design, Supply, Installation, Testing & Commissioning of Solar PV Pumping System for Community Facilities (in Garissa, Mandera, Wajir, Kilifi, Kwale, Isiolo, Samburu, West Pokot, Turkana, Tana River, Marsabit, Taita Taveta, Narok & Lamu Counties), comprising of Eleven (11) lots

Volume II

Part 2, Section VII, Schedule of Requirements

RFB No: KE-REA-457124-CW-RFB

Project: Kenya Off-grid Solar Access Project (KOSAP)

Purchaser: Rural Electrification and Renewable Energy Corporation (REREC).

PART 2 – SUPPLY REQUIREMENTS

Section VII. Schedule of Requirements

Contents

1. List of Goods and Delivery Schedule

Line Item N°	Description of Goods	Quantity	Physical unit	Final (Project Site) Destination as specified in BDS	Delivery Date *following the date of effectiveness the Contract*	Bidder's offered Delivery date *[to be provided by the bidder]*
1	Delivery of Samples for Approval as detailed in the specification	As defined in Lot contract	*Per Lot*	Nairobi	*Within twenty eight (28) days*	
2	Delivery of equipment for Pilot Installation sites	One systems for each Lot	*Per Lot*	At sites in project area acceptable to Purchaser in each Lot	*Within seventy-seven (77) days*	
3	Shipment of First Tranche of equipment for first sites	Per Lot	*Per Site*	Project Areas per Lot	*Within seventy-seven (77) days*	
4	Delivery of First Tranche of equipment for first sites	Per Lot	*Per Site*	Project Areas per Lot	*Within one hundred-thrrty-three (133)) days*	
5	Delivery on site of final tranche of equipment for remaining sites, including spares	Final equipment	*Per Site*	Project Areas per Lot	*Within one-hundred sistxy-one (161)days*	

2. List of Related Services and Completion Schedule

Service	Description of Service	Quantity	Physical Unit	Place where Services shall be performed	**Final Completion Date(s) of Services** *following the date of effectiveness the Contract*
1	Inception report	One per Lot	Per Lot	At selected installation sites	Within forty-two (42) days
2	Completed Installation Services for Pilot /Test Facilities	One per Lot	Per Lot	At pilot installation sites	Within ninety-one (91) days
3	Establishment of necessary management facilities, physical facilities for installation services, and trained staffing for Installation Services	One per Lot	Per Lot	Project area	Within ninety-one (91) days
4	Training of staff as per *Chapter 3 Section B.2.7.1*	One per Lot	Per Lot	Pilot installation site	Within 100 days
5	Training of staff as per *Chapter 3 Sections B.2.7.2*	2-3 per Lot	Per county	On site	1st training within 180 days
6	Commencement of installation services for PVP systems in all project areas	First tranche of installations in each Lot	Per Lot	In Project Lot/Lots	Within one hundred-thrrty-three (133)) days
7	Installation services for final tranche of PV systems for PVP in all project areas	Remainder of all installations	Per Lot	In Project Lot/Lots	Within two-hundred-eighty (280) days)

8	Final documentation for commissioning for final tranche of PV systems for PVP in all project areas	Remainder of all installations	Per Lot	In Project Lot/Lots	Within three-hundred-ten (310) days)
9	Provision of After Sales Services and Defects Liability Period including the Warranty Period till end of contract period	All equipment supplied and all installations, plus spares supplied	Per lot	Project area	Period being twelve (12) months after Acceptance of final installation.
10	Warranty support for individual components	All components under warranty	Per lot	Project area	End of component warranty period

For details see following Scope of Work and Technical Specifications.

3. Scope of Work and Technical Specifications

List of Tables

Abbreviations

AC	Alternating current
BoQ	Bill of quantities
CBK	Central Bank of Kenya
CBO/WRUAs	Community-based Organisation/Water Resources Users Association
DB	Distribution board
DC	Direct current
ELP	Earth leakage protection unit
ESMF	Environmental and Social Management Framework
ESMP	Environmental and Social Management Plan
FFL	Finished floor level
GoK	Government of the Republic of Kenya
IEC	International Electro-technical Commission
IECEE (IEC)	International Commission of rules for approval of electrical equipment
IVA	Independent Verification Agent
LED	Light emitting diode
KOSAP	Kenya Off-grid Solar Access Project
KPLC	Kenya Power and Lighting Company
kWh	kilowatt hour
MCB	Miniature circuit breakers
MWSI	Ministry of Water and Sanitation and Irrigation
O&M	Operation and maintenance
PVP	Photovoltaic pump system
REREC	Rural Electrification and Renewable Energy Corporation
RCD	Residual current device
TDH	Total Dynamic Head
VSD	Variable speed drive
W	Watt
Wh	Watt hour
WRA	Water Resource Authority
EPRA	Electricity and Petroleum Regulatory Authority
WASREB	Water Services regulatory Board
WSPs	Water Service Providers
WAJWASCO	Wajir Water and Sewerage Company Ltd
LAWASCO	Lamu Water and Sewerage Company Ltd

GAWASCO	Garissa Water and Sewerage Company Ltd
MANDWASCO	Mandera Water and Sewerage Company Ltd

3. SCOPE OF WORK AND TECHNICAL SPECIFICATIONS

A: Information on Tender and Project Area

A.1. Introduction

This Chapter 3 contains the complete ***Technical Specifications*** for supply, installation, commissioning and maintenance of Solar PV pumping systems (herein referred to as packages), for use in a structured tender process. The complete documentation comprises of:

Part A: Information on Tender and Project Area
Part B: Scope of Work
Part C: Technical Specifications and Standards for PV pump systems
Part D: Technical Specification: After sales service

Chapter 4: ***Technical Bid Submission Forms, Declaration of Performance and BoQ***
Chapter 5: ***Schedule of Drawings***
Chapter 6: ***Schedule of Tables***
Chapter 7: ***Inspection and Commissioning Tests***

A.2. Location of Project Area

The purpose of this tender is to convert existing diesel water-pumping facilities to solar water pumping systems with diesel back-up, in community-based schemes. The schemes are operated by water service providers (WSPs) who are county government owned water utility companies or Community-based Organisation (CBO) or Water Resources User Associations (WRUAs) working in collaboration with the county governments, in the Counties of **Kilifi, Kwale, Isiolo, Samburu, West Pokot, Turkana, Tana River, Lamu, Marsabit, Mandera, Garissa, Wajir, Taita Taveta and Narok in the Republic of Kenya.**

The electrification of these water pumping installations will be using stand-alone photovoltaic water pumpijng systems together with diesel back-up. The scope of work covers design, supply, installation and commissioning of the equipment for existing functional water schemes in proper working order, a warranty period covering quality of workmanship, the provision of equipment warranties, spare parts and training. Maintenance services shall be provided by the Supplier during 12 Months Defect Liability Period (DLP). The project area is divided into eleven (11) lots as follows:

Lot 1: Isiolo & Marsabit	**(Approximate size is 187 kWp)**
Lot 2: Taita Taveta & Lamu	**(Approximate size is 234 kWp)**
Lot 3: Kilifi & Tanariver	**(Approximate size is 152 kWp)**
Lot 4: Kwale	**(Approximate size is 141 kWp)**
Lot 5: Narok	**(Approximate size is 429 kWp)**
Lot 6: Samburu	**(Approximate size is 148 kWp)**
Lot 7: West Pokot	**(Approximate size is 246 kWp)**
Lot 8: Turkana	**(Approximate size is 360 kWp)**
Lot 9: Garissa	**(Approximate size is 634 kWp)**
Lot 10: Mandera	**(Approximate size is 372 kWp)**
Lot 11: Wajir	**(Approximate size is 281 kWp)**

For maps of the project area please see ***Appendix 1***. Detailed locations of sites and overall quantities are provided in *Appendix 3*.

A.3. Completing the Technical Documentation

Chapter 4: Technical Bid Submission Form and BoQ provides all the forms for the technical information that is required to be completed. Each of these forms form an integral part of the bid, and the failure to complete them adequately may result in the rejection of the bid.

Form 1: Technical Compliance Submission Forms

(to be completed for each major component)

- Technical Form 1: Compliance with standards and warranties
- Form 1.1 Solar PV Panel
- Form 1.2 Pump controller / inverter
- Form 1.3 Pump / motor
- Form 1.4 Diesel generator
- Form 1.5 Data-logging and on site display
- Form 1.6 Remote Monitoring Software and Dashboards
- Form 1.7 Laptop

Form 2: System Diagram and Sub-System Performance Curves

(to be completed for each motor/pump/Pumpcontroller combination)

- Form 2.1 System Diagrams
- Form 2.2 Performance Curves - Daily Output Curves
- Form 2.3 Performance Curves - Instantaneous Output Curves

Form 3: Schedules of Information for Solar Pumping System

(*To be completed for each system)*

- Form 3.1 General site and system information
- Form 3.2 Table of declaration of system water output vs. solar radiation and head

Form 4: Bill of Quantities for Solar Pumping System

(*To be completed for each system)*

- Form 4.1 Main equipment BoQ
- Form 4.2 Diesel genset BoQ
- Form 4.3 Additional Minor Works BoQ

(*To be completed for each Lot)*

- Form 4.3 (A) Schedule of Variation Prices for Additional Minor Works
- Form 4.4 Mandatory Spares
- Form 4.5 Maintenance Kit

Form 5: Recommended Spare Parts Schedule

(*To be completed for Lot)*

- Form 5 Recommended spares schedule

Appendix 4: Detailed explanation on *Schedule Technical Proposal*

A.4. General Environmental Conditions in Project Area

Solar radiation and design data
Solar radiation information available indicates variable solar resource throughout Kenya. There are also many sources of solar radiation data. All systems in this tender must be designed using solar radiation figures which are most generally applicable to the Region. Refer to ***Appendix 2.***

Temperatures
Ambient temperatures in targeted regions of Kenya are high. Refer to ***Appendix 2.*** High ambient temperatures, also affect electronic component life. Electronic component life decreases by approximately 50% for every 10^o Celsius above 25^oC. Components are to be de-rated for high temperature life expectancies, to ensure compliance with the component warranties.

Lightning risk issues
The targeted region of Kenya is a medium risk area for lightning strikes. Refer to ***Chapter 6, Table 5 2.***Systems should be designed with moderate Class II lightning protection only. Sound earthing practice must be followed as detailed in the specification.

A.5. General Conditions on Site

Storage facilities for each Lot
The supplier is responsible for the organization of secure centralized storage depot for all equipment for each Lot. The supplier is responsible for the security of all goods till after comissioning.

Operational community facilities
Note that systems shall be installed in operational facilities serving the rural population. The Supplier is obliged to ensure minimal disruption to the rendering of water services by Water Service Provider (WSP)

The supplier is responsible for secure storage of equipment that will be delivered to site prior to commencement of the installation. The Supplier will also be responsible for arrangement of sleeping and other facilities for their installation technicians on the project site. The Suppliers shall ensure that all staff respect the local customs of affected communities and comply with Kenya national laws when interacting with stakeholders and that at all stages during the execution of project works adhere to associated safeguards procedures.

Electricity and water
No electricity supply is available on site and supplier is required to take care of own energy needs. Supplier may not assume to use any existing diesel generators used for water pumping on site, without prior arrangement with the facility, in writing.

Interface with other works
The solar PVP installations shall interface with the existing diesel water pumping systems – in a hybrid configuration so that the existing diesel generator can be used as back-up on the solar pump.

- The solar pump shall connect into the existing water storage and reticulation system.

- In all cases the existing pumps shall be withdrawn and replaced.
- Water storage repair works shall be required, and reticulation system repair shall be required.

The supplier shall be provided with a clear scope of work for each site after the supplier has taken a careful inventory of existing works at the *Inception Stage (section B.2.4)* prior to commencing the new installations.

Note that no existing water pumping equipment may be removed from site.

Environmental and Social Code of Practice

The Supplier, all contractors and subcontrators shall ensure that all staff respect the local customs of beneficiary communities and comply with national laws when interacting with stakeholders. The Supplier, at all stages during the execution of project works, must adhere to associated safeguards procedures outlined in the project's documents (refer Volume III)

B: Scope of Work

B.1. Scope of Contract

The tender is for **design, supply, installation, commissioning, warranties, spares, training of operators and technicians, and provision of after-sales-service for solar photovoltaic pumping (PVP) systems**, without batteries, with diesel generator interface and new diesel generators (for ALL sites), and remote performance monitoring, to specification and in proper working order, for pre-identified village community water supply facilities. Suppliers are required to remove existing water pump systems in each case.

The total duration of the contract is 12 **months for supply and installation** (3 months preparation, 8 months installation and 1 month inspections and verification)**,** followed by 12 **months Defects Liabiltiy Period and provision of After Sales Services**. Solar water pumping testing and commissionsing will be a continuous activity after 4 months of contract signing. This will be determined by sites completed by the contractor.

1. Provision of Solar PVP system installations for community facilities, to specification, with components trackable using barcode system, and remote performance monitoring system.
2. A period of procurement, installation and commissioning for all community facilities of a maximum as stated in ***Section VII -Chapters 1 and 2. Delivery Schedule*.**
3. The Supplier shall visit sites with the Purchaser representative and shall produce *an Inception Report* based on the visits. The Supplier will conduct due diligence of the Lot(s) and areas awarded to it to determine whether the conditions and situation in the project area and the status of the facilities are materially different from those stated in the bidding document. The Supplier will report on the activities and results of the due diligence. The Purchaser may issue Change Orders based on the results of the due diligence.
4. *Samples for approval***:** the Supplier is required to provide samples for approval prior to the Pilot Installations and bulk manufacturing or shipping.
5. *Pilot installations*: At least one PVP system in a project area acceptable to the Purchaser shall be installed in one village, then, commissioned and accepted by Purchaser prior to proceeding with the other installations. The Pilot Installations will be completed within ***Section VII - Chapters 1. and 2.Delivery Schedule*.** The Pilot installations serve as the "Blueprint" for all the subsequent installations under this contract. The installation requirements and procedures (not the price) may be adjusted based on the results of Pilot installations and mutual agreed.
6. Installation of the remainder of PVP should be completed within the time frames in ***Section VII-Chapters 1. and 2.Delivery Schedule*,** concurrent with removal of existing pump systems.
7. Provision of the Construction Environmental, Social, Health and Safety Management Plan, E&S monthly Implementation Reports.
8. Provision of the Final E&S Implementation Report before project commissioning.
9. Practical Completion, Commissioning, Inspection and Acceptance as per this scope of work.
10. Training of staff of the WSPs and Government Technicians as per specification shall be conducted by the Supplier.
11. Warranties on quality of work provided by the Supplier during the twelve (12) month Warranty Period and the Component Warranty Period after Acceptance of each system. Manufacturer's Authorization for warranties on equipment shall be provided by the Supplier as detailed in this scope of work. During the Warranty Period the Supplier shall attend to all defects without additional cost for both the system and components.

12. *Defects Liability Period* of twelve (12) months, commencing after Acceptance of the Final installation in the Lot, as specified in ***Section VII-Chapters 1 and 2. Delivery Schedule***. The Supplier has maintenance obligations for both routine preventative maintenance, and breakdown repair (callouts) as specified in this scope of work. After the Maintenance Period the Purchaser may optionally procure additional long term maintenance there-after.
13. *Spares management* shall be conducted by the Supplier. At end of the Contract Period obligations the Supplier shall hand-over the spares in good working order to the Purchaser.

B.2. Supply and Installation of Solar PVP systems

B.2.1. System Descriptions

Solar PVP systems are to be supplied and installed at selected facilities and villages within the project area, according to the procedures outlined below.

The community facilities shall receive PVP systems depending on their existing functional situation on site with regards to their water supply infrastructure (See ***section B.2.2*** for exact details of what systems are to be supplied to each specific facility). The PVP systems are detailed in ***Section C: Technical Specifications and Standards for PVP Systems*** - *n*ote that ***Section C*** takes precedence over these short descriptions.

Functional description of PVP system comprising of:

Submersible borehole pump powered by solar PV array, sized to meet the specified water demand for the specified season. PVP system is to include diesel engine for back-up operation for low solar radiation or increased water demand.

Its worth noting that the employer may change the number of sites for implementation for various reasons and site conditions as may be necessary and this may consequently change the overall cost of the contract of the bidder. However, the per unit cost of component items will remain unchanged during contract period.

Refer to schematic of the systems in to ***Schedule of Drawings: DWG.SCH.2.:Schematic of PVP configuration.***

B.2.2. Location of Systems and Overall Quantities

Each Lot encompasses a number of community facilities, as identified in ***Table 1***.The approximate size of each Lot is indicated by kWp of PV required.

Table 1: Identification of Lots and summary data

Lot	County	No of sites	Aproximate Total kWp / County
1	Isiolo & Marsabit	15	187
2	Taita Taveta & Lamu	34	234
3	Kilifi & Tana River	57	152
4	Kwale	28	141
5	Narok	35	429
6	Samburu	18	148
7	West Pokot	33	246
8	Turkana	33	360
9	Garissa	20	634
10	Mandera	28	372
11	Wajir	15	281
TOTAL		**316**	**3,184**

The village location and the number of facilities where the PVP systems are to be placed for each Area/Lot are set out in the ***Appendix 3***.

The number, location and sizing of each PVP system provided in the bidding document provides the basis for pricing. The bidder shall provide unit cost of each system in the BoQ. Final numbers may be adjusted before signing of the contract.

GPS co-ordinates of the sites are in the detailed lists are provided in ***Appendix 3***.

B.2.3. Delivery Schedule

The delivery of the systems shall be in four stages as per the time frames in ***Section VII - Chapters 1. and 2. Delivery Schedule*** (and in case of discrepancy, the Chapters 1 and 2 take precedence):

1. Inception report, Samples for Approval, and Pilot installations

1.1 ***Inception Report*** shall commence on contract execution and be finalised within **forty-two (42) days**.

1.2 ***Samples for approval*** shall be requested on contract award and submitted within **twenty-eight (28) days**.

1.3 ***Pilot Installations*** shall be supplied and installed for inspection and approval by the Purchaser as **per ninety-one (91) days** of contract signature.

2. Establishment of facilities for installation services

The Supplier shall set-up the necessary management infrastructure, facilities, outlets and staffing to provide quality installation services, within **ninety-one (91) days** of contract signature.

3. Balance of installations

After the approval of the Pilot installations, then commencement of the balance of installations may proceed. First tranche of systems installation must be within ***one-hundred thirty three***

(133) days of signature. All systems identified above must be delivered, installed and ready for commissioning within two-***hundred eighty (280) days*** of contract signing. Commissioning is to be completed by 310 ***days.***

4. Warranty, after sales service and maintenance
The Supplier shall provide after sales service for all systems and maintain the community systems installed (see ***Section B.3***), for a period ending of a minimum of **twelve (12) months** after commissioning of the last system in the lot.

B.2.4. Inception Report

Immediately after signature of the contract, the Supplier together with the Purchaser's representative shall conduct inception missions to every site in each Lot. Supplier shall also make detailed assessments of the sites, villages, access and logistical issues. In particular Supplier shall confirm and report the hydraulic conditions.

The Supplier shall provide the necessary qualified staff to lead the tasks, including an Electrical Engineer and a Project Manager. During the inception mission to these facilities, final clarifications will be made on the positioning of PV modules, the manner in which they are installed, placement of the outline of the wiring. The Supplier will provide drawings of all proposed installations, including wiring diagrams, construction drawings and typical placement of components in the Inception Report.

The final Inception Report shall contain at least the following sections:

- Validation of listed facilities, and facility status, in conjunction with REREC and WSP office:
  - Confirmation of hydraulic design conditions on site
    - existing pump and generator size and operational condition
    - existing storage tank sizes, condition, rehabilitation needs
    - existing borehole internal diameter
    - existing diesel engine size, condition
    - yield under test using existing pump (with supplementary / portable generator as required)
    - TDH calculation comprising of: static head, pipe diameters, lengths (***Chapter 4, Form 3.3: Hydraulic information and pumping head calculation sheet***)
  - PVP systems and scope of works to be installed at each facility per site,
  - Requirement for additional works to integrate supplementary storage tanks per site
  - Confirmation of minor additional components necessary site

- List of all sites with
  - proposed PV system(s) type to be installed at each,
  - proposed diesel genearator size,
  - minor works required, including repairs to tanks and reticulation networks
  - Updated BoQ for each/all sites site with site specific additional work (DB, new cabling routes, additional rooms, etc), showing total cost implications per facility. Use the same format as the BoQ provided.
  - Site plan for location of solar PV array, buildings, fencing at each site.

- Proposed Solar PV types

   - DC-AC Wiring diagrams for each system type, showing in addition, earthing, lighting protection (internal and external), and monitoring sensors
   - Detailed construction drawings for PV module mounting structures
   - Functional description of the operation and variables of the data logging and remote monitoring system
   - Communication wiring diagrams for each PV system type

- Implementation Approach and Staffing
   - A description of the installation method if different from ***Volume 1, Section IV, PQ Form 3*** of the proposal
   - Staffing approach if different to proposal
   - Schedules for implementation and related assumptions
   - Final Gantt chart

- Support requirements from Purchaser, to be agreed
   - Itemised support required (i.e. permissions from country government/WSP for access to certain areas project)
   - Responsibilities and schedule for the support.

The Supplier shall finalise the Inception Report and submit to the Purchaser as per time frames in ***Section VII -Chapter 1 and 2. Delivery Schedule.*** The Supplier will be informed about approval of the final Inception Report within ***fourteen (14) days*** weeks after submission, and any change-orders necessary.

B.2.5. Samples for Approval

Once the contract is awarded and at the time of the *Inception stage*, the successful bidder shall provide documemtation for verification together with samples for approval or factory inspection reports prior to placement of orders, bulk manufacturing or shipping.

The Supplier shall provide selected components from each system type on this project, for inspection. In general the samples inspection shall entail visual inspection, to ensure that samples correspond with the documentation offered at time of bidding. However, in case of doubt the Purchaser may require testing of the samples by a nominated certified laboratory.

The Supplier shall replace any components or systems which do not meet the requirements of the applicable specification at their own expense. These samples shall be held over after scrutiny, until handover of the project to ensure that the same items as tested or inspected are installed.

Samples of <u>one of each type</u> of the following equipment for approval should be provided prior to the Pilot installations:

- PV modules
- Pump controller / inverter of each type
- Pump of each type
- Array structure (s)
- Any other components requested
   - water meters, valves, connectors

- Diesel engine

- Change-over mechanism (from PV to diesel)
- Remote monitoring transducers
- Demonstration of remote monitoring system
- Demonstration of barcoding system

(Since this tender requires rationalisation of models of pumps and controllers, implication is rationalisation of numbers of samples required. Assuming all systems offered are from same brand and same "family of components" (with only size variations), then this would reduce the numbers of samples required.)

Sample approval does not release the supplier from obligations with respect to quality and component performance this is a process to verify that the product proposed in the bids are same in the sample and final delivery.

B.2.6. Pilot Installations

The Supplier shall install at least one complete PVP installation to be approved by the Purchaser, in each Lot. (The Pilot installation shall include the entire hardware for a complete functional installation to be signed off as acceptable, covering all major equipment and all minor and balance of systems equipment for installations; array structures, fencing, remote monitoring systems, etc.)

The Pilot installations will benchmark the installation practice to be used, and will serve as the approved "blueprint" for the standard of installation. The Purchaser will review the quality and functionality of components, individually and as a system, and the quality of installation against requirements stated in this document; and revise, as needed, based on the benchmark pilot installations - any equipment changes, installation or procedural changes required for this blueprint will become mandatory for the balance of the installations. The supplier shall provide the necessary qualified staff to lead the tasks, including an Electrical Engineer and a Project Manager.

The Pilot installations shall follow the process below:

1. The Supplier shall expedite delivery of the equipment for the installations, as soon as practical after approval of the Inception Report and Samples.
2. The Supplier shall agree a date with the Purchaser for completion of the Pilot Installations and for the Blueprint inspections, within the project schedule as in ***Section VII -Chapters 1 and 2. Delivery Schedule.***
3. The Supplier shall provide technical and managerial staff on site capable of and authorised to make any necessary decisions on site.
4. The Supplier shall install the equipment according the installation guidelines agreed in the Inception Report.
5. The supplier shall give the Purchaser at least three days' notice to inspect the Pilot works.
6. The Purchaser shall inspect the Pilot installations and equipment at the agreed date, and make recommendations for modifications to improve quality with respect to equipment quality, locations of key equipment and installation planning, cabling and wiring, plugs and sockets, light locations, installation methods, labelling, and functionality of the remote monitoring system, etc.
7. Any necessary changes shall be implemented while the Supplier and Purchaser are on site, with the objective of approving the Pilot Installations.

8. If the modifications required are of a major nature, then a second Inspection visit shall be scheduled with the same Supplier team, within 2 weeks.
9. Once the installations are to standard, then the Pilot Installations will be accepted according to the process in ***Section B.2.9***.
10. The Supplier shall update electrical diagrams, instructions to installers based on the approved Pilot Installations.
11. The Purchaser will issue an *Authorization to Proceed* with balance of installations.
12. The Supplier will train all his supervision and installation staff to undertake installations to the standards agreed at the Blueprint.
13. The Supplier will commence the balance of installations to the same standards.

At the Pilot installation, the component documentation, commissioning procedures, manuals and other documentation will also be tested and validated against the specific equipment provided. The Supplier may confirm that the procedures and forms for Practical Completion, Commissioning Inspections and Acceptance and other steps are practicable, and propose any revisions that may make them more effective and efficient.

B.2.7. Training Requirements

B.2.7.1. *National level REREC Engineers*

The Supplier will conduct a training to key member of technical engineering staff at the national level. Key staff (electrical engineers or similar) at REREC will be designated by the Purchaser.

The objectives of this training will be to ensure that the selected trainees master the key installations points: functioning principle of each key components, local display unit, distance monitoring system, routine maintenance and repair tasks, supervision using remote monitoring, and finally how to upgrade a system.

This training will take place at the first pilot sites that shall be installed, once it has accepted (after Final acceptation). Between 2-3 REREC engineers, in charge of supervision of future systems will be part of the trainees. This training session shall not last less than 3 days.

B.2.7.2. *County Water Engineers*

Another training session will be conducted under the supervision of the Supplier, with the assistance of key REREC and county staff (that have been trained see above). The target group will be the County water engineners in charge of the future systems, once several other systems are installed. Duration of training will also be at least 3 days with a maximum of 10 participants per each training session and will be conducted also at a pilot installation (or a PV system that has been accepted). The total of engineers and technical staff to train is 24. Therefore, 2-3 training sessions will be required per LOT.

The teaching content of these above described trainings will be proposed by the Supplier and agreed upon by the Purchaser. It will be theorical and practical (60% of practical exercices)

This training will take place at the first pilot system in a County after Final acceptaance).

B.2.7.3. *Operators of community facility systems*

Operator-training and provision of documentation for the systems installed at the community facilities is required. Training shall be conducted in English and Swahili languages. Training is directed at the WSPs operators and the administrators of the community public facilities systems in the villages. These include the following specific components:

- Basic use of solar PVP systems – operating principles, basic operating modes and practices, safety issues, energy and power limitations of solar PV systems, change-over to diesel mode (were applicable)
- The uses and limitations of the system installed;
- Basic fault diagnosis and key indicators of system or component failure
- Operator-maintenance responsibilities, administration of maintenance visits and completion of user-sections of maintenance log sheets
- Safety procedures and precautions, including handling of heavy components;
- Contact information for queries and break-down maintenance service.
- Warranty support

Operator training in the system operation shall be provided at each system installed, to at least two WSP pump operators appointed by the WSP. Training in the system operation shall be provided to the operators at each system installed for a duration of at least 3 hours

B.2.7.4. ***On site and follow-up training***

County engineers /super-techncíain in each countty shall nominate qualified technicians to be responsible to liaise with the WSP for long term technical support, general maintenance supervision and upgrading of systems required during and after the initial warranty/maintenance period of the systems.

For each site, the Supplier shall be responsible for providing on the job maintenance training to operators and WSP technician with its own maintenance kits in the course of the warranty/maintenance period. In other words, routine maintenance and repair job will be done by the Supplier technician and while doing so, this will include training of users and to the WSP technician. The follow-up training should target i) operators and staff that received the first training and ii) new operators and staff. Technicians within WSP must be trained to provide this level of support to the users.

Maintenance report and/or repair job report, indicating clearly the training time for users and WSP technicians, will have to be cosigned by the Supplier, the WSP technician, the operators and head of health facilities and submitted to the Purchaser

B.2.8. Documentation to be Provided

B.2.8.1. ***Operator Poster***

A Poster intended for the operator must be provided with each system. The Poster shall be specific to each system type, and shall be approved, in English, during the Pilot Installations, and later translated to Swahili language. The Purchaser shall review and provide the final version of the manual to be used by all suppliers. The final version of User’s Manual shall be printed in both English and Swahili languages, after approval by the purchaser.

The documentation should be simple and easy to understand. Use of sketches or graphics should be used to make the manual easier to use. The documentation is to include the following:

- Simple explanation of how the PVP indicator lights work:
- Indications of available water supplied by the system, in seasons.
- Emergency shutdown procedures and recommendations for extended periods of system non-use.

- A simple user trouble shooting guide.
- Basic maintenance to be done by user, including frequent cleaning of the panel especially during dry season to remove dust, deal with array shading,
- Name address and telephone number of call-centre for fault reporting, and to be contacted if dealer/supplier does not meet its obligations.
- Name address and telephone number of dealer/ supplier and the technician(s) responsible for warranty and service claims

B.2.8.2. ***O&M technical manual***

The Supplier must provide an Operations and Maintenance Manual to be used by the service technicians. The copy shall always remain on site after Acceptance of the system. The O&M Booklet is a pre-requisite for Acceptance Tests and inspections.

The O&M Booklet shall be written in English and must be graphically illustrated for unambiguous interpretation and understanding by operators and maintenance staff. Special attention must be drawn to fault finding and remedial action.

All drawings shall be annotated in English. All drawings shall comply with BS 308. All drawing symbols must be standardised according to BS, DIN or IEC symbols and must be consistently used.

A booklet shall be provided. Each section shall be partitioned with labelled plastic dividers. The main sections are outlined below:

- ***Operator section***
  - The Operator Section shall include:
  - Introduction
  - Instructions on safety techniques
  - Operating and serving instructions with details of service schedules, with start-up and shut-down procedures, functional description and interpretation of status and error indicators
  - Fault finding instructions, normal and fault indicators
  - Rules for action in error situations
  - Repair of minor faults
  - Regular maintenance procedures, plant care and cleaning, maintenance schedule (NBNB)
  - Schematic description in the form of an overview drawing with references to the relevant detail drawings, indicator lights etc.

- ***Contacts for backup***
  - Local agents
  - Installer
  - Manufacturer
  - Purchaser (if relevant)

- ***Maintenance required***
  - Taken from ***Chapter 4: Technical Bid Submission-Maintenance Schedule.***

- ***Log book and maintenance section***
  - Records of date and water meter reading , and reservoir level if relevant
  - Forms to enable the keeping of a log book and collection of data and maintenance records.

- ***Spare parts list***

- Parts list in agreement with the graphical documents quoting all the data necessary for ordering as required in section.

- ***Performance section***
  - Commissioning sheet/Acceptance certificates (ex project Purchaser) and Performance Test Sheets.
  - Performance requirements (from *Project Specification*)
  - Performance tendered (completed by Bidder, from ***Chapter 4: Technical Bid Submission Form 3.2***)
  - System performance section (as detailed in ***Section C.2.11 System Performance Information,*** and ***Chapter 4: Technical Bid Submission Form 2***).
    - Daily output curves - water delivery for system at different radiation levels and heads.
    - Instantaneous output curves - water delivery for system at different radiation levels and heads.
    - Array curves - different radiation levels (and at operating temperature).
    - Power conditioning - instantaneous efficiency over the full range of operating conditions expected.
    - Pump curves, motor curves.

- ***As-built' drawings***
  - A set of "As-built" drawings of the new installation shall be furnished. The set shall consist of separate drawings of each of the following:
    - Single line diagram / system schematic.
    - General assembly drawing of the motor / pumping system, including exploded drawings of the pump unit with particular attention paid to the labelling of working parts operation instructions.
    - General assembly drawing of the array mounting structure.
    - Detailed electrical layout drawings, electrical circuit and regulatory diagrams, implementation plans, wiring and terminal diagrams, including wiring sizes, lengths, etc.

- ***Technical section***
  - Detailed technical servicing for trained/specialist technical staff.
  - Complete parts list (to be supplied by the Bidder)
  - Component specifications (from ***Chapter 4: Technical Bid Submission Form** 1*), submitted by Bidder), including:
    - Module certification, degradation, and all component data-sheets.

- ***Upgrade path***
  - Upgrade path (if applicable, the performance achievable by simple upgrade, costs etc)

- ***Installation***
  - Installation instructions

B.2.8.3. ***Equipment documentation***

The Supplier is required to supply certain documentation with the equipment. This documentation shall include:

Softcopy database for each major component supplied including the following fields:

- Unique barcode, manufacturer name, model number, serial number, supplier name, date of purchase

The Purchaser reserves the right and discretion to require pre-shipment inspections by the Purchaser or Purchaser's nominated independent inspection agent. The pre-shipment inspections will occur at the premises of the Supplier or the manufacturers of the Supplier. The cost of these inspections would be borne by the Purchaser.

B.2.8.4. ***Claims documentation for systems installed***

For payments related to installation services, periodic (monthly or longer) claims shall be submitted by the Supplier. The claims documentation shall comprise of the following documents linked to each site, whetherr in formal MIS provided by the Purchaser (for example *Odyssey*^{TM} or *Edison*^{TM} platforms), or a simple sharefolder, with one directory per site.

1. Practical completion sheet for each site
2. Certificate of Electrical Compliance (for each site where relevant)
3. Spreadsheet with equipment inventory:
   - System number and name (i.e. 1..CDS-1)
   - Dated Practical Completion / Acceptance Receipt signed by HC staff
   - Province, district, village,
   - Location for verification purposes (i.e. GPS co-ordinate).
   - Key equipment supplied and installed
     - Technical Manual, user poster
     - Module type, rating, qty, serial numbers, barcode serial numbers
     - Pump type and capacity, qty, barcode numbers
     - Inverter type, capacity, barcode serial number
4. As-built site layouts
   - Layout of PV array, platform, DBs
   - Overall of entire site with cabling routes.
5. Photos
   - WSP facility members
   - Array location, lack of shading, solar arrays,s tructure
   - Control enclosure
   - Safety signage
   - Model and serial numbers of each major component excl modules.
   - Minor works undertaken (control room, etc)
   - Operator Poster, Manuals,
   - Site fencing

B.2.9. Procedures for Practical Completion, Commissioning Inspections and Acceptance of the Systems

Note that the risk passes from the Supplier to the Purchaser only on satisfactory inspection and commissioning of the public facilities and hand over to the client along with complete Acceptance Certificates to ensure that equipment is on site and fully functional. The Purchaser acknowledges that there may be risk of theft and/or vandalism between the period of completion of installation and Acceptance. The Supplier should carry insurance or other means of safeguarding the PV systems until the Acceptance Certification is signed by the Purchaser. It is expected that any costs associated with insurance or other means of safeguarding the PV installations will be paid for under this Contract.

Practical Completion

1. The Supplier shall satisfy himself that the installations are completed in accordance with the Specifications, the Pilot Installation standards and any variations that have been issued before requesting an inspection by the Purchaser.
2. The Supplier will complete the Practical Completion Log-sheet.
3. The Supplier will train the facility staff in basic operational procedure and first line maintenance before commissioning. The system may be used by the staff.
4. The Supplier shall capture each system data, and Practical Completion Log-sheet, to spreadsheet.
5. After checking, the Supplier shall submit the uploaded data in the MIS, in a Claims Batch. This Claims Batch will form the softcopy database to the specified format, of the sites completed and ready for inspection in the Claims Batch (***section B.2.8.4*****).** Claims batches must be made up of facilities located in one geographic area of the Lot. Otherwise inspections will occur at a frequency of not more than once every month.

Acceptance, Commissioning and Verification

6. Sometime after Practical Completion of the installation the systems will be subject to Acceptance/Commissioning/Verification Inspection by the Purchaser.
7. Prior to inspection, the Supplier shall hand over to the Purchaser all technical and other necessary Claims Documentation.
8. E&S condition of acceptance: In addition to the technical conditions of acceptance, for any Lot to be fully accepted, all outstanding EHS issues due shall be addressed by the contractor, unless those covered under valid insurance like WIBA, which validity can be extended to cover the expected completion period.
9. The Acceptance/Commissioning/Verification Inspection by the Purchaser will occur in Claims Batches, within 15 days of notification and handing over submission of the Claims Batch and the necessary documentation.
10. The Purchaser will determine whether the staff has been adequately trained in basic operational procedure and first line maintenance.
11. The Supplier and Purchaser will be present at the Commissioning Tests.

12. At the Acceptance Inspection the Supplier will be issued with a certificate stating all defects of the installation or part at that time.
13. If the defects are minor and of fewer than the agreed number, then the installation will be handed over by the Purchaser using the Acceptance Certificate. If defects are of a major nature, or large quantity of a minor nature, then the Supplier will correct these defects and request a further inspection.

Acceptance Certificate

14. An Acceptance Certificate will only be issued once major defects mentioned above have been rectified and inspected, and staff have been trained satisfactorily.
15. The acceptance of the Claims Batches will determine the payment for the complete claims batch. Payments shall be withheld proportionally for systems found to be un-Acceptable, on a pro-rata basis. Payments for those shall only be released after further verification.
16. The Warranty Period will commence from the date of Acceptance of the last installation in the Lot, as dated in the ***Acceptance Certificate.***

B.2.10. Commissioning Tests

Draft commissioning process is given as ***Chapter 7***. These will be updated to meet the requirements of the Supplier's specific products at the time of the "Pilot installations":

1. The commissioning document is an initial record after the system has been installed and made operational, and contains pertinent data on condition and performance of the system. These measurements are necessary for future servicing, repair and warranty issues of the system.
2. The technical documents referred to as ***Section B.2.8*** should be an integral part of the commissioning document as well as other design documents from the supplier as these are the reference documents of this "Commissioning Document".
3. The commissioning officer should be qualified to measure voltage and current parameters required in this document, in a safe manner, and should have read and understood in detail the above-mentioned annexes and supplier design data. The commissioning officer will have been trained on a Pilot installation.

B.3. After-Sales Services and Defects Liability Period for Solar PVP Systems

The period of after-sales services is from commencement of the Warranty period until end of Contract Period.

Activities covered under after-installation services are:

- *Warranty period* on quality of workmanship and all parts
- *Component warranty* on key system components
- *System performance guaranty*
- *Routine maintenance* services
- *Break-down repair* services
- *Spare parts* support
- Provision of maintenance services to be purchased after the contract

The Purchaser shall give notice to the Supplier of any Defects before the end of the Contract. The Defects liability period shall be extended for as long as Defects remain to be corrected. Every time notice a Defect is given, the Supplier shall correct the notified Defect within the length of time specified by the Purchaser. If the Service Provider has not corrected a Defect within the time specified in the Purchaser's notice, the Purchaser will assess the cost of having the Defect corrected, the Supplier will pay this amount, and a Penalty for Lack of Performance calculated as described in PCC 13.3.3

B.3.1. Warranty Period

The Supplier shall provide a twelve (12) month unconditional Warranty Period on the installation from the date of Acceptance of the last installation in the Lot, as per ***section B.2.9 clause 15.***

The Warranty Period shall cover all materials, components and quality of workmanship for each system. Should any faults arise, this warranty will provide for the necessary repair or component replacement in order for full functionality to restore full functionality within time period of reported fault in ***Table 6.***

B.3.2. Component Warranties

The warranties on the individual components for installations shall meet the following requirements:

- 25 years on PV modules (performance not less than 80% of name plate output), and 10 years against manufacturing defects
- 5 years warranty on Pump controller/Inverter/Converters
- 5 years warranty on Pump/motor
- 2 years warranty on diesel generator
- 3 years for all other PV system components
- 1 year on all unspecified hydraulic components.

Specific Manufacturer Warranties shall be provided signed by an authorized official of the manufacturer with company seal, on the company's letterhead with specific reference to this procurement. Standard/nominal printed documentation without the signed warranty commitment is not acceptable. Manufacturers' Warranties must be transferable to the "Purchaser or nominee" after the Contract Period.

The Supplier shall be responsible for the managing the Component Warranties till the end of Contract.

B.3.3. System Performance Guarantee

Overall system performance guarantee of 12 months shall be provided, during which time average monthly water output from the solar PVP system (without diesel back-up) shall not drop below that of the specification performance level required. System efficiency indicators as defined in ***Section C.2,*** as declared by Supplier and as measured during commissioning (***Chapter 7***) shall not show measurable decrease.

B.3.4. Spares Management

The Supplier shall supply all ***Mandatory Spare*** part for inspection, and may utilize these on an exchange and repair basis during the Maintenance Period. At end of the Maintenance Period the Supplier shall hand-over and replace all used Mandatory Spares in good working order to the Purchaser.

The Bidder shall also submit a list of additional ***Recommended Spare*** parts, i.e. in addition to the Mandatory Spares (***Section C.2.10***), for components which may require replacement caused by normal 'wear and tear' within the initial Maintenance Period after handover, as required in ***Chapter 4: Technical Bid Submission Form 5 Recommended Spares Schedule.***

The above does not obligate the system owner or other responsible party to order the spares scheduled in the list at the prices stated during or after the contract.

B.3.5. Maintenance and Service, Reporting and Tracking

The Supplier shall provide on-site maintenance services for PVP systems from the date of Acceptance of the <u>last installation in the Lot</u>, as per ***Section B.2.9 clause 15.*** (i.e. date of commencement concurrent with commencement the Warranty Period).

Maintenance is the responsibility of the Supplier until end of Contract Period. During this time the contractor will inspect, maintain and service the installation as part of the contract.

The Supplier will ensure that maintenance is conducted as follows:

- A routine maintenance regime will be implemented according to the technical specifications provided in ***Sections D.1 and D.2.*** The routine maintenance will be undertaken for every solar PV system installed at community facilities in accordance with this scope of work;
- In addition, a break-down repair service operated by the Supplier shall be available to users in accordance with ***Section D.3.***
- Supplier shall manage Warranty period ***(Section B.3.1)*** Component warranty (***Section B.3.2***), System performance guarantee (***Section B.4.3***) and Spares ***(Section B.3.4).***
- Declaration by the contractor stating that the maintenance work and any repair work has been completed and accurately recorded, co-signed by the community system operator or water committee chairperson on site.
- Forwarding of copies of the Maintenance Form to the relevant parties specified on the Maintenance Form.

The Supplier will maintain organizational, staffing, logistical, inventory, recording and reporting capabilities and other arrangements sufficient to meet the managerial and technical requirements of providing the maintenance and other post installation services to comply with the requirements established in ***Sections D.1 to D.5***.

A Maintenance period may be renewed thereafter, or may be awarded to another maintenance contractor.

Fault reporting

The fault reporting channels shall be established to be unchanged from time of installation till completion of the contract and handover to Purchaser. Fault reporting shall be via a call center operated by Purchaser.

The Purchaser shall provide a call center for customer support (WSP, not individual customers). The call centre shall log PDWS system related faults and complaints, and shall used to draw up job cards for action, including all customer related details, the nature of the complaint, with a unique reference number. Each logged complaint and notification of system failure shall be recorded by the Fault Report Call-centre, forwarded to Supplier (and copied to WSP). Feedback from Supplier job cards will be used to assess customer perception of the system performance and assess speed of response to problems.

For ease of reporting, each User manual, and each system shall include a label:

- Name address and telephone number of call center for fault reporting, and to be contacted if dealer/supplier does not meet its obligations.
- Name address and telephone number of dealer/ supplier and the technician(s) responsible for warranty and service claims
- Users shall be instructed to first contact the call centre, and to follow-up with complaints to call centre if the repair is not addressed within 3 working days.

B.3.6. Rejection of Faulty Equipment

If, within the first twelve (12) months of the Warranty period, ten percent (10%) of more of any class of equipment fails based on record-keeping tracking tools, the Purchaser may, at his sole discretion, have the right to demand the replacement of all of that class of component or material throughout the entire set of equipment supply or tender installations awarded to that Supplier.

C: Technical Specifications and Standards for PVP systems

C.1. General

This specification is intended for solar PV water pumping systems in the range 50Wp to 400kWp. The configuration would generally be stand-alone systems, without batteries, but with back-up electrical generator.

Many modern solar pumps can be operated selectively from different power supplied, for instance one of solar, or even grid supply. These hybrid solar/diesel configuration systems are considered in the commissioning and acceptance procedures as pure solar systems. The employer may change the number of sites for implementation for various reasons as may be necessary and this may consequently change the overall cost of the contract of the bidder. However, the per unit cost of component items will remain unchanged during contract period.

C.1.1. Introduction

The ***Standard Technical Specification*** details the general system requirements, standard of design and workmanship, and quality of material for the installation, and is supported by the drawings listed in the ***Chapter 5: Schedule of Drawings***, and tables in the ***Chapter 6: Schedule of Tables***.

Project-specific data are given in the ***Project Specificatio*****n** ***(Appendix 3).*** .

C.1.2. Scope of Standard Specification

The scope of this specification covers the following items: supply, installation, testing, commissioning, hand-over in proper working order and maintenance. Any cost or other requirements for coordination and liaison with other contractors or relevant parties is also included in this contract.

The scope of the contract includes, but is not limited to, the following:

Major equipment

- Photovoltaic Modules
- Pump controller (Maximum power point tracking devices, DC/DC converters, DC/AC inverters, etc.)
- Water pump(s) and motors (as specified in the ***Project Specification***).
- Diesel generator and change-over interface to operate the pump efficiently
- Remote monitoring, data-logging and remote control (as specified in the ***Project Specification***).

Minor equipment

- Borehole riser pipes
- Borehole head
- Pump mountings for sumps where required
- Non-return and control valves, strainers
- Water flow and pressure meters
- Complete balance-of-systems (BOS) equipment including array supports, bypass diodes, fuses, wiring, connectors, junction boxes, isolators and switchgear.
- Earthing and bonding

- Lightning protection against induced surges, but not direct strikes (as specified in the ***Project Specification***).
- Additional water storage tanks (as specified in the ***Project Specification***).
- All other materials and labour to install, test, commission and hand over the systems in terms of the Specification and Schedules.
- Spares for the number of years operation

C.2. System Performance Requirements and Design

C.2.1. General Design Requirements

The purpose of this specification is to maximise the following system characteristics:

- Robustness and reliability of the installation
- Security of the system
- Consistent and adequate performance of the system
- Cost-effectiveness of water output over the system lifetime
- Low maintenance of the system
- Operation, maintenance and fault-finding simplicity (able to be performed by community operator without specialised tools)
- Long life of the system
- Adequate attention to backup services and parts availability over the system lifetime
- Upgrade-ability
- Minimal environmental impact and aesthetically pleasing

These characteristics will constitute the key criteria whereby tenders are evaluated, and are at the core of the system acceptance test. The onus rests on the bidder/contractor/supplier/installer to ensure that systems are optimally designed, configured, installed and supported in accordance with the above requirements.

The systems, including all supporting infrastructure, shall be designed and constructed to operate normally under the environmental conditions summarised in table below.**Error! Reference source not found.**

Table 2: Environmental conditions

Criteria	**Condition**
Minimum Ambient Temperature (oC)	15 ºC
Maximum Ambient Temperature (oC)	40 ºC
Humidity (%)	85%
Wind Speed (m/s)	Up to 35m/s or 120km/h
Altitude (m)	1,500 m AMSL
Corrosion	Compliance with ISO-12944, C5M

C.2.2. System Configurations

This Standard Specification is intended to cover one configuration of PV pump, being solar PV with change-over to generator back-up.

Refer to schematic of the systems in to ***Schedule of Drawings: DWG.SCH.1. and DWG.SCH.2.:Schematic of PVP configuration***.

The specific design parameters and configurations required are presented in the ***Project Specification.***

C.2.3. Design Parameters

The system performance requirements are defined by the following design parameters:

- Pump rating (kW) (see ***Project Specification***)
- Array size (kWp) (see ***Project Specification***)
- Pump controller rating (kW) (see ***Project Specification***)
- Borehole characteristics: (see ***Project Specification***)
- System lifetimes: 20 years
- Component lifetimes: 10 years

System performance will be confirmed in the Acceptance Test before the system is deemed acceptable (see ***Chapter 7 Acceptance Test Procedures for Solar PVP Systems***).

Unless provided in the ***Project Specification***, final site, water source, and hydraulic characteristics must be assessed on site by the supplier before ordering equipment.

C.2.4. Maximum Allowable Performance Degradation

Maximum acceptable performance degradation over the system lifetime is to be 10% of the output required in the Project Specification. If greater degradation is expected, systems should be oversized to ensure that the acceptable lifetime degradation level is not exceeded.

Zero performance degradation is allowed within the first year of operation.

C.2.5. Theft and Vandalism Resistance

Systems shall be designed, configured and installed such that they are subject to reduced risk of theft and vandalism. The risk applies primarily to solar panels. The risk of the systems to vandalism and theft has a principal effect on their viability, and hence this specification focuses on technical measures in the system configurations to minimise the effects of theft and vandalism.

Other technical measures (such as alarms, fencing, and very secure solar panel mounting) and social measures (via strong community participation and allocation of responsibility to watch over panels) will need to be well considered to reduce the instances of theft and vandalism.

C.2.6. Fault-Finding and User Friendliness

The system design and configuration shall allow for easy fault-finding by system operators. This may include the use of LEDs or volt/amp meters to determine whether various components or groups of components are performing as per specification, or are faulty.

C.2.7. Maintenance

Systems should be as maintenance free as possible, and maintenance requirements should be predictable. System operation and routine maintenance should be within the capabilities of community pump operators, but would exclude withdrawing of deep borehole pumps. Where special tools are required, they are to be supplied as a part of the contract, and included in the tender price.

C.2.8. System Efficiency

Since high system efficiencies are critical to minimize system initial costs, the system is to be configured such that overall daily efficiency is maximized.

Performance data for each of key components and sub-system components shall be provided as per ***Section C.2.9 System Performance Information, & Chapter 4: Technical Bid Submission Form 2***).

C.2.9. System Performance Information

In relation to the System Efficiency data to be provided. Since high system efficiencies are critical to minimize system initial costs, the system is to be configured such that overall daily efficiency is maximized.

C.2.9.1. *Array performance data*

Array performance curves shall be provided. This data shall be used for assessing system performance during bid evaluation, and Acceptance Testing (see ***Chapter 7: Acceptance Test Procedure)***.

The performance curves shall reflect the maximum power available at the power conditioner input (assuming maximum power point tracking), and shall include all diode and wiring losses:

- Instantaneous DC power output at maximum power point (MPP) versus instantaneous solar irradiation. The power output shall be for typical operating temperatures for that irradiation (NOCT), and the operating temperature shall be declared on the curves.
- Average daily DC energy versus daily solar insolation. The energy shall be determined at NOCT.

The curves shall be used as input to the *Subsystem Performance Data curves ('wire-to-water' curves).*

C.2.9.2. *Power conditioner performance data*

Power conditioning throughput efficiency curves shall be provided for the range of operating conditions expected of the system.

Instantaneous electrical efficiencies should preferably be above 95% over the full range of operating conditions.

Refer to ***Schedule of Tables: 2 Power Conditioner Performance Data*** for the data typically required.

Note that any reduction in array power output caused by the power conditioner operating off the array maximum power point (i.e. tracking inefficiencies) shall be specifically excluded from the power conditioner efficiency, as this is likely to be both array and power conditioner specific. In other words, the input to the subsystem performance data ('wire-to-water' curves below) shall be the maximum array power achievable at NOCT, together with a further separate allowance for >tracking efficiency=.

C.2.9.3. ***Motor performance data***

Motor manufacturer test certificates may be requested by the Purchaser. Sufficient data to meet the requirements stated in ***Section C.2.10 System Performance Information*** shall be provided.

C.2.9.4. ***Pump performance data***

A set of curves indicating pump output under a range of head and RPM shall be provided. More detailed curves (i.e. pump output vs. kW & rpm / motor torque & speed / etc, and head starting torque) shall also be offered. Sufficient data to meet the requirements stated **in *Section C.2.11 System Performance Information*** shall be provided.

C.2.9.5. ***Sub-system performance data ('wire-to-water' curves)***

Performance curves for the complete sub-system comprising 'Power Conditioner/ Motor/ Pump' shall be furnished. These will be used in evaluating system performance during *Acceptance Testing* (see ***Chapter 7: Acceptance Test Procedure***), in conjunction with the *Array Performance Data*, and an estimate of the >tracking efficiency=.

Refer to ***Schedule of Tables: 1: Sub-system Performance Data*** for typical data required.

The sub-system performance curves shall show the wire to water conversion, but shall specifically exclude the tracking efficiency by the power conditioner of the PV array maximum power point:

- Instantaneous water output versus DC input power to the power conditioner at various heads
- Average daily water delivery versus daily DC energy input to the power conditioner at various heads.

While the curves shall be constructed from actual measured data for the complete sub-system, sufficient data on the individual components in the subsystem shall be provided to enable construction and checking the curves from a theoretical perspective.

C.2.9.6. ***System efficiency***

C.2.9.6.1 Instantaneous sub-system power efficiency: η(Instantaneous sub-system)

This is defined as the *instantaneous 'wire-to-water' efficiency*, from the DC power input measured to the power conditioner, to the power output of water delivered by the pump at the working head and pressures.

$$\eta(\text{Instantaneous sub-system}) = \eta(\text{Power conditioner}) \times \eta(\text{motor}) \times \eta(\text{pump}) \times \eta(\text{losses})$$
$$= \text{hydraulic power / DC input power}$$

Where:

Hydraulic power (kW) = flow (m^3/hour) x pumping head (m) x 9.8 /3,600

DC input Power (kW) = Irradiation(kW/m^2) x Array STC power(kWp) x η(array tracking)

Reference will be made to the provided pump data sheets for each site to determine the technical performance adequacy of the water pump

C.2.9.6.2 Average daily sub-system energy efficiency: η(average daily sub-system)

This is defined as the *average daily 'wire-to-water' Efficiency*, from the DC energy input to the power conditioner, to the energy output of water delivered by the pump at the working head and pressures. It is usually determined by integrating energy and water delivery over the duration of a complete operating day.

$$\eta(\text{average sub-system}) = \Sigma\,[\,\eta(\text{Instantaneous sub-system})\,]$$

$$= \Sigma\,[\,\eta(\text{Power conditioner}) \times \eta(\text{motor}) \times \eta(\text{pump}) \times \eta(\text{losses})\,]$$

= hydraulic energy / DC input energy

Where:

Hydraulic energy (kWh) = volume (m^3/day) x pumping head (m) x 9.8 /3,600

DC input energy (kWh) = Insolation (kWh/m^2/day) x Array STC power(kWp) x η(array tracking)

Reference will be made to the provided pump data sheets for each site to determine the technical performance adequacy of the water pump

An estimate of the *Daily Energy Efficiency* for the electrical subsystem shall also be given (power to water efficiency, excluding the array).

C.2.9.6.3 Instantaneous water output

The instantaneous water output (m^3/hour) shall be estimated by calculating:

= Irradiation(kW/m^2) x Array STC power(kWp) x η(array tracking) x η(Instantaneous sub-system)
/ [pumping head (m) x 9.8 /3,600]

C.2.9.6.4 Average daily water output

The average daily water volume deliverable (m^3/day) for any month shall be estimated by calculating:

= Insolation(kWh/m^2/day) x Array STC power(kWp) x η(array tracking) x η(average daily sub-system$_{month}$)
/ [pumping head (m) x 9.8 /3,600]

C.2.10. Spares

Sets of spares are required to maintain immediate spares stocks for the number and type of systems in each project Area. The bidders shall price for both *Mandatory Spares*, and *Recommended Spares*.

Each LOT requires at least the minimum number of spares specified below. The Supplier shall supply the following *Mandatory Spares,* and compose and deliver at the end of the Warranty Period an optimal package of spare parts typically comprising the following items. **See *Chapter 4: Technical Bid Submission Form 4.4.***

In addition, the Bidder shall draw up a list of *Recommended Spares*, comprising of high-usage and high-value items of components and spare parts, for usage in the initial period of operation specified in the Maintenance Period, and to cost for these items. **See *Chapter 4: Technical Bid Submission Form 5.*** Failure to cost for these recommended spares will result in an incomplete bid.

C.3. Code of Practice for Installation of Solar Pumping Systems

C.3.1. Installation Standards

The AC elements of installations shall comply with the *British Wiring Standards BS 7671*. The other relevant international standard for wiring of buildings is **IEC 60364.**

Kenyan electrical installation personnel shall be registered with an installation license issued by Electricity and Petroleum Regulatory Authority (EPRA), relevant to the type of installation, who shall sign off the works.

As noted in ***Section B.2.6***, the installation requirements may be revised based on the benchmarks established during the Pilot installations.

C.3.2. Protection Against Theft and Vandalism

Solar PV systems are inherently at risk to theft and vandalism. Bidders shall provide specific descriptions of the measures which are included in the supply and installation of the systems to minimize the risks of theft and vandalism. These anti-theft and anti-vandalism measures must be based on an understanding and analysis of the modes of theft or vandalism which are possible in the service areas. For instance, location of the array in an inaccessible position, use of tamper proof modules screws, and nuts and bolts on array frames spot-welded after installation.

C.3.3. PV Array Mounting

C.3.3.1. ***Structure assembly***

The structure for large installations shall be designed for mounting on the ground onto a concrete base. Pole-mount structures are acceptable for installations of small sub-arrays (further below).

The array mounting structure will hold the photovoltaic module(s). The module(s) must be mounted on a support structure made of corrosion resistant material that assures stable and secure attachment.

The structure shall be corrosion resistant; and shall be hot-dipped galvanized steel in accordance with IEC-ISO 1461(2009), or anodized aluminium. All nuts, bolts and washers shall be stainless steel, and any other mounting material shall be of corrosion resistant material. Any welding, holes drilled, or surface damage to galvanising shall be treated with Galvadip™, Adensotape™ or Petrotape™ systems, or other approved cold-galvanising treatments substantially equivalent to those.

The method of fixing the PV modules to the support structure and the support structure to the base shall reduce the risk of theft and vandalism (e.g. using stainless steel rivets rather than aluminium rivets or bolts). The suggested method is to weld array security frames onto the structure after module installation. The security frame assembly should be designed to integrate as part of the total original structure and take into consideration the actual modules used.

Refer to ***Schedule of Drawings: DWG.STR 2: Array and module structure security assembly***.

The structure and mounting arrangements shall be compatible with the earthing requirements called for in ***Section C.3.14.1 Array grounding***. Specifically, the structure shall make provision for earthing of the each module frame, see ***Schedule of Drawings: DWG.STR.6. Array frame flange grounding for module earth.***

PV array and support structure shall be designed to withstand loads from wind gusts of 120 km/hour.

Bidders are to provide detailed drawings of their proposed structure for each system type, including foundations, pole base mounting arrangements, and wind loading calculations.

Pole mount structures are suitable for individual sub-arrays of up to 2.5 m^2 in area. The vertical pole shall be supported by means of a concrete base without guy wires. The assembled array structure installed on top of the pole shall be reasonably balanced, and the lowest part shall be at least 2m above ground level. The selected array tilt angle shall be maintained and secured by multiple bolts and lateral bracing (tensioning by a single axial bolt is unacceptable). Detailed drawings of mounting structures shall be submitted.

Ground mount structures: large installations shall utilize ground mount lattice array structures, secured onto concrete bases. The lowest part of any modules mounted on the structure shall be at least 2m above ground level to reduce access and minimize vandalism. Detailed drawings of mounting structures shall be submitted.

C.3.3.2. ***Selection of the PV site***

In all cases, the design of the mounting structure shall to ensure compliance with the requirements of:

- Orientation: array shall face the equator, and inclination angle will be between 5 -15 degrees facing the equator. REREC project engineers will provide guidance as necessary.
- Shading: array location shall be chosen such that there will be no shading from trees, antennas, other building parts, etc. onto the PV modules between 08:30 and 16:00, in all seasons of the year.
- Concrete plinths of the structures may not damage or interfere with any existing structures nor interfere with local activities, plans or services. Structures must themselves be protected from mechanical damage.
- Lowest part of any module from the ground shall be 2m to reduce vandalism risk, and to prevent shading by grass or other vegetation and to minimise settling of dust on the modules. Consideration should be given to possible future shading by vegetation growth (e.g. the position of young trees) over the system lifetime.
- Sufficient space around the array mounting shall allow for additional structures should the system be upgraded in the future. Particular attention should be given to future shading from fencing or from the new array structures.
- Sufficient space around the array mounting shall allow for solar PV cleaning and maintenance

No deviations from these requirements will be tolerated, and no claims for additional costs will be entertained.

C.3.4. Array Cabling and PV Module Interconnection

The installation of the large and higher voltage PV arrays shall comply with the standard of

- *IEC 62548 Ed.1: Design requirements for photovoltaic arrays*
- *IEC 60364-9-1: Low-voltage electrical installations - Part 9-1: installation, design and safety requirements for photovoltaic systems (PV).*

Wiring shall be permanently shaded from UV radiation. Wiring shall be *'Flexible multi-strand copper conductor cables in flexible UV resistant (e.g. Neoprene) sheath compatible with gland seals',* with any array junction boxes as may be required.

Modules shall be interconnected using professional PV array quick connectors available for array fly-leads cables in the 2-4mm2 range, for example Multi-Contact™, Tyco™, SunClix™.

- the array junction boxes, alternatively quick-connector Y connectors may be used to parallel strings.

C.3.5. Security Enclosure

A security enclosure or lockable room shall house the control cubicle, with power conditioner, switchgear and controls, and remote monitoring systems.

The security enclosure shall be vandal resilient, secure and with no exposed bolts to enable it to be tampered with. It shall be lockable, and locks recessed and inaccessible to vandals.

The enclosure need not provide more environmental protection more than IP13 as its primary purpose is to provide security. Key components within the security enclosure shall include the control cubicle (which should provide IP54 or higher protection), and the power conditioner which may also be installed within the control cubicle.

Refer to ***Schedule of Drawings: DWG.STR.2:Security enclosure around the control cubicle and power conditioner***

C.3.6. Control Cubicle and Controls

C.3.6.1. *General*

The water pumping system shall be managed by an operator. The layout, general safety features and labelling shall enable the operator to control the system without any damage either to the system, or individual components or to themselves.

It is recognised that some features mentioned below may be integrated into power conditioners. In instances when required features are not integrated into the power conditioner, then a separate control cubicle shall be provided. Where practical, the power conditioner may then be integrated into the control cubicle design.

The control cubicle shall be IP54 at least, and insect-proof. It shall be lockable even though within the Security Enclosure. Where practical, all required indicators shall be visible without unlocking the control cubicle.

If both DC and AC circuits are routed through the control cubicle, then these shall be clearly physically separated and necessary safety precautions taken in system design and layout, with necessary warning notices posted.

C.3.6.2. *Operational configuration of the control cubicle*

The control cubicle shall include the following features and control gear, which shall be clearly labelled:

- *Array isolator* (array feed to control cubicle): A manual override switch shall be provided to disconnect the power conditioning from the array (unless the power conditioning and modules are integral units, in which case a switch shall be provided to disconnect the motor from the power source).

- *Pump/motor isolator* (power conditioner feed to pump motor): pump and motor must be manually controllable B manual switch B marked MANUAL ON/OFF (should be left on usually)@.
- *Hi-level cut-off relay* (if required in ***Project Specification***): to cut-off when tank is full, and to reset only when tank level drops below pre-determined level again. Indicator light to show this has happened, and an override switch shall be included.
- *Low level cut off relay* (if required in ***Project Specification***): to cut-off when the well or borehole level becomes low, and to reset when borehole or well rises to predetermined level. Indicator light and an override switch shall be included
- *Indicators & electronic meters*: diagnostic equipment to be considered: Voltmeters, Ammeters, Indicator lights for fault diagnosis and state diagnosis (cut off, run dry, component failure, etc)
- *Generator CB*: 2 pole of 4 pole as required
- *Lightning surge arrestor protection* with indicators on the following cables (where required in the ***Project Specification***):
  - DC inputs from array
  - AC/ DC outputs to motor
  - DC cables to level switches

  Lightning protection requirements are specified in ***Section C.3.15. Lightning protection***.

Refer to ***Schedule of Drawings: DWG.SCH.4: Schematic of the control cubicle, with isolators & optional lightning protection*** and ***DWG.SCH.1 and 2: Schematic of solar PVP configurations***

Diagram for control cubicle to be provided with submission.

C.3.6.3. *Component specification within the control cubicle*

Overload protection circuit breakers

Overload protection Circuit-breaker's shall be rated as follows:

Mounting	Modular DIN rail mounting (same cutout as MCB)
Type:	Thermal-magnetic current limiting circuit-breaker
Breaking capacity:	at least 3kA at AC 220V
Trip characteristic:	10 to 14 x I rated (trip time <0.1 s)
	1 to 1.5 x I rated (trip time <10 s)
Rating:	full operating current plus 50%

Array breaker

A conventional single or dual-pole DC rated breaker for the array input.

Pump/motor breaker

A conventional multi-pole breaker, to ensure power conditioner has additional over-current or short-circuit protection. DC pump systems should include dual-pole isolation or dual-pole breakers.

High-level cut out relay (& low-level)

A logic-linked circuit which automatically prevents pumping when a signal is received from the three-wire electronic/mercury float switches in the header tank, sump or borehole. The circuit may be integral to the power conditioner. Manual over-ride or bypass switches are required.

The over-ride switches to the cables shall be breakers, and isolators are not acceptable. The cables to the level switches are a primary source of induced lightning surges and power conditioner faults, and for this reason they shall always be protected by breakers.

Refer to ***Schedule of Drawings: DWG.SCH.4: Schematic of the control cubicle, with isolators & optional lightning protection***

Generator CB
A conventional dual, or 3, or 4 pole AC-rated breaker for input from generator.

Generator change-over switch or system (where there is existing generator)
A break-before-make change-over switch rated for generator and pump start currents, and for necessary number of poles, and in N-PE earthing arrangement, neutral shall not be switched.

Alternatively, an integrated VSD or electronic change-over system shall be provided as a power conditioning component (refer *Section C.4.3*).

C.3.7. Pump and Motor

C.3.7.1. *General*

Non-return valves to be installed where pump type and header pipe volumes are such that significant backflow can occur, i.e. more than 2% of the daily water delivery.

At sites where freezing is a possibility, positive displacement pumping systems must be installed with suitable pressure relief valves fitted to prevent damage in the event of pipe freezing. Refer to ***Section C.3.8.5 Pressure-relief valves.***

Manufactures installation instructions are to be followed.

C.3.7.2. *Submersible pumps*

Pumps are to be suspended at least 1.5 meters from the bottom of the borehole or sump to avoid silting up of pump. Project Specification will stipulate exact depth. The additional weight of water in the rising main to be taken into account when the pipe and support cables are fully extended.

Straining wire to be used for lowering all submersible pumps (either stainless wire for large pumps, or non-degradeable rope for small pumps), with the exception of units installed with steel riser pipes or line shafts, or with ‘Boreline^{TM}’ or similar flexible hosing. Straining wire is to be strapped to the riser pipes every 5m, while the power cable is to be unstressed and taped every 3m. At the borehole head, a bore-cap to be used to support the weight of the entire submersible installation on the borehole head.

C.3.7.3. *Installation of motor*

Surface mount motors to be bolted onto a single stable concrete plinth, and protected against direct sunlight and rain by a removable shield and to add to theft resistance.

C.3.8. Rising Pipes and Valves

C.3.8.1. *General*

All pipes and fittings shall be constructed of suitable corrosion resistant materials. Water quality tests (see ***Project Specification***) are to be considered in this regard.

Surface pipes shall be smooth, with low relative roughness, to minimise dynamic pressure losses. High Density Polyethylene (HDPE) or drawn galvanised steel pipes shall be used.

Borehole riser pipes shall be 'Boreline' or similar flexible material for ease of access for submersible pump servicing.

Rising pipes, joins and valves are to be installed leak-free, using accepted joining methods. PTFE tape is to be used for high pressure joins.

Where it is important that pipes are vertical (as with line-shaft systems), spacers are to be used at suitable intervals.

C.3.8.2. *Dynamic head pressure losses*

The dynamic head loss of pipework from pump to borehole head water-meter outlet shall not exceed the static head by more than 10%.

The total dynamic head loss of the entire system from pump to water tanks shall be reduced should this be deemed critical within the ***Project Specification***.

Maximum flowrate for sizing

The maximum flow rate for calculating the dynamic head shall be calculated as follows:

$$Q_{MAXIMUM} = V_{DESIGN} / 5 \text{ hour pumping period x } 110\%$$

Note: that the design flowrate may be required to be higher by a specified percentage to cater for future expansion of the system.

Rating of pipes and fittings

The pressure ratings for pipes and fittings selected shall be for continuous operation at least 150% of the total head. The piping and fittings shall be rated for operation at 20°C.

The wall thicknesses of all pipes shall comply with 10MPa design stress. 18MPa design stress pipes not suitable, as they are designed primarily for irrigation and are not appropriate for reticulation purposes.

Minimum ratings for piping

- For total head < 10m - use at least Class 6 pipe i.e. rated for 600kPa or 6 bar
- For total head > 10m - use at least Class 10 pipe i.e. rated for 1,000kPa or 10 bar
- For steel galvanised piping in general, pipes of OD >25mm shall be of Medium Wall Thickness.

Minimum ratings for fittings

- at least 1,000kPa rating (10 bar), but preferably 1,600kPa (16 bar)

Calculation of dynamic head

Dynamic head losses may be calculated from the charts included in ***Schedules of Tables 3 (a,b). Pressure losses through pipe fittings***. The following charts shall be the basis of the total head calculation:

- pipe losses
- pipe elbows
- non-return valves
- globe/gate valves
- water meters

Where Bidders offer particular components that perform better than the typical, those performance curves may be included for consideration. However, the charts shall take precedence for design flow calculations.

If performance for any particular component is likely to be worse than the losses expected from the data in the charts, then the Bidder shall be obliged to mention this specifically in **the *Chapter 4: Technical Bid Submission Form 1***, and those figures shall then form the basis for the pressure drop calculation.

C.3.8.3. ***Gate & globe valves***

Gate or globe valves shall be installed to enable servicing and isolation of main components. See ***Schedule of Drawings: DWG.STR.3: Location of main valves and metering*** for the typical layout:

- at the manometer, to enable removal or replacement, or to enable or disable readings
- between the pump and the water meter, but after the manometer, usually at the borehole head
- at any other locations in the riser and transmission pipe that may be required to facilitate servicing.

All valves shall have the facility to be locked into the relevant open/closed or partially open positions to prevent damage to the system caused by unauthorised tampering or inadvertent valve closure.

Valves shall be selected with minimum K factor in open position to minimise dynamic head losses.

C.3.8.4. ***Non-return valves***

All external non-return valves should be of stainless-steel material, and further the plastic check valves offered as integral to some centrifugal pumps should be replaced with stainless-steel types.

In general, non-return valves are supplied integral with the specific pumps that require them to optimize performance. This is usually where the pump type is such that backflow can occur, i.e. certain submersibles. The issue is most important to system efficiency in instances where large volumes are water are stored in the riser and transmission pipes. See ***Schedule of Drawings: DWG.STR.3 Location of main valves and metering*** for the typical layout.

- A non-return valve is to be located as close to the pump outlet as is practically possible to minimise daily backflow losses.

Valves shall be selected with minimum K factor in open position to minimise dynamic head losses.

C.3.8.5. ***Pressure-relief valves***

In general, pressure relief valves are not required. However, at sites where control/globe or gate valves have been installed in combination with sensitive diaphragm pumps, and where sudden closure of such valves could cause pump damage, suitable pressure relief valves are to be installed at the control/gate valve inlet.

Further, at sites where water freezing is a possibility, positive displacement pumping systems must be installed with an additional, suitably rated pressure relief valve fitted to the pump to prevent damage to the pump in the event of pipe freezing. See ***Schedule of Drawings: DWG.STR.3. Location of main valves and metering*** for the typical layout.

C.3.9. Water-Meter

C.3.9.1. *General*

The water meters shall be a flow totaliser of a mechanical nature. The meter shall be robust and protected against external damage by a suitable cover. It shall be constructed of suitable corrosion resistant materials against internal damage. Water quality tests (see ***Project Specification***) are to be considered in this regard.

The water meter at borehole head shall be pulse output type, compatible with logging system.

C.3.9.2. *Accuracy and resolution*

Diameter to be as per pipework, and to minimise pressure losses.

The meter should be operational relative to the *design flow rate* in the pump systems.

- Q_{min} < 2% x design flow,
- Q_t (transitional) > 10% x design flow
- Q_n < design flow < Q_{max} , where Q_{max} >150% x design flow

Where

Q_n	is the designated flow of the meter
Q_{max}	is the maximum flow with maximum permitted error
Q_{min}	is the lowest flow within maximum permitted error
Qt	is the low at which maximum error changes

In general a Class B meter will suffice. The accuracy of the meter shall be at worst

- 5% at Q_t
- 2% at Q_n

C.3.9.3. *Dynamic-head pressure drop*

Valves shall be selected with minimum K factor in open position to minimise dynamic head losses.

Refer to ***Schedule of Tables: 3 (a,b) Pressure losses through pipe fittings***

C.3.10. Manometer Pressure Gauge

C.3.10.1. *General*

The pressure gauge shall be a manometer type. The manometer shall be robust, suitable for outdoor use, and protected against external damage by a suitable cover. It shall be manufactured from suitable corrosion resistant material against internal damage. The gauge shall be operational over the entire pressure range of 10% of total head to 150% of the design head.

C.3.10.2. *Accuracy and resolution*

The accuracy of the meter shall be 3% at 10% of the design head. Full scale of the meter shall be no more than 150% and not less than 120% of the design head.

C.3.10.3. *Installation*

The unit shall be installed on a T-piece and shall be isolated from the system by a gate or globe valve. The meter shall be located as close to the pump as practical. Refer to ***Schedule of Drawings: DWG.SR.3 Location of main valves and metering*** for the typical location.

C.3.11. Borehole /Well Head

The borehole /well head is to be closed with a concrete plinth and lockable baseplate. The baseplate is to be galvanised, and have an attachment for the submersible pump safety cable.

At the borehole head, a bore-cap or base-plate, to be used to support the weight of the entire submersible installation on the borehole head. The entire baseplate is to be sealed with protection for the pump power cable against chafing.

C.3.12. Supplementary Water Storage Tanks

Any supplementary storage required shall be high quality UV-resistant polyethylene, similar to Kiboko^{TM} or SimTank^{TM} tank, and each additional tank shall be of minimum volume 10,000 litres.

The supplementary tanks shall be stored adjacent to the main storage tank. They shall be installed at a level so that the useable supplementary volume required in the specification is achieved by simple interconnection to the main storage tank (without any additional controls). All necessary interconnections to main storage shall be provided.

Additional earthworks or structures required shall be provided by the supplier under change-order after Inception Visits. Should additional supplementary storage tanks be required due to achieve the specified usable supplementary storage volumes, then these shall be treated as change-orders after Inception Visits.

Water tanks shall be supplied and installed on 6m tall steel stand structure (for purposes of bidding).

NB: The tank steel stand structures for Tana River shall be 9m tall.

C.3.13. Chlorinator

Prime cost pricing for component similar to *WaterMissions^{TM} Potable Water Chlorinator* to be provided in ***Chapter 4: Technical Bid Submission, Form 4.3 BoQ for Additional works***.

The chlorinator(s) shall be installed adjacent to the main storage tank on the incoming water main. It shall be installed in a shaded environment protected out of direct sunshine and protected from elements, and from tampering. All necessary interconnections to water main shall be provided. The manufacturer’s installation requirements shall be followed and it shall be accessible for operational adjustments.

C.3.14. Diesel Generator Installation

All diesel generators shall be installed on a concrete plinth, under cover and protected from elements, in a secure and lockable building or security enclosure. The exhaust shall be vented direct to outside the building. This is in addition to their enclosed canopy. Also, provide additional storage fuel tank -100 Litre minimum capacity, rectangular mild steel complying with requirements of BS 799: part 5.

C.3.15. Cables, Wires and Electrical Connectors

C.3.15.1. *General*

All external wiring, cabling, insulation material and junction boxes must be UV-resistant and terminals protected against dust and moisture (IP rating: 54). Refer to ***Schedule of Tables:4. Degrees of protection provided by enclosures***.

With the exception of steel wire armoured (SWA) cable, or array cables, no exposed wiring shall be permitted. Submersible pump cable shall be not be exposed except within the borehole. All wiring shall be inside galvanised conduit, galvanised kick-pipes, within junction boxes or control cubicles. The wiring installation shall be both physically robust against bumping and tugging, and electrically robust.

All wiring and connectors should have a design lifetime of 20 years.

All wiring shall be colour-coded and/or labelled, as follows:

- DC circuits
  - Red = positive (however PV single conductor cable wiring can be black)
  - Black or blue = negative
  - Green-yellow = earth
- AC 1-phase circuits
  - Red only = live
  - Bluek only = neutral
  - Green -yellow = earth
- AC 3-phase circuits
  - Brown = L1
  - Black = L2
  - Grey = L3
  - Blue = neutral
  - Green-yellow = earth

In addition, where a mix of AC and DC circuits are used within any enclosure or building, the circuits shall be clearly labelled on each wire.

C.3.15.2. *Electrical connectors and cable-ends*

All wiring must be neatly done and secured by means of appropriate fasteners at regular intervals. Wiring lengths shall be sufficiently looped to allow ease of connection and disconnection in the case of component replacement, and for maintenance.

Conductor lugs should be used to terminate all wiring. Lugs and connectors should be crimped or soldered, and mechanically and electrically sound. Critical connections of less than 16A connections may be made using terminal blocks. Higher current DC connections shall be ferruled.

Any wiring connections (with the exception of borehole or underground connections), whether internal, external, high voltage or low voltage shall be inside accessible junction boxes.

Borehole connections and underground connections shall be avoided by using correct wiring lengths, but where they cannot be avoided then they shall be made using recognised and approved wiring splicing kits.

C.3.15.3. *Junction boxes*

All junction boxes shall be rated to IP54 with bottom entry glands. They shall be located to facilitate inspections with sufficiently long wiring loops.

Any medium and high voltage junction boxes shall be labelled as such, and shall be lock-able or accessible only with a special key. These junction box shall be also be clearly numbered, and shall include a relevant wiring diagram inside the lid or the wiring shall be clearly numbered, and cross-referenced to the 'as-built' drawings.

C.3.15.4. *Underground cables*

All buried cables shall be steel wire armoured (SWA). Any underground cable connections must be approved watertight corrosion resistant types.

Cables crossing roads or driveways should be protected by steel or concrete pipes buried in the ground, or suspended by brackets and strain reliefs at a suitable height above the ground.

- Wires must be clearly labelled with the circuit number at each end
- Underground cable runs to buried 600 mm below ground level.

C.3.15.5. *Submersible pump/motor cables*

Underwater joints in submersible cables shall be avoided Where they are used, they are to be of high quality, using splicing kits rated for this purpose and with an extended lifetime.

Submersible cables are to conform to *EN 50525-2-21 and VDE 0298-300* standards.

C.3.15.6. *Wiring losses and allowed voltage drops*

Wire gauges shall be selected to minimise energy losses or system performance problems through wire degradation.

Source circuits

> (i.e. array - power conditioning) shall be designed to limit round trip voltage drops between array junction-box and power conditioning terminals to 2% of the nominal wiring voltage for peak array current ratings at 25°C ambient temperature and 1,000 W/m^2 solar radiation. Voltage drops to include connector losses. (Voltage drop would be the difference between voltages measured simultaneously at the array junction box (positive and negative) and power conditioner input (positive and negative)).

Load circuits

> (i.e. power conditioning - motor) circuits shall be designed to limit round trip voltage drops between power conditioning terminals and the motor to 5% of the nominal wiring voltage for full load current ratings. Voltage drops to include connector losses.

The cables shall be insulated copper wires. The minimal cross section shall be

$$S = \frac{0{,}023 * L * I_m}{V * \Delta V\%}$$

where

S	is the cable cross section area ($mm^{2)}$
L	is the one-way cable length for a single cable (m)
Im	is the maximum current (A)
V	is the nominal voltage of the appliance (V)
ΔV%	is the maximum allowed voltage drop (%)

Notwithstanding the above calculations, the minimum wire size requirements below shall apply.

C.3.15.7. ***Wiring types and specific installation requirements***

The following minimum wiring guidelines shall apply, over and above the previous requirements:

All cables exposed to outdoors shall be UV resistant sunlight, damp and heat resistant.[1]

- ***PV module interconnection:*** *'Flexible multi-strand copper single conductor cables in flexible UV resistant sheath (e.g Neoprene) compatible with gland seals'*. Minimum $2.5mm^2$ XSA conductor
- ***Array (JB) to Power Conditioner/Control Cubicle:*** *'Flexible multi-strand copper conductor, with single conductor in flexible UV resistant sheath (e.g. Neoprene), with polarity indication'*. Minimum $4.0mm^2$ XSA conductor [Preferably installed within galvanised conduit for protection].
- ***Power conditioner/control cubicle to surface pump:*** either
    - *Steel Wire armoured* **(SWA):** 'high conductivity stranded plain copper conductors, insulated and coded with general purpose PVC; insulated cores are PVC bedded and SWA and PVC sheathed*'. Minimum $2.5mm^2$ XSA conductor*
      or
    - *Correctly rated wire within galvanised conduit:* 'high conductivity stranded plain copper conductors, insulated and coded with general purpose PVC*'. Minimum $2.5mm^2$ XSA conductor, installed within galvanised conduit.*
- ***Submersible pump cable:*** '*high conductivity stranded plain copper conductors, insulated and coded with general purpose PVC; insulated cores are PVC nitrile sheathed, water resistant*'. Minimum $3.0mm^2$ XSA conductor
- ***Power conditioner/control cubicle to submersible pump:*** either
    - SWA with junction box at borehole head changing to submersible pump cable: ***SWA:*** '*high conductivity stranded plain copper conductors, insulated and coded with general purpose PVC; insulated cores are PVC bedded and SWA and PVC sheathed*'. Minimum $2.5mm^2$ XSA conductor
      or
    - Submersible pump cable protect in galvanised conduit buried underground.
- ***Sense cables (remote water level switch at sump or primary storage):*** Any underground cable runs SWA with junction box connection to level switch cable. ***SWA*:** '*high*

conductivity stranded plain copper conductors, insulated and coded with general purpose PVC. These insulated cores are PVC bedded and SWA and PVC sheathed'. Minimum 1.5mm^2 XSA conductor.

C.3.16. System Grounding

C.3.16.1. *System equipotential bonding*

As a rule, all metallic parts of the installations must be at the same potential.

The array structures of all systems require grounding. The systems shall be provided with an equipment ground where the PV array metal structure and the roof structure if metal are connected to an earth electrode via insulated stranded copper earth wire 6 mm^2 minimum). The maximum allowable earth cable resistance between array frame and earth electrode shall be 2.0 Ohms, including earth electrode connection (but excluding the earth electrode earth impedance

C.3.16.2. *Electrical earthing*

Neither the positive nor the negative DC conductors are grounded.

C.3.16.3. *Earth electrode*

The maximum earth electrode earth impedance target is 100 ohms. This figure is sufficient to fulfil functions of (i) array lightning surge earth path, (ii) system bonding and equipment protection, and (iii) enable earth leakage device fault tripping.

In sites with high earth contract resistances, then the following additional steps shall be taken towards this target:

- Electrodes shall be buried with activated charcoal or salt to improve contact resistance
- Up to three electrodes may if necessary be inter-connected (OR increased in length) to minimize the earth contact resistance.

No additional steps shall be required hereafter.

C.3.16.4. *Submersible Pump Motor Earthing*

The pump supplier may specify special requirements for submersible pump earthing which are compatible with its power conditioner. The pump itself may not be used as a systems or equipment earth electrode.

The electrical configuration of the power conditioner and its specifications must be checked, together with specific supplier's requirements for earthing. The Bidder shall supply information relating to power conditioner galvanic isolation and internal earthing in the ***Chapter 4: Technical Bid Submission Form 1.2***.

C.3.17. Lightning Protection

C.3.17.1. *Locations Requiring Additional Lightning Protection*

Where there is an increased risk of lightning activity, either direct strikes or nearby lightning strikes which will cause induced surges in cables, then additional protection precautions must be taken. ***Schedule of Tables:5.Lightning ground flash density*** indicate approximate distribution of lightning activity.

If the ***Project Specification*** does not stipulate the level of lightning protection required, then the Ground Flash Density map will apply. Risks of lightning damage to electronic components are serious at locations where the Ground Flash Density is greater than 3.5. For detailed calculations of the actual frequency of strikes expected, refer to http://lightningsafety.com/nlsi_info.html

C.3.17.2. ***General***

The lightning protection devices are not designed to prevent damage caused by direct strikes. Direct strikes will usually be destructive.

However, the lightning protection devices are designed to prevent any voltage spikes induced in buried or overhead wires from reaching any of the system components via the power cable conductors, by offering a controlled path to earth under surge conditions. Lightning surge protection devices are generally placed between the system components and the sources of induced surge. Lightning protection devices are generally located on cables between:

- Array junction box and power conditioner
- Pump power conditioner output and motor
- Control cubicle and float level switches
- Any other any long distribution power or signal cables.

C.3.17.3. ***DC side lightning protection***

DC lightning protection in the form of a SPD Class 2 (using metal oxide varistor and internal deconnection) at the input to the inverters is obligatory as specified in *section C.4.5* as a minimum on all systems, irrespective of PV system size.

More sophisticated power conditioners already incorporate some or high levels of DC and AC lightning protection.

- Class 2 protection requirements
    - if Class 2 devices are contained within the power conditioner, then this protection shall suffice for Class 2 protection.
    - if not included within the power conditioner, then Class 2 protection shall require this external components as per below:

C.3.17.4. ***Additional Protection Requirements (Class 1 & Class 2)***

Class 1 & Class 2 combined protection shall always require this additional protection, and the requirements stated below are in-addition to any internal protection devices.

The following additional protection specifications shall apply unless similar specification protection devices are included and integrated within the power conditioner:

- ***Lightning protected array junction box***: as per specification for External DC lightning protection system (***Section C3.17.5***), and shall be located near the array structure earth point or stud (Class 2 or Class 1&2 as required).
- ***Lightning protected power conditioner DC input*** (often integral to power conditioner): When the power conditioner is located physically far away from the array or separated by

underground cable, then a separate external protection system shall be installed (as for array JB), located near the power conditioner (Class 2 or Class 1&2 as required).

- ***Lightning protected power conditioner AC output*** (often integral to power conditioner): (Class 2 or Class 1&2 as required).
- ***Lightning protected earth point at motor or wellhead***. Any long power cable runs between power conditioner and borehole head shall be separately protected, (as for relevant DC/AC lightning protection), in a junction box located at the wellhead for submersible pumps (Class 1 or Class 1&2 as required), or at surface motor earth point.

Refer to ***Schedule of Drawings: DWG.SCH.5: Lightning protection system for PV pumping system*** of a complete lightning protection system.

C.3.17.5. *Specifications of the Lightning Protection System*

External DC lightning protection systems (array junction box)

As per ***Schedule of Drawings: DWG.SCH.6. Over-voltage protected circuitry for junction box for DC circuits***,

Device breakdown voltage to be maximum of 5 times the nominal wire voltage.

- Class 2 protection lightning surge arrestors with visual fault indication, 25kA according to IEC 61643-1 for sensitive electronics, clamping voltage to less than 1,500V. Similar to *SALTEK™ PV 500V Class 2, or Cirprotec™ PSM3-40/600PV Class2*
- Class 1 protection lightning surge arrestors with visual fault indication, 25kA according to IEC 61643-1 for sensitive electronics, clamping voltage to less than 1,500V. Similar to *Cirprotec™ PSC3-12.5/600PV Class 1&2.*

AC lightning protection systems

As per ***Schedule of Drawings: DWG.SCH.7. Over-voltage protected circuitry for junction box for AC circuits***, . Device breakdown voltage to be maximum 5 times the nominal wire voltage.

- Class 2 protection lightning surge arrestors with visual fault indication, 25kA (8/20) according to IEC 61643-1 for sensitive electronics, clamping voltage to less than 1,500V. Similar to *Dehnguard™ Class 2 952110.*
- Class 2 protection lightning surge arrestors with visual fault indication, 25kA (8/20) according to IEC 61643-1 for sensitive electronics, clamping voltage to less than 1,500V. Similar to *Dehnguard™ Class I&2 951110.*

C.3.18. Safety Signs, labels and Notices

C.3.18.1. *General*

Industrial quality signs shall be used, complying with the general requirements of *ISO 3864-2: 2004*.

In particular, all signs, labels and notices are to be made of weather resistant material and shall be properly secured by means which will not decay with moisture or sunlight over the period of the system lifetime.

Signs shall be of a size that they can be easily read, and shall make use of good use of colour for clarity, and shall follow the SABS guidelines for use of colour.and shapes. Refer to ***Schedule of Tables:6(a,b,c,d) Safety sign conventions*** for an extract from the *ISO 3864-2: 2004* documentation.

While standard industrial signage may be available, the exact meaning of the sign shall be accessible and appropriate to the level of understanding of the operators and persons likely to come into contact with the system. If necessary, modified signs shall be developed using the general guidelines for shapes and colours.

Samples of all signs, labels and notices shall be available for inspection, discussion with and approval by the Purchaser prior to manufacture.

C.3.18.2. ***Signs Required***

The following mandatory signs are to be attached in the relevant places:

Danger /warning signs

- **Electrical Danger - High Voltage DC!** Signs located on power conditioner and any DC junction boxes where voltages are 100V DC or above. The system voltage is to be clearly displayed inside the cover of the junction box.

Electrical safety information

- Separate trunkings shall be used for DC cables, AC cables, and instrument or communication cables. These trunking shall be clearly labelled.
- All cables inside junction boxes, enclosures and trunking are to be numbered, and the numbers shall cross-refer to the wiring diagrams.

Prohibition signs

- Clear signage shall be displayed to caution against any specific instances where action may cause damage or injury. For example: if sudden valve closure may damage the pump; or if extreme high pressure water may be released; or if change-over from solar to diesel generator requires specific cautions.

Instruction signage

A single A4 sheet shall be posted to describe each of the following operations:

- Emergency switch off procedures
- Basic start-up procedures
- Change-over from solar power to diesel generator back-up (where relevant)
- Daily and weekly reading and measurements

Information signs

- General notice: regarding information around the pumping system implementation: i.e. Community name, date, funding agency, implementation agency.
- Installation contractor: A notice with the local pumping system agent contact details and the installers contact details if different (including contact person, telephone number and postal address) must also be suitably located on the system.
- Wiring connection diagrams are to be attached inside main enclosures, and in the manuals.

Safety signs

- **First aid signage**, shall be displayed if appropriate, including treatment for electrical burns and shock if system voltages are over 220V in any location.

Additional signage may be required for specific systems or installations.

C.3.19. Compliance with Regulations and Codes

The entire contract must be carried out in accordance with the latest revisions and amendments of the following:

- *IEC 60364-1:2005,Low voltage electrical installations*, and the latest amendments.
- *IEC 60364-9-1: Low-voltage electrical installations - Part 9-1: installation, design and safety requirements for photovoltaic systems (PV).*

C.3.20. Maintenance kits

The supplier shall supply:

- 1 x (one) complete maintenance kit for each site.
- 1 x (one) engineer maintenance kit for LOT

The kits shall include the minimum components listed below. Please refer to ***Chapter 4: Technical Bid Submission Form and BoQ form 4.5***:

Table 3: Maintenance kit components

		Maintenance per LOT engineer	**Maintenance kit per site**
		Qty	**Qty**
Item	**Description**		
Laptop	Refer *Tech form 1.7*	2	0
Digital clamp . Multi-meter	(minimum range 0-600V DC, 0-300 V AC, accuracy min 1%, 0.01V resolution)	1	1
Current clamp meter	(range 0-40A, accuracy 1%, resolution 0.1A for AC and DC 40 A, including thermocouple and leads. Recommended model: TCM 02 DC/AC clamp meter – 600 VDC	1	1
Basic tool kit	Including set of insulated screwdrivers to fit all terminals on DIN rail/inverter/power conditioner; small/narrow pliers, wire cutters/strippers, crimp tool with set of lugs, insulating tape, etc.	1	1
Stop watch	Digital	0	1
Step ladder	to reach solar array	0	1
Solar PV Analyser	(range 0-20A, 1000 VDC. Direct MC4 connector fill factor measurement, ground continuity measurement PV string short circuit/ open circuit, memory for records with USB download for PC, instant data transfer using mobile app & have an Eye contrast display screen	1	0
Water bucket		0	1
Squeegee	to clean solar array	0	1
Marker pens		0	5

C.4. Component Technical Specifications and Standards

These specifications and standards provide the overall specifications for main components and materials supplied within the bid. Individual components must comply with the technical specification and technical standard(s) indicated in the sections below (*sections C.4.1 to C.4.5*).

Specific technical details regarding the solar PVP systems minor component are set out in ***Section "C.3. Code of Practice for Installation"***.

C.4.1. Accredited Laboratories

Individual components must comply with the technical specification and technical standard(s) indicated in the sections below (*sections C.4.2 to C.4.5*).

The systems and components to be used under this procurement, must have valid test certificates for their qualification as per specified IEC or equivalent standards[2], from ISO 17025[3] certified or equivalent accredited test center. An accredited test center is one of (a) Test Center accredited by ILAC Full Member or Associate (b) one of National Accreditation Board for Testing & Calibration Laboratories (NABL)-Accredited Test Centers in India; (c) one of the China National Accreditation Service for Conformity Assessment (CNAS)-Accredited Test Centers in China; (d) laboratories under the Hydraulic Institute Pump Test Laboratory Approval Programme. ***A copy of the accreditation certificate issued to the Test Center authorizing it to conduct and certify the specific tests in the standard under consideration must be provided[4].***

C.4.1.1. *IEC Standard certificate*

In general the full standard of the International Electro-technical Commission (IEC) is applied. Specifically, a certified quality test certificate is required from an accredited testing and certification organization acceptable to the Purchaser to confirm that the specific model of products or components offered complies with the entire referenced technical standard, based on the sampling approach of that technical standard.

- A certified copy of the **component's Compliance Certificate** shall be required from the ISO17026 accredited Certification Body corresponding to the accredited Test Center.
- A copy of the **Test Center's accreditation certificate, to conduct and certify the specific tests in the standard** under consideration must be provided.
- Detailed test results may be requested for the specific tests in the standard.
- This form of accreditation is required for the following components only:
    - PV modules - all certificates
- This form is but is also accepted for all required component certificates as below:

[2] The equivalence is to be provided by the bidder in order for the equivalence standard to be acceptable. Examples of equivalent standards include those under BS, IS, DIN, IECEE etc,

[3] ISO/IEC 17025:2005 - General requirements for the competence of testing and calibration laboratories.

[4] Certification Organisation links:
- http://ilac.org/about-ilac/
- http://www.nabl-india.org/index.php?option=com_content&view=frontpage&Itemid=123, https://www.cnas.org.cn/english/index.shtml

  - Power conditioner / inverters /converters (Safety; Efficiency / performance; Noise and emissions)
  - Pumps and motors (Safety; Performance characterisation)
  - Monitoring systems (Performance)

C.4.1.2. ***Test result certification based on testing to partial IEC standard, without Certification***

The testing of components in ISO17025 certified laboratories to the full IEC standard using the required sampling is both time-intensive and expensive. Therefore provision is made for testing to only the relevant parts of the standard. Certified test results are required from an accredited testing and certification organization acceptable to the Purchaser to confirm that the specific model of products or components offered have been tested to referenced test procedure in the standard, based on the sampling approach of that technical standard.

- A copy of the **Test Center accreditation certificate, to conduct and certify the specific tests in the standard** under consideration must be provided.
- Detailed test results shall be provided for the specific tests conducted in the standard for all the samples tested.
- This form of accreditation is acceptable for the following component certificates only:
  - Power conditioner / inverters / converters
    - Safety, Efficiency / performance, Noise and emissions
  - Pumps and motors
    - Safety, Performance characterisation
  - Monitoring systems
    - Performance

C.4.1.3. ***ISO9001 In-house certifications based on in-house R&D test results***

The testing of components in ISO17025 certified laboratories to the full IEC standard using the required sampling is both time-intensive and expensive. In addition many manufacturers perform rigorous in-house testing of their components before going to market. Therefore the ISO9001 Declaration of Compliance Form was developed to qualify components of ISO9001 certified manufacturers which are tested in their in-house ISO9001 research and development laboratories, to either full or partial standard. The ISO9001 Declaration certificate may only be used for components manufactured by ISO9001 company, AND tested to the relevant full standard (or partial standard procedures) referenced in the bid document. The Declaration must be supported by the test results for all the samples tested.

- See ***Section IV: Bid Forms: Statement of Compliance for Components by ISO 9001 Certified Manufacturer*** .
- Proof of the manufacturer's ISO9001 accreditation from an approved accreditation agency is required.
- **Proof of competence of the manufacturer's testing facility**: its existence, equipment and equipment calibrations, staffing, and suitability to undertake the specific tests. This competence shall preferably be **via inspection and reference from a National Certification Body**[5].
- Presentation of detailed **supporting test results** is required for all samples tested, complemented by reference to the standard test method or detailed alternative **test**

methodology where standards do not exist, and supported by an **inventory of test equipment** used.

- This form of accreditation is acceptable for the following component certificates only:
  - Power conditioner / inverters/ converters
    - Efficiency, performance
  - Pumps and motors
    - Safety, Performance characterisation
  - Monitoring systems
    - Performance

Bidders must submit detailed documentation for each component proving that the products offered comply with the technical standards via one of the means set out above. Products or components that do not comply with any of the above quality certification requirements will not be acceptable.

C.4.2. Photovoltaic (PV) Modules

C.4.2.1. ***Certification standards***

Compulsory certifications for crystalline modules:

- *IEC 61215 (2005-04): Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval*
- *IEC 61730-1:2016: Photovoltaic (PV) module safety qualification - Part 1: Requirements for construction and related test method in Part 2.*
- *IEC 61701 Ed.2: Salt mist corrosion testing of photovoltaic (PV) modules*

PV modules shall meet the following requirements:

C.4.2.2. ***Particular requirements***

a) The photovoltaic (PV) array shall consist of mono-crystalline or poly-crystalline modules. Note that thin film modules are not acceptable.

b) High-power high-voltage modules are favoured over low power low-voltage modules

c) Only a maximum of two standard size of module (one manufacturer) shall be used to facilitate spares and parts management.

C.4.2.3. ***General requirements***

a) All PV modules within an array shall be of the same type and hence interchangeable.

b) Each module must be factory equipped with 14 to 12 AWG (2.0 to 4mm^2) fly-leads length approximately 800mm with weather-proof connectors for interconnection of modules into strings without any additional wiring. There are a multitude of professional PV array quick connectors available for array fly-leads cables in the 2-4mm^2 range, for example Multi-Contact™, Tyco™, SunClix™. The connectors shall have the following features:

- Class II rating for fly-leads and connectors
- system voltage 1,000V maximum,
- IP65 protection rating
- temperature up to 90^{o}C
- 20A current rating
- 2.5-4mm^2 cables

- Snapping locking system

c) The module framing should be such that it permits secure connection to the mounting structure, prevents edge damage and has the longevity to withstand environmental factors for the duration of the module warranty period.

C.4.2.4. ***Electrical performance***

a) The tolerance of rated output of the PV modules offered shall be positive only. Negative tolerances are not allowed.

b) Module warranty: 25 years: The PV modules shall be warranted to retain at least 80 percent of its nominal rated output measured at STC for at least twenty-five years.

C.4.2.5. ***Labelling and documentation***

a) Labelling: Each module must be labelled indicating at a minimum:
   - Manufacturer, Model Number, Serial Number,
   - Maximum Power Point Watt Rating (Wp ± tolerance),
   - Maximum Power Point Current,
   - Maximum Power Point Voltage,
   - Open Circuit Voltage and Short Circuit Current of each module.

b) The supplier is required to provide for each PV Module offered the following data: Equipment Origin, Type of Certification, and the following general data
   - I-V Curves at AM1.5, NOCT,
   - Electrical data
     - Maximum Power Point Watt Rating (Wp ± tolerance),
     - Maximum Power Point Current,
     - Maximum Power Point Voltage,
     - Open Circuit Voltage and Short Circuit Current of each module.
   - Dimensions,
   - Warranty,
   - Product brochure

c) The supplier is required to provide for each Panel supplied the following test data
   - Flash test information for each individual module shall be provided.

C.4.3. Power Conditioners / Inverters/ Converters

C.4.3.1. ***Certification standards***

The required safety standard:

- *IEC 62109 Safety of power converters for use in photovoltaic (PV) power systems - Part 1: General requirements. Part 2: Particular requirements for inverters.*

Compulsory performance standard:

- *IEC 61683 Ed. 2.0: Photovoltaic systems - Power conditioners - Procedure for measuring efficiency*

For noise and emission the following shall apply:

- *IEC CISPR 22 Radio disturbance characteristics – limits and methods of measurement.*

- *IEC 61000-4-2 Electromagnetic compatibility (EMC) Testing and measurement techniques – electrostatic discharge immunity test.*
- *IEC 61000-4-3 Electromagnetic compatibility (EMC) Testing and measurement techniques - radiated, radio frequency, electromagnetic field immunity test.*

In addition power conditioners shall meet the following requirements:

C.4.3.2. ***Particular requirements***

a) Variations of *power conditioning* equipment are applicable to solar water pumping, including those listed below. Whichever power conditioning is offered, it shall be well matched with the array and motor such that overall system efficiency is maximised.
   - DC systems: linear current boosters, sometimes included within each module terminal box
   - DC/AC inverter, variable frequency inverter, either single phase or three phase
   - Maximum power point trackers (MPPT), often used in conjunction with inverters
   - Stand-alone programmable variable speed drives (VSD)
   - Powerpack converters: allowing automatic changeover between DC solar array power and AC diesel generator power; or simultaneous parallel operation from both DC solar arrays and AC diesel generators for sites with existing generators.

b) Power conditioning should maximize water delivery, dealing with pump start-up torque requirements, and should start pumps early in the day even in inclement weather conditions. Inherent inefficiencies in the power conditioner through the day should be offset by the gains made in early pump starting and water delivery.

c) The electrical outputs of the power conditioner shall preferably be fully galvanically isolated from the DC. The state of galvanic isolation between power conditioner input and output shall be declared in the ***Chapter 4: Technical Bid Submission Form 1.2***.

d) Power conditioners shall be capable of operating the solar pump from diesel generator power as back-up, either directly or via additional componentry, without reprogramming of the power conditioner. Simultaneous solar power and diesel operation is not required.

e) Only one brand of each power conditioner type shall be used to facilitate spares and parts management.

C.4.3.3. ***General requirements and electrical performance***

a) Rated output power (kVA) shall be at temperature of at least 25^{o}C

b) High conversion efficiency devices are required with the following minimum requirements when measured according to *IEC 61683 Ed. 2.0: Photovoltaic systems - Power conditioners - Procedure for measuring efficiency*. The conversion efficiency shall be supplied.

c) Easy to service: easy to repair or replace in the field by the service technicians.

C.4.3.4. ***Electrical protection***

a) Protection must include at least the following sustained normal conditions without cut-out:
   - output current overload and starting surge capacity before cut-out (300% of maximum capacity for 20 seconds is desirable, or soft-start ability,
   - maximum array open circuit voltage on the input terminals (cold clear weather) - normal operation without cut-out

b) Protection must include at least the following sustained fault conditions without damage:

- output current overload - sustained fault condition
- short circuit on input or output terminals - sustained fault condition
- under-or over-voltage conditions - sustained fault condition
- lightning-induced surges on all or any input or output terminals: all terminals subject to common and differential mode surges of 5kV for 50 micro-seconds.
- electronic overload/cut-out above 200% of the rated output and short-circuit protection on its output. A fused output is not acceptable.
- reverse polarity protection on DC input terminals.
- thermal overload protection.
- protection against N-E and L-E grounding downstream of conditioner.

C.4.3.5. *Noise and emissions*

a) Quiet operation: Acoustic noise generated by the inverter shall not exceed 35 dBA at a distance of 1m from the power conditioner under all loading conditions.

b) Electromagnetic interference: The power conditioner shall not cause conducted or radiated e.m.i. over the entire power range at a distance greater than 1m, when measured according to the requirements of IEC CISPR 22 for class B and IEC 61000-4-3.

c) Electrostatic discharge: The inverter shall comply with the requirements of the test procedures given in IEC 61000-4-2.

C.4.3.6. *Documentation and labelling*

a) Each power conditioner / inverter must be labelled with the minimum information:

- Manufacturer name and model
- Serial number
- Input and output voltage and rated power
- Array, supplementary power and load connection points and polarity

b) The supplier is required to provide the following data for each power conditioner offered:

- System rating (kW/kVA) with temperature de-rating curves/tables
- Input Voltage (DC) range for solar
- Supplementary input range (V, kW) for generator/grid
- Output Voltage (DC/AC)
- Output Frequency and Waveform
- Efficiency versus Power output graph
- Warranty
- Product brochure

C.4.4. Electric Pump & Motor

C.4.4.1. *Certification standards*

The required performance tests standards are one of

- *IEC 62253 Ed.1: Photovoltaic pumping systems - Design qualification and performance measurements*
- *ISO 9906: 2012: Rotodynamic pumps – Hydraulic performance acceptance tests – Grades 1, 2 and 3*
- *ANSI/ HI 14.6: 2011: Rotodynamic pumps for hydraulic performance acceptance tests (*Hydraulic Institute of North America)

- *ANSI/HI 11.6:2012: Rotodynamic* submersible pumps for hydraulic performance, hydrostatic pressure, mechanical, and electrical acceptance tests. *(*Hydraulic Institute of North America)

  The required safety standards are one of

- *IEC 60034-18-41: Rotating electrical machines - Part 18-41: Partial discharge free electrical insulation systems (Type I) used in rotating electrical machines fed from voltage converters - Qualification and quality control tests*
- *IEC 60034-18-42: Rotating electrical machines - Part 18-42: Partial discharge resistant electrical insulation systems (Type II) used in rotating electrical machines fed from voltage converters - Qualification tests.*

  In addition the motor/pumps have to meet the following requirements:

C.4.4.2. ***Particular requirements***

a) The motor/pump performance should match the system head/flow characteristics for optimum system performance.

b) The motor/pump at system design operating point, must have capacity for production of at least 15% more water by application of additional power to the motor. Motor/pump should be sized to handle the maximum power that can be produced by the array and power conditioning, plus at least 15%.

c) Any motor types are allowed provided that they meet system performance and system maintenance requirements.

d) Any pump types are allowed provided that they meet system performance and system maintenance requirements.

e) Only one brand of motor and one brand of pump shall be used to facilitate spares and parts management. Additionally the number of models should be minimised: a maximum of 5 models or sizes each of motor and pump is allowed. (Bidders which cannot meet the system performance requirements without introducing additional models should clearly state so in their offer (in the ***Technical Bid Submission Form***), and should also tabulate the models of motor/pumps offered and number for each.)

C.4.4.3. ***Mechanical requirements***

a) Submersible motors shall be constructed of corrosion resistant materials suitable for permanent total immersion in water. In general, stainless-steel pump shall be used at a minimum (EN/DIN 1.4301 or AISI 304). Water quality tests (see *Project Specification*) are to be considered in this regard. In high water salinity (>1,000 ppm Cl) and high water temperature (> 20^{o}C) environments then stainless steel of EN/DIN 1.4401 / AISI 316 and even EN/DIN 1.4539 / AISI 904L shall be used.

b) Surface mount motors shall be to at least IP43 ratings against water, sand and dust penetration and damage. Surface motors shall be corrosion resistant, both the casing and windings shall be treated, and any flow of moist corrosive air shall not cause expansion of windings into the stator.

c) Motors/pump units should be constructed such that any failure of a pump component (diaphragms etc) does not cause damage to the motor.

d) The casings of both surace and submersible motors shall have earth points suitable for bonding to other equipment. The motor shall be fully electrically isolated from the casing.

e) The expected motor and pump lifetime shall be declared.

f) Pumps / motors requiring regular routine and preventative maintenance, such as brush replacement on DC motors, or diaphragms on some positive displacement pumps, should have maintenance requirements are to be specifically noted in the ***Chapter 4: Technical Bid Submission Form 1.3 and Appendix 2, and recommended spares in Appendix 3***.

g) Pumps shall be able to handle up to 5% suspended solids (50mg/litre) without damage and should have a 1mm screen around the inlet. Water quality tests (see ***Project Specification***) are to be considered in this regard, for up to 15% suspended solids (150mg/litre). To minimise the effects of silting and wear of impellers on system performance, impellers should generally be manufactured from stainless steel, rather than from plastic/elastomer, but where necessary FKM rubber wear rings may be specified to achieve the long life. In all cases, impellors are to be changeable as they wear, preferably in the field.

h) Submersible pumps must be able to operate at different submergence levels, since seasonal groundwater level variations can be significant in some parts of the country. Exact maximum depth of submergence is specified in the ***Project Specification***.

C.4.4.4. ***General requirements and electrical performance***

a) Pumps are to be high efficiency with certified performance curves (***Section C.2.11.3, C.2.11.4 and C.2.11.5)***

b) Variable speed pumps or with soft-start are preferred.

C.4.4.5. ***Electrical protection***

a) Running dry protection shall be provided, and the motor shall not restart until the motor/pump/inlet is again fully submersed as required. Indicator lights on the control cubicle shall be provided showing that the dry-running cut-out is effective. Refer also to ***Section C.3.6 High & Low Level Cut-out relays.***

b) Pump / motor protection must include at least the following sustained fault conditions without damage:

- output current overload - sustained fault condition
- short circuit on input or output terminals - sustained fault condition
- under-or over-voltage conditions - sustained fault condition
- lightning-induced surges on all or any input or output terminals: all terminals subject to common and differential mode surges of 5kV for 50 micro-seconds.
- Electronic overload/cut-out above 200% of the rated output and short-circuit protection on its output. A fused output is not acceptable.
- reverse polarity protection
- thermal overload protection.
- protection against N-E and L-E grounding downsteam of conditioner.

C.4.4.6. ***Documentation and labelling***

a) Each pump / motor must be labelled with the minimum information:
- Manufacturer name and model
- Serial number/barcode
- Input voltage and rated power

b) The supplier is required to provide for each motor offered the following data:
- Rating (kW/kVA) with temperature de-rating curves/tables
- Input Voltage (DC/AC) range
- Certified motor and pump performance curves (***Section C.2.11.3, C.2.11.4 and C.2.11.5)***

- Warranty
- Product brochure

C.4.5. Remote Monitoring, Data-Logging and Remote Control

C.4.5.1. *Certification standards*

The required standard is:

- *IEC 61724 Ed 1: PV System Performance Monitoring Guidelines for measurement, data exchange and analysis* (to be superseded by Ed 2).

C.4.5.2. *Introduction*

The facility to remotely monitor PV pump system operational status is a significant advantage when operating multiple pumps in remote locations. Further, developments in electronic data-interfaces and improved cellphone internet coverage make this a totally achievable goal.

There are five levels of system monitoring and tiers of data access required are:

Local display

1. ***On-site display for user & operator interface***
    - Overall real-time display of system status and energy and power flows, across major components groups and too loads
        - PV generation (total)
        - Dieel generation)
    - Real-time current operational status / error notificaions
    - Access to individual electronic components, paramerters, performance and error-codes.
    - Historical trends data-logging of key performance parameters and operational status
    - Password protection “View access” and “Control access” tier accreditation required

Remote Access

2. ***Dashboard providing remote overview for <u>all sites:</u>***
    - Web-based interface (compatible with 2G coverage)
    - Overview of all sites with operational status, key parameters, and any error warnings.
    - Ideally compatible with AMMP^{TM} or Odyssey^{TM} or similar.
    - “Overiew access” tier accreditation required
3. ***Detailed performance remote access for <u>each site:</u>***
    - Drill down access via Dashboard to each site
    - Remote real-time monitoring of current operational status and some performance parameters
    - Historical trends data-logging of key performance parameters and operational status
    - API accessible to AMMP^{TM} or Odyssey^{TM} or similar.
    - On-site display for operator interface

- Password protect "View access" and "Control access" tier accreditation required

4. ***Detailed remote status for <u>each component:</u>***
    - Drill down access from each site to each sites's component
    - Access to individual electronic components, paramerters, performance and error-codes.
    - "Site access" tier accreditation required, password protected.
5. ***Remote control***
    - If provided, shall be "Control access" tier accreditation required, password protected.

This section describes each of these, as well as the minimum parameters required to be useful.

It is noted that different PV pump manufacturers have different approaches to remote data monitoring, and so the specification if intended to be non-prescriptive, but to establish set a minimum standard of functional specification.

C.4.5.3. *C.4.5.3 Communication*

To enable real time performance tracking of PV system, the required components and transducers shall be provided as a system with an interface to communicate with base station data-logger. Communication between main components and with logger may be via RS485 /Ethernet. The logger shall communicate with the outside world via GSM/GPRS or other cloud-based connection, depending on the available coverage.

The logger shall store data at short time intervals for long time-durations, and routinely upload to a cloud-based server which is easily accessible for data analysis of performance trends.

Ideally data above should be:

- recorded, aggregated at maximum 10 minute intervals, and stored on the on-site logger
- uploaded at least once daily to the cloud based information system, preferably more frequently
- accessible on the cloud-based system at any time.

Integrated hardware systems which provide the transducers and communication interface are to be used.

C.4.5.4. *Remote monitoring and key parameters*

Pump system information may variously include the following outputs in real-time:

- ***Pump status***
    - Pump status (running / waiting/ fail /stopped)
    - Pump electrical power (kW) and other electrical parameters (V,A)
    - Pump speed (rpm)
    - Flow rate (m^3/hr)
    - Pump temperature (^oC)
    - Power source (solar or diesel)
    - Solar irradiation (kW/m^2)
    - Water depth in borehole and drawdown
    - Pump operating pressure (kPA) (optional)

- ***Status indicators***
    - Level control information (water tank full)
    - Alarms
        - Dry running alarm
        - Service needed alarms (overvoltage, overload, over-temperature)
    - Message log

- ***Cumulative performance***
    - kWh consumed (kWh)
    - Water meter reading (cumulative m^3 total delivered)
    - Operating hours (hrs)
    - Number of starts (qty)
    - Cumulative solar radiation (kWh/m^2)
    - kWh generated by solar
    - kWh generated by diesel, and diesel runtimes

This system information should be accessible on web-based system, either on computer software or cellphone App.

These apps also allow remote control of the pump system.

C.4.5.5. ***Transducers***

The logging system shall include all necessary transducers, and shall specifically include the following:

- Water meter of pulse type matched to max flow at borehole head
- Transducer for borehole water depth (hydro-static level sensor 4-20mA, submersible pressure sensor), or equivalent;
    - Units similar to SensorsOne™ units: https://www.sensorsone.com/borehole-water-level-transducer-recharge-rates/ or https://www.sensorsone.com/imcl-low-cost-submersible-pressure-sensor/
- Pressure sensor at borehole head (optional)
- Solar radiation reference cell for instantaneous measurement and integration
- Pump power measurement
- Genset controller (AGS) or interface to determine power source (solar or diesel).

C.4.5.6. ***Historical trends data-logging of key performance parameters and operational status***

The requirement (or not) for off-site historical trend data-logging is specified in ***Project Specification***.

The transducer interface in shall record the short term performance data, and may or may not store much long-term performance data. Ideally performance data should be stored at short time intervals for long time-durations, and routinely uploaded to a cloud-based server which is easily accessible for data analysis of performance trends.

Ideally data above should be:

- recorded, aggregated at maximum 10 minute intervals, and stored on the on-site logger

- uploaded at least once daily to the cloud based information system, preferably more frequently
- accessible on the cloud-based system at any time.

This system information should be accessible via cloud based data, using a dedicated data manager for PV pump performance viewing, for example:

- Lorentz^{TM} PumpManager App.
- Grundfos^{TM} GO App or Grundfos Remote Management (GRM)

The data manager should provide summations to facilitate viewing and comparison of performance data for the key variables over the following time periods:

- Hourly (i.e. compare and see the performance for sequences of several hours)
- Daily (i.e. compare performance for sequences of several days)
- Monthly (i.e. compare months)
- Annual (i.e. compare years)

The data manager should allow tracking of fleets of pumps, providing active reporting of status and problems, which greatly facilitates maintenance planning and remote diagnosis.

C.4.5.7. *Compatibilility, agility & longevity*

The monitoring system for each site shall be provided with a single dashboard enabled for all sites.

Furthermore, hardware and software is be proven and supported for 10 years. Manufacturer to have proven history of long lasting software historical support (5 years historical operation with backward compatibility of versions).

C.4.5.8. *Documentation and labelling*

a) The supplier shall provide information on software data-logging user interface for each pump system:
- Product brochure
- Technical specifications (comms, storage, software requirements, hardware requirements)
- Graphical interface; functional description, variables logged, summations
- Description of custom software requirements for this project
- Web-link to web-portal with demonstration of the features

b) The supplier is required to provide for each hardware logging set the following data:
- Product brochure
- Technical specifications (comms interfaces, data interfaces, power supply options, memory, firmware etc.)
- Operational costs of data transfer
- Warranty

C.4.6. Diesel Generator

C.4.6.1. Certification standards

The required standard is:

- *ISO 8528-1: 2005: Reciprocating internal combustion engine driven alternating current generating sets: Part 1: Application, ratings and performance..*
- *ISO 8528-6: 2005: Reciprocating internal combustion engine driven alternating current generating sets: Part 6: Test methods.*

The required safety standards are one of

- *IEC 60034-18-41: Rotating electrical machines - Part 18-41: Partial discharge free electrical insulation systems (Type I) used in rotating electrical machines fed from voltage converters - Qualification and quality control tests.*

  IEC 60034-18-42: Rotating electrical machines - Part 18-42: Partial discharge resistant electrical insulation systems (Type II) used in rotating electrical machines fed from voltage converters - Qualification tests.

C.4.6.2. Particular requirements

a) Generator performance shall be optimised to match requirements of the pump head/flow and power characteristics. The operational capacity shall include capacity for production of at least 15% more water by application of additional power to the motor from design operating point.

b) Sizing of the generator to meet the starting requirements of the pump controller / pump under design conditions is entirely the responsibility of the Supplier. General rules of thumb include kVA of:
   - 2.5 x pump power for non-soft-start systems
   - 1.5 x pump power for soft-start systems

c) Only one brand of generator shall be used to facilitate spares and parts management. A maximum of 5 models or sizes is allowed.

C.4.6.3. Mechanical requirements

a) Generator is required to include enclosed canopy, electric start with battery, and integrated fuel tank.

b) Casing of generator shall have earth points suitable for bonding to other equipment.

c) Expected lifetime of generator shall be declared, together with service requirements and fuel consumption curves. Local service centre and support.

C.4.6.4. Electrical protection

a) Rated at: frequency 50Hz, voltage 230Vac single phase, or 400Vac 3 phase

b) Generator protection must include at least the following sustained fault conditions without damage:
   - output current overload - sustained fault condition
   - short circuit on output terminals - sustained fault condition
   - under-or over-voltage conditions - sustained fault condition
   - electronic overload/cut-out – fused output is not acceptable.

c) Compatibility with PVP electrical earthing, i.e. Neutral shall be isolated from casing.

C.4.6.5. Documentation and labelling

a) Each generator must be labelled with the minimum information:
   - Manufacturer name and model

- Serial number/barcode
- Output voltage, phases, frequency, rated power

b) The supplier is required to provide for each motor offered the following data:

- Rating (kW/kVA) with temperature de-rating curves/tables
- Warranty
- Product brochure
- Expected lifetime of generator, with service requirements and fuel consumption curves.
- Local service centre and support in Kenya.

D: Technical Specifications: Maintenance Services

The maintenance of the solar PVP systems installed at facilities during the defects liability period is an integral part of the requirements to ensure the full benefits of the systems. Maintenance shall be carried out by the Supplier according to the following GUARANTEED maintenance regimes.

- System performance reporting using remote monitoring
- Routine preventative maintenance
- Breakdown repair maintenance service

D.1. System Performance Tracking Using Remote Monitoring

The Supplier, as part of the monthly routine maintenance, shall monitor the PVP system performance using the remote monitoring software. The supplier shall report on each system monthly as follows:

- System performance tracking and reporting based on the remote monitoring system for each installation. The information shall be reported for
  - each month
  - each day in the month
- Operational statistics to be reported monthly and daily include, but are not limited to:
  - Total water volume delivered
  - Water delivered using solar PVP
  - Water delivered when powered by diesel,
  - Solar hours pumped
  - Diesel hours operated
  - Total insolation
  - System efficiency
  - Average borehole water level
- System performance guarantee: confirmation that the system is operating within the specification for meeting the system performance guaranty, based on the remote data logging.
- Reporting on system performance degradation and suggested interventions.

D.2. Routine Maintenance

Each PVP system should be visited according the following schedule for routine maintenance:

Table 4: Routine maintenance schedule

Routine visit no.	Within Maintenance Period	Outside of Maintenance Period
Maintenance Interval	Every 6 months	Ideally every 6 months, but outside of this scope of works

At each routine maintenance visit, the following actions should be undertaken:

Coordination tasks

- Confirm maintenance visit with responsible WSP/REREC member.
- Meet the responsible WSP/REREC on site
- Check status of the system WSP/REREC member and obtain feed-back on performance since the last maintenance visit.

Technical tasks

- Perform visual inspection – starting with appliances and working back towards the array. Check for corrosion, rust and physical damage to installation.
- Perform measurements of system status and performance – do not disconnect any wires or components, i.e. these measurements must be 'non-invasive' to avoid creating new problems.
- Diagnoses of any problems identified, check all array wiring and all connections, repair of any loose connections, corroded parts, or electrical cabling problems;
- Ensure that array is not shaded and that panel surfaces are clean.
- Check status of all isolating switches and set correctly.
- Checking pump performance wrt irradiation, head, and flow.
- Confirm functionality, calibration and reliability of the remote monitoring system.
- Pulling of pump if recommended in the maintenance schedule of the supplier), and undertaking any maintenance actions
- Check level of spares on site and make replacements as required.
- Replacement of any faulty or damaged equipment.

Administration tasks

- Record status and measurements on the maintenance log sheets
- Obtain signature of the staff member on log sheets
- Complete hard copy documentation
    - Place one copy of the completed log sheet in the O&M manual stored at site
    - Retain one copy of the log sheet for storage at solar PV company office
    - Retain one copy for submission with the annual report to the Purchaser
- Capture the maintenance activity to spreadsheet. This shall include at least the following:
- Dated Maintenance;
    - Verification of system identifier
        - Name of purchaser,
        - System unique number,
        - Region, district, village,
        - Location for verification purposes (i.e. GPS co-ordinate)
    - Items checked
    - Components replaced and new component information:
        - Module type, rating, qty, serial numbers
        - Inverter controller type, capacity, serial number
        - Pump type, capacity, serial number

- In the event of a breakdown, the maintenance tasks will be focused on the specific problem as identified by a fault diagnosis procedure. The maintenance staff must again complete a maintenance log sheet and store a copy both at the site and at the company office.

Training tasks

- Based on communications with WSP/REREC assess staff member understanding and responsibility for systems. Check whether there has been staff change and whether new staffs are on site.
- Provide follow-training to staff as part of the maintenance tasks. The follow-up training should target i) end-users and staff that received the first training and ii) new end-users and staff.

D.3. Breakdown Repair Maintenance Service

Over the course of the Defects Liability Period, a breakdown repair service, defined below, will be available to deal with system breakdowns. Users at each of the solar PVP systems installed in accordance with this scope of work will have access to this breakdown repair service.

During the Warranty Period all callouts shall be unconditionally for the Supplier's account.

Table 5: Breakdown repair maintenance services

Warranty Period (Defects and maintenance)	**Maintenance Period after Warranty period**
As many as necessary, unconditionally for Supplier account	Supplier to budget for breakdown repairs

Breakdowns may be identified through complaint reported through the Fault Report call-center, or via the remote monitoring and reporting of system performance.

Breakdowns and faults are defined and layered in terms of responses required:

Table 6: Breakdown repair response times

Breakdown Type	**Results and impact**	**Response Time for Making Good**
Tier 1: no water delivered at all for one (1) working day, likely due to electrical, mechanical or communication faults with both Solar pump.	No water access for scheme.	24 hours for diagnosis, including remote monitoring. 48 hours after Supplier receives Fault Report.
Tier 2: limited water supply, due to failure of the PV pump system, with reliance on water storage	Failure is limiting and restricting water supply, with dependency on water stirage	5 working days after Supplier receives Fault Report

A response to a recorded enquiry or complaint should be provided within (48) forty-eight hours and the system should be restored to full functional capability within the period specified in ***Table** 6*.

Each logged complaint and notification of system failure shall be recorded by the Fault Report Call-centre, forwarded to Supplier (and copied to REREC), and the actions taken and action time should be recorded using the log sheet provided in ***Section D.5***.

D.4. Maintenance/Breakdown Log Sheets

A pair of templates for maintenance log sheets are presented below for routine maintenance and breakdown maintenance. Three copies of these log sheets must be completed for each system at the time of each routine maintenance or breakdown visit. One copy should be inserted in the O&M manual on site, one should be retained for submission semi-annually to the Purchaser; and the third should be kept by the Supplier.

Table 7: Routine maintenance log sheet

<table>
<tr><td colspan="4">Site details
Customer ID
System ID</td></tr>
<tr><td>Site name:</td><td></td><td>Starting time:</td><td></td></tr>
<tr><td>Date:</td><td></td><td>Finishing time:</td><td></td></tr>
<tr><td>Weather conditions:</td><td colspan="3"></td></tr>
<tr><td>Type of system:</td><td colspan="3"></td></tr>
<tr><td colspan="4">System status on arrival</td></tr>
<tr><td colspan="2">Inverter
Status?
Power output?</td><td colspan="2">Array
Status?
Current and voltage?</td></tr>
<tr><td colspan="2">Pump
Status?
Water output?</td><td colspan="2"></td></tr>
<tr><td colspan="4">Maintenance tasks (tick each box as complete)
☐ Clean PV array and check for damage
☐ Trim vegetation so PV array not shaded
☐ Check for corrosion, rust and physical damage to installation
☐ Check all array wiring connections
☐ Check array earthing connections and continuity *(make check-box for readings)
☐ Check array electrical isolation and resistance readings *(make check-box for readings)
☐ Check status of all isolating switches and set correctly
☐ Check status of all time switches and set correctly
☐ Check lightning protection systems and indicators in all locations
☐ Check pump status and operation
☐ Check water quality output and take sample for future testing reading *(make check-box for readings)
☐ Check remote monitoring system, and compare outputs to on-site meter reading *(make check-box for readings)
☐ Download remote monitoring system readings to laptop, check wifi and internet ability
☐ Remove pump from borehole
☐ Replace pump components *(make check-box for readings)
☐ Replace pump into borehole
☐ Confirm system operational *(make check-box for readings)
☐ Conduct system performance tests as per specification *(make check-box for readings)</td></tr>
<tr><td colspan="4">Register of equipment replaced: Note each item & serial number of equipment replaced during this visit</td></tr>
<tr><td colspan="2">Existing equipment removed:</td><td colspan="2">Replacement equipment provided:</td></tr>
<tr><td colspan="2">Responsible staff member</td><td colspan="2">Maintenance technician</td></tr>
</table>

Signature:	Signature:
Name:	Name:
Date	Date

Table 8: Breakdown maintenance log sheet

<table>
<tr><td colspan="4">Site details
Customer ID
System ID</td></tr>
<tr><td>Site name:</td><td></td><td>Starting time:</td><td></td></tr>
<tr><td>Date:</td><td></td><td>Finishing time:</td><td></td></tr>
<tr><td>Weather conditions:</td><td colspan="3"></td></tr>
<tr><td>Type of system:</td><td colspan="3"></td></tr>
<tr><td colspan="4">Description of problem(s)
What problems are reported by the customers / users ?</td></tr>
<tr><td colspan="4">Description of repair(s)
Describe all the repairs which have been made.
Complete routine maintenance checklist also.</td></tr>
<tr><td colspan="4">Register of equipment replaced: Note each item & serial number of equipment replaced during this visit</td></tr>
<tr><td colspan="2">Existing equipment removed:</td><td colspan="2">Replacement equipment provided:</td></tr>
<tr><td colspan="2">Responsible staff member</td><td colspan="2">Maintenance technician</td></tr>
<tr><td colspan="2">Signature:</td><td colspan="2">Signature:</td></tr>
<tr><td colspan="2">Name:</td><td colspan="2">Name:</td></tr>
<tr><td colspan="2">Date</td><td colspan="2">Date</td></tr>
</table>

D.5. Maintenance Reporting and Tracking

The Supplier will maintain organizational, staffing, logistical, inventory, recording and reporting capabilities and other arrangements sufficient to meet the managerial and technical requirements of providing the maintenance and other post installation services to systems installed in public facilities.

The Supplier will establish and maintain clear, accessible communications channels for the users and managers of PVP facilities to report faults and other problems.

The Supplier will maintain recording and reporting systems within a database that enables:

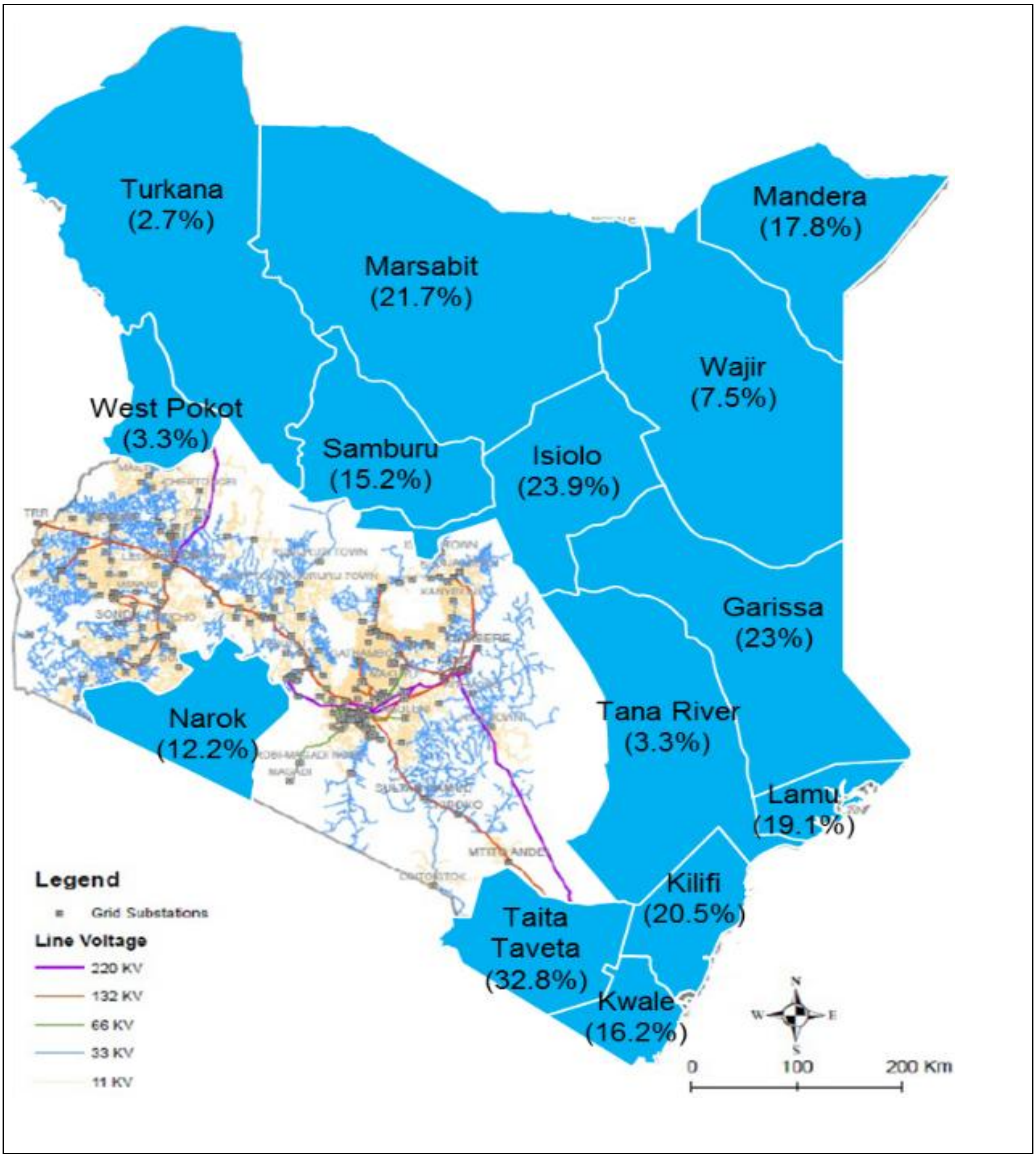
- accurate tracking of component and system performance and maintenance services, including records of complaints, repairs, component or system failures, downtimes and component replacements.
- capture the maintenance activities to spreadsheet . This shall include at least the following:
    - Dated Maintenance;
    - Verification of system identifier
        - Name of purchaser,
        - System unique number,
        - Region, district, village,
        - Location for verification purposes (i.e. GPS co-ordinate)
    - Items checked
    - Components replaced and new component information:
        - Module type, rating, qty, serial numbers
        - Inverter controller type, capacity, serial number
        - Pump type, capacity, serial number
- Access by the Purchaser to current electronic records and systems for tracking repair requests, responsiveness and status of systems.
- Accurate reporting by the Supplier on a bi-annual basis to the Purchaser.

The Supplier will submit bi-annual reports to the Purchaser that provide details on the status of the systems and the maintenance activities conducted. The reports will include the log sheets. The information to be provided will include complaints, repairs, component or system failures, downtimes and component replacements.

END

Appendix 1: Project Area Maps

Project being implemented in the Counties marked in colour blue in the Kenya Map hereunder



Appendix 2: Project Site Data

The following solar data have been used for this functional design (source *Homer Pro*[TM]: *NASA Predictor of Worldwide Energy Resource [22 year period Jun 1983-Jun 2005]*).
The design month shall be September for all lots. The tilt angle shall be 15 degrees.

	Global solar horizontal radiation (GHI) (kWh/m²/day)													
	COUNTY DATA													
Month	**Garissa**	**Lamu**	**Tana River**	**Wajir**	**Mandera**	**Kilifi**	**Kwale**	**Isiolo**	**Samburu**	**Marsabit**	**West Pokot**	**Turkana**	**Taita Taveta**	**Narok**
Jan	5.53	5.55	5.44	6.11	6.54	5.71	5.8	6.47	6.49	6.13	6.2	6.18	6.18	6.1
Feb	6.05	5.96	5.94	6.51	6.98	6.2	6.07	7.05	6.98	6.62	6.67	6.58	6.57	6.58
Mar	6.02	5.95	5.98	6.17	6.57	5.95	5.7	6.71	6.68	6.49	6.44	6.39	6.04	6.49
Apr	5.76	5.47	5.69	5.62	5.46	5.43	5.15	6.18	6.2	5.96	5.94	5.8	5.32	5.95
May	5.48	4.79	5.16	5.46	5.25	4.75	4.58	6.07	6.2	5.84	5.76	5.79	4.59	5.69
Jun	5.1	4.57	4.76	5.01	4.68	4.56	4.49	5.75	5.94	5.55	5.38	5.66	4.32	5.53
Jul	5.24	4.72	4.84	5.03	4.65	4.61	4.58	5.72	5.89	5.86	5.21	5.71	4.37	5.48
Aug	5.57	5.16	5.13	5.38	5.15	4.87	4.86	6.08	6.26	6.2	5.55	6.17	4.7	5.81
Sep	6.15	5.7	5.77	5.87	5.82	5.51	5.46	6.86	6.9	6.79	6.34	6.62	5.58	6.3
Oct	6.07	5.8	5.93	5.48	5.1	5.76	5.56	6.24	6.29	6.14	5.97	6.06	5.85	6.08
Nov	5.36	5.54	5.44	5.08	5.06	5.55	5.55	5.45	5.65	5.54	5.54	5.68	5.57	5.6
Dec	5.25	5.41	5.32	5.43	5.88	5.54	5.63	5.86	6.05	5.67	5.88	5.87	5.79	5.82
Mean	**5.63**	**5.39**	**5.45**	**5.60**	**5.60**	**5.37**	**5.29**	**6.20**	**6.29**	**6.07**	**5.91**	**6.04**	**5.41**	**5.95**

Note: To calculate Solar design volume – Water Delivery (m³/day) the respective *Mean Global solar horizontal radiation (GHI)* (kWh/m2/day) was used for each lot.

Major wet season

Dry season

	Ambient Temperature (ºC)													
	COUNTY DATA													
Month	Garissa	Lamu	Tana River	Wajir	Mandera	Kilifi	Kwale	Isiolo	Samburu	Marsabit	West Pokot	Turkana	Taita Taveta	Narok
Jan	28.9	28.0	28.6	28.8	28.0	27.4	27.5	21.7	21.7	26.9	23.9	29.1	24.2	19.1
Feb	29.9	28.3	29.6	30.1	29.3	27.7	28.0	22.8	22.8	28.1	25.0	30.2	25.1	19.8
Mar	30.3	28.8	29.5	30.6	30.7	28.0	27.8	23.5	23.5	28.6	25.6	30.7	25.1	19.7
Apr	28.7	28.3	27.6	28.7	29.2	27.4	26.6	22.9	23.3	27.4	24.7	29.7	23.9	18.3
May	27.1	27.1	26.4	27.5	28.1	26.3	25.4	22.3	22.9	27.0	23.8	29.2	22.6	17.0
Jun	26.1	25.9	25.5	26.6	27.4	25.1	24.2	21.6	22.2	26.1	22.8	28.3	21.3	16.0
Jul	25.5	25.2	24.9	26.2	26.8	24.4	23.7	21.0	21.5	25.7	22.1	27.9	20.8	15.7
Aug	25.9	25.2	25.2	26.8	27.3	24.4	23.8	21.4	21.7	26.1	22.5	28.4	21.2	16.6
Sep	27.1	25.9	26.4	28.1	28.7	25.0	24.7	22.4	22.7	27.2	23.7	29.5	22.4	17.9
Oct	28.0	26.7	27.0	28.6	28.7	25.9	25.7	22.6	22.9	27.5	24.0	29.8	23.4	18.7
Nov	27.7	27.4	26.7	27.7	27.6	26.7	26.4	21.5	21.8	26.2	23.1	28.8	23.6	18.5
Dec	28.0	27.8	27.4	27.7	27.3	27.2	26.9	21.2	21.3	26.2	23.1	28.7	23.5	18.7
Mean	**27.8**	**27.0**	**27.1**	**28.1**	**28.3**	**26.3**	**25.9**	**22.1**	**22.4**	**26.9**	**23.7**	**29.2**	**23.1**	**18.0**

Appendix 3: Locations of sites and overall quantities (Project Specification)

Appendix 3.1: PVP Project requirements for all sites

Reference	Item	Requirement
C.3.3.1	Array security frames	*Y*
C.3.5	PVP switchgear enclosure or room	Y
C.4.6	Diesel generator	Y Bidders to cost to replace all generators except where the grid is available
C.3.14	Diesel Generator Room	Y If not pre-existing
C.3.13	Chlorinator	No
	Fencing and gate around array	Y
C.3.17	Lightning protection Class II	Y
	Float switch at tank	Y
C.4.5	Remote data logging online	Y
C.4.5.6	Remote control of pump	Not mandatory

Appendix 3.2 PVP DESIGN DATA

Appendix 3.2.1 Isiolo County

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth(m)	Static Head ESTIMATED (m)	Total Dynamic Head(TDH) ESTMATED (m)	Borehole Yield(m^3/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m^3/day)	*Aprox Solar Pv array Capacity(KWp)*
1	Isiolo	Merti	Bullesa old	0.9564811	38.559692	No	39	35	37	34	6	2	300	210.8	10
2	Isiolo	Merti	New Lakole	1.06622	38.67889	No	150	146	154	4	6	2	300	24.8	5
3	Isiolo	Merti	Dogogicha	1.2263574	38.478966	No	178	174	183	6	6	2	300	37.2	9
4	Isiolo	Merti	Urura	1.545605	38.778983	No	180	176	185	8	6	2	300	49.6	12
5	Isiolo	Merti	Yamicha	1.7310562	38.61000	No	170	166	175	6	6	2	300	37.2	8
6	Isiolo	Isiolo	LMD-Kilimani	0.3563533	37.56437	No	165	161	170	8	6	2	300	49.6	11

Appendix 3.2.2 Marsabit County

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth(m)	Static Head ESTIMATED (m)	Total Dynamic Head(TDH) ESTMATED (m)	Borehole Yield(m^3/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m^3/day)	*Aprox Solar Pv array Capacity (KWp)*
1	Marsabit	Kargi	Bagasi	2.5727778	37.6302778	No	66	62	66	12.7	6	2	300	77.089	7
2	Marsabit	Moyale	Badanrero	2.7680556	38.8577778	No	195	191	201	8	6	2	300	48.56	13
3	Marsabit	Moyale	Ambalo 1	3.0369444	38.8497222	No	195	191	201	12	6	2	300	72.84	19
4	Marsabit	Moyale	Ambalo 2	3.0372222	38.8441667	No	195	191	201	8	6	2	300	48.56	13
5	Marsabit	Moyale	Kobb Adadi	3.6008333	38.5888889	No	190	186	196	12	6	2	300	72.84	18

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth(m)	Static Head ESTIMATED (m)	Total Dynamic Head(TDH) ESTMATED (m)	Borehole Yield(m^3/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m^3/day)	*Aprox Solar Pv array Capacity (KWp)*
6	Marsabit	Moyale	Golole 2	2.9547222	37.6630556	No	195	191	201	23	6	2	300	139.61	36
7	Marsabit	North Horr	Ramat Os Tullow	2.5922222	37.9377778	No	90	86	91	12	6	2	300	72.84	9
8	Marsabit	Saku	Shegel III	2.2683333	38.2180556	No	200	196	206	6	6	2	300	36.42	10
9	Marsabit	Saku	Dololo Dokatu	2°16'06"N	38°13'05"E	No	200	196	206	7	6	2	300	42.49	11

Appendix 3.2.3 Taita Taveta County

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth(m)	Static Head ESTIMATED (m)	Total Dynamic Head(TDH) ESTMATED (m)	Borehole Yield(m^3/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m^3/day)	*Aprox Solar Pv array Capacity(KWp)*
1	Taita Taveta	Taveta	Rekeke booster pump	-3.4187997	37.7342149	No	3	23	25	15	6	2	300	81.15	3
2	Taita Taveta	Taveta	Bura Ndogo-C Borehole	-3.3953067	37.687764	Yes	32	52	55	11	6	2	300	59.51	5
3	Taita Taveta	Taveta	Mrabani Primary shallow well	-3.4676074	37.6414802	No	10	30	32	10	6	2	300	54.1	2
4	Taita Taveta	voi	Kisimenyi Primary	-3.7242341	38.6453268	No	240	236	248	5	6	2	300	27.05	10
5	Taita Taveta	Mwatate	Mvita/Kwa Scaver BH	-3.417116	38.4196991	No	100	96	101	10	6	2	300	54.1	8

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth(m)	Static Head ESTIMATED (m)	Total Dynamic Head(TDH) ESTMATED (m)	Borehole Yield(m^3/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m^3/day)	*Aprox Solar Pv array Capacity(KWp)*
6	Taita Taveta	Voi	Birikani Kisimenyi	-3.7613329	38.6640864	No	150	146	154	6	6	2	300	32.46	7
7	Taita Taveta	Mwatate	Msau Polytechnic Borehole	-3.415222	38.4142254	No	100	96	101	10	6	2	300	54.1	8
8	Taita Taveta	Mwatate	Manoa Borehole	-3.6075005	38.3301465	Yes	240	236	248	8	6	2	300	43.28	15
9	Taita Taveta	Mwatate	Nyangoro borehole	-3.4399017	38.275724	Yes	150	146	154	17	6	2	300	91.97	20
10	Taita Taveta	Wundanyi	Kishushe sharp corner	-3.2773895	38.3067479	No	200	196	206	5	6	2	300	27.05	8
11	Taita Taveta	Wundanyi	Kisima borehole/Kishushe	-3.2993526	38.2555925	No	280	276	290	10	6	2	300	54.1	23
12	Taita Taveta	Wundanyi	Paranga Borehole	-3.2723214	38.4026798	No	250	246	259	20	6	2	300	108.2	40
13	Taita Taveta	Taveta	Lutheran Borehole	-3.3936488	37.6730908	Yes	80	76	80	10	6	2	300	54.1	6
14	Taita Taveta	Taveta	Lessesia Borehole	-3.3931308	37.6728536	Yes	100	96	101	20	6	2	300	108.2	16
15	Taita Taveta	Taveta	Eldoro Borehole	-3.4742055	37.6822065	No	100	96	101	10	6	2	300	54.1	8
16	Taita Taveta	Taveta	Ulawani community borehole	-3.2204393	37.7012699	Yes	250	246	259	7	6	2	300	37.87	14

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth(m)	Static Head ESTIMATED (m)	Total Dynamic Head(TDH) ESTMATED (m)	Borehole Yield(m³/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m³/day)	*Aprox Solar Pv array Capacity(KWp)*
17	Taita Taveta	Taveta	Chumvini water project	-3.2077854	37.7128335	Yes	120	116	122	10	6	2	300	54.1	9
18	Taita Taveta	Taveta	Njukini borehole	-3.1870684	37.7265384	Yes	100	96	101	10	6	2	300	54.1	8
19	Taita Taveta	Taveta	Wololo borehole	-3.2424623	37.7088371	No	100	96	101	10	6	2	300	54.1	8

Appendix 3.2.4 Lamu County

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth(m)	Static Head ESTIMATED (m)	Total Dynamic Head(TDH) ESTMATED (m)	Borehole Yield(m³/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m³/day)	*Aprox Solar Pv array Capacity(KWp)*
1	Lamu	Lamu East	Ndau Desalination Plant	E 41◦ 12’ 46’’	N -2° 0’53’’	No	8	12	13	5	6	2	300	26.95	1
2	Lamu	Lamu East	Mkokoni Desalination Plant	E 41◦ 12’ 46’’	N -1° 55’14’’	No	7	11	12	8	6	2	300	43.12	1
3	Lamu	Lamu West	Maishamash	E 40◦ 32’ 24’’	N -2° 24’42’’	No	20	24	26	5	6	2	300	26.95	1
4	Lamu	Lamu West	Kisuke Primary School	E 40◦ 45’ 13’’	N -2° 19’55’’	No	8	12	13	2	6	2	300	10.78	1
5	Lamu	Lamu West	Mikinduni Primary School	E 40◦ 34’ 59’’	N -2° 19’14’’	No	21	25	27	5	6	2	300	26.95	1

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth(m)	Static Head ESTIMATED (m)	Total Dynamic Head(TDH) ESTMATED (m)	Borehole Yield(m^3/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m^3/day)	*Aprox Solar Pv array Capacity(KWp)*
6	Lamu	Lamu West	Holy Angels Primary School	E 40◦ 38' 02''	N -2° 17'09''	No	25	29	31	5	6	2	300	26.95	2
7	Lamu	Lamu West	Sefu Primary	E 40◦ 36' 23''	N -2° 21'38''	No	38	42	45	5	6	2	300	26.95	2
8	Lamu	Lamu West	Jericho Primary School	E 40◦ 35' 04''	N -2° 26'14''	No	21	25	27	3	6	2	300	16.17	1
3	Lamu	Lamu East	Faza Primary School	E 41◦ 12' 46''	N -2° 03'23''	No	7	11	12	5	6	2	300	26.95	1
5	Lamu	Lamu West	Soroko Primary	E 40◦ 28' 15''	N -2° 24'18''	No	28	32	34	5	6	2	300	26.95	2
7	Lamu	Lamu West	Poromoko Primary School	E 40◦ 33' 17''	N -2° 18'21''	No	30	34	36	5	6	2	300	26.95	2
8	Lamu	Lamu West	Rehema Primary	E 40◦ 33' 17''	N -2° 18'21''	No	32	36	38	5	6	2	300	26.95	1
9	Lamu	Lamu West	Bahati Primary School	E 40◦ 42' 35''	N -2° 18'21''	No	13	17	18	5	6	2	300	26.95	1
14	Lamu	Lamu West	Mini Valley Primary School	E 40◦ 38' 07''	N -2° 21'23''	No	30	34	36	5	6	2	300	26.95	2
15	Lamu	Lamu West	Bomani Primary School	E 40◦ 38' 44''	N -2° 22'51''	No	23	27	29	5	6	2	300	26.95	1

Appendix 3.2.5 Kilifi County

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth (M)	Static Head ESTIMATED (M)	Total Dynamic Head(TDH) ESTMATED (M)	Borehole Yield (m^3/hr)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m^3/day)	*Aprox Solar Pv array Capacity(KWp)*
1	Kilifi	Kilifi North	Mtondia Kwa ngonyo	-3.5790162	39.868526	No	25	29	31	4	6	2	300	21.48	1
2	Kilifi	Kilifi North	Kwa katana wa chome Majaoni	-3.5609303	39.8675386	Yes	20	24	26	3	6	2	300	16.11	1
3	Kilifi	Kilifi North	Tezo agriculture borehole	-3.543301	39.8776211	No	16	20	21	3	6	2	300	16.11	1
4	Kilifi	Kilifi North	Samson Nyanje borehole	-3.5068841	39.88952	No	25	29	31	4	6	2	300	21.48	1
5	Kilifi	Kilifi North	Mwambani Kwa Mundu	-3.5102779	39.8810079	Yes	20	24	26	3	6	2	300	16.11	1
6	Kilifi	Kilifi North	Mkunguni Chumani	-3.4900505	39.9141333	No	10	14	15	3	6	2	300	16.11	1
7	Kilifi	Kilifi North	Wesa Ngerenya borehole	-3.4843205	39.914957	No	20	24	26	5	6	2	300	26.85	1
8	Kilifi	Kilifi North	Roka Maweni	-3.448866	39.9278848	No	12	16	17	3	6	2	300	16.11	1
9	Kilifi	Kilifi North	Kadenge paka borehole	-3.4534729	39.9188358	No	23	27	29	3	6	2	300	16.11	1
10	Kilifi	Malindi	Sea breeze Msabaha wa juu	-3.435229	39.9009448	No	24	28	30	5	6	2	300	26.85	1
11	Kilifi	Malindi	Takaye Kwa Diwani	-3.262601	40.0622883	No	34	38	40	4	6	2	300	21.48	1
12	Kilifi	Malindi	Takaye Kwa chiguba (chigunda)	-3.2509772	40.1020835	Yes	30	34	36	3	6	2	300	16.11	1
13	Kilifi	Malindi	Msoloni Kwa jasho	-3.2605229	40.1002437	No	25	29	31	4	6	2	300	21.48	1
14	Kilifi	Malindi	Gahaleni	-3.2718827	40.0889852	No	31	35	37	4	6	2	300	21.48	1
15	Kilifi	Magarini	Magarini Mabrui	-3.0943659	40.1454817	Yes	15	19	20	5	6	2	300	26.85	1
16	Kilifi	Magarini	Majengo Centre Borehole	-3.0788161	40.1427341	No	10	14	15	3	6	2	300	16.11	1

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth (M)	Static Head ESTIMATED (M)	Total Dynamic Head(TDH) ESTMATED (M)	Borehole Yield (m^3/hr)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m^3/day)	*Aprox Solar Pv array Capacity(KWp)*
17	Kilifi	Kilifi North	Kwa Muye Bh	-3.4803624	39.9018751	No	23	27	29	4	6	2	300	21.48	1
18	Kilifi	Kaloleni	Mwakanga Walea Primary BH	-3.8220387	39.6354536	No	3	7	8	5	6	2	300	26.85	1
19	Kilifi	Kilifi South	Mzambaraoni(kwa Abdla heri) BH	-3.9380425	39.7475434	No	25	29	31	1	6	2	300	5.37	1
20	Kilifi	Kaloleni	Mwakonzi BH	-3.814429	39.6395934	No	8	12	13	10	6	2	300	53.7	1
21	Kilifi	Kilifi South	Shariani Kwa Akida BH	-3.788958	39.8254239	Yes	4	4	5	5	6	2	300	26.85	1
22	Kilifi	Ganze	Migodomani BH	-3.443381	39.7103612	No	225	221	233	3	6	2	300	16.11	5
23	Kilifi	Kilifi North	Kwa William Shida	-3.390071	39.9273533	No	18	22	24	3	6	2	300	16.11	1
24	Kilifi	Kilifi North	Roka Youth Polytechnic	-3.467887	39.8996295	No	20	24	26	3	6	2	300	16.11	1
25	Kilifi	Kilifi North	Kadenge Kavumbe Borehole	-3.453473	39.9188358	No	17	21	23	4	6	2	300	21.48	1
26	Kilifi	Malindi	Msabaha Kwa mwasaha	-3.259813	40.0491641	No	30	34	36	5	6	2	300	26.85	1
27	Kilifi	Kilifi North	Dungicha BP	-3.271883	40.0889852	No		100	105	5	6	2	300	26.85	4
28	Kilifi	Kilifi	Tsalu BP	-3.078816	40.1427341	No		50	53	32	6	2	300	171.84	13
29	Kilifi	Rabai	Masaani Booster pump	-3.480362	39.9018751	No		50	53	20	6	2	300	107.4	8
30	Kilifi	Kilifi South	Mapawa Kolewa BP	-3.794289	39.7551981	No		50	53	20	6	2	300	107.4	8
31	Kilifi	Ganze	Mweza Bp	-3.491783	39.6630601	No		50	53	3	6	2	300	16.11	1
32	Kilifi	Ganze	Mbonga BP	-3.591623	39.6871926	No		150	158	18	6	2	300	96.66	22
33	Kilifi	Ganze	Palakumi BP	-3.6002618	39.6069579	No		200	210	26	6	2	300	139.62	43

Appendix 3.2.6 Tana River County

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth(M)	Static Head ESTIMATED (M)	Total Dynamic Head(TDH) ESTMATED (M	Borehole Yield(m^3/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m^3/day)	*Aprox Solar Pv array Capacity(KWp)*
1	Tana River	Tana River	Bububu	-1.7558838	40.1015759	No	28	42.5	45	3	6	2	300	16.35	1
2	Tana River	Tana River	Duwayo Borehole	-1.6993869	40.0835637	No	17	31.5	34	3	6	2	300	16.35	1
3	Tana River	Tana River	Hola Water Supply B	-1.4935861	40.037051	Yes	36	50.5	54	3	6	2	300	16.35	1
4	Tana River	Tana River	Rhoka	-1.2337606	39.9734036	No	20	34.5	37	3	6	2	300	16.35	1
5	Tana River	Tana River	Laini	-1.37343	40.007755	No	25	39.5	42	3	6	2	300	16.35	1
6	Tana River	Tana River	Ghalamani	-1.4206017	40.022154	No	30	44.5	47	3	6	2	300	16.35	1
7	Tana River	Tana River	Chanani	-1.5608046	40.0548273	No	36	50.5	54	3	6	2	300	16.35	1
8	Tana River	Tana Delta	Gadeni Furaha	-2.2615225	40.1522914	No	25	39.5	42	3	6	2	300	16.35	1
9	Tana River	Tana River	Hola Water Supply A	-1.4941753	40.0362891	Yes	40	54.5	58	3	6	2	300	16.35	1
10	Tana River	Tana North	Bura Water Works	-1.1782657	39.8288481	Yes	40	54.5	58	3	6	2	300	16.35	1
11	Tana River	Tana Delta	Ngao Water Supply	-2.4106339	40.2029375	Yes	30	44.5	47	3	6	2	300	16.35	1
12	Tana River	Tana Delta	Tarasaa Secondary	-2.4426827	40.1610718	No	40	54.5	58	3	6	2	300	16.35	1
13	Tana River	Tana Delta	Kipini Secondary	-2.2683513	40.1858354	No	30	44.5	47	3	6	2	300	16.35	1
14	Tana River	Tana Delta	Arap Moi Primary	-2.4134933	40.2023555	No	30	44.5	47	3	6	2	300	16.35	1

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth(M)	Static Head ESTIMATED (M)	Total Dynamic Head(TDH) ESTMATED (M	Borehole Yield(m^3/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m^3/day)	*Aprox Solar Pv array Capacity(KWp)*
15	Tana River	Tana Delta	Baomo	-1.9121247	40.1209275	No	100	114.5	121	3	6	2	300	16.35	3
16	Tana River	Tana Delta	Buyani Secondary School	-2.5141223	40.2967426	No	50	64.5	68	3	6	2	300	16.35	2
17	Tana River	Tana Delta	Majiweni Primary School	-2.2683333	40.18583	No	40	54.5	58	3	6	2	300	16.35	1
18	Tana River	Bangale	Maramtu A	-0.4832626	39.6206683	No	30	44.5	47	3	6	2	300	16.35	1
19	Tana River	Tana Delta	Ziwani	-2.2682822	40.1859646	No	25	39.5	42	3	6	2	300	16.35	1
20	Tana River	Bangale	Taleo Kolati	-0.6031833	39.7276983	No	20	34.5	37	3	6	2	300	16.35	1
21	Tana River	Tana North	Chewele Ghaigopa Msikitini	-1.1643651	39.919375	No	8	22.5	24	3	6	2	300	16.35	1
22	Tana River	Tana Delta	Wema Kulesa	-2.2615198	40.1522273	No	20	34.5	37	3	6	2	300	16.35	1
23	Tana River	Tana Delta	Bara Moyoo	-2.2683058	40.1858925	No	15	29.5	31	3	6	2	300	16.35	1
24	Tana River	Tana River	Nyangwani	-1.2373611	39.9690025	No	30	44.5	47	3	6	2	300	16.35	1

Appendix 3.2.7 Kwale County

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth(m)	Static Head ESTIMATED (m)	Total Dynamic Head(TDH) ESTMATED (m)	Borehole Yield(m^3/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m^3/day)	*Aprox Solar Pv array Capacity (KWp)*
1	Kwale	Lungalunga	Ganda	-4.536139	39.24809	No	70	66	70	6	6	2	300	31.74	3
2	Kwale	Lungalunga	Kifuku	-4.472799	39.287875	No	85	81	86	10	6	2	300	52.9	7
3	Kwale	Lungalunga	mabafweni	-4.424014	39.332528	No	90	86	91	8	6	2	300	42.32	6
4	Kwale	Matuga	Kidiani ecd	-4.393737	39.376791	No	85	81	86	10	6	2	300	52.9	7
5	Kwale	Matuga	Mwanamkuu	-4.384028	39.339353	No	80	76	80	8	6	2	300	42.32	5
6	Kwale	Matuga	Haraka	-4.362952	39.310376	No	105	101	107	4	6	2	300	21.16	3
7	Kwale	Matuga	Mwagodzo	-4.381182	39.404674	Yes	147	143	151	10	6	2	300	52.9	12
8	Kwale	Matuga	Bowa	-4.201819	39.597646	No	65	61	65	4	6	2	300	21.16	2
9	Kwale	Matuga	Kombani central	-4.197444	39.582473	No	80	76	80	25	6	2	300	132.25	16
10	Kwale	Matuga	Madibwani	-4.14356	39.606078	No	121	117	123	20	6	2	300	105.8	19
11	Kwale	Matuga	Magundo	-4.174895	39.592094	No	33	29	31	4	6	2	300	21.16	1
12	Kwale	Matuga	Jeza A	-4.165343	39.455875	No	150	146	154	5	6	2	300	26.45	6
13	Kwale	Matuga	Mwananyahi	-4.267675	36.474285	No	120	116	122	1	6	2	300	5.29	1
14	Kwale	Matuga	Mazumalumee	-4.246653	39.503395	No	120	116	122	5	6	2	300	26.45	5
15	Kwale	Msambweni	Mbuwani	-4.29	39.5	No	120	116	122	10	6	2	300	52.9	9
16	Kwale	Msambweni	Kibarani	-4.36	39.5	No	50	46	49	6	6	2	300	31.74	2
17	Kwale	Msambweni	Darigube	-4^0 3’ 8’’	$39^0$24’5’’	No	98	94	99	6	6	2	300	31.74	5
18	Kwale	Matuga	Muungano	-4^0 3’ 54’’	$49^0$48’	No	100	96	101	4	6	2	300	21.16	3

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth(m)	Static Head ESTIMATED (m)	Total Dynamic Head(TDH) ESTMATED (m)	Borehole Yield(m^3/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m^3/day)	*Aprox Solar Pv array Capacity (KWp)*
19	Kwale	Lungalu nga	Godo	-4^{0} 31’ 49’’	39^{0}12’13”	No	150	146	154	2	6	2	300	10.58	2
20	Kwale	Matuga	Mwamnyuti	-4^{0} ^{1}3’ 25’’	39^{0}32’59’’	No	85	81	86	6	6	2	300	31.74	4
21	Kwale	Msamb weni	Vumilia	-4^{0} 19’ 48’’	39^{0}29’42’’	No	80	76	80	10	6	2	300	52.9	6
22	Kwale	Lungalu nga	Mahuruni	-4^{0} 32’ 11’’	39^{0}9’39’’	No	50	46	49	3	6	2	300	15.87	1
23	Kwale	Msamb weni	Mwendo Wa Bure	-4.5	39.4	No	60	56	59	12	6	2	300	63.48	6
24	Kwale	Msamb weni	Vukani	-4^{0} 15’ 46’’	39^{0}31’28’’	No	50	46	49	4	6	2	300	21.16	2
25	Kwale	Msamb weni	Kandarasi	-4^{0} 30’ 55’’	39^{0}24’54’’	No	100	96	101	5	6	2	300	26.45	4
26	Kwale	Lungalu nga	Mwamose	-4^{0} 34’ 15’’	39^{0}12’28’’	No	50	46	49	3	6	2	300	15.87	1
27	Kwale	Msamb weni	Ngori	-4^{0} 16’ 20’’	39^{0}33’21’’	Yes	50	46	49	4	6	2	300	21.16	2
28	Kwale	Msamb weni	Maphombe	-4.396 39’’	18 4’’	No	70	66	70	4	6	2	300	21.16	2

Appendix 3.2.8 Narok County

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth(m)	Static Head ESTIMATED (m)	Total Dynamic Head(TDH) ESTMATED (m)	Borehole Yield(m^3/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m^3/day)	*Aprox Solar Pv array Capacity(KWp)*
1	Narok	Narok central	Katakala borehole	-1.0836183	35.79608	Yes	110	106	112	3	6	2	300	17.85	3
2	Narok	Narok central	Katakala C/o Saoli	-1.0924458	35.7698893	Yes	130	126	133	3	6	2	300	17.85	3
3	Narok	Narok central	Olopito water point (spring)	-1.0660521	35.9397278	Yes	130	126	133	30	6	2	300	178.5	31
4	Narok	Narok South	Ichangipusi inside building hope academy school	-1.1812017	35.7579733	No	140	136	143	13	6	2	300	77.35	14
5	Narok	Narok South	Ole pariata borehole	-1.372085	35.8478383	No	202	198	208	2	6	2	300	11.9	3
6	Narok	Narok South	Olkirankawuo	-1.1961755	35.7509089	No	122	118	124	3	6	2	300	17.85	3
7	Narok	Narok South	Nkoben	-1.0187659	35.7345653	No	106	102	108	4	6	2	300	23.8	3
8	Narok	Narok central	Nkareta BH	-0.9796322	35.7369791	No	94	90	95	4	6	2	300	23.8	3
9	Narok	Transmara south	Oldonyorok bh	-1.3476669	34.7913212	No	130	126	133	12	6	2	300	71.4	12
10	Narok	Transmara east	Mugenyi/ njipship BH	-0.9468531	35.0167839	No	92	88	93	15	6	2	300	89.25	11
11	Narok	Narok South	Sogoo	-0.8537712	35.5596334	Yes	230	226	238	27	6	2	300	160.65	50
12	Narok	Narok South	Marinwa	-0.8523564	35.5576366	Yes	230	226	238	27	6	2	300	160.65	50

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth(m)	Static Head ESTIMATED (m)	Total Dynamic Head(TDH) ESTMATED (m)	Borehole Yield(m^3/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m^3/day)	*Aprox Solar Pv array Capacity(KWp)*
13	Narok	Transmara east	Simutwet shallow well	-1.0109512	35.1945522	No	12	8	9	1	6	2	300	5.95	1
14	Narok	Narok North	Enesampulai BH	-1.0147172	36.0506794	No	150	146	154	10	6	2	300	59.5	12
15	Narok	Narok East	Kitororonyi BH	-1.402497	36.0801824	No	200	196	206	10	6	2	300	59.5	16
16	Narok	Narok West	Mpuaai	-1.4218617	35.2091983	No	140	136	143	7	6	2	300	41.65	8
17	Narok	Narok West	Mosimowok/ laluk	-0.9382433	35.4577483	No	220	216	227	2	6	2	300	11.9	4
18	Narok	Narok West	Nkamurunya	-1.2160245	35.4755555	No	180	176	185	2	6	2	300	11.9	3
19	Narok	Narok East	Olepunywa/ olchoro leletuya	-1.0460895	36.0919458	Yes	150	146	154	25	6	2	300	148.75	30
20	Narok	Narok East	Oloikumkum bh	-1.4019392	36.0809701	No	110	106	112	9	6	2	300	53.55	8
21	Narok	Narok East	Olooiturot BH	-1.31835	36.0211484	No	150	146	154	5	6	2	300	29.75	6
22	Narok	Narok West	Omomet bh	-1.0106633	35.4126617	No	106	102	108	5	6	2	300	29.75	4
23	Narok	Narok central	Sheep and goats	-1.0754533	35.8793467	No	190	186	196	12	6	2	300	71.4	18
24	Narok	Transmara south	Angata-barrakoi	-1.3707645	34.7704734	No	10	6	7	2	6	2	300	11.9	1
25	Narok	Narok West	Ilmedeketa bh	-1.0833051	35.4929918	No	230	226	238	14	6	2	300	83.3	26
26	Narok	Narok South	Enkoseremai	-1.8510583	35.6610017	No	121	117	123	9	6	2	300	53.55	9
27	Narok	Narok South	Morijo Loita	-1.6998518	35.8016472	No	103	99	104	7	6	2	300	41.65	6
28	Narok	Narok South	Intasati	-1.610068	35.828738	No	140	136	143	4	6	2	300	23.8	4

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth(m)	Static Head ESTIMATED (m)	Total Dynamic Head(TDH) ESTMATED (m)	Borehole Yield(m^3/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m^3/day)	*Aprox Solar Pv array Capacity(KWp)*
29	Narok	Narok South	Iladoru	-1.167288	35.6939604	No	150	146	154	15	6	2	300	89.25	18
30	Narok	Narok West	Endonyo Narasha	-1.25962	35.4984333	No	180	176	185	10	6	2	300	59.5	14
31	Narok	Narok South	Enkejuarro	- 1.7855883	35.758945	No	220	216	227	2	6	2	300	11.9	4
32	Narok	Narok South	Koseka	- 1.5725068	35.8797055	No	100	96	101	6	6	2	300	35.7	5
33	Narok	Narok West	Entagotuo	-1.672542	35.744342	No	200	196	206	22	6	2	300	130.9	35
34	Narok	Narok West	Ole Tarkash	- 1.1551856	35.4420993	No	220	216	227	2	6	2	300	11.9	4
35	Narok	Narok West	Olkinyei water project	-1.19736	35.4253467	No	102	98	103	11	6	2	300	65.45	9

Appendix 3.2.9 Samburu County

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth(m)	Static Head ESTIMATED (m)	Total Dynamic Head(TDH) ESTMATED (m)	Borehole Yield(m^3/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m^3/day)	*Aprox Solar Pv array Capacity(KWp)*
1	Samburu	Samburu West	Ngambo	0.978941	36.7914598	No	200	196	205.8	15	6	2	300	94.35	24
2	Samburu	Samburu West	Miyai Borehole	0.929904	36.8304762	No	150	146	153.3	5	6	2	300	31.45	6
3	Samburu	Samburu West	Lemisigiyo	1.090702	36.6289591	No	60	56	58.8	7	6	2	300	44.03	3
4	Samburu	Samburu West	Seketet	1.13792	36.5978795	No	235	231	242.55	12	6	2	300	75.48	23
5	Samburu	Samburu West	Lesidai	1.138659	36.5578333	No	200	196	205.8	6	6	2	300	37.74	10

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth(m)	Static Head ESTIMATED (m)	Total Dynamic Head(TDH) ESTMATED (m)	Borehole Yield(m³/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m³/day)	*Aprox Solar Pv array Capacity(KWp)*
6	Samburu	Samburu West	Loibor	1.122817	36.5578568	No	200	196	205.8	6	6	2	300	37.74	10
7	Samburu	Samburu West	Rangau	0.944493	36.583013	No	200	196	205.8	6	6	2	300	37.74	10
8	Samburu	Samburu West	Sirata	1.053597	36.6575238	No	60	56	58.8	8	6	2	300	50.32	4
9	Samburu	Samburu West	Nkenju	1.000388	36.6624464	No	200	196	205.8	7	6	2	300	44.03	11
10	Samburu	Samburu West	Ledero	1.034656	36.7495749	No	100	96	100.8	8	6	2	300	50.32	6
11	Samburu	Samburu West	Malta	0.979902	37.33683	No	60	56	58.8	9	6	2	300	56.61	4
12	Samburu	Samburu West	Shabaa	1.102995	36.7213017	No	200	196	205.8	8	6	2	300	50.32	13
13	Samburu	Samburu West	Simiti	0.913262	36.7600343	No	90	86	90.3	5	6	2	300	31.45	4
14	Samburu	Samburu East	Jelmen	0.965492	37.3174671	No	126	122	128.1	1	6	2	300	6.29	1
15	Samburu	Samburu East	Loijuk	0.746465	37.3956	No	97	93	97.65	4	6	2	300	25.16	3
16	Samburu	Samburu East	Lderkesi	0.650043	37.6576484	No	130	126	132.3	7	6	2	300	44.03	7
17	Samburu	Samburu North	Bendera 1	1.794233	36.807718	No	72	68	71.4	8	6	2	300	50.32	4
18	Samburu	Samburu North	Baragoi boys	1.76471	36.7813127	No	80	76	79.8	10	6	2	300	62.9	6

Appendix 3.2.10 West Pokot County

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth(m)	Static Head ESTIMATED (m)	Total Dynamic Head(TDH) ESTMATED (m)	Borehole Yield (m^3/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m^3/day)	*Aprox Solar Pv array Capacity (KWp)*
1	West Pokot	Pokot West	Katikomor Pri School	1.26808	34.8459117	No	150	146	154	5	6	2	300	29.55	6
2	West Pokot	Pokot West	Auskiyon	1.4147935	34.9557964	No	200	196	206	8	6	2	300	47.28	13
3	West Pokot	Pokot West	Habari Njema	1.4553181	34.9933067	No	200	196	206	8	6	2	300	47.28	13
4	West Pokot	Pokot West	Kariwo	1.5178216	35.094085	No	200	196	206	8	6	2	300	47.28	13
5	West Pokot	Pokot West	Tamugh	1.5702206	35.2686677	No	170	166	175	8	6	2	300	47.28	11
6	West Pokot	Pokot West	Kotimoril	1.6037057	35.3040197	No	170	166	175	3.5	6	2	300	20.685	5
7	West Pokot	Pokot West	Kapkata	1.6256531	35.2789549	No	100	96	101	3.2	6	2	300	18.912	3
8	West Pokot	Pokot West	Cheptuya	1.255686	35.0081355	No	165	161	170	4	6	2	300	23.64	5
9	West Pokot	Pokot West	Tilak Pri School	1.2731433	35.1005235	No	100	96	101	8	6	2	300	47.28	6
10	West Pokot	Pokot South	Chelombai	1.2990145	35.1912431	No	130	126	133	5	6	2	300	29.55	5
11	West Pokot	Pokot South	Pserum St. Mary's Sec Sch.	1.3926821	35.2156691	No	100	96	101	8	6	2	300	47.28	6
12	West Pokot	Pokot South	Tomoi	1.4707844	35.1671265	No	160	156	164	3	6	2	300	17.73	4
13	West Pokot	Pokot South	Senetwo	1.3209982	35.1729327	Yes	100	96	101	5	6	2	300	29.55	4
14	West Pokot	Pokot Central	Rorok	1.3668896	35.6719976	No	200	196	206	8	6	2	300	47.28	13
15	West Pokot	Pokot Central	Poto	1.4533543	34.4935958	No	200	196	206	8	6	2	300	47.28	13

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth(m)	Static Head ESTIMATED (m)	Total Dynamic Head(TDH) ESTMATED (m)	Borehole Yield (m³/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m³/day)	*Aprox Solar Pv array Capacity (KWp)*
16	West Pokot	Pokot Central	Weiwei Sec School	1.49052926	35.465707	Yes	100	96	101	8	6	2	300	47.28	6
17	West Pokot	Pokot central	Cheprukot	1.5183362	35.6386441	No	200	196	206	8	6	2	300	47.28	13
18	West Pokot	Kacheliba	Kopulio pri.School	1.417943	34.9139418	No	140	136	143	4	6	2	300	23.64	4
19	West Pokot	Kacheliba	Lokii ECDE Borehole	1.4746224	34.88895	No	90	86	91	4	6	2	300	23.64	3
20	West Pokot	Kacheliba	Katuwot borehole	1.7983719	35.0876209	No	150	146	154	4	6	2	300	23.64	5
21	West Pokot	Kacheliba	Longolesia Borehole	1.574074	34.9640159	No	200	196	206	8	6	2	300	47.28	13
22	West Pokot	Kacheliba	Reretiang borehole	1.5679146	35.042368	No	190	186	196	3	6	2	300	17.73	5
23	West Pokot	Kacheliba	Kaskuroi ECDE borehole	1.497882	34.999127	No	170	166	175	2	6	2	300	11.82	3
24	West Pokot	Kacheliba	Losam Borehole	1.9434966	35.0503236	No	140	136	143	4	6	2	300	23.64	4
25	West Pokot	Kacheliba	Lamada borehole	1.6572121	35.0674108	No	200	196	206	2	6	2	300	11.82	3
26	West Pokot	Pokot North	Mbaru borehole	2.0613866	35.156742	No	150	146	154	3	6	2	300	17.73	4
27	West Pokot	Kacheliba	Nasakam borehole	1.9477336	35.071101	No	200	196	206	8	6	2	300	47.28	13
28	West Pokot	Pokot North	Kasei boys	2.0108986	35.2063459	No	200	196	206	3	6	2	300	17.73	5
29	West Pokot	Pokot North	Cheporon Borehole	2.1157528	34.9698581	No	200	196	206	8	6	2	300	47.28	13
30	West Pokot	Pokot North	Lochariamo nyang borehole	2.1938848	35.0225151	No	200	196	206	8	6	2	300	47.28	13
31	West Pokot	Pokot North	Naruoro borehole	2.2788069	35.0475045	No	120	116	122	5	6	2	300	29.55	5

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth(m)	Static Head ESTIMATED (m)	Total Dynamic Head(TDH) ESTMATED (m)	Borehole Yield (m³/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m³/day)	*Aprox Solar Pv array Capacity (KWp)*
32	West Pokot	Pokot North	Oron borehole	2.2289797	35.0606 282	No	150	146	154	3	6	2	300	17.73	4
33	West Pokot	Pokot North	Lodonyo Borehole	2.2698261	35.0102 168	No	200	196	206	8	6	2	300	47.28	13

Appendix 3.2.11 Turkana County

Site code	*County*	*Sub-county*	*Site name*	Site Coordinates	Grid Availability	*Borehole depth(m)*	*Static Head ESTIMATED (m)*	*Total Dynamic Head(TDH) ESTMATED (m)*	*Borehole yield (m³/h)*	*Borehole diameter (inches)*	*Rising main diameter (inches)*	*Borehole to tank distance (m)*	*Solar design volume (m³/day)*	Aprox Solar Pv array Capacity (KWp)
1	Turkana	Loima	Kanyangpus	3.5929971, 35.5114788	No	120	116	122	18	6	2	300	108.72	17
2	Turkana	Loima	Lokatul	3.1861707, 35.2114304	No	100	96	101	12	6	2	300	72.48	9
3	Turkana	Loima	Namoruakwak	2.64198°,35.10194°	No	60	56	59	5	6	2	300	30.2	2
4	Turkana	Loima	Turkwel centre	2.93167°,35.40149°	Yes	30	26	28	7	6	2	300	42.28	2
5	Turkana	Turkana Central	Nasurut water supply	3.50817°,35.66778°	No	70	66	70	15	6	2	300	90.6	8
6	Turkana	Turkana Central	Lorengelup	3.05437°,35.92177°	No	88	84	89	18	6	2	300	108.72	12
7	Turkana	Turkana Central	Kadinyangole	3.094885°,35.65940°	No	93	89	94	22	6	2	300	132.88	16
8	Turkana	Turkana East	Lotubwae	2.01522°,36.13721°	No	120	116	122	20	6	2	300	120.8	19
9	Turkana	Turkana East	Katilia Girls	2.140015°,36.13817°	No	80	76	80	10	6	2	300	60.4	6

Site code	*County*	*Sub-county*	*Site name*	Site Coordinates	Grid Availability	*Borehole depth(m)*	*Static Head ESTIMATED (m)*	*Total Dynamic Head(TDH) ESTMATED (m)*	*Borehole yield (m^3/h)*	*Borehole diameter (inches)*	*Rising main diameter (inches)*	*Borehole to tank distance (m)*	*Solar design volume (m^3/day)*	*Aprox Solar Pv array Capacity (KWp)*
10	Turkana	Turkana East	Lokwii SDA	1.97331º,36.12712º	No	80	76	80	18	6	2	300	108.72	11
11	Turkana	Turkana North	Lomenguru(Na peto)	3.5003973, 35.2389548	No	150	146	154	15	6	2	300	90.6	18
12	Turkana	Turkana North	Lokumwae	4.4406531, 35.5870417	No	150	146	154	15	6	2	300	90.6	18
13	Turkana	Turkana North	Koriomoreng	4.402731, 35.5898922	No	150	146	154	15	6	2	300	90.6	18
14	Turkana	Turkana North	Nimwae	3.8076413, 35.4433963	No	150	146	154	15	6	2	300	90.6	18
15	Turkana	Turkana North	Lowarengak	4.27275, 35.8204534	No	50	46	49	15	6	2	300	90.6	6
16	Turkana	Turkana North	Murueris	4.3222916, 35.5272315	No	150	146	154	9	6	2	300	54.36	11
17	Turkana	Turkana North	Naurkorio	3.5833986, 35.3556491	No	150	146	154	15	6	2	300	90.6	18
18	Turkana	Turkana North	Natedelim	3.5280131, 352590442	No	150	146	154	15	6	2	300	90.6	18
19	Turkana	Turkana North	Loitangule	3.7977349, 35.395943	No	150	146	154	15	6	2	300	90.6	18
20	Turkana	Turkana South	Katilu	2.27972º,35.42809º	No	80	76	80	8	6	2	300	48.32	5
21	Turkana	Turkana south	Lokichar[Chines e borehole]	2.38072º,35.64445º	Yes	70	66	70	9	6	2	300	54.36	5
22	Turkana	Turkana south	Kapelbok	2.102217º,35.42278º	No	30	26	28	15	6	2	300	90.6	3
23	Turkana	Turkana south	Lomeleku	2.3648º,35.96887º	No	85	81	86	10	6	2	300	60.4	7
24	Turkana	Turkana south	Kasuroi	2.50523º,35.63438º	No	95	91	96	12	6	2	300	72.48	9
25	Turkana	Turkana south	Lomoonyang	2.32716º,35.50709º	No	90	86	91	12	6	2	300	72.48	9

Site code	*County*	*Sub-county*	*Site name*	Site Coordinates	Grid Availability	*Borehole depth(m)*	*Static Head ESTIMATED (m)*	*Total Dynamic Head(TDH) ESTMATED (m)*	*Borehole yield (m^3/h)*	*Borehole diameter (inches)*	*Rising main diameter (inches)*	*Borehole to tank distance (m)*	*Solar design volume (m^3/day)*	*Aprox Solar Pv array Capacity (KWp)*
26	Turkana	Turkana south	Loupwala	2.53564⁰,36.21889⁰	No	65	61	65	8	6	2	300	48.32	4
27	Turkana	Turkana South	Nagetei	2.060241⁰,35.59832⁰	No	90	86	91	12	6	2	300	72.48	9
28	Turkana	Turkana West	Loteteleit	3.9835354, 34.3316109	No	88	84	89	15	6	2	300	90.6	10
29	Turkana	Turkana West	Lokichioggio UN compound	4.2066948, 353651024	Yes	87	83	88	15	6	2	300	90.6	10
30	Turkana	Turkana West	Locheriangamo r	3.8549732, 34.3825555	No	90	86	91	15	6	2	300	90.6	11
31	Turkana	Turkana West	Akalaliot	4.2086793, 34.3244512	No	120	116	122	15	6	2	300	90.6	14
32	Turkana	Turkana West	Nakwangat 2	3.7506889, 34.8515318	No	80	76	80	15	6	2	300	90.6	9
33	Turkana	Turkana West	Oropoi w/s	3.8106119, 34.3588709	No	80	76	80	15	6	2	300	90.6	9

Appendix 3.2.12 Garissa County

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth (m)	Static Head ESTIMATED (m)	Total Dynamic Head (TDH) ESTMATED (m)	Borehole Yield (m^3/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m^3/day)	*Aprox Solar Pv array Capacity (KWp)*
1	Garissa	Fafi	Nanighi Sec	-0.8736034	39.8829	No	120	116	122	8	6	2	300	45.04	8
2	Garissa	Ijara	Hara borehole	-1.8763171	40.142946	No	100	96	101	20	6	2	300	112.6	16
3	Garissa	Ijara	Kotile borehole	-1.877675	40.143075	No	100	96	101	20	6	2	300	112.6	16
4	Garissa	Fafi	Sadh gosa borehole	-0.265102	40.787163	No	250	246	259	20	6	2	300	112.6	40
5	Garissa	Lagdera	Shanta-abaq borehole	0.4579124	39.74734	No	250	246	259	20	6	2	300	112.6	40
6	Garissa	Lagdera	Kathalash	0.3286542	39.55915	No	120	116	122	20	6	2	300	112.6	19

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth (m)	Static Head ESTIMATED (m)	Total Dynamic Head (TDH) ESTMATED (m)	Borehole Yield (m^3/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m^3/day)	*Aprox Solar Pv array Capacity (KWp)*
7	Garissa	Lagdera	Gurufa bh	0.8007263	39.464963	No	220	216	227	20	6	2	300	112.6	35
8	Garissa	Dadaab	Abakeile BH	0.0754973	40.097165	No	250	246	259	18	6	2	300	101.34	36
9	Garissa	Dadaab	Gubakibir	0.0750647	40.240336	No	250	246	259	18	6	2	300	101.34	36
10	Garissa	Dadaab	Kadakso	0.2072267	40.594215	No	250	246	259	18	6	2	300	101.34	36
11	Garissa	Dadaab	Kulan borehole 2	0.2222529	40.642185	No	180	176	185	18	6	2	300	101.34	26
12	Garissa	Dadaab	Sheldub	-0.0090634	40.580041	No	200	196	206	18	6	2	300	101.34	29
13	Garissa	Dadaab	Homajo	-0.0198432	40.948851	No	200	196	206	18	6	2	300	101.34	29
14	Garissa	Dadaab	Damajale BH	0.1035507	40.784826	No	250	246	259	25	6	2	300	140.75	50
15	Garissa	Dadaab	Dad quran	0.1898192	40.871465	No	250	246	259	18	6	2	300	101.34	36
16	Garissa	Dadaab	Liboi BH 1 police camp	0.3535832	40.877038	No	250	246	259	18	6	2	300	101.34	36
17	Garissa	Dadaab	Landiig BH	0.1246425	40.155795	No	250	246	259	18	6	2	300	101.34	36
18	Garissa	Lagdera	Lolol BH	0.3706129	39.696591	No	250	246	259	18	6	2	300	101.34	36
19	Garissa	Lagdera	Qone BH 1,2,3,4	0.9571475	39.370452	No	250	246	259	30	6	2	300	168.9	60
20	Garissa	Ijara	Hulugo water point	-1.146682	41.075918	No	100	96	101	15	6	2	300	84.45	12

Appendix 3.2.13 Mandera County

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth(m)	Static Head ESTIMATED (m)	Total Dynamic Head(TDH) ESTMATED (m)	Borehole Yield	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m^3/day)	*Aprox Solar Pv array Capacity(KWp)*
1	Mandera	Mandera North	Barwaqo	3.839751	41.027052	No	126	122	129	9	6	2	300	50.4	9
2	Mandera	Mandera North	Rhamu	3.9376	41.21024	Yes	70	66	70	12	6	2	300	67.2	7
3	Mandera	Mandera North	Morothile	3.3315	40.52347	No	250	246	259	10	6	2	300	56	20
4	Mandera	Mandera North	Daidai	3.68198	40.70489	No	260	256	269	6	6	2	300	33.6	13
5	Mandera	Banisa	Malkamari	4.23515	40.69427	No	280	276	290	2	6	2	300	11.2	5
6	Mandera	Banisa	Eymole	4.03779	40.19608	No	270	266	280	10	6	2	300	56	22
7	Mandera	Banisa	Birkan	3.95705	40.12082	No	295	291	306	10	6	2	300	56	24
8	Mandera	Mandera West	Darwed	3.43448	40.23233	No	220	216	227	6.5	6	2	300	36.4	11

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth(m)	Static Head ESTIMATED (m)	Total Dynamic Head(TDH) ESTMATED (m)	Borehole Yield	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m^3/day)	*Aprox Solar Pv array Capacity(KWp)*
9	Mandera	Mandera West	Dandu	3.44051	39.92962	No	150	146	154	7.5	6	2	300	42	9
10	Mandera	Mandera West	Wangai Dahan	3.3466	40.32949	No	250	246	259	15	6	2	300	84	30
11	Mandera	Mandera West	Kobadadi	3.2075	40.41035	No	220	216	227	7.5	6	2	300	42	13
12	Mandera	Mandera South	Elele	3.26972	40.72556	No	259	255	268	5	6	2	300	28	10
13	Mandera	Mandera South	Qoloy	3.90635	41.74689	No	260	256	269	8	6	2	300	44.8	17
14	Mandera	Mandera East	Koromey	3.8943	41.78944	No	270	266	280	9	6	2	300	50.4	20
15	Mandera	Lafey	Hareri	3.95541	41.41759	No	250	246	259	5	6	2	300	28	10
16	Mandera	Lafey	Gari	3.43342	40.97272	No	260	256	269	2.2	6	2	300	12.32	5
17	Mandera	Lafey	Waranqara	3.4109	41.0166	No	160	156	164	2	6	2	300	11.2	3
18	Mandera	Lafey	Lafey	3.15083	41.18871	No	160	156	164	7	6	2	300	39.2	9
19	Mandera	Lafey	Alungu	3.05435	41.05769	No	200	196	206	9	6	2	300	50.4	14
20	Mandera	Mandera South	Borehole 11	2.70981	40.91931	No	200	196	206	15	6	2	300	84	24
21	Mandera	Mandera South	Kabo	3.2734	41.21975	No	200	196	206	4	6	2	300	22.4	6
22	Mandera	Mandera South	Shimbir Fatuma 1	3.00745	40.531	No	292	288	303	8	6	2	300	44.8	19
23	Mandera	Mandera South	Shimbir Fatuma 2	3.03538	40.5145	No	289	285	300	5	6	2	300	28	12
24	Mandera	Mandera South	Qalanqalesa	2.86165	40.5572	No	270	266	280	8	6	2	300	44.8	17
25	Mandera	Mandera South	El Tul	2.92149	40.53131	No	270	266	280	5	6	2	300	28	11
26	Mandera	Mandera South	Harbate	2.97922	40.6317	No	265	261	275	5	6	2	300	28	11
27	Mandera	Mandera East	Bida	2.71032	40.91109	No	200	196	206	8	6	2	300	44.8	13
28	Mandera	Mandera East	Omar Jillo	3.75181	41.66652	No	100	96	101	12	6	2	300	67.2	9

Appendix 3.2.14 Wajir County

Code	County	Sub-County	Project Name	Coordinates		Grid Availability	Borehole depth (m)	Static Head ESTIMATED (m)	Total Dynamic Head (TDH) ESTMATED (m)	Borehole Yield (m^3/h)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Solar design volume (m^3/day)	*Aprox Solar Pv array Capacity (KWp)*
1	wajir	Khorofarar	Konton	2.0264387	40.903213	No	150	146	154	18	6	2	300	100.8	27
2	wajir	Dadajabula	Lagdub borehole	0.469662	40.881802	No	200	196	206	14	6	2	300	78.4	22
3	wajir	Basir	Basir Tito2	2.5770749	38.876249	No	105	101	107	5	6	2	300	28	4
4	wajir	Danaba	Qarari	2.9789303	39.853498	No	200	196	206	20	6	2	300	112	32
5	wajir	Danaba	Qarsabula	3.2933789	39.669174	No	120	116	122	10	6	2	300	56	9
6	wajir	Batalu/Buna	Batalu	2.8363305	39.847746	No	72	68	72	3	6	2	300	16.8	2
7	wajir	Sarman	Mashin ben	2.4488548	39.915523	No	50	46	49	5	6	2	300	28	2
8	wajir	Sarman	Kabatula	2.6260321	39.804465	No	120	116	122	20	6	2	300	112	19
9	wajir	Benane	Sariba borehole	0.610947	40.160022	No	200	196	206	18	6	2	300	100.8	29
10	wajir	Admasajida	Lagdima borehole	1.0639418	39.554247	No	220	216	227	23	6	2	300	128.8	41
11	wajir	Admasajida	Wara borehole	1.2589548	39.362385	No	204	200	210	12	6	2	300	67.2	20
12	wajir	Hadado ward	Baragothey borehole	1.391174	39.307355	No	200	196	206	12	6	2	300	67.2	19
13	wajir	Hadado	Athibohol borehole2	1.707881	39.209028	No	220	216	227	12	6	2	300	67.2	21
14	wajir	Hadado	Hadado new borehole	1.5349086	39.44131	No	220	216	227	8	6	2	300	44.8	14
15	wajir	Lagbogol	Allan-uss	1.1229088	39.705036	No	200	196	206	12	6	2	300	67.2	19

Appendix 3.3: ADDITIONAL MINOR WORKS

Appendix 3.3.1 Isiolo County

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required				Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
1	Isiolo	Merti	Bullesa old	0	1	0	0	0	1	1	0	1
2	Isiolo	Merti	New Lakole	0	1	0	0	0	1	1	0	1
3	Isiolo	Merti	Dogogicha	0	1	0	0	0	1	1	0	1
4	Isiolo	Merti	Urura	0	1	0	0	0	1	1	0	1
5	Isiolo	Merti	Yamicha	0	1	0	0	0	1	1	0	1
6	Isiolo	Isiolo	LMD-Kilimani	0	1	0	0	0	1	1	0	1

Appendix 3.3.2 Marsabit County

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required				Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
1	Marsabit	Kargi	Bagasi	0	1	0	0	0	1	1	0	1
2	Marsabit	Moyale	Badanrero	0	1	0	0	0	1	1	0	1
3	Marsabit	Moyale	Ambalo 1	0	1	0	0	0	1	1	0	1
4	Marsabit	Moyale	Ambalo 2	0	1	0	0	0	1	1	0	1
5	Marsabit	Moyale	Kobb Adadi	0	1	0	0	0	1	1	0	1
6	Marsabit	Moyale	Gololе 2	0	1	0	0	0	1	1	0	1
7	Marsabit	North Horr	Ramat Os Tullow	0	1	0	0	0	1	1	0	1
8	Marsabit	Saku	Shegel III	0	1	0	0	0	1	1	0	1
9	Marsabit	Saku	Dololo Dokatu	0	1	0	0	0	1	1	0	1

Appendix 3.3.3 Taita Taveta County

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required				Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
1	Taita Taveta	Taveta	Rekeke booster pump	0	1	0	0	0	1	1	0	1
2	Taita Taveta	Taveta	Bura Ndogo-C Borehole	0	1	0	0	0	0	1	0	1
3	Taita Taveta	Taveta	Mrabani Primary shallow well	0	1	0	0	0	1	1	0	1
4	Taita Taveta	voi	Kisimenyi Primary	0	1	0	0	0	1	1	0	1
5	Taita Taveta	Mwatate	Mvita/KwaScaver BH	0	1	0	0	0	1	1	0	1
6	Taita Taveta	Voi	Birikani Kisimenyi	0	1	0	0	0	1	1	0	1
7	Taita Taveta	Mwatate	Msau Polytechnic Borehole	0	1	0	0	0	1	1	0	1
8	Taita Taveta	Mwatate	Manoa Borehole	0	1	0	0	0	0	1	0	1
9	Taita Taveta	Mwatate	Nyangoro borehole	0	1	0	0	0	0	1	0	1
10	Taita Taveta	Wundanyi	Kishushe sharp corner	0	1	0	0	0	1	1	0	1
11	Taita Taveta	Wundanyi	Kisima borehole/Kishushe	0	1	0	0	0	1	1	0	1
12	Taita Taveta	Wundanyi	Paranga Borehole	0	1	0	0	0	1	1	0	1
13	Taita Taveta	Taveta	Lutheran Borehole	0	1	0	0	0	0	1	0	1
14	Taita Taveta	Taveta	Lessesia Borehole	0	1	0	0	0	0	1	0	1
15	Taita Taveta	Taveta	Eldoro Borehole	0	1	0	0	0	1	1	0	1
16	Taita Taveta	Taveta	Ulawani community borehole	0	1	0	0	0	0	1	0	1
17	Taita Taveta	Taveta	Chumvini water project	0	1	0	0	0	0	1	0	1

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required				Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
18	Taita Taveta	Taveta	Njukini borehole	0	1	0	0	0	0	1	0	1
19	Taita Taveta	Taveta	Wololo borehole	0	1	0	0	0	1	1	0	1

Appendix 3.3.4 Lamu County

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
1	Lamu	Lamu East	Ndau Desalination Plant	0	1	0	0	0	1	0	1
2	Lamu	Lamu East	Mkokoni Desalination Plant	0	1	0	0	0	1	0	1
3	Lamu	Lamu West	Maishamash	0	1	0	0	0	1	0	1
4	Lamu	Lamu West	Kisuke Primary School	0	1	0	0	0	1	0	1
5	Lamu	Lamu West	Mikinduni Primary School	0	1	0	0	0	1	0	1
6	Lamu	Lamu West	Holy Angels Primary School	0	1	0	0	0	1	0	1

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
7	Lamu	Lamu West	Sefu Primary	0	1	0	0	0	1	0	1
8	Lamu	Lamu West	Jericho Primary School	0	1	0	0	0	1	0	1
3	Lamu	Lamu East	Faza Primary School	0	1	0	0	0	1	0	1
5	Lamu	Lamu West	Soroko Primary	0	1	0	0	0	1	0	1
7	Lamu	Lamu West	Poromoko Primary School	0	1	0	0	0	1	0	1
8	Lamu	Lamu West	Rehema Primary	0	1	0	0	0	1	0	1
9	Lamu	Lamu West	Bahati Primary School	0	1	0	0	0	1	0	1
14	Lamu	Lamu West	Mini Valley Primary School	0	1	0	0	0	1	0	1
15	Lamu	Lamu West	Bomani Primary School	0	1	0	0	0	1	0	1

Appendix 3.2.5 Kilifi County

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/ room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
1	Kilifi	Kilifi North	Mtondia Kwa ngonyo	0	1	0	0	0	1	0	1
2	Kilifi	Kilifi North	Kwa katana wa chome Majaoni	0	1	0	0	0	0	0	1
3	Kilifi	Kilifi North	Tezo agriculture borehole	0	1	0	0	0	1	0	1
4	Kilifi	Kilifi North	Samson Nyanje borehole	0	1	0	0	0	1	0	1
5	Kilifi	Kilifi North	Mwambani Kwa Mundu	0	1	0	0	0	0	0	1
6	Kilifi	Kilifi North	Mkunguni Chumani	0	1	0	0	0	1	0	1
7	Kilifi	Kilifi North	Wesa Ngerenya borehole	0	1	0	0	0	1	0	1
8	Kilifi	Kilifi North	Roka Maweni	0	1	0	0	0	1	0	1
9	Kilifi	Kilifi North	Kadenge paka borehole	0	1	0	0	0	1	0	1
10	Kilifi	Malindi	Sea breeze Msabaha wa juu	0	1	0	0	0	1	0	1
11	Kilifi	Malindi	Takaye Kwa Diwani	0	1	0	0	0	1	0	1
12	Kilifi	Malindi	Takaye Kwa chiguba (chigunda)	0	1	0	0	0	0	0	1
13	Kilifi	Malindi	Msoloni Kwa jasho	0	1	0	0	0	1	0	1
14	Kilifi	Malindi	Gahaleni	0	1	0	0	0	1	0	1
15	Kilifi	Magarini	Magarini Mabrui	0	1	0	0	0	0	0	1

Code	County	Sub-County	Project Name	Chlori nator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/ room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
16	Kilifi	Magarini	Majengo Centre Borehole	0	1	0	0	0	1	0	1
17	Kilifi	Kilifi North	Kwa Muye Bh	0	1	0	0	0	1	0	1
18	Kilifi	Kaloleni	Mwakanga Walea Primary BH	0	1	0	0	0	1	0	1
19	Kilifi	Kilifi South	Mzambaraoni(kwa Abdla heri) BH	0	1	0	0	0	1	0	1
20	Kilifi	Kaloleni	Mwakonzi BH	0	1	0	0	0	1	0	1
21	Kilifi	Kilifi South	Shariani Kwa Akida BH	0	1	0	0	0	0	0	1
22	Kilifi	Ganze	Migodomani BH	0	1	0	0	0	1	0	1
23	Kilifi	Kilifi North	Kwa William Shida	0	1	0	0	0	1	0	1
24	Kilifi	Kilifi North	Roka Youth Polytechnic	0	1	0	0	0	1	0	1
25	Kilifi	Kilifi North	Kadenge Kavumbe Borehole	0	1	0	0	0	1	0	1
26	Kilifi	Malindi	Msabaha Kwa mwasaha	0	1	0	0	0	1	0	1
27	Kilifi	Kilifi North	Dungicha BP	0	1	0	0	0	1	0	1
28	Kilifi	Kilifi	Tsalu BP	0	1	0	0	0	1	0	1
29	Kilifi	Rabai	Masaani Booster pump	0	1	0	0	0	1	0	1
30	Kilifi	Kilifi South	Mapawa Kolewa BP	0	1	0	0	0	1	0	1
31	Kilifi	Ganze	Mweza Bp	0	1	0	0	0	1	0	1
32	Kilifi	Ganze	Mbonga BP	0	1	0	0	0	1	0	1
33	Kilifi	Ganze	Palakumi BP	0	1	0	0	0	1	0	1

Appendix 3.2.6 Tana River County

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tank and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
1	Tana River	Tana River	Bububu	0	1	0	0	0	1	0	1
2	Tana River	Tana River	Duwayo Borehole	0	1	0	0	0	1	0	1
3	Tana River	Tana River	Hola Water Supply B	0	1	0	0	0	0	0	1
4	Tana River	Tana River	Rhoka	0	1	0	0	0	1	0	1
5	Tana River	Tana River	Laini	0	1	0	0	0	1	0	1
6	Tana River	Tana River	Ghalamani	0	1	0	0	0	1	0	1
7	Tana River	Tana River	Chanani	0	1	0	0	0	1	0	1
8	Tana River	Tana Delta	Gadeni Furaha	0	1	0	0	0	1	0	1
9	Tana River	Tana River	Hola Water Supply A	0	1	0	0	0	0	0	1
10	Tana River	Tana North	Bura Water Works	0	1	0	0	0	0	0	1
11	Tana River	Tana Delta	Ngao Water Supply	0	1	0	0	0	0	0	1
12	Tana River	Tana Delta	Tarasaa Secondary	0	1	0	0	0	1	0	1

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tank and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
13	Tana River	Tana Delta	Kipini Secondary	0	1	0	0	0	1	0	1
14	Tana River	Tana Delta	Arap Moi Primary	0	1	0	0	0	1	0	1
15	Tana River	Tana Delta	Baomo	0	1	0	0	0	1	0	1
16	Tana River	Tana Delta	Buyani Secondary School	0	1	0	0	0	1	0	1
17	Tana River	Tana Delta	Majiweni Primary School	0	1	0	0	0	1	0	1
18	Tana River	Bangale	Maramtu A	0	1	0	0	0	1	0	1
19	Tana River	Tana Delta	Ziwani	0	1	0	0	0	1	0	1
20	Tana River	Bangale	Taleo Kolati	0	1	0	0	0	1	0	1
21	Tana River	Tana North	Chewele Ghaigopa Msikitini	0	1	0	0	0	1	0	1
22	Tana River	Tana Delta	Wema Kulesa	0	1	0	0	0	1	0	1
23	Tana River	Tana Delta	Bara Moyoo	0	1	0	0	0	1	0	1
24	Tana River	Tana River	Nyangwani	0	1	0	0	0	1	0	1

Appendix 3.3.7 Kwale County

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
1	Kwale	Lungalunga	Ganda	0	1	0	0	0	1	0	1
2	Kwale	Lungalunga	Kifuku	0	1	0	0	0	1	0	1
3	Kwale	Lungalunga	mabafweni	0	1	0	0	0	1	0	1
4	Kwale	Matuga	Kidiani ecd	0	1	0	0	0	1	0	1
5	Kwale	Matuga	Mwanamkuu	0	1	0	0	0	1	0	1
6	Kwale	Matuga	Haraka	0	1	0	0	0	1	0	1
7	Kwale	Matuga	Mwagodzo	0	1	0	0	0	0	0	1
8	Kwale	Matuga	Bowa	0	1	0	0	0	1	0	1
9	Kwale	Matuga	Kombani central	0	1	0	0	0	1	0	1
10	Kwale	Matuga	Madibwani	0	1	0	0	0	1	0	1
11	Kwale	Matuga	Magundo	0	1	0	0	0	1	0	1
12	Kwale	Matuga	Jeza A	0	1	0	0	0	1	0	1
13	Kwale	Matuga	Mwananyahi	0	1	0	0	0	1	0	1
14	Kwale	Matuga	Mazumalumee	0	1	0	0	0	1	0	1
15	Kwale	Msambweni	Mbuwani	0	1	0	0	0	1	0	1
16	Kwale	Msambweni	Kibarani	0	1	0	0	0	1	0	1

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
17	Kwale	Msambweni	Darigube	0	1	0	0	0	1	0	1
18	Kwale	Matuga	Muungano	0	1	0	0	0	1	0	1
19	Kwale	Lungalunga	Godo	0	1	0	0	0	1	0	1
20	Kwale	Matuga	Mwamnyuti	0	1	0	0	0	1	0	1
21	Kwale	Msambweni	Vumilia	0	1	0	0	0	1	0	1
22	Kwale	Lungalunga	Mahuruni	0	1	0	0	0	1	0	1
23	Kwale	Msambweni	Mwendo Wa Bure	0	1	0	0	0	1	0	1
24	Kwale	Msambweni	Vukani	0	1	0	0	0	1	0	1
25	Kwale	Msambweni	Kandarasi	0	1	0	0	0	1	0	1
26	Kwale	Lungalunga	Mwamose	0	1	0	0	0	1	0	1
27	Kwale	Msambweni	Ngori	0	1	0	0	0	0	0	1
28	Kwale	Msambweni	Maphombe	0	1	0	0	0	1	0	1

Appendix 3.3.8 Narok County

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
1	Narok	Narok central	Katakala borehole	0	1	0	0	0	0	0	1
2	Narok	Narok central	Katakala C/o Saoli	0	1	0	0	0	0	0	1
3	Narok	Narok central	Olopito water point (spring)	0	1	0	0	0	0	0	1
4	Narok	Narok South	Ichangipusi inside building hope academy school	0	1	0	0	0	1	0	1
5	Narok	Narok South	Ole pariata borehole	0	1	0	0	0	1	0	1
6	Narok	Narok South	Olkirankawuo	0	1	0	0	0	1	0	1
7	Narok	Narok South	Nkoben	0	1	0	0	0	1	0	1
8	Narok	Narok central	Nkareta BH	0	1	0	0	0	1	0	1
9	Narok	Transmara south	Oldonyorok bh	0	1	0	0	0	1	0	1
10	Narok	Transmara east	Mugenyi/ njipship BH	0	1	0	0	0	1	0	1
11	Narok	Narok South	Sogoo	0	1	0	0	0	0	0	1
12	Narok	Narok South	Marinwa	0	1	0	0	0	0	0	1

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
13	Narok	Transmara east	Simutwet shallow well	0	1	0	0	0	1	0	1
14	Narok	Narok North	Enesampulai BH	0	1	0	0	0	1	0	1
15	Narok	Narok East	Kitororonyi BH	0	1	0	0	0	1	0	1
16	Narok	Narok West	Mpuaai	0	1	0	0	0	1	0	1
17	Narok	Narok West	Mosimowok/ laluk	0	1	0	0	0	1	0	1
18	Narok	Narok West	Nkamurunya	0	1	0	0	0	1	0	1
19	Narok	Narok East	Olepunywa/ olchoro leletuya	0	1	0	0	0	0	0	1
20	Narok	Narok East	Oloikumkum bh	0	1	0	0	0	1	0	1
21	Narok	Narok East	Olooiturot BH	0	1	0	0	0	1	0	1
22	Narok	Narok West	Omomet bh	0	1	0	0	0	1	0	1
23	Narok	Narok central	Sheep and goats	0	1	0	0	0	1	0	1
24	Narok	Transmara south	Angata-barrakoi	0	1	0	0	0	1	0	1
25	Narok	Narok West	Ilmedeketa bh	0	1	0	0	0	1	0	1
26	Narok	Narok South	Enkoseremai	0	1	0	0	0	1	0	1
27	Narok	Narok South	Morijo Loita	0	1	0	0	0	1	0	1

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
28	Narok	Narok South	Intasati	0	1	0	0	0	1	0	1
29	Narok	Narok South	Iladoru	0	1	0	0	0	1	0	1
30	Narok	Narok West	Endonyo Narasha	0	1	0	0	0	1	0	1
31	Narok	Narok South	Enkejuarro	0	1	0	0	0	1	0	1
32	Narok	Narok South	Koseka	0	1	0	0	0	1	0	1
33	Narok	Narok West	Entagotuo	0	1	0	0	0	1	0	1
34	Narok	Narok West	Ole Tarkash	0	1	0	0	0	1	0	1
35	Narok	Narok West	Olkinyei water project	0	1	0	0	0	1	0	1

Appendix 3.3.9 Samburu County

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
1	Samburu	Samburu West	Ngambo	0	1	0	0	0	1	0	1
2	Samburu	Samburu West	Miyai Borehole	0	1	0	0	0	1	0	1
3	Samburu	Samburu West	Lemisigiyo	0	1	0	0	0	1	0	1
4	Samburu	Samburu West	Seketet	0	1	0	0	0	1	0	1
5	Samburu	Samburu West	Lesidai	0	1	0	0	0	1	0	1
6	Samburu	Samburu West	Loibor	0	1	0	0	0	1	0	1
7	Samburu	Samburu West	Rangau	0	1	0	0	0	1	0	1
8	Samburu	Samburu West	Sirata	0	1	0	0	0	1	0	1
9	Samburu	Samburu West	Nkenju	0	1	0	0	0	1	0	1
10	Samburu	Samburu West	Ledero	0	1	0	0	0	1	0	1
11	Samburu	Samburu West	Malta	0	1	0	0	0	1	0	1
12	Samburu	Samburu West	Shabaa	0	1	0	0	0	1	0	1

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
13	Samburu	Samburu West	Simiti	0	1	0	0	0	1	0	1
14	Samburu	Samburu East	Jelmen	0	1	0	0	0	1	0	1
15	Samburu	Samburu East	Loijuk	0	1	0	0	0	1	0	1
16	Samburu	Samburu East	Lderkesi	0	1	0	0	0	1	0	1
17	Samburu	Samburu North	Bendera 1	0	1	0	0	0	1	0	1
18	Samburu	Samburu North	Baragoi boys	0	1	0	0	0	1	0	1

Appendix 3.3.10 West Pokot County

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
1	West Pokot	Pokot West	KatikomorPri School	0	1	0	0	0	1	0	1
2	West Pokot	Pokot West	Auskiyon	0	1	0	0	0	1	0	1
3	West Pokot	Pokot West	Habari Njema	0	1	0	0	0	1	0	1
4	West Pokot	Pokot West	Kariwo	0	1	0	0	0	1	0	1
5	West Pokot	Pokot West	Tamugh	0	1	0	0	0	1	0	1
6	West Pokot	Pokot West	Kotimoril	0	1	0	0	0	1	0	1
7	West Pokot	Pokot West	Kapkata	0	1	0	0	0	1	0	1
8	West Pokot	Pokot West	Cheptuya	0	1	0	0	0	1	0	1
9	West Pokot	Pokot West	Tilak Pri School	0	1	0	0	0	1	0	1
10	West Pokot	Pokot South	Chelombai	0	1	0	0	0	1	0	1
11	West Pokot	Pokot South	Pserum St. Mary's Sec Sch.	0	1	0	0	0	1	0	1
12	West Pokot	Pokot South	Tomoi	0	1	0	0	0	1	0	1
13	West Pokot	Pokot South	Senetwo	0	1	0	0	0	0	0	1

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
14	West Pokot	Pokot Central	Rorok	0	1	0	0	0	1	0	1
15	West Pokot	Pokot Central	Poto	0	1	0	0	0	1	0	1
16	West Pokot	Pokot Central	Weiwei Sec School	0	1	0	0	0	0	0	1
17	West Pokot	Pokot central	Cheprukot	0	1	0	0	0	1	0	1
18	West Pokot	Kacheliba	Kopulio pri.School	0	1	0	0	0	1	0	1
19	West Pokot	Kacheliba	Lokii ECDE Borehole	0	1	0	0	0	1	0	1
20	West Pokot	Kacheliba	Katuwot borehole	0	1	0	0	0	1	0	1
21	West Pokot	Kacheliba	Longolesia Borehole	0	1	0	0	0	1	0	1
22	West Pokot	Kacheliba	Reretiang borehole	0	1	0	0	0	1	0	1
23	West Pokot	Kacheliba	Kaskuroi ECDE borehole	0	1	0	0	0	1	0	1
24	West Pokot	Kacheliba	Losam Borehole	0	1	0	0	0	1	0	1
25	West Pokot	Kacheliba	Lamada borehole	0	1	0	0	0	1	0	1
26	West Pokot	Pokot North	Mbaru borehole	0	1	0	0	0	1	0	1
27	West Pokot	Kacheliba	Nasakam borehole	0	1	0	0	0	1	0	1
28	West Pokot	Pokot North	Kasei boys	0	1	0	0	0	1	0	1

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
29	West Pokot	Pokot North	Cheporon Borehole	0	1	0	0	0	1	0	1
30	West Pokot	Pokot North	Lochariamonyang borehole	0	1	0	0	0	1	0	1
31	West Pokot	Pokot North	Naruoro borehole	0	1	0	0	0	1	0	1
32	West Pokot	Pokot North	Oron borehole	0	1	0	0	0	1	0	1
33	West Pokot	Pokot North	Lodonyo Borehole	0	1	0	0	0	1	0	1

Appendix 3.3.11 Turkana County

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
1	Turkana	Loima	Kanyangpus	0	1	0	0	0	1	0	1
2	Turkana	Loima	Lokatul	0	1	0	0	0	1	0	1
3	Turkana	Loima	Namoruakwak	0	1	0	0	0	1	0	1

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
4	Turkana	Loima	Turkwel centre	0	1	0	0	0	0	0	1
5	Turkana	Turkana Central	Nasurut water supply	0	1	0	0	0	1	0	1
6	Turkana	Turkana Central	Lorengelup	0	1	0	0	0	1	0	1
7	Turkana	Turkana Central	Kadinyangole	0	1	0	0	0	1	0	1
8	Turkana	Turkana East	Lotubwae	0	1	0	0	0	1	0	1
9	Turkana	Turkana East	Katilia Girls	0	1	0	0	0	1	0	1
10	Turkana	Turkana East	Lokwii SDA	0	1	0	0	0	1	0	1
11	Turkana	Turkana North	Lomenguru(Napeto)	0	1	0	0	0	1	0	1
12	Turkana	Turkana North	Lokumwae	0	1	0	0	0	1	0	1
13	Turkana	Turkana North	Koriomoreng	0	1	0	0	0	1	0	1
14	Turkana	Turkana North	Nimwae	0	1	0	0	0	1	0	1
15	Turkana	Turkana North	Lowarengak	0	1	0	0	0	1	0	1
16	Turkana	Turkana North	Murueris	0	1	0	0	0	1	0	1
17	Turkana	Turkana North	Naurkorio	0	1	0	0	0	1	0	1
18	Turkana	Turkana North	Natedelim	0	1	0	0	0	1	0	1

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
19	Turkana	Turkana North	Loitangule	0	1	0	0	0	1	0	1
20	Turkana	Turkana South	Katilu	0	1	0	0	0	1	0	1
21	Turkana	Turkana south	Lokichar[Chinese borehole]	0	1	0	0	0	0	0	1
22	Turkana	Turkana south	Kapelbok	0	1	0	0	0	1	0	1
23	Turkana	Turkana south	Lomeleku	0	1	0	0	0	1	0	1
24	Turkana	Turkana south	Kasuroi	0	1	0	0	0	1	0	1
25	Turkana	Turkana south	Lomoonyang	0	1	0	0	0	1	0	1
26	Turkana	Turkana south	Loupwala	0	1	0	0	0	1	0	1
27	Turkana	Turkana South	Nagetei	0	1	0	0	0	1	0	1
28	Turkana	Turkana West	Loteteleit	0	1	0	0	0	1	0	1
29	Turkana	Turkana West	Lokichioggio UN compound	0	1	0	0	0	0	0	1
30	Turkana	Turkana West	Locheriangamor	0	1	0	0	0	1	0	1
31	Turkana	Turkana West	Akalaliot	0	1	0	0	0	1	0	1
32	Turkana	Turkana West	Nakwangat 2	0	1	0	0	0	1	0	1

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
33	Turkana	Turkana West	Oropoi w/s	0	1	0	0	0	1	0	1

Appendix 3.3.12 Garissa County

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
1	Garissa	Fafi	Nanighi Sec	0	1	0	0	0	1	0	1
2	Garissa	Ijara	Hara borehole	0	1	0	0	0	1	0	1
3	Garissa	Ijara	Kotile borehole	0	1	0	0	0	1	0	1
4	Garissa	Fafi	Sadh gosa borehole	0	1	0	0	0	1	0	1
5	Garissa	Lagdera	Shanta-abaq borehole	0	1	0	0	0	1	0	1
6	Garissa	Lagdera	Kathalash	0	1	0	0	0	1	0	1
7	Garissa	Lagdera	Gurufa bh	0	1	0	0	0	1	0	1
8	Garissa	Dadaab	Abakeile BH	0	1	0	0	0	1	0	1

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
9	Garissa	Dadaab	Gubakibir	0	1	0	0	0	1	0	1
10	Garissa	Dadaab	Kadakso	0	1	0	0	0	1	0	1
11	Garissa	Dadaab	Kulan borehole 2	0	1	0	0	0	1	0	1
12	Garissa	Dadaab	Sheldub	0	1	0	0	0	1	0	1
13	Garissa	Dadaab	Homajo	0	1	0	0	0	1	0	1
14	Garissa	Dadaab	Damajale BH	0	1	0	0	0	1	0	1
15	Garissa	Dadaab	Dad quran	0	1	0	0	0	1	0	1
16	Garissa	Dadaab	Liboi BH 1 police camp	0	1	0	0	0	1	0	1
17	Garissa	Dadaab	Landiig BH	0	1	0	0	0	1	0	1
18	Garissa	Lagdera	Lolol BH	0	1	0	0	0	1	0	1
19	Garissa	Lagdera	Qone BH 1,2,3,4	0	1	0	0	0	1	0	1
20	Garissa	Ijara	Hulugo water point	0	1	0	0	0	1	0	1

Appendix 3.3.13 Mandera County

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
1	Mandera	Mandera North	Barwaqo	0	1	0	0	0	1	0	1
2	Mandera	Mandera North	Rhamu	0	1	0	0	0	0	0	1
3	Mandera	Mandera North	Morothile	0	1	0	0	0	1	0	1
4	Mandera	Mandera North	Daidai	0	1	0	0	0	1	0	1
5	Mandera	Banisa	Malkamari	0	1	0	0	0	1	0	1
6	Mandera	Banisa	Eymole	0	1	0	0	0	1	0	1
7	Mandera	Banisa	Birkan	0	1	0	0	0	1	0	1
8	Mandera	Mandera West	Darwed	0	1	0	0	0	1	0	1
9	Mandera	Mandera West	Dandu	0	1	0	0	0	1	0	1
10	Mandera	Mandera West	Wangai Dahan	0	1	0	0	0	1	0	1
11	Mandera	Mandera West	Kobadadi	0	1	0	0	0	1	0	1
12	Mandera	Mandera South	Elele	0	1	0	0	0	1	0	1
13	Mandera	Mandera South	Qoloy	0	1	0	0	0	1	0	1
14	Mandera	Mandera East	Koromey	0	1	0	0	0	1	0	1
15	Mandera	Lafey	Hareri	0	1	0	0	0	1	0	1
16	Mandera	Lafey	Gari	0	1	0	0	0	1	0	1
17	Mandera	Lafey	Waranqara	0	1	0	0	0	1	0	1
18	Mandera	Lafey	Lafey	0	1	0	0	0	1	0	1
19	Mandera	Lafey	Alungu	0	1	0	0	0	1	0	1
20	Mandera	Mandera South	Borehole 11	0	1	0	0	0	1	0	1
21	Mandera	Mandera South	Kabo	0	1	0	0	0	1	0	1
22	Mandera	Mandera South	Shimbir Fatuma 1	0	1	0	0	0	1	0	1
23	Mandera	Mandera South	Shimbir Fatuma 2	0	1	0	0	0	1	0	1

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
24	Mandera	Mandera South	Qalanqalesa	0	1	0	0	0	1	0	1
25	Mandera	Mandera South	El Tul	0	1	0	0	0	1	0	1
26	Mandera	Mandera South	Harbate	0	1	0	0	0	1	0	1
27	Mandera	Mandera East	Bida	0	1	0	0	0	1	0	1
28	Mandera	Mandera East	Omar Jillo	0	1	0	0	0	1	0	1

Appendix 3.3.14 Wajir County

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
1	wajir	Khorofarar	Konton	0	1	0	0	0	1	0	1
2	wajir	Dadajabula	Lagdub borehole	0	1	0	0	0	1	0	1
3	wajir	Basir	Basir Tito2	0	1	0	0	0	1	0	1
4	wajir	Danaba	Qarari	0	1	0	0	0	1	0	1
5	wajir	Danaba	Qarsabula	0	1	0	0	0	1	0	1
6	wajir	Batalu/Buna	Batalu	0	1	0	0	0	1	0	1
7	wajir	Sarman	Mashin ben	0	1	0	0	0	1	0	1
8	wajir	Sarman	Kabatula	0	1	0	0	0	1	0	1
9	wajir	Benane	Sariba borehole	0	1	0	0	0	1	0	1

Code	County	Sub-County	Project Name	Chlorinator	Supplementary Storage	Minor Works Required		New Civil Works Required			Electrical Works
				Qty	*New 10,000 liter tanks and Support Structure*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
10	wajir	Admasajida	Lagdima borehole	0	1	0	0	0	1	0	1
11	wajir	Admasajida	Wara borehole	0	1	0	0	0	1	0	1
12	wajir	Hadado ward	Baragothey borehole	0	1	0	0	0	1	0	1
13	wajir	Hadado	Athibohol borehole2	0	1	0	0	0	1	0	1
14	wajir	Hadado	Hadado new borehole	0	1	0	0	0	1	0	1
15	wajir	Lagbogol	Allan-uss	0	1	0	0	0	1	0	1

4. The Technical Bid Submission Form and BoQ

Contents

FORM 1: TECHNICAL COMPLIANCE SUBMISSION FORMS

Provide the necessary supporting documentation to show that equipment provided complies with the standards and warranties set out in the Scope of Work and Technical Specifications. **Complete the Technical Submission Form on the following pages, and sign the declaration, and attach the supporting documentation listed below.**

PV modules

- Data sheet for solar modules
- IV curves of modules at 100, 500, 1000 W/m^2 and 25ºC (STC)
- IV curves as above for Normal Operating Cell Temperature (NOCT)
- IEC Standard Certificate for the solar modules

Power conditioner / inverters/ converters

- Data sheets for the power conditioner
- Efficiency curves
- Certification based on one of:
    - IEC Standard Certificate
    - Test result certification based on testing to partial IEC standard
    - ISO9001 In-house certifications based on in-house R&D test results

Motor / pump

- Data sheets for the motor / pump (separate if they are physically separate)
- Pump curves
- Certification based on one of:
    - IEC Standard Certificate
    - Test result certification based on testing to partial IEC standard
    - ISO9001 In-house certifications based on in-house R&D test results

Remote monitoring, data-logging and remote control

- Data sheets for the remote monitoring, transducers, data-logger, communication
- Data sheet for App and data manager
- App link for example of system
- Certification based on one of:
    - IEC Standard Certificate
    - Test result certification based on testing to partial IEC standard
    - ISO9001 In-house certifications based on in-house R&D test results

Sundry components: i.e. ball valves, non-return valves, manometer, water-meter, lightnin protection, any test equipment

- Brochure and data sheets

Maintenance schedule

- A maintenance schedule for the motor/pump combination, detailing the work required and spares required.

Notes

- **Brochures and manufacturer's data sheet.** Detailed manufacturers data sheets to be provided for each component

- **Declaration of compliance.** Suppliers general declaration of compliance that systems overall, and individual components too, comply, or will be replaced or corrected at no cost to the project.
- **Manufacturer's Authorisation to Bid.** Certificate of Manufacturer's Authorization to bid for this specific bid offering the specific components, signed by the manufacturer.
- **Manufacturer's Authorisation for Warranty.** For compliance with warranties: Manufacturer's Warranty Certificates are required, bid for this specific bid offering the specific components, signed by the manufacturer. Since the warrantee periods are much longer than the contract period, these warranties shall be transferable to the eventual owner.

Notes on certificarions (from *Chapter 3, Section C.4.1*), options:

C.4.1.1. IEC Standard certificate: In general the full standard of the International Electro-technical Commission (IEC) is applied. Specifically, a certified quality test certificate is required from an accredited testing and certification organization acceptable to the Purchaser to confirm that the specific model of products or components offered complies with the entire referenced technical standard, based on the sampling approach of that technical standard.

- A certified copy of the **component's Compliance Certificate** shall be required from the ISO17026 accredited Certification Body corresponding to the accredited Test Center.
- A copy of the **Test Center's accreditation certificate, to conduct and certify the specific tests in the standard** under consideration must be provided.
- Detailed test results may be requested for the specific tests in the standard.
- This form of accreditation is required for the following components:
    - PV modules - all certificates
- This form is but is also accepted for all required component certificates as below:
    - Power conditioner / inverters /converters (Safety; Efficiency / performance; Noise and emissions)
    - Pumps and motors (Safety; Performance characterisation)
    - Monitoring systems (Performance)

C.4.1.2. Test result certification based on testing to partial IEC standard: The testing of components in ISO17025 certified laboratories to the full IEC standard using the required sampling is both time-intensive and expensive. Therefore provision is made for testing to only the relevant parts of the standard. Certified test results are required from an accredited testing and certification organization acceptable to the Purchaser to confirm that the specific model of products or components offered have been tested to referenced test procedure in the standard, based on the sampling approach of that technical standard.

- A copy of the **Test Center accreditation certificate, to conduct and certify the specific tests in the standard** under consideration must be provided.
- Detailed test results d shall be provided for the specific tests conducted in the standard for all the samples tested.
- This form of accreditation is acceptable for the following component certificates only:
    - Power conditioner / inverters /converters (Safety; Efficiency / performance; Noise and emissions)
    - Pumps and motors (Safety; Performance characterisation)
    - Monitoring systems (Performance)

C.4.1.3 ISO9001 In-house certifications based on in-house R&D test results: The testing of components in ISO17025 certified laboratories to the full IEC standard using the required sampling is both time-intensive and expensive. In addition many manufacturers perform rigorous in-house testing of their components before going to market. Therefore the ISO9001:2015 Declaration of Compliance Form was developed to qualify components of ISO9001:2015 certified manufacturers which are tested in their in-house ISO9001:2015 research and development laboratories, to either full or partial standard. The ISO9001 Declaration certificate may only be used for components manufactured by ISO9001:2015 company, AND tested to the relevant full standard (or partial standard procedures) referenced in the bid document. The Declaration must be supported by the test results for all the samples tested.

- See ***Section IV: Bid Forms: Statement of Compliance for Components by ISO 9001 :2015 Certified Manufacturer*** .
- Proof of the manufacturer's ISO9001:2015 accreditation from an approved accreditation agency is required.
- **Proof of competence of the manufacturer's testing facility**: its existence, equipment and equipment calibrations, staffing, and suitability to undertake the specific tests. This competence shall preferably be **via inspection and reference from a National Certification Body**[6].
- Presentation of detailed **supporting test results** is required for all samples tested, complemented by reference to the standard test method or detailed alternative **test methodology** where standards do not exist, and supported by an **inventory of test equipment** used.
- This form of accreditation is acceptable for the following component certificates only:
    - Power conditioner / inverters /converters (Efficiency / performance)
    - Pumps and motors (Safety; Performance characterisation)
    - Monitoring systems (Performance)

Technical Form 1: Compliance with standards and warranties

Chapter 3 clause	Clause Title	Manufacturer and model	Minimum data to be provided by bidder	Brochures	Declaration of compliance	Certification and supporting documents	Manufacturers Authorisations and supporting documents
Section C.4.2	PV Modules		Specification sheet and documentation to be provided in bid submission. IEC Certifications of Compliance to standards, from laboratories accredited under ISO 17025. *Refer Tech Form 1.1.*	Y	Y	Y	Y
Section C.4.3	Power conditioner / inverter /converter		Specification sheet and documentation to be provided in bid submission. IEC Certifications of Compliance to the required standards, from laboratories accredited under ISO 17025. *Refer Tech Form 1.2.*	Y	Y	Y	Y
Section C.4.4	Pump and motor		Specification sheet and documentation to be provided in bid submission. IEC Certifications of Compliance to the required standards, from laboratories accredited under ISO 17025. *Refer Tech Form 1.3.*	Y	Y	Y	Y
Section C.4.6	Diesel generator		Specification sheet and documentation to be provided in bid submission. IEC Certifications of Compliance to the required standards, f *Refer Tech Form 1.4.*	Y	Y	Y	Y
Section C.4.5	Remote monitoring and data logging system		Full brochures, user manuals and documentation of capabilities, interconnection requirements, IEC Certifications of Compliance to the required standards Component list for the complete system. *Refer Tech Form 1.5.*	Y	Y	Y	Y

Chapter 3 clause	Clause Title	Manufacturer and model	Minimum data to be provided by bidder	Brochures	Declaration of compliance	Certification and supporting documents	Manufacturers Authorisations and supporting documents
Section C.4.5	Remote software		Brochure, user manual, demonstration software and links to demonstration systems *Refer Tech Form 1.6.*	Y	Y	Y	Y
Section C.4.5	Laptop computer		Brochure, user manual, demonstration software and links to demonstration systems *Refer Tech Form 1.7.*	Y	Y	N	Y
Section C.3.3	Module mounting structure		Specification sheet and documentation to be provided in bid submission showing the array mounting superstructure, extrusions, clamp mounting fasteners and bolts, and module earthing details. Bidders are to provide detailed drawings of their proposed structure for each system type, including foundations, pole base mounting arrangements, and wind loading calculations.	Y	Y	N	N
Section C.3.4	Array quick connectors		Specification sheet and documentation for cables and wiring quick interconnection to be provided in bid submission.	Y	Y	N	N
Section C.3.5	Security enclosure		Bidders are to provide detailed drawings of their proposed enclosure.	Y	Y	N	N
Section C.3.6	Control Cubicle		Bidders are to provide detailed drawings of their proposed enclosure.	Y	Y	N	N
Section C.3.8	Valves and pipework		Specification sheet to be provided for each type	Y	Y	N	N
Section C.3.9, Section C.3.10	Metering		Specification sheet to be provided for each type	Y	Y	N	N
Section C.3.12	Water tanks		Specification sheets for each component to be provided.	Y	Y	N	N
Section C.3.12	Water tank stand		Bidders are to provide detailed drawings of their proposed enclosure.	Y	Y	N	N
Section C.3.15	Cables and connectors		Specification sheet to be provided for each type	Y	Y	N	N
Section C.3.16	Earthing		Specification sheets for each component to be provided.	Y	Y	N	N
Section C.3.17	Lightning protection		Specification sheet to be provided for each type	Y	Y	N	N

Tech form 1.1: Solar PV Module				
Technical description	**Specification offered by Bidder**			**Remarks**
Manufacture and model				
Panel type, cell size				
Total Wp and tolerance				
Panel voltage and number of cells				
Junction box and IP protection				
Cable Connector type (MC4)				
Module dimensions (mm x mm x mm)				
Thicknes of glass (mm)				
Performance guaranty (years and % of STC power)				
Supporting documentation				
Product brochure				
Component compliance accreditation	***IEC 61215***	***IEC 61730***	***IEC 61701***	
IEC Standard Certificate for component from Certification Body (Cert number, date, expiry)				
ISO 17025 Laboratory – Laboratory Accreditation (Name and CB number)				
ISO 17025 Laboratory – Certificate to conduct the specific tests and standards				
Test results from ISO 17025 Laboratory (incl Y/N)				
Authorisation to bid				
Manufacturer's Authorisation - to bid				
Manufacturer's Warranty Certificate				

Tech form 1.2: Power conditioner / inverter / converter				
Technical description	**Specification offered by Bidder**			**Remarks**
Manufacture and model				
Type (DC-DC, DC-AC etc)				
Output power (kW) • voltage(V) & phases • frequency (Hz) • rating temperature (ºC)				
Number of array inputs and MPPT's				
Array voltages and power				
Auxiliary power inputs: number • voltage (AC/DC) • power • Automatic array / genset / grid changeover (Y/N)				
Efficiency curves				
Max humidity (%), max temperature (ºC) enclosure IP rating,				
Display and functions: (i.e. operating parameters: frequency, voltage,amperage,input power: pump speed) (i.e. historical data: PV energy generation, maximum power and operating times, faults)				
Programable functions: (i.e. mini/max frequency, VoC)				
Lighting and surge protection (DC and AC)				
Warranty number of years at capacity				
Supporting documentation				
Product Brochure				
Component compliance accreditation	***IEC 62109***	***IEC 61683***	***Noise / emissions***	
IEC Standard Certificate for component from Certification Body (Cert number, date, expiry)				
ISO 17025 Laboratory – Laboratory Accreditation (Name and CB number)				
ISO 17025 Laboratory – Certificate to conduct the specific tests and standards				
Test results from ISO 17025 Laboratory (Y/N)				
In-house laboratory – Laboratory Accreditation				
Test results from in-house laboratory				
Authorisation to bid				
Manufacturer's Authorisation - to bid				
Manufacturer's Warranty Certificate				
ISO9001 Manufacturer - Declaration of Compliance				

ISO9001 Manufacturer Certificate		

Tech form 1.3: Pump / motor			
Technical description	**Specification offered by Bidder**		**Remarks**
Manufacture and model			
Configuration (submersible /surface/line shaft)			
Pump type (positive displacement / progressive cavity / multistage centrifugal)			
Motor type (DC /permanent magnet / AC / phases)			
Test report and IEC standard(s)			
Input power, voltage and phases			
Pump power (kW), head (m), flow (m^3/hr)			
Pump materials: • impeller material • shaft material • diffuser material • bearing material			
Pump/motor power vs flow v head curves			
Protection • dry running • thermal motor protection • other			
Earthing system			
Warranty number of years at capacity			
Supporting documentation			
Product Brochure			
Component compliance accreditation	***Performance***	***IEC 60034-81-41/42***	
IEC Standard Certificate for component from Certification Body (Cert number, date, expiry)			
ISO 17025 Laboratory – Laboratory Accreditation (Name and CB number)			
ISO 17025 Laboratory – Certificate to conduct the specific tests and standards			
Test results from ISO 17025 Laboratory (Y/N)			
In-house laboratory – Laboratory Accreditation			
Test results from in-house laboratory			
Authorisation to bid			
Manufacturer's Authorisation - to bid			
Manufacturer's Warranty Certificate			
ISO9001 Manufacturer - Declaration of Compliance			

ISO9001 Manufacturer Certificate		

Tech form 1.4: Diesel generator			
Technical description	**Specification offered by Bidder**		**Remarks**
Manufacture and model			
Test report and IEC standard(s)			
Engine: • kVA, kW • rated temperature • speed (rpm)			
Cooling: water/ air			
Alternator: • kVA, kW • voltage(V) & phases • frequency (Hz) • rating temperature (ºC)			
Other features • Electric start • Enclosed unit Integrated fuel tank			
Electrical Protection:			
Fuel consumption: litres/hour • 50% capacity • 75% capacity • 100% capacity			
Expected lifetime (hrs)			
Warranty number of years			
Supporting documentation			
Product Brochure			
Component compliance accreditation	***ISO 8528-1/6***	***IEC 60034-18-41/42***	
IEC Standard Certificate for component from Certification Body (Cert number, date, expiry)			
ISO 17025 Laboratory – Laboratory Accreditation (Name and CB number)			
ISO 17025 Laboratory – Certificate to conduct the specific tests and standards			
Test results from ISO 17025 Laboratory (Y/N)			
In-house laboratory – Laboratory Accreditation			
Test results from in-house laboratory			
Authorisation to bid			
Manufacturer's Authorisation - to bid			
Manufacturer's Warranty Certificate			
ISO9001 Manufacturer - Declaration of Compliance			

ISO9001 Manufacturer Certificate		

Tech form 1.5: Data-logging and on site display		
Technical description	**Specification offered by Bidder**	**Remarks**
Manufacture and model		
Power supply and back-up		
Variables: • solar radiation • pump status • pump power • pump speed • flow rate • pump temperature • pump pressure • diesel runtime		
External transducer provided (list)		
Status indicators • level • alarms		
Cumulative performance daily/monthly / totals • kWh used • water delivered • etc		
Communications interface on site (RS485 /Canbus / other)		
Communication hardware for remote access: (explain)		
Communcation protocol and requirement: (2G, 3G, other)		
Supporting documentation		
Product Brochure		
Component compliance accreditation	***IEC 61724***	
IEC Standard Certificate for component from Certification Body (Cert number, date, expiry)		
ISO 17025 Laboratory – Laboratory Accreditation (Name and CB number)		
ISO 17025 Laboratory – Certificate to conduct the specific tests and standards		
Test results from ISO 17025 Laboratory (incl Y/N)		
In-house laboratory – Laboratory Accreditation		
Test results from in-house laboratory		
Authorisation to bid		
Manufacturer’s Authorisation - to bid		
Manufacturer’s Warranty Certificate		
ISO9001 Manufacturer - Declaration of Compliance		

ISO9001 Manufacturer Certificate		

Tech form 1.6: Remote Monitoring Software and Dashboards				
Technical description	**Specification offered by Bidder**			**Remarks**
Manufacture and model				
Years of proven operation (years)				
Years of proven backward compatibility of versions (years)				
Web-link to web-portal with demonstration of the features				
Warranty term				
Supporting documentation				
Product Brochure				
Component compliance accreditation	***NA***	***NA***	***NA***	
IEC Standard Certificate for component from Certification Body (Cert number, date, expiry)				
ISO 17025 Laboratory – Laboratory Accreditation (Name and CB number)				
ISO 17025 Laboratory – Certificate to conduct the specific tests and standards				
Authorisation to bid				
Manufacturer’s Authorisation - to bid				
Manufacturer’s Warranty Certificate				
ISO9001 Manufacturer - Declaration of Compliance				
ISO9001 Manufacturer Certificate				

Tech form 1.7: Laptops for Monitoring System	
LAPTOP SPECS	SPECIFICATION REQUIRED
Display	15" anti-glare display, up to FHD (1920 x 1080)
Processor	7th Generation Intel® Core™ i7 or similar
Memory	16 GB DDR$ minimum
Storage	1 TB PCIe NVMe SSD or 2 TB HDD Storage
Graphics and Video Support	Intel® HD Graphics 620 or NVIDIA GeForce® 940MX (2GB 2.5GHz GDDR5 memory) or similar
Connections and Expansion	2 x USB 3.2 1 x USB C port 3.5 mm Combo Audio Jack 1 x HDMI™ 1 x RJ45 Gigabit LAN 1 x Media Card Reader (SD 3.0, UHS-I) 1x Micro SIM
Keypad and Trackpad	Precision Keyboard with Number Pad
Electrical Requirements	Line voltage: 240V AC Frequency: 50Hz
Software	64-bit Microsoft® Windows® 10 (minimum)

FORM 2: SYSTEM DIAGRAM AND SUB-SYSTEM PERFORMANCE CURVES

The Bidder shall provide the following information and output curves for each combination offered for

- Power conditioner / motor /pump

Form 2.1: System Electrical diagram

The Bidder shall provide a system diagram for each system type hsowing clearly:

- DC-AC Wiring diagram for each system type, showing in addition
  - earthing, lighting protection internal to any components, lighting protection added within any components, and external lighting protection
  - location of sensors for monitoring system, with communcation cables to data-logger.

Form 2.2: Performance Curves – Instantaneuous Output Curves

The Bidder shall provide the following instantaneous output curves for:

- DC power output of the PV array (W) vs Insolation (kWh/m^2) on the tilted surface in the plane of array
- controller-pump-piping subsystem: water output (litres/second) versus DC input power (W)

These curves shall be used to assess credible instantaneous performance of the system offered. It should also be possible to derive the ‘Daily Water Output curves’ from these instantaneous curves

Form 2.3: Performance Curves – Daily Output Curves

.The Bidder shall provide the following daily output curves for:

- DC energy output of the PV array (kWh/day) vs Insolation (kWh/m^2/day) on the tilted surface in the plane of array
- controller-pump-piping subsystem: water output (m^3/day) versus DC input energy (kWh/day).
- Average array tracking efficiency.
- Average sub-system wire-to-water efficiency.

These curves shall be used to assess credible daily performance of the system offered.

Note that the data in provided shall be used to assess and measure the system performance and acceptance during the tests under non-design conditions.

FORM 3: SCHEDULES OF INFORMATION FOR SOLAR PUMPING SYSTEM

The Bidder shall provide the following data for each site:

*NOTE: If the Manufacturers Pump sizing software produces all the required variables in a Sizing Report, then this may be submitted as **FORM 3.1**, and shall be clearly labelled as such.*

Form 3.1: Solar Pump System Summary

a) General Site Data

1.	Name of site or project	
2.	Geographic location (region / district)	
3.	Site Number	

b) Array Configuration

Item	Description	Data
1.	Module model and Wp	
2.	Array Wp	
3.	Modules in series strings and VoC strings	
4.	Strings in parallel	

c) Pump controller

Item	Description	Data
1.	Manufacturer and Model	
2.	Rating (kW, voltage, phases)	

d) Pump / Motor Configuration

Item	Description	Data
1.	Manufacturer and Model	
2.	Motor rating (VA, voltage, phases)	
3.	Design head	
4.	Design flow	
5.	Max head	
6.	Max flow	

e) Diesel Generator Configuration
(may be provided as separate table if necessary)

Item	Description	Data
1.	Manufacturer and Model	
2.	Motor rating (kW)	
3.	Alternator rating (kVA, voltage, phases)	

Form 3.2: Declaration of system water output vs. solar radiation and head

The Bidder shall provide the following data for <u>each site</u>:

NOTE: If the Manufacturers Pump sizing software produces all the required variables in a Sizing Report, then this may be submitted as ***FORM 3.2****, and <u>shall be clearly labelled as such</u>.*

Site name:……………………………………………………………….. Site unique number:……………………………………………………………….

This table is a declaration of the system output under the design conditions listed below. The following information shall be provided to assess the system performance during adjudication and on acceptance, by using the sub-system wire-water efficiency provided for each month.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A	Water output required (m^3/day)												
B	Total Pumping head (m)												
M	Average Water Delivery from System offered (m^3/day) (from sizing software)												
	Design check												
C	Array tilt angle used for each month												
D	Average daily insolation on the array for each month at above tilt angle. (kWh/m^2/day)												
E	Nominal array power (kWp)												
F	Array tracking efficiency (%) (% of STC output including array losses, wiring losses, typically 77.4%).												
G	***Average Daily Sub-system wire-to-water efficiency*** (%) (to be <u>declared</u>) (typically 30-50%) *= (M x B x 9.8 / 3,600) / (D x E x F)*												
	Commissioning test requirements												
H	Required water delivery (m^3/day) under commissioning conditions: = D_{meas} *x E x F x G / (B x 9.8 / 3,600)*												
	Declaration: We declare the performance precicion to be accurate based on the site and solar data used. Sites which do not perform shall eb corrected at no cost to project Signed												

Form 3.3: Hydraulic information and pumping head calculation sheet

Not required to be completed for bidding.

Please refer to this form and referenced drawing for any notation queries.

This form shall be completed during *Inception Stage*, and prior to request for commissioning of each system.

	Abbreviation	Name / description	Formula or Constraint	Data	Units of data
Static head data	Hs	Static Water Level below ground level at source			M
	H e	Elevation difference from ground level at source to base of primary storage tank			M
	H t	Height of Tank Inlet from base			M
	H static	Total Static Head	= Hs+He+Ht		M
Dynamic head data	H d	Dynamic water level			M
	D	Drawdown	= Hd-Hs		M
	H m	Head loss in Watermeter (use charts supplied)	< 2 m max. losses allowed		M
	H nr	Head loss in Non-Return Valve(s) (use charts supplied)	< 2 m max. losses allowed		M
	H r	Head loss in Riser Pipe (use charts supplied)	< 5% of Static head max losses allowed		M
	H p	Head loss in Transmission Pipe (use charts supplied)	< 5% of Static head max losses allowed		M
	H dymanic	Dynamic head losses	=D+Hm+Hnr+Hr+Hp <10% of Hstatic		M
Total	H total	Total design pumping head	=Hdynamic + Hstatic		M
Check	H pump	Depth of Pump-Intake			M
	H immers	Maximum allowed pump submersion on site (submersible pumps only)	< H pump – Hs		M
	H suction	Maximum allowed suction head on site (surface pumps only)	< Hd		M
Site data	H w	Total depth of well or sump			M
	D w	diameter of well casing			M
	D r	diameter of riser pipe			Mm
	D p	diameter of transmission pipe			Mm
	L p	length of transmission pipe			M
	V	Volume of primary storage			M^3

Refer to ***Schedule of Drawings: DWG 4a,b:*** **the diagrammatic illustration of the variables**.

FORM 4: BILLS OF QUANTITIES

The Bidder shall complete the BoQ for each site.

a) For each site provide a bill of quantities in a format similar to that provided below. ~~(~~structure of "items" and "descriptions" may be changed to fit bid), as outlined in the Scope of Work and Technical Specifications).

b) Bidders shall provide BoQ information and unit prices for each component for each packages included in each Lot. This table will be used for ensuring completeness of the systems. If any component is found missing, unit price presented in this table may be used for making adjustments to the ***price schedules in Vol I, Section IV***. After contact award, if variation orders or change orders are required due to adjust component or system quantities on site (either plus or minus), then the unit/system prices supplied in the BoQ shall be used.

c) For each Lot, provide a complete bill of quantities for Spares (see ***Chapter 3, Section C.2.10*** requirements for Mandatory spares).

Presented below is an **illustrative** bill of quantities (BOQ) for the PVP System. **Bidders are required to use this format, but component sizes and quantities may be adjusted to suite the specific components offered.** Bidders shall provide BoQ information and unit prices for each component for each package included in each Lot.

- *Form 4.1. Solar PV Pump BoQ (per site)*
- *Form 4.2. Diesel Generator Set replacement (per site)*
- *Form 4.3. Additional Minor Works BoQ (per site)*
  The above Forms 4.1 to 4.3 maybe submitted per site as one continuous flowing form, provided sections are clearly divided as per illustrations.

- *Form 4.3(A) Schedule of Variation Prices process for Additional Minor Works*
- *Form 4.4. Mandatory Spares Schedule (per Lot)*
- *Form 4.5. Maintenance kit (per Site)*

Form 4.1: PV Pump BoQ

		Use Separate Bill of Quantities for each Lot LOT number: __________		Unit cost (USD)		Site 1		Site 2		Site 3	
						Qty	USD	Qty	USD	Qty	USD
		Item	Description		Units						
FORM 4.1 Solar PV Pump BoQ	Array	PV modules	**Total kWp**			**7.5**		**15.0**		**25.0**	
			Wp module (V)		Ea					1	
		PV array mounting super-structure	Pole mount structure up to 400 Wp, including foundations		Ea						
			Ground mount frame, up to 1 kWp, including foundations		Ea						
			Module mounting security frames		Ea						
		Module earthing clamps	per 1 kWp		Set						
		Array interconnects			Ea					1	
		Array junction box	IP65 with terminals and glands		Ea	0		0		0	
	Main control system	Power conditioner	Size 1:		Ea					1	
			Size 2:		Ea						
			Size 3:		Ea						
			Size 4:		Ea						
			Size 5:		Ea						
		Submersible pump	Size 1:		Ea					1	
			Size 2:		Ea						
			Size 3:		Ea						
			Size 4:		Ea						
			Size 5:		Ea						
		Security enclosure	for containing Control Cubcle, power conditioner, and remote data logger system		Ea	1					
		Control Cubicle	with circuit breakers, indicators, change-over switches, but exl lightnign protection								
			Size 1:		Ea	1		1			
			Size 2:		Ea	1		1			
			Size 3:		Ea	1		1			
			Size 4:		Ea	1		1			
			Size 5:		Ea	1		1			
		Remote data logger	System		Set	1				1	
			Transducers		Set	1					
			Cabling and conduit		Set	1					
			Communications module		Set	1					
			Remote montoriing software		Set	1					
		Lightning protection (AC and DC)	AC Surge arrestors (class 2 1PH + N)		Ea	1		0		0	
			AC Surge arrestors (class 1&2 1PH + N)		Ea	0		0		0	
			DC Surge arrestors (class 2)								
			enclosure		Ea	0					
	Hydrau- lic pipe-work	Riser pipe (pump to borehole head)	Flexible pipe to spec		m	100					
			fittings to pump		Ea	1		0		1	
			Non-return valve		Ea	1					
			Strain relief cable		meter	100					
		Borehole head	Borehole cap		Ea	1				1	
			Rising main pipe fittings		Set	1		1			
		Instrumentation	Water meter (pulse type)		Ea	1		1		1	
			Pressure guage		Ea	1		1		1	
			Valves		Ea	1		1		1	
			Pipework and mountings		Set	1		1		1	
		Chlorinator	Passive flow	750	Set	1	750	1	750	1	750

		Use Separate Bill of Quantities for each Lot		Unit cost (USD)		Site 1		Site 2		Site 3	
		LOT number: __________				Qty	USD	Qty	USD	Qty	USD
		Item	Description		Units						
FORM 4.1 Solar PV Pump BoQ	Cabling	Submerisible pump cable	4mm2 3 core		meter	110		0		0	
			6mm2 4 core		meter	110		0		0	
			10mm2 4 core		meter	110		0		0	
			Splice kit		Ea	1					
		SWA cable	4mm2 3 core		meter	20					
			6mm2 4 core		meter	20					
			10mm2 4 core		meter	20					
		Sense cables	Level switches		Ea	1					
			Sense cables		meter	50					
		Array grounding and Electrical earthing	Ø16 mm x 1500 mm earth spike		Set	0		0		1	
			16mm^2 bare copper earth conductor		Set	0		0		1	
		Other	bidder to specify								
		Warning signs	as per specification		Ea	1		1		1	
		User manual			Ea	1		1		1	
		O&M manual	for customers and technicians		Ea	1		1		1	
		Sub-total Equipment									
		Sub-total Transport and clearances, insurance									
		Sub-total Equipment (to Price Schedules: Goods, Item 2)									
		Sub-total Installation, Inspection. MIS data capture, commissioning etc (to Price Schedules: Related Services, Item 3)									
		Total unit costs for Supply and Installation of Solar Pump System									

Nb: The Bidder is free to Quote in the local currency (Kenya Shilling)

Form 4.2: Diesel Genest Replacement BoQ

FOR: 4.2 Diesel Genset Replacement BoQ

Use Separate Bill of Quantities for each Lot		Unit cost (USD/KSHS)		Site 1		Site 2		Site 3	
LOT number: __________				Qty	USD	Qty	USD	Qty	USD
Item	**Description**		**Units**						
Existing diesel engine	**kVA**			**10.0**		**19.0**		**40.0**	
Alternator	Size 1: kW / kVA		Ea						
	Size 2: kW / kVA		Ea						
	Size 3: kW / kVA		Ea						
Control Panel 3phase	Size 1: kVA		Ea						
	Size 2: kVA		Ea						
	Size 3: kVA		Ea						
Base frame	Size 1:		Ea						
	Size 2:		Ea						
	Size 3:		Ea						
Mounting adaptors	Rubber mountings 75mm diameter		Ea						
	Control panel frame		Ea						
Battery MF	65-100Ah MF		Ea						
Fuel guage	c/w float system		Ea						
Electrical Adaptors	Bayonet coupling LR-180mm		Ea						
	Coupling adaptor		Ea						
Other	Miscelleneous bolts, cables, etc								
Warning signs	as per specification		Ea						
User manual			Ea						
O&M manual	for customers and technicians		Ea						
Sub-total Equipment									
Sub-total Transport and clearances, insurance									
Sub-total Equipment (to Price Schedules: Goods, Item 3)									
Sub-total Installation (to Price Schedules: Related Services, Item 3)									
Total unit costs for Supply and Installation of Diesel component									

Nb: The Bidder is free to Quote in the local currency (Kenya Shilling)

Form 4.3: Additional Minor Works BoQ

						1		2		3	
		Use Separate Bill of Quantities for each Lot		**Unit cost (USD)**		**Site 1**		**Site 2**		**Site 3**	
		LOT number: __________				**Qty**	**USD**	**Qty**	**USD**	**Qty**	**USD**
		Bidders are to provide *Unit Costs* for all items below. These shall be used as indicative prices. For pricing of each site, bidders are to use the *Prime Cost* amounts shown.									
		Item	**Description**		**Units**						
FORM 4.3 Additional Minor Works BoQ	**Supplementaty storage**	Water Tank	Water tank 10,000 litres		Ea						
			Valves and fittlings for interconnection		Ea						
			Installation of tank and fittings		Ea						
		Foundation	Conctrete and sand foundation per tank		Set						
		Elevation	6m elevated platform, steel per 1 tank								
			6m elevated platform, steel per 2 tanks								
			Installation		Ea						
	Minor Work required	Masonary Tank repair (parts and labour)		**PRIME COST**			**1,200**		**1,200**		**1,200**
		Bulk water meter at pump house (supply and install)		**PRIME COST**			**1,000**		**1,000**		**1,000**
		Bulk water meter at tank (supply and install)									
		Gate valve (supply and install)									
		Sluice valve (supply and install)									
		Bleed valve (supply and install)									
		Non-Return Valve on rising main (supply and install)									
		Pressure gauge (supply and install)									
		other									
	New Civil Works	Control room (new), materials	Materials	**bidder to cost**							
			Labour								
		Diesel Engine enclosure (new)	Materials	**bidder to cost**							
			Labour								
		Fencing of entire site (new)	Materials	**PRIME COST**			**3,000**		**3,000**		**3,000**
			Labour								
		Chlorinator enclosure ar tanks (new)		**NA**			-		-		-
	Elect rical	Sense cables	Level switches	**PRIME COST**			**200**		**200**		**200**
			Sense cables (SWA) (200m)								
		Sub-total Equipment									
		Sub-total Transport and clearances, insurance									
		Sub-total Equipment (to Price Schedules: Goods, Item 4)									
		Sub-total Installation (to Price Schedules: Related Services, Item 4)									
		Total unit costs for Supply and Installation of Minor Additional Works									

Nb: The Bidder is free to Quote in the local currency (Kenya Shilling)

Form 4.3 (A): Schedule of Variation Prices for Additional Minor Works

		Use Separate Schedule for each Lot		**Unit cost (USD)**	
		LOT number: __________			
		Bidders are to provide UNIT COSTS for all items below. These shall be used for ***Variation Pricing***			
		Item	**Description**		**Units**
FORM 4.3 (A) Variation Pricing	**Minor Components**	Bulk water meter at pump house (supply and install)	Size 1: 1.5 inches		Ea
			Size 2: 2 inches		Ea
			Size 3: 4 inches		Ea
			Size 4: 6 inches		Ea
		Bulk water meter at tank (supply and install)	Size 1: 1.5 inches		Ea
			Size 2: 2 inches		Ea
			Size 3: 4 inches		Ea
			Size 4: 6 inches		Ea
		Gate valve (supply and install)	Size 1: 1.5 inches		Ea
			Size 2: 2 inches		Ea
			Size 3: 4 inches		Ea
			Size 4: 6 inches		Ea
		Sluice valve (supply and install)	Size 1: 1.5 inches		Ea
			Size 2: 2 inches		Ea
			Size 3: 4 inches		Ea
			Size 4: 6 inches		Ea
		Bleed valve (supply and install)	Size 1: 1.5 inches		Ea
			Size 2: 2 inches		Ea
			Size 3: 4 inches		Ea
			Size 4: 6 inches		Ea
		Non-Return Valve on rising main (supply and install)	Size 1: 1.5 inches		Ea
			Size 2: 2 inches		Ea
			Size 3: 4 inches		Ea
			Size 4: 6 inches		Ea
		Pressure gauge (supply and install)	Size 1: 1.5 inches		Ea
			Size 2: 2 inches		Ea
			Size 3: 4 inches		Ea
			Size 4: 6 inches		Ea
		other	Size 1: 1.5 inches		Ea
			Size 2: 2 inches		Ea
			Size 3: 4 inches		Ea
			Size 4: 6 inches		Ea
	New Civil Works	Control room (new)	Materials		Set
			Labour		Set
		Diesel Engine enclosure (new)	Materials		Set
			Labour		Set
		Fencing of entire site (new)	Materials		Set
			Labour		Set
		Chlorinator enclosure ar tanks (new)	Materials		Set
			Labour		Set
	Elect rical	Sense cables	Level switches		Ea
			Sense cables (SWA)		meter

		Use Separate Schedule for each Lot LOT number: __________		Unit cost (USD)	Unit cost (USD)	Unit cost (USD)	Unit cost (USD)	Unit cost (USD)
		Bidders are to provide UNIT COSTS for all items below. These shall be used for ***Variation Pricing***						
				Raiser height (m)				
		Item	**Tank size (m³)**	**0**	**3**	**6**	**9**	**12**
FORM 4.3 (A) Variation Pricing	**Masonary tank repair (materials and labour)**	Ceiling replacement	25					
			30					
			40					
			60					
			80					
			100					
			125					
		Ceiling repair	25					
			30					
			40					
			60					
			80					
			100					
			125					
		Minor external cracks	25					
			30					
			40					
			60					
			80					
			100					
			125					

Nb: The Bidder is free to Quote in the local currency (Kenya Shilling)

Form 4.4: Mandatory Spares

Each LOT requires at least the minimum number of spares. The Supplier shall supply the following *Mandatory Spares*, and compose and deliver at the end of the Warranty Period an optimal package of spare parts typically comprising the following items.

	Use Separate Bill of Quantities for each Lott LOT number: __________		Unit cost (USD)		Requirement		Mandatory Spares	
					% of total supplied	Minimum qty	Qty	USD
Array	**Item**	**Description**		**Units**				
	PV modules	Wp module (V)		Ea	1%	**5**		
Main control system	Power conditioner	Size 1:		Ea	1%	1		
		Size 2:		Ea	1%	1		
		Size 3:		Ea	1%	1		
		Size 4:		Ea	1%	1		
		Size 5:		Ea	1%	1		
	Submersible pump	Size 1:		Ea	1%	1		
		Size 2:		Ea	1%	1		
		Size 3:		Ea	1%	1		
		Size 4:		Ea	1%	1		
		Size 5:		Ea	1%	1		
	Control Cubicle / Power packs	with circuit breakers, indicators, change-over switches, but exl lightnign protection						
		Size 1:		Ea	1%	1		
		Size 2:		Ea	1%	1		
		Size 3:		Ea	1%	1		
		Size 4:		Ea	1%	1		
		Size 5:		Ea	1%	1		
	Remote data logger	System		Set		1		
		Transducers		Set		2		
		Cabling and conduit		Set		1		
		Communications module		Set		2		
		Remote montoriing software		Set		1		
	Lightning protection (AC and DC)	AC Surge arrestors (class 2 1PH + N)		Ea	5%	3		
		AC Surge arrestors (class 1&2 1PH + N)		Ea	5%	3		
		DC Surge arrestors (class 2)			5%	3		
		enclosure		Ea	2%	2		
	Diesel generator	Size 1:		Ea		1		
		Size 2:		Ea		1		
		Size 3:		Ea		1		
		Size 4:		Ea		1		
		Size 5:		Ea		1		
	Change-over devices	Size 1:		Ea		1		
		Size 2:		Ea		1		
		Size 3:		Ea		1		
	Sub-total Equipment							
	GRANT TOTAL							

Form 4.5: Maintenance kits

Each SITE shall be supplied with one Maintenance Kit per site and one Engineer Kit per LOT.

Use Separate Bill of Quantities for each Lot **LOT number: __________**		**Unit cost (USD)**		**Maintenance per LOT engineer**		**Maintenance kit per site**	
				Qty	**USD**	**Qty**	**USD**
Item	**Description**		**Units**				
Laptop	Refer *Tech form 1.7*		Ea	2		0	
Digital clamp . Multi-meter	(minimum range 0-600V DC, 0-300 V AC, accuracy min 1%, 0.01V resolution)		Ea	2		1	
Current clamp meter	(range 0-40A, accuracy 1%, resolution 0.1A for AC and DC 40 A, including thermocouple and leads. Recommended model: TCM 02 DC/AC clamp meter – 600 VDC			2		1	
Basic tool kit	Including set of insulated screwdrivers to fit all terminals on DIN rail/inverter/power conditioner; small/narrow pliers, wire cutters/strippers, crimp tool with set of lugs, insulating tape, etc.		Set	2		1	
Stop watch	digital		Ea	0		1	
Step ladder	to reach solar array		Ea	0		1	
Water bucket			Ea	0		1	
Squeegee	to clean solar array		Ea	0		1	
Marker pens			Ea	0		5	
Sub-total Equipment							
GRANT TOTAL							

Nb: The Bidder is free to Quote in the local currency (Kenya Shilling)

FORM 5: RECOMMENDED SPARE PARTS SCHEDULE

The Bidder shall recommend all the necessary major spare parts for operating the systems for the duration of the Maintenance Period. The bidder may utilise these spares.

The Bidder shall draw up a list of *Recommended Spares*, comprising of high-usage and high-value items of components and spare parts, for usage in the initial period of operation specified in the Maintenance Period, and to cost for these items.

Form 5: Recommended Spare Parts Schedule

	Use Separate Bill of Quantities for each Lot LOT number: __________		Unit cost (USD)		Recommended Spares	
					Qty	USD
	Item	Description		Units		
Arra	PV modules	Wp module (V)		Ea		
Main control system	Power conditioner	Size 1:		Ea		
		Size 2:		Ea		
		Size 3:		Ea		
		Size 4:		Ea		
		Size 5:		Ea		
	Submersible pump	Size 1:		Ea		
		Size 2:		Ea		
		Size 3:		Ea		
		Size 4:		Ea		
		Size 5:		Ea		
	Control Cubicle / Power packs	with circuit breakers, indicators, change-over switches, but exl lightnign protection				
		Size 1:		Ea		
		Size 2:		Ea		
		Size 3:		Ea		
		Size 4:		Ea		
		Size 5:		Ea		
	Remote data logger	System		Set		
		Transducers		Set		
		Cabling and conduit		Set		
		Communications module		Set		
		Remote montoriing software		Set		
	Lightning protection (AC and DC)	AC Surge arrestors (class 2 1PH + N)		Ea		
		AC Surge arrestors (class 1&2 1PH + N)		Ea		
		DC Surge arrestors (class 2)				
		enclosure		Ea		
	Diesel generator	Size 1:		Ea		
		Size 2:		Ea		
		Size 3:		Ea		
		Size 4:		Ea		
		Size 5:		Ea		
	Change-over devices	Size 1:		Ea		
		Size 2:		Ea		
		Size 3:		Ea		
	Sub-total Equipment					
	GRANT TOTAL					

Appendix 4: Detailed explanation on Bid Form Technical Proposal

This information shall be evaluated under ***Volume I Section III.2.1 (ii) (b) of Qualification.***

The bidder shall provide a technical proposal of approach and method statement per ***Volume I Section IV, Schedule Technical Proposal*** that will include

- Work organisation
- Method statement
- Mobilization Schedule
- Installation schedule
- Personnel
- Equipment
- Training

1. Inception phase

Describe the approach, staffing, logistical arrangements and schedule for conducting the due diligence and preparing the Inception Report as per the requirements of ***Chapter 3 Section B.2.3, Section B.2.4*** and ***Section B.2.5.***

2. Pilot installation phase

Describe the approach, staffing, logistical arrangements and schedule for Pilot Installations as per the requirements of ***Section B.2.6***.

3.Supply and installation phase

Describe the approach, staffing plan, logistical arrangements and schedule for the supply and installations of the systems as per the requirements of ***Section B.2.3, B.2.4, B.2.8, B.2.9, B.2.10 and C.3,*** with adequate detail to permit verifying:

- the completeness and realism of approach, methodology and logistics for the supply, including procurement and delivery, and installation of the Goods, including the Pilot installations.
- Installation practices, commissioning tests and initial user-training comply with specifications.
- delivery schedule is consistent with the required time-frame. If bidders are bidding for more than one Lot, describe the additional capacity and availability that will ensure that time-frames for completion will be met if more than one Lot is awarded to the bidder.
- adequate managerial competence, including for supervision and financial controls. The description and plan should cover the provision of the appropriate skills at offices serving the project area, as well as back-up support from other offices.
- adequate technical competence, including for quality assurance, installation and maintenance support services. Cover the provision of the appropriate skills at offices serving the project area, as well as back-up support from other offices.
- describe the Supplier's own arrangements and procedures for quality control of the equipment supply and installations.

Include a detailed work breakdown and GANTT chart. Also, provide qualification requirements, job descriptions and names of the principal staff that will provide management, installation and maintenance support to the project areas. Include an organogram indicating the organizational structure and location of key staff and organizational units.

- **Specific numeric data to be provided for each LOT**

    - **Key management staff:** list of tasks, qty people,
    - **Key logistics staff and vehicles: list of tasks, qty people, qty vehicles**

- **Installation teams per Lot:**
  - qty PVP installation teams,
  - qty MIS inspection teams
- **per PVP installation team;**
  - list of tasks,
  - qty people/team,
  - qty PVP installed/team/day
- **Per MIS team**
  - list of tasks,
  - qty people/team,
  - qty PV systems captured/team/day

- **Key assumptions per village**
  - **Time for movement between village**
  - **Time for site establishment (P&G) per village**

- **Spreadsheet: For each lot, show schedule demonstrating**
  - **District P&G time**
  - **Village (for each village)**
    - **Time for movement to village**
    - **Village P&G time**
    - **Works required**
      - qty PVP
    - **Resources allocated per village**
      - qty PVP teams, qty MIS teams
    - **Time to complete the works in village** based on
      - allocation of qty PVP teams, MIS teams
      - number of installations per team per day.

4. Warranty/Maintenance phase

This phase includes maintenance, continued user training, reporting, other after-sales services and staffing.

Describe the plan and approach to ensure responsive maintenance, continued user training and after-sales services to meet the standards established in ***Sections B.2.8, B.3, and D.1- D.5***.

Describe in sufficient detail to permit verification:

- the completeness and realism of approach, methods and logistics for maintenance and breakdown services that meet the specifications established at ***Sections D.1-D.5***.
- facilities for facility managers and staff to communicate with the Supplier to report failures and request repairs.
- Post-installation user training for system use and upkeep, both refresher training and training for new facility staff and local technicians.

Describe staffing plan to demonstrate:

- adequate qualification requirements and job descriptions for the personnel that will provide these after-sales services
- adequate managerial competence of the personnel proposed to provide the services, including for supervision and financial controls. Cover the provision of the appropriate skills at offices serving the project area, as well as back-up support from other offices.
- adequate technical competence of the personnel proposed to provide the services, including for quality assurance, for the maintenance and other support services in accordance with the maintenance specifications. Cover the provision of the appropriate skills at offices serving the project area, as well as back-up support from other offices.

- **Specific numeric data to be provided for each LOT**

- **Key maintenance management staff:** list of tasks, qty people,
- **Key logistics staff and vehicles: list of tasks, qty people, qty vehicles**
- **Maintenance teams per Lot:**
  - qty PVP maintenance teams,
  - qty MIS inspection teams
- **per Maintenance team;**
  - qty people/team,
  - qty systems maintained/team/day
- **per MIS inspection team;**
  - qty people/team,
  - qty systems MIS captured/team/day

Describe the scheduling, management, recording and reporting systems that will be deployed that will enable:

- real time tracking of complaints and responses, repair requests and responses, faults and responses, component replacements, warranties and status of systems
- access by the Purchaser to the records and systems for tracking the complaints, repair requests, faults, component replacements, maintenance and status of systems
- accurate reporting by the Supplier on a bi-annual basis to the Purchaser.

Describe the reporting and barcode systems

- Suppliers system for tracking equipment supply, system installation, claims and maintenance, (supported by suppliers MIS in see ***sections B.2.9.3 and B.2.9.4*****),**
- Barcoding method, data collection and reporting requirements, data records to be recorded,
- Software selected for processing and reporting, including sample database and sample reports.

5.Training

Describe the approach to training as required in ***Section B.2.7.1-B.2.7.3.*** for

- Operators of community facility systems training (on-site training),
- Technical training
- Follow-up training during routine maintenance (on-site)

Note: training is priced as Related Services (***Volume I Section IV Bidding Forms, Related Services)***

- Operator training (included in *Item 3: Installation services*)
- Technical training (*Item 5: Technical training*)
- Follow-up training (included in *Items 6,7,8,9 After sales*)

6.Other qualifications

- Experience from the region, and working in dispersed project sites within rural communities in low income developing countries is important, as is experience in East Africa as indicated by the experience of the Bidder, sub-contractors, or local-partners or staff. Bidders are encouraged to partner with established local solar PV companies to develop local capacity for ongoing support and market development.
- If at the time of bidding, a bidder does not have local presence in Tanzania, the bidder must categorically indicate the strategy as to how they wish to establish local presence in Tanzania if they win the contract(s). This strategy and other information (if any) should be submitted with the bid.

The bidder shall furnish a list of Key-staff including their qualification and experience for the following positions (including Joint Venture and sub-contractor staff) for each lot using ***Schedule PQ no 4: Schedule of Key Staff*** and ***Schedule PQ no 5: Schedule of Named Sub-contractor*** forms provided.

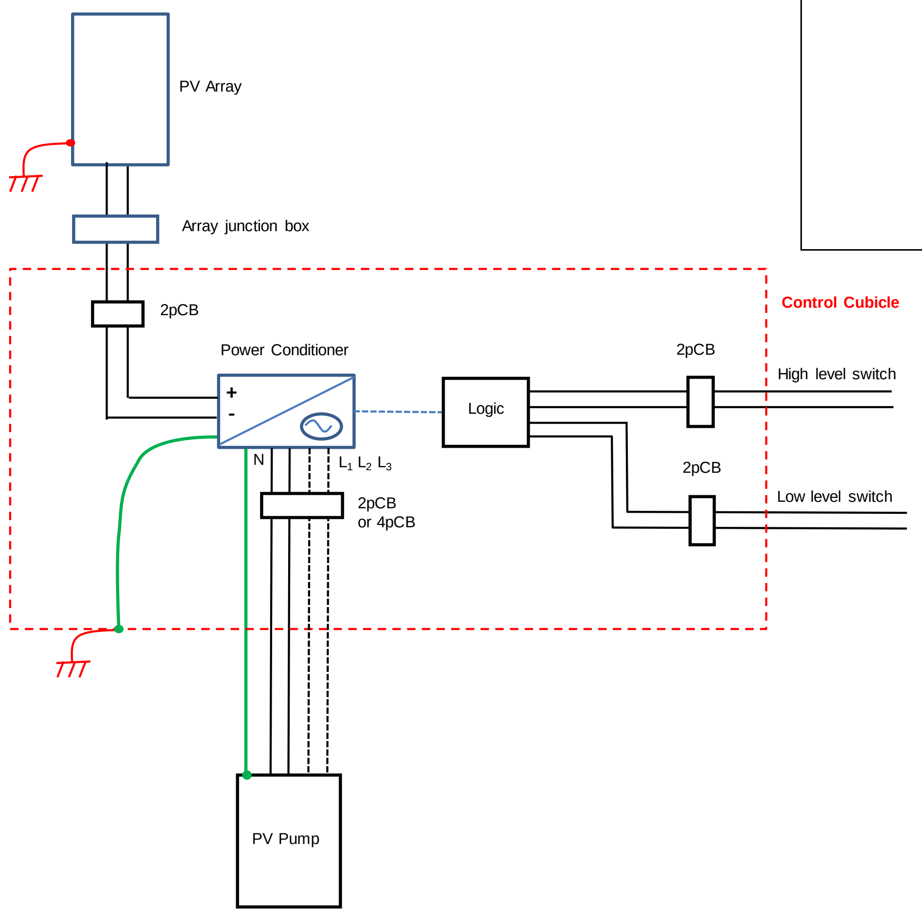
5. Schedule of Drawings

The Bidding Documents include the following drawings.

List of Drawings

	Drawing Name	Purpose
System typical electrical diagrams		
DWG SCH.1.	Electrical diagram for typical solar DC PV packages	Electrical schematic
DWG SCH.2.	Electrical diagram for typical solar AC PV packages	Electrical schematic
DWG SCH.3.	Interconnection of PV array, blocking diodes, by-pass diodes and array junction box	Electrical schematic
DWG SCH.4.	Schematic of control cubicle, showing isolators and optional lightning protection	Electrical schematic
DWG SCH.5.	Diagram of full lightning protection system	Electrical schematic
DWG SCH.6.	Typical diagram of overvoltage protection circuitry in external junction box for DC circuits	Electrical schematic
DWG SCH.7.	Typical diagram of overvoltage protection circuitry in external junction box for AC circuits	Electrical schematic
System typical structural diagrams		
DWG-STR.1	Array and module structure security assembly	Diagram of typical structure
DWG.STR.2	Security enclosure around the control cubicle and power conditioner	Diagram of typical structure
DWG.STR.3	Location of main valves and metering	Diagram of typical structure
DWG.STR.4	Hydraulic information - line-shaft / submersible pump system	Diagram of typical structure
DWG.STR.5	Hydraulic information - surface pump system	Diagram of typical structure
DWG STR.6.	Array frame flange grounding for module earth	Diagram of typical structure
Site layout drawings (A4 or A3)		
DWG 1.A4	Typical site plan - top view	Schematic of site layouts
DWG 2.A4	Typical site plan – profile	Schematic of site layouts

DWG SCH.1. Electrical diagram for typical solar PVP system without back-up

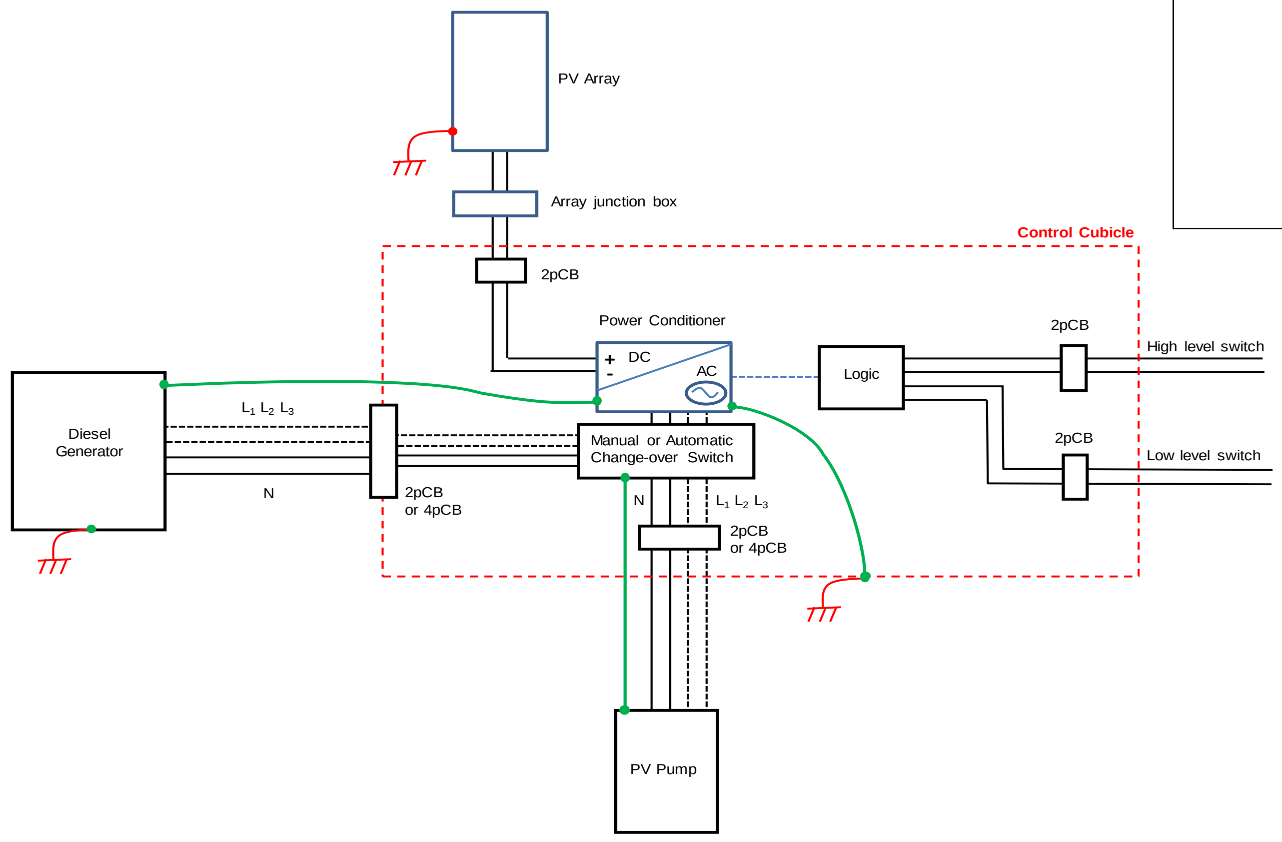


Notes

Solar Pumping for Communities	Description	**Electrical diagram for typical solar PVP system without back-up**	**DWG SCH.1** Scale Drawn by: NCL Date: February 2017 Job no. EDG 2015-163

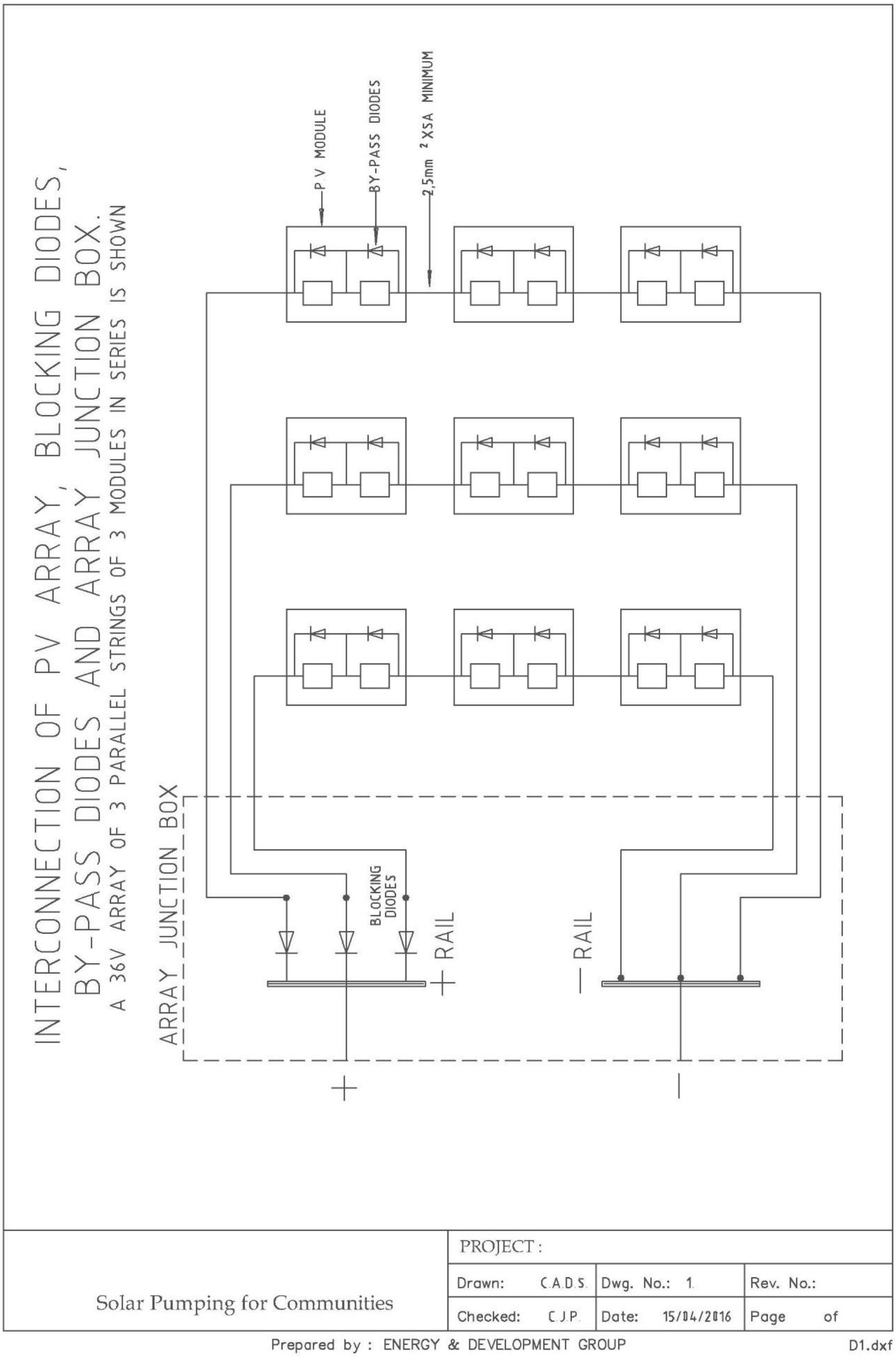
DWG SCH.2. Electrical diagram for typical solar PVP system with generator back-up

Notes

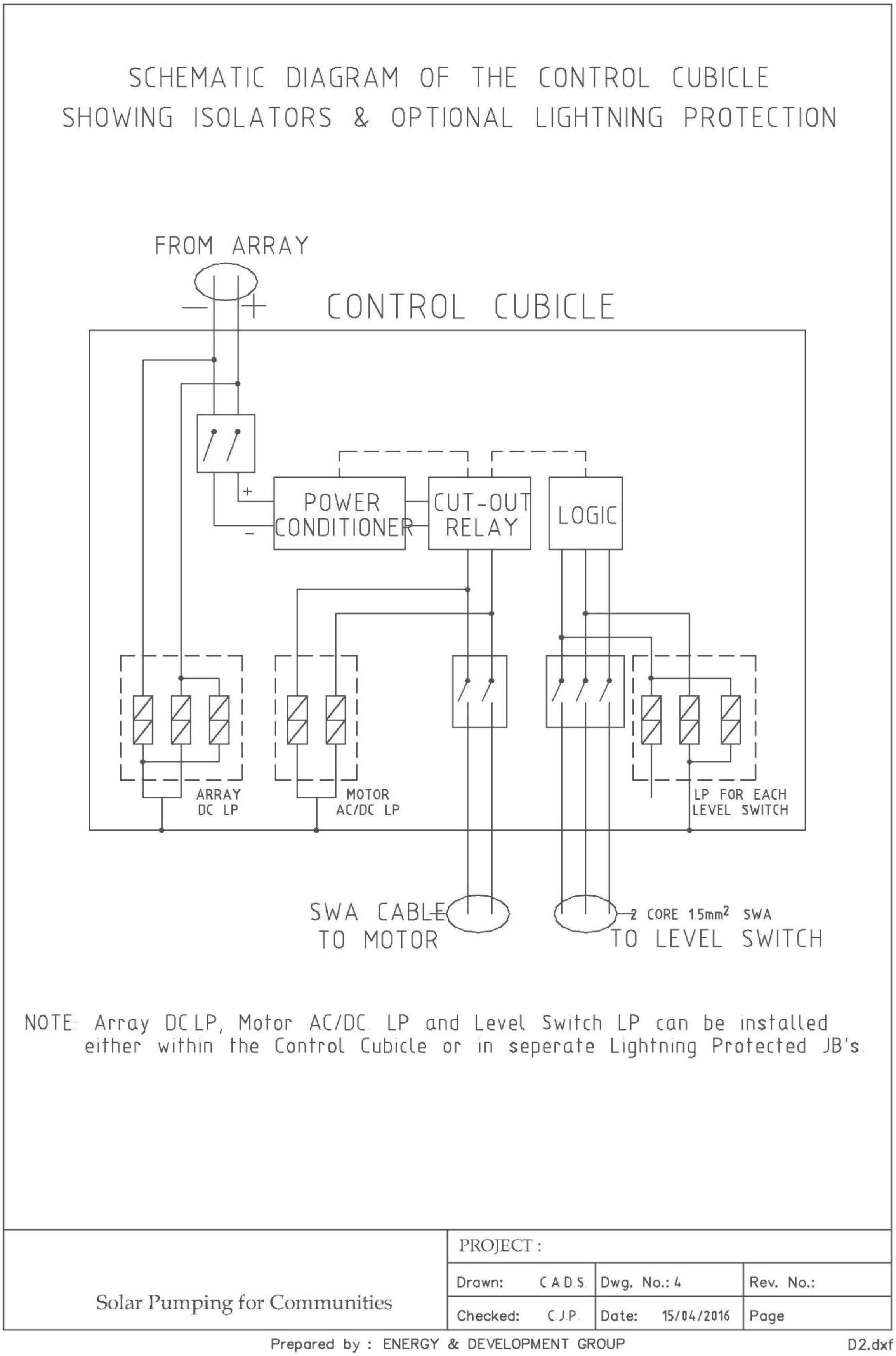


Solar Pumping for Communities	Description **Electrical diagram for typical solar PVP system with generator back-up**	**DWG SCH.2**	Scale
			Drawn by: NCL
			Date: February 2017
			Job no. EDG 2015-163

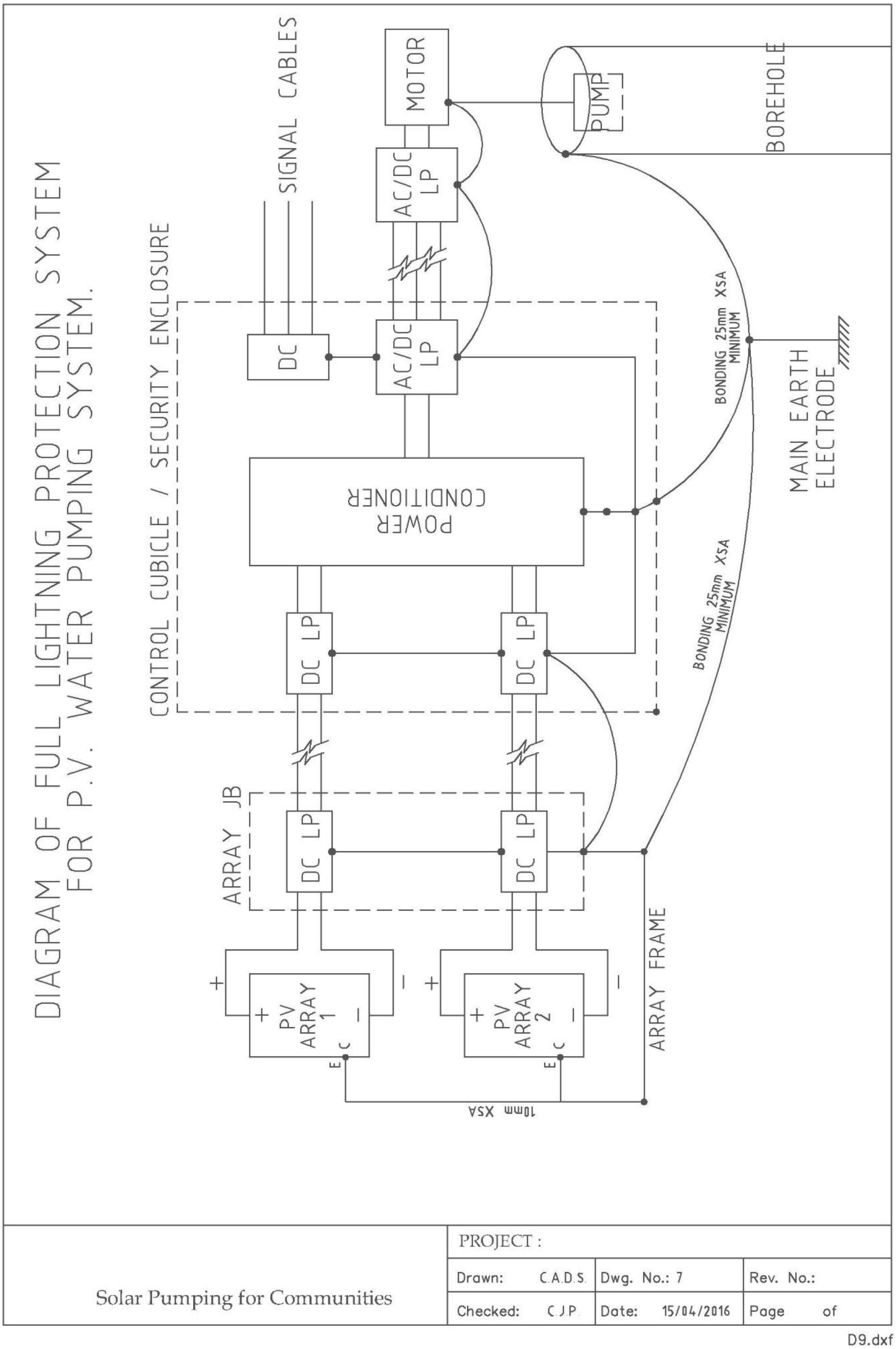
DWG.SCH.3. Interconnection of PV array, blocking diodes, by-pass diodes and array junction box



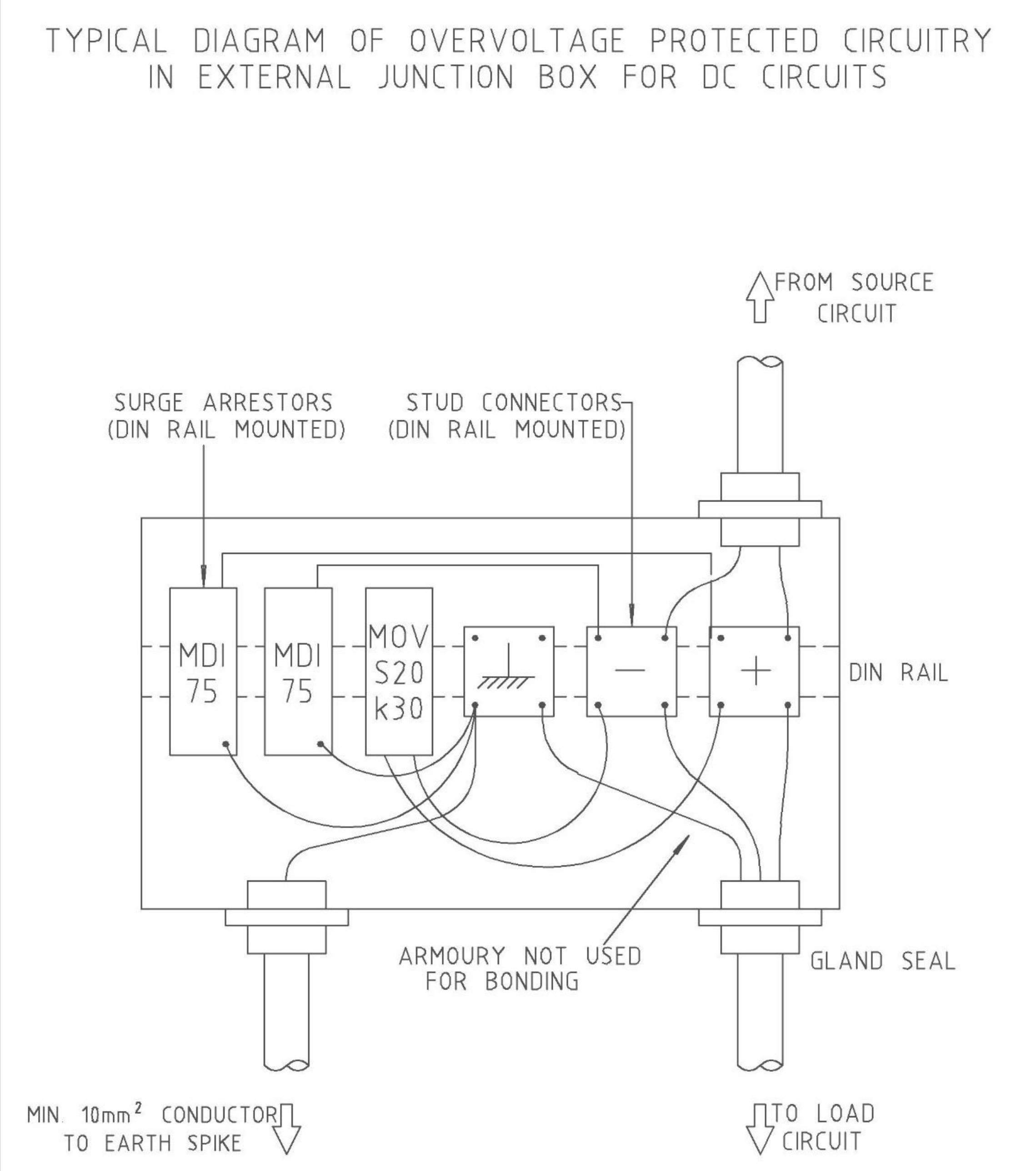
DWG.SCH.4. Schematic of control cubicle, showing isolators and optional lightning protection



DWG.SCH.5. Diagram of full lightning protection system



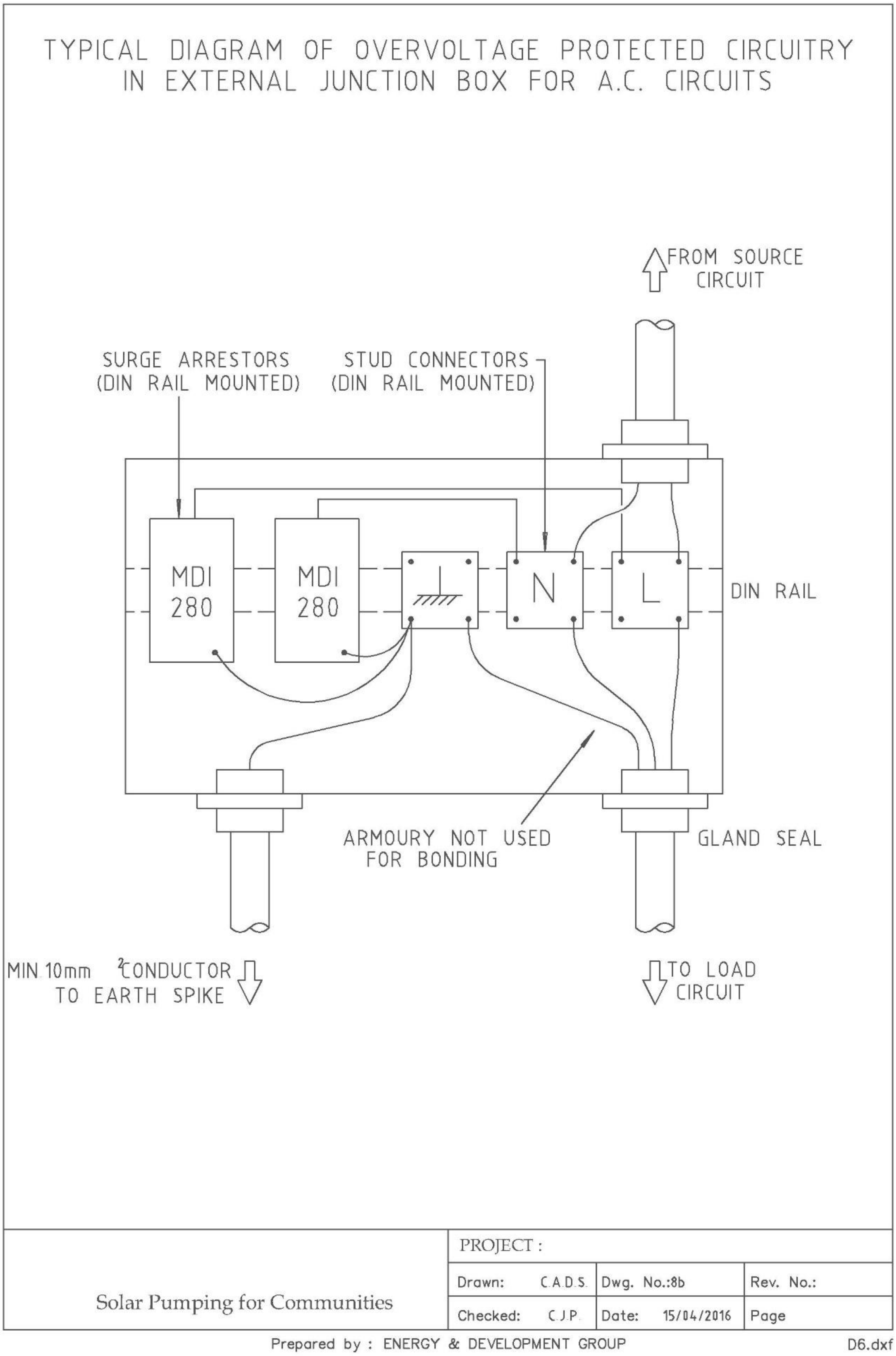
DWG.SCH.6. Typical diagram of overvoltage protection circuitry in external junction box for DC circuits



Solar Pumping for Communities	PROJECT :		
	Drawn: C.A.D.S.	Dwg. No.: 8a	Rev. No.:
	Checked: C.J.P.	Date: 15/04/2016	Page of

D012–0–0.dxf

DWG.SCH.7. Typical diagram of overvoltage protection circuitry in external junction box for AC circuits



DWG-STR.1 Array and module structure security assembly

Ideal arrangement of fence and array security frames

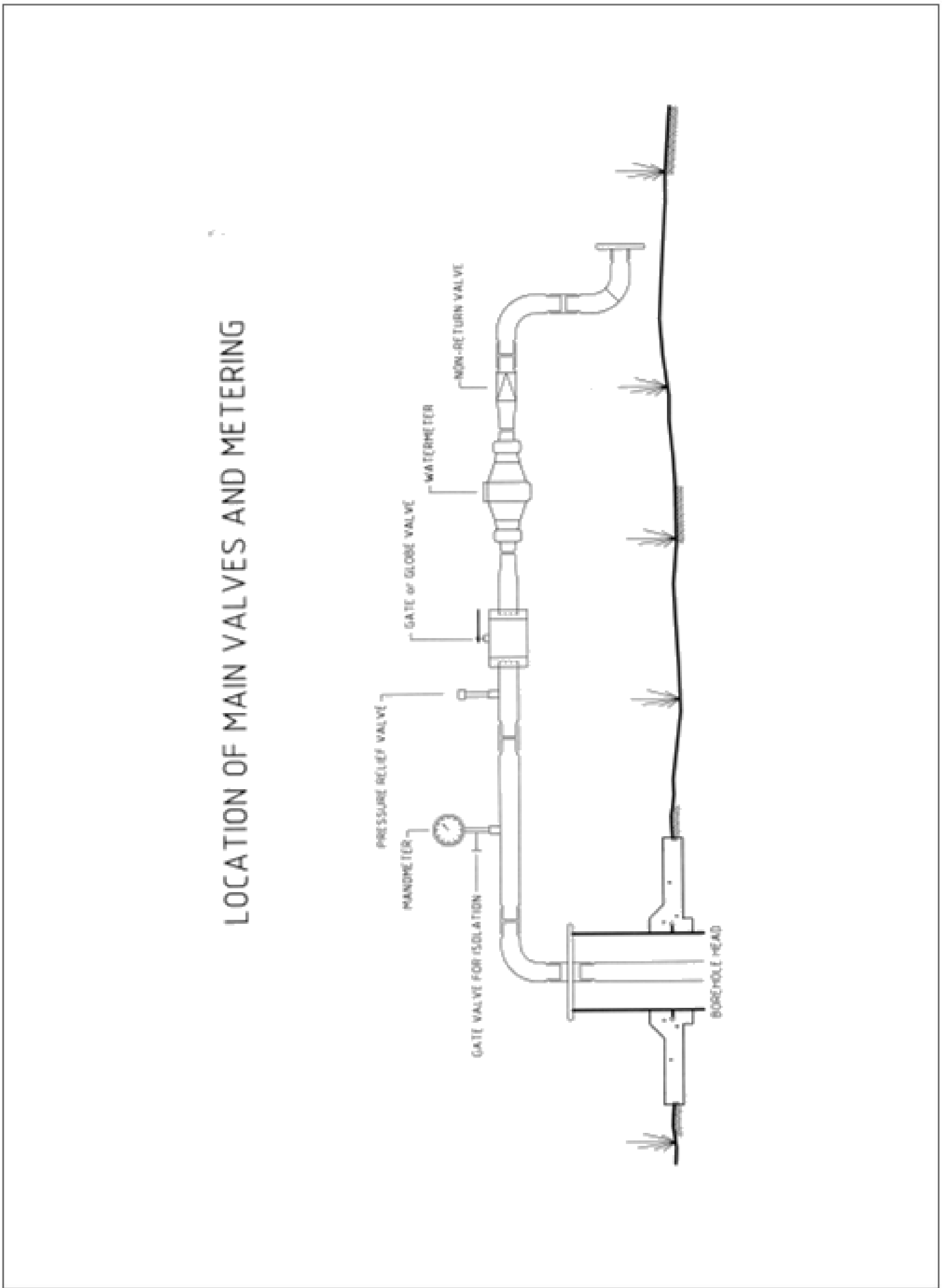
Detail of security frames enclosing modules onto structure

Solar Pumping for Communities	PROJECT :		
	Drawn: C.A.D.S.	Dwg. No.:2	Rev. No.:
	Checked: C.J.P.	Date: 15/04/2016	Page

DWG.STR.2 **Security enclosure around the control cubicle and power conditioner**

Solar Pumping for Communities	PROJECT :		
	Drawn: C A D S	Dwg. No.:3	Rev. No.:
	Checked: C J P	Date: 15/04/2016	Page

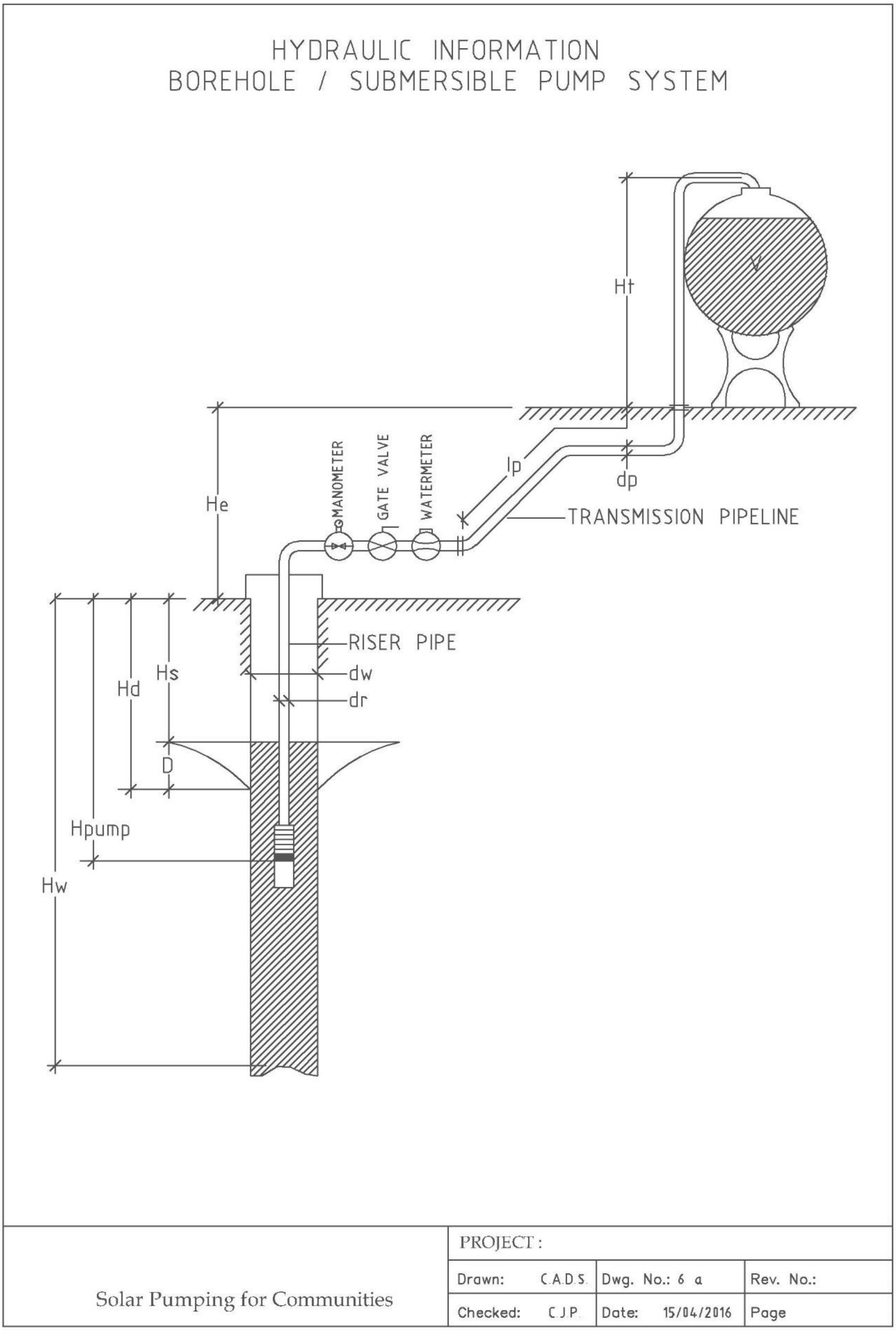
DWG.STR.3 Location of main valves and metering



Solar Pumping for Communities	PROJECT :		
	Drawn: C.A.D.S.	Dwg. No.: 5	Rev. No.:
	Checked: C.J.P.	Date: 15/04/2016	Page

Prepared by : ENERGY & DEVELOPMENT GROUP D7.dxf

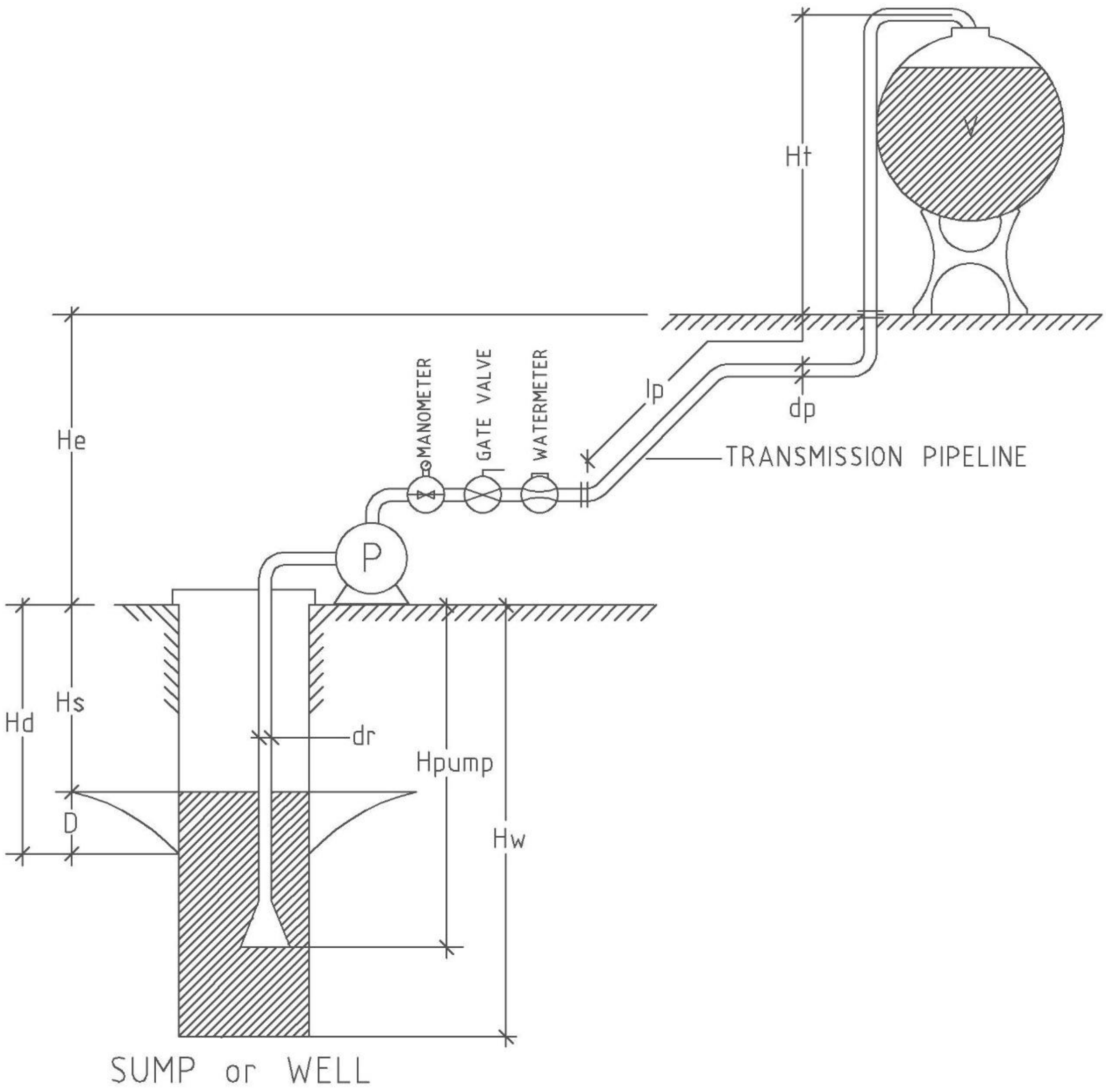
DWG.STR.4 **Hydraulic information - line-shaft / submersible pump system**



Prepared by : ENERGY & DEVELOPMENT GROUP D7.dxf

DWG.STR.5 Hydraulic information - surface pump system

HYDRAULIC INFORMATION
SURFACE PUMP SYSTEM



Solar Pumping for Communities	PROJECT :		
	Drawn: C.A.D.S.	Dwg. No.: 6b	Rev. No.:
	Checked: C.J.P.	Date: 15/04/2016	Page

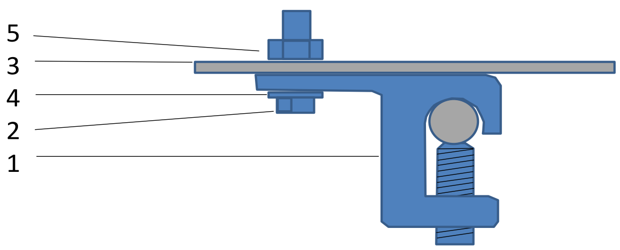
Prepared by : ENERGY & DEVELOPMENT GROUP D8.dxf

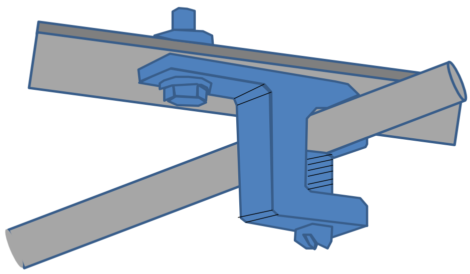
DWG-STR.6 Array frame flange grounding for module earth

Notes

1 Modules to face equator as aligned with roof

2 Space left for access for cleaning

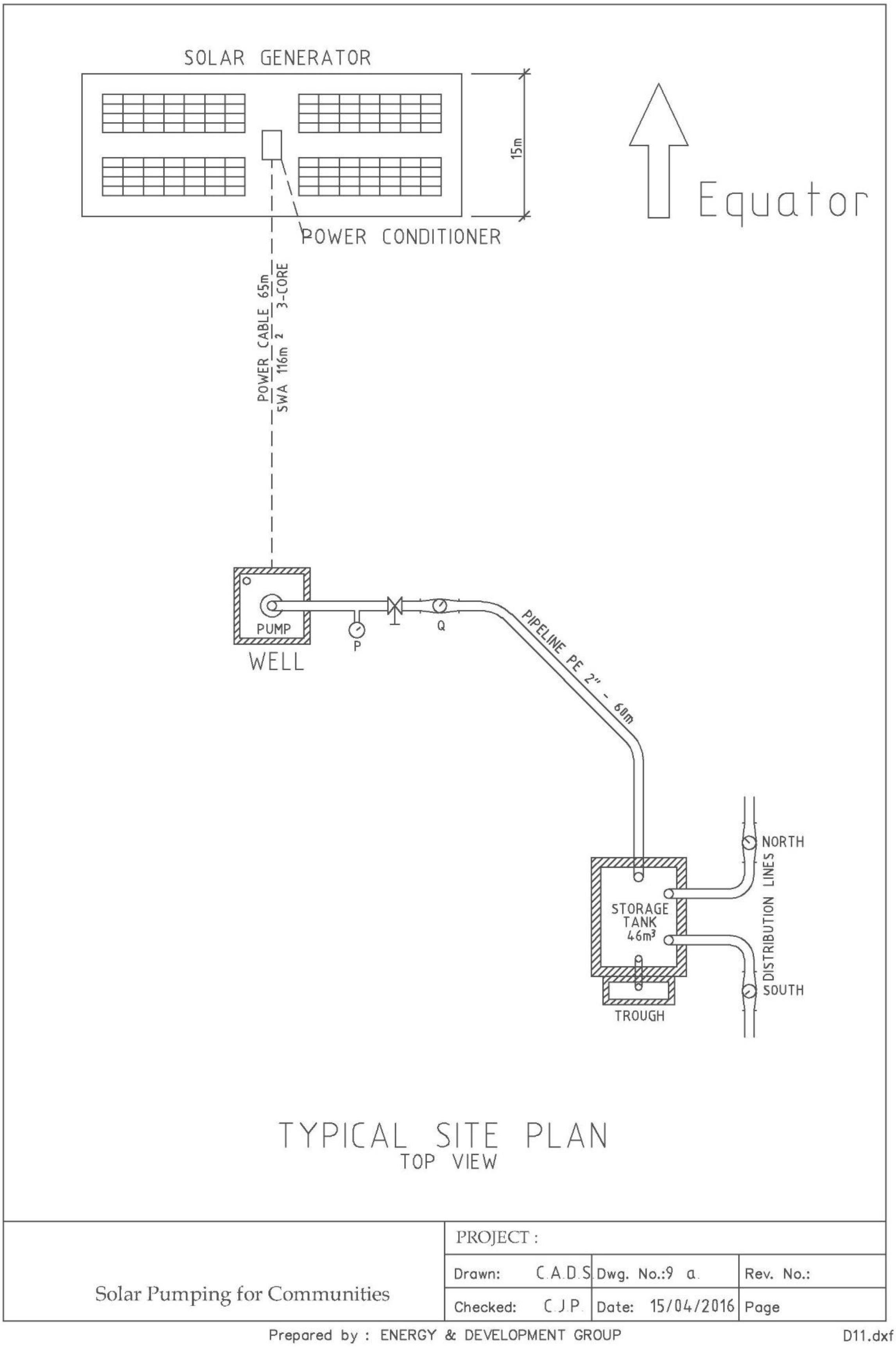




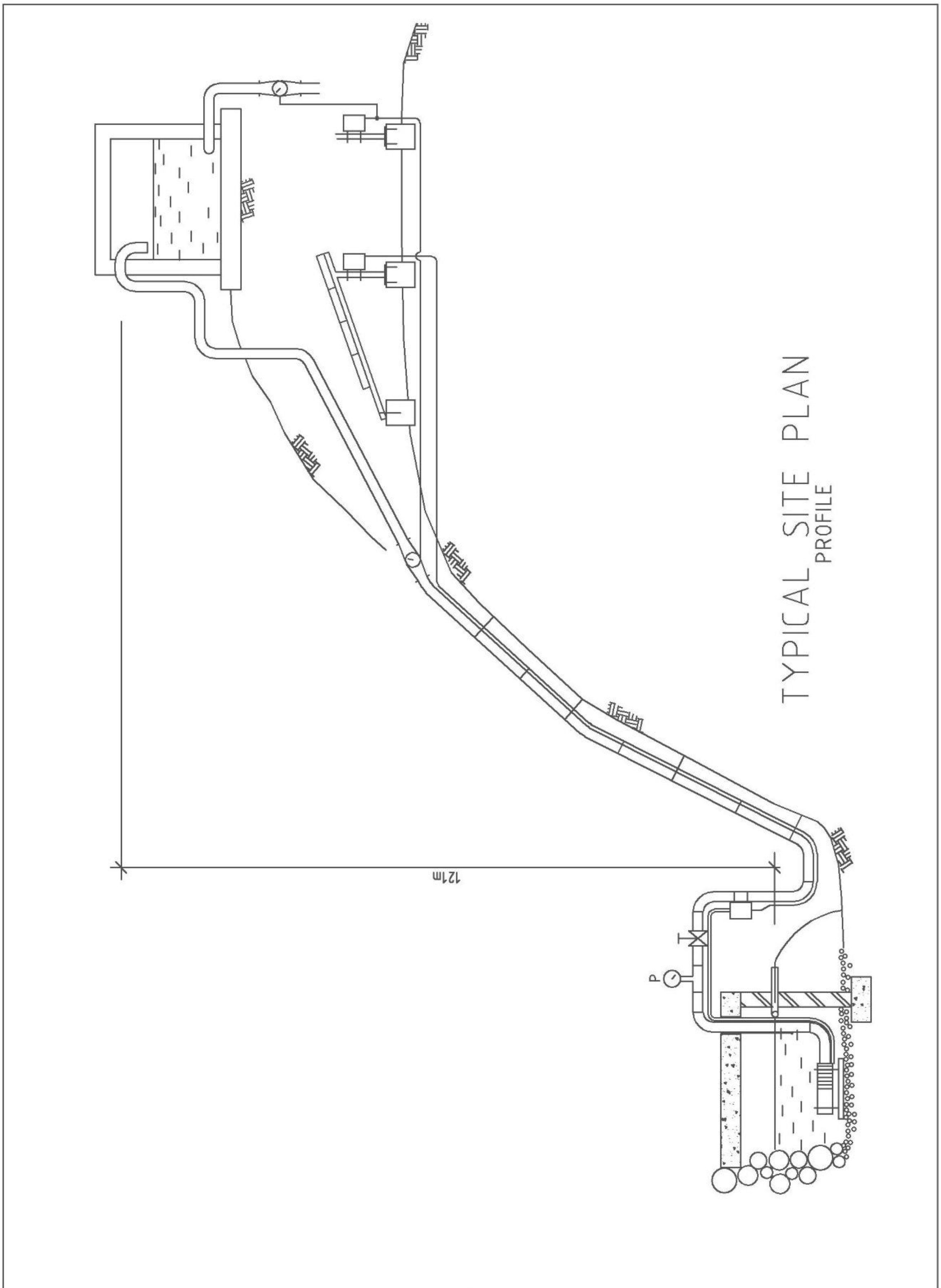
1) Lay-in Lug 2) Bolt 3) Serrated washer 4) Washer 5) Nut

Solar Pumping for Communities	Description **Array frame flange grounding for module earth**	**DWG STR.6**	Scale
			Drawn by: NCL
			Date: February 2017
			Job no. EDG 2015-163

DWG 1.A4 Typical site plan - top view



DWG 2.A4 Typical site plan – profile



Solar Pumping for Communities	PROJECT :		
	Drawn: C.A.D.S	Dwg. No.:9 b.	Rev. No.:
	Checked: C.J.P.	Date: 15/04/2016	Page

Prepared by : ENERGY & DEVELOPMENT GROUP D11.dxf

6. Schedule of Tables

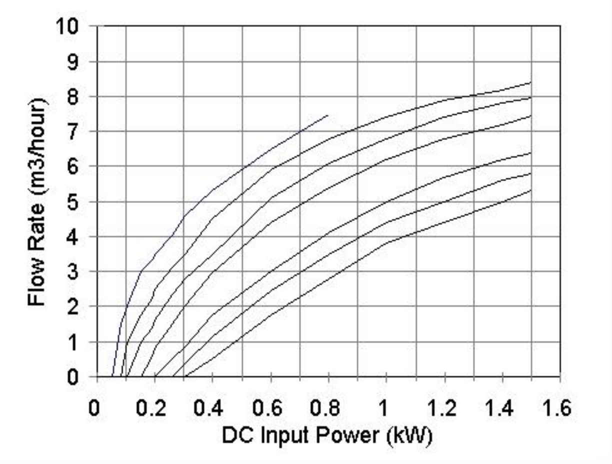
The Bidding Documents include the following tables.

List of Tables

TABLE 1 Sub-system performance data

Instantaneous Sub-system Performance Data

Water Output versus Maximum Power Available (at input to the Power Conditioner)



5 m
10 m
15 m
20 m
25 m
30 m
35 m
40 m

Note:
This graph represents the measureable "Wire to Water" power conversion.
It includes:
- Power conditioner conversion losses
- Motor / pump loses
- Any mechanical transmission losses

but excludes any array MPP tracking inefficiencies.
Power conditioner tracking is accounted for outside of the graph.

↑

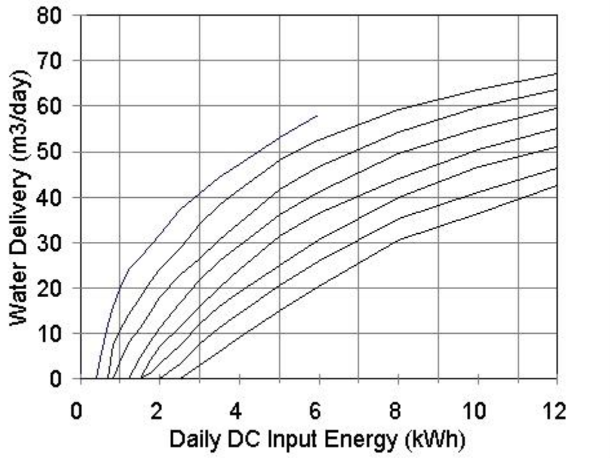
Power Conditioner Power Tracking Efficiency (often module or array-specific)	
typically	98% for MPPT
	93% for CV controller
	85% for no tracking

↑

MPP Power available from the PV Array

Daily Sub-system Performance Data

Daily Water Output versus Energy Available (at input to the Power Conditioner)



5 m
10 m
15 m
20 m
25 m
30 m
35 m
40 m

Note:
This graph represents the measureable "Wire to Water" power conversion.
It includes:
- Power conditioner conversion losses
- Motor / pump loses
- Any mechanical transmission losses

but excludes any array MPP tracking inefficiencies.
Power conditioner tracking is accounted for outside of the graph.

↑

Power Conditioner Power Tracking Efficiency (often module or array-specific)	
typically	98% for MPPT
	93% for CV controller
	85% for no tracking

↑

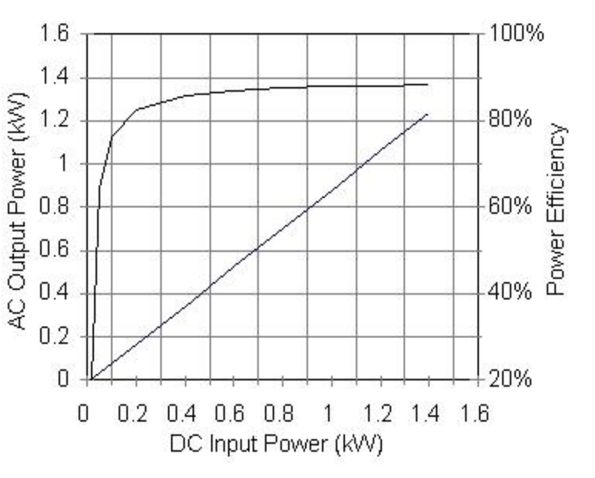
MPP Power available from the PV Array

TABLE 2 Power conditioner performance data

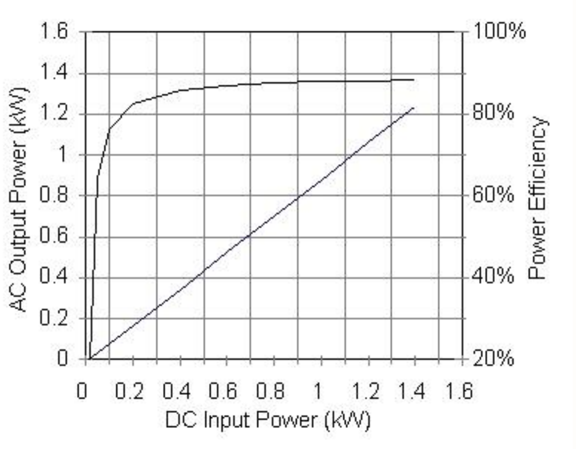
Instantaneous Power Conditioner Conversion Efficiencies

Note that Array Tracking Efficiencies are excluded, and are to be separately accounted for.

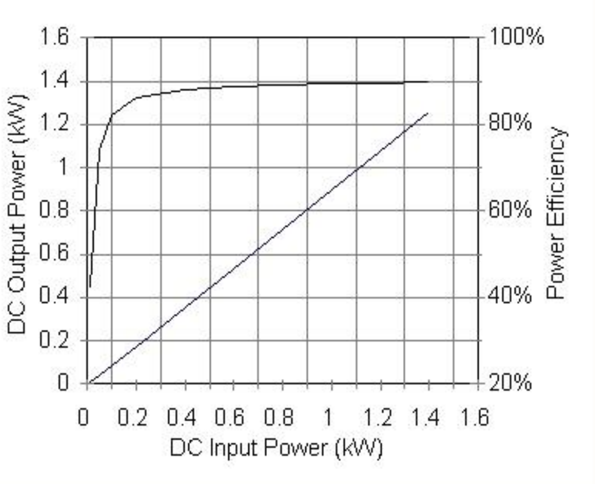
1. **Variable speed inverter with MPPT**



2. **Variable speed inverter with CV operation**



3. **DC/DC converter with MPPT**



4. **CV DC/DC converter**

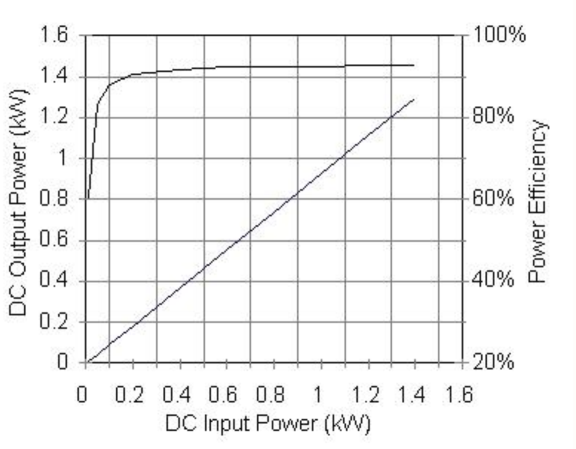
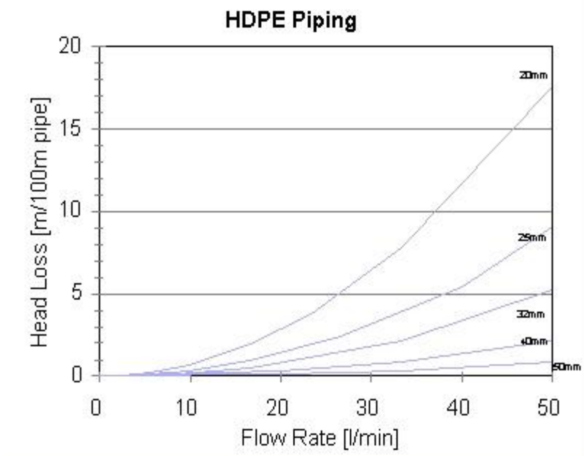
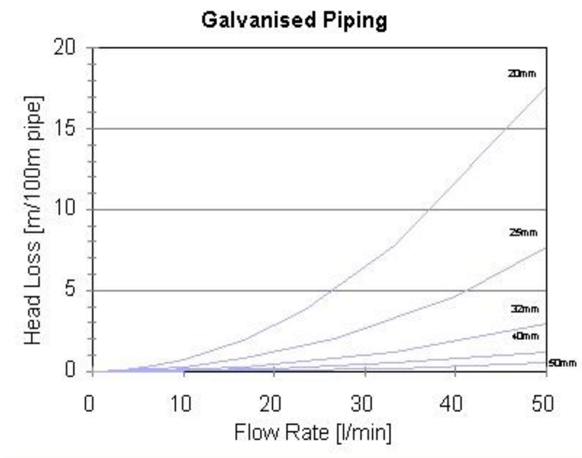
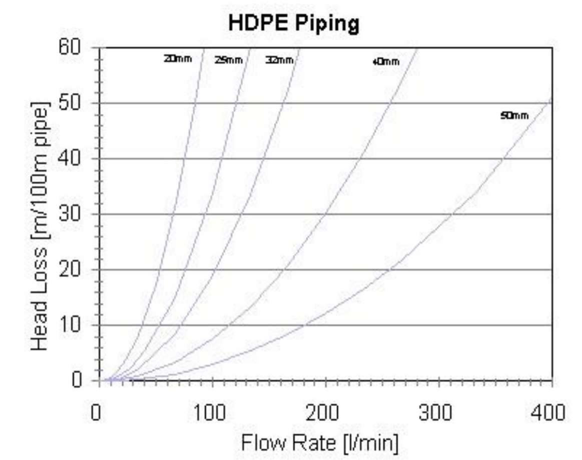


TABLE 3 A Head losses in pipes







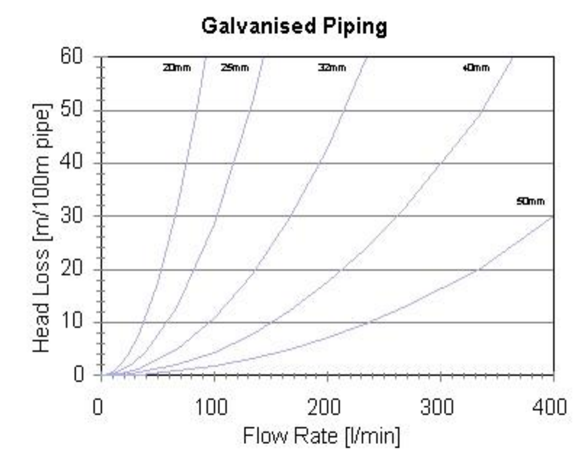


TABLE 3 b **Head losses in fittings**

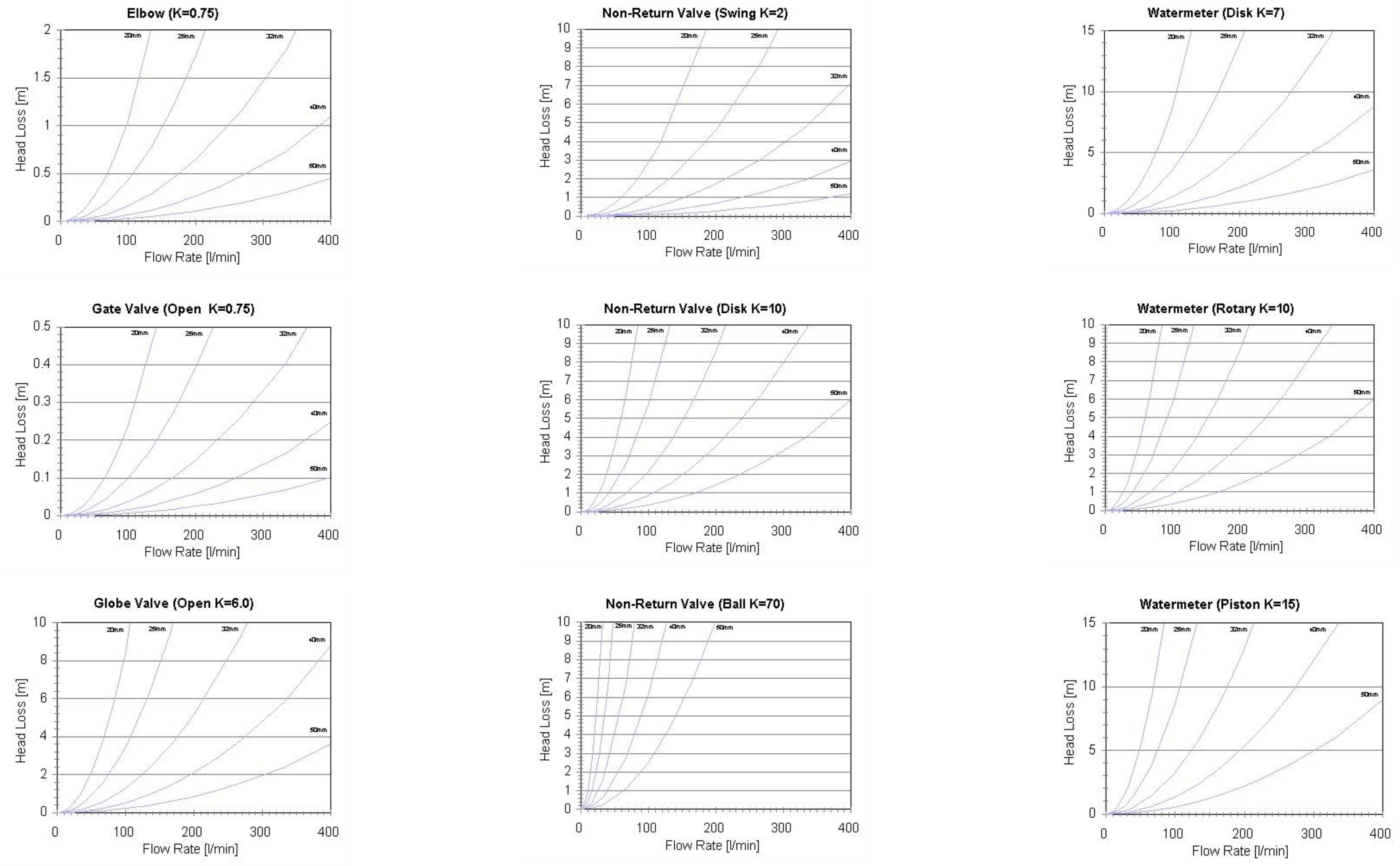


TABLE 4 Degrees of protection provided by enclosures (IP),
(from IEC 60529:2013 Degrees of protection provided by enclosure)

First Digit: Degree of Protection Against Contract and Foreign Bodies

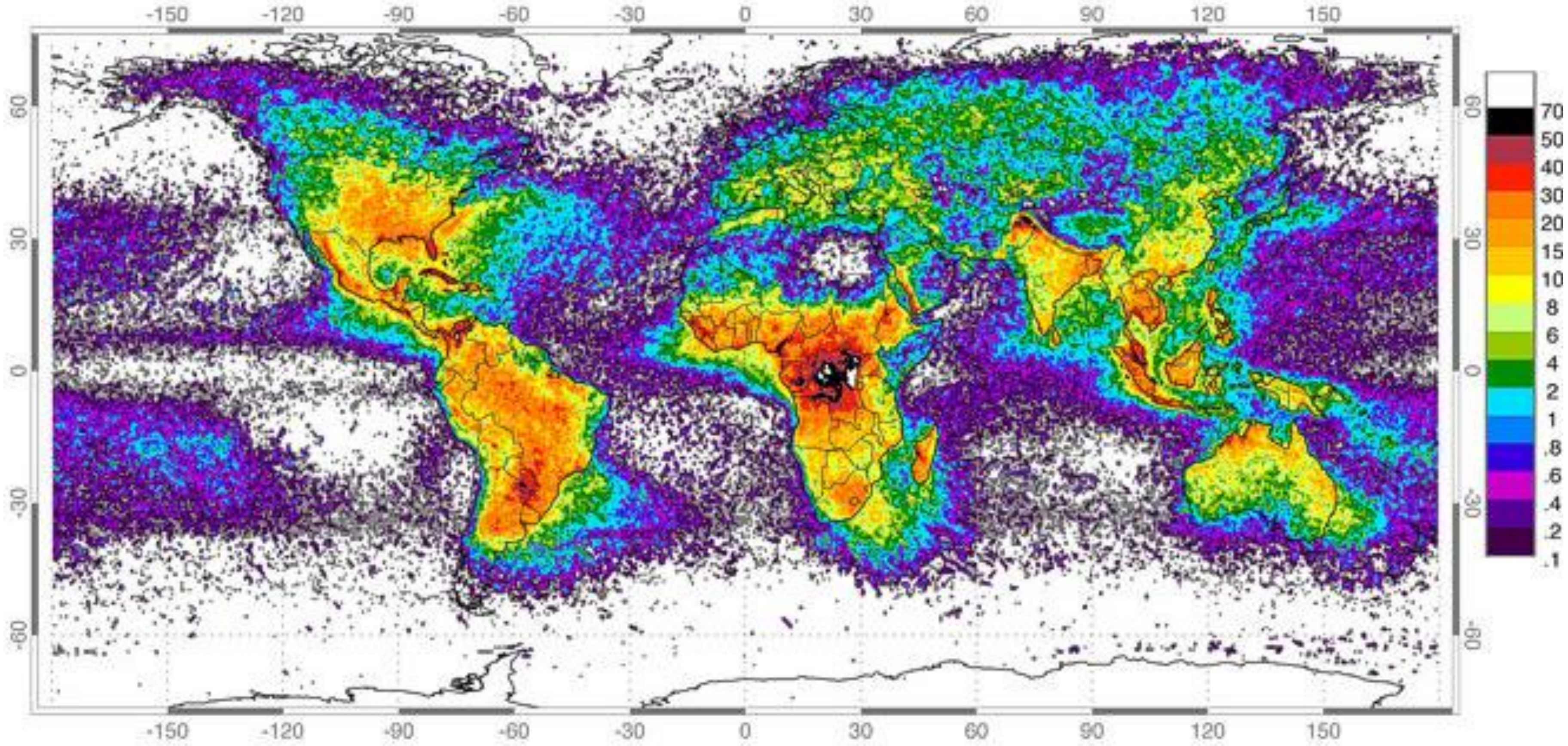
1st Code No.	Extend of Protection	
	Designation	**Comment**
0	No Protection	No special protection against direct contact by persons with energized or moving parts.
1	Proof against large foreign bodies	Protection against accidental extensive contact with energized parts or internal moving parts, e.g. hand contact, but no protection against intentional access to these parts. Protection against penetration by solid foreign bodies with a diameter greater than 50 mm.
2	Proof against medium-sized foreign bodies	Protection against finger-contact with energized parts or internal moving parts. Protection against penetration by solid foreign bodies with a diameter greater than 12 mm.
3	Proof against small foreign bodies	Protection against contact with energized parts or internal moving parts by tools, wires or similar objects with a thickness greater than 2.5 mm. Protection against penetration by solid foreign bodies with a diameter greater than 2.5 mm.
4	Proof against granular foreign bodies	Protection against contact with energized parts or internal moving parts by tools, wires or similar objects with a thickness greater than 1 mm. Protection against penetration by solid foreign bodies with a diameter greater than 1 mm.
5	Proof against dust deposits	Complete protection against contact with energized parts or internal moving parts. Protection against harmful dust deposits. Dust penetration is not completely prevented, but dust may not penetrate in quantities sufficient to affect the proper functioning of the equipment.
6	Fully dustproof	Complete protection against contact with energized parts or internal moving parts. Full protection against dust penetration.

Second Digit: Degree of Protection Against Water

2nd Code No.	Extend of Protection	
	Designation	**Comment**
0	No Protection	No special protective measures.
1	Proof against vertical dripping	Vertical drips may not produce any damaging effects.

2	Proof against oblique dripping	Drips falling at an angle of up to 15º to the vertical may not produce any damaging effects.
3	Spray-proof	Water falling at any angle up to 60º may not produce any damaging effects.
4	Splash-proof	Water splashing against the equipment from any direction may not produce any damaging effects.
5	Water-jet-proof	A jet of water playing on the equipment from any direction may not produce any damaging effects.
6	Flood-proof	Temporary flooding, for example due to heavy seas, may not cause water in damaging quantities to penetrate the equipment.
7	Immersion-proof	No damaging quantities of water may penetrate the equipment if it is immersed in water for a fixed time at a fixed pressure.
8	Submersion-proof	No damaging quantities of water may penetrate the equipment if it is submerged.

TABLE 5 **Lightning ground flash densities**
http://www.weather.gov/images/pub/lightning/hirez_world_annual_flashrate_72dpi.jpg

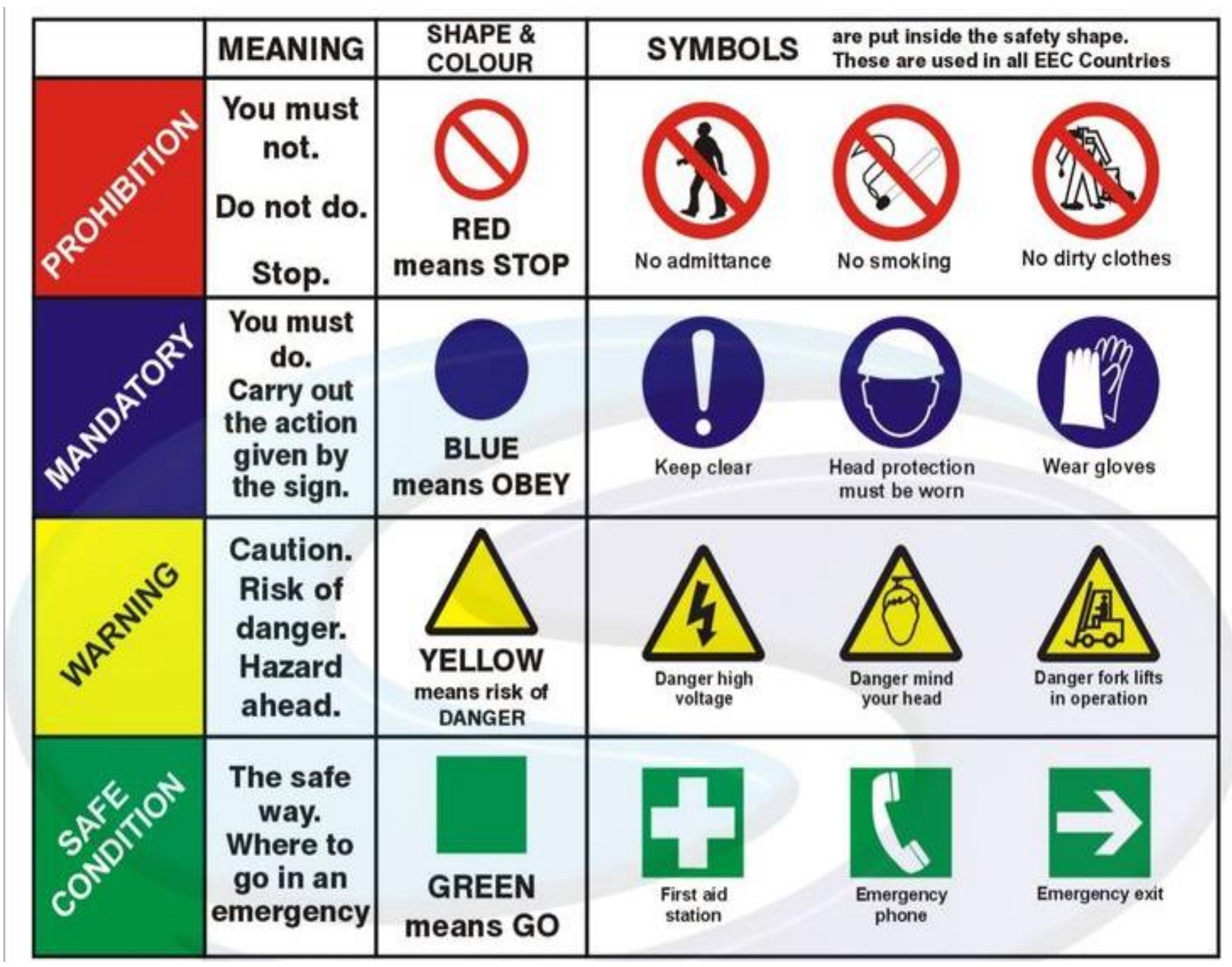


High Resolution Full Climatology Annual Flash Rate

Global distribution of lightning April 1995-February 2003 from the combined observations of the NASA OTD (4/95-3/00) and LIS (1/98-2/03) instruments

TABLE 6 General requirements for safety signs

Table 6a – Signage Conventions - General Meaning of Safety Colours and Shapes



	MEANING	SHAPE & COLOUR	SYMBOLS are put inside the safety shape. These are used in all EEC Countries		
PROHIBITION	You must not. Do not do. Stop.	RED means STOP	No admittance	No smoking	No dirty clothes
MANDATORY	You must do. Carry out the action given by the sign.	BLUE means OBEY	Keep clear	Head protection must be worn	Wear gloves
WARNING	Caution. Risk of danger. Hazard ahead.	YELLOW means risk of DANGER	Danger high voltage	Danger mind your head	Danger fork lifts in operation
SAFE CONDITION	The safe way. Where to go in an emergency	GREEN means GO	First aid station	Emergency phone	Emergency exit

(from ISO 3864-2: 2004: Graphical symbols –safety colours and safety signs)

(from IEC 80416-1: 2008: *Basic principles for graphical symbols for use on equipment – Part 3: Guidelines for the application of graphical symbols)*

Table 6b – DC Junction Box and PV enclosures

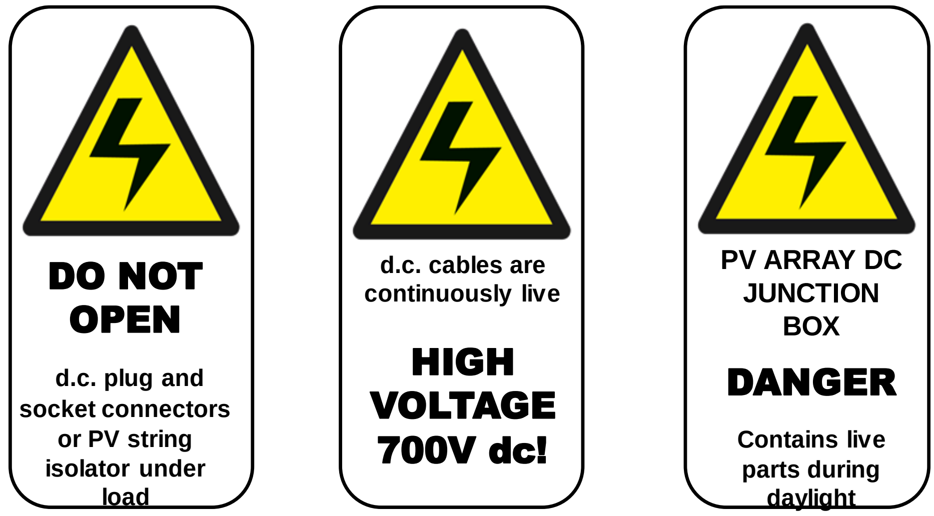


Table 6c – Generator / Fuel storage

Table 6d – Safety signage

Eye protection is available here
EXIT
EXIT
USE TO SMOTHER FIRES
USE TO SMOTHER FIRES
Chip pan fires
Deep fat fires
Waste bin fires
CLOTHING FIRES
Wrap tightly round someone whose clothes are burning to extinguish flames
FOAM SPRAY
A
USE ON: Wood, Paper and Textiles
B
USE ON: Flammable Liquids
DO NOT USE ON: Live Electrical Equipment
DO NOT USE ON: Flammable Metal Fires
DRY POWDER
B
Safe for: Flammable liquids.
C
Safe for: Gaseous fires.
Safe for: Live electrical equipment.
Not for: Wood, paper and textiles.
FIRST AID KIT
EMERGENCY EYE WASH STATION

7. Acceptance Test Procedures for Solar PVP Systems

The Inspection and Commissioning Tests Procedures and Forms shall be updated by the Supplier to meet the specific requirements of the components and systems to be provided and installed, within one month of contract effectiveness. These revised Commissioning Procedures will be tested and approved by a commissioning officer of the Purchaser or Blue Print Consultant at the “Test” or “Blueprint“ installations prior to full roll-out.

A proposed procedure, subject to revision by the Supplier to comply with requirements specific to the products supplied, is given below.

Acceptance Test Procedures for Solar Pumping Systems

ANNEX B.2.1: Performance test sheet (blank)

ANNEX B.2.2: Performance test sheet: Demo sheet (completed eg.)

ANNEX C” (Informative) - Interpreting IV curve shapes (IEC 62246)

1. ACCEPTANCE PROCEDURE

Acceptance checks are an important part of quality control and assurance procedures designed to ensure that systems are performing to specification, and will continue to function well after the maintenance and guarantee period, and that they will be economically viable to operate. Acceptance process comprises of the following:

Figure 1: Flow of acceptance tests

1. Documentation Check
- System data
- Single line diagrams
- Systems operational manuals
- Component technical manuals

2. Component Visual Inspections
Compliance of each component with
- Labelling, standard, and rating as per approved SLD
- Quality of component installation
- Electrical safety sign-off: part 1

3. Component Test and Measurements
Compliance of each component test with
- Correspondence with isolating device
- Basic measurements
- Category 1 tests - Electrical safety sign-off part 2
- Array IV curve tests

4. System Performance Tests
Category 2 tests:
- System benchmark tests vs test pumping head

The Contractor shall allow for/facilitate such tests as described in the ***Project Specification***.

2. DOCUMENTATION CHECK

A check for all required documentation and data, and correspondence of this with the specification.

2.1 Operations and Maintenance booklet

Check the requisite sections, and specifically:

- ***System information***
  - Project identification reference (where applicable)
  - Rated (nameplate) system power (kW DC and kVA AC)
  - PV modules, MPPT, batteries and inverters - manufacturer, model and quantity
  - Installation date
  - Customer name
  - Site address

- ***System supplier information:*** As a minimum, the following information shall be provided for all bodies responsible for the supply and warranty of the system. Where more than one company has responsibility for the design of the system, the following information should be provided for all companies together with a description of their role in the project.
  - System supplier, company
  - System supplier, contact person
  - System supplier, postal address, telephone number and e-mail address.

- ***System installer information*** As a minimum, the following information shall be provided for all bodies responsible for the installation of the system. Where more than one company has responsibility for the installation of the system, the following information should be provided for all companies together with a description of their role in the project.
  - System installer, company
  - System installer, contact person
  - System installer, postal address, telephone number and e-mail address

- ***Wiring single line diagram:*** As a minimum, a single line wiring diagram shall be provided. This diagram shall be annotated to include the information detailed in the following sub-clauses.
  - Array electrical details
  - DC-AC system
  - Earthing and overvoltage protection

- ***Technical datasheets:*** All component data-sheets and operation manuals. As a minimum, datasheets must be provided for the following system components
  - Module datasheet for all types of modules used in system
  - Inverter datasheet, installation and operation manuals
  - MPPT datasheet, installation and operation manuals
  - Battery datasheet, installation and operation manuals

3. VISUAL INSPECTIONS

A general visual inspection shall be performed. The inspections are undertaken prior to testing. The inspections include system configuration and safety of earthing inspections, basic correspondence of key component and quantities with SLD and labelling, quality of installation, inspection for damage during installation.

3.1 Electrical Safety Sign-off - Part 1

The objective is to sign-off on the items numbered *3.1.1 –3..1.7* for the system as a whole. Practically this requires at least a visual inspection of each component and checking the items.

3.1.1 System design is appropriate

a) SLD are approved (i.e. the DC system has been designed, specified and installed to the requirements of IEC 60364 in general and IEC 60364-9-1 in particular.)
b) System has been mechanically designed to standard and conditions on site, including wind, temperature and corrosion.

3.1.2 System components are suitable for purpose

Confirm that components are suitable for purpose as per SLD, and appropriately installed:

a) Main components installed and comply with ratings as per *approved SLD*,
b) All necessary switching components are installed as per SLD to comply with IEC 60349-9-1
c) Wiring systems have been selected and erected to with stand external influences such as wind, temperature, UV radiation, and general tampering.
d) Connectors of appropriate nature are used and comply with IEC60349-9-1

3.1.3 DC system - Protection against the effects of insulation faults

Inspection of the DC installation shall include, as a minimum, verification of the measures in place for protection against the effects of insulation faults, including:

a) Galvanic separation in place inside the inverter/MPPT or on the AC
b) Functional earthing of any DC conductor
   NOTE: knowledge of the galvanic separation and functional earthing arrangements are necessary in order to determine if the measures in place to protect against the effects of insulation faults have been correctly specified.
c) That a PV Array Earth Insulation Resistance detection and alarm system is installed – to the requirements of IEC 60364-9-1
d) That a PV Array Earth Residual Current Monitoring detection and alarm system is installed
   - to the requirements of IEC 60364-9-1

3.1.4 DC system - Protection against overcurrent

Inspection of the DC installation shall include, as a minimum, verification of the measures in place for protection against overcurrent in the DC circuits:

a) For systems with array / sub-array over-current protective devices: verify that:
   - over-current protective devices are fitted and correctly specified to the requirements of IEC 60364-9-1.
b) For systems without string over-current protective device: verify that:
   - $I_{MOD\_MAX\_OCPR}$ (the module maximum series fuse rating) is greater than the possible reverse current;

- string cables are sized to accommodate the maximum combined fault current from parallel strings

  Note: see IEC60364-9-1 for calculation of array reverse currents

c) For systems with string over-current protective device: verify that:
   - string over-current protective devices are fitted and correctly specified to the requirements of IEC 60364-9-1.

3.1.5 DC system – earthing and bonding arrangements

Inspection of the DC installation shall include, as a minimum, verification of:

a) Array frame bonding arrangements have been specified and installed to the requirements of IEC 60364-9-1
b) Where protective earthing and/or equipotential bonding conductors are installed, verify that they are parallel to, and bundled with, the DC cables
c) Array structure earth spike(s) connected to ground. This should be clearly marked on the SLD.
d) NO earthing of the DC side of the electrical installation- or only one DC earthing location
e) Where the PV system includes functional earthing of one of the DC conductors, the functional earth connection has been specified and installed to the requirements of IEC 60364-9-1. And clearly marked in SLD.
f) Where a PV system has a direct connection to earth on the DC side, a functional earth fault interrupter must be provided to the requirements of IEC 60364-9-1 and clearly marked in the SLD.

3.1.6 DC system - Protection against the effects of lightning and overvoltage

Inspection of the DC installation shall include, as a minimum, verification of:

a) To minimise voltages induced by lightning from the array circuits, verify that the area of all incoming wiring loops has been kept as small as possible
b) Measures are in place to protect long DC cables (e.g. screening or the use of DC-rated Surge Protection Devices (SPD)
c) Where DC-rated SPDs are fitted, check that they have been installed to the requirements of IEC 60364-9-1, and are clearly marked in the SLD.

3.1.7 AC system - Protection against the effects of lightning and overvoltage

Inspection of the AC installation shall include, as a minimum, verification of:

d) To minimise voltages induced by lightning from the AC load circuits, verify that the area of all wiring loops been kept as small as possible
e) Measures are in place to protect long AC cables and underground cables (e.g. screening or the use of AC-rated SPDs)
f) Where AC-rated SPDs are fitted (underground cables or long overhead cables, they have been installed to the requirements of IEC 60364-9-1 in the AC DB, and are clearly marked on the SLD.

3.2 Component Inspection Sequence

These visual inspections descriptions highlight the important items to be checked. The full details should be on individual component inspection checklist sheets.

3.2.1 Array structure - visual inspection

a) Check for mechanical soundness of structure, including upper structure quality, foundation quality, corrosion resistance and galvanisation quality. Confirm module mounting using stainless bolts, and avoidance of contact between dissimilar metals or confirm module clamping location against manufacturer specification. Check for obvious torsional stress on modules.
b) Check cable tray quality, to same standards as per structure.
c) Check orientation, tilt angle, possible shading.
d) Check for anti-theft measures and quality of the measures (array frames, tamper-proof bolts, high mast etc), and confirm they do not affect panel shading or performance.
e) Confirm array structure earthing, including connection quality to module frames, continuity between arrays, and check for dissimilar metals (future corrosion). Verify that array frame and/or module frame protective earthing conductors have been correctly installed i.e. ground wire attachment with nut and bolt combination including star washer or WEEB clip installation, and are connected to earth. Confirm earth spike location

3.2.2 Array - visual inspection

a) Check for correspondence of each array labelling with SLD, arrangement and numbering including substring numbering. Check module type. Check quantity of arrays, modules per array, series and parallel connections.
b) Confirm each module has serial numbers for scanning, and correct product labelling with specifications for warranty support.
c) Check for any damage: surface and glass damage, back-plate and EVA damage, torsional stress on modules.

3.2.3 Array Junction Box - visual inspection

a) Check for correspondence of labelling with SLD, especially arrangement and numbering.
b) Check quality: Combiner Box is outdoor rated, IP65 and gland seals, internal CB and rating compared with SLD, internal Lightning Protection (LP) devices.
c) Check and inspect “strain reliefs” and gland seals to ensure cables cannot be pulled or chaffed against knockouts
d) Check cable routing, and quality and consistency of MC connectors.
e) Confirm earthing arrangement of internal LP devices. Confirm absence/presence of array conductor cable earthing. Confirm cable labelling.

3.2.4 Array cable entry & combiner - visual inspection

a) Check correspondence of labelling with SLD: arrangement and numbering, combiner box numbering
b) Check quality: Combiner Box is outdoor rated, internal CB and rating compared with SLD.
c) Confirm absence/presence of array conductor cable earthing. Confirm cable labelling.
d) Check cable entries to room, and quality of entry. Check and inspect “strain reliefs” and gland seals to ensure cables cannot be pulled or chaffed against knockouts

3.2.6 Power Conditioner / Inverters - visual inspection

a) Check for correspondence of labelling with SLD: inverter type and model, arrangement and numbering, quantities.
b) Check that sufficient space for ventilation surrounding the inverter has been left.
c) Check and inspect “strain reliefs” and gland seals to ensure cables cannot be pulled or chaffed against knockouts
d) Check earthing arrangement and configuration: chassis earthing and earth cabling connection, and confirm DC positive or negative cables are unearthed at inverter.

e) For functional earth leakage protection, confirm inverter ELP compatibility and N-E bridge location.
f) Check for provision of LP on incoming DC cables from array and note whether Class 1 or Class 2. Check for LP on DC cables to float switches and external relays and note Class 1 or 2. Check for continuity in LP device, and earthing connections and earth path.
g) Check for provision LP on outgoing DC cable to pump, or check for provision of SPD on outgoing AC cables to pump and note Class 1 or 2. Check continuity of LP or SPD device, and earthing connections and earth path.

3.2.7 Pump - visual inspection

This inspection is possible only for surface pumps, or pumps that have not yet been installed:

a) Check for correspondence of labelling with SLD: pump type and model, arrangement.
b) Check and inspect "strain reliefs" and gland seals to ensure cables cannot be pulled or chaffed against knockouts.
c) Check earthing arrangement and configuration: chassis earthing and earth cabling connection, and confirm DC positive or negative cables are unearthed.
d) Check strain cable length attachment and compare with borehole depth, to ensure pump is suspended at least 1.5m above borehole base.
e) Check pump riser pipe attachment at pump, check quality of fittings.

3.2.8 Cables and connectors - visual inspection

This visual inspection checks cables types, and general cable routing practices. Visual inspections to confirm cabling types are appropriate:

a) PV array cabling
b) Submersible pump cable
c) AC cable types

Check cable routing by opening conduits and cable trays:

d) For all enclosures, check and inspect "strain reliefs" and gland seals to ensure cables cannot be pulled or chaffed against knockouts
e) DC cables are separated from AC cables, and separated from COMMS cables at all routings.
f) Where protective earthing and/or equipotential bonding conductors are installed, verify that they are parallel to, and bundled with, the DC cables (IEC 60364-7-712.54:2002).
g) to minimize voltages induced by lightning, verify that the area of all wiring loops has been kept as small as possible (IEC 60364-7-712.444.4:2002).
h) Inspect for any joins and splicing of cables hidden underneath cable trunking, inside conduits or in cable trays. All wiring joining and splicing should be avoided. All cable connections, especially high power DC ones, should be INSIDE INSPECTION ENCLOSURES. Splicing and joins with ferrules and heat shrink are UNACCEPTABLE! And will heat up over time.

3.2.8 Pipework, metering and valves

a) Check and compare arrangement with borehole heard drawing, noting gate valves, pressure release, water metering, pressure metering, and non-return valves.
b) All labelling is in correspondence with the SLD
c) Check pump riser pipe attachment at pump, check quality of fittings.
d) Check borehole head concrete finish and metallic borehole head lock.
e) Check for quality of connections.

3.2.9 Generator - visual inspection

a) Check for correspondence of labelling with SLD: inverter type and model, arrangement and numbering, quantities.
b) Check Main load CB rating compared with SLD.
c) Check and inspect “strain reliefs” and gland seals to ensure cables cannot be pulled or chaffed against knockouts.
d) Earthing and bonding compatibility: Check for N-E bridge location in Genset DB or within generator.
e) Confirm whether own equipment bonding spike and location. Confirm whether own AC Electrical earth spike and location.
f) Confirm Generator Change-Over switch earthing is clearly marked in SLD, and if earth is switched, that this is not in conflict with any N-E bonding.

3.2.10 Signage and labelling - visual inspection

The signage and labelling installed on site is critical. Inspection of the PV system shall include, as a minimum, verification that:

a) Approved single line wiring diagram is displayed on site
b) All labelling is in correspondence with the SLD
c) All circuits, protective devices, switches and terminals are suitably labelled to the requirements of IEC 60364 in general and IEC 60364-9-1 in particular
d) All long cable runs are labelled as necessary
e) All DC junction boxes (PV generator, PV array boxes, PV combiner boxes, DC DB and busbars) carry a warning label indicating that active parts inside the boxes are fed from a PV array and may still be live after isolation from the PV inverter.
f) Means of isolation on the AC side is clearly labelled
g) Installer details displayed on site
h) Shutdown procedures displayed on site
i) Emergency procedures displayed on site (where relevant)
j) All signs and labels suitably affixed and durable
NOTE: the requirements for signs and labelling of the PV system are detailed in IEC60364-9-1

3.2.11 Remote monitoring, data-logging and remote control

The communications components cover those for interlinking the major power components within the site, as well as a link to the outside world.

- Confirm presence of integrated comm package as per SLD.
- Confirm presence of presence of at least one ComBox.

4. SAFETY AND COMPONENT TESTS

The objective is to sign off on basic functional switching, electrical safety tests vis-à-vis polarities, earthing continuity and insulation resistances, and cabling. The following checks will be undertaken:

- Correspondence of all CB and isolators, and labels thereof, with the switched equipment,
- Electrical Safety Sign-off - part 2
  - continuity of earthing and equipotential bonding conductors
  - polarity tests
  - junction and combiner box tests
  - V_{oc} and basic voltage range checks
  - PV string short circuit tests
  - PV insulation resistance tests
- Cable distance measurements for voltage drop calculations
- Terminal torque settings for main connections

4.1 Correspondence of isolators and labels with switched devices

Check functional correspondence of all CB and isolators and labels with switched devices: i.e. check which isolators turn on which devices. This is best achieved before system switch on by measuring resistances – however some components can be checked simply by switching.

4.2 Electrical Safety Sign-off - Part 2

These tests are used to confirm measurements of basic electrical safety before system switch on.

4.2.1 Continuity of earthing and equipotential bonding conductors

Where protective earthing and/or equipotential bonding conductors are fitted on the DC side, such as bonding of the array frame, chassis of MPPT and inverters, electrical continuity tests shall be made on all such conductors. The connection to the main earthing terminal should also be verified.

4.2.2 Polarity tests

The polarity of all DC cables shall be verified using suitable test apparatus (i.e. Seaward Solar PV150, which can be used for testing Isc, Rpe and Riso tests along with Voc and Polarity in this section.) Once polarity is confirmed, cables shall be checked to ensure they are correctly identified and correctly connected into system devices such as switching devices or inverters.

NOTE: For reasons of safety and for the prevention of damage to connected equipment, it is extremely important to perform the polarity check before other tests and before switches are closed or string over-current protective devices inserted. If a check is made on a previously connected system and reverse polarity of one string is found, it is then important to check modules and bypass diodes for any damage caused by this error.

4.2.3 Junction and combiner box tests

The purpose of combiner box test (or indeed any junction box where paralleling of connections occurs) is to ensure all strings interconnected at the combiner box are connected correctly, before switching on the combiner breakers or fuses. The following test sequence indicates a reverse connection through a substantially different voltage reading. The test procedure is as follows and shall be performed before any string fuses are inserted for the first time:

- Use a volt meter with voltage range at least twice the maximum system voltage.
- Ensure all strings share a common negative bus (as per SLD)
- Ensure all positive CB are off for the test.
- Measure the open-circuit voltage of the first string, positive to negative, and ensure it is an expected value.
- Leave one lead on the positive pole of the first string tested, and put the other lead on the positive pole of the next string. Because the two strings share a common negative reference, the voltage measured should be near-zero, with an acceptable tolerance range of +/-15 volts
- Continue measurements on subsequent strings, using the first positive circuit as the meter common connection.
- A reverse polarity condition will be very evident if it exists - the measured voltage will be twice the system voltage.

4.2.4 PV string -current measurement

The purpose of PV string current measurement test is to verify that there are no major faults within the PV array wiring. These tests are not to be taken as a measure of module / array performance.

The short circuit current of each PV string should be measured using suitable test apparatus. (i.e. Seaward Solar PV150, which can be used for testing Isc, Rpe and Riso tests along with Voc and Polarity) .The making / interruption of string short circuit currents is potentially hazardous and a suitable test procedure, such as that described below, should be followed.
Measured values should be compared with the expected value. For systems with multiple identical strings and where there are stable irradiance conditions, measurements of currents in individual strings shall be compared. These values should be the same (typically within 5% of the average string current, for stable irradiance conditions).

Short circuit test procedure

A temporary short circuit shall be introduced into the string under test. In these procedures[7] this is achieved use of a test instrument with a short circuit current measurement function (eg a specialised PV tester), with an irradiance meter reading or visual appraisal of the sunlight conditions may be used to consider the validity of the current readings, for on-stable irradiance conditions[8].

- Ensure that all switching devices and disconnecting means are open and that all PV strings are isolated from each other.
- Ensure that the test instrument has a rating greater than the potential short circuit current and open circuit voltage. It shall also be ensured that where a switching device and/or short circuit conductor is utilised to form the short circuit, that these are rated greater than the potential short circuit current and open circuit voltage.
- The short circuit current can then be measured using test instrument with a short circuit current measurement function.

4.2.5 PV array - insulation resistance tests

PV array DC circuits are live during daylight and, unlike a conventional AC circuit, cannot be isolated before performing this test. Performing this test presents a potential electric shock hazard (150-600Vdc in this case), it is important to fully understand the procedure before starting any work. It is recommended that careful safety measures are followed.

The test should be repeated for each PV Array as minimum. It is also possible to test individual strings if required.

Where the structure/frame is bonded to earth, the earth connection may be to any suitable earth connection or to array frame (where the array frame is utilised, ensure a good contact and that there is continuity over the whole metallic frame).

For installations where the array frame is not bonded to earth (i.e. class II installation) the commissioning engineer may choose to do two tests: i) between Array cables and Earth and an additional test ii) between Array cables and Frame.

Insulation resistance test procedure

It is assumed that the test shall be done using a test device such as Seaward Solar PV150 (which can be used for testing Isc, Rpe and Riso tests along with Voc and Polarity in this section).

- Before commencing with the test:; isolate the PV array from MPPT/inverter (typically at the array switch disconnector); and disconnect any piece of equipment that could have impact on the insulation measurement (i.e. overvoltage protection) in the junction or combiner boxes.
- The insulation resistance test device shall be connected between earth and the array cable(s) as appropriate to the test method adopted. Test leads should be made secure before carrying out the test.
- Follow the insulation resistance test device instructions to ensure the test voltage is according to table below and readings in MΏ.
    - For PV arrays of up to 10kWp, the insulation resistance shall be measured with the test voltage indicated in Table below.
    - The result is satisfactory if each circuit has insulation resistance not less than the appropriate value given in Table below.
- Ensure the system is de-energised before removing test cables or touching any conductive parts.

Table 1: Minimum values of insulation resistance – PV arrays up to 10kWp

System Voltage (Voc_{stc}x1.25)	**Test voltage**	**imum insulation resistance**
<120V	250V	0.5MΏ
120V-500V	500V	1MΏ
>500V	1000V	1MΏ

4.2.8 Terminal torque settings

Check connection quality of a broad selection of random locations which are critical to system performance, and which indicate consistency in quality of installation:

4.3 Array IV tests

The IV curve test on an array benchmarks the overall performance against nameplate, of the array comprising of:

- modules performance under measured temperature and insolation regime
- correct module interconnection
- array junction box and combiner box performance
- array cabling losses up to the MPPT / PV INV input

IV curves can provide detailed information on:

- measurements of string open circuit voltage (V_{oc}) and short circuit current (I_{sc})
- measurements of max power voltage (V_{mpp}), current (I_{mpp}), and max power (P_{max})
- measurement of array performance
- Identification of module / array defects or shading issues

Ideally, IV curves shall be done on all arrays at each site.

If this is impractical, then IV curves can be done for at least 2 arrays, and the acceptable performance of those arrays confirmed. Thereafter the MPPT / PV INV performance on those arrays can be confirmed. Subsequent array performance can be benchmarked by comparing MPPT performance (identical input current, input voltage, and output power). However if there are significant discrepancies, then further IV curve measurements on those arrays shall be required to isolate the problems quickly and effectively.

4.3.1 IV Curve test procedure

The suppliers of the specific IV test equipment such as SEALINK™ or TriKA™ provide detailed test procedures to follow and may differ slightly from product to product. The procedures that follow are therefore for completeness only.

The procedure for undertaking the IV curve test shall be as follows:

- PV string and array performance measurements shall be performed at stable irradiance conditions of at least 400W/m^2 as measured in the plane of the array.
- The IV test instrument should be programmed with the characteristics, type and quantity of modules under test. And with details of the cabling lengths and type from the modules to the IV tester.
- Ensure PV system is shut down and that no current is flowing.
- The string(s)/array under test should be isolated and connected to the IV curve test device. The location of this connection could be at the combiner box for strings, or at MPPT or PV INV input for complete array.
- The irradiance meter paired with the IV curve tester should be mounted in the plane of the array and not subject to any localised shade or reflected light (albedo). Where a reference cell device is used, this shall be checked to ensure it is of the same cell technology as the array under test, or suitably corrected for the difference in technologies.
- Where the IV curve tester utilises a cell temperature probe, this shall be in firm contact with the rear of the module and in the centre of a cell towards the centre of a module. Where temperature corrections are calculated by the IV curve test device, a check shall be undertaken to ensure that the correct module characteristics are inputted into the device and that the string Voc value is within the range expected.

NOTE: A check of Voc is performed to ensure that the string has the correct number of modules – the wrong number would cause an error in determining temperature.

- Prior to commencing the test, the irradiance levels shall be checked to ensure they are greater than 400 W /m^2 in the plane of the array.

On completion of the test, the measured maximum power value should be compared to the rated (nameplate) value of the array under test (corrected for cable losses where relevant). The measured value should lie within the stated power tolerance for the modules under test (together with an allowance for the accuracy of the IV curve test equipment).

4.3.2 Interpretation of IV test curve shape

The IV curve shape is also useful for troubleshooting defects such as:

- Damaged cells/modules
- Shirt circuited bypass diodes
- Local shading
- Module mismatch
- Shunt resistance
- Excessive series resistance (cables losses)

On recording an IV curve, the shape shall be studied for any deviation from the predicted curve. Deviations to IV curves demand particular attention as they can signal otherwise undetected and significant faults within the PV array. Information on interpreting deviations to an IV curve is contained in Annex 2.

For systems with multiple identical strings and where there are stable irradiance conditions, curves from individual strings shall be compared (overlaid). Curves should be the same (typically within 5% for stable irradiance conditions).

5. SYSTEM PERFORMANCE TESTS

The System Performance Tests shall determine whether the system is able to perform to specification in terms of water delivery relative to available solar resources on site, and pumping head conditions on site. The tests are intended to be relatively simple checks of system performance, and use the techniques of power balance (instantaneous) and energy balance (over half a day of full day).

The longer duration *energy balance tests* over full day or half day are more generally credible and reliable as they account for variability during the day, including cloud cover and pump stop/starts.

The *power balance* is more difficult to conduct, requiring greater dexterity and requires greater experience with PV and pump as well as better equipment, but are much faster.

In the event of any uncertainty in results, or in even of a dispute, then a long term energy balance test will be required as the power balance test is simply less accurate.

5.1 Test Equipment Required for the Performance Tests

5.1.1 Energy balance tests

- Stop watch / watch with second hands
- Kipp & Zonen Class 3 Solarimeter or calibrated reference cell or equivalent, plus multi-meter capable of measurement, with integrator
- Water flow meter at borehole head: to the requirements of the Standard Specification will be sufficiently accurate to measure water quantity in the above time interval. Alternatively an ultrasonic water flow meter similar to *GREYLINE INSTRUMENTS(USA) Portable Doppler flow meter PDFM5.1*™ (http://www.greyline.com/index.php/2015-05-10-23-47-35/agricultural/flow-ultrasonic-flow-meters-3/pdfm-5-1-portable-doppler-flow-meter-1-detail)
- Borehole depth: .a plump-line system with meter to sense the water level using conductivity. Lazer tape water depth measurement, similar to *SOLINST Water level indicator (Model 102)*™ (http://www.solinst.com/products/level-measurement-devices/102-water-level-indicator/datasheet/)
- *Manometer gauge:* Manometers fitted to the system should enable an estimate of static and dynamic head losses. It may be necessary to estimate borehole water levels using appropriate methods.
- Digital multi-meter: minimum range 0-1,000 VAC / VDC, accuracy minimum 1%, 0.1V resolution)
- Current clamp-meter: for current measurement of each array input to the power conditioner. Range to be range sufficient to meet current and voltage requirements. (Range 0-50A, 0-200A, accuracy 1%, resolution 0.1A).
- Functional and operational ***"Remote monitoring and data-logging system"*** as specified in ***Technical Specification section 18***. Ideally, the test measurements will also be calibrated against the reading from this system.

5.1.2 Power balance tests

- All of the previous equipment plus additional equipment

- Power meter (single of three phase), capable of measuring AC or DC power from the power conditioner (alternatively another clamp-meter and voltmeter set with suitable range for power conditioner outputs).
- Container and mass measurement scale (sufficient to contain and measure 10 minute flow output at maximum flow rate)

5.2 Test set-up

- Stop watch in hand
- Solarimeter, mounted in plane of array
- Manometer gauge at borehole head
- Borehole depth measurement at borehole head
- Water meter /flowmeter at borehole head
- DC current clamp-meter, on array output or power conditioner input
- DC voltmeter, on array output or power conditioner input
- AC/DC current clamp-meter, on power conditioner output or pump motor input
- AC/DC voltmeter, on power conditioner output or pump motor input

5.3 Conditions Required

A worksheet is provided for the each Short Test for the Pumping System Performance Tests *(see **Annexure B.2.1.**)*

5.3.1 Energy balance tests / full day test

- The performance variables shall be recorded preferably over a whole day, from sunrise to sunset. Alternatively for at least half a day starting at sunrise, till midday; or from midday sunset.
- The solar predictions for the day should be typical for the month. i.e. totally clear skies for the whole day, or totally overcast days, that might be atypical should be avoided if possible.
- Radiation levels and weather conditions should be stable for at least each measurement period if any instantaneous readings are to be taken. If conditions are very variable then only the integrated values can be used.
- Reservoir level switches are over-ridden or disconnected.

5.3.2 Power balance tests / Short test

- The performance variables shall be recorded carried out for at least 3 different radiation levels over the course of the day.
- Instantaneous radiation levels should be close to: 200, 500, and greater than 800 W/m$^{2.}$ The greater the difference in radiation levels the better, ranging from close to sunrise or sunset, to midday.
- Radiation levels and weather conditions should be stable for at least each measurement period.

- Reservoir level switches are over-ridden or disconnected.

5.4 Record (over each measurement period)

Record the following on the record sheet in ***Annexure B.2.1***.

- Event (*line 1a*) (i.e. pump starts turning, water starts being delivered etc.)

Record these for energy balance inputs, at regular time intervals (30 minutes)

- Time (*line 1b*)
- Cumulative flow water meter reading (*line 1n*) (litres)
- Insolation (*line 1d*): the cumulative irradiance over the test period (Wh/m2)
- Manometer pressure (*line 1e*) (kPa)
- Borehole water level below manometer (*line 1f*) (m)

For power balance, quickly record the following within a 30 second interval, to make them as simultaneous as possible!! Take several reading sets at each irradiation level as close to 200, 400 and 800 W/m^2 as possible.

- Time (*line 1b*)
- Irradiation (*line 1c*) : Instantaneous radiation levels (W/m^2)
- Array current (*line 1h*) (A dc)
- Array voltage (*line 1i*) (V dc)
- Power conditioner output current (*line 1j*) (A ac/dc)
- Power conditioner output voltage (*line 1k*) (V ac/dc)
- Water flowrate (*line 1l*)
  (litres/minute)

5.5 Performance Check based on Instantaneous Measurements

5.5.1 Calculations based on Instantaneous measurements

This is to identify unusually low efficiencies and possibility of mismatched components. These can be calculated while doing the longer term tests. Calculate the following on the sheet:

- Total head (m) = dynamic head above borehole head + borehole water level
  1g = 1e/9.8 + 1f
- hourly flowrate (litres/hr) = litres / minute x 60
  1m = 1l x 60
- Expected STC array power (W) = qty modules x module (Wp) x irradiation (W/m^2)
  2d = 2b x 2c x 1c/1000
- Measured array power (W) = measured array current (A) x voltage (V)

2f = 1h x 1i

- Array tracking efficiency (%) = measured array power / expected STC array power

  2e = 2f / 2d

- Measured power to pump (W)= measured current to pump (A) x measured voltage to pump (V)

  2h = 1j x 1k

- Controller throughput efficiency (%) = power out/power in = measured power to pump / measured array power

  2g = 2h / 2f

- Hydraulic power (W) = hourly flowrate (m^3/hr) x total dynamic head (m) x 9.8/3.6

  2k = 1m /1000 x 1f x 9.8/3.6

- Pump efficiency (%) = hydraulic power (W) / measured electrical power to pump (W)

  2j = 2k / 2h

- Instantaneous sub-system efficiency (%)= hydraulic power (W) / measured array power (W)

  2l = 2k / 2f

5.5.2 Check of instantaneous efficiency performance figures

Array tracking efficiency

Should be close to 77%. If it is too low, then either:

- the pumping head very much lower than design, and array tracking is possibly reduced,
- or panel output is much lower than expected. If there is still a query then check whether the instantaneous DC array power matches the array power output curves provided by the supplier? (Should be within 10%. If not, find the array problem: check each sub-array for output.)

Converter efficiency

Should be close to 95% plus. If it is lower, it suggests a problem.

Combined motor/pump efficiency

Depends on the pump configuration, but the following are guidelines. Figures provided which are much higher than these below should be cause for further enquiry, and validation.

System type	**Expected pump/motor efficiency.**
AC centrifugal pump	35%-83% depending on pump size
AC/DC/permanent magnet centrifugal pump	55%-85%
DC positive displacement pump	70%

Subsystem efficiency

Depends on the system and pump configuration:

System type	**Expected system wire-to-**

	water efficiency.
AC centrifugal pump	30%-65%
AC/DC/permanent magnet centrifugal pump	55%-70%
DC positive displacement pump	60%

Check that the instantaneous sub-system efficiency is approximately equal to:

η(Instantaneous sub-system) = η(Power conditioner) x η(motor) x η(pump) x η(losses)

5.5.3 Check of water output estimates

Instantaneous water delivery

- Determine whether the calculated water flowrate output matches the actual water output at this irradiation level,

  If the water flow-rate is within 10% of the specified supply rate, then accept. If not, then reject.

  Look for faults, voltage drops, and note that an explanation is required.
- From the instantaneous water output curves (wire to water), check the expected water delivery at the measured DC array power determined above. If within 10%, then the power-conditioner subsystem appears to be performing fine, if not then correct the power-conditioner/pump problem.

The instantaneous water output (m^3/hour) shall be estimated by calculating:

= [Irradiation(kW/m^2) x Array power(Wp) x η(array tracking) x η(Instantaneous sub-system)]

/ [pumping head (m) x 9.8/3.6]

5.5.4 Comparison of instantaneous measurement with supplier data supplied

Calculate flowrate from manufacturer's performance curves in each interval :
From the instantaneous water output curves (*Instantaneous Array and Sub-system Performance Data* supplied at tender time and which form the basis of technical compliance).

Calculate

- Hourly flowrate (litres/hr)

  3f = 3e x 60
- Hydraulic power (W) = hourly flowrate (m^3/hr) x total dynamic head (m) x 9.8/3.6

  3h = 3f /1,000 x 1c x 9.8 / 3.6
- Sub-system efficiency (%) = hydraulic power(W) / measured array power(W)

  3i = 3h / 3b

5.6 Performance Check based on Energy Balance Measurements

These calculations are based on either on full day test, or half day test which includes either sunrise or sunset.

5.6.1 Calculate Expected Water Delivery at test conditions

This is based on test condition measurements and declared sub-system efficiency.

η(declared daily sub-system), declared for each month by the bidder is read from ***Chapter 4: Schedules of Technical Information: Form 3.2(G),*** corresponding to the same month as the test conditions.

Array power STC (Wp) is the installed capacity Wp.

η(declared tracking), declared for each month by the bidder is read from ***Schedules of Technical Information: Form 3.2(F)***, corresponding to the same month as the test conditions.

Expected Test Daily Water Output deliverable ($m^{3/}$day) shall be estimated by calculating:

= [Insolation(kWh/m^2/day) x Array STC (Wp) x η(Declared tracking) x η(Declared daily sub-system)]

/ [pumping head (m) * 9.8/3.6]

Q: Is measured water output less than expected water output?

5.6.2 Calculate Subsystem Efficiencies at test conditions

Measured subsystem efficiency based on test conditions, and compare with declared figures.

Insolation(kWh/m^2) – is the measured solar insolation in the test

Measured water output (m^3) – is the measured water delivered in the test

η(measured tracking) x η(measured daily sub-system)

= [Measured water output (m^3) x pumping head (m) x 9.8/3.6]

/ [Insolation(kWh/m^2) x Array power STC (Wp)]

Q: Is this substantially less than the declared figures in ***Schedules of Technical Information: Form 3.2(F and G)****:*

η(Declared tracking) x η(Declared daily sub-system)

5.6.3 Calculate Commissioning Water Delivery based on test results

Commissioning Water Delivery based on design conditions based on test conditions performance

Commissioning Daily Water Output deliverable (m^3/day) shall be estimated by calculating:

= [Design kWh/m^2/day) x Array STC (Wp) x η(measured tracking) x η(measured daily sub-system)]

/ [Design pumping head (m) x 9.8/3.6]

Q: Is this substantially less than design month declared output (***Schedules of Technical***

Information: Form 3.2(M)?

5.7 Calibration of the Remote Monitoring System

The readings taken over the course of the day during the Energy Balance Test (section 3.4) should be taken in parallel and onto a separate sheet, directly from the Monitoring System. This will enable comparison of results and inspire confidence in the Remote Monitoring System.

It shall also make clear which critical variables are not accurately recorded by the Monitoring System, or which critical variables might be missing.

5.8 Long Term Monitoring

The absolute test for acceptance is long term monitoring of the system. It is critical that some form of long term monitoring is done, and that the range of operational conditions is also tracked and design assumptions validated (water demand, pumping head, solar radiation).

As demonstrated in the performance tests, it is possible to assess system performance under non-design conditions to ensure that value for money is provided.

5.8.1 Remote Monitoring

Ideally, long term monitoring can be done via remotely, using a calibrated Remote Monitoring System which tracks ALL the requisite variables for performing doing an energy balance (including pumping head, solar radiation, water delivered). Daily energy balances can be done to assess performance compared with design.

This can be used for dispute resolution if required.

5.8.2 Operator record keeping

If a Remote Monitoring System is not installed, then the long term evaluation will require operator intervention. This is likely to be a severely limiting as the only variable recorded would likely be water output, and therefore no system performance tests can be benchmarked.

Long term: Ensure that the operator records daily water output and reservoir level for on a daily basis. T

END

ANNEXURE B.2.1: OUTLINE FOR TEST DATA (BLANK)

B.2.1.1. Electronic performance data collected

1a	1b		1c	1d	1e	1f	1g	1h	1i	1j	1k	1l	1m	1n	1p
Event data			Solar data measured in the Plane of array		Pumping head data			Electrical data				Water flow data From water meter			
Event	Time				Pressure at borehole head gauge (kPa)	Borehole water level (m)	Total Pumping head (m)	Array		Pump 1		Flow rate		Meter reading (litres)	Total water delivery (litres)
			Radiation (W/m^2)	Insolation (Wh/m^2)				Current (AC/DC) (A)	Voltage (AC/DC) (V)	Current (AC/DC) (A)	Voltage (AC/DC) (V)	(l/min)	(l/hr)		

Formulae
1g = 1e / 9.8 + 1f 1m = 1l x 60

B.2.1.2. Analysis (identification of problem components, or problems with the test)

2a	2d	2e	2f	2g	2h	2i	2j	2k	2l	2m
Time	Expected Array Power @ MPP	Tracking efficiency Operating point derated wrt MPP (>80% acceptable)	Measured Array Power (W)	Controller thoughput eff Energy % (>90% acceptable	Measured Pump Power (W)	Measured Water flow (l/hr)	Pump Efficiency Elec to water Energy % (>25% expected)	Hydraulic power (W)	System Efficiency Elec to water eff Power % (+- 50% expected)	Comparison of instantaneous measurement of eletrical to water efficiency, with manufacturer's spec.
	Wp (= 2b) Qty (= 2c)									

Formulae
2d = 1c x 2b x 2c 2f = 1h x 1i 2e = 2f / 2d 2h = 1j x 1k 2g = 2h / 2f 2i = 1m 2k = 2i /1000 x 1g x 9.8/3.6 2j = 2k / 2h 2l = 2k / 2f

B.2.1.3. Analysis of instantaneous water output (from Manufacturer spec sheets)

3a	3b	3c	3d	3e	3f	3g	3h	3l
Time	Measured Array power (W) 0.85	Pumping Head (m)	Measured Pump Power (W) 0.9	Spec water flow rate from manufacturers curves		Total water delivered (litres)	Hydraulic Power calculated (W)	Elec to water eff expected from manufacturers curv
				(l/min)	(l/hr)			

Formulae
3b = 2f 3c = 1g 3d = 2h 3e = from curves 3f = 3e x 60 3h = 3f/1000 x 3c x 9.8 /3.6 3l = 3h / 3b

B.2.1.4. Estimate of Daily Water Delivery

Variable	Unit	Declared			Test Conditions			Normalised to design conditions		
			Formula	Value		Formula	Value		Formula	Value
Nominal installed array power (STC) (Wp)	Wp	4a	***Form 3.2 (E)***		4a	***Form 3.2 (E)***		4a	***Form 3.2 (E)***	
Insolation	**kWh/m²**	4b	***Form 3.2 (D)***		4c	Measured 1d		4b	***Form 3.2 (D)***	
Pumping head at which estimates where made	Metres	4d	***Form 3.2 (B)***		4e	Average of 1g		4d	***Form 3.2 (B)***	
Average array tracking efficiency: η(tracking)	%	**4f**	***Form 3.2 (F)*** η(declared tracking)		4g	η(measured tracking) x η(measured daily sub-system) = 4g x 4i = [4e x 4k x 9.8 /3.6] / [4a x 4c]		4g	= η(measured tracking) x η(measured daily sub-system) = 4g x 4i	
Average daily subsystem efficiency: η(daily sub-system)	%	**4h**	***Form 3.2(G)*** η(declared daily sub-system)		4i			4i		
Measured Water output	m³		NA		4k	Measured 1p		4l	***Commissioning Water Output*** = [4a x 4b x 4g x 4i] / [4d x 9.8/3.6]	
Expected Water output	m³	**4j**	***Form 3.2 (H)***		4m	***Expected Test Water Output*** = [4a x 4c x 4f x 4h] / [4e x 9.8/3.6]		4j	***Form 3.2 (H)***	
Measured Water Output exceeds Expected Water Output?	logical		NA			**YES / No**			**YES / No**	

Notes*: taken from ***Chapter 4: Schedules of Technical Information: Form 3.2 Declaration of system performance***

ANNEXURE B.2.2: OUTLINE FOR TEST DATA (DEMO SHEET)

Kuile mono
30 October 1999
Array Tilt: 1:30 deg
Orientation: True North

Mono solar S4M with 30xm55

B.2.2.1. Electronic performance data collected

1a	1b		1c		1d	1e	1f	1g	1h	1i	1j	1k	1l	1m	1n	
Event data			Solar data measured in the Plane of array		Pumping head data			Electrical data				Water flow data From water meter				
								Array		Pump 1						
Event	Time		Radiation (W/m²)	Insolation (Wh/m²)	Pressure at borehole head gauge (kPa)	Borehole water level (m)	Total Pumping head (m)	Current (AC/DC) (A)	Voltage (AC/DC) (V)	Current (AC/DC) (A)	Voltage (AC/DC) (V)	Flow rate (l/min)	(l/hr)	Meter reading (litres)	Total water delivery (litres)	
Test start	06:15AM	6.25	21	0												
	06:35AM	6.58	40	10	1200	5	125	0.24	88	2.50	4	0	0		0	
Turn fast	07:05AM	7.08	152	58	1200	5	125	1.07	87	4.60	18	0	0		0	
± 80rpm	07:20AM	7.33	190	101	1200	5	125	1.55	88	4.80	28	0	0		0	
	07:35AM	7.58	163	145	1200	5	125	2.22	88	5.00	37	0	0		0	
water begins	07:50AM	7.83	262	198	1200	5	125	3.00	87	5.15	50	4	240		30	
	08:15AM	8.25	451	347	1200	5	125	4.23	87	5.33	67	8	480		280	
	08:35AM	8.58	530	510	1200	5	125	4.89	92	5.40	80	12.5	750		485	
	09:00AM	9.00	631	752	1200	5	125	6.00	111	5.89	111	20	1200		891	
	09:10AM	9.17	662	860	1200	5	125	6.12	145	6.00	145	21	1260		1096	
	09:15AM	9.25	700	917	1200	5	125	6.12	162	6.00	162	22	1320		1204	
	09:45AM	9.75	789	1289	1200	5	125	6.57	168	6.00	168	20	1200		1834	running dry
	09:50AM	9.83	796	1355	1200	5	125	6.70	168	5.70	168	18	1080		1929	running dry

Formulae
1g = 1e / 9.8 + 1f 1m = 1l x 60

B.2.2.2. Analysis (identification of problem components, or problems with the test)

2a	2d	2e	2f	2g	2h	2i	2j	2k	2l	2m
Time	Expected Array Power @ MPP 55 Wp (= 2b 30 Qty (= 2c	Tracking efficiency Operating point derated wrt MPP (>80% acceptable)	Measured Array Power (W)	Controller thoughput eff Energy % (>90% acceptable)	Measured Pump Power (W)	Measured Water flow (l/hr)	Pump Efficiency Elec to water Energy % (>25% expected)	Hydraulic power (W)	System Efficiency Elec to water eff Power % (+- 50% expected)	Comparison of instantaneous measurement of eletrical to water efficiency, with manufacturer's spec.
06:15AM	35	80.0%	0	ERR	0	0.0	ERR	0.00	ERR	**ERR**
06:35AM	66	32.0%	21	47.3%	10	0.0	0.0%	0.00	0.0%	**ERR**
07:05AM	251	37.1%	93	88.9%	83	0.0	0.0%	0.00	0.0%	**ERR**
07:20AM	314	43.5%	136	98.5%	134	0.0	0.0%	0.00	0.0%	**ERR**
07:35AM	269	72.6%	195	94.7%	185	0.0	0.0%	0.00	0.0%	**ERR**
07:50AM	432	60.4%	261	98.7%	258	240.0	31.7%	81.67	31.3%	**ERR**
08:15AM	744	49.5%	368	97.0%	357	480.0	45.7%	163.33	44.4%	**ERR**
08:35AM	875	51.4%	450	96.0%	432	750.0	59.1%	255.21	56.7%	**ERR**
09:00AM	1041	64.0%	666	98.2%	654	1200.0	62.5%	408.33	61.3%	**ERR**
09:10AM	1092	81.2%	887	98.0%	870	1260.0	49.5%	428.75	48.3%	More than 25% higher than Manuf.Spec
09:15AM	1155	85.8%	991	98.0%	972	1320.0	46.2%	449.17	45.3%	More than 25% higher than Manuf.Spec
09:45AM	1302	84.8%	1104	91.3%	1008	1200.0	40.5%	408.33	37.0%	Within 25% of Manuf.Spec
09:50AM	1313	85.7%	1126	85.1%	958	1080.0	38.4%	367.50	32.6%	More than 25% higher than Manuf.Spec

Formulae
2d = 1c x 2b x 2c 2f = 1h x 1i 2e = 2f / 2d 2h = 1j x 1k 2g = 2h / 2f 2i = 1m 2k = 2i /1000 x 1g x9.8/3.6 2j = 2k / 2h 2l = 2k / 2f

B.2.2.3. Analysis of instantaneous water output (from Manufacturer spec)

3a	3b	3c	3d	3e	3f	3g	3h	3I
Time	Measured Array power (W) 0.85	Pumping Head (m)	Measured Pump Power (W) 0.9	Spec water flow rate from manufacturers curves (l/min)	(l/hr)	Total water delivered (litres)	Hydraulic Power calculated (W)	Elec to water eff expected from manufacturers curv
06:15AM	0	0	0	0	0	0	0.00	ERR
06:35AM	21	125	10	0	0	0	0.00	0.0%
07:05AM	93	125	83	0	0	0	0.00	0.0%
07:20AM	136	125	134	0	0	0	0.00	0.0%
07:35AM	195	125	185	0	0	0	0.00	0.0%
07:50AM	261	125	258	0	0	0	0.00	0.0%
08:15AM	368	125	357	0	0	0	0.00	0.0%
08:35AM	450	125	432	0	0	0	0.00	0.0%
09:00AM	666	125	654	0	0	0	0.00	0.0%
09:10AM	887	125	870	5.00	300	25	102.08	11.5%
09:15AM	991	125	972	13.33	800	71	272.22	27.5%
09:45AM	1104	125	1008	18.33	1100	546	374.31	33.9%
09:50AM	1125	125	958	12.50	750	623	255.21	22.7%

Formulae
3b = 2f
3c = 1g
3d = 2h
3e = from curves
3f = 3e x 60
3h = 3f/1000 x 3c x 9.8 /3.6
3I = 3h / 3b

B.2.2.4. Estimate of Daily Water Delivery

Variable	Unit	Declared			Test Conditions			Normalised to design conditions		
			Formula	Value		Formula	Value		Formula	Value
Nominal installed array power (STC) (Wp)	Wp	4a	***Form 3.2 (E)***		4a	***Form 3.2 (E)***		4a	***Form 3.2 (E)***	
Insolation	**kWh/m²**	4b	***Form 3.2 (D)***		4c	Measured 1d		4b	***Form 3.2 (D)***	
Pumping head at which estimates where made	Metres	4d	***Form 3.2 (B)***		4e	Average of 1g		4d	***Form 3.2 (B)***	
Average array tracking efficiency: η(tracking)	%	**4f**	***Form 3.2 (F)*** η(declared tracking)		4g	η(measured tracking) x η(measured daily sub-system) = 4g x 4i = [4e x 4k x 9.8 /3.6] / [4a x 4c]		4g	= η(measured tracking) x η(measured daily sub-system) = 4g x 4i	
Average daily subsystem efficiency: η(daily sub-system)	%	**4h**	***Form 3.2(G)*** η(declared daily sub-system)		4i			4i		
Measured Water output	m^3		NA		4k	Measured 1p		4l	***Commissioning Water Output*** = [4a x 4b x 4g x 4i] / [4d x 9.8/3.6]	
Expected Water output	m^3	**4j**	***Form 3.2 (H)***		4m	***Expected Test Water Output*** = [4a x 4c x 4f x 4h] / [4e x 9.8/3.6]		4j	***Form 3.2 (H)***	
Measured Water Output exceeds Expected Water Output?	logical		NA		**YES / No**			**YES / No**		

Annex C (Informative) - Interpreting IV curve shapes (IEC 62246)

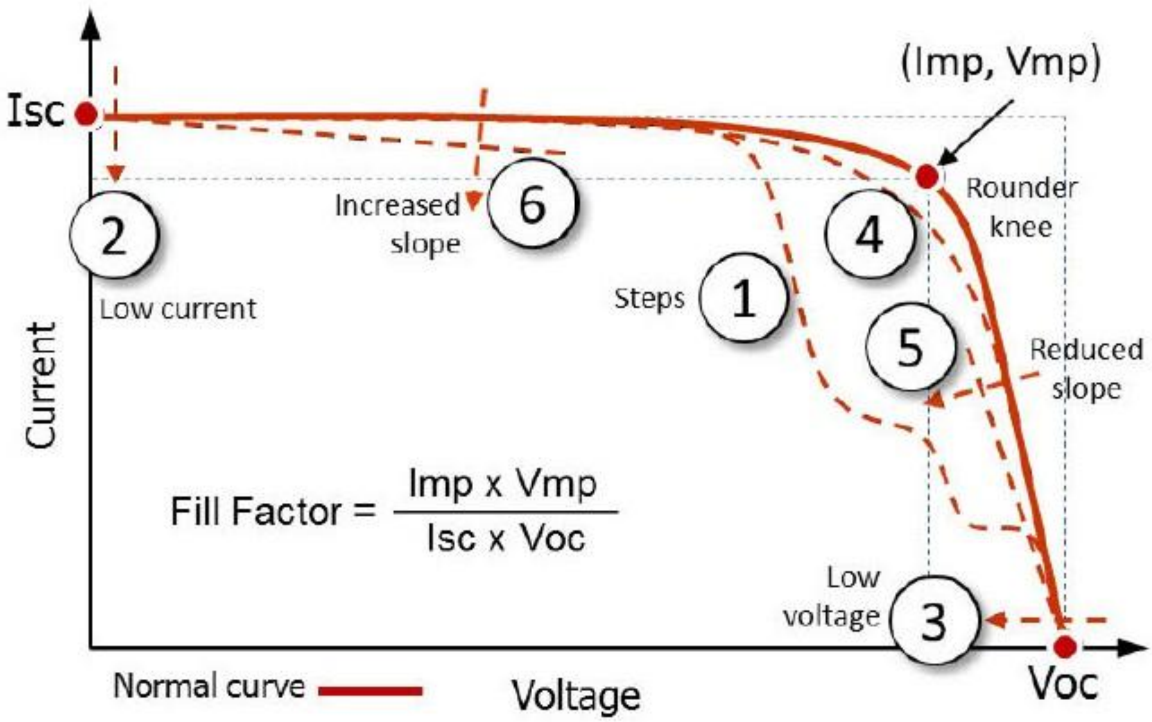
1 General

A normal I-V curve has a smooth shape with three distinct parts:

- A “horizontal leg” (slightly sloping down)
- A “downward leg” (approaching vertical)
- A bend or “knee” in the curve between these two regions

In a normal curve, these three parts are smooth and continuous. The slopes and the shape of the knee depend on cell technology and manufacture. Crystalline silicon cells have sharper knees; thin film modules usually have rounder gradual knees.
A number of factors can influence the shape of an IV curve. The following diagram illustrates the main types of deviation that may be present. These shape variations may be present individually or in combination.

Figure 2: IV curve shapes



Small deviations between the measured and predicted I-V curves are to be expected, given the normal uncertainties associated with the measurement of irradiance, temperature and voltage. Small variations between PV modules, even of a given manufacturer and model, will also have an effect. Shading and soiling, will also impact the shape of the curve.
When deviations are seen, a check should first be made to ensure that difference in shape between the measured curve and that predicted is not due to measurement errors, instrument set-up problems or due to an incorrectly entered module / string data.

2 Variation 1 - Steps or notches in curve

Steps or notches in the IV curve are indications of mismatch between different areas of the array or module under test. The deviation in the curve indicates that bypass diodes are activating and some current is being bypassed around the internal cell string protected by the diode (string unable to pass the same current of other strings). This can be due to a number of factors including:

- Array or module is partially shaded
- Array or module is partially soiled or otherwise obscured (snow etc)
- Damaged PV cell / module
- Shorted circuited bypass diode

NOTE: Partial shading of even just one cell in a module can cause the associated bypass diode to turn on and cause a notch in the curve.

3 Variation 2 – Low current

A number of factors can be responsible for a variation between the expected current and the measured current. These are summarised below

Array causes

- Uniform soiling
- Strip shade (modules in portrait orientation)
- Dirt dam (modules in portrait orientation)
- PV modules are degraded

NOTE: Strip shade and dirt dam effects have an effect similar to uniform soiling, because they reduce the current of all cell groups by approximately the same amount.

Modelling causes

- PV module data incorrectly entered
- Number of parallel strings incorrectly entered

Measurement causes

- Irradiance sensor calibration or measurement problem
- Irradiance sensor not mounted in the plane of the array
- Irradiance changed between irradiance and I-V curve measurements
- Albedo effects cause irradiance sensor to record overly high irradiance
- Irradiance is too low or sun is too close to the horizon

NOTE: While the variation shown on the diagram above is a current lower than expected, it is also possible to find that measured value is above that predicted by the model IV curve.

4 Variation 3 – Low voltage

Potential causes for a variation in voltage include:

Array causes

- Conducting or shorted bypass diodes
- Wrong number of modules in PV string
- Potential Induced Degradation (PID)
- Significant and uniform shading to whole cell / module / string

Modelling causes

- PV module data incorrectly entered
- Number of modules in string incorrectly entered

Measurement causes

- PV cell temperature different to measured value

As cell temperature affects the voltage from the PV module, a disparity between the actual cell temperature and that measured (or assumed) by the IV curve tracer will cause this shape defect. In such cases a check of the cell temperature measurement method should be instigated before proceeding (eg checking a temperature sensor is still attached to the module).
A group of strings measured in close succession will often exhibit slightly different amounts of deviation compared with the predictions of the PV model. This is to be expected given that the temperature is usually sensed at a single module and the temperature profile of the array is non-uniform and varying with time. However, if a single string shows substantially more deviation than the others, this is an issue, particularly if the deviation corresponds to module Voc/N where the modules have N bypass diodes
NOTE: While the variation shown on the diagram above is a voltage lower than expected, it is also possible to find that measured value is above that predicted by the model IV curve.

5 Variation 4 – Rounder knee

Rounding of the knee of the IV curve can be a manifestation of the aging process. Before concluding that this is the case, check the slopes of the horizontal and vertical legs of the IV curve. If they have changed, it can produce a visually similar effect in the shape of the knee.

6 Variation 5 – Shallower slope in vertical leg

The slope of the latter portion of the IV curve between the maximum power point (Vmpp) and Voc is influenced by the series resistance to the circuit under test. An increased resistance will reduce the steepness of the slope in this portion of the curve.
Potential causes of increased series resistance include:

- PV wiring damage or faults (or cables insufficiently sized)
- Faults at module or array interconnects (poor connections)
- Increased module series resistance

When testing arrays with long cable runs, the resistance of these cables will influence the curve shape and can have an impact on the curve as described here. If this is suspected, either the model can be adjusted to allow for these cables; or the test can be repeated closer the array (bypassing the long cables)
Where this error is noticed on a curve, special attention should be taken of the quality of the wiring and interconnections within the solar circuit. This error can indicate a significant wiring fault or subsequent damage or corrosion affecting the array circuit.
Increased module series resistance can be due to high resistance faults within cell interconnects or within the module junction box – due to degradation, corrosion or manufacturing error.

An IR scan, as described in the Category 2 test sequence, can be a useful tool to identify high resistance faults.

7 Variation 6 - Steeper slope in horizontal leg

A variation in slope in the upper portion of the IV curve is likely due to:

- Shunt paths in PV cells
- Module Isc mismatch
- Tapered shade or soiling (eg dirt dams)

Shunt current is any current that bypasses the solar cell – usually due to localised defects in either cell or cell interconnects. Shunt currents can lead to localised hot spots which may also be identified through IR testing.

Differences in Isc between modules in a string can be due to manufacturing discrepancies. If the mismatch is small and randomly distributed across the string, steps or notches may not be present.
While more significant shading will cause steps or notches in the IV curve, minor shade on some modules in a string or some tapered shade patterns can cause this effect.

END