Section- 6: Employer’s Requirements

I. Confidential and Proprietary Content

8.2 Obst & Ziehmann International GmbH (named hereinafter: "8.2 Obst & Ziehmann International") has been commissioned by the client to prepare the following Employer's Requirements (the "ER"). The ER summarizes the findings obtained during on-site visit(s) and/or through the assessment of project related documents which have been provided by the client. The ER is confidential and proprietary and has been prepared exclusively for the benefit of the client. The ER may solely be used for the intended purpose by the client and his or her professional advisors who are bound by confidentiality obligations. The ER shall not inform or protect any third party. It shall not be used by any third party or for any other purpose. The client shall not disclose, publish, copy or otherwise reveal any of the confidential information embodied in the ER to any third party without the prior written consent of 8.2 Obst & Ziehmann International.

II. Assumptions, Limitations and Disclaimer

The ER is based solely on findings obtained during on-site visit(s) by 8.2 Obst & Ziehmann International as well as on information from documents which have been provided by the client until the date of delivery of the ER. It is further noted that:

1.) The accuracy of the ER depends on the accuracy of the provided information. 8.2 Obst & Ziehmann International acts on the assumption that the client provided true, complete, accurate, non-misleading and up-to-date information. In general, the information is provided as a copy of the original. 8.2 Obst & Ziehmann International acts on the assumption that those provided copies are true and complete reproductions of the originals. Neither the authenticity of the information nor the authority of any signatories has been checked. 8.2 Obst & Ziehmann International acts on the assumption that the information is valid and binding upon the parties thereto.

2.) Regarding summaries, tables and abstracts of documents which have been provided to 8.2 Obst & Ziehmann International: 8.2 Obst & Ziehmann International is not in a position to evaluate if these summaries, tables and abstracts are accurate and contain all the information which is important for the final assessment of the underlying facts and data.

3.) The ER is based solely on the information and documents provided to 8.2 Obst & Ziehmann International by the client. It cannot be ruled out that further information and/or documents not provided to 8.2 Obst & Ziehmann International would have been important for the preparation of the ER.

4.) The ER shall not be regarded as the equivalent of a comprehensive, formal and specialized expert's opinion. The ER has been prepared as a summary of the main issues and concerns based on the provided information. The ER shall not be treated as a substitute for a specific consultation concerning specific circumstances with regard to the project. For such specific circumstances, an additional detailed consultancy may be necessary.

5.) The ER does not assess any legal, commercial, financial, insurance, tax or accounting implication of the information.

6.) Provided that the ER refers to or is based on notes, reports, statements, opinions or advice from the client and/or any third party (indicated as such in the ER), that party remains solely responsible for the content of such documents or statements. 8.2 Obst & Ziehmann International expressly does not adopt these notes, reports, statements, opinions or advice from the client and/or any third party as its own.

7.) Certain information which has been provided by the client may be subject to confidentiality agreements. 8.2 Obst & Ziehmann International acts on the assumptions that all the information has been provided by the client legitimately and that 8.2 Obst & Ziehmann International is entitled to use the information for the ER as well as to communicate the ER and/or its content to other project participants in accordance with project related confidentiality agreements. No liability is accepted for non-project related confidentiality agreements.

8.) In the case of information and documents having been provided by the client in languages other than English or German, the assessment of 8.2 Obst & Ziehmann International has been limited to a plausibility check without detailed analysis and detailed evaluation of such information and documents.

Abbreviations

a	Year
A	Ampere
AC	Alternating Current
API	Application Programming Interface
BMS	Battery Management System
CB	Combiner Box
CE	Conformité Européenne
CH_4	Methane
CHP	Combined-Heat-and-Power
COD	Commercial Operations Date
CV	Curriculum Vitae
DC	Direct Current
d	Day
DM	Dry Matter Content
DoD	Depth of Discharge
EN	European Standard
EL	Electroluminescence
EPC	Engineering, Procurement and Construction
FM	Fresh Matter
GHI	Global Horizontal Irradiance
GJB	Generator Junction Box
GSM	Global System for Mobile
h	Hour
HV	High Voltage
H_2S	Hydrogen Sulfide
I	Electric Current
IAM	Incidence Angle Modifier
IEC	International Electrotechnical Commission
INV	Inverter
INVS	Inverter Station
ISO	International Organization for Standardization
kg	Kilogramm
kV	Kilovolt
kVA	Kilovolt Ampere
kW	Kilowatt
kWh	Kilowatt Hour
kWp	Kilowatt-Peak
l	Litre (Volume)
LCOE	Levelized cost of electricity
LD	Liquidated Damages
LED	Light-Emitting Diode
LV	Low Voltage

LTA	Lender's Technical Advisor
m^3	Cubic Meter
MPP	Maximum Power Point
MPPT	Maximum Power Point Tracker
MV	Medium Voltage
MVA	Megavolt ampere
MW	Megawatt
MWh	Megawatt Hour
MWp	Megawatt-Peak
Nm^3	Norm Cubic Meter
NOCT	Nominal Operation Cell Temperature
O&M	Operations and Maintenance
oDM	Organic Dry Matter Content
O_2	Oxygen
P&ID	Piping and Instrumentation Diagram
PE	Potential Equalization
PID	Potential Induced Degradation
POA	Plane of Array
PPA	Power Purchase Agreement
PR	Performance Ratio
PV	Photovoltaic
RMS	Remote Monitoring System
SCADA	Supervisory control and data acquisition
SLD	Single Line Diagram
SPF	Surge Protection Devices
STC	Standard Test Conditions
t	ton (metric)
V	Volt
W	Watt
Wh	Watt Hour
Wp	Watt-Peak

Definitions

Agreement	Means the Design, Supply, Installation, Commissioning and Operation & Maintenance Agreement together with recitals and the schedules, provided in Section VI of the RFP.
Battery	A Battery is an electric device consisting of one or more electrochemical cells with external connections provided to store electricity.
PV Biogas Hybrid System	A PV Biogas Hybrid System, according to these Employer's Requirements, is a power plant system which consists of a PV system, a biogas system and a battery bank. It needs to be designed and installed in order to work both (i) in parallel to the electricity grid and (ii) in off-grid-mode when the electricity grid is not available.
Total PV Module STC Power	Means the combined nominal power (nameplate power) of all PV Modules of each PV Biogas Hybrid System under STC conditions
Design for Approval	Any design document that is considered ready for execution by the Contractor and submitted to the Employer / Employer's Designated Consultants for approval.
Approved Design	Any design document that has been approved by the Employer / Employer's Designated Consultants and is used for execution of the works.
Design Document	All documents, like drawings (including executable CAD drawings), technical descriptions, calculations, data tables and alike, that are either standardised documents from a supplier or manufacturer of equipment to be used in the Project, or developed specifically for the execution of the Project.
Complete design folder	It comprises all design drawings, technical data and descriptions that enable Employer and its Employer's Designated Consultants to understand the PV Biogas Hybrid System and verify if it is planned in accordance with the requirements of the EPC Contract. It typically contains (as a minimum): datasheets, technical descriptions, electrical and mechanical design drawings, installation instructions, service manuals, test certificates, warranty certificates, etc.
Project Management Plan	The formal, approved document that defines how the Project is executed, monitored and controlled.
PVsyst	PC software package for the study, sizing, simulation and data analysis of complete PV systems.
PV Generator	The term PV Generator refers to the total of all PV modules of each PV Biogas Hybrid System which are electrically interconnected including the supporting structure.
Standard Test Conditions:	Test conditions for nominal power rating of PV modules, defined as: - Irradiance: 1,000W/m2 - Module Temperature: 25° C - Sunlight spectrum: Air Mass (AM) 1,5G.
Site	Means the foreseen location of a PV Biogas Hybrid System.

Gantt – Chart	A document that illustrates the Project time schedule. It visualizes the elementary tasks, activities and milestones of the Project, their dependencies and the critical path. During execution, progress bars show the actual progress of activities on a snapshot basis.
Work Breakdown Structure	A hierarchical and incremental decomposition of the Project into phases, deliverables and work packages, usually presented in the form of a graphical tree structure diagram and/or a hierarchical itemized list.

Contents

Employer's Requirements

1. General Requirements

1.1. Introduction

The University of Agriculture, Faisalabad, ("UAF", "Employer") is developing a bio energy research campus, the Punjab Bio Energy Institute. The project which includes the construction of an integrated solar PV and biogas power plant ("PV Biogas Hybrid System"). The plant will provide reliable and environment friendly electricity supply for a part of the new campus and also functions as a model project which could be replicated in rural areas of Punjab. The execution of turn-key Engineering, Procurement and Construction Services ("EPC") of this PV Biogas Hybrid System is the scope of work of the assignment described in this document.

The PV Biogas Hybrid System, located on the new campus ("PARS") of the UAF, consists of a PV part (photovoltaic power plant, "PV System"), a biogas energy part (biogas power plant including all necessary components, "Biogas System"), battery storage ("Battery"), grid connection including grid circuit breakers, a control system and all necessary periphery.

The PV Biogas Hybrid System shall provide the connected UAF buildings with a reliable electricity supply around the clock and throughout the year, thus minimizing environmental and financial impact of the campus' energy needs.

The PV Biogas Hybrid System shall at the same time function as an asset for students' research which will allow students to study detailed aspects of solar and biogas energy technology.

The PV Biogas Hybrid System shall generate electricity based on the two underlying renewable energies (solar irradiation and biogas). It shall be connected to the electricity grid but shall also operate in off-grid mode when the electricity grid will not be available. Electricity produced shall primarily be used for supplying buildings of the campus, the required design criteria include the following

- In times of availability of the electricity grid, the PV Biogas Hybrid System shall be connected to the grid. Any electricity which exceeds the electricity demand of the connected buildings will be evacuated to the grid. Any excess electricity demand of the connected buildings which cannot be covered by the PV Biogas Hybrid System (residual load) shall be supplied from the grid.
- In times of unavailability of the electricity grid, the PV Biogas Hybrid System shall automatically detect the outage of grid power (e.g. caused by load shedding, and other outages) and generate as well as manage its own micro grid in order to supply electricity to the connected buildings. The PV Biogas Hybrid System shall also automatically detect when the grid availability is restored and re-synchronize with the grid.
- The PV Biogas Hybrid System shall have a black-start capability.

The monitoring, detection and switching operations required to ensure the continuous electricity supply shall be performed automatically and without requirement of human interference.

All plant components, control implementation and strategy as well as operation shall be designed such that

- The electricity outage time for the connected buildings will be minimized and

- The energy production based on the given resources will be maximized (thereby, the Levelized cost of electricity ("LCOE") will be minimized).

Further details of control and grid/off-grid operation are described in 3.5.1.

The PV-Biogas Hybrid System must comprise components that have a high reliability, have an extended service life while meeting international quality, safety and performance standards. The components shall also be easy to service, repair and replace if and when required.

These Employer's Requirements outline the technical specifications and design of the PV Biogas Hybrid System, as well as the standards the assigned equipment must meet, in order to ensure that the complete PV Biogas Hybrid System to be installed will perform according to the requirements during its proposed service lifetime.

1.2. Structure of Employer's Requirements

The Employer's Requirements are divided into the following sections:

1) **General Requirements (this section)**

2) **Functional Requirements**
The section defines the overall working principle of the PV Biogas Hybrid System and the integration of the components.

3) **Scope of Services for EPC Works**
The Contractor is required to provide all the components as per the standards and specifications given under this section. The proposed equipment components must have all the necessary certifications, as required, and must be integrated to meet the designs as given under *2 Functional Requirements*.

4) **Scope of Services for O&M Works**
After the completion of the EPC Works, the Contractor must provide Operation and Maintenance services for the PV Biogas Hybrid System for a period of 2 years. During this period, it will be the responsibility of the Contractor to ensure that monitoring, periodic preventive maintenance, corrective maintenance and reporting will be provided for the PV Biogas Hybrid Systems. Details of the required O&M services are provided under this section.

5) **Independent Quality Assurance and Validation of the Components**
For the purpose of additional quality assurance, the Employer requires independent inspections of the main equipment which includes PV modules, inverters, and batteries.

6) **Acceptance Procedure**
This section describes the acceptance tests that the Contractor will have to perform successfully in order to obtain Final Acceptance of the PV Biogas Hybrid System.

1.3. Scope Information

The scope of services to be provided by the successful Bidder is defined as follows

- Turn-key EPC scope:
    - Engineering, Procurement, Construction and Commissioning of the PV Biogas Hybrid System.

- Final Acceptance of the PV Biogas Hybrid System after the O&M period.

- O&M scope:
  - 2 (two) years of full service O&M for the PV Biogas Hybrid System

The following functional specifications of sections 2, 3, 4, 5 and 6 ("Specifications") cover the overall technical requirements for the EPC and O&M Contract. The details of the concept, the detailed design, the sizing, the complete scope and the specifics of the installation are at the discretion of the EPC and O&M Contractor, as long as they are consistent within the Specifications.

In these Specifications:

1. "EPC Contractor" refers to the company selected by Employer to perform the EPC Contract; and
2. "O&M Contractor" refers to the company selected by Employer to perform the O&M Contract.

1.4. Bid Information

The bidders have to provide the technical bid including documentation, certifications and datasheets in (a) paper form and (b) soft copy form. The information provided in both forms shall be consistent with the Employer's Requirements.

The bidders are instructed to provide only the specific information that has been asked in the Employer's Requirements.

The technical concept must be presented in the structure according to the format described in Annex C: Information and Structure of Technical Concept of Technical Bid.

Along with the bid, the bidders shall provide all relevant documentation, certifications and datasheets for the proposed systems and equipment according to the provided templates, Excel formats and folder structure. The folder structure of the soft copy form is defined in Annex B: Excel-Format of Component Checklist. Also, confirmation of technical specifications and respective references shall be given in the same Excel sheet by the bidder.

Additionally, key component information on the proposed components shall be provided in the Excel format as defined in Annex B: Excel-Format of Component Checklist (sheet "Annex B: Component Info").

Incomplete or inconsistent submissions will be rejected as unresponsive.

Any unnecessary information must be avoided under all circumstances. This includes documentation such as:

I. Company profiles of the component manufacturers.
II. Datasheets/certifications for products which are not proposed by the bidder.
III. Brochures and promotional materials of components and services.
IV. Any other unnecessary documents.

2. Functional Requirements

The PV-Biogas Hybrid System design must be based on proven and highly efficient equipment. The EPC Contractor shall provide a list of all vendors / subcontractors for all main equipment.

The PV-Biogas Hybrid System design shall assure a safe, reliable and efficient operation for 20 years' lifetime under the environmental conditions at the site with minimum operations cost.

The EPC Contractor will be required to follow good Engineering and Construction practices.

The O&M Contractor will be required to follow good Operation and Maintenance practices.

The PV-Biogas Hybrid System has to adhere with all applicable (international and regional) norms, standards and shall be in compliance with the requirements of the Grid Connection Code of Pakistan, and further relevant requirements of the grid operator, including all measures required to ensure compatibility with the net metering policy, if and when it is implemented.

2.1. General Functional Requirements

The PV-Biogas Hybrid System, consisting mainly of a PV System, a Biogas System and Battery, will be connected to the medium voltage level of the electricity grid, while the components will be connected to the low voltage level as described in section 3.5.2. All necessary breakers and other equipment of the grid connection required for safety and control of the system shall be included in the bid and their design, delivery and installation will be in the responsibility of the EPC contractor.

The Single Line Diagram (SLD) presented in Figure 1 provides an overview of the electric configuration and grid connection of the system as it is foreseen by the Employer. Adaptations are acceptable - subject to approval by the Employer's Designated Consultants - as long as the Specifications of these Employer's Requirements are maintained. Details of the grid connection are outlined in section 3.5.2. hereof.

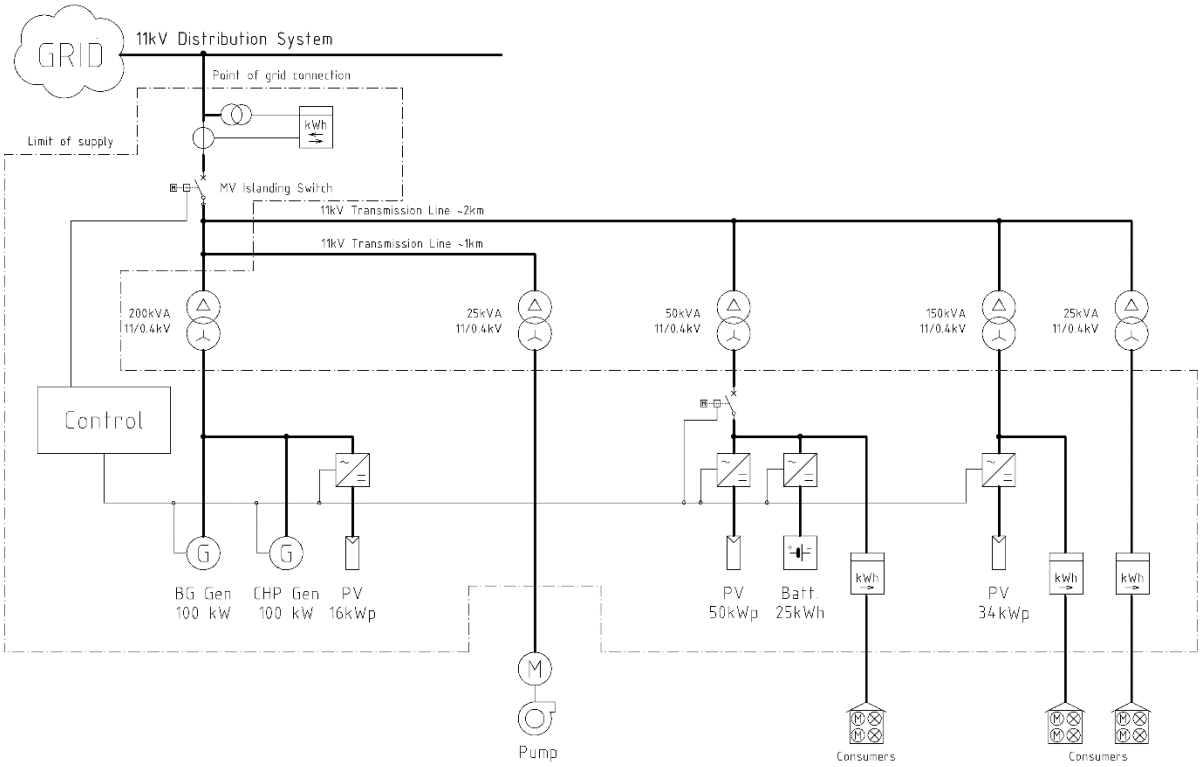


Figure 1: Proposed Single Line Diagram (PV Biogas Hybrid System)- Turn-Key EPC Scope in dotted box.

The following Table 1 defines the minimum sizing of the individual components of the PV Biogas Hybrid System.

The PV Biogas Hybrid System includes two separate generators for the Biogas System. The generators are dimensioned in a way that the Biogas System can, based on the available biogas and load profile, either run on the base load generator only (CHP), or on both generators combined (peak load). The split of the Biogas System power part into two generators has been foreseen to ensure a better part-load behavior in comparison to a single generator concept.

Table 1: Main Components and Sizes of PV Biogas Hybrid System

Component	**Defined Minimum Values**
PV System	
Rooftop PV: Maximum rated power (STC)	100 kWp
Batteries	
Total electric storage capacity	25 kWh
Maximum electric power output	21 kW
Biogas System	
Base Load Generator (CHP) electric power output	100 kW
Base Load Generator (CHP) thermal power output	108 kW
Peak Load Generator electric power output	100 kW
Total Gas Storage Capacity	2,000 m³

2.2. Functional Requirements for Biogas System

In the following section, the required functional specifications for the Biogas System components are defined. The **available substrates** foreseen as the input material for the Biogas System are shown in Table 2.

Table 2: Available Substrates (Range of amount (FM) and qualities (DM)) for Biogas System

Available Substrates	**Available Amounts (FM)**
Cattle dung (12-40 % DM)	8-20 t/d
Chicken manure (55-65% DM)	1-2 t/d
Corn silage (30-35% DM)	1-1.5 t/d
Recirculate/Fresh water	x t/d, t.b.d. by EPC contractor

Although available amount and dry matter (DM) content may vary during the operation, the Biogas System shall be designed and installed to be able to digest the available substrates within the above given ranges of amounts and qualities. The amount of fresh matter (FM), especially of the available cattle dung may vary during the operation, while the intention during operation is to keep the total amount of organic dry matter (oDM) of the substrates close to constant. Therefore, Table 3 of functional requirements concerning the required biogas and energy yields is based on the available organic dry matter of each substrate. The amount of needed fresh water or liquid recirculation phase shall be defined by the EPC Contractor and indicated in the bid. The **main numeric functional requirements of each Biogas System** are as follows:

Table 3: Functional Requirements for Biogas System: Available substrate values and required system values

Available Organic Matter of Substrates	**Available Values**
Cattle Dung	2.47 t oDM/d
Chicken manure	0.61 t oDM/d
Corn silage	0.45 t oDM/d
Recirculate/Fresh water	t/d, t.b.d. by EPC contractor
Digestion Rate and Biogas Production	**Required Values**
Min. Degree of decomposition of organic matter during digestion process (before leaving the system as slurry)	55 %
Min. Biogas yield	1.250 Nm^3/d
Min. CH_4- content of biogas	55 %
Min. CH_4 yield	687,5 Nm^3/d
Base Load Generator (CHP)	
Min. Electric power output and efficiency	100 kW (35 %)
Min. Thermal power output and efficiency	108 kW (38 %)
Peak Load Generator	
Min. Electric power output and efficiency	100 kW (35 %)
Min. total installed electric capacity	200 kW
Max. self-consumption of electricity	10% of electricity generation
Min. total Biogas Storage Capacity	2,000 m^3

The composition of the generated biogas in the Biogas System after cleaning process shall comply with the technical quality requirements for the operation of the biogas generators given by the manufacturer. Notwithstanding that, **minimum quality requirements for the biogas composition** after the drying and the complete desulfurization process are described in Table 4:

Table 4: Quality Requirements for the Composition in Biogas System

Methane (CH_4)	> 55 Vol.-%
Carbon dioxide (CO_2)	30-50 Vol.-%
Oxygen (O_2)	< 1 Vol.-%
Hydrogen Sulphite (H_2S)	< 100 ppm
Condensate (H_2O)	0 Vol.-%
Max. relative humidity related to the lowest expected gas temperature	80 %
Max. particle size of dust	5 µm
Max. quantity of dust	10 mg/Nm³ of CH_4

The Biogas System shall be able to produce the respective amounts of biogas for up to 30 hours, while no biogas generator is operating, the corresponding amount of gas storage needs to be foreseen by the bidder, i.e. a minimum of 2,000 m³.

Furthermore, electricity supply for the electric equipment which is required for the safe and efficient operation of the biogas plants must be guaranteed by the system on a 24/7 basis, either by electricity from the grid, or from the PV Biogas Hybrid System itself.

For the Biogas Systems, the quality requirements and design recommendations of Annex F: Safety Rules for Biogas Systems, shall be considered for the selection and the installation of each component and equipment of the Biogas System.

The described functional requirements of the Biogas System shall be demonstrated, measured and documented within the Performance Acceptance Procedure as described under section 6.3.2. hereof.

2.3. Functional Requirements for PV and Battery System

In the following Table 5, the required functional specifications for the PV System and Battery components are defined.

Table 5: Functional Requirements for PV and Battery Systems

	Required Specification
PV Systems (Rooftop)	
Maximum rated power (STC)	100 kWp
Inclination / orientation of PV modules	Low ballast roof mounted fixed tilt 15° / South and East/West (To be finally confirmed during project implementation)
Minimum Performance Ratio	78 %
Batteries	
Total storage capacity	25 kWh
Maximum power output	21 kW

The PV systems with a combined capacity of up to 100 kWp are divided into three different rooftop locations, with respective installed capacities of 16, 50 and 34 kWp each; for further details see Annex A: Site Map and Description.

2.4. Interaction of PV System, Biogas System, Battery and Grid Connection Devices

A PLC (programmable logic controller)-based control system (covering all sub-systems of the PV Biogas Hybrid System) shall ensure the main functionalities as described in section 1 General Requirements (e.g. on- and off-grid operation) and shall optimize the operation of the PV Biogas Hybrid System in terms of maximum availability of electricity to the UAF buildings (hours per day) and economically efficient electricity generation (low LCOE). This control system shall communicate with sensors and main components of the PV System, the Battery and applicable grid connection devices, and it shall communicate in a minimal way with the control system of the Biogas System which shall be separate.

The full foreseen interaction of PV System, Biogas System, Battery and applicable grid connection devices is described in detail in section 3.5.1.

2.5. Geographic Location

The project site is located on the new PARS campus of the UAF, at the South-Western edge of Faisalabad city, Punjab, Pakistan.

Figure 2: Location of Project Site (source: Google Earth)

3. Scope of Services for EPC Works

3.1. Project Design and Design Approval

3.1.1. Technical Qualification during Tender Phase

The bidders shall submit all required information in their technical proposal for the evaluation of their bid as specified in *Annex C: Information and Structure of Technical Concept of Technical Bid* and *Annex B: Excel-Format of Component Checklist* and as per *Schedules A* and *F to Bid*.

Incomplete bids with information missing or not presented according to the specified structure as defined in *Annex C: Information and Structure of Technical Concept of Technical Bid/Schedules A and F* might be qualified as unresponsive.

The technical proposals will be evaluated based on the technical feasibility of the proposed PV Biogas Hybrid System and a bidder will be declared as technically qualified in case the respective proposed PV Biogas Hybrid System is sufficiently documented, meets the Employer's Requirements defined herein and gives sufficient evidence that the bidder has understood the scope correctly.

The design as proposed in the bid must later on be adhered to by the winning bidder during project implementation; any changes during execution in comparison to the original design proposed in the technical proposal of the winning bidder require the Employer's prior written consent.

3.1.2. Project Design and Design Approval for each PV Biogas Hybrid System

The EPC Contractor shall deliver the 'Project Designs for Approval' within the following deadlines:

1. 30 (thirty) days, from the Commencement Date for the following:
   I. List of major equipment suppliers, final product data (if not included previously in the bidding documents).
   II. P&ID- Diagrams of Biogas System including all equipment, instruments, valves, controls and accessories
   III. General electric plans (SLD including control and safety devices, string plan for PV modules, etc.) for PV Biogas Hybrid System.
   IV. General physical plant layout of PV Biogas Hybrid System.

2. 40 (forty) days, from the Commencement Date for the following:
   <u>PV System, Battery and Control & Grid Connection System:</u>
   I. Complete design folder of all main components
   II. Complete construction design folder for physical layout, supporting structures and foundations including static load calculations
   III. Complete cable design and plan folder
   IV. Complete design folder for control system (control plan, description of control strategy, physical layout and description of user interface etc.)

3. 60 (sixty) days, from the Commencement Date for the following:
   <u>Biogas System:</u>
   I. Complete construction design folder of each tank, platform and main component
   II. Complete cable design and plan folder
   III. Complete piping design folder
   IV. Complete automation and control plan

V. Complete design folder of biogas system

4. 80 (Eighty) days, from the Commencement Date for the following:

I. Revisions of all Project Designs of no. 1, 2 and 3 above
II. All other systems and components related to the construction of the PV Biogas Hybrid System.

All Project Design documents shall be provided in digital form through upload to a data room (provider and type of data room to be defined between Employer and EPC Contractor) and appropriate notification shall be given to the Employer. The EPC Contractor shall allow Employer and the Designated Consultants a reasonable time for review, commenting and approval/rejection of the documents. If not agreed otherwise, the time for approval shall be 14 working days for each initial provision of documents and 7 working days for document resubmissions after prior rejection.

All EPC works have to be executed strictly in accordance with the approved Project Designs. Any amendment deemed necessary by the EPC Contractor needs to be approved by the Employer and the Consultant.

After the finalization of the EPC works, but not later than one month after COD of the Project, a complete set of "As-Built" documentation for each of the Hybrid Systems shall be submitted to the Employer.

3.1.3. Field Visits

In parallel to the Project Design activity (as defined in section 3.1.2), the EPC Contractor shall immediately start verifying the actual conditions on-site. This activity shall include the selection of the adequate positioning of the different components of the PV Biogas Hybrid System in collaboration with the Employer and its designated Consultant. It shall also include proper soil testing for finalization of foundation design. The EPC Contractor shall ensure that the exact locations for all major components including grid connection will be defined within twenty-one (21) days from the Commencement Date.

It is also within the responsibility of the EPC Contractor to identify any issues on-site that might hinder the implementation of the Project within the proposed timeline. In case such issue will be identified, the EPC Contractor shall collaborate closely with the Employer and its designated Consultant to overcome the issue within the proposed timeframe and Project budget.

3.1.4. Quality Assurance

In case the EPC Contractor does not provide the project deliverables in time as defined in these Employer's Requirements, the Employer may decide, in its sole discretion, to contract a third-party Consultant who will assist the EPC Contractor during the execution of the scope of work through additional reviews, testing and recommendations. Any costs related to the work of the third-party Consultant, any repeated test or any other additional work caused by the EPC Contractor, such as repeated inspections and revisions of designs, shall be borne by the EPC Contractor.

3.2. Project Management Plan

The EPC Contractor shall prepare and maintain a Project Management Plan (PMP) that defines how the Project is executed, monitored and controlled in accordance with the requirements of the Agreement. It shall cover following aspects:

I. Scope Management (e.g. work breakdown structure)

II. CV's of Key Persons, e.g. Project Managers and Logistics Managers
III. Schedule Management (Project Gantt Chart) detailed for
    a. Site Verification / Resolution of any issues
    b. Design
    c. Procurement,
    d. Logistics& Packaging,
    e. Installation
IV. Quality Management
V. Resource Management including proof of level of authority for local Project Manager and Logistic Manager.
VI. Communications Management
VII. Risk Management
VIII. Procurement Management

The Project Management Plan shall be approved by the Employer and his designated Consultant prior to the start of the EPC works.

The EPC Contractor shall execute all EPC Works in accordance with the Agreement and the Project Gantt Chart with special attention to the critical path. A proper workflow, considering the logistical challenges, the approval and testing procedures, shall be considered.

The EPC Contractor has to provide weekly updated progress reports comparing the actual Project status against the original schedule.

3.3. Biogas System Component Specification

In the following, a technical concept for the biogas system is described.

Adaptions of the technical concept described here are acceptable if the Specifications of the Employer's Requirements (Section 2.2 and 6.3.2) are maintained and the minimum daily biogas production based on the available input substrates as per Table 2 **is ensured. Any adaption to the herein explained technical concept shall be mentioned and explained explicitly within the technical bid. If the bidder proposes to take out main components of the hereafter presented technical concepts, these components must be replaced by a substitute of equivalent quality, even though the function of the substitute may differ.**

If relevant equipment which is necessary to fulfil the functional requirements according to section 2.2 is missing according to the opinion of the Bidder, the Bidder is required to comment and add the respective equipment in the scope of his bid.

Also, all components and equipment of the Biogas System are to be constructed and installed according to the requirements of chapter 2 "Part of the System" in the "Safety Rules for Biogas Systems", prepared by the German Agricultural Occupational Health and Safety Agency (please see Annex F: Safety Rules for Biogas Systems).

The hereafter described technical concept does neither contain numerical data concerning materials for the installation of the equipment (e.g. fittings, sealings, screws, supports, etc.) nor information about the required quantities and length of pipelines, cables, etc.). It shall be the responsibility of the EPC Contractor to define this in the respective detailed and executive planning.

The main components of the technical concept for the Biogas System are defined in Table 6 below.

Table 6: Component Overview of the Biogas System

Component Overview of the Biogas System		
No	**Description**	**Quantity**
1	Substrate storage platforms	2
2	Reception tank 90 m³ incl. stirrers, sensors	1
3	Substrate heat exchanger	1
4	Pump station and substrate distribution	1
5	Main digester with a min. 1,500 m³ usable digestion volume incl. stirrers, biogas roof storage, sensors and additional equipment	1
6	Station for solid separation	1
7	Open slurry pond (for digestate storage)	1
8	Substrate pipelines	1
9	Internal desulfurization unit (air injection)	1
10	External desulfurization unit (activated-carbon filter)	1
11	Biogas flare	1
12	Biogas pipelines and external gas storage	1
13	Biogas cooling and condensate trap	1
14	100 kW el Biogas CHP generator incl. heat exchanger and heat storage	1
15	100 kW el Biogas generator	1

The elaboration of the detailed design and installation of the Biogas System shall be carried out by the EPC Contractor based on the selected equipment and prevailing site conditions. A baseline for the

design is provided in the Employer's Requirements for the guidance of the EPC Contractor (please see also Annex D: Flow Diagram for Biogas System).

The EPC Contractor will be required to follow good engineering and construction practices.

3.3.1. Baseline for Biogas System Plant

The technical concept described in the following sections was developed based on the average amounts and qualities of the available substrates given in the table below. However, the final design also needs to be able to take in and process the substrate amounts and qualities within the range described under Table 2.

Table 7: Biogas Yield per Substrate

Expected Biogas Yield per Substrate									
Substrates	**Fresh Material**		**DM**	**oDM**	**oDM**	**Production of CH_4**		**Production of Biogas**	
	t/a	**t/d**	**% FM**	**% DM**	**t/d**	**%**	**m³/day**	**l/kg oDM**	**m³/d**
Cattle dung	**2,737**	8.22	40.0%	75%	2.47	55%	**407**	300.0	**740**
Chicken manure (dry)	**416**	1.25	65.0%	75%	0.61	60%	**218**	500.0	**304**
Corn silage	**500**	1.5	32.0%	94%	0.45	55%	**98**	550.0	**248**
Water and recirculated liquid phase	**6,660**	20	0,0%	0%	0	0%	**0**	0.0	**0**
Total	**10,313**	**31**	**14.8 %**		**3.5**		**723**		**1,292**

The Biogas System will convert the produced biogas into electrical energy and heat energy according to the following estimated production rates shown in Table 8:

Table 8: Energy Conversion of Biogas

Energy Conversion of Biogas		
Production of CH_4	241,807	m³/a
Caloric value of CH_4	9.968	kWh/m³
Losses	5.0	%
Energy yield	2,289,824	kWh/a
Full operation time	8,000	hours/a
Energy potential capacity	286	kW
Electrical efficiency	35	%
Electrical capacity	100	kW
Electricity generation	801,438	kWh/a
Thermal efficiency	38	%
Thermal capacity	109	kW
Heat generation	870,133	kWh/a
Self-consumption electricity	10	%
	80,144	kWh/a
Self-consumption heat	25	%
	217,533	kWh/a
Peak demand heat	50	kW

The demand for the heat self-consumption for the pre-heating or heating of the substrate shall be provided by the generated heat from the base load CHP unit.

According to the functional requirements as defined in section 2.2, the Biogas System shall be able to constantly generate an electric base load power of 100 kW based on the biogas produced by the given substrate mix while the electric peak power available shall be 200 kW.

The therefore needed gas storage - consisting of one internal double membrane roof storage on the main digester and one additional external double membrane gas storage - shall have a total capacity of 2,000 m³ to buffer the produced biogas during the time, while no electricity is generated.

When the CHP unit cannot provide heat directly, because the electricity from the biogas plant (CHP Unit) is temporarily not required, the heat for the preheating of the substrate shall be provided by a heat storage, which is fed with warm water from the CHP unit during normal operation. The required heat storage shall therefore provide a minimum volume of 5,000 litres.

3.3.2. Component Specification and Process Description

The technical design shall consist of a partly open reception tank, a main digester and a slurry pond, and the electric power part (CHP and/or peak power generator) plus additional required equipment for substrate storage, treatment, analysis, mixing and transportation and biogas treatment, storage, analyzing, transportation and conversion.

In the following the main components and the desired process flow will be specified. Further information regarding the technical concept is given *Annex D: Flow Diagram for Biogas System* .

3.3.2.1. *Substrate Reception and Pre-Treatment*

The solid substrates which will be coming from stabled and non-stabled animals from the surrounding villages (cattle and chicken dung, plus corn silage from the local market) shall be stored for the required intervals at the storage platform. Cattle and chicken manure may possess higher shares of sand (up to 15% of DM), which shall be removed on the best possible way through quality control within the substrate logistics and by conducting a pretreatment-sedimentation process. The corn silage shall be treated, compacted and covered with silage membranes right after harvesting and the respective amount shall endure until the next harvest period (needed yearly amount: 400 t/a). All substrates shall be fed manually in constant intervals into the 90 m³ reception tank, which for these purposes shall be installed underground. This allows to buffer the overall substrate input mix (around 30 m³ per day) for almost 3 days. The reception tank shall be divided into 2 chambers of 45 m³ each by a middle wall, where the substrate can flow by an overflow from the first into the second chamber. In the first chamber of the reception tank, cattle and chicken dung shall be mixed with the recirculated liquid phase, and potential sediments within the dung shall settle on the ground of the first chamber, while the mixed organic substrate flows into the second chamber. There it shall be homogenized with the “sediment-free” substrates, e.g. corn silage. From the second chamber, the homogenized substrate shall flow via the central pumps into the main digester. In the reception tank, the substrates shall be stirred with one propeller stirrer in each chamber and mixed with the separated liquid phase of the plant`s digestate or additional water to maintain the dry matter content of the substrate input into the digester below 12 % in order to operate with a flowy substrate input.

The liquid level of the reception tank and the temperature of the substrate mix shall be constantly measured and monitored with the respective sensors. As a redundancy back-up for the main pumping system, there shall be installed a submersible slurry pump, which shall be able to facilitate the flow of the substrate into the main digester during e.g. maintenance times of the pumping distributor.

Required Main Equipment and Components

a) Silage platform (asphalted platform with a drainage system surrounded by concrete walls with a protection layer) for up to 500 tons of silage (e.g. area of 25 m x 8 m with 3 m side walls)
b) Asphalted storage platform for up to 50 tons of dung surrounded by concrete walls
c) Partly open underground reception tank of 90 m³ (stainless-steel or acid-resistant concrete) with electronic level meter, temperature meter and connection for water dosage, height: max. 5 m, width: ca. 3 m, length approx. 6 m
   If installed with concrete, the material specifications for the concrete shall be as follows: Material: in-situ reinforced concrete, compression strength class ≥ C25/30, exposition class XA2, high water entrance resistance, used cement shall be highly resident against sulphate
d) 2 x 7,5 kW 3-blade high efficiency propeller stirrer for reception tank with following specifications: designed for substrate dry matter content of up to 15 %, substrate temperature of up to 55°C, pH-value 5 - 8.2, propeller diameter of min. 600mm, including mast and cable for height (± 2m) and direction shifting (± 120°), completely sealed motor housing and epoxy coating for agitator protection (type IP 68)

3.3.2.2. *Substrate Distribution*

The substrate distributor with the two central pumps is one of the core pieces of the Biogas System. It shall allow to suction and pump from and to all relevant substrate vessels within the process (reception tank, substrate heat exchanger, main digester, separation tank and slurry pond) and thereby shall facilitate a constant substrate flow within the process. Additionally, overflows shall be installed between the main digester, the separation tank and the slurry pond in order to alternatively facilitate the substrate flow by gravitation. The different pumping directions and ways shall be facilitated through automatic pneumatic valves. Since the substrate to be moved consists of mainly solid biomass with high fiber material, central pumps shall be rotary lobe pumps, which shall be capable to pump high viscous substrates with proportions of interfering substances and long-fiber substances.

After the biogas process, a press screw separator shall receive the digestate (around 28 t/d) with a DM of around 7-8 % and shall separate it by pressing the material into a liquid phase (24 t/d) with a DM below 5 % and a solid phase (4 t/d) with a DM of around 25-30 %. The liquid phase shall be used for recirculation into the reception tank and hydrolyzation of the solid input substrate or shall be stored in the slurry pond, while the solid phase shall be further dried on the dung storage platform and used as a fertilizer.

Figure 3 below describes the substrate distributions system within the technical concept.

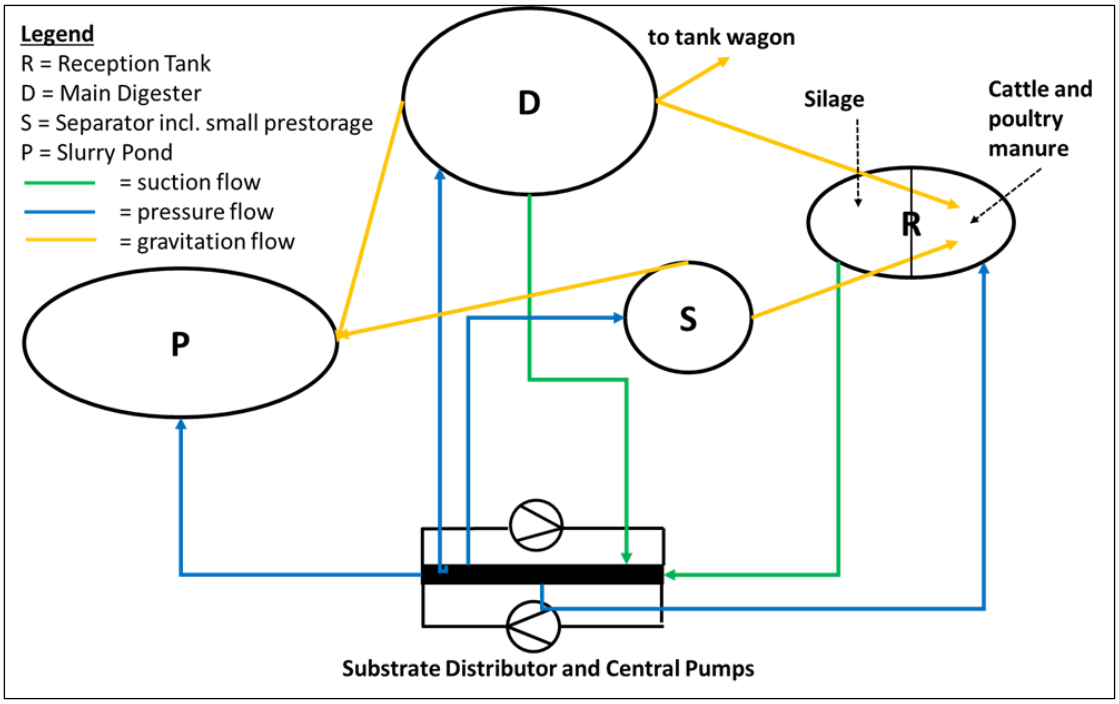


Figure 3: Substrate Distribution System

Following substrate flow direction shall be facilitated:

Substrate Distributor and Central Pumps:

- 2. Chamber of Reception Tank → Main Digester
- 2. Chamber of Reception Tank → Slurry Pond
- Main Digester → Slurry Pond
- Main Digester → Separator
- Main Digester → 1. Chamber of Reception Tank

Substrate flow through gravitation

- Separator → 1. Chamber of Reception Tank
- Separator → Slurry Pond
- Main Digester → Slurry Pond
- Main Digester → Separator
- Main Digester → 1. Chamber of Reception Tank
- Main Digester → Tank Wagon and additional mobile pump (option, not included in scope of Employer's Requirements)
- Slurry Pond → Tank Wagon and additional mobile pump (option, not included in scope of Employer's Requirements)

Required Equipment and Components

a) 1 (one) stainless steel substrate distributer for substrate distribution connected to reception tank, main digester, separator and open slurry pond (see above substrate flow figure). The system shall be installed in a container or a roofed building.

b) 2 (two) central rotary lobe pumps with following specifications per pump: 5 kW mechanical power for pumping load with a volume flow of up to 15 m³/h and 8 m height, capable for pumping substrates with high solid contents (operating intermittent)

c) 1 (one) compressor station for pneumatic valves

d) Min. 6 (six) pneumatic valves for substrate distributor including sealings, connecting tubes and fittings, DN 200 (suction side) – DN 150 (pressure side), PN 10, epoxy coated, metal-to-metal sealing, stainless steel gate, min. pressure 10 bar, open-close system

e) Min. 7 (seven) manual valves for sealing of tubes from main digester and separator, including sealings and fittings, DN 200 (suction side) – DN 150 (pressure side), PN 10, epoxy coated, metal-to-metal sealing, stainless steel gate, min. pressure 10 bar, lockable in all positions

f) Substrate pipeline HDPE, PN 10, SDR 17, DN 200 (suction side) – DN 150 (pressure side), overall length according to the final piping design of the EPC Contractor, connecting distances shall be kept as short as possible

e) Heat exchanger system with 50 kW of thermal power for substrate preheating, which preheats recirculated substrate from the main fermenter or internal heating system installed in concrete walls and fundament of the main digester. The heating system shall facilitate the maintaining of the required process temperature of 35°C inside the main digester throughout a minimum outside temperature of -5°C.

f) Overflows between main digester and slurry pond as an additional way to direct the substrate within the process flow

g) 2 (two) electronically readable flow meters to constantly measure and document the pumped substrate flow on the substrate distributor in all directions

h) Separation system for digestate consisting in press screw separator of 3-5 kW to separate around 3 m³/h of digestate with a DM input of around 5-8 %, including reception tank, if needed, and integration into existing biogas system by recirculation into main digester. The solid output of the separator shall reach a minimum dry matter content of 25 %.

3.3.2.3. *Main Digester*

The main parameters for the design of digesters are the hydraulic retention time and the daily organic loading rate. The hydraulic retention time (HRT) is the average holding time of the substrate in the digester. For pre-digested materials like manure or for substrates with high fats and protein contents a HRT of 20 to 30 days is enough for industrialized biogas plants, while for substrates with high contents of celluloses, lignin or fiber material more like e.g. maize silage or straw, HRTs of more than 45 days are recommendable. The daily organic loading rate is the amount of substrate fed into a digestion plant per day in relation to the volume of the digester (unit: kg oDM/(m³d)). In order not to overload the methane producing bacteria with organic material, the organic loading rate should not exceed 5 kg oDM/(m³d). If chicken manure is being used, the daily organic load should not exceed 3.5 kg oDM/(m³d). Table 9 provides the relevant design parameters for the selected digester design for the Biogas System.

Table 9: Design Parameters for the Biogas System

Design Parameters Plant	Amount	Unit
Daily Input	31	m³/d

Volume Digester	1,500	m^3
Average Retention time	48.4	d
Daily Organic Load*	2.35	kg oDMS/(m^3 d)

*According to envisaged substrate-mix stated under section 3.3.1

Required Equipment and Components

a) Insulated digester concrete tank with following specifications:
   - Digesting volume: min. 1,500 m^3
   - Overall height: 6.5 m
   - Max. liquid level height 6 m
   - Diameter 18 m
   - Thickness of concrete wall: 0.25-0.3 m depending on final static requirements
   - Material: in-situ reinforced concrete, compression strength class ≥ C25/30, exposition class XA2, high water entrance resistance, used cement shall be highly resident against sulphate
   - Thermal insulation with at least normal combustibility, e.g. B2 DIN 4102, in the area of 1 m around gas openings, the insulation shall be made of hard material that is difficult to ignite, e.g. B1 DIN 4102, min. thermal conductivity of 0.04 W/m^2K
   - Weather protection layer (e.g. aluminium) for thermal insulation
   - Epoxy protection layer of upper 2-3 m of the inner tank wall
   - Concrete fundament according to local water/leakage protection standard (incl. geomembranes, leakage visualization, etc.)
b) Working platform on upper level of the digester with stairs and bullseye to the digester
c) Sample take-out including valve
d) Double membrane for roof gas storage incl. roof blower, fixing system and security valve with ASTM standard. The external membrane shall fulfil at least following technical requirements: permeability of CH_4: < 1000 cm^3/m^2d bar, low flammability, Adhesion > 150 N/5cm, destruction resistance > 800 g/m^2
e) Synthetic safety-net plus wooden beam support covering the digester below the gas membranes for maintenance purposes and for capturing solid sulphur after internal desulfurization
f) Concrete column in the centre of the digester to maintain wooden beam as a support for the grid
g) Electronic pressure sensor in gas hood
h) Electronic liquid level meters/sensor inside digester
i) Electronic temperature sensor inside digester
j) Slow running agitator for high DM contents, 11 kW for fermenters with gas-hood, outside motor, with 2 stainless steel or polymer/steel core propellers (diameters 2.650 and 1.500 mm)
k) Fast running propeller stirrer, 1 x 7.5 kW 3-blade high efficiency propeller stirrer for a substrate dry matter content of up to 10 %, substrate temperature up to 55°C, pH-value 5 - 8.2, propeller diameter of min. 600 mm, including mast and cable for height (± 2m) and direction shifting (± 120°), completely sealed motor housing and epoxy coating for agitator (type IP 68).

3.3.2.4. *Gas Treatment*

The biogas captured within the gas hood of the digester requires a treatment process in order to achieve the quality criteria for being used in the generators. The main applied treatment processes for the proposed design are the following:

- Desulfurization through reduction of hydrogen sulphide (H_2S) by air injection into the gas hood and by external adsorption of the biogas flow with an activated-carbon filter to reach a maximum H_2S-content of 100 pm
- Drying of the biogas through cooling and respective collection of condensate
- Compression of the biogas in order to increase the initial biogas pressure of around 5 mbar on up to the required pressure for the combustion

For safety reasons, e.g. when the gas storages are accumulating too much gas and the generators are not working, a semiautomatic safety flare shall be in place to burn the exceeded biogas. The flare shall start to operate after certain pressure in the gas storage is reached (pressure sensors). The flare itself shall be operating independently from the rest of the gas pipeline with an own blower and own flame flap-trap. Although the gas storages shall have additional over-pressure valves, which shall discharge biogas in case of gauge pressure as well, these security valves should not be used to emit methane gas which has a high Global Warming Potential (GWP).

The required overall biogas storage volume including storage roofs on main digester and the external storage shall be at least 2,000 m³. If statics allow installing a double membrane storage roof on the digester with a total volume of 2,000 m³, and if the EPC Contractor provides a storage volume of 2,000 m³ within the gas membrane roof storage, the external gas storage will not be required.

Required Equipment and Components

a) UV-resistant biogas pipeline, stainless steel or HDPE, DN 150. The biogas pipes shall have a specific inclination and shall be equipped with condensate traps. The biogas piping installed over ground shall be made of stainless steel or polyethylene. For underground installations, non-UV resistant pipes can be used.
b) Gas flow meter (electronical readable) for constant measuring and documentation of biogas flows between 5 and 150 Nm³/h
c) Semiautomatic safety flare 150 m³/h
d) Internal biological desulfurization system by air injection into the gas hood of the main digester
e) External desulfurization unit with activated carbon filtration (both systems together shall guarantee the required H_2S-concentrations described under section 2.2)
f) Gas analyser for CH_4, H_2S, O_2 for constant measuring and documentation of biogas flows between 5 and 100 Nm³/h
g) Biogas chiller for cooling and condensation (de-moisturing) for the required biogas flow, humidity and temperature
h) Biogas condensation tank with submergible pump and piping for pumping condensation water into storage lagoon
i) Biogas blower up to 150 m³/h and 250 mbar incl. safety valves
j) External gas storage balloon:
    - Single-membrane type
    - Min. volume: 2,000m³ - V (roof storage main digester)
    - Technical specifications: permeability of CH_4: < 1000 cm³/m²d bar, low flammability, Adhesion > 150 N/5cm, destruction resistance > 800 g/m²

3.3.2.5. *Slurry Pond*

Although most of the digestate shall be separated after the biogas process and the liquid phase shall be recirculated and the solid phase shall be used as an organic fertilizer, the Biogas System shall

provide a storage for the liquid digested material, e.g. for the excess digestate and in case the separation (see 3.3.2.2) does not work or for any other reasons. This can be realized in an open lagoon, which shall fulfil the local standards concerning semi-anaerobic treatment lagoons. The liquid digestate shall later be distributed as a liquid fertilizer on close-by arable land of the local community.

Required Equipment and Components

a) Open Lagoon for 5,000 m³ digestate including geomembrane/soil cover which complies with local ground water protection standards

3.3.2.6. *Control and Automation:*

The control and automation concept shall facilitate the complete automatic operation of all mechanical equipment of the Biogas System, document the relevant process parameters and provide a safe and adequate alarm chain. It shall include the following:

- Controlling the operation time of pumps, pneumatic and electric valves, agitators and blowers
- Setting up the process and alarm hierarchy, e.g. blocking pumps and agitators when certain liquid level is reached, starting safety flare when gas pressure is too high, and starting gas blowers when gas composition and gas pressure in gas storage can allow the operation of the generators, etc.
- Measuring and documenting substrate flows, process temperature, liquid levels of reception tank, main digester and separation unit, gas pressure in storages, gas flows, gas composition, gas temperature and tank levels
- Visualizing the ongoing process and the relevant parameters and settings for operators
- Facilitating remote control via internet access
- Allowing manual parameter setting, protected by an operator password

The interaction between the control and automation of the Biogas System and the control system of the PV Biogas Hybrid System is described in section 3.5.1.

Required Equipment and Components

a) Control cabinet and automation unit(s) for feeding, pumping, stirring, managing of CHP & flares, alarm settings regarding temperature, liquid levels, pressure, pH, CH_4, H_2S and regarding the handling of other installed equipment (blowers, valves etc.)
b) Adequate container or housing for control interface (HMI) (ideally same as for the control system of the PV Biogas Hybrid System)

3.3.2.7. *Biogas Conversion and Electric Integration*

The biogas conversion shall consist of two generation units. The first one shall be a highly-efficient co-generation (CHP) unit which generates electricity with a minimum required electrical efficiency of 35% and a thermal efficiency of 35%. This unit shall be used for the average base load generation of 100 kW and shall also provide the required thermal energy (hot water with 90°C) for heating up the substrate on the process temperature of 35-40°C according to the measured process temperature in the main digester. To buffer the time, when no generator is operating, a heat accumulator of 5 m³/80 kWh shall be installed. If the average substrate flow of around 1.25 m³/h needs to be heated

by 20 K, around 30 kW of thermal energy shall be provided. The CHP unit shall provide minimum 108 kW of thermal power.

For the peak electricity production, a simple biogas generator will be utilized.

The electrical connection to the grid is described in the following sections below. However, it should be stated, that it is estimated, that the biogas plant will have an own constant electric power demand between 5-25 kW (average 8-9 kW). The supply shall be provided by three options: (a) by the Biogas System generators, (b) by the electricity grid or (3) by the PV System in case the generators are in operation.

Required Equipment and Components

a) 1 x 100 kWel biogas co-generation unit including heat exchanger for exhaust gas and cooling water, thermal capacity min. 108 kW, el. efficiency of min. 35%, thermal efficiency of min. 35%, cooling unit for thermal energy, catalysator, internal control cabinet, minimum methane content of biogas = 50%, the generator shall be designed according to the following standards: CEI 2-3, IEC 34-1, EN 60034-1, VDE 0530, BS 4999-5000, C22.2 No14-95-No100-95, max. exhaust emissions with catalysator: NOx: 500 mg/Nm³, CO: 300 mg/Nm³, Formaldehyde: 40 mg/Nm³, Dust Particles: 20 mg/Nm³, SO2: 35 mg/Nm³
b) 5 m³ insulated heat buffer tank and respective heating system incl. pumps, valves and connection for heating circuit 90/70°C (for further connection to substrate heating system)
c) 1 x 100 kW biogas generator, el. efficiency of min. 35%, design based on standard conditions according to DIN ISO 3046-1
d) Electric integration of all components and equipment
e) Sound-proof canopy, building or container for CHP and generator

3.4. PV System Component Specifications

3.4.1. PV Modules

The EPC Contractor shall provide crystalline type PV Modules of a reputed manufacturer. The total PV module STC power of each PV System shall be equal or higher than the one required as per section 2.1.

Every PV Module has to have a stabilized power, which is equivalent or greater than its nominal power at STC conditions.

The PV modules shall be manufactured in a factory adhering to the standards as defined in Annex H: PV Module Manufacturing Standards. The Bill of Material (BoM) of the offered PV Module type shall be provided with the bid (according to table in Annex E: Information on Bill of Materials of PV Modules. The specific product datasheets of the EVA and the back sheet shall be provided with the bid.

The EPC Contractor shall ensure that the BoM of PV Modules proposed for the Project is identical to the BoM of the PV modules during the certification process according to the IEC standard. In case the proposed BoM is different to the original BoM during certification, the PV Modules with the new BoM shall be certified by an independent certified testing laboratory.

The PV Modules shall meet the following minimum technical specifications as shown in Table 10.

Table 10: Minimum Technical Specifications of PV Modules

No	Characteristic	Specification
1.	Type	Mono- or polycrystalline
2.	Maximum rated power (STC)	265-320 Wp or higher (60 or 72 cell modules only)
3.	Rated power tolerances (+/-)	Positive tolerance only
4.	Power at 200 W/m² (25°C, AM 1.5)	Linear behavior with power not less than 95% of the expected output
5.	PV module product warranty	10 years or more
6.	PV module performance guarantee	25 years or more
7.	Power output within 10 years	Shall not fall below 90%
8.	Power output within 25 years	Shall not fall below 80%
9.	Type of performance guarantee	Shall be linear after 1st year
10.	Temperature coefficient of maximum power (TC P_{mpp})	0.43% / C or less
11.	Certifications	IEC 61215 & IEC 61730
12.	Cable	4 mm² (IEC), 1000 mm or above flexible (tin coated), UV resistive, IEC compliant with IP 65 weather proof clips
13.	Ingress Protection (IP) rating of junction box	IP67
14.	Extended lifetime tests	Following test reports from independent certified lab must be provided if the bidder is not using critical items of the BOM as set forth in Annex E. The following extended lifetime test result must be provided. 1) Damp Heat – 300 hours 2) Thermal Cycling – 600 cycles 3) Humidity Freeze – 30 cycles

The following technical characteristics of the PV Modules have to be provided by the Bidder:

Table 11: To be provided Technical Characteristics of PV Modules

No	Characteristic	Specification
1.	Manufacturer	
2.	Type of equipment	
3.	Maximum rated power	
4.	Rated power tolerances (+/-)	
5.	Power conversion efficiency at STC	
6.	Maximum efficiency at 200 W/m² (25°C, AM 1.5)	
7.	Series fuse rating	
8.	Materials and workmanship warranty	Minimum of 10 years
9.	Duration of Performance Guarantee	Minimum of 25 years
10.	Power output within 10 years	Shall not fall below 90%
11.	Power output within 25 years	Shall not fall below 80%
12.	Type of Performance Guarantee	Shall be linear
13.	Voltage at the maximum power point (V_{mpp})	
14.	Current at the maximum power point (I_{mpp})	
15.	Open-circuit voltage (V_{oc})	
16.	Short-circuit current (I_{sc})	
17.	Maximum system voltage (V_{max})	
18.	Temperature coefficient of short-circuit current (TC I_{sc})	
19.	Temperature coefficient of open-circuit voltage (TC U_{oc})	
20.	Temperature coefficient of maximum power (TC P_{mpp})	
21.	Tolerance to wind (maximum load) and hailstone impact	
22.	No. of integrated bypass diodes	

No	Characteristic	Specification
23.	Dimensions	
24.	Weight	
25.	No. of cells in series	
26.	Type of frame	
27.	Ingress Protection (IP) rating of junction box	
28.	Cable length	
29.	DC Connector manufacturer and type	
30.	Ingress Protection (IP) rating of DC Connectors	
31.	Total no. of PV Modules and total kWp	
32.	Manufacturer's installation guidelines	To be provided
33.	Manufacturer's confirmation of suitability of PV Module for specific weather conditions and high UV-radiation	To be provided
34.	Provision of guarantees and datasheets	To be provided
35.	Provision of flash test data	To be provided upon shipment of PV Modules
36.	Key to module serial numbers in relation to production line and production date.	To be provided
37.	Provision of specification and quality test certificates of: glass, encapsulant, cell, EVA, adhesives, busbar, sealant, back sheet, frame, junction box, cable, DC connector	To be provided
38.	Bill of Materials (PV Module)	To be provided
39.	Datasheet EVA	To be provided
40.	Datasheet Backsheet	To be provided

The following PV module standards must be met, as applicable to crystalline silicon:

- IEC 61215
- IEC 61730
- IEC 60904-1, IEC 60904-3
- Other applicable standards.

Extended lifetime tests:

A. The selected PV modules must either have proof of the following extended lifetime tests (performed by an independent laboratory for the exact same BoM):
   - Extended life time tests. IEC 61215 defines three climate chamber tests, Damp Heat for 1,000 h (DH 1000), Thermal cycling with 200 cycles (TC 200) and Humidity freeze with ten cycles (HF 10) as under:
   - For the approval of the PV Modules the IEC 61215 climate chamber tests must be applied three times in a row by the same PV Modules with a maximum power loss of five percent (5 %).
   - Each test (DH 3000 h, TC 600 cycles and HF 30 cycles) will be applied to samples which will either be taken out of mass production or which are built under supervision of the Employer.

Or

B. As alternative to A, the Bidder can propose at least two (2) different PV Module types with different BoMs. In order to become qualified for this alternative each proposed BoM shall include the EVA and the backsheet from one of the manufactures as defined in Annex E: Information on Bill of Materials of PV Modules. The specific product datasheets of the EVA and the backsheet shall be provided with the bid. If qualified for this alternative, the Employer shall have the sole right the choose one of the proposed PV module types / BoM.

3.4.2. Inverter System

The "inverter system" refers to the total of all PV inverters and battery inverters of the system.

In order to ensure that the highest quality and durable inverter/components are provided, the inverter must be provided with a transferrable warranty period of five (5) years.

3.4.2.1. *DC/AC PV Inverter*

The DC/AC PV Inverter which converts the power from the PV modules to AC power shall meet the following technical specifications as minimum according to Table 12.

Table 12: Minimum Technical Specifications of DC/AC PV Inverters

No	Characteristic	Specification
1.	Inverter Rated Power (AC) (Output)	As per design
2.	IP Rating	IP 20 or higher when inside a housing, IP 65 when outside
3.	Output Type	Sine wave
4.	THD	< 3 %
5.	EU/CEC efficiency	> 95 %
6.	Safety Standards	Must meet IEC62109-1/2 certifications
7.	EMC	IEC 61000 family or equivalent
8.	Grid Connection requirements	The grid tied inverter must meet grid connection certificate for a country with utility voltage & frequency similar to local grid. Any certification such as VDE 126-1-1, VDE 4015, G83, G59, AS/ NZS 4777.2, AS / NZS 4777.3 will be acceptable.
9.	Brand	Renowned and verifiable brand having successful history in similar climatic conditions.
10.	Warranty	5-year transferable warranty from the original inverter manufacturer shall be provided

All documentation, certificates and routine test procedures, shall be provided with the bid.

The selected inverter shall not only deliver DC to AC conversion for use by the AC load, but also offer the following functionalities:

I. Maximum Power Point Tracking (MPPT) and string/sub-array management
II. Matching grid voltage and frequency at point-of-coupling
III. Anti-islanding protection
IV. Frequency regulation
V. Limitation of voltage fluctuation due to switching operations and long-term flicker
VI. Limitation of short-circuit current
VII. Advanced communication, with intelligent alerts/warnings and another relevant operational parameter, either with
    - Built-in remote monitoring system or
    - Separate remote monitoring system connected to communication ports of the inverter

The inverter design shall be in compliance with the applicable standards of Pakistan, the requirements of the Net Metering Grid Connection requirements of Pakistan and further relevant requirements of the grid operator.

Both string-type and central-type inverters are acceptable. Especially for central-type inverters, the Bidder should explain the concept for minimizing downtime in case of failure.

Inverters may be placed outside (rain protection to be foreseen) or within an additional housing; IP rating as per table. Inverters at the battery location shall use the battery housing (see 3.4.4).

The following technical characteristics of the DC/AC solar inverter have to be provided by the bidder:

Table 13: To be provided Technical Characteristics of DC/AC PV Inverters

No	Characteristic
1.	Manufacturer
2.	Type/Model number
3.	Datasheet
4.	Certifications
5	Warranties
6	Installation Guide
7	Manual

3.4.2.2. *DC/AC Battery Inverter (Bi-directional)*

The DC/AC Battery Inverter (bi-directional) may be provided as a separate device or as in-built feature of the DC/AC PV Inverter installed at the same location. It shall meet the following technical specifications as minimum.

The inverter of the battery (see SLD in chapter 2)) shall be of hybrid type and be able to work both as grid-tied system (synchronizing to the frequency and voltage of the electric grid from the DISCO connection or established by the biogas generator(s)) as well as an off-grid system (defining and setting the frequency and voltage of the island grid connected to it when both the electricity grid and the biogas generators are not available). In island grid mode, the same 11kV line and main breaker of the system will be used as shown in the SLD in chapter 2, so that all PV power installations can feed into the island grid, and all connected buildings can draw electricity from that same grid, as long as the total demand can be matched by PV and battery.

Switching between grid-tied mode and off-grid and vice versa shall be performed by the overall control unit. The inverter shall also be able to work as battery charge controller in order to charge the batteries with power from the PV Biogas Hybrid System and grid electricity.

Additionally, when working in grid-tied mode the inverter shall be able to feed electricity to the grid in case of surplus production and shall be able to use grid electricity for powering the remaining local residual load in case that the generated power does not fully meet the load requirements of the connected loads.

The battery inverter shall be placed in the container as per 3.4.4.

Table 14: Minimum Technical Specifications of DC/AC Battery Inverters

No	Characteristic	Specification
1.	Inverter Rated Power (AC) (Output)	As per design
2.	IP Rating	IP 20 or higher
3.	AC input	170 Vac – 250 Vac per phase
4.	Safety Standards	Must meet IEC62109-1/2, IEC62477-1 or equivalent certifications
5.	EMC	IEC 61000 family or equivalent
6.	EU/CEC efficiency	> 90 %

6.	Brand	Renowned and verifiable brand
7.	Warranty	5-year warranty
8.	Battery Management System	Adequate BMS for proper control of battery charging and maximum lifetime

All documentation, certificates and routine test procedures, shall be provided with the bid.

The selected inverter shall not only deliver DC to AC conversion, but also offer the following functionalities:

I. Defining and setting the frequency and voltage in off-grid mode
II. Frequency regulation
III. Limitation of voltage fluctuation due to switching operations and long-term flicker
IV. Limitation of short-circuit current
V. Advanced communication, with intelligent alerts/warnings and other relevant operational parameter, either with
    a. Built-in remote monitoring system or
    b. Separate monitoring system connected to communication ports

The inverter design shall be in compliance with the applicable standards of Pakistan, the requirements of the Net Metering Grid Connection requirements of Pakistan and further relevant requirements of the grid operator.

To ensure the lifetime of the PV Biogas Hybrid System and its satisfactory performance, a Battery Management System must be used which controls voltages and currents for optimal performance and lifetime of the batteries.

The following technical characteristics of the DC/AC Battery Inverter have to be provided by the bidder:

Table 15: To be provided Technical Characteristics of DC/AC Battery Inverter

No	Characteristic
1.	Manufacturer
2.	Type/Model number
3.	Datasheet
4.	Certifications
5	Warranties
6	Installation Guide
7	Manual

3.4.3. Batteries / Electricity Storage System

The following technical characteristics of the batteries have to be provided by the bidder:

Table 16: To be provided Technical Characteristics of batteries / Electricity storage system

No	Characteristic
1.	Manufacturer/Supplier
2.	Supplier experience with BSS: at least 5 units delivered and operating for off-grid and/or hybrid applications
3.	Supplier operational experience in BSS market: at least 1 year
4.	Type/Model number
5.	Datasheet

6.	Certifications
7.	Warranties
8.	Installation Guide
9.	Manual

The usable storage capacity shall be limited to 90% DoD through the control software of the PV Biogas Hybrid System. The minimum usable storage capacity of the lithium batteries is 25 kWh.

The discharge shall be possible within a period of 1.1 hours or less (i.e. C-rate of 0.9C or higher).

The lithium battery storage system shall meet the following technical specifications as minimum.

Table 17: Minimum Technical Specifications of Batteries

No	Characteristic	Specification
1.	Battery type	Lithium based battery, rack based
2.	Individual battery voltage	As per proposed design
3.	Battery life	>4500 cycles @ 90% DoD or better
4.	C-rate	0.9C or higher for charge and discharge
5.	Battery Management System	Integrated
6.	Self-discharge	< 4%/month @25C according to IEC 60 896-21
7.	Certifications	IEC 62619, UL 1642, UN/DOT 38.3 or equivalent
8.	Manufacturer	Renowned international supplier with fully automated production facilities
9.	*Manufacturing date	< 6 months before installation

* Manufacturing date will be checked according to best international industrial practices.

The following technical characteristics of the batteries (independent from variant) have to be provided by the bidders:

Table 18: To be provided Technical Characteristics of Batteries

No	Characteristic
1.	Manufacturer
2.	Type/Model number
3.	Datasheet
4.	Certifications
5	Warranties
6	Installation Guide (during implementation phase)
7	Manual (during implementation phase)

3.4.4. Container for Inverters and Batteries

At least for the location of the battery, all local inverters (PV and battery inverter), batteries, battery charge controller and any protection devices such as fuses and circuit breakers shall be installed in an adequate housing in form of a container or a similar, compact and closed housing (later on referred to as “container”). The selection of the required location of the container shall be made by the EPC Contractor but approved by the Employer or its designated Consultant. The container shall have a robust locking mechanism in order to prevent any component theft.

The container shall house the following components:

- Inverter(s) and battery charge controller
- Protection devices, breakers/fuses, isolation switch as far as possible

- Battery/electricity storage system

Adequate ventilation and cooling shall be present for the container so as to ensure an efficient cooling and prevent excessive heat build-up. Thermal calculations proving sufficient ventilation under Punjab climate conditions with the proposed equipment need to be provided. The compartment design shall ensure that each component will be operating within its defined range of operating temperatures (as defined in the corresponding datasheet) for ambient temperatures up to 50°C.

The container shall be sufficiently reinforced in areas with higher static load requirements such as the battery compartment in order to meet static requirements. The enclosure cabinet shall be made out of M.S sheet with 18 standard wire gauge (SWG) or better, powder coated to matt finish.

The final design of the container is subject to approval from the Employer or its Consultant.

The IP rating of the container shall be IP 54.

The following technical characteristics of the container must to be provided by the bidders:

Table 19: To be provided Technical Characteristics of Container

No	Characteristic
1.	Design/drawing of the container(s)
2.	Material specifications
3.	Documentation which proves the suitability for Project
4.	Datasheet
5.	Brief documentation of cooling system (design cooling load, datasheets of cooling devices, brief concept description)

3.4.5. Supporting Structure for PV Modules

The supporting structures of the PV System shall be fixed structures, fixed on the building roofs.

The systems shall be fixed-tilted and preferably be south-facing. The tilt angle for the module installation, the angle between the modules and the horizontal plane, shall be of 15° which is the optimum for summer in Punjab region. Having stated this, the exact angle and direction will be finalized between the winning bidder and Employer, and the designated Consultant, during design phase according to the roof orientation of the new buildings etc.

The modules will be fixed on the building roofs in the quantities as described in 2.3 on the locations as depicted in *Annex A: Site Map and Description*.

The height of the modules above rooftop level shall also be carefully chosen, considering factors such as damage from sand driven by wind and clearance from the ground to allow for cooling air to circulate at the back of the module and any condensation of moisture to dissipate.

Mounting structure to support the module must be made of durable aluminium material, resistant to sandstorms, high wind speeds (up to 40 m/s), corrosion (passing the salt spray test IEC 61701, among other verification), and UV induced degradation. The material must be compatible with the module frame material so as to avoid any adverse electrolytic/galvanic effects.

In general, lightweight structures of aluminium with no need for roof manipulation (like drilling) shall be used. Any other proposed design shall be explicitly explained in the bid in terms of avoidance of rooftop damage.

The rooftop of the Energy Systems Building (34 kWp) is already constructed and does not have any provision for anchors. The rooftops of Lab and Control Buildings may foresee metal anchors for mounting of structures in order to avoid roof drilling; this will be finalized between Contractor and Consultant during planning phase.

The bidders shall provide detailed drawings of any foundations they plan to use.

All fastening structures must be verified for durability and resistance to environmental degradation for 25 years, the lifetime requirement of the complete structure. Stainless steel fasteners with anti-seize lubricant are required. The structural elements shall consist of anodized aluminium or materials with equivalent if not better properties. The applicable construction codes for each structural element should be quoted.

The use of certified racking systems with clips clamping the module to the rail, without the need of bolts and nuts, may be considered.

The mounting structure must come with an anti-theft protection to impede demounting of modules.

The mounting structures must be earthed for maximum short-circuit current and lightning protection. A racking design that removes the need of module to module grounding by using the common rail for the grounding is recommended.

The supporting structure shall match the specific requirements of the roof conditions (including rainwater drainage) / ground conditions and rodents at site. The Contractor shall submit detailed drawings of the supporting with an explanation of the methods to be used for installing the PV Modules. The stability of the supporting structure after installation shall be certified and guaranteed by the Contractor.

Standards:

- IEC 61730 (as above)
- STS 531

The following technical characteristics of the proposed supporting structure have to be provided by the bidders:

Table 20: To be provided Technical Characteristics of supporting structures

No	Characteristic
1.	Manufacturer information
2.	General Design/Drawing of mounting structure
3.	Material specifications
4.	Datasheet
5.	Design calculations / structural analysis
6	Applicable construction codes
7	Certifications
8	Warranties

3.4.6. DC Cables

The main design requirement is to reduce ohmic losses of DC cabling, without adversely affecting the cost trade-off, to < 1 % at full power under STC conditions. Design calculations through cable loss simulation have to be provided by the bidder for review & approval.

String cables shall be of the following type: single conductor type, copper, cross-sectional area of 4 mm² or higher, 1000 V / Class II (according to protection class II / 1000V, IEC 61140, single core cable, tinned copper conductor, XLPE Insulation, double EVA jacket (resistant to heat and cold, resistant to ozone, UV, oil and chemicals), Temperature: 90 º C (Temperature Max. allowable: 120 º C), Halogen free. DC cables shall be suitable for the environmental conditions at the Project site, including UV protection and rodents.

The following technical characteristics of the DC cables have to be provided by the bidders:

Table 21: To be provided Technical Characteristics of DC cables

No	Characteristic
1.	Manufacturer information
2.	Datasheet
3.	Detailed technical specifications
4.	Certifications
5	Cable loss simulation (during implementation phase)
6	Warranties

3.4.7. DC Connectors

The following design factors shall be met:

I. High current rating
II. Minimal contact resistance
III. Convenient handling
IV. Broad compatibility
V. Incompatibility with AC connectors to avoid mistakes during installation
VI. Force required to unlock connectors from cables, whether a tool is required for it or not
VII. Minimum Ingress Protection (IP) rating: IP 67

If Multi Contact MC4 compatible DC connectors are used, a combination of different manufacturers is allowed. MC4 compatible connectors have to be certified in written by the manufacturer Multi Contact.

The compatibility between the chosen DC connectors and the DC connectors attached to the PV Modules (if different) needs to be certified by both manufacturers.

The following technical characteristics of the DC connectors have to be provided by the bidders:

Table 22: To be provided Technical Characteristics of DC connectors

No	Characteristic
1.	Manufacturer information
2.	Datasheet
3.	Certifications
4	Warranties
5	Compatibility statements

3.4.8. AC Cabling

AC cables shall be made of copper. Rated voltage, nominal voltage between phase and neutral and nominal voltage between phases shall be according to Pakistani grid code. AC cables shall be suitable for the environmental conditions at the Project site, including UV protection and rodents. The main

design requirement is to reduce ohmic losses of AC cabling, without adversely affecting the cost trade-off, to below 0.5 % under STC conditions. Design calculations through cable loss simulation to be provided by the bidders for review & commenting.

The following technical characteristics of the AC cables have to be provided by the bidders:

Table 23: To be provided Technical Characteristics of AC cables

No	Characteristic
1.	Manufacturer information
2.	Datasheet
3.	Certifications
4	Cable loss simulation (during implementation phase)
5	Warranties

3.5. Control and Grid Connection Component Specifications

3.5.1. Control System

3.5.1.1. *Overview*

The overall control system shall be a user friendly, integrated solution for reliable energy management. It shall also include data logging.

The control system shall centralize monitoring data, control and any error recording in a central place, providing all relevant parameters for analysis and reporting through a network of devices (inverters, generators etc.) as well as all required metering and protection devices.

The scope includes provision of all components, software, and systems integration for a complete operational control system designed for the following functions.

3.5.1.2. *Description of current situation*

The electric grid on site is not available several hours per day due to load shedding, depending on the season of the year. The situation is assumed to remain unstable. During power supply, power quality is often poor (voltage etc.). The operating DISCO (FESCO) did not give any forecast for the next years.

3.5.1.3. *Goal of Control*

The plant shall be controlled in a way that the following functionalities are ensured.

Functionality:

1. The system is connected to the electric grid when the grid is available. When the grid goes off, the system will disconnect a branch of the grid from the main grid and establish a mini-grid (island mode). When grid comes back, the system synchronizes and re-connects to the grid.
2. When operating in island mode, Solar, Biogas and Battery Systems are synchronized so they can all feed into the mini-grid at the same time.
   When biogas is not available, the battery will establish the mini-grid where the PV System can feed in. For this situation, the local LV grid where the battery is installed shall additionally be able to disconnect from the 11kV line to run as a local mini-grid via an additional automatic breaker (see Figure 4: SLD).

Optimization:

3. Supply to the connected mini-grids is as close to a 24/7 power supply as possible and economically feasible. If a small number of hours per year of outages occur, there is no penalty associated with them.
   This specifically means that:
   - At grid outages like load shedding, a short interruption is permitted. However, the startup of the island grid needs to be quick and automatic.
   - Storage resources, i.e. biogas and battery storage are used intelligently to provide power supply during load shedding hours as much as possible.
4. Secondary to the first guideline, generation costs per kWh shall be minimized as much as possible. This specifically means that:
   - Solar power is utilized as much as possible, either through direct load consumption, grid export or charging of batteries for later usage. An intelligent battery charging mechanism is therefore required.
   - The biogas power system generators (CHP and/or generator) are operated as much as possible in their preferred operating range. Intelligent control between the two biogas generators as well as intelligent supporting charge and discharge of battery power is mandatory to achieve this.

Further development:

5. The system shall be designed such that it can further be optimized during operation. This means, for example, that actual grid availability data as well as load data during island grid operation are logged so that the battery charging and discharging strategy can be adapted, i.e. that the thresholds/control functions for control of storage resources, generators etc. can be adjusted so that the intelligent power supply can be continuously improved based on real-world load profiles acquired during operation.

Interaction with biogas control:

The overall control system should be separate from the biogas control system for higher robustness and easier troubleshooting. The suggestion for the interface between both systems is as follows:

- The overall control system communicates with and controls the CHP and generators for start-up, shut-down, output power set points etc.
- The overall control system receives a signal on biogas storage level from the biogas storage via a pressure sensor (or directly from the biogas control system) to estimate the remaining generation hours available from biogas storage.
- The biogas control system does not control the CHP / generators; it only gives a “CHP/generator available” signal to the overall control system when the conditions are met for the CHP/generator to run.

Basic input and output parameters:

The following list gives an overview of the main input and output parameters of the system as perceived by the Consultant. This is only an indicative list; the guiding principle for final definition of inputs and outputs is the control goal as described earlier and the Contractor will have to finalize this definition during design stage.

Indicative input parameters:

- Voltages, currents of all devices (inverters, biogas generators)
- Solar Irradiation
- Biogas and battery storage levels
- Auxiliary consumption of the system (foremost: biogas system)
- Status/position of all breakers involved in connection and disconnection of the grid
- Time of the day (for load profile estimation, load shedding estimation etc.)
- Status and error occurrences of all devices

Indicative output parameters:

- Battery charging and discharging power setpoint (battery charger)
- Biogas generator output setpoint (from 0/off to maximum for both CHP and generator)
- Solar inverter MPPT signal (reduction of solar power extraction in case that not all of it can be utilized or stored)
- Connection & disconnection of the grid (breaker command)
- Any additional commands required for synchronizing between grid and input sources or between different input sources
- Re-setting and programming of all devices as required
- Emergency off commands

SLD, tentative:

Under grid operation, the Islanding Switches is closed. When grid is not available, the system will open the Islanding Switch for operation in island mode. When the grid comes back, the system will close the switch again and synchronize with the grid.

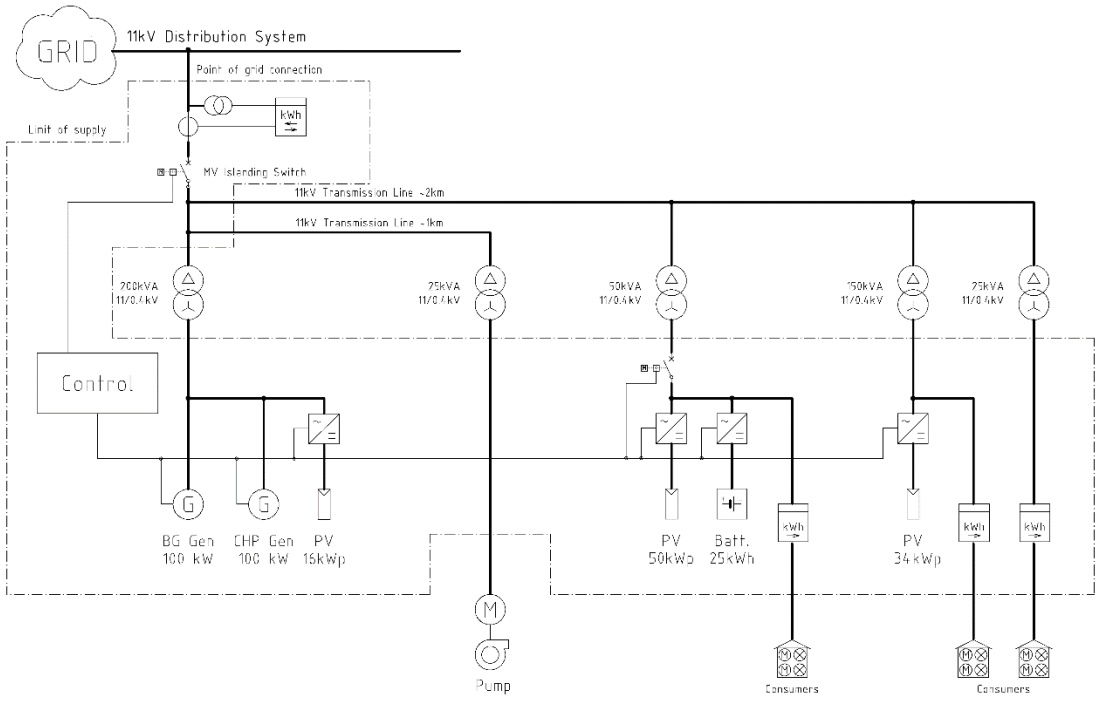


Figure 4: SLD

3.5.1.4. *Description of Monitoring*

Remark: Small details of the monitoring solution may differ from the following, but only as long as the Goal of Control as described above is maintained in the same quality.

1. Provide a platform for automated monitoring and preventive maintenance of the power plant.
2. Provide reliable, up-to-date monitoring information (such as voltage, current, power, and energy and demand data) on the status of devices, systems, and processes to the system operator.
3. Provide a user interface view of alarms and events and the ability to acknowledge the events.
4. Log control system data to a hard disk at user-specified intervals.
5. The system shall be equipped with a standardized Human Machine Interface (HMI) / Supervisory Control and Data Acquisition (SCADA) software for displaying data from monitored devices.

   The software shall be capable of configuring and displaying the following customized graphic screens (deviations are permissible as long as the same purpose is maintained):

   a. Site plan: Graphic plan of all major components with basic current parameters; sub-groups or devices (as mentioned in following points) that can be accessed directly from overall view
   b. Electric Single Line Diagram (SLD) including all breakers, switches, safety devices and generators and consumers
   c. Biogas power system screen – including status of generators, biogas storage level etc.

      Volume flows, temperatures, pressures etc. are desirable, but not mandatory to display as these are part of the biogas control system.
   d. Solar power screen – including status of inverter, currents, solar irradiation etc.
   e. Battery Monitor screen – including overall charge level, voltages, currents, temperatures etc.
   f. Device Screens with data for any other monitored devices
   g. Status of any other inputs and outputs such as safety trips, fans, a/c etc.
   h. Alarms sortable by date, time, device type or type of alarm
   i. Event log
   j. PLC screen (if useful)
   k. Overall System Status/Health screen

   The system should have the accessibility and by based on a fairly standard programming software so that professional IT staff in the future can add features like:

   a. Further develop custom screens and reports.
   b. Provide diagnostic system analysis reports.
   c. Define and view trends for any of the parameters available.
2. Provide the ability to perform off site and/or remote monitoring (Web access and viewing).
3. The system shall provide a data storage backup/redundancy on a separate hard drive or cloud for all data.
4. Software shall be provided with graphical interface to view the current and archived data in form of charts and time plots.
5. Data shall be easy to export via .csv, .xlsx formats.

3.5.1.5. *Integration of Devices*

1. The system will collect all data recorded by the system devices.
2. The control system shall communicate all system values and data via Modbus connectivity or equivalent, dry contacts, analog 4-20 mA signals, or a combination with each of the devices (Switches, Batteries, Generators, Main Switchboards, Trip Units, Meters/Relays etc.); or it may use Ethernet TCP/IP technology.
   If another protocol is required, the Contractor shall indicate the proprietary protocol and provide the equipment with gateway devices and/or drivers necessary to convert to Modbus or TCP/IP. No proprietary protocol be accepted.
3. Ethernet switches shall be managed, industrial hardened switches using the appropriate cable to handle bandwidth and speed in the case of copper and for fiber optics.

3.5.1.6. *Time Synchronization*

1. The system data collection layer shall use a GMT standard to account for time zones and time changes.
2. The collected data shall use time stamps for unambiguous logging.
3. The System shall be capable of synchronizing the monitor clocks using Internet based time synchronization services.

3.5.1.7. *Alarm and Event Management*

1. The system shall gather and locally store historical operation/fault.
2. The system shall foresee the option of automatic email generation with the error text message upon alarm events.
3. All alarms and associated alarm information will be recorded in an alarm log.

3.5.1.8. *Access*

1. The control system shall be web enabled with the ability to specify and administer security/user access roles and permissions with at least the following two levels: Business Users and Engineers can view data and reports generated by the system, while only Engineers can have full access to the monitor data, set control parameters etc.

3.5.1.9. *Architecture*

1. The control system shall be supplied with user-friendly application software running on a centralized application server or PLC. The server/PLC shall serve as central control station by monitoring and displaying the configured devices in the control system; recording events; indicating alarm conditions, and logging device data.
2. The system shall support remote monitoring via web viewer software and a commercially available web browser or a client software.

3.5.1.10. *On-line help*

1. Systems should be capable of providing (basic) context sensitive on-line help.

Alternatively, a comprehensive help manual needs to be provided, covering all parts of the software and the system. Alternatively, help documentation in written form needs to be provided.

3.5.2. Grid connection

The PV Biogas Hybrid System shall be connected to the electricity grid as shown in the SLD from section 2.1. The only connection to the DISCO grid will be at the 200 kVA transformer at the biogas site. The 11 kV line including transformers will be built by a third party and is not part of the scope (see dotted box in SLD of chapter 2.1). The Employer will make sure that the consumer transformers at the buildings and the farm site are only connected to loads of the respective size and not to any other electric grid.

Included in the EPC scope is the control system that connects all PV, battery and biogas components into one controlled system (covering the shown distances of about 2 km). This control system shall also operate the islanding breaker (MV switchgear described in next chapter) near the biogas plant where the connection point to the DISCO grid is located.

The Contractor shall ensure that the appropriate safety and protection equipment, such as fuses and breakers, is installed between the electricity grid and PV Biogas Hybrid System. The Contractor shall include the appropriate safety and protection equipment in the system design.

The switching between grid and island mode shall be automatic and be operated by the control system of the PV Biogas Hybrid System.

The PV Biogas Hybrid System design shall be compatible with the net metering scheme of Pakistan.

3.5.3. MV Switchgear

MV Switchgear

The MV Switchgear shall be SF6 gas insulated or VCB (Vacuum circuit breaker). The MV Switchgear shall be automatic so that it can be controlled by the control system. The separating equipment shall be installed with visible disconnection (pivotable disconnectors). Interlocks will also be mechanically interlocked between line MV switchgears.

The following design factors need to be detailed in the Bid:

Table 24: To be provided Technical Characteristics of MV Switchgear

No	Characteristic
1.	Manufacturer information
2.	Datasheet including System nominal voltage, System maximum voltage, Rated lightning impulse voltage, Rated power frequency withstand voltage, Rated short circuit current, Rated duration of short circuit current
3.	Certifications
4	Warranties

Standards:

- IEC 62446
- IEC 62271-200
- IEC 60529

- Other applicable standards

3.5.4. Surge Protection Devices and Lightening Protection

Each PV Biogas Hybrid System shall have surge protection devices connected externally to the inverter on the following sides. The SPD supplied must be certified according to IEC 61643-11.

1) Grid input side – Type 2
2) PV input side – Type 2

The following technical characteristics have to be provided by the bidder:

Table 25: To be provided Technical Characteristics of surge protection device

No	Characteristic
1.	Manufacturer information
2.	Datasheet
3.	Certifications
4	Warranties

Furthermore, the mounting structure must be equipped with adequate grounding of the complete structure.

3.6. Site Preparation

The Contractor shall provide mounting structures and all civil works in accordance with the site conditions. The Contractor shall be fully responsible for the required examination of ground conditions in order to determine the required parameters for the design of the PV Biogas Hybrid System including the structural analysis and the earthing concept/calculations. Site works shall include provision of all roads and open spaces required within the site for operation and maintenance of biogas plant (substrate delivery, slurry collection etc.).

For solar and battery plants, the existing infrastructure (buildings, roads, electric connection points) needs to be taken into account.

The site layout plant will be part of the design documents and will be subject to approval by the Consultant.

3.7. Other Infrastructure

3.7.1. Earthing

A comprehensive description and drawing of the earthing concept shall be provided by the bidder. The PV Biogas Hybrid System shall be properly grounded to ensure safety of the PV Biogas Hybrid System, the electricity grid and the connected loads.

The Contractor shall provide and install the suitable earthing pits on-site. For the rooftop installations, earthing connection points may be provided by the respective buildings; however, in case of absence of suitable connection points, it is the Contractor's responsibility to foresee the required earthing by additional pits.

The ground electrode shall be designed according to the Electricity Act of Pakistan. It is required that the ground electrode shall have a ground resistance of 5 Ohms or less. If the installation of one ground electrode does not meet the 5 Ohm requirement, an additional installation of the ground electrode

will be required, or a change in sizing of the electrode or a change in composition of charcoal and salts will be made to satisfy the criteria.

3.7.2. Safety

The EPC Contractor must fulfil all applicable health and safety requirements of the authorities of Pakistan during the construction phase as well as during the Operation and Maintenance phase.

The Biogas System must have all the safety elements required to assure the correct operation of the system, including pressure relief and safety valves. All biogas pipelines must have all the safety elements required to ensure the correct operation of the system, including pressure relief and safety valves, traps, etc. The equipment that is essential for the success of the safety measures must be supplied with electrical power for at least 3 hours in case of interruptions of the public grid supply or the PV systems.

All electrical and mechanical devices must be appropriately labelled according to the respective explosive area (zone 0, 1 or 2 according to Annex F: Safety Rules for Biogas Systems).

The site must also be equipped with all necessary safety features such as fire extinguishers and other as per local regulation and technical common sense.

For the biogas system, the quality requirements and design recommendations of the Annex F: Safety Rules for Biogas Systems shall be considered and valid for the selection and the installation of every component and equipment of the biogas plants.

All electric parts of the system (PV system, batteries, inverters, breakers, transformers, grid connection etc.) shall have all required protection and safety gears as required by the Electricity Act of Pakistan. International norms for grid-connected electric installations (LV/MV) shall also be fulfilled in order to ensure safety of humans and protection of equipment.

The safety plan shall be part of the design documents and will be subject to approval by the Consultant.

3.8. Labelling

An ID numbering / coding system shall allow unique identification of all components of all PV Biogas Hybrid Systems. It shall follow international best practice. The logic/syntax shall be understandable, and a manual shall be provided to the Employer for review and approval prior to the start of construction phase.

The following characteristics of the ID numbering / coding system are required as a minimum:

I. Tags shall be weather and UV resistant.
II. Warning signs shall be placed at outer existing wall, entrance gate and on the exterior of all components according to international standards.
III. Labelling shall be provided for the following as a minimum:
   - PV inverter(s).
   - PV modules.
   - Supporting structure tables.
   - DC string cables.
   - AC cables.
   - Grounding system.

- Battery/electricity storage system.
- Solid feeder
- All Pumps and stirrers
- Gas blower and chiller
- Electric valves
- Air pump and compressors
- Further components (e.g. remote monitoring system).

IV. Numbering system shall already be applied during the construction phase.

V. The IDs shall correspond to all design drawings, as-built documentation and remote monitoring system.

3.9. PV Biogas Hybrid System Documentation

The complete as-built documentation of the PV Biogas Hybrid Systems shall be provided.

PV System documentation shall be in compliance with IEC 62446. Additionally, all serial numbers of the PV modules shall be listed including its individual location within the PV Biogas Hybrid System. Flash report list and electroluminescence images of all PV modules shall be provided in digital form.

For the biogas system, the Contractor shall provide all necessary documentation of each equipment, component, part and materials in English language including the declarations of conformity. For the biogas plant, the Contractor shall provide a detailed operation manual including maintenance plan, safety guidelines and fire protection plan according to the local standards. Besides the instructions on the daily safe operation of the biogas plant, the operation manual shall include instructions for initial startup, restart and a safe shut down of the biogas plant, operations instruction in the case of malfunction of equipment, an alarm and hazard defense plan.

3.10. Spare Parts Inventory

By or before the operations start date, the Contractor shall setup a spare parts inventory at the site. During the construction of commissioning phase of the PV Biogas Hybrid System, the spare parts inventory has to be set-up and maintained.

The spare parts inventory shall be maintained and replenished throughout the entire O&M period by the Contractor.

In the event that any portion or all of the spare parts are used during the course of the O&M period, the Contractor shall ensure that the spare parts inventory will be replenished within the same quarter of the year.

At the end of the O&M period i.e. the Contract Completion Date, the Contractor shall hand over all spare parts to the Employer, free of any additional cost, charges or fee.

Spare parts shall cover the complete PV Biogas Hybrid System with all subsystems as listed below:

Table 26: To be provided spare parts

No	Item Description	Quantity (if percentage is less than one piece: provide one piece)
1	PV modules	3 %
2	Inverter(s)	N-1 security
3	Battery cells	2 %
4	Electrical system (LV). i.e. breakers/contactors	2 %

5	DC and AC cabling	3 %
6	Safety relays	2 %
7	Rotor blades for stirrers	1 for each stirrer
8	Filter basket and spare part set for press screw separator	1
9	Pneumatic valve according to specifications above	1
10	Manual valve according to specifications above	1
11	Spare part set for CHP unit (lubrication, set of ignition plug, sealings, etc.)	1
12	Activated carbon for external desulfurization for min. 2 fillings	1

3.11. Equipment and System Warranty

3.11.1. PV System

The Contractor shall provide complete components, system and installation workmanship warranty of 2 years with below mentioned exceptions. After the first 2 years of operations the Employer will assess the status of each PV Biogas Hybrid System.

PV Module Product Warranty

The Contractor shall provide a PV module product warranty of at least 10 years.

PV Module Performance Guarantee

The Contractor shall provide a PV module Performance Guarantee (ensuring the maximum annual degradation of the PV modules) which shall be linear with a fixed annual factor over 25 years.

Battery Warranties

The Contractor shall provide a product warranty for the lithium ion batteries of at least 2 years and a performance guarantee of 8 years.

Supporting Structure Warranty

The Contractor shall provide a product warranty for the supporting structure of at least 10 years.

The guarantees from equipment and component manufacturers shall be procured by the EPC Contractor for the Project and transferred to the Employer (transfer of rights needs to be defined in EPC Contract).

Additional guarantees may be agreed and defined in the EPC Contract. A detailed list of all warranty/guarantee conditions for the main equipment shall be defined in the EPC Contract.

3.11.2. Biogas system

At least 1 year of guarantee for the biogas system is required. This includes:

- Replacement of equipment in case of rupture / breakage
- Supply of spare parts
- Technical advice remotely
- Technical advice in situ in case of a shutdown of the whole plant

Construction Product Warranty

The EPC Contractor shall provide a product warranty for all tanks, buildings, pipelines and fundaments of at least 5 years.

Product Warranty for electrical and mechanical equipment

The EPC Contractor shall provide a product warranty for electrical and mechanical equipment of at least 1 year.

The guarantees from equipment and component manufacturers shall be procured by the EPC Contractor for the Project and transferred to the Employer (transfer of rights needs to be defined in EPC Contract).

Additional guarantees may be agreed and defined in the EPC Contract. A detailed list of all warranty/guarantee conditions for the main equipment shall be defined in the EPC Contract.

3.12. Miscellaneous

A state-of-the-art PV Biogas Hybrid System is required. The fulfilment of all relevant IEC and Pakistani Norms, standards and regulations is full responsibility of the Contractor.

4. Scope of Services for O&M Works

The PV Biogas Hybrid System is designed for an operation lifetime of at least 25 years. Its optimal performance is sensitive to best-in-class O&M practices, which will ensure the best performance during the 25-years period. The bidder is required to describe in detail his definite plans how to execute the below described requirements for the O&M period. As part of that the bidder shall provide an organisational chart and CVs of the O&M staff as well as the locations where staff will be located (site, office).

4.1. General Scope of Work

The Contractor shall provide operational guarantee for the PV Biogas Hybrid System for the first 2 (two) years after commissioning. Any repair or replacement of component(s) shall be at the expense of the Contractor. The Contractor will provide the complete O&M service during this duration at his own expense.

The Contractor has to warrant the performance of the PV Biogas Hybrid System within his area of influence, as well as the availability and time consumed for detection of malfunctions and its repair. During the O&M period, the Contractor shall provide a full-service Operation and Maintenance in order to maintain a fully functional PV Biogas Hybrid System including all equipment, subsystems and structures.

This shall include, but not be limited to, the following items:

- Substrate management, incl. coordination of the logistics, substrate procurement, quality assurance, storage, feeding and digestate disposal
- 24/7 on-site monitoring and control of the PV Biogas Hybrid System
- Technical operation of the PV Biogas Hybrid System including presence of O&M personnel close to the Project site as required to fulfil all O&M Contract obligations.
- Preventive maintenance according to maintenance programs, such as periodic preventive maintenance of inverters, batteries, pumps, motors, valves, agitators, gas membranes, filters, generators and PV modules etc., according to manufacturers' requirements.
- Scheduled inspection routines: e.g. PV modules to check for discoloration, first signs of delamination, loose wires in the electronics, corrosion of mounting structures, erosion.
- Maintenance of spare parts inventory (prompt replenishment of used spare parts) including continuous reporting of status and consumption.
- Corrective maintenance with guaranteed response and reaction times, including all repair and replacement costs.
- Daily cleaning of the PV Biogas Hybrid System site, preventive and corrective maintenance of civil works and cabinets.
- Ensuring smooth functioning of data communications over Remote Monitoring System.
- Provision of quarterly service reports about performance, repairs, maintenance, and tests.
- Ensuring that any warranties and insurance policies for the PV Biogas Hybrid System are assignable / transferrable to Employer in case of change of Contractor.
- Provision of all O&M personnel, trained and certified as far as applicable. The staffing concept and selected key employees shall be presented to the Employer for approval.

- Arrangement of service contracts with specialized sub-contractors, permitting the requested response and reaction times and quality of work required to maintain the PV Biogas Hybrid System.
- Report of O&M activities in a monthly report

4.1.1. Hiring / Training Period / Initial Inspection

The Contractor's Personnel must be nominated by the Contractor no later than 8 weeks prior to operations start date of the PV Biogas Hybrid System and contractually hired no later than 4 weeks prior to operations start date of the PV Biogas Hybrid System.

During the construction phase of the PV Biogas Hybrid System, the Contractor's Personnel shall familiarize itself with the PV Biogas Hybrid System and its documentation, to enable an efficient operation & maintenance. The staff on site shall also understand all pending items (e.g. punch-list) and performance deficits (if any) for which the EPC Contractor is responsible for, after operations start date.

The O&M Contractor shall familiarize himself with the specific PV Biogas Hybrid System equipment and maintenance requirements as imposed by the component manufacturers and Employer. In addition, the O&M Contractor shall arrange and provide all training as a prerequisite for the selected staff, and provide the respective certificates.

The EPC Contractor will be required to deliver at least 16 hours of theoretical and hands-on training to the operators and further individuals as selected by the Employer.

The training shall include a maintenance and safety plan for the installed equipment and the corresponding documentation, as well as for information about hazards that results from the installation conditions.

The O&M Contractor's key staff shall be available for all training at the PV Biogas Hybrid System site. This must include all equipment provided by the Contractor within the Contractor's scope of supply, even if training has already been provided prior to start of commercial operation of the PV Biogas Hybrid System.

The O&M Contractor shall establish all maintenance routines, inspection checklists, working files, etc. as required.

At this phase, the O&M Contractor must always coordinate with Employer and keep Employer updated regarding progress of preparation, status of construction, pending issues of construction, commissioning and testing.

4.1.2. Allocation of Operating Staff

The contractor will provide operating staff, trained and certified, for each of the plants. The staffing schedule shall ensure that there is always one operator present on site on a 24/7 basis throughout the year. Operator shall be sufficiently trained to operate the plant and control system, make adjustments to operating parameters, perform safety measures such as emergency shutdowns, inspect all components etc.

4.1.1. Operational manual

The EPC Contractor shall develop an operational manual for the PV Biogas Hybrid System and all its components and raw and operating materials (such as substrate, active carbon and other consumables etc.), including the appropriate technical specifications, operation safety guidelines, fire and explosion protection plan and maintenance instructions.

4.1.2. Allocation of O&M Personnel

The Contractor will provide all O&M personnel, trained and certified, as far as required additionally to the operator. The staffing concept and selected key employees shall be presented to the Employer for approval.

The Contractor shall arrange service contracts with specialized sub-contractors permitting the requested response times and the required quality of work to maintain the PV Biogas Hybrid System.

4.1.1. Bank Guarantee/Performance Security

A bank guarantee issued by an internationally reputable bank amounting to 10% of the total EPC and O&M contract value will have to be submitted by the Contractor to the Employer upon the award of contract. This bank guarantee will only be returned after the successful completion of the two-year O&M period. Any remaining shortcomings by the O&M contractor during this period will have to be fully rectified or financially compensated before the returning of the bank guarantee. If it seems likely from previous faults or findings that specific components or installations might cause a warranty claim within the warranty period, then the Employer will withhold that expected sum from the final payment (retention/performance bond).

4.2. Scope of Supply and Services for the O&M of PV Biogas Hybrid System

4.2.1. Daily Operation of the Biogas System

The biogas system requires the 24/7 on-site availability of at least one trained person in charge (in the following: the operator) for the safe and efficient operation of the plant. The operator will conduct the following tasks.

4.2.1.1. *Substrate management and feeding*

- Procurement and payment coordination of input substrate and logistics in cooperation with the Client (see also 4.2.10 and Instructions to Bidders section)
- Quality control and adequate storage and management of incoming substrate. Quality control of the substrate should at least be visual. Impurities, such as stones etc. shall be removed immediately during reception, storage and feeding.
- Manual feeding of the reception tank according to the process instructions. The feeding intervals shall be conducted constantly in small charges (at least twice per day) in order not to destabilize the biogas process.
- Coordination and storage of the solid digestate for fertilizer purposes
- Coordination of distribution of liquid digestate, if necessary

4.2.1.2. *Maintaining of Daily Operation Log*

The operator shall document the main process parameters on daily basis in the operation log, which includes:

a) Amount and type of fed substrates for biogas plants
b) Maintenance works and results
c) Unusual incidents and undertaken measures

Although above stated information from a) to c) shall also be documented in digital form within the automation software, the daily operation log shall be maintained manually.

4.2.1.3. *Plant Control and Management*

The operator shall monitor and adjust the operation of all relevant equipment which assure the expected biogas production yield and quality and the respective electricity generation. Substrate quality, outside temperature, malfunctions and other conditions and circumstances may require the adjustment of operation time and intervals of pumps, agitators, valves, separator, blowers and generators, which shall be done by the respectively trained operator.

4.2.1.4. *Standby-duty for malfunctions, unexpected damages and hazards*

The Operator needs to make sure that any failures of equipment are detected immediately, and measures are established to avoid any damage to the plant, environmental or person injury of involved staff or the neighboring communities. The standby-duty requires a reaction time of maximum one hour on all automatic alarms and alerts, visual or other danger notices, e.g. from thirds, to ensure human safety and avoid damage of any system component.

All set malfunction alerts of lower impact, e.g. failure of monitoring sensors, must be checked by direct personal inspection of the respective equipment.

4.2.2. Regular Inspections and Maintenance of the Biogas System

Independent of the following maintenance instructions, the operating instructions of the manufacturers of all individual components must be observed, such as for pumps, agitators, blowers, valves, compressors, gas membranes, flare, meters and sensors, generators and flares, etc.

4.2.2.1. General Inspection Requirements

- During filling and emptying of tanks and vessels, attention must be given to pressure fluctuations and good accessibility to the operating equipment (pumps, agitators, blowers, valves, etc.) must be ensured.
- All kinds of ignition sources in the clarified zones of explosion protection must be avoided.

4.2.2.2. Daily Inspection Requirements

- Recording of the operation data further detailed under section 4.3
- Check of motor oil level of the generators
- Check of the process visualization, whether the malfunction lights are illuminated
- Check of water pressure in the substrate heating system
- Functional check of the air-dosing pump of the desulfurization system
- Selection of agitation and substrate feeding intervals, so that no layer of scum or sediment develops

- For all inlets and outlets, assure that the substrate flow is maintained according to the process regulations
- The injected airflow for desulphurization must be matched to the current gas production rate (max. 6% vol.)
- Check of fill levels of reception tank, main digester, separation tank and slurry pond
- Check of membranes connectors of the gas storages

4.2.2.3. *Weekly Inspection Requirements*

- Check of fill level of the sealing liquids in the overpressure and under-pressure protectors and condensate separators; if necessary, in the case of a danger of frost, check the antifreeze agent (if the weather warrants, daily checks are also required)
- Functional check of submerged pumps and agitators (propeller), observe whether vibrations are present
- Visual inspection of all electric motors (pumps, agitators, blowers, compressors, etc.) and the connection lines
- Check of biogas flare, gas pipeline valves for function, contamination and tightness
- Analysis of dry matter content and organic matter content of all input substrates and the digestate

4.2.2.4. *Monthly Inspection Requirements*

- Actuation of all mechanically moving equipment a few times so that they are not stuck
- Possibly remove the oil deposits in the CHP unit and clean the oil catch basin

4.2.2.5. *Bi-annual Inspection Requirements*

- Functional check of the ventilation and exhaust in the machine room of the generators and in the control room
- Inspection of the electrical systems for damage
- Functional check of the under-pressure monitor of the gas system
- Functional check of the gas sensors, fire detector

4.2.2.6. *Annual Inspection Requirements*

- Check of gas-carrying system parts for damage, tightness and corrosion
- Calibration of gas sensors and meters according to the manufacturers specification
- Functional check of the fire extinguishers (every 2 years)

4.2.2.7. *Inspections and Maintenance Requirements for the generators*

For the maintenance of the biogas generators and the CHP unit, the requirements of the manufacturers must be strictly followed and only trained personnel from service companies with the respective manufacturer`s references shall conduct all these maintenance activities which go beyond visual inspection and other activities, which the generator`s manufacturer authorizes to be conducted by the operator after the respective training. For this regard and especially if the Contractor is not the manufacturer of the generators, it is strongly recommended to contract a full maintenance service with the manufacturer or the local distributor of the generators.

4.2.3. Bi-annual Inspections of the PV System

The Contractor shall perform biannual inspections of the PV Biogas Hybrid System, preferably in spring and autumn, within a period of five (5) to seven (7) months from the previous inspection date. The first inspection takes place six (6) months after operations start date. The biannual inspections must follow the detailed inspection procedure and documented accordingly. The scope must include the following (as a minimum):

4.2.3.1. PV Modules and Supporting Structure

- Visual inspection of all PV modules regarding damage.
- Visual damage inspection of all accessible cable trenches and cable trays.
- Visual inspection and random testing of PV module DC connectors.
- Check for loosening of PV module clips. Clips should be replaced if necessary. (Scope: Min. 10% per inspection including documentation of location; 100% during 5-year PV Biogas Hybrid System inspection).
- Testing of sturdiness of mounting foundation / system and random substructure corrosion inspection.

4.2.3.2. Inverters

- Functional check of inverter ventilator system and filters (if applicable).
- Test of the internal circuit breakers and power switches, emergency shutoff test.
- Visual inspection of all fuses.
- Inspection of overvoltage protection and upstream fuses regarding external damage.
- Functional check of internal and external overvoltage and under voltage protection through operation of test terminal.
- Functional insulation monitoring check.
- Check of control and auxiliary voltages.
- Check of the safety circuit for the interruption of the AC-grid protection in the case of failure (emergency shutoff, over-/ under voltage, over temperature, etc.).
- Visual inspection of AC and DC clamps for tightness and discolouring, tightening of clamps.
- Inspection of the interior of the inverter regarding dust deposit, dirtiness, humidity, water penetration from outside. The inverter shall be cleaned if necessary.
- Testing of inverter features according to manufacturer's maintenance schedule.
- Maintenance of inverters according to manufacturer's instructions.

4.2.3.3. Battery Management System

- Inspection of the battery management system regarding dust deposit, dirtiness, humidity. The battery management system components shall be cleaned if necessary.
- Testing of battery management system features according to manufacturer's maintenance schedule.
- Maintenance of battery management system according to manufacturer's instructions.

4.2.3.4. Batteries / Electricity Storage

- Inspection of the exterior of the batteries regarding dust deposit, dirtiness, humidity. The batteries shall be cleaned if necessary.

- Testing of battery features according to manufacturer's maintenance schedule.
- Maintenance of batteries according to manufacturer's instructions

4.2.3.5. Container for Inverters and Batteries

- Functional check of container ventilator system and filters.
- Inspection of the interior of the electrical cabinet regarding dust deposit, dirtiness, humidity, water penetration from outside. The cabinet shall be cleaned if necessary.
- Visual damage inspection of all accessible cable trenches and cable trays.

4.2.3.6. Security System / Theft Protection

- Random test and retightening of security bolts if necessary, according to manufacturer's instructions.

4.2.3.7. Additional Inspections

- Functionality testing of the monitoring system and remote access.
- Adequacy of settings for battery charge settings.
- Maintenance of all PV Biogas Hybrid System components according to manufacturer's instructions.
- If applicable: Inspection of all aspects required from the applicable permits (environmental, building, etc.).

The Contractor must modify the inspections routines as well as the frequency of the special inspection in case of specific the requirements and/or norms will be defined or modified by relevant authorities in Pakistan, provider recommendations and/or grid operators.

4.2.4. Performance of Maintenance and Repair Works

The contractor will be responsible for performance of all necessary maintenance and repair works during the first two years. This includes the provision of the respective maintenance material as e.g. all required lubricants, filters, ignition plugs etc. as well as repair and replacement of all components as required for a smooth and efficient functioning of the plant, be it from component failure, wear and tear or wrong operation. The contractor is encouraged to make use of component warranties as applicable by the respective suppliers to minimize his costs.

The results of the inspection and maintenance works, as well as the deactivations, must be documented in a report (blank maintenance report example shall be delivered by the Contractor as part of the O&M Works and the Consultant will review and comment for improvement).

For the performance of the contractual services, the Contractor will be obliged to observe and respect the component manufacturer's maintenance and operation specifications and regulations (especially for the PV modules, inverters and batteries and the equipment of the biogas plant), in particular during the warranty period.

For the performance of the contractual services, the Contractor will be obliged to observe and respect local laws, regulations and international PV and biogas standards.

Throughout the duration of the Contract, the Contractor will be held responsible for public safety at the PV Biogas Hybrid System.

4.2.5. Fault management

Every fault message must be registered and stored by the on-site and remote monitoring software. According to the fault message, the Contractor will issue a fault diagnosis within a response time of max. 1 hour (24/7) and, as far as possible, immediately restart the operation of the affected part of the PV Biogas Hybrid System.

- All fault messages and results relevant for the operation of the PV Biogas Hybrid System are to be documented on daily basis. Any fault messages resulting in fault calls must be documented in the corresponding monthly reports.
- Fault management procedures must include necessary communication of faults, coordination of on-site appointments with service staff or service partners, as well as the corresponding and general operational structure.
- Fault management procedures must include the preparation, handling and support in events covered by insurance, and the enforcement of claims for compensation to third parties, including the component manufacturers.
- The Contractor is obliged to identify potential warranty defects and support Employer in obtaining rectification from the respective manufacturer. The Contractor shall be responsible for coordinating through Employer all claims related to warranty defects and their rectification during the respective product warranty period.

4.2.6. Approval of Extensive Repairs

Extensive repairs requiring an amendment of the PV Biogas Hybrid System or an exchange of original equipment for different types (i.e. the installation of non-original components), must be approved by Employer. All non-original components (e. g. a specific inverter or battery type) must be procured from the original component manufacturer (e. g. the inverter manufacturer needs to remain the same, but the inverter or battery type can be modified).

4.2.7. Repair Works Documentation

All major repair works (defined as all repair works which require spare parts not fully provided by the spare parts inventory) and insurance compensations must be documented in the corresponding monthly reports.

4.2.8. Inspection of Repair Works

The Employer reserves the right to inspect the repair works within three months (90 days) of receiving the repair works documentation. Employer reserves the right to consult an independent expert in the event that any doubt arises as to the Contractor's performance.

4.2.9. Spare Parts Inventory and Maintenance Tools

The Contractor will provide a spare parts inventory by the start of O&M Period at the latest. The spare parts inventory will be located in a specific container (or separate section of battery or control system housings) with safety locks.

The Contractor shall operate and maintain the spare parts inventory during the term of the O&M Period. The Contractor will be responsible for the immediate replenishment of the spare parts. The Contractor is responsible to cover all cost for the replenishment of the spare parts inventory within its annual remuneration under the Agreement.

The status and consumption of the spare parts inventory must be included in the corresponding monthly reports.

The Contractor must provide the necessary set of maintenance tools to perform the services.

4.2.10. Scope of operation of the PV Biogas Hybrid System

The operation part of the O&M obligations of the Contractor consists of operation of the plant for two years. During this time, the Operator is responsible to operate the plant in a professional and responsible manner with the aim of maximizing the energy yield.

Framework conditions for this are as follows:

- **Operation**: The Operator is responsible for operating the plant in a way that maximizes output and maintains its substance and performance for a system lifetime of 20 years. The Operator shall provide trained personnel as required for continuous operation of the plant. The Operator also needs to make sure that any failures of equipment are detected immediately and taken measures are taken to avoid any damage to the plant. See also 4.2.1 and following chapters.
- **Electric connection and arrangement**: The electricity produced by the plant will go into the electric grid at the connection point provided by the DISCO (see 3.5.2). This will be both the case for operation when the electric grid is available and for island grid operation, where the island switch is open and the plant itself establishes the island grid and supplies directly to the connected buildings via the island grid.
- **Substrate management and logistics:** The substrate management and logistics is fully in the hands of the Operator.
- **Cattle dung availability:** Cattle dung availability has been analyzed in a separate document (see Annex I: Cattle dung availability).
- **Other biomass**: The assessment of market prices and availability of other biomass types such as silage, chicken manure etc. is up to the bidder. Only biomass which does not affect the function or cause any damages or increased tear and wear of the biogas plants possess any environmental or social negative impacts is permitted for use; the final decision whether a specific biomass is permitted is on the Owner.

4.3. Reporting of all O&M Activities

The reporting of O&M activities shall be conducted via the daily operation log, monthly and annual reports. Monthly and annual reports based on the data of the remote monitoring are to be prepared by O&M Contractor and provided to Employer within 4 four weeks after the end of the corresponding reporting period. The reports must include the documentation of the production results and the explanation any deviations from the expected performance of the PV Biogas Hybrid System in the daily operation log.

Any fault messages resulting in fault calls must be documented as well in the daily operation log as in the corresponding monthly reports indicating start and end of fault, reason and/or any performed repair works, as well as the respective components of the PV Biogas Hybrid System.

The status and consumption of the spare parts inventory must be included in the corresponding monthly reports.

The results of inspection, performed maintenance works and biologic analysis of the biogas plants, as well as deactivations must also be documented in a report.

The specific reporting format of each report type will be subject to review and approval by Employer and its Consultant prior to the execution of the O&M Contract.

4.4. Miscellaneous

4.4.1. Change of Inspection and Maintenance Work Procedures

The Contractor shall perform the work in accordance with all applicable laws. In case of conflict between the specified requirements and the applicable law, the Contractor shall propose a solution to adapt the works accordingly and resolve the matter in a mutual sense for Employer's approval.

4.4.2. Person in Control of PV Biogas Hybrid Systems

The Contractor must propose at least one main responsible and suitable person in charge of the PV Biogas Hybrid Systems, the "O&M Manager". This person must fulfil all local requirements, permits and standards, must have sufficient experience and be approved by Employer. Any replacement or substitute of these persons will be subject to approval by Employer.

4.4.3. Handover of Documentation after end of O&M Contract

Within one month after the end of the O&M Contract, the Contractor must hand over the complete electronic, printed and written documentation for the O&M of the PV Biogas Hybrid Systems. This includes the complete documentation which was previously handed over to the Contractor by Employer or its service provider. This also includes the complete raw data of the PV Biogas Hybrid System monitoring acquired though the monitoring system.

4.5. Codes, Standards, Régulations, Permit, etc.

State of the art O&M is required. The fulfilment of all relevant IEC and Pakistani norms, standards and regulations including grid connection requirements is the full responsibility of the Contractor.

The Contractor must comply with all applicable permits and the conditions imposed on the PV Biogas Hybrid System by all authorities.

The Contractor must fulfil all applicable health and safety standards required by the relevant Pakistani authorities during the entire Operation and Maintenance phase.

A CE conformity declaration for all installed equipment of the PV Biogas Hybrid System must be included into the documentation of the plant.

5. Independent Quality Assurance and Validation of the Components

5.1. Quality Assurance for PV Modules Pre-Shipment

i. Pre-shipment flash tested data shall be provided for each PV module. The sun simulator must meet the class AAA requirements of IEC 60904-9. The sun simulator must be calibrated with a reference cell, which itself was calibrated by a member of the WPVS scheme, with a maximum uncertainty of Isc of 1 %. The flash testing report shall contain the unique barcode and labelled performance headlines (maximum power, short- circuit current, open-circuit voltage,) of the PV module. The flash-test data must be equal to or higher than the single nameplate ratings of the PV module supply. The testing and calibration may be witnessed by the Employer or its Consultant / laboratory selected by the Consultant.

ii. A narrow range of PV module power tolerances is expected.

iii. All PV modules must undergo Electroluminescence (EL) inspection with a resolution of minimum 4 Mega Pixel prior to shipment. The EL pictures must be provided to Employer at the time of the shipment. A maximum of 5 minor defects and no major defects per PV module are allowed.

iv. A sufficient EVA cross linking of 75% has to be verified per production line through a gel content test supervised by an accredited independent certified PV module testing agency (accepted by Employer).

5.2. Quality Assurance for PV Modules Post-Shipment

3 PV module samples shall be taken by a testing laboratory which is selected by the designated Consultant, in order to perform Electroluminescence inspection tests (EL imaging). The analysis shall be performed in order to ensure that no transport damage occurred to the PV modules as basis for the operations start date acceptance. In case of there is a clear evidence of shipment damage, where multiple major defect(s) are found in the PV modules, the delivery container shall be rejected. In this case the Contractor may request to inspect all PV modules on-site and replace the PV modules with major defects at its own cost. The cost of such additional testing is not included in the quality assurance cost of the PV Biogas Hybrid Systems.

5.3. Quality Assurance for Inverters

The Contractor will conduct/accept the following quality assurance tasks for inverters:

I. Factory acceptance tests of the inverters shall be well documented for gauging quality standards of the inverter.
II. Check of protection against overload, short-circuit, grid-failure, internal failure, over-temperature (de-rating), surge protection, detection of insulation faults of AC cables.
III. Test run in the field for maximum and European efficiency of all inverters.
IV. The Contractor shall deliver detailed protocols of performance test run (warm power test) for every single inverter.

V. After commissioning, sample inverters may be measured for the following on-site, by an approved independent technical consultant on behalf of the Employer. The following tests will be performed.
   - DC-AC conversion efficiency (maximum and European efficiency).
   - Thermography / temperature measurement.

5.4. Component Inspections after Delivery

The components and equipment of the PV Biogas Hybrid System shall be checked by Consultant after arrival on site and evaluated based on the laboratory tests, datasheets, quantity and requirements defined in the Employer's Requirements.

6. Acceptance Procedure

6.1. General Acceptance Conditions

Each PV Biogas Hybrid System and its components shall be checked regarding completion and functionality. The Employer may also demand that some components undergo a performance test, based on guaranteed performance data, as a precondition for the complete system performance and acceptance test.
There will be two separated acceptance procedures, being described in the following chapters:

- Works Acceptance Procedure
- Performance Acceptance Procedure

6.2. Works Acceptance Procedure

1) Completion Certificates - Civil

For the PV Biogas Hybrid System, prior to start of mechanical erection, all platforms, foundations and tanks shall be checked and certified to be in accordance with drawings and design requirements for the individual site.

Certificates shall be provided with original signatures from the civil and the mechanical works supervisor and shall be kept and form part of project documentation.

2) Completion Certificates - Mechanical

For the PV Biogas Hybrid System, mechanical completion shall be checked and certified prior to start of electrical works. Checks shall verify accordance with construction drawings and manuals, workmanship, alignment, no damages on materials, etc.

Certificates shall be provided with original signatures from the mechanical and the electrical works supervisor of the EPC Contractor and shall be kept and form part of project documentation.

3) Completion Certificates - Electrical

For the PV Biogas Hybrid System, electrical completion shall be checked and certified prior to testing of systems. Checks shall verify accordance with construction drawings, proper routing, bending and fixing of cables (UV protection, bending protection, etc.) and certify the correct connection of each cable, testing of cable, labelling, etc.

Certificates shall be provided with original signatures from the electrical works and the commissioning supervisor of the EPC Contractor and shall be kept and form part of project documentation.

Defects or deficiencies in the construction or the installation of the equipment shall be effaced according to the agreed terms and valid (FIDIC Gold Book). Only after removing all announced defects or deficiencies the final payment of the EPC contract will be executed accordingly.

6.3. Performance Acceptance Procedure

For performance tests, the testing parameters will be

1. PV System: Performance Ratio (PR / %)
2. Battery system: Output power (kW / kVA)
3. Automatic switching between grid and island mode and successful simultaneous feed-in of PV, Biogas and Battery Systems (functional test, no specific number to be reached)
4. Biogas system: Process performance in terms of biogas yield and quality and output power of CHP and generator (kW/kVA) and efficiency of the same (%) (see 6.3.2 for more details).

All parameters need to reach the specified values as per these Bidding Documents or, if specified otherwise in the later Contract, as per Contract. For point 3, the functionality needs to be demonstrated.

Based on the information in this section, the successful bidder shall prepare a detailed commissioning and performance test procedure and protocol in line with the applicable norms and standards for PV Biogas Hybrid Systems for points 1 and 2 for approval from Employer/Consultant (for point 4, testing procedure is defined in the following). Employer/Consultant will comment on the proposed procedure and EPC Contractor will adjust accordingly until a mutually agreed procedure is defined.

The EPC Contractor has to announce the acceptance tests 5 days before its execution to the Employer.

6.3.1. PV System

If the EPC Contractor fails to meet the specified values, he has the possibility to adjust the plant configuration at his own cost and initiate new acceptance tests.

6.3.2. Biogas System

The process acceptance will be issued after verification of the following process parameters:

The biogas plant reaches a constant biogas production of 53.2 Nm³/h with a methane content of 55% by using the given substrates according to Table 27.

Table 27: Biogas Production of Substrates

Biogas Production of Substrates									
Substrates	**Fresh Material**		**DM**	**oDM**	**oDM**	**Production of CH4**		**Production of biogas**	
	t/a	**t/d**	**% FM**	**% DMS**	**t/d**	**%**	**m³/day**	**l/kg oDM**	**m³/day**
Cattle dung	2,737	8.22	40.0%	75%	**2.47**	55%	407	300.0	740
Chicken manure (dry)	416	1.25	65.0%	75%	**0.61**	60%	183	550.0	304
Corn silage	5,000	1.5	32.0%	94%	**0.45**	55%	149	650.0	248

Water and recirculated liquid phase	6,660 *	20*	0.0%	0%	**0**	0%	0	0.0	0
Total	10,313*	31*	14.8%*		**3.5**		738		1,292

*(t.b.d by Contractor)

Since especially the DM of the substrates may vary significantly, the required biogas and methane yields will be measured according to the available and fed amount of organic matter of these substrates (see column oDM in t/d in the table above).

Depending on the average organic dry matter feeding amount of the whole substrate mix, the expected biogas yield is 350 m³ of biogas per ton of organic dry matter and 192.5 m³ of methane per ton of organic dry matter. Any deviation in provided amount of the above given substrates or their dry matter and organic dry matter content are under the responsibility of the Employer and are therefore considered for the calculation of the required biogas yield to be reached in favor to the Contractor. Therefore, measurements of the overall quantity, the DM and the oDM are taken during the process acceptance period over 5 days with 3 samples per day and substrate.

The gas production and gas quality shall comply with the above given values. There must be taken 3 samples/measurements a day. The gas quantity will be converted into standard cubic meter.

The gas quality must reach 55 % methane content. This value is the intermediate value from a measuring period over 5 days with 4 samples a day. The measuring point is before the desulphurization.

If the gas production is lower or higher than the contract value and the gas quality in return is higher or lower, the deviation can be credited to the other value taking into account the primary energy produced. For verification of the contract values the average values from all measurements over the period of 5 days is taken.

The electricity outputs of the CHP unit and the simple generator have to reach an electrical efficiency of 35%. The output will be measured in kWh_{el} and compared to the amount of input in Nm³ of methane (assumed lower heating value of methane = 9,986 kWh/Nm³).

The EPC Contractor must announce the process acceptance 5 days before its execution to the Employer. If the EPC Contractor fails to meet the contract values he has in total three trials for the process acceptance. On the other hand, the Employer must ensure the substrate characteristics for the test. The Employer has in total two trials for the supply of the substrate mix characteristics that meet the contract conditions with a tolerance of 30%. There can be in maximum 20 days between the single trials.

If the EPC Contractor fails to meet the contract values he has the possibility to adjust the plant configuration without costs for the Employer and start a new process acceptance.

If the Employer fails to supply the above given substrate combination meeting the contract conditions within the modalities mentioned above, the process acceptance shall be deemed to be passed.

When the process acceptance has been passed, both parties shall sign the process acceptance.

6.3.3. Penalties

In case the commissioning of the plant is delayed beyond the time plan which is stated in the contract, the final payment to the EPC Contractor will be reduced by the equivalent of the revenues that the plant would have generated during this time (at the applicable net metering or grid electricity retail tariff to the UAF, whichever is higher). Exempted is *Force majeure*.

In case of any dispute, the Golden Book by FIDIC will apply.

Additionally, for the PV System, in case the EPC Contractor fails to meet the specified values within 30 (thirty) days of the first acceptance test intent, the Employer has the right to reject parts of the respective system (e.g., the inverters of the solar system in case the PR is not reached), reduce payments to Contractor accordingly and finish the plant at his own cost.

Additionally, for the Biogas System, if the EPC Contractor fails to meet the contract values for gas or electricity output for the given substrate even after three trials for rectification, a penalty will apply which will be a percentage of up to 10 % of the total biogas plant construction costs, where the percentage is defined by the difference between the actual electricity or gas value and the contract value (electricity output or gas content, whichever is lower).

6.4. Taking Over Criteria and Certificate

Upon the end of the initial O&M period of two (2) years, the Employer will hire a third party technical expert to perform a detailed inspection of the PV Biogas Hybrid System prior to issuing the Final Acceptance Certificate to the Contractor. The Contractor shall ensure, prior to the inspection, to have rectified all warranty defects and shall have replaced all warranty spare parts consumed.

The third party technical expert shall perform the following measures in order to evaluate the correct functionality of the PV Biogas Hybrid System:

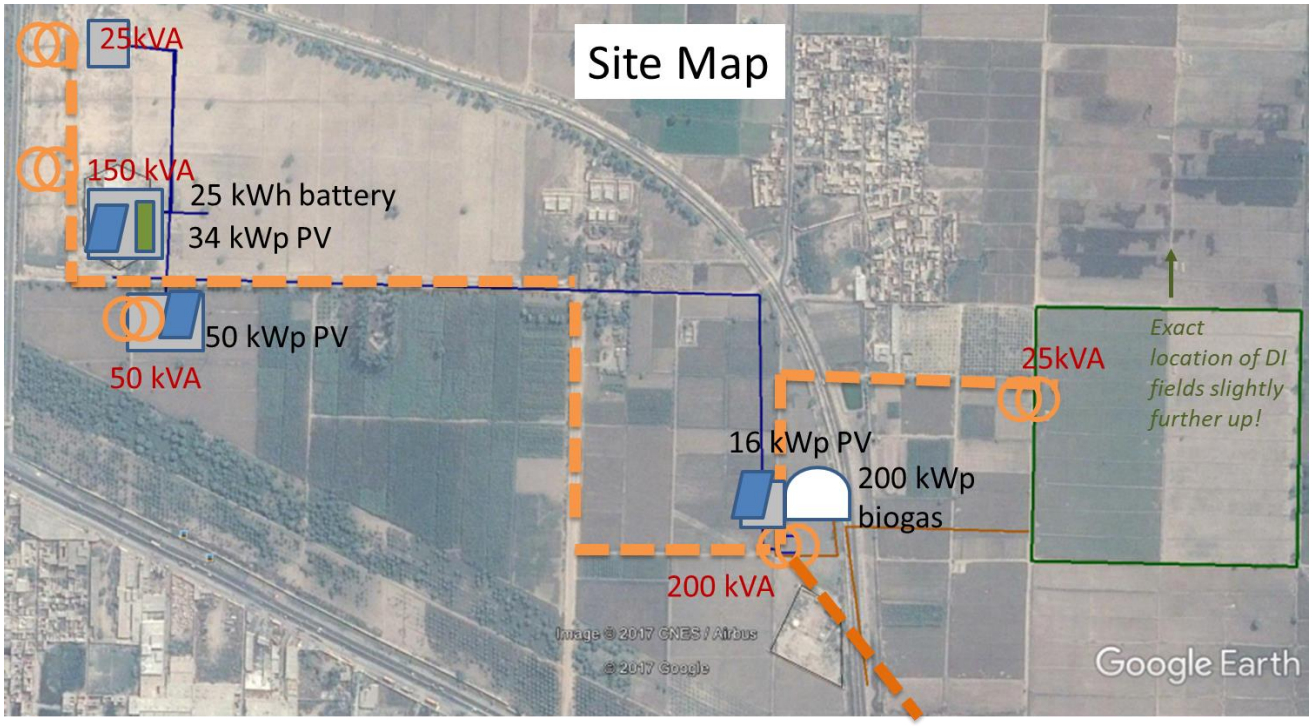
a) Visual Inspection of each PV Biogas Hybrid System in order to determine the state of the complete system and the individual components. The PV Biogas Hybrid System shall be fully operational and work according to the functional specifications of the Employer's Requirements. All components (inverters, PV modules, batteries, etc. and its sub-components) shall be fully operational.

b) Inspection of operating data of the PV Biogas Hybrid System in order to determine the functional state of the complete system and the individual components.

The Certificate for Final Acceptance will be issued once these inspections have been completed positively, and in any case only after the successful completion of all the tests mentioned in the Performance Acceptance Procedure.

Upon successful Taking Over, the bank guarantee as per 4.1.1 will be released.

Annex A: Site Map and Description



	UAF 11 kV line
	FESCO 11 kV line
50 kVA	Transformer ratings
200 kWp	Generation capacities (peak power)
	Buildings (not to scale)

Transformers (not part of EPC scope):

- Hostel: 25 kVA
- Energy system building: 200 kVA (load will be limited to 150 kW max.)
- Laboratory building: 50 kVA
- Drip irrigation: 25 kVA (drip irrigation of 30 acres)

Load Profile: Laboratory and Energy system buildings mainly daytime use, hostel mainly evening and night time use.

PV on buildings

- Laboratory Building: 50 kWp
- Energy system Building: 34 kWp (to the front of the building for visibility)
- Small control building: 16 kWp
- Total: 100 kWp

Biogas:

- 100 kW average generation (8,000h per year), 200 kW peak

11 kV line:

The 11 kV line including transformers is NOT part of the EPC scope; it will be constructed by a third party.

Part of the EPC scope, however, is the control system that shall encompass all PV, battery and biogas components and shall control the grid connection/disconnection switch.

Annex B: Excel-Format of Component Checklist

Will be provided as additional Excel or zip-file.

For each Component/Subtopic as per the “Annex B Component Info” in the provided Excel sheet, the Bidder shall make a separate folder in his soft-copy part of the bid, in which the respective documentation is placed.

Annex C: Information and Structure of Technical Concept of Technical Bid

(See also Schedules to Bid A and F and evaluation information in Excel Sheet)

The following documentations have to be provided in the bid, in the same sequence as given here. Approximate page numbers are given to the bidder for orientation; they don't need to be matched exactly, but information which is highly insufficient or highly excessive might be given less score.

The bidders must ensure that the proposed equipment meets all the requirements mentioned under these sections. All proposed components of the PV Biogas Hybrid System will be verified and will serve as basis for the technical evaluation. The bidders will not be allowed to change any component after the submission of the bid.

1. Functional requirements (SCHEDULE – A TO BID):
    a. Description of the system proposed by the bidder in words: general overview, functionality, special features etc. (3 pages)
    b. SLD of overall system for both sites separately, with protection functions, including all required protection devices, ratings of components and overall functional design to demonstrate inter-compatibility of the individual components, in line with specifications from 2.1
    c. Layouts of Biogas System for both sites separately. This includes a preliminary flow-sheet diagram with all relevant civil and electro-mechanic components and equipment and a general layout of the constructions (tanks, pipelines, platforms, housings) for all main components of the biogas system.
    The layouts may be similar or different as the proposed design as per Annex D: Flow Diagram for Biogas System , but it must fulfill the functional requirements as per 2.2.
    d. General layout drawing of PV and Battery Systems of the PV Biogas Hybrid System including layout of the PV modules, inverter, batteries, container, etc. for both sites separately (minimum SLD and string plan including main breakers; rough physical layout). Must fulfill functional requirements as per 2.3.
2. EPC Scope, component specification (SCHEDULE – F TO BID):
    a. Component information: List of major electromechanical equipment suppliers, final product data, datasheets and specifications as defined in:
        i. Biogas: Supplier and model name for all major components of both plants as listed in 2.2; incl. data sheets for the following components: membranes, pumps, agitators, generators and CHP. Description and supplier of biogas control; all component information as specified in the relevant chapters (see 3.3 etc.)
        ii. PV and Battery: All component information as specified in the relevant chapters (see **Error! Reference source not found.**)
        iii. Grid connection and switchgears: Supplier and model name for all switchgears (automated and manual) and safety and surge protection devices. Must be compliant with 3.5.2, 3.5.3, 3.5.4.
        iv. Control: Description of the planned control system: Supplier and model name for main hardware (PLC), software solution description (platform, self- or

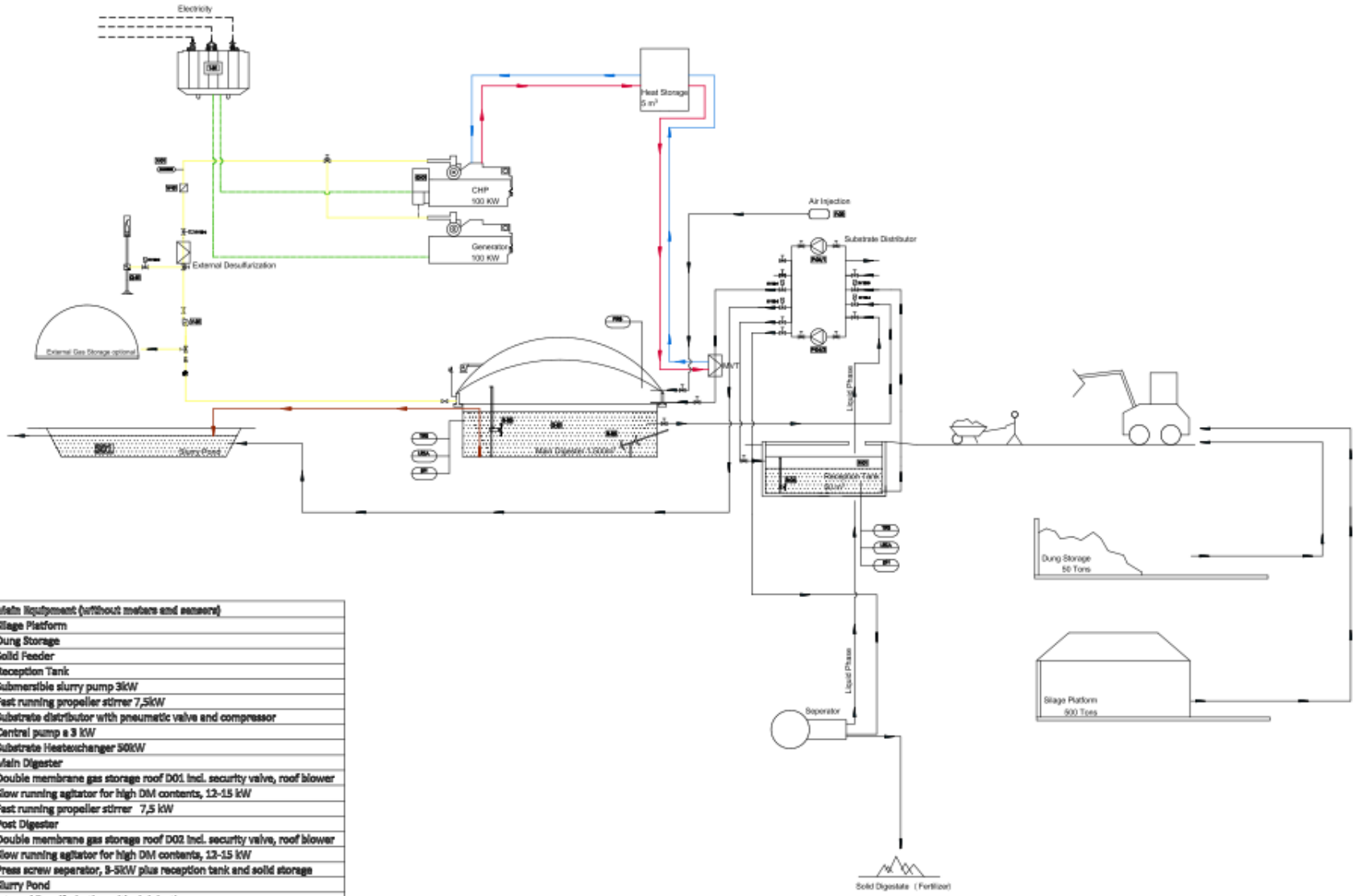
third-party developed, if possible 2-3 screenshots of HMI etc. – approx. 3 pages). Must be compliant with 3.5.1

b. Description of Component Warranties: Must comply with 3.11.

3. O&M Scope (SCHEDULE – A TO BID):
   a. Brief description of planned maintenance concept: staff, schedules, relationships with equipment suppliers. (2-3 pages). Must meet 4.
   b. Brief description of planned operation concept: staff, schedules, fault management, operation quality assurance and optimization. (2-3 pages). Must meet 4.

Annex D: Flow Diagram for Biogas System

(see next page)



TAG	Amount	Main Equipment (without meters and sensors)
R01	1	Silage Platform
R02	1	Dung Storage
R03	1	Solid Feeder
R04	1	Reception Tank
P01	1	Submersible slurry pump 3kW
A01	1	Fast running propeller stirrer 7,5kW
B01	1	Substrate distributor with pneumatic valve and compressor
P02+03	2	Central pump a 3 kW
H01	1	Substrate Heatexchanger 50kW
D01	1	Main Digester
I01	1	Double membrane gas storage roof D01 incl. security valve, roof blower
A02	1	Slow running agitator for high DM contents, 12-15 kW
A03	1	Fast running propeller stirrer 7,5 kW
D02	1	Post Digester
I02	1	Double membrane gas storage roof D02 incl. security valve, roof blower
A04	1	Slow running agitator for high DM contents, 12-15 kW
C01	1	Press screw seperator, 3-5kW plus reception tank and solid storage
S01	1	Slurry Pond
E01	2	Internal Desulfurization with air injection
E02	1	External Desulfurization (activated-carbon filter)
F01	1	Semiautomatic Emergency Flare
V01	1	Gas blower Emergency Flare 1 kW
V01	1	Main gas blower 1kW
W01	1	Biogas chiller and condensation tank with sumergible pump
X-01	1	Gas analysis
G01	1	100kW Biogas CHP
G02	1	100 Biogas generator
H02	1	Heat buffer tank 5 m³

Projekt:

Biogas plant Site 1
Tandlianwala, Pakistan

Firma:

8.2 Obst & Ziehmann
International GmbH
Brandstwiete 4
20457 Hamburg

Verfasser:

Thomas Mitschke

Annex E: Information on Bill of Materials of PV Modules

(See also Excel sheet)

The bidder shall to provide the BoM list of their proposed PV module(s), which must include the following information as minimum.

Table 28: To be provided BOM info

No	Material	Supplier	Type and Description
1	Cell		
2	Glass (Front Cover)		
3	Backsheet		
4	Encapsulation		
5	Frame		
6	Junction Box		
7	Adhesive (For Frame)		
9	Ribbon		

The bidder can avoid the extended lifetime test procedure (as defined in section 3.4.1) of the PV modules by proposing at least two (2) different PV module types with different BoMs. In order to become qualified for this alternative each proposed BoM shall include the EVA and the backsheet from one of the manufactures as defined in the tables below. The specific product datasheets of the EVA and the backsheet shall be provided with the bid. If qualified for this alternative, the Employer shall have the sole right the choose one of the proposed PV module types / BoM.

Table 29: Specified EVA and backsheet manufacturers

No	EVA
1	Bridgestone Corporation (G.M.G Corporation)
2	3M
3	Hangzhou First PV Material Co., Ltd
4	Changzhou Sveck Technology Co., Ltd
5	Shanghai HIUV New Materials Co., Ltd
6	Guangzhou Lushan New Materials Co., Ltd

No	Backsheet
1	KREMPEL-GROUP (KREMPEL GmbH)
2	Isovoltaic AG
3	Taiflex Scientific Co., Ltd
4	Coveme S.p.a.
5	SFC Co., Ltd
6	Cybrid Technology Inc
7	Jolywood (Suzhou) Sunwatt Co., Ltd
8	Hangzhou First PV Material Co., Ltd
9	Changshu Top Solar Material Co., Ltd
10	Zhongtian Photovoltaic Materials Co., Ltd

Annex F: Safety Rules for Biogas Systems[1]

See separate document.

[1] Safety rules for biogas systems by GIZ, Project Development Programme (PDP) South-East Asia

Annex G: Financial Bid Breakup

See *Section 3 Letter of Price Bid*, *Schedule L*

Annex H: PV Module Manufacturing Standards

1: ISO 9001: Implementation of a proper Quality Management System dealing with incoming quality control (IQC), In-process Quality Control (IPQC) and Outgoing Quality Assurance (OQA).

2: ISO 14001: Environmental management system.

3: OSHAS 18001: Occupational Health Safety guidelines.

Annex I: Cattle dung availability near biogas site

Table 30: Biogas feedstock survey UAF biogas project at PARS campus (Survey results)

No.	Village	Distance from selected Biogas plant site (km)	Stables	Floor Type		Bufallows / Cattle	Cattle Dung available kg/day	Silage required kg/day
				Clay	Bricks			
1	Risala	0.50	21	17	4	400	4,000	14,000
2	Risalewala	2.50	18	12	6	1,200	12,000	42,000
3	Kakuana	1.25	22	20	2	650	6,500	22,750
4	Babuwala	1.50	12	9	3	150	1,500	5,250
5	Chohla	1.75	16	9	5	250	2,500	8,750
Total			**89**	**67**	**20**	**2,650**	**26,500**	**92,750**

The results have been obtained through survey in September, 2017. The cattle owners showed interest to provide cattle dung for the project in exchange for silage and/or biomass slurry.