**Work Package 1:**

**Technical Tender Specifications Leguan 0.60MWp Solar PV Farm 13.8kV**

January 3, 2023

**Project: Renewable Energy Solutions for the Hinterland - Leguan**

**IDB funding ID: Energy Matrix Diversification and Institutional Strengthening of the Department of Energy (GY-L1066)**

**Site: Leguan, Region 3 – Upper Essequibo Islands, Guyana**

This document provides the technical specifications for the procurement of a Turnkey Solar PV Farm in Leguan. This document is an Annex of the Bidding package prepared by Guyana Energy Agency with IDB procurement templates.

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**Acronyms:**

EA Executing Agency

DG Distributed Generation

DOD Depth of Discharge

EPA Environmental Protection Agency

ESAR Environmental and Social Analysis Report

ESMP Environmental and Social Management Plan

ESRA Electricity Sector Reform Act 1999

GEA Guyana Energy Agency

GEI Government Electrical Inspectorate

GoG Government of Guyana

GYD Guyana Dollar

H&S Health and Safety

GPL Hinterland Electrification Company Inc.

IDB Inter-American Development Bank

kWh Kilo Watt Hour

kWp Kilo Watt Peak

LCOE Levelized Cost of Energy

LFO Light Fuel Oil

MoPI Ministry of Public Infrastructure

MWp Mega Watt Peak

O&M Operation and Maintenance

PCU Project Coordinating Unit

PUC Public Utilities Commission

RE Renewable Energy

RET Renewable Energy Technology

T&D Transmission and Distribution

USD United States Dollar

# Introduction

## Hinterland Electrification Programme

### Guyana is 98% dependent on imported fossil fuel for its energy needs. The cost and reliability of electricity are also recognized by the Government as a major factor for profitability and efficiency in business operations, especially in energy-intensive industries such as manufacturing.

### To counter this vulnerability, Guyana, in its revised National Energy Policy and Green State Development Strategy, has re-committed itself to the development of its indigenous renewable energy resources and to pursue 100% renewable energy in electricity generation.

### The project is being facilitated by the Ministry of Public Works (MoPW) of the Government of Guyana (GoG) as part of the national development priority to transition to renewable energy sources and to ensure stable, reliable and economic energy supply for all in Guyana. The Guyana Energy Agency (GEA) has been identified as the Executing Agency (EA) and a Project Coordinating Unit (PCU) dedicated to the project has been established. The main objectives of the project are to reduce fossil fuel consumption for electricity generation, increase energy security particularly for hinterland utilities and support of Government’s drive for a greener economy.

## Leguan

### Leguan Island is a small island situated in the Delta of the Essequibo River on the coast of Guyana. The island is 14 km long and 3.2 km wide at its widest making it roughly 19 km2 in area. The island has an estimated population of 2,500 living in 36 demarcated villages. Leguan is primarily a rice farming and cattle rearing community. Other occupations on the island include government administration, teaching, health care and policing. The island has three main paved roads, two running along the north and south coasts and a road that bisects the island connecting the coastal roads.

## Electrical demand

### Electricity is provided on a 24-hour basis from an isolated grid with an installed capacity of 1.23 MW that is owned and operated by the Guyana Power and Light Inc. (GPL). The peak demand and annual generation as of 2019 are 0.38 MW and 1,833 MWh respectively (Guyana Power and Light Inc, 2020)..

### Annex 1.1: Leguan Hourly Load Profile provides an hourly demand during 2021 - 2022.

## Diesel Power Generation

### The distribution grid and the power plant are managed by the Guyana Power and Light (GPL).

### The installed generation capacity at the diesel power station is 1.23 MW provided by three (3) diesel generator sets of nominal capacity of 0.410MW.

### Leguan Diesel Power Plant is located at Lat: 6°54'51.20"N and Lon: 58°24'0.01"W and is shown in the map below.

### *Annex 1.2 and Annex 1.3* provide the technical specifications of generators, generator controls.

### *Annex 1.4a, 1.4b, 1.4c* provides Leguan Diesel Plant Site Layout-Proposed, Leguan Diesel Plant SLD-Existing, and Leguan Diesel Plant SLD-Proposed respectively.

## 

Figure 1: Map showing the location of Leguan Diesel Power Plant

## Leguan solar PV Farm

### The proposed site for the 0.600 MWp solar PV farm is located at latitude 6°55'49.72"N and longitude 58°22'10.96"W. The site is approximately 2.81 acres and is located approximately 4.0 km by road from Leguan 1.455MW diesel power generation station.

### The site is relatively clear containing mostly shrubs and small trees which would require clearing before the commencement of this project.

### *Figure 2* provides a google earth image of the proposed location of the solar PV farm. A new 13.8kV transmission line shall be built for interconnecting the solar PV plant to the Leguan diesel power plant. A detailed scope of works for the interconnecting line can be found in work package 2.

### The medium voltage (MV) output of the transformer at the solar plant shall be connected to a 13.8 kV transmission line which shall be constructed in parallel with the construction of the PV power plant and as describe in Work Package 2.

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Figure 2: Solar PV farm location

## Stakeholders

### The Inter-American Development Bank (IDB) is the funding agency for the Turnkey Delivery of the solar PV plant as well as the supply and installation of the new transmission line (see the scope of work list in *Item 2.1.1*). Procurement and contracting will follow the IDB’s standard procedures and templates.

### The Guyana Energy Agency (GEA) is the executing agency. GEA has established a Project Coordinating Unit (PCU) for the Hinterland Electrification Programme.

### GPL is the operator of Leguan Power Plant and Leguan Transmission and Distribution Grid.

### The PCU will be responsible for the administrative, technical and operational management of the project during tendering, contracting and implementation phase. The PCU will act as a liaison between the Contractor and all stakeholders which include but are not limited to GEA, GPL and IDB.

# Scope of Work

### This scope of work describes the requirements for a photovoltaic (PV) power plant with battery energy storage system (BESS) which will be interconnected to the Leguan grid as follows:

### Turnkey Delivery of 0.600 MWp solar PV power plant with 2 hours of energy storage, including the engineering, procurement, construction, testing, commissioning, and training of operators.

### The design, supply and installation of the solar PV system and its interconnection to Leguan grid must comply with the **National Grid Code** which can be found in Annex 3

### The 0.600 MWp solar PV plant shall consist of two (2) PV sub-systems with install capacity of 0.300 MWp or more for each array.

### The battery storage system (energy storage and battery inverter) shall provide the primary function of ‘grid forming’ and shall supply the entire power demand of the Leguan mini-grid without any support from the diesel generators, during the periods for which solar PV output and battery State of Charge meet predefined values. Please refer to Annex 1.1 for Leguan Hourly Load Demand/Profile. The battery system shall be capable of working in paralell with the exisiting diesle engines, providing grid support (frequency and voltage regulation) and rapid response to variations in the intermittent solar PV source and variations in the grid demand.

### The solar PV Plant shall be the primary source of energy for consumers connected to the mini-grid during the period 07:00 hrs to 16:00 hrs, while the existing diesel generator shall only be utilized in instances where the load demand exceeds the capacity of the PV Plant or in the event the state of charge (SOC) of the battery energy storage system meets some predefined critical level.

### This ‘predefined critical level’ of the SOC mention in 2.1.5 shall be selectable or adjustable by the operator.

### Electricity generated from the PV arrays shall be used for real-time consumption, and recharging of the battery energy storage system. Excess energy shall be curtailed as required to match generation to the load(s) being and shall NOT be back-fed to the existing diesel generator; thus, appropriate reverse power protection must be employed.

### In instances of parallel operation of the solar PV Plant and Leguan’s Diesel Power Plant, the system must consider the minimum load requirements of the diesel gensets.

### The solar PV power plant and battery system shall have a point of common coupling within the boundaries of the solar farm and connected to a Low Voltage (LV) terminal of a 1 MVA/13.8 kV step-up transformer located within the boundaries of the solar PV power plant.

### The Contractor shall provide all required hardware and software for the SCADA system to control and monitor the solar PV plant and the existing diesel generators from the Control Room at the Leguan Diesel Power Plant. The contractor shall design, supply, install and commission the new control system and the necessary modifications to the diesel controls and engines to fulfil the requirements in this tender. All human-machine interfaces shall be in the English Language.

### The following civil works must be provided by the Contractor for the area needed to install the 0.600MWp requested with the associated equipment mentioned in this tender: Site Clearance and Land Preparation, Foundation and Housing for any new equipment installed. Fencing of the solar PV farm, and construction of Security Shed(s) as needed to adequately secure the site. Annex 1.5 shows a proposed layout of panels, indicating the area needed for the 0.600MWp.

### The Contractor shall provide a Quality Control Plan, a Health and Safety Plan and Environmental and Social Management Plan. The Contractor shall comply with the requirements and proposed mitigation measures proposed in the Environmental and Social Analysis Report (ESAR) – Annex 5. All works must comply with the mentioned plans.

### Special attention must be paid to the tropical, high humidity and, the marine and saline environment regarding the selection of the materials to be used for the erection of support structures and buildings, fencing as well as the PV power system components themselves.

# Technical Specifications – General

## Introduction

### All designs, materials, installations, and services under this tender shall comply with the latest issues of the following standards:

* Relevant standards and publications of the International Electrotechnical Commission (IEC) for electrical equipment
* Relevant Institute of Electrical and Electronics Engineers (IEEE) standards and recommendations.
* The Contractor shall ensure that the entire generation system, including the PV and BESS is solidly grounded and shall provide an effective grounding design as per IEEE 62.92 recommendations.
* NFPA 855, Standard for the Installation of Stationary Energy Storage Systems
* National Electrical Code (NEC) 2020
* GPL´s National Grid Code
* EPA’s Permitting Requirements for Solar Photovoltaic Systems

### The annual average Horizontal Irradiance (GHI) for a typical meteorological year is shown in figure 2. It should be noted that these are indicative conditions and therefore it is strongly recommended that the Contractor conduct his/her own assessment at the site.

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Figure 2: Leguan Global Horizontal Irradiance – GHI (W/m2)

## Quality Assurance

### To ensure that the Works are in accordance with the outlined specification, regulations and authorised international standards, the Contractor shall have in place suitable Quality Assurance Programs and Procedures.

### The Contractor must demonstrate that all equipment is from manufacturers using technology that have been proven to work reliably.

### The Contractor must submit a Provisional Quality Assurance Plan in the Bid. The final Quality Assurance plan shall be approved by the contracting agency before signing of Contract.

### The Contracting Agency is entitled to supervise or to have supervised the Quality assurance Plan of the Contractor with respect to the Works in all phases of the project (design, engineering, material handling, manufacturing, testing, inspection, construction and erection, commissioning). When required by the Contracting Agency, the Contractor must facilitate all requested tests, inspections and sample submissions.

### The Quality Assurance Plan must contain the procedure, schedule and considerations for the realization, review and approval of the design. The considerations must comply with the requirements of the Contract. Considerations may include calculations, tests, or certificates. The Quality Assurance Plan must outline the relevant considerations.

### In cases where test results or other characteristics of similar components or parts deviate significantly from each other, the Contracting Agency is entitled to reject them.

## Health and Safety Plan

### The Contractor shall comply with the Occupational Safety and Health Act of the Contracting Agency and Guyana. The OSHA of Guyana can be found in Annex 4: Occupational Safety and Health Act of Guyana**.**

### The Contractor shall submit their own Health and Safety (H&S) plan with mitigation measures in the Bid. During the design stage, the final H&S plan shall be shared with the Contracting Agency together with the final design of the system.

### All contractors, staff and third party shall be well informed and trained on all H&S issues at the site. All facilities shall be designed to enhance safety planning. All activities shall be executed within the confines of the relevant legislation as well as stakeholders’ interests. All project activities shall be properly managed through careful planning and the application of relevant safety policies such as:

### Environmental Operation Permit

### H&S meetings before embarking on a job

### Use of appropriate personal protective equipment (PPE)

### Prohibition of alcohol in the project area

### Proper journey management

### Regular emergency drills

### Use of appropriate caution signs

### Control of Atmospheric Emissions

## Environmental and Social Management Plan (ESMP)

### The Contractor shall comply with the Environmental and Social Analysis Report prepared for Solar PV Farm in Leguan. The report can be found on the IDB’s website (<http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=EZSHARE-1460553615-30>) as well as in Annex 5: Environmental and Social Analysis Report.

### The successful bidder/contractor will be responsible for developing a Construction ESMP (C- ESMP) adhering to the ESMP provided in Annex 5, the DRMP and the conditions of the Government of Guyana Environmental Permit. This C- ESMP must be delivered to GEA for approval prior to beginning construction activities.

### The C-ESMP must include a Worker Code of Conduct (In Environmental, Social, Safety and Health,) that establishes: a) the minimum eligible age for work as 15 years (or if Guyanese law establishes older, use that age); b) non- discrimination, gender equality, and zero tolerance for gender-based and sexual harassment and violence, and penalties for non-compliance.

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### b) non- discrimination, gender equality, and zero tolerance for gender-based and sexual harassment and violence, and penalties for non-compliance.

### The Contractor shall be responsible for ensuring that all areas of the site are left in the same conditions as prior to the commencement of the works.

### All site clearance works shall be carried out within defined perimeters and only when necessary. The maximum permissible time lapse between site clearing and initiation of construction operations shall be reduced to the bare minimum. Clearing of vegetation shall be kept to the barest minimum necessary to permit safe operations. Trees felled from the project site shall be made available to the host communities for re-use prior to decision on the disposal of the materials at the authorized landfill.

### Dirt roads and exposed construction areas shall be moisturized during the dry season to prevent and minimize dust emissions. Construction equipment shall be well maintained to minimize exhaust emissions into the atmosphere.

### Noise levels shall comply with relevant regulations. The personnel, as well as the environment that shall be affected by any established noise source, shall be provided or equipped with an appropriate protective or corrective device to ameliorate noise effect.

### Adequate waste management shall be integrated into the implementation of the PV system. The principle of waste reduction, recycling, recovery and re-using shall be practised whenever possible. All wastes, which cannot be reused, will be managed and disposed of in accordance with the regulatory standards. Some of the waste management options and waste disposal systems that will be considered for this project are:

### Segregate components such as wood, plastic and paper shall be recycled or reused whenever possible, with preference for reusing and recycling given to interested stakeholder(s), principally the local community for their benefit.

### Reduce packaging wastes such as paper and plastic using bulk handling systems

### Dispose of all wastes at approved municipal dumps

### Refilling and reusing of containers

### Appropriate mobile septic tanks/sanitary facilities shall be provided during installation/pre-construction and construction phases. Construction of permanent septic tank system shall be included in the facilities design. Septage during the pre-construction, construction and operation phases shall be collected by EPA approved Contractors.

### Hazardous waste can be generated during construction due to accidental spills of fuel for the operation of construction equipment. It is recommended that waste from any fuel clean-up activities be stored on site in closed and clearly labelled containers and disposed of through an EPA approved Contractor.

### All debris, spoilt materials, rubbish, and other waste, shall be cleared from the site during construction and disposed of accordingly at the Government’s designated dump/landfill sites for such wastes. The burning of any type of waste shall be strictly prohibited. Waste disposal records shall be kept and shall include as a minimum the following information:

### Date of dispatch

### Description of waste

### Waste quantity/container type

### Designated disposal site and method

### Consignee /driver name and means of transportation

### Confirmation of actual disposal (time and date)

### The Environmental and Social Analysis Report mentioned in *Item 3.4.1*, provides recommended mitigation measures to comply with the environmental and social specifications. The Contractor shall provide his/her own measures and its breakdown cost in the submission of this Bid.

## Site Visit

### The proposed site is approximately 4 km by road from central Leguan and the Leguan Diesel Power Plant. Short shrubs and small trees are associated with the project site.

### The Contractor is advised to visit and examine the site where the plant is to be installed, its surroundings and the road/path access and obtain for itself on its own responsibility all information that may be necessary for preparing the Bid. The cost of visiting the site shall be at the Contractor’s expense.

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### *Figure 3: Photo of PV farm site*

## Civil works

### All civil works shall be guided by the recommendations of Geotechnical and Flood and Coastal Erosion Risk Report included as Annex 6 and Annex 7 respectively. These recommendations include but is not limited to the following mitigation strategies:

### Critical infrastructure should be placed at a Minimum elevation of +2.1m AMSL with the use of stilts for the PV panels and plinths for the BESS.

### The Bidder should coordinate with Sea Defense Board on the construction of the shoreline protection revetment, which is currently being built by the Sea Defense Board.

### An assessment and design of the drainage for the project site, based on the recommendations from the Derisking Studies for Leguan Solar PV Project to be conducted by CEAC Solutions Company Limited .

### The Contractor shall design and provide the following civil works in accordance with the recommendations of Geotechnical and Flood and Coastal Erosion Risk Report included as Annex 6 and Annex 7 respectively:

### All necessary work to prepare the road and footpath for delivery of all equipment.

### All site clearance and land preparatory works shall be carried out within defined perimeters and only when necessary. The maximum permissible time lapse between site clearing and initiation of construction operations shall be reduced to the bare minimum. Clearing of vegetation shall be kept to the barest minimum necessary to permit safe operations.

### A suitable drainage system shall be constructed to minimize disturbances to natural drainage patterns and incorporate erosion control and storm water management to ensure no water stagnation occur at the facility. The drainage system should be capable of handling the probable maximum precipitation during a storm event.

### Trenching for conduits and cables

### Foundation for the structure of the solar PV arrays

### Foundation and housing for inverters, battery system, switchgear and transformers

### Foundation and housing for the security shed

### Removal of temporary construction facilities and completion of restoration works.

### The cost of the civil works shall be provided in the Bid with a breakdown as per *Item 3.8.*3

### The Contractor shall prepare the land, including but not limited to cut and disposal of the trees in a designated area by the Contracting Agency within Leguan.

### The site must be prepared with the objective of producing a level surface upon final installation of the arrays to eliminate shading of the photovoltaic arrays.

### The project site shall be filled and levelled above koker level as per topographic data provided.

### Installation of trenches will be required for conduits to prevent exposure of cables to the environment.

### Foundation works for the solar PV structure should be in the form of strips, pads or a combination of both and allow for suitable fixations to secure mounting racks. Regarding the foundation works, reference must be made to Guyana National Building Code. The Contractor must conduct a detailed site investigation to verify the site’s soil conditions, and to ensure that the foundation designs (for all structures) can withstand all loads (live & dead) imposed upon it to avoid the risk of failure. The finding of this investigation must be made available to the executing agency.

### The Contractor shall design and provide for all associated civil and construction works necessary for the complete installation of all equipment, including but not limited to excavations, concrete works, backfilling, earth ramming and foundations.

### The Contractor shall design, supply and install all structures and housing necessary for the installation of the PV modules, cables, inverters, battery, switchgear, transformers and all other items of equipment necessary to complete the installation.

### The Contractor shall design, supply and install at least two (2) security guard cabins (one inclusive of a toilet facility). The location of one of those security sheds will be agreed with GPL during the design stage.

## Fencing

### The Contractor shall design, supply and install the perimeter fencing to surround the boundaries of proposed Solar PV Plant only, annex 1.5 can be used as a guide as is relates to the extent of the fencing required. Fencing of the solar plant is essential for protecting the asset against theft and to provide safety for the individuals involved in the operation and maintenance of the plant. The fence should be grounded to the facility grounded grid as per NEC 110.31.

### The Contractor shall supply all necessary materials, equipment, tools and labour for the installation of a chain-link fence on the boundaries of the solar farm with rates inclusive of galvanizing poles, runners, RC pad foundation, end caps, non-corrosive paint, transportation, etc. to complete installation.

## Lighting and auxiliary services

### The Contractor shall design, supply and install a lighting system of the whole fenced area. The provided lamps shall be 60W self-contained solar powered security lights with battery installed in fifteen (15) feet poles at 50 feet apart along the whole perimeter fence of the solar farm.

### The auxiliary power required by the 0.600 MWp PV power plant should be provided by a dedicated UPS backup capable of supplying power for a minimum of 1 hour.

### The Contractor shall design, supply and install a water supply network for cleaning of solar modules using industry standard methods and best practices. The water supply shall include trestle, water storage, water pump, adaptors, etc. to make the water supply system complete and functional.

### The Contractor shall design a rainwater collecting system. The system shall be designed with all necessary water filtering and treatment to ensure the water used for cleaning purposes is as per module manufacture recommendations.

### The Contractor shall install a Fire Detection and Suppression (FDS) System for all enclosed structures that houses equipment such as, inverters, batteries and switchgears. The FDS shall comply with the recommendations of the NFPA 72, NFPA 850 & 855 or EN15004.

### The Contractor shall install a weather monitoring station to accurately record and log/store the following meteorological data:

### Precipitation (rainfall)

### Wind speed and direction

### Solar irradiation (GHI and POA)

### Relative humidity

### Temperature (ambient and cell)

### Air pressure

### The weather station shall be compliant with IEC61724-1 Class A for Utility scale PV system

## Installation

### Since water and power are not available at the site, the Contractor shall provide such during installation activities.

## Security

### The Contractor shall be responsible for the security of all materials delivered and installed before official handover.

## Taxes

### The Contractor shall pay all applicable taxes as it relates to the equipment and services accordingly to the current Laws of Guyana.

### Solar PV components (including batteries) are duty-free. The Contracting Agency will facilitate instructions regarding duty-free clearance. Tax exemption on solar equipment can be found at https://www.gra.gov.gy/publications/notices/834-tax-exemptions-on-solar-equipment

## Work permit

### Foreign Contractors/employees may need to obtain a visa and arrange all necessary work permits in relation to the PV systems.

## Transport

### This Turnkey Project includes all transport and installation of the 0.600 MWp PV power plant and other equipment at the power station in Leguan.

### All transportation up to the construction site shall be included in the Contractor’s scope of supply, including, but not limited to, insurance, storage, demurrage, handling and fork-lift truck.

### Road alone or road and river transport from Georgetown are to be considered. The Contractor should also take into account the transport routes of heavy equipment to the power station at Leguan, which can/will take place on sand roads or paved roads with a limited axle load capacity.

### The Contractor is fully responsible for organising and guaranteeing timely delivery and transport of the equipment to the installation site.

### The Contractor is requested to present detailed information on the schedule of delivery and transport modalities of the equipment to the project site. Close coordination with responsible staff from the contracting agency is recommended. The Bidder is requested to consider site conditions having a potential influence on delivery and installation.

## Identification

### Labels of all systems and components of the PV system and associated equipment shall be in English. All outdoor labelling should be weather resistant.

### All systems and components shall be provided with unique codes. The Contractor shall determine the assignment of codes in consultation with GPL/GEA.

### Nameplates and coding labels must be attached permanently on a clearly visible spot of the apparatus.

## Documentation

### All engineering documents and drawings shall be sent to GPL/GEA for review, prior to the construction of the solar PV system.

### During the design and engineering phase, the Contractor shall submit a draft Operation and Maintenance manual.

### After the completion of the installation, the Contractor shall submit the AS-BUILT drawings and any other document that has changed from the design phase.

### The manual must contain at least the following information:

### Description of the installation

### Construction and assembly instructions

### Design considerations

### Operational procedures for all possible normal and abnormal conditions, including failure assessment, fault identification/interpretation and fault clearing

### Maintenance schemes and instructions

### Data sheet and specifications

### Design drawings

### Manufacturer, type, rating, serial number and test reports of each part of the installation

### Settings of trips and alarms

### Local and remote-control function and procedures

### Complete commissioning manual

### Parts manual

### Address of components deliverers or manufacturers

### Startup and commissioning spares, critical and operational spares.

### All requested information must be in **English**. All manuals and diagrams must be supplied also in digital form in CAD or other standard software formats (Microsoft Project, Microsoft Excel and Microsoft Word), in addition to all documents in PDF.

## Tools and Spare parts

### The Contractor shall supply two (2) complete sets of all required tools for the safe and efficient operation and maintenance of the PV system.

### The Contractor shall supply under the contract all consumables and spares for operation and maintenance of the whole solar PV system up to and including the first general scheduled maintenance.

### All software used to program/ adjust settings of equipment should be provided along with their instruction manuals.

### All tools, spare parts and consumable shall be new.

# Technical Specifications – Particular

## General

### This tender document is for an EPC of a solar PV power plant of 0.600MWp with battery energy storage system for 2 hour to be integrated into the existing grid in Leguan (Guyana) and technical support for two (2) years for the same solar PV plant.

### The scope of works under this tender are described in *Chapter 2.*

### The design, materials, installation, and services shall comply with the codes, standards and regulations mentioned in *Chapter 3.1*.

### The Contractor shall design, supply and install the whole system in such a way, utilizing only robust components of reputable vendors fit for utilization in tropical high humidity and marine environment conditions as outlined in *Chapter 3.1*, that it should have a minimum technical lifespan of twenty-five (25) years without the replacement of main components due to related defects or malfunctions.

### To increase reliability and prevent total loss of capacity due to a single point of failure, the PV system shall be designed in a modular fashion. The PV power plant should be composed of two (2) independent PV sub-systems.

### The Contractor shall design the system to facilitate easy integration of future expansion of the solar PV farm. The current design is for 0.600MWp with battery storage capable of grid forming when there is enough solar PV radiation. The design shall allow for future expansion of the solar PV system planned within the first five (5) years of operation, thereby increasing the solar PV capacity and upgrades the battery storage system with energy storage to provide solar energy during the night

### The Contractor shall design and engineer the PV components including the battery system and advice on the type of inverter and battery to be utilized, based on the required functionalities and power distribution system requirements.

### The solar PV Plant shall be designed to maximize the utilization of energy generated from the solar PV system while reducing the amount of energy curtailed. The PV system must be designed as an AC coupled system.

### The plant layout shall be designed to ensure ease of maintenance.

### The method of isolation of the sub-systems component shall be by means of over current protection devices (circuit breakers).

## PV modules

### All PV modules shall be from the same manufacturer and model and all PV modules shall have the same nominal output power.

### PV modules shall be Crystalline Silicon type with a minimum efficiency of 20%.

### All electrical parameters shall be provided at Standard Test Conditions STC (Air Mass AM1.5, Irradiance 1000W/m2, Cell temperature 25ºC).

### PV modules must be tested and certified by an accredited certified agency according to IEC61701, IEC61215 and IEC61730.

### Each module shall be labelled, in English, indicating the manufacturer, model, serial number (to be able to identify the date of manufacture for each of the panels), peak power, voltage and current at peak power, open circuit voltage and short circuit current.

### The minimum power output tolerance at Pmax shall be 0%.

### PV modules shall be framed. The frame shall be aluminium or stainless steel, which shall be electronically compatible with the structural material used for mounting the modules.

### All material component and claddings should be designed to resist sand and dust deposits, wind, suction and uplift loading at any point without damage.

### Anti-reflective tempered glass cover shall be used as the protective shield for the active surface area of the module and should be chosen for high impact and thermal shock resistance.

### The encapsulating material shall fill all spaces inside the module and shall adhere to the front glass and back sheet. The encapsulating material shall be stable at elevated temperature and high UV exposure.

### The expected service life of PV modules shall be twenty-five (25) years.

### PV modules shall have a minimum of ten (10) years of the product warranty.

### PV modules shall have a minimum power output warranty of 90% of nominal peak power in year ten (10) and 80% of nominal peak power in year twenty-five (25).

### The PV module cables shall have excellent properties and high-water resistance for outdoor installation. They shall have high durability and resistance to external influences, such as UV, Ozone, temperature, and chemicals. They shall be halogen-free, flame resistant, self-extinguishing and with double insulation to prevent short circuit and earth fault.

### Each PV module shall have a sealed junction box with a minimum Ingress Protection rate IP65.

### Modules shall have by-pass diodes to avoid damage of the cells and their circuits due to partial shading.

### PV modules should be in accordance with international standards (IEC 61215, IEC 61730, IEC 61701, UL1703 etc.) and the National Electrical Code 2020.

## PV structure

### The mounting structure of the solar modules shall be made of corrosion resistant material, which shall be electronically compatible with the PV module’s frame material.

### The solar structure and foundations shall be designed specifically for the existing soil conditions to withstand wind gust up to 160km/h without damage.

### The mounting structure shall be designed to allow the thermal expansion and contraction of the structure without affecting the integrity of the modules.

### PV modules must be oriented in a southern direction with an inclination of between 8 to 10 degrees and must be able to absorb and transfer the mechanical loads to the ground properly.

### Furthermore, the construction of the foundation shall be guided by the Geotechnical and Flood and Coastal Erosion Risk Report included as Annex 6 and Annex 7 respectively.

### Elevation of the Array shall be guided by the attached Flood and Coastal Erosion Risk Report included as Annex 7.

### The PV modules should be placed at a minimum elevation of +2.1m AMSL with the use of stilts.

### PV structures shall have a minimum of ten (10) years of the product warranty.

### 

## PV arrays

### The Contractor shall design the PV array to maximize efficiency and reliability.

### The minimum voltage of a string shall be 1000 Vdc.

### The Contractor shall provide appropriately sized fuses and surge protection.

### Each string must have a blocking diode to prevent reverse current flow. Each string must have string protection through fuse and disconnect switch.

### The positive and negative DC cables shall be laid separately and consisting of adequately sized single core copper cable each.

### All cables and connectors to be used for installation of solar PV power plant must be of solar grade which can withstand harsh environmental conditions for 25 years and voltages as per the latest IEC standards. All DC cables shall be UV resistant, rodent proof and termite repellent.

## Inverters

### This section refers to the PV inverters as well as the battery inverters.

### Inverters shall provide a pure 3 phase sine wave output with operating frequency of 60Hz with a field selectable adjustment range of ±3Hz.

### Inverters shall have a minimum European or CEC efficiency of 97%.

### Inverters shall have an adjustable power factor between 0.8 lead to 0.8 lag.

### Inverters shall have a maximum total harmonic distortion of 3% at nominal power.

### Operation own consumption of inverter at maximum load shall be lower than 0.5% of the nominal output power. Stand-by consumption of inverter shall be lower than 0.1% of nominal power output.

### Each of the independent PV systems, as per *Item 4.1.5*, shall have their synchronization provisions for parallel operation with the other inverters as well as synchronization provisions for parallel operation with the diesel gensets.

### Inverters shall have the capability for remote power off.

### PV inverters shall have MPPT integrated to maximize the energy output from the PV arrays.

### PV inverters shall be able to curtail the active power when demanded by energy management system.

### Inverters shall have a minimum of ten (10) years of product warranty.

## Battery station

### The battery-based inverter and storage system shall be designed for grid forming to allow maximum power output from the solar PV inverters into the grid. The battery system must be able to provide the load to the grid without the support from any diesel generator.

### The battery system shall provide a rapid response against the solar power output variations and will enable a smooth transition of the load provided by solar PV to the generators when the SOC meet some predefined critical level. Consideration and adequate time should be giving for the synchronization of gensets from ‘cold-start’

### The Contractor shall select the capacity to comply with the requirement stated in this document.

### Batteries shall be Li-ion type. The battery must have an expected life over 4000 cycles at 80% depth of discharge.

### The batteries must have a minimum of eight (8) years warranty.

### Battery station should, under normal operating conditions, be able to serve for a period of eight (8) years for the batteries or any other main component of the installation.

### Battery station shall have a minimum nominal power of 600kW.

### Battery storage shall be capable of providing a minimum of 300 kW (usable) for a duration of 2 hours whilst retaining a minimum state of charge (SOC) of 20%.

### The BESS should be placed at a Minimum elevation of +2.1m AMSL with the use of plinths for the construction of the base.

## AC Balance of plant

### The Contractor shall design, supply and install all distribution boards and switchgear necessary for the correct and safe operation of the system in accordance with the relevant IEEE, IEE and NEC 2020 standards and where applicable the NESC as it relates to 15kV class equipment.

### The Contractor shall deliver and install copper conductor power cables with insulation rating for 1 kV, secondary cables and accessories for the interconnection of the 0.600 MWp PV power plant to the 1 MVA Step-up transformer (to be carried out under the supervision of PCU and GPL). All power and secondary cables to be delivered and installed shall be in accordance with the International Electrotechnical Commission (IEC) standards and the National Electrical Code (NEC) 2020.

### The Contractor shall design, supply and install the adequate protection system for the solar power system against possible damage due to the abnormal operation or fault conditions, resulting either from internal equipment failure or wiring issues or from external natural causes, such as lightning.

### The protection system shall provide for fast and safe clearing of the fault on the system to minimize any damages to the system as well as to prevent hazard to personnel.

### The protection system shall be designed with, but not limited to, all the necessary protections against short-circuits, overloads, overvoltage, reverse power to solar array and lightning. The protection system shall comply with relevant IEC standards on solar system protection.

### The Contractor shall design, supply and install a copper grounding system for all elements installed under this tender with a voltage over 48V. All electrical components and structures shall also be grounded in accordance with the NEC 2020 standards.

### The Contractor shall perform a soil resistivity measurement on-site, which shall serve as input for the final design of the grounding system.

### The Contractor shall design, supply and install the lightning arrestor system.

## Transformer

### The Contractor shall supply and install a Pad Mounted Step Up Transformer.

### The transformer shall be rated for inverter source operation and the environment in which it will operate.

### The transformer must have a power rating of one (1) MVA or above with a step-up voltage of 13.8kV and low voltage input to match the output of the inverter along with all protection switchgear, circuit breakers, cables, etc.

### The transformer should be the oil filled type and constructed of ventilated metal enclosure. Removal type, and outdoor duty operating under direct sunlight as per IS2026.

### The winding material should be of electrolytic grade copper for both HV and LV windings.

### Transformers should have all necessary protection features like silica gel breather, Buchholz relay, pressure relief device, magnetic oil level gauge, oil temperature indicator and winding temperature indicator.

### Meet the following standards -: IEEE® C57.12.00, IEEE C57.12.34, IEEE C57.12.28, IEEE C57.12.29, IEEE C57.12.70, IEEE C57.12.80, IEEE C57.12.90, IEEE C57.91, DOE 10 CFR Part 431 and NEMA®.

### The three (3) phase 60 Hz transformer shall be installed.

### Transformer shall be supplied with a no-load tap changer with high voltage taps capable of operating at 2.5% above and below the nominal voltage at full rating.

### Transformer shall be supplied with a fused disconnect switch on the transformer high voltage side to isolate the transformer in case of an internal fault.

### Grounding system must be in accordance with the 2020 National Electrical Code.

## Interconnection

### The Contractor shall design, supply and install the interconnection of medium voltage power, control and monitoring between the PV system and the existing GPL grid and gensets.

### Each independent 0.300 MWp PV sub-system must also be equipped with synchronization provisions, to provide for parallel operation with the other 0.300 MWp PV sub-system and/or battery inverter and/or the generator sets in the diesel power station. It should be possible to close the PV sub-system circuit breaker when the MV bus is de-energized (switching to the dead bus).

### Similarly, each diesel generator set in the diesel power station shall be capable of synchronization with the PV plant and its sub-systems.

### Parallel operation of the new 0.600 MWp PV power plant with the existing generator sets must not result in abnormal operating conditions.

### *Annex 1.4a, 1.4b, 1.4c* provides Leguan Diesel Plant Site Layout-Proposed, Leguan Diesel Plant SLD-Existing, and Leguan Diesel Plant SLD-Proposed respectively.

### The Solar PV Farm shall be interconnected to the Leguan Diesel Power Plant via extending the existing F1 East Feeder. The full scope of the interconnection of the PV Plant is described in Work Package 2.

## Control

### The Contractor shall supply and provide the installation and complete configuration of the Plant Energy Management System software for the supply management of the power generation including the integration with the existing diesel generator sets.

### The installation of an Optical Ground Wire (OPGW), which is included in Work Package 2 shall be installed to provide the function of communication and lightning protection forthe interconnecting line between Leguan’s diesel power plant and the new solar PV power plant.

### The controls must be capable of communicating with all devices/sub-systems connected to it and shall provide all necessary real-time management and control functions.

### Communication protocol shall adhere to the IEC60870-5-104

### The solar PV system control shall be integrated with the current gensets control. The Contractor shall bear the cost of necessary modification(s) or upgrade(s) to the gensets control system to allow remote on/off control of the gensets.

### When the solar PV output and the battery SOC reach a pre-set level that will allow the solar PV system (including the battery storage) to provide the whole power of the Leguan grid, the control system must be able to switch off the diesel generator.

### During parallel operation of the PV and Diesel Plants, the control system must be able to control the PV inverters output (curtailment) to maintain the diesel genset running at least 50% of its nominal power or the minimum specified gensets requirement. This shall be selectable/controllable based on the operator’s input.

### The Contractor shall design, supply and install the SCADA system including the hardware and software and provide training and technical support on its operation.

### Each independent 0.300 MWp PV sub-system shall be controlled from the local control panel, the hardware shall be installed in the BESS building/container which is to be erected/installed near the PV sub-system by the Contractor and the visualization and control equipment and software in Leguan power plant. Disconnection and connecting of the PV sub-systems shall also be possible from the Control Room in the existing diesel power station (both manually and automatically).

### After synchronization, the power and voltage control are supervised by the Operator in the Control Room. The electrical parameters of each 0.300 MWp PV sub-system (inverter AC output voltage, current, power, frequency, etc.) must be displayed on the local control panels. Additionally, a local SCADA system must be provided with the possibility for real-time monitoring of all required PV sub-system parameters.

### The 0.600 MWp PV power plant shall be remotely controlled from the Control Room and all required information with regard to the configuration of the system shall be made available (circuit breaker positions, parameter value monitoring etc.) and presented on a display.

## Monitoring

### The electrical meters must be class 0.5 as per ANSI 12.20.

### The monitoring unit shall be equipped with a suitable communication interface for remote monitoring. The relays, control units and communication interface should be compatible with IEC 61850.

### The monitoring unit must be able to display the following data:

### Solar irradiation on the inclined plane of the panels

### Atmospheric temperature and module temperature

### In each DC string: voltage, current and power

### In each inverter AC output (PV inverter and Battery inverter): voltage, current, power for each phase and frequency

### For battery inverters AC input (battery charging): voltage, current and power

### Point of Interconnection at the solar PV farm: voltage, current and power. This meter will be used for calculating the performance guarantee energy.

### Point of Interconnection at the diesel power plant: voltage, current and power. This meter will be used for calculating the losses in the transmission lines.

### All parameters listed in the *Item 4.11.3* must be available in monitoring displays in the battery inverter station as well as in the Control Room of the existing diesel power plant.

### All the parameters listed in the *Item 4.11.3* must be logged on an hourly basis (average values), more frequent loggings will also be accepted. The system shall be able to store all data for a period of one (1) year.

## Commissioning

### Commissioning refers to inspection and testing the solar PV power plant after installation and certifying that it operates as expected and is installed in accordance with the engineering and design plans and complies with all the regulations and standards specified.

### The Contractor shall submit to the Contracting Agency the test procedures and protocols eight (8) weeks before testing.

### The commissioning shall include at a minimum:

### Complete integrity test of all equipment

### Test and commissioning of the laid cables, according to IEC standards

### Electrical protection system commissioning, according to IEC standards

### Perform Voc, Imp string testing

### Perform IV curve tracing

### Perform thermal hotspot check with infrared images

## Training

### The Contractor shall provide as part of the EPC, the cost for training of GPL staff on safety and best practice operation and maintenance of the 0.600 MWp PV power plant.

### The training shall be provided on-site by a certified engineer after commissioning of the installation

## Technical Support

### The Contractor shall provide technical support of the whole solar PV system for a period of one (1) year.

### Technical support shall include (but not limited to): on-demand troubleshooting (if and when required), system performance monitoring; guidance on operation and maintenance procedures, and a follow-up visit by the Contractor’s technical personnel at the end of the one (1) year period.

### All Contractor’s personnel involved in any of the technical support activities shall be qualified individuals. A qualified person, as defined in the National Electrical Code (NEC) is, “*One who has skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to recognize and avoid the hazards involved*”.

### The Contractor and GPL shall agree in the plan for knowledge transfer to GPL staff, aiming that when the Contractor Service Contract of technical support is finished, GPL staff are fully trained in operation and maintenance of the entire solar PV system.

### The contractor is required to provide a detailed operation and maintenance manual for the entire Solar PV Plant

## Economic evaluation of Bid submission

### The EPC cost submitted by the Bidder will be converted to a “Simple Levelized Cost of Energy” (Simple LCOE) with the intention to favour the good quality and high efficiency equipment in the economic comparison of Bids.

### The Bidder is required to fill the Annex 8 -EPC and whole life cost breakdown in which is included an anticipated cost of replacement of the battery and inverter over twenty (20) years.

### The simple LCOE is only used for comparison purposes and it should not be seen as an accurate calculation of the cost of energy, as it does not include the actual operation and maintenance cost of the solar farm. Annex 8 (excel file) includes a tab with an example of the calculation of the simple LCOE, which is provided to the bidder for information purposes.

### The simple LCOE will be calculated by the Contracting Agency with the information provided by the Bidder in Annex 8 and the data sheets and product warranties submitted in the technical proposal.

### The simple LCOE (USD/MWh) is equal to Total Expenditures over 20 years (in USD) divided by Total Expected Energy Generated over 20 years (in MWh).

### The inputs for the calculation of the energy generated over twenty (20) years are:

#### Nominal power output of the solar farm, in kWp

#### Nominal efficiency of inverters (will be calculated as a weighted arithmetic mean of the efficiency weighted with the nominal output power

#### Minimum tolerance of the output power for the panels, in % of the nominal power)

#### Power output warranty of the PV panel. This information will be extracted from the PV panel power output warranty certificate.

### The inputs for the Total Expenditure are:

#### EPC cost

* Battery rank replacement cost over 20 years
* PV inverters cost replacement over 20 years
* Battery inverters cost over 20 years