Design specifications of PV-diesel hybrid system for Mandhoo island

Ministry of Communication, Science and Technology – Republic of Maldives

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1. INTRODUCTION

The SMILES project ("Strengthening Maldivian Initiatives for a Long-term Energy Strategy") is jointly being undertaken by the Maldivian Ministry of Communication, Science and Technology (MCST), the French Agency for Energy and the Environment (ADEME) and the Utrecht Centre for Energy research (UCE) of the Netherlands, EXPLICIT of the France, the Maldivian State Electric Company Limited (STELCO), the Maldivian Ministry of Atolls Development and the Maldivian Ministry of Transport and Civil Aviation (MTCA). The SMILES team cooperates closely with the partners of the UN RETDAP project. As part of SMILES a PV-diesel hybrid pilot project will be realised on an existing island.

These specifications refer to the PV part of the PV-diesel system, which is to be implemented at Mandhoo island. Mandhoo island is located in the western part of South-Ari atoll, about 100 km South-West of Male. The exact coordinates are: latitude 3:41 North, longitude 72:42 East. The average temperature on the island is around 30 degrees C year round, with humidity levels around 70% - 80 %. The island is inhabited by about 40 families, each of which has an electricity connection.

The PV system is planned to operate in conjunction with the existing diesel system on the island, whereby the PV system in principle provides power during the day, and the diesel system during the evening and night.

The system also will be used as a standby system in case of the diesel system failure due to some natural phenomenon like the tsunami of 26th December 2004, where communication was cut off due to electricity failure.

2. THE PRESENT POWER SYSTEM

2.1 Diesel generator sets

Electricty is being generated by two diesel-generator sets, with the following information on their nameplates:

1. GMI genset (Spain) with Deutz diesel (F4L 912) and ECO alternator (32 3S) of 43 kVA (34 kW at cos phi 0.8). Manufactured in 2002, installed in Mandhoo in 2003.
2. SunPower genset (Singapore), with Perkins diesel (3.1524) and alternator (BC 184 G) of 28 kVA (22 kW at cos phi 0.8). Manufacturing date unknown, probably installed in 1997 or 1998.

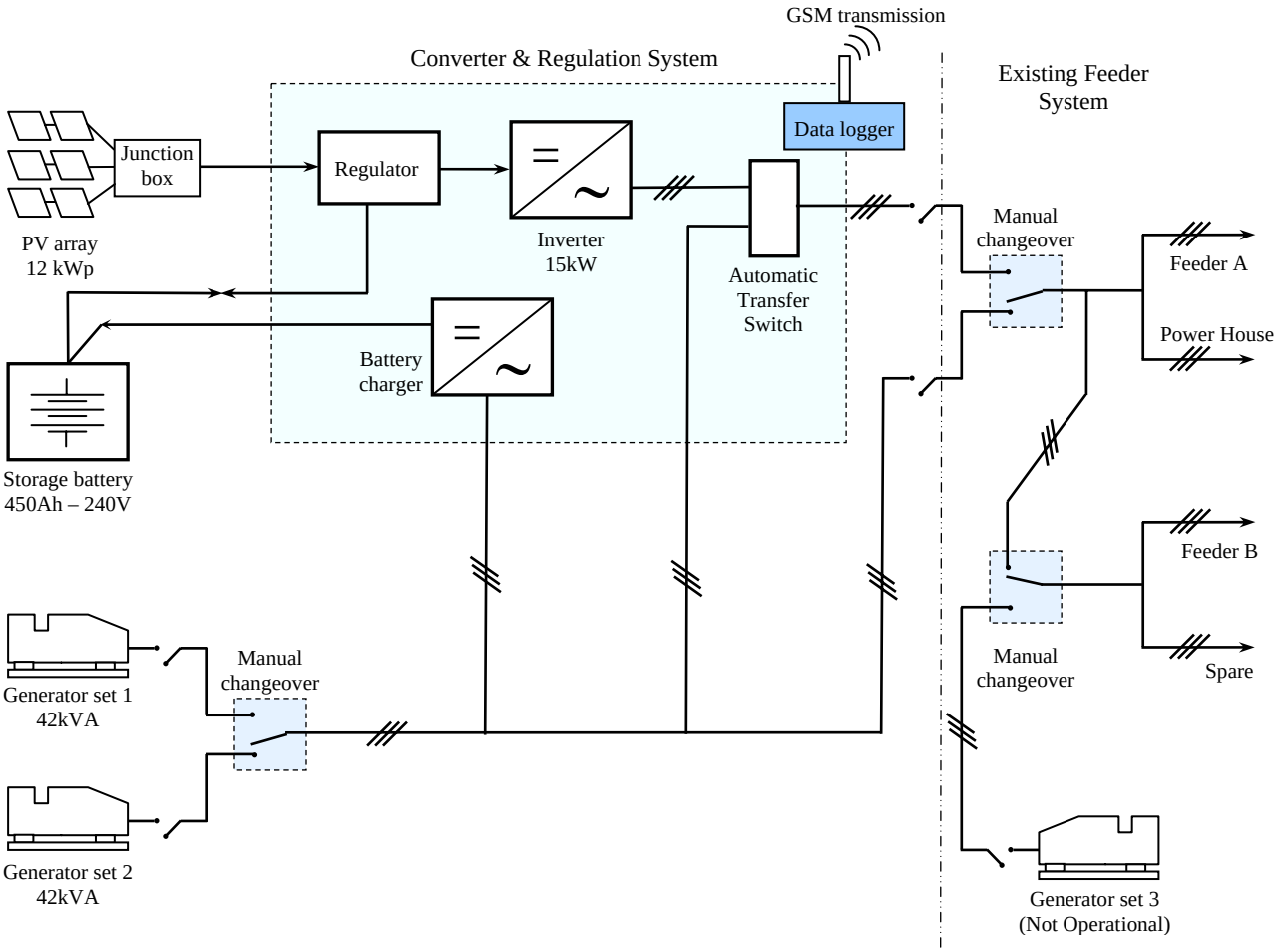
The electricity is provided to the consumers at 230 V, 50 Hz. The distribution system is fed through two feeders, which are usually connected at the powerhouse, but can also be operated independently. Most consumers have a single-phase connection.

2.2 Operation

The present system is manually operated by one operator. Only one diesel runs at a time, and a **manual switch** is used to change the load from one to the other genset. The larger unit runs from the end of the afternoon (17:50) until early morning (6:00) to take the peak load of the evening. In the morning the smaller engine is started and takes over the daytime load. This implies that the two engines cannot run in parallel.

3. THE PROPOSED PV-DIESEL HYBRID POWER SYSTEM

3.1 The proposed system layout



3.2 System Description

In the proposed system, electricity will be generated either by photovoltaic array or by diesel generators. A battery bank will be used to store excess electricity from the PV array and the

diesel generators. The converter and regulation system controls the overall system operation by: charging or discharging of the battery bank, converting DC to AC or AC to DC for charging the batteries, and supplying AC to the grid either by diesel generators or through inverter. The functions of the system components are given in section 3.4. The proposed system includes the following items excluding the exiting power system equipments;

- 12 kWp, 240V photovoltaic array
- 108 kWh battery bank
- 01 Converter and Regulation system that contains;
    - 01 Regulator
    - 01 Battery charger (rectifier)
    - 02 inverters 7.5 kW each
    - 01 Automatic transfer switch
    - 01 battery status indicator and warning system
- 01 Data logging and transmission equipment
- Power distribution monitoring meters

3.3 Operation

The system is design in such a ways so that the peak load is supplied by diesel generator sets. Whenever diesel generators' power is not available the 'Converter & Regulation System' should automatically supply power to the network by using PV and/or battery bank without any interruption. The diesel generator set 1 or 2 is expected to supply power to the network during night time, from 17:50 until 07:00 o'clock. On normal days, PV system and battery bank is expected to supply power during day time (from 07:00 until 17:50). During day time, if the battery bank is drained beyond certain limit (e.g. 50%), of its' capacity then the 'Converter & Regulation System' should **generate an alarm so that operator will know when to start one of the diesel generators to supply power to the network**

3.4 Component Functions

PV array: The photovoltaic array is composed of individual PV modules connected to create 12kWp photovoltaic array at 240V.

Battery bank: The battery bank shall be wired together to create the 240 volt. The capacity battery bank shall be 108 kWh.

Regulator: The regulator controls the power incoming from PV array. During day time, the battery power is supplied to the inverter through the Regulator. When the solar radiation increases the PV arrays gradually takes over the load, and also starts recharge the battery, when extra power is available.

Battery charger: The charger charges the battery bank while any of the diesel generators is operating depending on the ON and OFF time setting of charger. The charger should have a real

time clock to control the ON and OFF time of the charger. These ON and OFF times must be adjustable by the operator of the power system. The charger is set to charge the battery bank only during the low load time to prevent the generator sets overloading. It is expected that the charger starts charging the battery bank at 00:00 o'clock and continues until 06:00 o'clock and this ON time is automatically control by the charger using inbuilt real time clock.
Input: 3- phase, 400 V, 48-52 Hz and Output: DC, 240V nominal.

Inverter: The inverter converts DC power from the battery bank and/or PV array to AC whenever power from diesel generator sets is not available. The inverter system should be consists of 2 (of 7.5 kW) inverters running in parallel to achieve total output of 15kW. Input: DC 240V nominal, and Output: 3- phase, 400 V, 50 Hz, 15kW max.

Automatic Transfer Switch (ATS): The ATS should automatically supply power from the inverter when power from diesel generator sets is not available. During inverter-operation, if the battery bank is drained beyond certain limit (e.g. 50%), then the ATS or the 'Converter & Regulation System' should generate an alarm so that operator will know when to start one of the diesel generators to supply power to the network

DC distribution: The battery bank and other equipments will be located in or near the power house, but the PV array will be installed at about 250m away from the existing power house. This requires cable of length about 250m for DC distribution from PV array to the power house.

Data logger: The logger should record 10-minutes average readings of the following power system parameters.

- PV array output kWh meter
- Battery charger output kWh meter
- Battery output kWh meter
- Inverter output kWh meter
- System parameters: Energy supplied to the network, frequency, 3-phase current and voltage
- Battery storage level

The data logger must send an email to a specific email address at a fixed time containing all readings recorded that day through GSM network available. The real-time readings (10-minutes average readings) must also be available on a memory chip in the data logger for monitoring purpose.

3.5 Overall functions of the 'Converter & Regulation System'

- Control battery bank charging by PV
- Control power from PV array
- Battery charging by AC generators at specific day time.
- Convert DC to AC

- Automatically supply power to the network by inverter when power from diesel generators are not available
- When battery storage is below a specified Depth of Discharge (DoD) the system should generate an alarm so that operator will know when to start one of the diesel generators to supply power to the network
- Input DC: 240V, 15kWp
- Input AC (Diesel generator): three phase, 400 V, 42kVA max, 48-52 Hz
- Output AC from inverter: three phase, 400 V, 15kW, 50 Hz
- Out put AC from ATS: three phase, 400 V, 42kVA max, 48-52 Hz