Solar Power Generation System Design Improvement to Increase Reliability and Availability at Offshore Wellhead Platform

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***Abstract* – The issues with solar power generation system in PHE ONWJ has been its reliability and availability especially during monsoon season where there is less sunlight, in simply stated, every hour of solar power system downtime equal loss of gas production. PHE ONWJ requires an improvement on the current design of solar power generation and needs a useful predictive model for reliability and availability. In configuration dual system at GGA NUI Offshore Platform have 99.99% availability, 0.17% higher than single system configuration.**

Keywords – GGA NUI Offshore Platform, Mean Time Between Failure (MTBF), Mean Time to Repair (MTTR), Reliability and Availability.

I. INTRODUCTION

GG field is located in the North West section java sea, approximately 18.7 miles offshore North Cirebon, West Java. GG field is 3-phase reserve and require facilities and pipelines for gathering and subsequent export. The GG field map is show in fig 1.

The facility for both GGA NUl Offshore Platform and OPF Balongan designed at 40 MMSCFD in lieu with its maximum gas production rate. Therefore, some adjustments have been done to meet this requirement and it is defined as the pro-rate adjustment. Since the gas rate has been adjusted, the other fluid rate (condensate and water rate) will also follow the pro-rate adjustment.

GGA NUl Offshore Platform is designed with minimum facility and minimum operator intervention during normal operation. Transportation of personnel is conducted by using a helicopter, while transportation of material can be done either by helicopter or supply boat.

Approximately platform visit by helicopter will be conducted every month for with minimum duration of 4 hours to conduct any of the following purposes:

- General facility inspection
- Filling up the chemical
- Change Nitrogen bottle tank
- Pigging
- Required equipment maintenance

In order to fulfill all of those activities, the design has accommodated the required tool or equipment in such a manner that regular maintenance can be scheduled timely and effectively.

The concept of GGA NUl Offshore Platform operation is as unattended facility. Therefore, visiting the platform regularly and appropriately is critical work to be done by operation personnel in order to ensure that the facility will run as per designed.

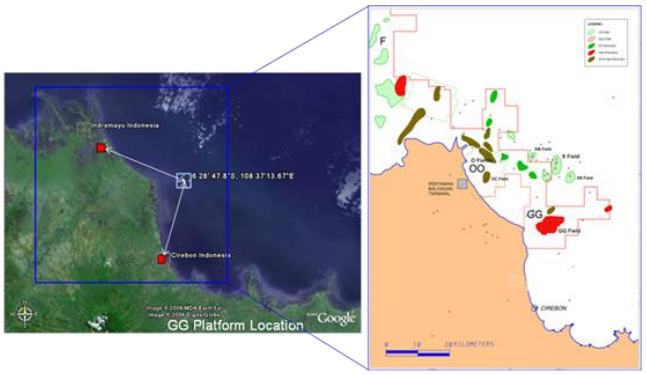


Figure 1. GG Field Map

The potential of renewable energy in Indonesia such as solar energy is high, and with this technology solar power generation system is applicable to generate power for offshore NUI at PHE ONWJ area. GGA NUI Offshore Platform is designed to be operated remotely from Onshore Processing

Electricity for GGA NUl Offshore Platform is fully sourced from solar power system utilizes 24VDC voltages with a voltage

variation ± 10% of nominal utilization voltage. The 24VDC power is supplied to all instrument, telecommunication, and electrical loads.

II. RELIABILITY AND AVAILABILITY

To illustrate further the significance of reliability and availability, terminology such as "mean time between failure" (MTBF) and "mean time to repair" (MTTR), and their correlation with the equipment warranty must have appreciation.

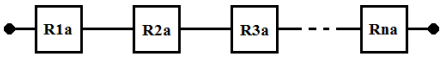
The relationship of MTTR and MTBF and availability is calculated with the following formula:

$$Availability = \frac{MTBF}{(MTBF+MTTR)} \quad (1)$$

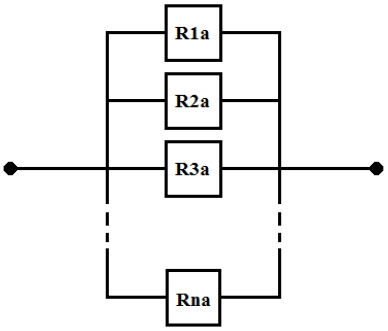
"Mean time between failure" (MTBF) is the time in a days or years that a piece of equipment or device is supposed to operate before it fails, commonly base on statistic data related to life span of a product.

"Mean time to repair," also referred to MTTR, is time required to repair equipment. MTTR is not quantifiable figure since is implies available of component, complexity design and repair, procurement, skill etc.

When configuring any system regardless of the technology, system reliability becomes subject to parallel and series deployment of various component or system equipment that is either used in series or tandem or parallel (figure 2) depicts series and parallel system configuration [3].



a. Series system configuration



b. Parallel system configuration

Fig 2. Series and parallel system configuration

In series configuration, the product of all reliability figure of the entire chain by following equation:

$$A_s = R_1a \; x \; R_2a \; x \; R_3a \; x \; R_na \quad (2)$$

In the case of parallel system configuration, by following equation:

$$A_p = 1 - (1 - R_1a) \; x(\; R_2a) \; x \; (1 - R_3a) \; x \; (R_na) \quad (3)$$

With,
A_s : Availability series
A_p : Availability parallel
$R_{1...n}$: Device or Equipment
a : Availability

III. STUDY AND DATA

This reliability study focused on solar power system of GGA offshore platform showing Figure 3. Solar power system are size to produce approximately 1000 watt and 8 days back-up time.

A. GGA NUI Offshore Platform

To get more reliability dual system (figure 4) are design to feed electricity load for GGA NUI offshore platform which consists of 100 crystalline silicon total modules.

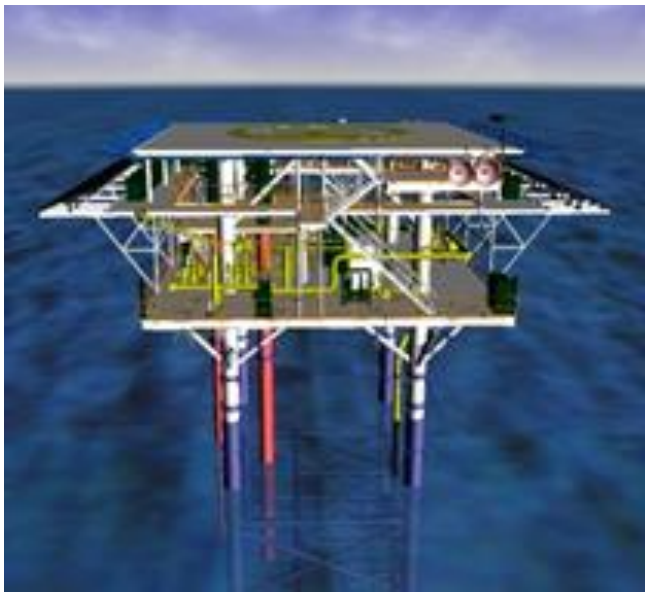


Figure 3. GGA NUI platform

This solar power generation system will cater various loads, this loads is divine in two category essential and non-essential loads.

Essential loads are various loads that affect the process, security and system shutdown such as:

- PLC safety system
- Remote terminal unit
- Field instrument devices
- Multi-phase flow meter
- Radio microwave system
- Security system (IP base PTZ camera)
- Telecommunication panel

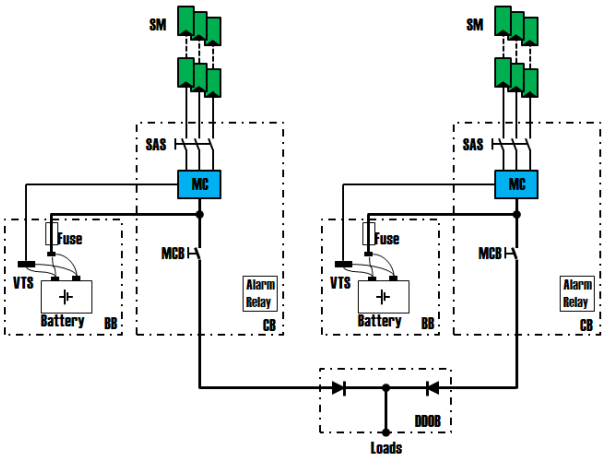


Figure 4. GGA NUI Offshore system configuration

Non-essential loads are classified by process not effect in loss of gas production such as:

- Navigation aids system
- Radar beacon
- Chemical Injection (Corrosion and Scale Inhibitor)

As show in figure 4, in a dual system set-up the solar power system consist of two identical sub systems describe bellow:

- Two solar arrays each with 50% of the total required solar modules for generating the energy.

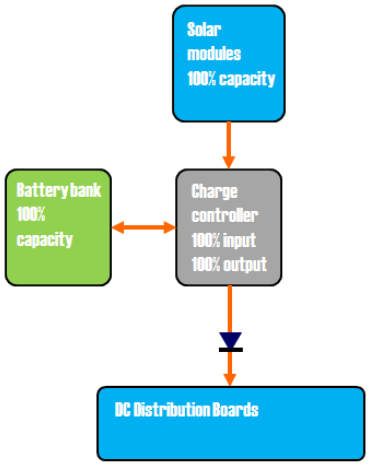


Figure 5. Single system configuration

- Two battery banks each with 50% of the battery capacity to supply energy to the loads during "no-sun periods".
- Two charge controllers, one for each sub-system.

Each sub system can supply 100% of the required power for the load.

The total number of solar modules and battery capacity provide the required energy and are divided over two systems. The full power can supply by each sub-system. Each sub-system has energy storage for 50% of the autonomy period. Each sub-system can therefore power the loads for at least haft the autonomy period under "no-sun conditions".

The load is connected via output diodes, each sub system has monitoring facility, which will provide a pre-warning low voltage or general alarm signal.

B. Equipment data

Photovoltaic connected to the charge control device with multi array configuration, manufacturers in the photovoltaic and charge control device are offering warranties of 20 years, MTTR assumption 72 hours and loss of availability in solar days during life cycle 3.61 hours other as bellow table.

TABEL 1. GGA NUI EQUIPMENT DATA

Equipment	**PV-System**	**CCD**	**Battery**
Reliability block ID	**PVa**	**CCDa**	**BATa**
MTBF-Years	20	20	15
Hour	24	24	24
Days per Year	365	365	365
Hours	175200	175200	131400
Hour per Year	8760	8760	8760
MTTR	72	72	72
Availability	99.96%	99.96%	99.95%

IV. MODELING SYSTEM

The following calculation is intended to demonstrate the effect and consequence of deployment single and dual system at GGA NUI Offshore system.

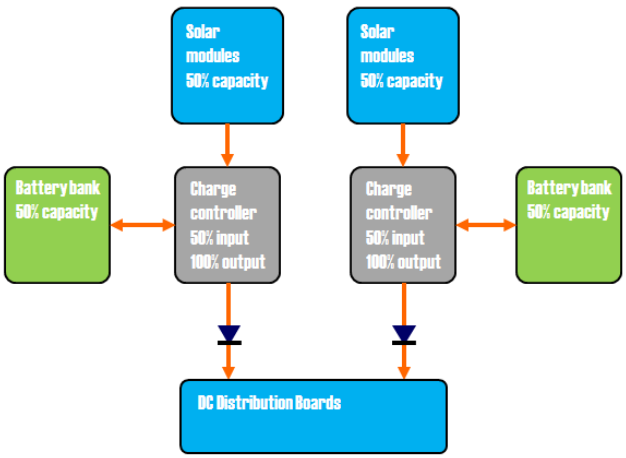


Figure 6. Dual System configuration

Availability system modeling which consists of three configurations for calculation, namely:

- PV parallel Configuration
- Single system configuration
- Dual system configuration.

A. PV Series Configuration

The crystalline silicon 155W (12V) series connected to digital charger controller specially designed for off-grid solar power application to utilizes 24VDC voltages with a voltage variation ± 10%, formulas for this configuration as bellow:

$$A_{SM} = PV_1a \; x \; PV_2a \quad (4)$$

B. Single System Configuration

The input capacity for solar array of one charger controller is 100%, based on figure 5, formulas for this configuration as bellow:

$$A_1 = 1 - (1 - ((SM_1a \; x \; CCDa)xBATa) \quad (5)$$

C. Dual System Configuration

In figure 6 describe design 2 x 50% allow for switching off and maintenance one subsystem while the other sub-system in providing energy to load without interruption, formula for availability as bellow :

$$A_2 = 1 - (1 - A_{11}a) \; x \; (1 - A_{22}a) \quad (6)$$

With:

A_1 : Single system configurations
A_2 : Dual system configurations
$PV_{1...n}$: Photovoltaic
$SM_{1...n}$: Solar modules
CCD : Charge controller devices
BAT : Battery
a : Availability

V. RESULT AND DISCUSSION

Based on the description in data and method section, can be determined the reliability and availability GGA NUI offshore platform, in the table 2, reliability dual system is 0.09% more higher than single system.

TABEL 2. RELIABILITY SYSTEM

Description	Reliability
PV series configuration	99.917859%
Single system (1 x 100%)	99.822117%
Dual system (2 x 50%)	99.999684%

TABEL 3. PV RELIABILITY AT THE SYSTEM

Description	Single System	Dual System
Differential reduction of availability	0.095742%	-0.081825%
Relative downtime hours per year	8.387027	-7.167845
Relative downtime hours per 20 years	167.740538	-143.356904
Daily solar insolation hours of operation	3.61	3.61
Lost of availability in solar days during life cycle	46.45 days	-39.71 days
Module capacity	155 watt	155 watt
Number of module @24VDC	50 modules	25 modules
Total lost solar days during lifes	2323 days	-993 days

Solar PV availability with dual system increase 185.46% than single configuration system.

VI. CONCLUSION

Application of the dual system configuration is one of the methods to increase reliability and availability system

By using the method of predictive models for reliability and availability we can get the value in quantitative.

With this simple method of predictive models can identify improvements in design and provide estimates of performance over the system's lifetime.

For next study recommended using commercial software, such as ReliaSoft Weibull++™ and some data necessary to detail interpretation specially modeling reliability block diagram for system behavior.

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REFERENCES

[1] PHE ONWJ, 2014, Dual Solar Power System Operation Principle. GG-E-SOP-0700.

[2] Elmer Collins, Michael Dvorack, Jeff Mahn, Michael Mundt, and Michael Quintana,. Reliability and availability analysis of a fielded photovoltaic System, Sandia National Laboratories.

[3] Peter Gevorkian, 2014, Large-Scale Solar Power Systems, Construction and Economics, Cambridge. ISBN: 9781107697171

[4] PHE ONWJ, 2005, Interim Investigation Report Loss of 24V DC Power Supply of APN-A Platform.