Maintenance Decision Models for Java-Bali 150kV Power Transmission Sub Marine Cable Using RAMS

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ABSTRACT

The application of Reliability, Availability, Maintainability and Security (RAMS) analysis is currently developing in many fields of electrical power system. The focus of this paper is to demonstrate the applicability of RAMS to analyze maintenance planning on 150 kV submarine cables of Java-Bali Power Transmission system in Indonesia. In this maintenance decision model, four alternatives of maintenance scheme are made based on maintenance interval and cable's mechanical protection. Monte Carlo simulation will be used to obtain RAMS value of each alternative. The decision is made based on cost-effectiveness parameter using life cycle cost analy-sis (LCCA).

KEYWORDS

Maintenance Decision Models, RAMS, Submarine Cable, Risk Analysis, Cost Effective Maintenance Strategy, Monte Carlo.

1. INTRODUCTION

Application of high-voltage submarine cable has been widely used around the world to deliver electricity between islands. In contrast to Europe where submarine cable has been widely applied, in Indonesia this type of cable is still rarely used. Indonesia is geographically separated between five major Islands. In the future, the development submarine cable's application is expected to be increased. It is based on the effort to improve the reliability by connecting the electrical system between Islands.

The first high voltage submarine cable in Indonesia is built on 1990 between Java Island (Banyuwangi substation) and Bali (Gilimanuk Substation). This 150 kV lines has a significant role in transfer electric power from Java to Bali. Load characteristic is shaped by the high demand for electricity in Bali as a rapid tourism area. On the other hand, power plants on Bali are not sufficient to meet the demand of its local electricity [2]. Along with the increasing load demand, two new cable lines (3 and 4) were built in 2013. As shown in figure 1, this installation is built with the combination of submarine cable (4.8 km) that laid under Bali strait, along with underground cable and overhead transmission lines on Java island and Bali island.

Due to the rapid development in using high voltage cable in Indonesia and high cost spent in each project, it is considered to be important to do the study of system's cost effectiveness based on engineering performance and cost analysis of the project. Many methodologies has been offered to achieve this goal. To measure the reliability aspect in complex integrations like Java-Bali transmission lines, the engineering integrity needs to be determined. Engineering integrity includes reliability, availability, maintainability and security of systems functions and their related equipment.

The concept of RAMS analysis is not new and has been progressively developed in many area, such as transportation, building, industrial manufacture as well as electrical power system. In the process of determining the RAMS parameters, each of these areas has a unique way to be approached. This is obvious because some or all of these parameter are strongly dependent of time characteristic of the particular systems, whether it is observated as a part or as an integration. Much consideration is being given to engineering design based on the theoretical expertise and practical experiences.

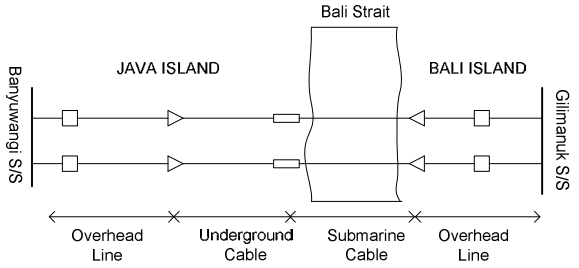

Fig.1: Configuration of Java Bali 150 kV line 3 and 4

In power transmission lines, especially one that using submarine power cables, the RAMS analysis is also considerably unique, based on the facts that submarine cable has a very long life cycle and it can not easily accessed for monitoring during its operational life. To achieve effectiveness in term of reliability and cost, treatment can be conducted in an operational and maintenance process. In the system that has been installed like Java-Bali transmission lines, the alternatives can be generated by modifying the mechanical protection of the installed system and rearrange the maintenance scheme.

2. METHODS

2.1 RAMS Parameter

RAMS are stands for reliability, availability, maintainability, and security of the system. All of this parameter are used together to determine the efectiveness of the system as an integration [6], formulated as:

$$\text{Effectiveness} = R(t)\times AF(t)\times M(t)\times S \quad [1]$$

To measure the effectiveness of the system, RAMS parameter are often combined with system cost, in order to determine the cost effective solution. In this stage, life cycle cost analysis (LCCA) are being used. Analysis is applied in operation process of the cable installation. In this case, four alternatives are generated based on the maintenance scheme, as can be seen in figure 2. Each