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STREAM FLOW ANALYSIS FOR SMALL HYDROPOWER SYSTEM BASED ON RUN-OF-RIVER SCHEMES

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ABSTRACT

Studies in renewable recently had captured the attention of the researcher due to benefits to environmental and green application. In Malaysia, renewable energy based on hydro especially in small hydropower system based on run-of-river schemes are less implemented even though there are abundant numbers of potential site that can be exploited. Small hydropower system generates energy from flowing of water therefore, the availability study of the stream flow is necessary to contribute to the success of the project. Probability distribution function comparison between GEV, Gumbel and Weibull will be used in this study to find the best fit probability distribution for the stream flow data that are obtained for the whole year of 2016. Monte Carlo simulation will be act as a tool to validate the distribution applied for the stream flow data obtained. GEV, Gumbel and Weibull distribution function were chose due to its capability to cater the extreme events occurred in the stream flow. From the result, both stream flow and simulation of Monte Carlo leads to same types of distribution that is suitable to be used in describing the events which is GEV distribution function.

Keywords: small hydropower, run-of-river, extreme events, Monte Carlo simulation, GEV.

INTRODUCTION

Small Hydropower plant can be described as one of the best alternatives renewable resources especially for rural electrification in generating electricity. This system is economic, non-polluting and environmental friendly. The source of power is derived from the energy of water moving from higher to lower elevation (Kumar A. *et al.* 2011). Basically this system requires the availability of the stream flow data (Kasamba C. *et al.* 2015). On average, Malaysia received approximately 3549mm or rain annually (Shafie *et al*. 2011). Besides, there are about 189 named rivers that are comes from the mountainous areas of the country's and it be estimated around 500 MW electricity generated for small hydropower system (Lidula NWA *et al*. 2007 and Oh TH *et al.* 2010).

There are three main type of hydropower technology according to the operation and type of flow and head which are Run-of-river (RoR), storage (reservoir) and pumped storage. Basic operation of the RoR is small portion of the water river will be diverted into a channel then to a penstock then through the hydraulic turbine connected with the electricity generator (Kumar A. *et al.* 2011). This schemes often used in application of small hydropower system and in Malaysia; it can be size up to 30 MW in capacity (Malaysia Report on Small Hydropower 2012). Small hydropower system depends on the availability of the water passed through the turbine then mechanical energy from the shaft drive the generator to produce electricity. The generation of electricity is directly proportional to the stream flow and head of the system (Abdullah S. *et al*. 2016).

Monte Carlo simulation is a technique to describe the randomness of a numbers in order to find a solution to a problem (Rubenstein R.Y. *et al.* 1981). It achieves an approximate solution of a mathematical or statistical problem by simulating random quantities (Sobol I.M. *et al.* 1974). This technique was first used by the scientist to develop the atomic bomb and "Monte Carlo" was comes from the city of Monaco that are famous for gambling (Palisade Corporation 2013). The advantage of this method is that if the mathematical models of the real data can be found then the actual test can be simulated as much as necessary to obtain the randomness of variables (Qamar *et al*. 2011).

In hydrology, this method was widely used and powerful tool due to hydrologic system inherent lots of randomness such as in study of flood frequency analysis (Rahman A.P. *et al.* 2002 and Loukas A. *et al.* 2002) rainfall-runoff modeling (Marshall L. *et al.* 2004) and low-flow scenarios for stream flow (Wilby R. *et al*. 2006). The important of these studies are the quantification of uncertainty by using the statistical and stochastic modeling.

Even though there are many researches had been done in stream flow analysis related to the small hydropower system yet, there is still lack of research focusing on the use of Monte Carlo simulation as validation support and GEV distribution as the main prediction analysis. The stream flow are in stochastic events with full off unpredictable events. Therefore, the aim of this paper is to study the suitable distribution used for prediction analysis of the stream flow and validate it using Monte Carlo simulation. This study will helps in helps in improve the prediction of the stream flow analysis based on the real data obtains and contributes for the future understanding in small hydropower system analysis.

METHODOLOGY

In this article, the research work was performed at a 5MW grid-connected small hydro power plant located at Sungai Perting, Bentong, Pahang. In order to obtain the stream flow rates of the small hydro power plant, the

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Signature Flow Meter with specialty in monitoring the open flow channel applications as the base meter is connected to the TIENET 310 Ultrasonic Level Sensor located at the water river intake of the river for each pairs of the stream channel. The Ultrasonic level sensor (refer Figure-1) is a non - contact liquid level measurement work by measuring the time interval between the transmission of the sound pulse of the river surface to the sensor and all the data obtained are in stochastic variables that will collected by Signature Flow Meter (refer Figure-2).

Figure-1. Ultrasonic Level Sensor locared on Sungai Perting Small Hydro power intake area.

Figure-2. Signature flow meter to monitor the water river level.

The main function of installing the equipment is to obtain stream flow rate of the river. In this research, Weibull ++ Software from Reliasoft was used to generate the prediction data that have same characteristic as the raw data which is the stream flow of the whole year in 2016. Then, statistical functions such as probability density function (PDF) and cumulative distribution function (CDF) were calculated and plotted using MATLAB computational package. Apart from that, comparisons between Weibull, Gumbel and generalize extreme value (GEV) distribution were used through the functions to determine the best fit distribution suitable for analyzing the stream flow and Monte Carlo simulation was used to validate the actual data obtained.

RESULT AND DISCUSSIONS

In this study, the data obtained from daily observation for the whole year in 2016. The stream flow (m3/s) data obtained by the Ultrasonic Level Sensor were in form of continuous qualitative variables. The probability distribution function of extreme values families (Weibull, Gumbel and GEV) were used in this analysis to model the real situation of the stream flow at the intake of the small hydropower system located at Perting River, Bentong Pahang. These distributions were chose due to the ability of the system to model extreme values or rare events observed in the stream flow. Monte Carlo simulation was used as tools to validate the suitable distribution applied on the model. The distribution of the stream flow shows unpredictable behavior due to dependency on the availability of the rainfall distribution that is influenced by the monsoon season.

Figure-3 shows the PDF of the raw data of the stream flow while Figure-4 shows the PDF of the stream flow data generated by Monte Carlo simulation. Based on the both figure below, it shows that, the curve of the GEV (brown) function is more covered up the entire density of the distribution data compared to the Weibull (blue) and Gumbel (red) function. The PDF functions in this model are affected by the parameter of scales (η) and shape (β).

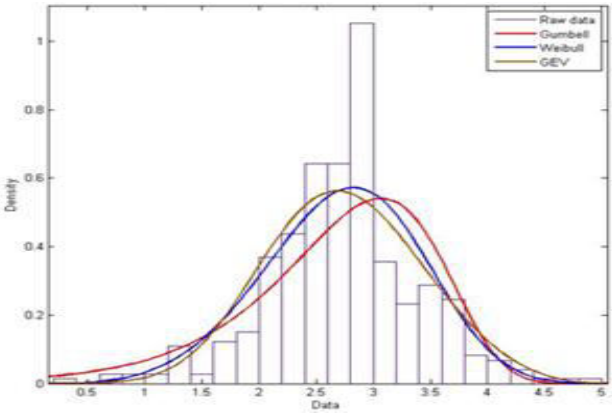

Figure-3. Probability Density Function (PDF) of stream flow.

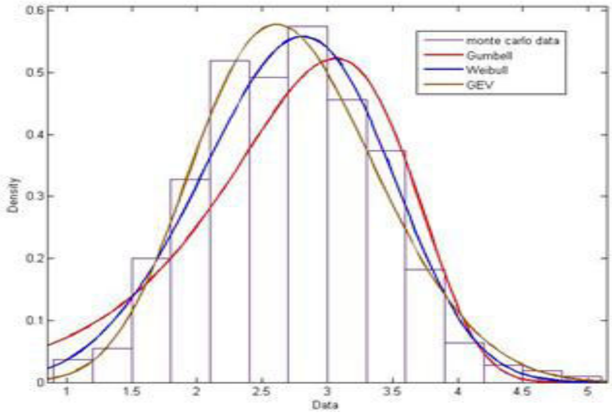

Figure-4. Probability Density Function (PDF) of Monte Carlo simulation.

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Figure-5 shows the CDF of the stream flow while Figure-6 shows the CDF of the Monte Carlo Simulation. Both CDF function for the stream flow and the Monte Carlo simulation shows that, the GEV (brown) function have more potential to be used in analyses the behavior of the stream flow compared to the Weibull (blue) and Gumbel (red) function. The curve of the GEV function is more covered up for the whole distribution of the CDF of stream flow and the stream flow generated by the Monte Carlo simulation.

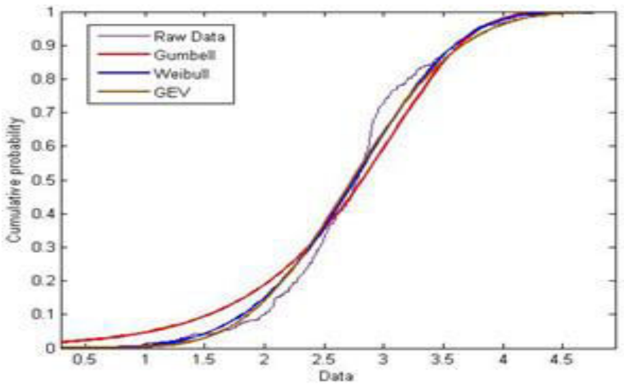

Figure-5. Continuous Distribution Function (CDF) of stream flow.

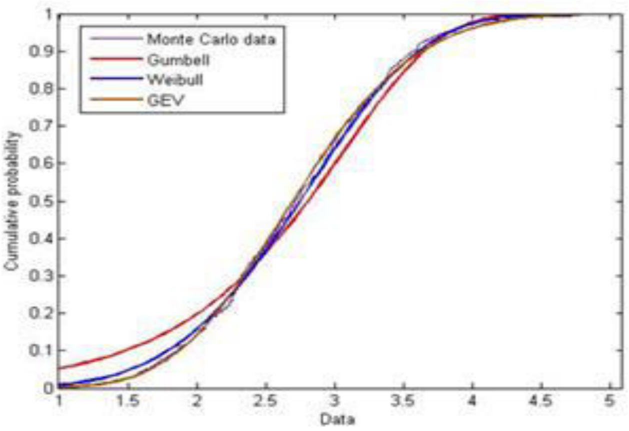

Figure-6. Continuous Distribution Function (CDF) of Monte Carlo simulation.

CONCLUSIONS

As a conclusion, the small hydropower system one of the best solution in fulfills the demand of the electricity needed in rural area especially using run-of-river schemes. The generation of the power in small hydropower system especially run-of-river schemes is depends on the availability of the stream flow. The flow assessment is important in maintain the reliable of the system. Besides, more data needed to be collected in order to study the feasibility of the system. Others factors such as sedimentation, water scarcity and river pollution also needed to be considered. Even though there are other methods available to be used, from this study it shows that, Monte Carlo simulation can yield good results as well in predicting the data based on the behavior of the raw data obtained. The stream flow distribution and the distribution generated by the Monte Carlo simulation both lead to the same result which is GEV distribution function is more reliable tools to be used in analyses the stream flow model compared to the Weibull and Gumbel distribution. This is due to the GEV distribution function considered the details of the extreme or rare events occurred in the stream flow. Extreme or rare events in this model are the highest and lowest values of the stream flow that are influenced by the rainfall distribution in that area. This finding will helps in better understanding of the small hydropower system and improvement for better future in exploiting the renewable energy sources based on water flow system especially in Peninsular Malaysia.

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