Faculty of Engineering

Case Study: Design and Development of Pico Hydro Power System for Underserved Community in Kampung Semulong Ulu

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CASE STUDY : DESIGN AND DEVELOPMENT OF PICO HYDRO POWER SYSTEM FOR UNDERSERVED COMMUNITY IN KAMPUNG SEMULONG ULU

MAH KAR WENG

This project is submitted in partial fulfillment of
the requirements for the Degree of Bachelor of Engineering with
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To my beloved parents

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ABSTRAK

Kampung Semulong Ulu ialah sebuah kampung yang terletak di Sri Aman, Sarawak. Kampung ini ialah salah satu komuniti yang telah mula membuat satu projek untuk membina penjana kuasa elektrik yang menggunakan air. Komuniti ini terdiri daripada 25 keluarga yang mempunyai 93 orang penduduk bumiputra yang berketurunan Iban. Penduduk di kampung ini telah memulakan penginapan di tempat tersebut lebih kurang 60 tahun yang lalu. Kampung ini terdapat sebuah rumah panjang sepanjang 143 meter and ada beberapa buah lagi rumah di sekeliling rumah panjang ini. Perjalanan ke kampung ini memerlukan 2 jam perjalanan kereta dan 2 jam perjalanan bot. Kajian ini dijalankan untuk mencadangkan penjana kuasa elektrik air yang bertaraf piko untuk penduduk di Kampung Semulong Ulu. Penjana kuasa elektrik air ini akan direka dari waduk sehingga ke penstok tidak termasuk rekaan elektrikal. Objektif kajian adalah untuk menentukan bahagian-bahagian penjana kuasa elektrik piko, mengkaji adakah keadaan di kampung tersebut sesuai untuk mengguna penjana kuasa elektrik piko, mengkaji faktor-faktor and bahagian bahagian penjana kuasa elektrik, dan mencadangkan satu rekaan penjana kuasa elektrik piko kepada penduduk di kampung tersebut. Cara yang digunakan untuk menentukan aliran sungai ialah “velocity-area method” dan ketinggian ditentukan menggunakan GPS. Perisian komputer HOMER akan digunakan untuk menyemak semula kiraan. Keputusan daripada perisian HOMER menunjukkan bahawa keputusaan kiraan manual adalah betul. Kuasa yang boleh dijana dari tempat yang dicadangkan ialah 6.35 kW dan kuasa yang boleh dijana menggunakan saiz paip and saiz waduk yang ditentukan ialah 4.55 kW dimana kuasa ini dapat memenuhi keperluan elektrik penduduk yang hanya memerlukan 4.46 kW.

ABSTRACT

Kampung Semulong Ulu is located in Sri Aman, Sarawak. It is one of many communities that have started their own hydro power project. This community consists of 25 families, consisting of 93 people of *Iban* ancestry. Those villagers have settled in the area since about 60 years ago. The kampung inhabits a 143 metre longhouse and a few houses near by. The transportation to the Kampung requires two hours car trip and another two hours boat trip. This research was carried out to propose a pico hydro power system for Kampung Semulong Ulu. The pico hydro power system will be design from reservoir to power house excluding electronic design. Objectives of this study are to determine the different components of pico hydropower system, to study the site condition of underserved communities that suitable for pico hydro power, to investigate the effect of different components and factors that affects the efficiency of the generation of power, to propose and develop a pico hydro system for the underserved communities. The method that has been used to determine the stream flow on site is velocity-area method and GPS device has been used to determine the head. Beside that, a software known as HOMER will be used to verify the mannual calculations. The HOMER results show that the minimum required water flow to generate 5kW of electricity is 50L/s and the software also recommends constructing a pico hydro power system in Kampung Semulong Ulu. Based on the result obtained from the calculations, the proposed location of reservoir and power house can produce 6.35 kW and the maximum power with the proposed reservoir and penstock size is 4.55 kW which is sufficient for the villagers' eletricity demand, 4.46 kW.

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CHAPTER 1

INTRODUCTION

1.1 Background

Sabah and Sarawak is blessed with high volume of rainfall every year and topographic condition is hilly and mountainous. These areas are also rich in water; forest other biological resources that sustain the livelihoods of many indigenous communities. Many of these communities are very remote and dispersedly located on these hilly and mountainous areas, making it challenging in terms of development.

In this new era of information and communication technology (ICT), electricity supply is the most essential infrastructure for development. Electricity is also the key infrastructure enhancement to provide opportunity for job generation and vital income for village residents. However, numerous rural communities in Sabah and Sarawak are without electricity services, which are a limiting factor in socio-economic development, education, and healthcare.

Rural electrification through “conventional methods” such as grid connection and diesel generators is either very costly, or - in the case of grid extensions – simply not in the plans for the foreseeable future. These conventional methods result in emissions that are harmful to human health and the environment. With the rise of fuel prices in recent year rendering many isolated diesel generators un-operational due to high maintenance cost. Even new solar hybrid systems are affected by the cost since these systems still runs almost 50% on diesel during rainy days; where in remote areas in Sabah and Sarawak average rainy days are almost all year long.

With the rise of fuel prices, diesel generators become an economic burden on low-income families. Remote rural communities have to pay more to enjoy diesel and petrol-fueled electricity supply, eliminating the economic benefits of electricity. The additional costs very often cover the long distance transportation. Hence they pay twice or more the actual market price for every liter to power generators, often for less than six hours a day. Already burdened by poverty, paying such a high cost for energy is like rubbing salt to their financial wound.

The proposal solutions to these problems to provide electricity to remote communities in Sabah and Sarawak are amazingly coming from its own obstacle which is its hilly and mountainous terrain and high rainfall. These conditions are ideal criteria for a pico hydro system. Hydro power is the oldest form for technology to harness energy from natural resources since the invention of the water wheel by humans. It uses simple but practical form of spinning wheel to harness power from water that is still in use today.

1.2 Problem Statement

Kampung Semulong Ulu is one of the communities who are not connected to the national grid power supply. In year 2004, the government had provided those villagers with solar energy system to generate electricity. The villagers were able to use electrical products ever since but unfortunately the systems were poorly maintained, and therefore in year 2006, most of the solar energy system capacity to produce electricity has been reduced.

Those villagers are facing a lot problem due to the lack of electricity. One of the major problems is in term of economy and business opportunity. Those villagers have to process their crop manually hence the production rate is very low and they were unable to use electrical machineries to process their raw material into its final products. In addition, those villagers have to stop their daily activities at 6:00pm because they do not have electricity to light up the longhouse. The development in this kampung is very slow because they do not have electricity supply.

In order to overcome these problems, residents of Kampung Semulong Ulu had purchased a few diesel generators to power up their longhouse. However, due to the price of diesel and its transportation to the village, they could only afford to operate the diesel generators for two to three hours during the night time, costing them about RM600 per month for the diesel.

Kampung Semulong Ulu is a place that blessed with high volume of rainfall every year and there are a few waterfalls near by this Kampung. The topography condition in this kampung is suitable to use hydro power system to generate electrictiy which will be of minimum cost to the community.

1.3 Location of Study

The selected location for this study is at *Kampung Semulong Ulu*, Sri Aman, Sarawak as shown in Figure 1.1. It is one of many communities that have started their own hydro power project. This community consists of 25 families, consisting of 93 people of *Iban* ancestry. Those villagers have settled in the area since about 60 years ago. The kampung inhabits a 143 metre longhouse and a few houses near the longhouse as shown in the Figure 1.1. The transportation to the Kampung requires two hours car trip and another two hours boat trip as shown in Figure 1.2.

Figure 1.1 : Location map and the router from UNIMAS to Kampung Semulong Ulu, Lingga, Sri Aman.
(Google Earth, 2009)

Figure 1.2 : Boat trip on the way entering the Kampung Semulong Ulu, Lingga, Sri Aman.

Figure 1.3 : Longhouse in Kampung Semulong Ulu, Lingga, Sri Aman.

1.4 Scope of Study

The scope is this study is focused on the pico-hydroelectric for the underserved community. This study is limit to the fundamental of hydraulic engineering, evaluating stream flow, site evaluation methodologies and hydraulic structures of pico-hydroelectric.

1.5 Aim

This study was aimed to propose and develop a renewable energy system. The proposed renewable energy in this report is pico-hydro power systems that will provide remote, rural villages with a reliable supply of electricity and this report focus on pump-as-turbine (PAT) systems. The pico hydro system is design for the underserved community in Kampung Semulong Ulu.

1.6 Objective

The objectives of this study are:

- To determine the different components of pico hydropower system.
- To study the site condition of underserved communities that suitable for pico hydro power.
- To investigate the effect of different components and factors that affects the efficiency of the generation of power.

- To propose and develop a pico hydro system for the underserved communities.

1.7 Outline of Chapters

Chapter 1 introduces the background of this study, its location and objectives.

Chapter 2 focuses on similar studies done by other researchers in micro and pico hydro systems, concentrating on the methods and techniques used and also the results obtained.

Chapter 3 presents the methodology used in this study. Selected methods and techniques that is applied in this study are discussed and described in detail. The methods and techniques are selected after review of other researches as discussed in the Chapter 2 Literature Review.

Chapter 4 elaborates the Results, Analysis and Discussions obtained using methods and techniques discussed in the Chapter 3. Then the results are then analyzed and compared. The factors that contribute to the inconsistentency of result if any will also be discussed.

Chapter 5 would focus on the Conclusions and Recommendations. In Conclusions and Recommendations, this research will be summarized. Recommendations are also proposed to improve the similar study in the future.

CHAPTER 2

LITERATURE REVIEW

2.1. Pico Hydro Power

2.1.1. Historical Background of Hydro Power

Hydropower started with the wooden waterwheel. Waterwheels of various types had been in use in many parts of Europe and Asia for some 2,000 years, mostly for milling grain. By the time of the Industrial Revolution, waterwheel technology had been developed to a fine art, and efficiencies approaching 70% were being achieved in the many tens of thousands of waterwheels that were in regular use. Improved engineering skills during the 19th century, combined with the need to develop smaller and higher speed devices to generate electricity, led to the development of modern day turbines. Probably the first hydro-turbine was designed in France in the 1820s by Benoit Fourneyron who called his invention a hydraulic motor. Towards the end of that century many mills were replacing their waterwheels with turbines, and governments were beginning to focus on how they could exploit hydropower for large-scale supply of electricity. (Paish, 2002)

2.1.2. Introduction of Pico Hydro Power

Moving water has potential energy that can be used by a hydropower system to generate electricity. Wherever there are mountains and streams, hydropower can bring low-cost electricity to isolated communities without polluting the air or water. Hydropower has been a very useful technology where people have been obtaining energy from falling water for thousands of years. Hydropower is still being used on many different scales for many purposes, from small grain-grinding facilities to huge hydroelectric dams that provide electricity to entire cities.(Greacen & Kerins)

Flowing and falling water have potential energy. Hydropower comes from converting energy in flowing water by means of a water wheel or through a turbine into useful mechanical power. This power is converted into electricity using an electric generator or is used directly to run milling machines. Most people in North America understand hydropower as involving big dams and large-scale generating facilities. Small-scale hydropower systems, however, are receiving a great deal of public interest as a promising, renewable source of electrical power for homes, parks and remote communities. Hydropower technology has been with us for more than a century. Many early mills, mines and towns in Canada built some form of power generation from small hydropower systems in the late 19th and early 20th centuries.(Josée Bonhomme, 2004)

Pico hydropower systems are relatively small power sources that are appropriate in most cases for individual users or groups of users who are independent of the electricity supply grid. Hydro-power systems are classified as large, medium, small, mini, pico and micro according to their installed power generation capacity. Electrical power is measured in watts (W), kilowatts (kW) or megawatts (MW). Systems that have an installation capacity of between 100 kW and 1000 kW (1.0 MW) are referred to as mini-hydro. Small hydro is defined as having a capacity of more than 1.0 MW and up to 10 MW. Pico hydro is considered as a small scale hydro power.(Josée Bonhomme, 2004)

Pico hydro is hydro power with a maximum electrical output of five kilowatts or less than 5kW. Hydro power systems of this size benefit in terms of cost and simplicity from different approaches in the design, planning and installation than those which are applied to larger hydro power. Pico hydro can be a cost-effective option to generate electricity of remote rural communities. Recent innovations in pico hydro technology have made it an economic source of power even in some of the world's poorest and most inaccessible places. It is also a versatile power source. AC electricity can be produced enabling standard electrical appliances to be used and the electricity can be distributed to a whole village. Common examples of devices which can be powered by pico hydro are light bulbs, radios, televisions, refrigerators and food processors. Mechanical power can be utilised with some designs. This is useful for direct drive of machinery such as workshop tools, grain mills and other agro-processing equipment.(Phillip Maher, 2001)

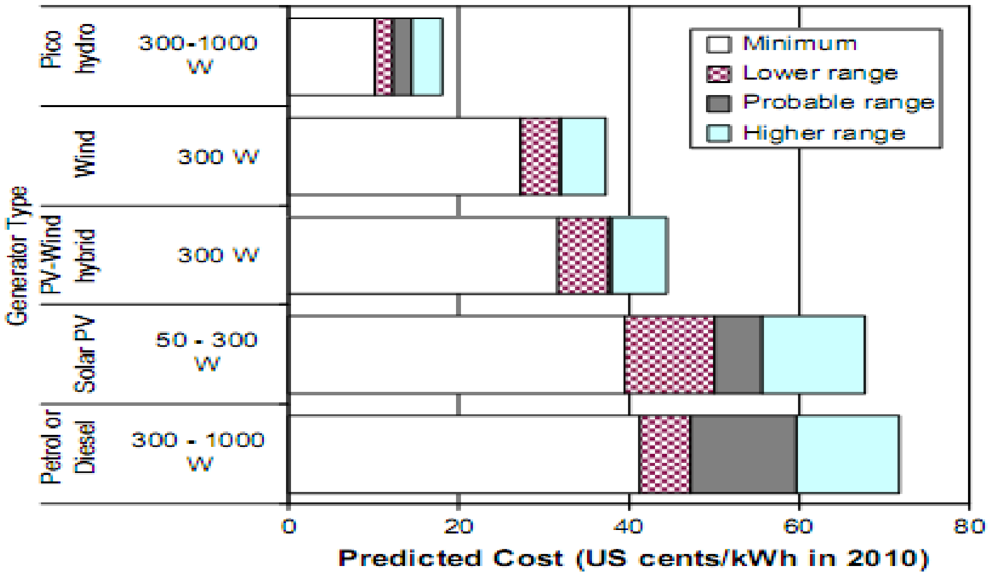

Figure 2-1: Predicted cost for off-grid electricity – data from World Bank (A.A. Williams 2009)

According to the Figure 2-1 above, pico hydro is the lowest cost generator type if compare to other types of generator therefore pico hydro has been proposed in this project.

2.2. How Small Scale Hydro Power Work

All hydropower systems use the energy in flowing water to produce electricity or mechanical energy. In small-scale hydropower, run-of-the-river systems, which do not require large storage reservoirs, are often used. For run-of-the-river systems, a portion of the river's water is diverted to a water conveyance, such as a channel or pipeline, which delivers the water to a waterwheel or turbine. The moving water rotates the wheel, which spins a shaft. The motion of the shaft produces electricity, which can then be used directly or fed into the grid.