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CoERE
Centre of Excellence for Renewable Energy

KeTTHA
KEMENTERIAN TENAGA, TEKNOLOGI HIJAU DAN AIR

FEASIBILITY STUDY FOR GREEN ENERGY ISLAND

FINAL REPORT

VOL. 1

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Executive Summary

The Green Energy Island (GEI) feasibility study has been awarded to the Centre of Excellence for Renewable Energy (CoERE), Universiti Malaysia Sarawak (UNIMAS) in June 2011. Due to the fact that Sarawak, which is the largest state in Malaysia, has extensive and a vast rural community, there are many rural community areas that have to be powered with electricity.

More than 200 of these sites have off grid communities that have yet been supplied with basic necessity such as electricity and treated water. However, Sarawak fortunately has abundant of water sources and if utilized well and properly can be used as the renewable energy source to supply electricity to these communities. The GEI project is presented as a solution to this problem.

The idea of GEI for the off grid communities is to develop a sustainable micro-hydro powered electricity system. The idea was translated into a complete proposal and submitted to the Ministry of Energy, Green Technology and Water (KeTTHA). CoERE was awarded a grant by the Akaun Amanah Industri Bekalan Elektrik (AAIBE) and KeTTHA to identify three (3) best off grid sites in Sarawak to apply the GEI concept in order to create sustainable micro-hydro system that will be maintained and operated by the community. The sites identified should also become exemplary projects of green village in which the community is in harmony with the technology and the existing environment. The income level should also be improved by the electricity generated.

This report consists of narrowing down more than 200 off grid sites based on the report by Kementerian Kemajuan Luar Bandar dan Wilayah (KKLW), Sarawak Energy Berhad (SEB) and Jabatan Kerja Raya (JKR) Sarawak to ten (10) sites that may have the potential for the GEI project implementation. The site investigations are carried out through rigorous and extensive site visits over eight (8) months period. Details of these site studies are presented in this report, covering the background of the selected sites, demographic data and technical data that includes hydrological data and load demand analysis.

Based on detailed desk study and literature review done by CoERE, parameters for the study are identified. The information on the technical and other aspects of the site are gathered on site during the visits through qualitative site observation and the quantitative method through the designed forms, surveys, on site measurements and calculations. The information obtained is also verified with data provided by key governmental and non-governmental agencies.

A total of ten (10) sites are chosen, studied and examined for the potential of GEI application to provide electricity to the residents. Based on the results from the site visits, three (3) sites are finally selected for further study and setting up of the trial sites of GEI. Detailed findings for these three (3) sites are presented in Volume 2 of the report.

1.0 Background

Sarawak is the largest state in Malaysia, which is located in the Island of Borneo. Although rich in natural resources and biodiversity, it has sparsely populated interiors, mountainous geographical landscape and large underdeveloped areas. The Crocker Range acts like a backbone to the state making it extremely challenging in terms of electrification and road development programs. As a result the poverty rate in the rural areas is higher in Sarawak. There are numerous communities living in the interior without electricity, proper health support, treated water, education and with low income.

This report contains information on the current energy scenario in Sarawak and how Green Energy Island (GEI) concept, developed by Universiti Malaysia Sarawak (UNIMAS) as the solution to the current energy shortage in the rural areas of Sarawak. With over 200 potential sites that had been furnished by the relevant governmental authorities and non-governmental bodies, ten (10) sites have been chosen as the pilot study for the GEI concept. The sites chosen are based on strict selection criteria which were developed through research form of literature review and desk study. Extensive questionnaire surveys were developed in order to collect the relevant information from these ten (10) sites in this preliminary study. The survey outline is presented in the succeeding section of this report.

1.1 The Sarawak Energy Scenario

In this section, a map of Sarawak (Figure 1.1), the schematic of the power grid are presented along with subsections on income generation activities, average income, percentage access to energy services, the current forms of energy and types of renewable energy resources.

Big scale wind energy generation has been found to be not feasible in Sarawak. However, Sarawak has major hydroelectric dams such as Bakun Dam and Murum Dam which is currently being constructed. On-going work on possibility of constructing micro or mini hydro is being conducted. GEI concept is to combine recent power generation technology with community efforts to be implemented at suitable locations in Sarawak.

1.1.1 Map of Sarawak

Shown in Figure 1.1 is the map of Sarawak. It can be observed that the transmission grid is connecting major cities in the state. Sarawak has vast potential for hydroelectricity power generations with many potential hydroelectric projects have been identified all throughout the state such as Limbang, Baram and Murum.

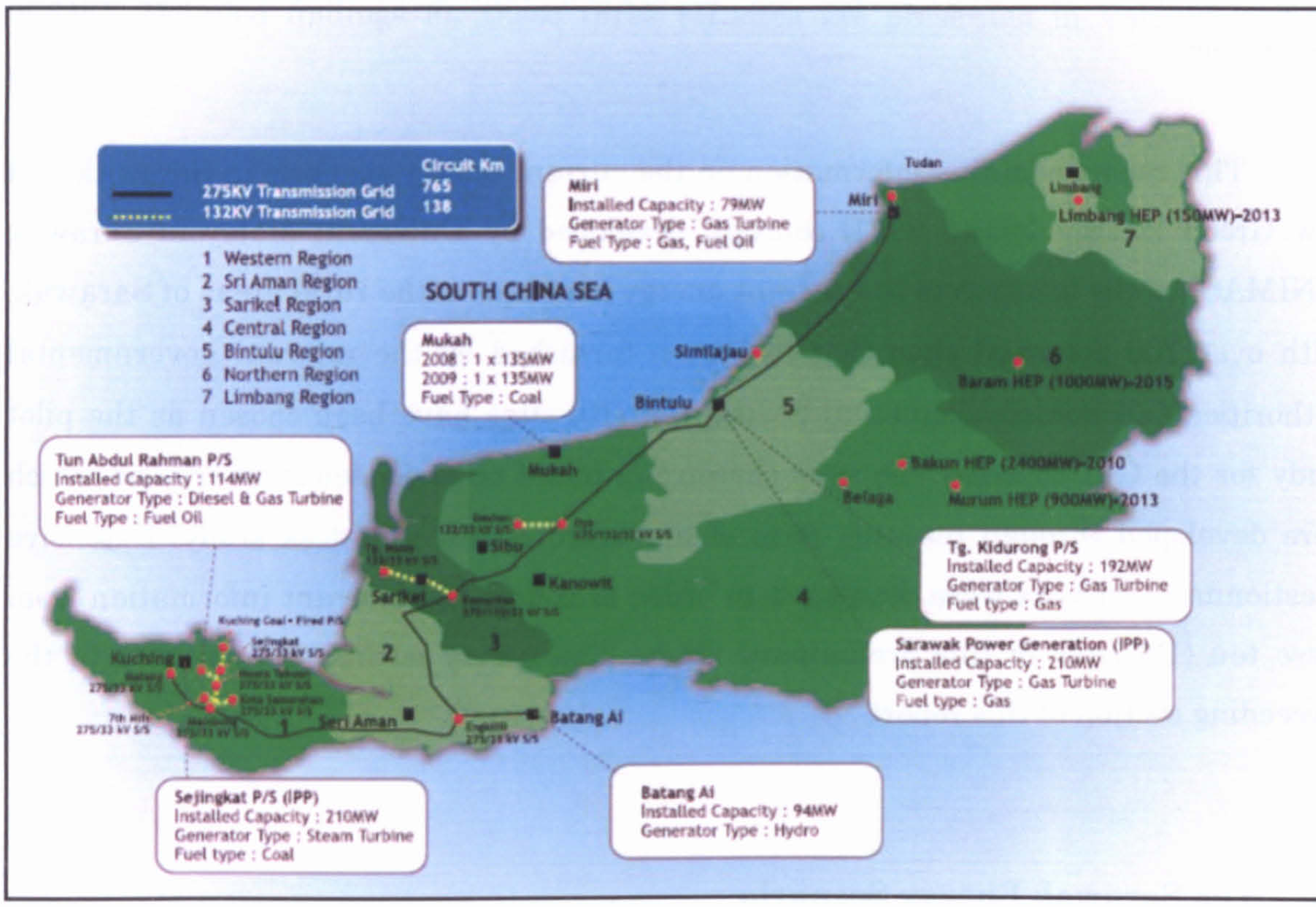

Figure 1.1: Electricity Grid System in Sarawak

1.1.2 Income Generation Activities in Sarawak

The economic activity of Sarawak is mostly in agriculture, mining and forestry sectors. Other sectors that also contribute to the economic activity are manufacturing, wholesale, retail trading and construction sector. The primary sectors are such as mining, agriculture, forestry, manufacturing and construction which contribute about 70% of the state total real Gross Domestic Product (GDP). Table 1.1 shows the economic activities in Sarawak.

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Table 1.1: Gross Domestic Product in 2010 by Kind of Economic Activity at Current Prices, Sarawak

Economic Sector	Value (RM Million) 2010 (estimation)
Agriculture & Livestock	3,590
Forestry & Logging	3,759
Fishery	738
Mining & Quarrying	9,380
Manufacturing	13,675
Construction	1,158
Services	18,960
GDP at Purchasers' Value	51,505

Sarawak is a state in Malaysia that is blessed with plenty of natural resources. Liquefied Natural Gas (LNG) and petroleum has been the main economic income contributors for Sarawak for the last few decades. Apart from that, Sarawak is also one of the world's largest exporters of tropical hardwood timber. Logging activities are carried out by private companies in the state and policies were introduced so as to ensure sustainable supply of raw materials for local processing.

Being the largest state in Malaysia, Sarawak has large regions of land suitable for commercial agricultural development. Approximately 32% (4.0 million hectares) of the state's total land area have been identified as suitable agricultural land (Department of Statistics Malaysia, 2010). Less than 9% of this is planted with productive permanent crops, while the remains are still under shifting cultivation for rice (more than 1.6 million hectares). In terms of commercial agricultural activities, crops such oil palm, sago, and pepper are the major plantation activities.

Sarawak has started to diversify and transform its economy from agricultural based into an industrialised based in the mid of 1980s. This endeavour has been met with continued success, with manufacturing and hi-tech industries now playing a significant role in shaping the economic expansion of the state. In 2008, Sarawak Corridor of Renewable Energy (SCORE) was developed aiming to transform Sarawak economy based on *knowledge based economy* and subsequently Sama Jaya Free

Industrial Zone has been proposed to attract high-tech industries to set up business in Sarawak.

1.1.3 Average Income in Sarawak

The average income per capita for Sarawak is above the national average. Sarawak has an privileged record of development and an overall poverty level of 7.5% in 2004. The poverty rate in 2007 is 4.2% (State Planning Unit, 2012). However, development in the rural areas has not been spectacular, and the rural poverty rate was 12.9% in 2004. The poor communities tend to be scattered along the rivers in the rural and remote areas.

1.1.4 Percentage Access to Energy Services of Sarawakians

The 3-5% of Sarawakians is located in remote areas inaccessible by the power grid (Lim, 2009). Getting them connected to major grid is a major problem due to many factors such as terrain, distance and small population density.

1.1.5 Current Forms of Energy in Sarawak

The electricity generation in Sarawak currently is from petrol, diesel, hydro, coal and gas as the 5 main types of power generation (Suruhanjaya Tenaga, 2011). Of these, the small scale hydroelectric power generation method is the most economical option for those living in the rural or remote areas to generate electricity for their own use such as lighting. For cooking, they normally use fire wood which is cheaper than gas and readily available.

1.2 World Energy Outlook

With the current projection of population growth around the world, energy crisis is expected to grow as the costs from fossil fuel is on a steady rise while the supply declining. The rise in intensity of continuous economic activities will drive the demand for energy especially with respect to electricity and transportation. This in turn affects the price of the energy and the technology used to produce them as can be seen at the crude oil price.

In addition, the emissions resulted from fossil fuel and the expanding economy in various sectors too is a concern. By 2020 it is expected that many countries will implement national measures to decrease carbon intensity. Many fossil fuel subsidies is phased out, which will in turn cause another change in the pricing of such energy.

In other words, rising prosperity inevitably pushes the energy price up and this relationship can only get stronger. Energy is derived primarily from fossil fuels. Therefore, keeping the energy supply secure, curbing the effects of emissions and rising climate changes and continuous rising of fuel costs remains the major challenges for international communities and most governments. If the situation persists and no alternatives are found, the world communities could be fronting with energy deficiency and be out of basic amenities such as electricity and treated water.

1.2.1 Trend towards Renewable Energy

According to the World Energy Outlook (2010), policy support for renewable energy has increased considerably for the past decade. The two drivers are limitation of growth in greenhouse emissions and the reductions of fossil fuels. To address these concerns, more and more governments are adopting targets and taking measures to increase the share of renewable energy mix.

Renewable based electricity output has increased by nearly a third from 2000 to 2008. While nearly 1000TWh increase came from hydropower, new forms of renewable grew very rapidly, notably wind power and solar photovoltaic electricity production. Biomass and geothermal power both increased too even though at a more moderate pace. Governments' effort and policies for renewable energy tend to focus on electricity, water supply and transport.

Renewable energy resource based is large and can adequately meet a huge proportion of the energy demand. However, it is to be noted that renewable energy cost are yet to be competitive and is still relying of various incentives. Such incentives exist in many countries with requirement imposed by the government to the suppliers to increase the share of renewable energy in electricity production, water supply and transport fuel.

In developing large scale of renewable energy power generation, cost effectiveness is essential. Renewable energy technologies are capital intensive, requiring significant upfront investments and most cannot currently compete on price with conventional technologies. However, costs have already reduced significantly for many renewable energy technologies. It is projected that there will be substantial increase in modern renewable energy applications. The growth projection is rapid in order to overcome the declining fossil fuel based energy that shall increase in their pricing and yet less environmentally friendly.

According to the world energy outlook as summarized above, it is inevitable for Malaysia to walk in pace with such trend. With our geographical locations, climate, and current infrastructures there are various options which can be and has been explored.

1.3 Renewable Energy Resources Available in Sarawak

There are six types of potential renewable energy resources in Sarawak namely biomass, solar, wind, hydropower and geothermal. Each of these renewable energy resources has its own potential to meet or complement the existing energy demand of the state.

1.3.1 Biomass

In Sarawak, jatropha is one of the alternatives of biomass power generation besides palm and wood waste. A planting scheme called *Projek Ekonomi Rakyat Sarawak* (PERS) is carried out by local agency and supported by a Malaysian industry executive group of BIONAS (The Borneo Post, 2010). With the current technology, each acre is expected to yield up to 3.6 tonnes per year. Jatropha produces seeds with an oil content of 37%. The by-products are pressed cake into a good organic fertilizer and the oil contains made into insecticide. In Sarawak, many areas such as 809 hectares in Jerijeh, Belawai, Tanjung Manis and the Rajang area in Mukah division had been identified for the cultivation of jatropha.

1.3.2 Solar

As a tropical country, Sarawak naturally has abundant of sunshine and thus solar radiation. However, it is extremely rare to have day completely clear sky even in periods of severe drought. The cloud cover cups of a large amount of sunshine and thus solar radiation. On the average, Sarawak receives about nearly six (6) hours sunshine per day. On the extreme Kuching receive only an average 3.7 hours per day in the month of January (Malaysia Meteorology Department, 2013). With maximum temperature of $35^{0}C$ and six (6) hours sunshine, it is easy to generate electricity by means of solar energy especially in the remote areas of Sarawak. There are few projects supported by the government, NGOs and private sectors on solar PV to provide basic electricity needs for rural of grid communities.

1.3.3 Wind

Wind speed is insufficient for big scale current windmill operation technologies in the state. But nevertheless, few locations located near the coastal side of Sarawak might be able to generate small-scale wind energy. Pico-scale wind energy generation can be considered for the rural area applications that may require only lighting. However, currently there is no matured technology that can harness pico-scale electricity from wind.

1.3.4 Hydropower

It is expected that the future energy demand for Sarawak will come from hydroelectric power. Batang Ai Dam in Lubok Antu, Sarawak generates 108MW of electricity while the fully operational Bakun Dam will be able to generate 2,400MW of electricity. Other dam that will be built is the Murun Dam with capacity of 900MW (Sarawak Energy Annual Report, 2010). The state also has planned to build other hydroelectric dams such as in Limbang and Baram. Most of the electricity generated will be supplied to energy intensive industries especially in the SCORE region. Rural communities may still not be connected to this grid due to factors such as terrain, distance and population density prior to cost effectiveness. A better option for the rural and remote communities will be the mini-hydro or micro-hydro systems which can be designed specifically to meet the energy demand of a small community or population.

1.3.5 Geothermal power

Of the 79 potential geothermal manifestation areas in Malaysia, 8 can be found in Sarawak (61 in Peninsular Malaysia and 10 in Sabah). There are numerous other thermal areas officially reported especially within the remote vicinities of Sarawak (Geothermal Potential, 2010). However, these occurrences are yet to be ascertained due to their inaccessibility.

2.0 Green Energy Island as Energy Intervention Solution

Green Energy Island (GEI) concept is to construct an independent energy generation solution for the selected remote areas in Sarawak, especially those away from the main grid of energy supply. Energy supplied will be solely used for the said sites and thus creating a green energy island effect. GEI concept will utilize the most abundant resource in Sarawak, especially rivers and streams. Where this resource exists, micro-hydropower offers a proven and reliable source of electrical or mechanical power on demand, usually at a lower life cycle cost than diesel engine, wind, or PV systems. Using the energy of falling water/flow, micro-hydro power system supply mechanical energy that can be used directly or be converted to electrical energy through a generator, for use in lighting, refrigeration, information and communications technologies (ICT) or to run electric motors.

Micro-hydro system typically produces more energy per rated kilowatt on a daily basis than wind energy or solar PV systems. This is possible since micro-hydro system operates round the clock whereas solar and wind power systems generate power for only a few hours each day. Hydropower plants of less than 500kW capacity are generally categorized as "micro-hydro".

Table 2.1: Definitions of Hydroelectric Schemes

Hydro Type	Generated Power
Small hydro	2-5 MW
Mini-hydro	500kW – 2MW
Micro-hydro	≤500kW
Pico-hydro	≤5kW

Hydroelectric plants in the 1-100kW range generally supply power through a mini-grid to rural community. Such plants mostly produce alternating current (AC) and as such the supply is not much different from the supply of electricity from the national grid. Figure 2.1a and Figure 2.1b show micro dam and a power house for small-scale generation of electricity.