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Take Advantage of Wasteful Batang Hari Irrigation For Electricity Services Improvement

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Abstract— This paper describes the Batang Hari Irrigation prospect to meet the electricity needs in its surrounding area in order to increase the electrical service for every level society. The use of Batang Hari irrigation is far from its capacity. Un-used water and infrastructures from Batang Hari irrigation can be used to generate hydro-electric. Based on the results of this study, it can be concluded that the Batang Hari Irrigation can be used to generate electricity power up to 1.6 MW. This hydro power service can increase the level of electric service in West Sumatra Province more than 1%.

Keywords—*Irrigation, Hydro Power , Electricity Service*

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I. INTRODUCTION

West Sumatra Province has an area of about 42300 km^2 in which consists of 4561 jorong. This region is geographically located in the west-central side of the Sumatra Island. The West Sumatra province still has a tropical forest of more than 57% of the total area. Based on its function, the forests in West Sumatra are dominated by protected forest and conservation forest. In general these forests are the main resource of water which flows through the rivers. These Province in which the equator goes through has more than 600 large and small rivers.

In the middle part of West Sumatra province there are many hills goes through from the north to the south as part of the Bukit Barisan hill. The hills are the starting point in where water of the rivers starts flowing along of the West Sumatra. In general the river in West Sumatra can be divided into two categories that one goes through the western part and the eastern part of the Bukit Barisan hill. This condition leads to a pattern of land use for the field of agricultural area and communities exist in both regions.

Most rivers and lakes in West Sumatra has been exploited as resources for large-scale electrical energy. Currently there are three large hydropower plants that are PLTA Singkarak (175 MW), PLTA Maninjau (68 MW) and PLTA Agam (10.5 MW). The Local Government has identified that in West Sumatra region there are 12 locations that have the potential for development of large-scale power plants (total electric power of 200 MW) [1]. While the potential power of medium and small scale power plants placed at 32 locations with a total electric power of 135 MW. By the end of 2012 the Government and the private sectors have built Micro and Pico hydro power plants (PLTMH and PLTPH) for a total up to 109 units. Those power plants spread across the district areas with a total capacity of 2.39 MW and serve 11,718 families.

The growth of electricity demand in the West Sumatra is 7.62% per year. The developments of electric power infrastructures in the West Sumatra has an indicator of Electrical Service Coverage which is the ratio of jorong number that are underserved divided by the whole jorong in the West Sumatra. In 2013 [2] the developments of electric power infrastructures only able to gain Electrical Service Coverage by 89.81%. This value was slightly less than the target value of 93%. In 2014 Electrical Service Coverage target is 94%. To catch this target it is necessary to do any effort in the developments of electric power infrastructures such a way to increase the number of jorong (term village in the West Sumatra) that has electricity services by take the advantage of the available potential water resources in the West Sumatra

Figure 1. The Map of West Sumatra Province

II. BATANG HARI IRRIGATION

A. *Batang Hari Irrigation at the original*

The description of the Batang Hari irrigation development has been published by the Ministry of Public Works [3] as summarized in this section. Batang Hari irrigation development is began in 1976. At the beginning of the construction, the irrigation project is done by constructing small dams. Then it was equipped with 6 unit of water pumps (Fig. 2). The water pump is used to raise the water from behind the dam to supply the main irrigation channel. Total capacity at the beginning of this irrigation is planned for 17.5 m^3/s for covering the area of 12646 hectares (Ha).

Figure 2. The house of 6 units pumps

However, this development failed to reach plan. The existing area at the moment that is capable to be covered by the irrigation is only 4938 Ha (only 39% of the target). The failure is caused by four main reasons:

1) The cost of operation and maintenance of pumps are very high.
2) The reduction of pump capacity due to the service life.
3) The sedimentation level at intake pump is very high.
4) The reduction of water supply flow of the river due to environmental degradation in the upstream of the dams.

B. *Batang Hari Irrigation at the moment*

To overcome the failure in original Batang Hari irrigation development, the Government has built a new irrigation dam in the Main Batang Hari river. This river is the largest river in the West Sumatra Province. The Batang Hari river has a potential discharge of 86 m^3/s. This new dam construction is located on the upstream of the old irrigation channels (Fig. 3).

In order to avoid the same mistakes as previous one, then the intake system and delivery of the water supply from the new dam is not by pumping but the gravity. Irrigation Batang Hari this time planned to have a capacity of 25 m^3/s with an additional irrigation area of 15271 Ha. the Batang Hari irrigation system then is combined with the old irrigation one then will be able to irrigate an area of 18936 Ha in 48 jorongs. The total area of the new irrigation area is the whole area at the beginning development combined with the new target of paddy fields of 13953 Ha.

The new Batang Hari irrigation development budget is obtained from the Loan of Japan Government through two phases that are Loan IP-478 and Loan IP-540. In the first phase the development cost up to IDR 484 billions and the second phase is IDR 611 billions. The total budget of the irrigation Batang Hari today construction is nearly IDR 1.1 trillions.

In fact, the implementation of irrigation work of Batang Hari also face some problems that can not be solved yet. The main problems are related to the development of new irrigation area will be watered. These problems are leaded by:

1) The ownership status of land is not clear.
2) The border lands which are not clear.
3) The owner of land can not be contacted.
4) The change of land use from paddy fields to rubber and oil palm plantations.

As a result of these problems, then the development of new paddy fields just reached 1715 Ha. At this time the total area of Batang Hari irrigation area is only 7652 Ha. That area is only about 40% of the irrigation target plan that is 18936 Ha. If that amount is converted to the amount of water, at the present then there is still un-used water flow not less than 15 m^3/s.

The Government is still searching the efforts to take the advantage of the Batang Hari irrigation water in other purposes / sectors. Development of other sectors to take advantage of the excess water can be in the field of fisheries, drinking water and another new paddy fields. The new paddy fields target in 2014 is 2000 Ha. If that

target is reached, then at the end of this year there is 12.5 m^3/s excess water of Batang Hari irrigation still useless. This is a real wasteful of the natural resources.

In highlight of the lack of interest of farmers to grow rice in paddy fields, it is necessary to thinking of the use of excess irrigation water to other sectors. One of them is electricity which is very needed by people.

III. USE OF WATER FOR ELECTRICITY

A. *Batang Hari Hydro-electric*

A Hydro-electric power can be generated if there is water resource available, but the water itself is not consumed [4]. In the areas of high density streams and plentiful water, hydropower is very important [5-8] and is regarded as one of the cheapest source of electricity [9-10] since it use no fuel and water is returned to the nature. Hydro-electric is a function of the hydraulic head multiplied by rate of fluid flow. The head indicates the potential energy every unit weight of water. The static head is proportional to the difference of the initial height through which the water falls. Then each unit of water can produce an amount of energy equal to its weight times the head.

In the mathematic forms, the hydro electric power produced by falling water can be calculated from the flow rate and density of water, the height of fall, and the local acceleration due to gravity, that is:

$$P = \eta\, Q\, \rho\, h\, g \qquad (1)$$

where: P is power in watts

η is the efficiency of the turbine and generator

Q is the flow in m^3/s

ρ is the density of water in t/m^3

h is the height difference of inlet and outlet in m

g is the acceleration due to gravity in m/s^2

The efficiency is the lost energy since it is converted from one form to another. The equipments used to convert the power of flowing water to electrical power are turbine and generator. To calculate the most realistic power output, it must take into account the friction losses in the penstock pipes as well [11-13]. Selecting the right equipment, for instance turbine [14] and draft tube [15] sometime is the most important step to increase the efficiency of hydropower system. Typical efficiency range for practical hydropower system is 70% to 90%.

In Batang Hari irrigation once there are 6 units of pipe that was used to deliver the water from pumps to the irrigation main channel. Those pipes can be used as a penstock pipes to flow the pressurized water from the irrigation channel to the turbine and generator then back to the river. The position of the turbine and generator placed on previous pump house (Fig. 3). Furthermore, the water that moves the turbine is discharged back into the river. This power generation scheme is the opposite of previous irrigation water pumping scheme.

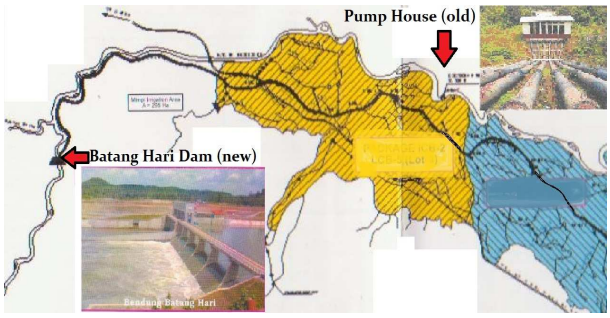

Figure 3. Batang Hari Site Map

The hydroelectric power of Batang Hari then can be calculated for unit water at 1 t/m^3 and a flow rate of 1 m^3/s for each previous penstock-pipe, gravity of 9.81 m/s^2 squared and with a net head of 32 m. The by taking the efficiency of 85%, the generated electric power then is:

Power (kW) = 0.85 x 1 x 1 x 9.81 x 32 = 267 kW

For 6 units, they will give 1.6 MW

B. *Cost and Electricity Service Coverage*

The budget required for electricity development in the Batang Hari can be estimated based on values commonly used to construct micro-hydro power plants (PLTMH). Development PLTMH can be estimated by the cost per kilowatt of IDR 30 millions. So as to develop a power of 1.6 MW in Batang Hari is required the maximum cost of:

Cost = 1600 kW x IDR 30 millions

= IDR 48 billions

These costs are the maximum estimated cost that required for generating power in Batang Hari irrigation area. The use of the old irrigation construction and the existing equipment such as pump houses as power house, pump pipes as penstock pipes and former inlets as tail race, will reduce the development cost. The real required cost will also depend on the choice of turbines and generators [16-17].

Furthermore, it is assumed the electricity served jorong is the same as Batang Hari irrigation jorong, that is 48 jorongs. Then this electric power development in Batang Hari will result the electrical service coverage levels in the West Sumatra Province increases by 1.05%.

This increase in the level of Electricity Service Coverage is enough to meet the target increment that indicate the success of development for 2013 to 2014 which is 1%. So that the development of electrical infrastructure in the West Sumatra Province just need to catch the lost performance in the previous year that is about 3%. To increase power harvest during peak hour, a pump-storage scheme may be applied with increased efficiency [18].

FINAL REMARKS AND CONCLUSIONS

Batang Hari Irrigation that has been built since 1976, in fact resulting un-used water resources. The expansion development of the capacity up to 25 m^3/s that finished in year 2011, did even make the wasteful water become larger. The excess of irrigation water in Batang Hari is

mainly due to the decrease in the farmer interest to grow rice convert to rubber and palm oil plantation. That problem needs to be solved by the use to other sectors. The use of the excess water for electricity is a very good initiative to be implemented since people need it very much. However, the upper catchment of the river must be kept forested in order to maintain consistent flow for a long term [19]. Otherwise, deforestation increases water yield for a short term due to direct surface runoff and reduced evapotranspiration, but decreases long term discharge and increases sedimentation. The use of hydropower as a renewable energy source must be endorsed by the government, since it is emission-free with proven technology [20], although recent studies suggested that a shallow-tropical reservoir produces methane gas that also contributes to global warming [21].

Old irrigation system in Batang Hari that was by water pump system is no longer used today. This unused system together with the Batang Hari irrigation excess capacity can be used to develop hydro-electric plant that much needed by community. The hydro-electric development can generate power up to 1.6 MW and also increase the level of Electricity Service Coverage in West Sumatra Province of 1.05%.

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