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Pico Hydropower Application on Tidal Irrigation CanalSupporting The Indonesian Agricultural Activities Case Study: Telang II – Banyuasin

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***Abstract*— A review of waterwheel history has conducted to evaluate the possibility and thetechnology development in its relation to harvest the energy from the flowing water inand out of irrigation canal regarding the tidal movement. The study has conducted atthe east shore of South Sumatra. Hydro energy became a promising renewable energyin order to achieve at least 5% of total Indonesian national energy mix consumption in 2025. Tidal turbine energy is technologically potential for Indonesian futureregarding the beach of 81,000 kilometers long and 20 millions hectares of tidalswamp area out of 33 millions hectares available. Mechanical torque of 30 Nm isproduced by a waterwheel of 0.38 meter radius. An estimation of 60 watt at the peakof rain season could harvested from each tidal irrigation canal in Telang II. Thismechanical energy is applicable to generate small quantity water pump, water aerationinjector and small electric energy energy appliances.**

***Keywords*— Hydropower; Renewable Energy; Tidal Energy; Irrigation Canal.**

I. INTRODUCTION

The world electric energy production become doubled in the last decade, from 9.5MTOe in 2001 to 19 MTOe in 2010 (Abbasi, 2011). 17% out of it comes fromhydropower or about 715.000 MW (BP, 2009). Some countries with lean fossil fuelresources, fulfill their national energy necessity with hydropower.e.g. Brazil with85.5% of its national capacity , Norwegia with 98.25% of national capacity andCanada with 61.12% of national capacity. (Wikipedia,2009) Hydro energy is aninteresting energy resource regarding the clean and safe impact on the environment.

Indonesia is trying hard to diversify the energy consumption, concerning the painexperiences of state economic disturbances when the oil price raise. The higher the portion of oil in national energy consumption, the more the dependency of stateeconomic on oil price. The government take some policies on the base of energyconservation, energy saving and energy diversification. In order to achieve the energydiversification target successfully, it is projected to consume energy mix as presentedin Table 1, as a compulsory target. Renewable energy resources as solar energy, waveenergy, tidal energy, wind energy are abundance in Indonesia regarding thegeographic position across the tropic area and archipelagic islands of the country.Hydropower is a possible energy to be developed in Indonesia regarding thehuge amount of hydro energy potential. It is estimated that Indonesian hydropowerpotential about 75,000 MW one-third of Asian hydropower potential. (Hayes, 2004;Kamarudin, 2005). Hydropower, especially Tidal Current Turbine take specialattentions for development in recent years. Tidal Current Turbines are classified assmall hydropower regarding the energy produced mostly below 50 MW.

TABLE II
INDONESIAN ENERGY COMSUMPTION RATE AT PRESENT AND COMSUMPTION PROJECTIONS IN YEAR 2025

No:	Energy Specifications	Present Consumption Rate *)	Consumption Rate Projection in the Year 2025 **)
1	Oil	47.5%	20%
2	Gas	26.5%	30%
3	Coal	24.3%	33%
4	Biofuel	-	> 5%
5	Geothermal	2.45%	> 5%
6	New and Renewable Energy	1.7%	> 5%
7	Others	-	> 2%

*) British Petroleum, Year 2008.
**) Perpres No5, Year.2006.

A. Greenhouse Gas Emission and Global Warming

Global warming is faced by the earth and threaten all nations on the globe. It ispredicted that no nations and no countries will safe on earth when thetemperature rise and climate change affected by the global warming is out ofcontrol.The greenhouse effect is the process of absorption and emission of infrared radiationby gases in the atmosphere and warm the planet's lower atmosphere and surface. Itwas proposed by Joseph Fourier in 1824. (Weart, 2008).The major greenhouse gases are water vapor, which causes about 36–70% of thegreenhouse effect (Schmidt, 2005) ; carbon dioxide (CO_2), which causes 9–26%;methane (CH_4), which causes 4–9%; and ozone (O_3), which causes 3–7%. (Russell,2007). Clouds also affect the radiation balance through cloud forcings similar togreenhouse gases. Indonesia menghasilkan emisi sekitar 2,1 Gt CO_2 equivalent di tahun 2005,halmana equivalent dengan 4.97% dari emisi gas rumah kaca dunia. Suatupeningkatan terjadi hingga mencapai angka 2,4% emisi dunia pada tahun 1993 atau ekivalen dengan 140 juta ton CO_2 (Petrich,1993). Sebagian besar emisi CO_2 Indonesiatidak berasal dari aktifitas industri seperti India, China dan Jepang, tetapi terkaitdengan kebakaran gambut dan deforestasi. (Indonesia National Climate Change Commision, 2010; Jupesta, 2011; Brockhaus, 2011).

B. Waterwheel

Waterwheel has established since 2000 BC. Doomsday Book reported in the year 1086 there are 5000 waterwheels in England and 60.000 waterwheels in Francein the year 1820 (Denny, 2004). It is reported that in China, India, olden Egypt,Paraguay, Brazil, Congo and African countries, waterwheels are used to pump thewater into rice fields.At the beginning most of the waterwheel operated with vertical shaft. Verticalshaft waterwheel is considered as much simplified the transmission system where themechanical energy could directly connected to the equipment wanted to the devicesuch as milling machine, pumps etc. Some decades after, waterwheel is constructedwith horizontal shaft, regarding the high efficiency and the development oftransmission system. Waterwheel has operated in Europe since 800 years ago to meetthe mechanical energy the people need that time.(Kaldellis, 2007).

C. Telang II – Banyuasin

Muara Telang is a Kecamatan in Kabupaten Banyuasin, Sumatera Selatan,Indonesia. This area is now being developed as a Kawasan Terpadu Mandiri(Integrated Self Sufficient Area) or abbreviated by KTM-Telang. This area includesDelta Telang I and Delta Telang II which is separated by Telang River. Delta Telang I and Delta Telang II is surrounded by four main rivers, Musi River on East,Banyuasin River on the West, Sebalik River and Gasing River on the the south, whileon the north bordered by Terusan PU and Banka Strait.Delta Telang I has an area of 26.680 hectares involving three Kecamatans,i.e.Kecamatan Muara Telang, Kecamatan Banyuasin II and Kecamatan Makarti Jaya.Delta Telang II has an area of 13,800 hectares including Kecamatan Tanjung Lago,Kecamatan Talang Kelapa and Kecamatan Muara Telang. Delta Telang II has 12villages, i.e. Desa Telang Sari, Desa Purwosari, Desa Mulya Sari, Desa Banyu Urip,Desa Bangun Sari, Desa Sumber Mekar Mukti, Desa Suka Damai, Desa Suka Tani,Desa Tanjung Lago, Desa Sri Menanti and Desa Kuala Puntian.

1) Climate and Hydrology: The climate of KTM Telang is categorized as tropical rain where warm andmoist is existed all the year. Average monthly temperature is 27 C dan relativehumidity is 87%. The area of KTM Telang categorized as agroklimat C1 zone. In wetseason (rain season) with period of 5-6 months the average rainfall is >200 mm permonthand in dry season (summer), of equal period the average rainfall is <100 mmper-month. Dry season does on October-April, and rain season does on May-September.Tidal irrigation canals are fully developed in KTM Telang concerning the

needs to watering the area of rice fields around it. Primary canals are stretchingconnecting between rivers and Secondary canals are stretching connecting between

primary canals. In general, the drainage system in KTM Telang is double-gridsystem. Mostly the distance between primary canals are 8.000 m. Secondary canals

are perpendicular and directly connected to primary canals. The distance betweensecondary canals are 1,150 meters each and 3,850 meters long. Most of KTM elangarea topographically are tidal swamp area with the elevation of 0,5 m - 2,25 m abovethe sea level. The water moving in and out of the canals all day long.

2) Bangun Sari Village: Bangun Sari is a village where the study of micro hydro power is focused on.Bangun Sari village is situated in Telang II and located at about one kilometers at theside of Jalan Raya Tanjung Api-api. Bangun Sari is an area of 1650 hectares square.This area is inhabitted by 3,390 people, consist of 1,786 man and 1,604 women orabout 681 Family Heads. Most of the people or about 60 % of the population arefarmers and some other informal jobs. Small community with public facility is at thecenter of the village where the people do trading and their daily activities. (Darmawi, 2011)From the local point of view, the needs of hydro power generating in Bangun Sarivillage is quite high, regarding the following reasons: firstly, the electricity isexpensive to install, meanwhile the hydro power is free of charge; secondly, thehydropower is strongly possible to generate the small farming engine such as paddy separators, corn shedder etc. and thirdly, supporting the Indonesian governmentprogram to ascend the people prosperous and the walfare by Desa Mandiri Energi(Energy Self-sustainable Village) program. The utilization of irrigation canal forenergy purpose could hopely change the culture of the local people from only water culture to techno-water culture. In the point of view of nationality, the hydro power is a way to bring the country out of oil dependence and protect the state economy from the influence of world oil price fluctuation.

II. THEORITICAL ENERGY STUDY

The study of hydro power is focused on the sluice of irrigation canal in BangunSari Village which is situated at 2.381 South Latitude and 104.42 East Longitude.

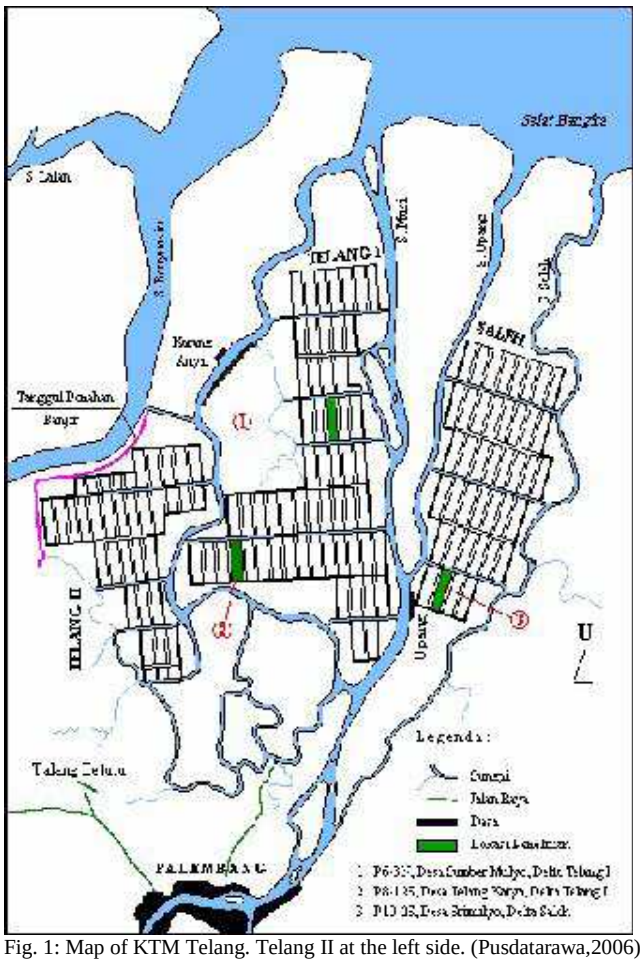


Fig. 1: Map of KTM Telang. Telang II at the left side. (Pusdatarawa,2006)

The observation conducted in March, 2011 noting that the water level at rain season is maximum at 95 cm from the baseline of sluice and the observation conducted in August the year 2011, the minimum water level at the dry season (summer) is at 30 cm, means that the cross section of flowing water at the irrigationsluice is 75 cm x 97 cm at the wet season and 10 cm x 97 cm at the dry season. Thespeed of flowing water in wet season measured by current meter is varying from zeroat the beginning of tide and 1.12 m/sec at the end of tide at wet season and 0.76 m/secat dry season. The maximum water level at dry season is 40 cm.

The maximum power contained in the flowing water at wet season is:

$$P = T \times \omega \qquad (1)$$

where:
P is the power contained in water (Watt)
T is the torque produce by flowing water at the shaft of the wheel (Nm).
ω is the circumferential speed of the wheel (rad/sec).

$$\text{Torque } T = F \times r, \qquad (2)$$

where F = Force acting on the wheel blade (Newton) and r is the distance between the shaft and the blade center point.The amount of the force acting on the blade is the total mass of water acting on theblade times the velocity of flowing water. ω is the angular speed of the wheel inrad/sec.In case, we assume that all of the water power could accomodated by the devicewe use to converts the flowing water into mechanical energy , the power will bemaximum at the wet season where the quantity of flowing water is maximum and theminimum power will be at at the dry season where quantity of flowing water throughthe gate is minimum. If the radius of waterwheel is assumed 0,75 meter, thecircumfrential speed of the wheel does the same with the velocity of water hence theangular speed of the wheel is 1.49 rad/sec and the rotation of the wheel is about 14.4rpm. The force of water acting on the blade of (0.75 x 0.97) m2 will equal to: ρ.m.Vwhich is equal to: ρ.A.V.V. where ρ is density of water 998,2 kg/m3. A is the area ofblade and V is the velocity of flowing water. The force acting on the blade will be998.2kg/m3 x (0.75x0.97)m2 x 1.12 m/sec x 1.12 m/sec = 90.938 Newton. The torqueat the center of the wheel shaft will be 90.938 N x 0.75 m = 68.203 Nm.

Hence thetotal power harnessed from the water flowing through the gate will equal to 68.203Nm x 1.49 rad/sec = 102,304 Watt.By the same way, the power contained in water in the dry season could estimatedas follows. From the preliminary measurements, the average velocity of water flowingout through the gate is 0.76 m/sec and the quantity of water acting on the blade is998.2 kg/m3 x (0.1x0.97)m2 x 0.76 m/sec x 0.76 m/sec = 5.5926 Newton. Torqueproduced is 5.6 x 0.75 = 4.2 Nm. If the circumferential speed of the wheel is the sameas the velocity of water, U = 0.76 m/sec and the angular velocity will be 1.01 rad/sec.The power produced is P = 4.2 x 1.01 = 4.24 Watt. (Darmawi, 2011)

III. FLOATING WATERWHEEL AND ENERGY HARNESSED

Waterwheel is constructed on the base of sluice gate sizes existed in Bangun Sari village on Telang II – Banyuasin.

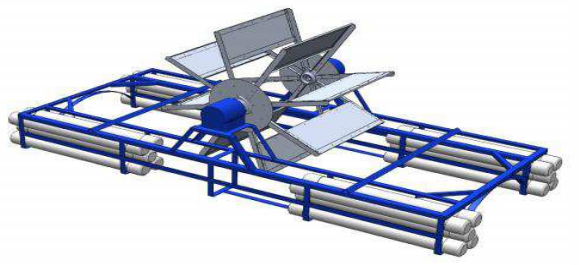


Fig. 2 Floating waterwheel with supporting PVC pipes on sides.

The wheel is made of Alluminium Alloy in the form of flat and L-profile.Connections are alluminium rivets. The overall sizes are 200 centimeters long and 90centimeters wide. The wheel diameter is 79 centimeters with eight flat blades of 50 x 20 centimeters in size.

(a) (b)

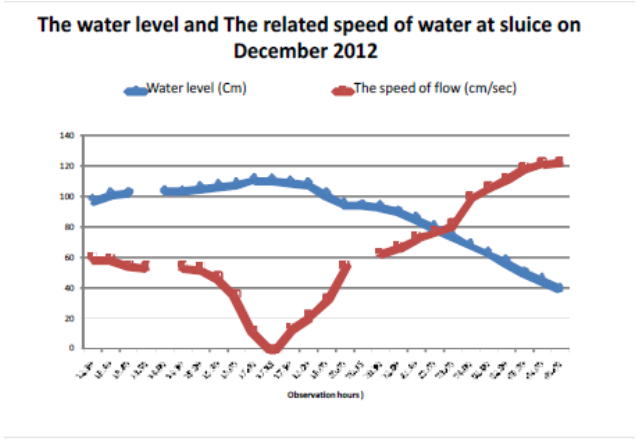
Figure 3: (a) The wheel and supporting frame in constructions. (b) The floating test is conducted with PVC pipes at the left and right sides.

(a) .(b)

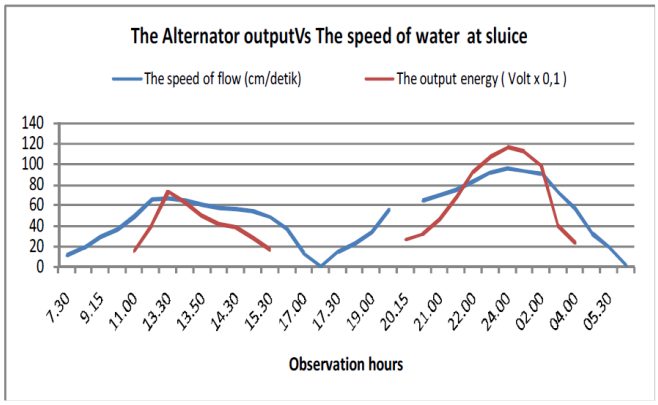
Figure 4: (a) Floating waterwheel on test on Musi River. (b) Floating waterwheel on test at sluice gate at Bangun Sari Village.

IV. Results of Test

The actual onsite test and measurements at the end of the year is shows theprofile of water level and the speed of water flow on sluice as Figure 5. Figure 5a,shows the relation between the water level and the speed of water current at the sluice.Figure 5b shows the relation between the speed of water at sluice and the electricenergy produced by the alternator.



(a)



(b)

Fig. 5 (a) The water level at tidal irrigation canal sluice and related speed of water flow. (b) The electric energy harnessed from the tidal current at sluice by applying the floating waterwheel.

V. Conclusions

By utilizing the floating waterwheel at the sluice, the electric energy harnessed atsluice as long as eleven hours in one day. The energy stored in the battery could usedfor the farmers daily life activity. The mechanical energy harnessed from the tidalirrigation sluice could also utilized for other agricultural activities supports such aswater aeration of fish ponds and couple the spiral pumps to lift the water from canal tothe rice fields.

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