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GREEN ENERGY WATER SUPPLY SYSTEM IN TIDORE ISLAND: A DESIGN

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ABSTRACT

Tidore Island is a small island which itsdomestic and non-domestic water requirments at 2018 was 125.21 *l/sec* and expected to be 167.98 *l/sec* by 2038. The existing data show the average of water source in the form of Deep Well in Tidore Island is 2.5 - 5 *l/sec*, in other words Tidore Island needs around 60 Deep Wells. The plant of Green Water Supply Concept is to make Shallow Wells with depths between 24 - 40 meter below ground level and pump them into 500 m^3 capacity reservoirs at an altitude of 469 meter and Micro Hydro Water Turbine which installed at an altitude of 134 meter. The potencial of ground water in Rawa Lembah Kramat is around 55 *l/sec*, make it suitable to be planted with a capacity of 50 *l/sec* water turbine and estimated will produce 105 KW electrical energy if it's total effeciency is 65% and it's difference falling altitude is 346 meter. The Calculation show the electrical power requirment for 50 *l/sec* capacity 120 meter head pumps is 98KW, this means the electrical energy generated by micro hydro turbine is able to meet the energy requirments of raw water pumps.

Keywords: rural communities, water quality, infrastructure, water supply, micro hydro turbine.

1. INTRODUCTION

The availability of water sources in the rural communities at a small island is quite limited. To overcome this limitation problems, it requires technological innovation at management of nature water supplyingwhich coversnation or global standarts such as"4K" standarts which stands for "*Kuantitas*"(Quantity),"*Kontinuitas*"(Continuity),"*Kualita s*"(Quality), and "*Keterjangkauan*" (Affordability). Above all things that cost in all kinds of technological inovation at supplying drinking water, the greatest cost is its electricity cost. As the rural communitiesof Tidore Island, which the island has a circumference about 48 km with a population of around 99,337 people [1], requires the provision of raw water for drinking water with a large enough capacity. The availability of potential raw water in this area is very limited and until now has relied on ground water sources. Most of the ground water are from deep ground water sourcewhich has high cost consequences in the production process. From this concern and conditions, a new breakthrough is needed to minimize the cost of production in the supply of drinking water by optimizing the potential ground water source that exists on the island of Tidore.

Rawa Lembah Keramatis one of potential ground water sources which is suitable to be developed (Figure-1). It's located on the east side of Tidore Island with an altitude of 396 m and can be distributed by gravity after being pumped ata appropriate altitude. It is a valley with an area of 11,695,081 m^2 and surrounds by hillsides which lead to it (Figure-2), make it an effective water catchment area.

Figure-1. Rawa Lembah Keramat.

The Idea of ready-to-drink water treatment equipment installment in this area is potential effort to overcome the problem of drinking water supply in Tidore Island (Figure-3), it goes like another area that are difficult to water, for example for rural areas in coastal areas or remote islands. Processing brackish swamp into ready to drink water is suitable for use in areas such as coastal areas, tidal swamp village areas, densely populated settlements in coastal areas, areas of settlements with poor groundwater quality [2]. One of the key factors in the successful development of swamps is the proper land management and water management techniques, so as to create a good growth medium for plants. By paying attention to technical, socio-economic and environmental aspects, the swamp area development will be carried out in stages which consist of three stages of development; the first stage is the initial stage, the second stage of the advanced stage and the third stage the system is fully controlled [3]. The role of swamps in supporting regional development and enhancing national food security needs to be increased given the vast potential of the area and several management technologies already available, but must remain cautious given that this agro ecosystem is unstable [4].

The concept of green water supply is also very appropriate along with the increasing amount of pollution due to electricity generation both diesel and steam power. It's because its ability to produce electrical energy with less pollution. With this concept, the provision of drinking water can be done well and is affordable by the community.

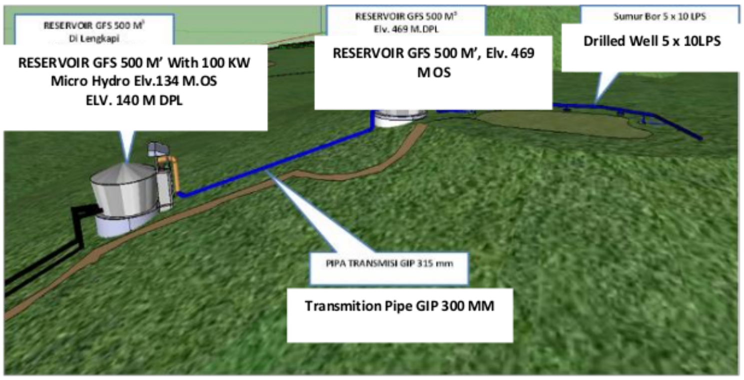

Figure-2. Schematic design of water supply.

2. MATERIALS AND METHODS

2.1 Calculation of Water Needs

Water needs are divided into two parts, namely domestic and non-domestic needs. Water needs for (domestic) households are calculated based on the number of residents in the planning year. Where this domestic drinking water can be calculated with the following equation:

$$\text{Water Needs} = \%\ \text{service} \times a \times b \quad (1)$$

Where:

a = the amount of water consumption (liters / person / day)
b = total population of service area (soul)

Non-domestic water needs, namely the need for water in non-domestic activities which constitute urban support activities, consisting of commercial activities in the form of industry, offices, businesses and social activities such as schools, hospitals and places of worship. The determination of non-domestic water needs is based on factors supporting the number of residents and the number of units of the facility. The urban facilities include public, industrial and commercial facilities. Calculation of non-domestic water needs, this calculation is assumed to be 15-20% [5, 6]. Clean water needs are calculated based on the projected population whose growth is analyzed using linear regression analysis. To design a clean water supply system, EPANET 2.0 software is used [7].

2.2 Recharge of Groundwater

The amount of groundwater reserves can be known by knowing the aquifer parameters of the area concerned obtained from drilling data, or from the approach of the amount of water that fills the ground (rocks) as a medium for the presence of ground water [8, 9]. This groundwater supply is known as groundwater recharge. The amount of groundwater recharge can be estimated from the amount of infiltration into the ground. The amount of recharge is calculated by the following equation:

$$Rc = \Sigma\ In \times A \quad (2)$$

Where:

Rc = Recharge of groundwater mm / year
In = Infiltration mm / year
A = The total area of the catch m²

2.3 Calculation of Micro Hydro Power

From the water capacity Q and high water fall H obtained the turbine output power. The turbine output power is calculated using the equation:

$$P = Q \times g \times H \times \rho \times \eta tot \quad (3)$$

Where:

Pa = Water power (kW)
Q = Water capacity (m^3/s)
ρ = Density of water (ton/m^3)
g = Gravity (m/s^2)
H = Head/ high water fall (m)

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ηtot = Total micro hydro efficiency

Power generated, if in an area there is potential for water with discharge Q (m^3/s) and falls from a height of H meters, then the energy generated is as the formula above [10, 11].

2.4 Pump Power Calculation

Pump power calculations performed by the following equation:

$$N = \frac{\gamma \times Q \times Htot}{102 \times \eta p} \quad (4)$$

Where:

N = Water power (Hp)
Q = Water capacity (m^3/s)
γ = Density of water (ton/m^3)
ηp = Pump's efeciency (%)
$Htot$ = Total head (m)

A water pump can drain water from a low surface to a high surface [6]. Water supply facilities which consist of fixed capacity intake pumps, reservoir tanks, and variable speed pumps [7].

3. RESULTS AND DISCUSSIONS

3.1 Water Needs

Water needs for domestic and non-domestic on the Tidore Island are calculated for the next 20 years projection year, starting at 2018 by taking data on average population growth in the last 10 years. The water needs obtained in the initial year of data is 125.21 liters/ second and until the end of the projected year 2038 with water requirements of 167.98 liters / second as can be seen in Table-1.

Table-1. Calculation of water requirements including the allowable leakage factor of a maximum of 20%.

Sub-district	**Domestic Needs (liters/ second)**				
	2018	**2023**	**2028**	**2033**	**2038**
South Tidore	26.5	26.9	29.1	33.4	35.6
North Tidore	31.1	31.6	34.1	39.2	41.7
Tidore	35.9	36.4	39.4	45.2	48.1
East Tidore	15.4	15.7	16.9	19.5	20.7
Total	108.88	110.65	119.50	137.22	146.07
Sub-district	Non-Domestic Needs (liters/ second)				
	2018	2023	2028	2033	2038
South Tidore	3.98	4.04	4.37	5.01	5.34
North Tidore	4.66	4.74	5.12	5.87	6.25
Tidore	5.38	5.47	5.90	6.78	7.22
East Tidore	2.32	2.35	2.54	2.92	3.11
Total	16.33	16.60	17.93	20.58	21.91
Sub-district	Domestic Non-Domestic Needs (liters/ second)				
	2018	2023	2028	2033	2038
South Tidore	30.49	30.99	33.47	38.43	40.92
North Tidore	35.73	36.31	39.22	45.03	47.94
Tidore	41.23	41.90	45.25	51.96	55.32
East Tidore	17.76	18.04	19.49	22.37	23.82
Total	125.21	127.25	137.43	157.80	167.98

Water loss (determination of leakage) is done by looking at water loss in the existing network, the percentage value can be taken multiplied by the average needs where the average needs are the total number of domestic needs and non-domestic needs) [7]. Water must be provided in a sustainable manner that is managed from nature. The concept of sustainable development is actually based on five main ideas. First, the development process must take place continuously which is supported by natural resources, the quality of the environment and people who develop continuously as well. Second, natural resources - especially air, water and land - have a threshold, where their use will reduce the quantity and quality. Third, environmental quality is directly correlated with quality of life. Fourth, the current pattern of natural resource use should not rule out the possibility of choosing other options in the future. And fifth, sustainable development presupposes transgenerational solidarity which make the welfare of the present generation does not reduce the possibility for future generations to improve their welfare. This is the main principle adopted and developed by the World Commission on Environment and Development [12-14].

3.2 Potential of Raw Water

Potential raw water is calculated based on hydrological and climatological data by calculating groundwater recharge. Groundwater recharge is used as a reference for groundwater potential. The data used in this calculation are the data of the last 10 years of rainfall, soil infiltration, and catchment area of Rawa Lembah Keramat. According to the results of calculations, Rawa Lembah Keramat has a groundwater recharge of 55 liters / second and this is quite helpful in the supply of drinking water for the Tidore islands, especially for the East Tidore region and Soasiuvillage [15].

Catch Area	=	11,695,081.00 m^2
Catch Area	=	0.00
Free Area	=	11,695,081.00
∑ Infiltration	=	148.57 mm/year (0.148570185 m/year)
Recharge	=	1,737,540.35 m^3/ year
	=	144.80 m^3/month
	=	4.76 m^3/day
	=	55.05 l/sec (recharge)

Potential raw water is calculated based on hydrological and climatological data by calculating groundwater recharge [16, 17]. Groundwater recharge is used as a reference for groundwater potential. Swamps have a variety of functions both ecological functions as freshwater tendons, a place to live flora and wildlife and economic functions for various activities to support human life [18]. Ecosystem-based swamp management has been extensively developed, with an approach to maintaining or improving the composition, structure and function of ecosystems to achieve long-term sustainability [19].

3.3 Potential Electric Power

With a water supply schematic as shown in Figure-3, the water supply system will be able to produce electrical energy from a system designed to drive a production pump. The working principle of this water supply system has three stages, namely:

a) Groundwater from a well at an altitude of 398 meters above sea level with a depth of 24 meters is pumped to a reservoir located at an altitude of 469 m with a distance of 287 meters, with initial pumping using PLN electricity or generators.

b) In the next stage, after the water has been filled up, it will be flowed to the next reservoir which also functions as a pressure relief tank at an altitude of 140m with a distance of 960 meters, so that it has a difference of 329 m height, it is used to move the micro hydro and after generating stable electrical energy. Then the electricity is supplied to the raw water pump by turning off the electricity of the PLN or generator set first. Furthermore, the pump will work based on the energy produced by water pressure.

$$P = 0.05 \times 9.81 \times 329 \times 1 \times 0.65$$
$$= 105 \text{ kW}$$

c) The water from the second reservoir, which at the same time acts as a press release tub, is used as a distribution reservoir that will serve the water needs of the East Tidore region and part of Soasiu city with a gravity system.

With this shcematic, this water supply system becomes a drinking water service system that is energy efficient and environmentally friendly.

4. CONCLUSIONS

From the results of the calculations that have been made, it can be concluded that Tidore island's drinking water needs for the next 20 years are quite large, reaching 167.98 liters / second and with limited groundwater potential, raw water supply is needed to optimize the available potential. Groundwater reserves in the Rawa Lembah Keramat that located in the village area of Talaga which reaches 55 liters/ second in accordance with the topographical conditions are suitable to be used with the concept of a green water supply system. In the shcematics, Thepump energy needs can be answered by electrical energy produced by micro hydro. Utilization of the potential energy of water from the transmission reservoir in the water supply system is very appropriate because it can generate electricity to drive the raw water pump. This concept can be developed and applied to areas with the same potential and topographic conditions, so that the production costs of drinking water supply can be reduced which will automatically reduce the selling price, making it affordable for the community.

Conflicts of Interest

The authors declare no conflict of interest.

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