Tidal Barrage Power Plant in Bay of Kendari

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Abstract

This report summarizes the results of a first assessment of the potentials of a tidal Barrage Power Plant in the bay of Kendari. Under assumption that the average household energy consumption in developing countries is in range of 2.5 MWh given power plant could satisfy the energy consumption of approximately 1600 households. Under assumption of the energy price of 0.05 €/kWh the income from energy could be defined as 200.000 €/year. Other positive effects of the project, additionally to the energy production could be seen as flood control and also a touristic attraction. Furher research will be needed to substantiate these findings.

1. Introduction

This report summarizes the results of a first assessment of the potentials of a tidal Barrage Power Plant in the bay of Kendari. This study is part of a larger study which encompasses an analysis of the revitalisation potentials of the bay including interventions in the river catchment of the Wangu river.

The objectives of this study are:

- Check of possibility for tidal power plant in the bay of Kendari and possible power output pre-estimation
- Check of possible solutions and challenges that have to be solved in the next project stages

The following assumptions have been made:

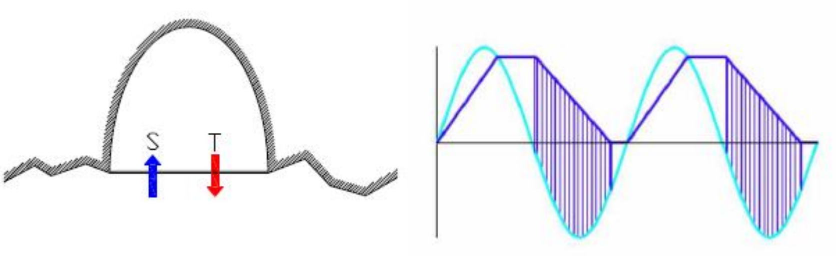
- Topography (form and layout) of the bay is taken from the from the Google earth and shown on the figure 1.
- Possible dam sites are shown on the Figure 1 (Alternative 1 with one dam structure and Alternative 2 with 2 dams)
- The area of the basin is calculated based on the existing satellite image of the bay. Alternative 2 was used in the consideration.
- Input data for the tidal range is taken from the internet source (http://tides.big.go.id/pasut/pdf/2016/PDF%20Zona%20C%20(%20Sulawesi,%20NTT,%20Malut,%20Maluku,%20Papua%20Barat,%20Papua)/KENDARI.pdf)

Figure 1: Kadira bay with possible dam sites, Alternative 1 (red) and Alternative 2 (green)

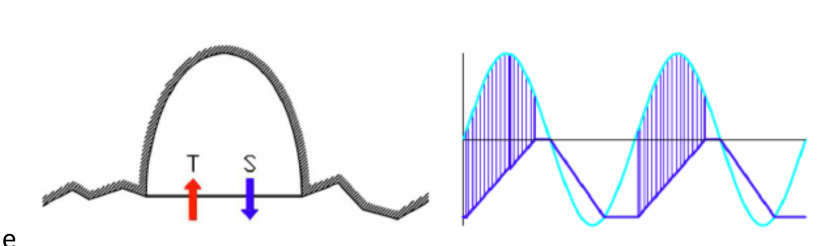
2. Types and functioning of the tidal barrage power plant

Tidal barrage power plant converts the potential energy of tides, different water levels between high and low tides, for the production of the electrical energy. Different water levels are normally achieved by construction of the dam closing the see bay and forming the closed reservoir. Separating the bay water from the rest of the sea by the dam and by operation of the sluices and turbines in the dam structure a different water level could be reached. This water level difference is used for energy production. Compared to other renewables, as wind and solar, the tidal power is more predictable, but the method traditionally suffers by relatively high costs and limited availability of the locations with sufficient high tides.

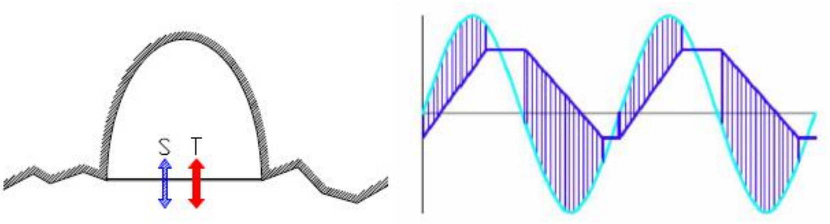
Most usual types of the tidal barrage power plants are:



- Single effect ebb-mode



- Single effect flood- mode



- Double mode

Several tidal power plants are in experimental or commercial operation around the world. Most known are Annapolis (Canada) as a single ebb mode, Shiwa (Korea) as single flood model and the La Rance (France) as a double mode plant. The power plant La Rance is the oldest tidal power plant, in operation from 1966.

From the generating explanation of the different types of barrage plant systems, it is obvious that the double mode system could not produce the double amount of energy and therefore, the implementation is not always advantageous.

3. Implementation of the tidal barrage power plant in case of Kendari bay

The situation by the Kendari bay is shown in Figure 1. In the same figure, also the possible locations for the barrage are suggested. The Alternative 1 with a single barrage of an approximate length 550m on the narrowest place of the bay and the Alternative 2 forming a basin by two dams approximately 300 m and 150m dam length respectively. Data about the sea depth at the proposed dam sites as also in the bay area was unknown in this project stage. Similar is with the geological conditions on the dam site, crucial for the selected dam characteristics and also the construction costs.

The alternative 2 seems to me more attractive because of the several reasons; slightly shorter total dam length, dam situated in a less populated area with easier access and possible construction area on one bank of the each dam and slightly bigger reservoir. The reservoir area is estimated with 10 km². All these considerations have been made just based on the existing data generated by the Google Earth®.

The tidal data for the Kendari bay is used from the tidal forecast for 2016 (reference see above). From given data for 2016 the tidal range is in the most time in the range of 1.2-0.7 meters, with extremes to 1.8 (2.0) or 0.3 m. In the further calculations, a mean tidal range of 1.0 m have been used. Typical data for June/July 2016 is shown in Figure 2.

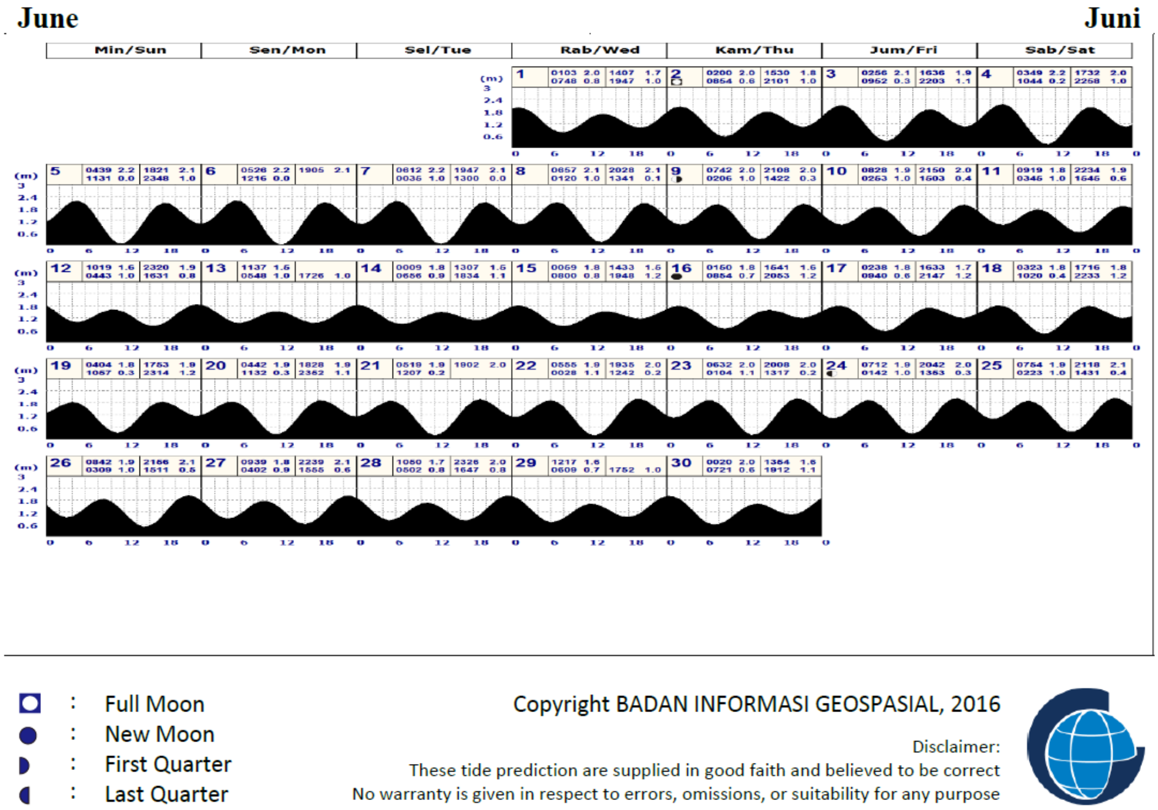


Figure 2: Typycal tidal data for June 2016

Based on given data the annual energy output (E_a) of the system could be estimated as follows:

$$E_a = c_e * n * \gamma * A * H_m^2$$

considering the estimated mean tidal range (H_m=1.0 m) and estuary area (A=10 km^2), number of tides per year (n=705), specific weight of salt water (γ =10.25 kN/m³) and the economic coefficient of the system (c_e = 0.20), the maximal annual energy output of the system could be estimated as

E_a=4.0 GWh/year

Under assumption that the average household energy consumption in developing countries is in range of 2.5 MWh given power plant could satisfy the energy consumption of approximately 1600 households. Under assumption of the energy price of 0.05 €/kWh the income from energy could be defined as 200.000 €/year

The turbine generating energy must be able to handle 10 Mm^3 of water in the time of approximately 5 hours that gives an average discharge of 500 m^3/s and the needed power output of approximately 1.5 MW.

The energy generation will be slightly increased considering additional water from the rivers discharging in the estuary. The amount and the possibility for use of this additional water makes the solution with a single system and working in the ebb mode as the most suitable. Additionally, the concentration of the flow out of the bay could be able to increase the sediment extraction from the estuary.

4. Possible project risks and risk evaluation

The project is connected with several risks that should be discussed in detail in the next project stages. At the moment following risk have been detected:

Detected risk	**Further design steps**	**Mitigation measure**
Geology on the dam site	Geological investigations,	Alternative dam site
Dam location and interference with existing structures	Detailed site evaluation	Alternative dam site
Sediment management	Detailed study about sediment circulation in the bay	Increase of the sediment circulation by activating of the density current
Sediment granulometry and abrasively	Data collection and tests	Resident turbines
Effect of dam on flood management in the bay	Flood simulations with and without dam	Increase of the evacuation possibilities Possibility of the dam as a measure against high tide
Navigation in and out of the bay	Definition of the navigation needs	Ship lock
Ecology of the bay	Detailed study of the water circulation in the bay	Location of the turbines and sluices in the dam

The positive effects of the project, additionally to the energy production could be seen as flood control and also a touristic attraction.

5. Open questions for the further studies:

1. Topography and geological data of the estuary
2. Digital tidal data for the Kendari bay for better and more accurate estimation
3. Hydrological data of the rivers in the estuary – additional input
4. Sediment data of the estuary (amount, granulometry, hardness and abrasivity, etc)
5. Navigation needs for the estuary (size and type of ships)
6. Ecological situation and possible problems