

Tidal Energy and its Prospects in Bangladesh

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Abstract— Bangladesh is a largely rural agrarian country of about 165.20 million in 2013 with plentiful supply of renewable sources of energy. Out of various renewable sources, ocean energy basically as tidal power can provide clean, reliable power and emerging turbine designs are making production of electricity from ocean energy technologically and economically feasible. However, the risk to the marine environment and marine organisms is not well known. In order to appropriately site and operate tidal power installations in Bangladesh, we need to better understand the risks of the technology in order to explore the potential contribution tidal power can make to a renewable energy portfolio. Despite a positive policy environment and modest government investment in tidal power research and development, permitting of tidal device deployment remains a considerable barrier to advancement. This paper addresses the need for effective mitigation strategies linked with tidal energy development in Bangladesh.

Keywords— *Bangladesh Energy Policy, RET (Renewable Energy Technology), Tidal Energy, Tidal Power.*

I. INTRODUCTION

Tidal power is not a new concept and has been used since at least the 11th Century in Britain and France for milling of grains. Tidal energy is produced through the use of tidal energy generators. It is similar to conventional hydro-electricity generation utilizing the use of natural motions of tides to fill up reservoirs and slowly discharge through electricity producing turbine. Another way to harness tidal power as energy is through tidal stream generator [1]. Similar to the way wind turbine works, tidal stream turbine uses kinetic energy to generate electricity. Although not yet widely used, tidal power has potential for future electricity generation. Tides are more predictable than wind energy and solar power [2]. Among sources of renewable energy, tidal power has traditionally suffered from relatively high cost and limited availability of sites with sufficiently high tidal ranges or flow velocities, thus constricting its total availability. However, many recent technological developments and improvements, both in design (e.g. dynamic tidal power, tidal lagoons) and turbine technology (e.g. new axial turbines, cross flow turbines), indicate that the total availability of tidal power may be much higher than previously assumed, and that economic and environmental costs may be brought down to competitive levels. Tidal energy is a renewable energy source. Historically, tide mills have been used, both in Europe and on the Atlantic coast of North America. The incoming water was contained in large storage ponds, and as the tide went out, it turned waterwheels that used the mechanical power it produced to mill grain.[3] The earliest occurrences date from the Middle Ages, or even from Roman times.[4-5] It was only in the 19th century that the process of using falling water and spinning turbines to create electricity was introduced in the U.S. and Europe.[6]

Tidal power is a clean renewable energy and it is appropriate in coastal Bangladesh [8]. It may be fitted as a candidate for emission trading of clean development mechanisms (CDM) principles of Kyoto Protocol Agreement [9]. Presently the CDM has attracted considerable attention and raised great expectations around the world.

Some recent studies have suggested that coastal Bangladesh is ideal for harnessing tidal electricity from the existing embankments and sluice gates by utilizing small-scale appropriate tidal energy technology. Bangladesh can take tidal power generation as a challenge and can easily overcome at least some of the power crisis [10-11]. Bangladesh can generate tidal power from these coastal tidal resources by applying Low head tidal movements and Medium head tidal movements, Low head

tidal movements which uses tides of height within 2m to 5m can be used in areas like Khulna, Barisal, Bagerhat, Satkhira and Cox's Bazaar regions and the height tidal movements which use a more than 5m of tides can be mainly used in Sandwip [12]. In this paper we include the physics of tidal power and its prospect in Bangladesh.

II. SYSTEM MODEL

Tidal power can be generated in two ways, 1. Tidal stream generators and 2. Barrage generation. The power created through tidal generators are generally more environmentally friendly and causes less impact on established ecosystems. Fig 1 represents the generation procedure of tidal energy and fig 2 to represent the concept of tidal power plant. From the figure we found that, similar to a wind turbine, many tidal stream generators rotate under water and is driven by the swiftly moving dense water. Tidal power or Tidal energy is a form of hydropower that converts the energy of tides into electrical power. As the tides are more predictable than wind and sunlight, tidal energy can easily be generated from the changing sea levels.

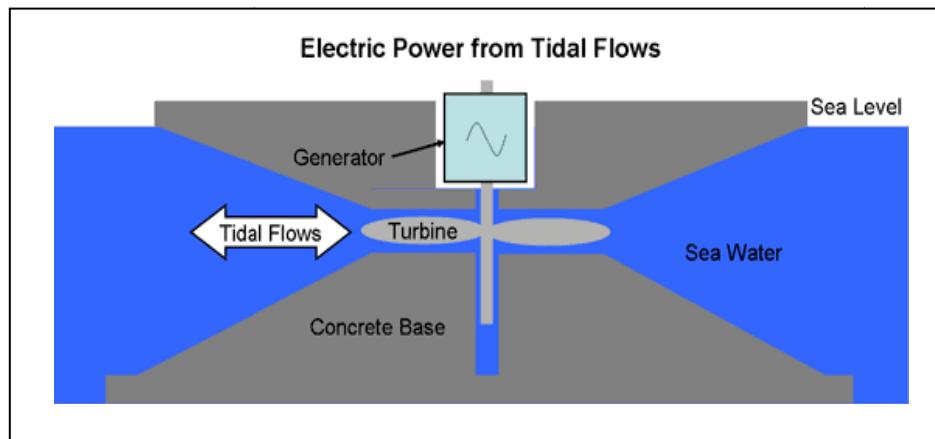


Fig 1: Generation of Tidal Energy.

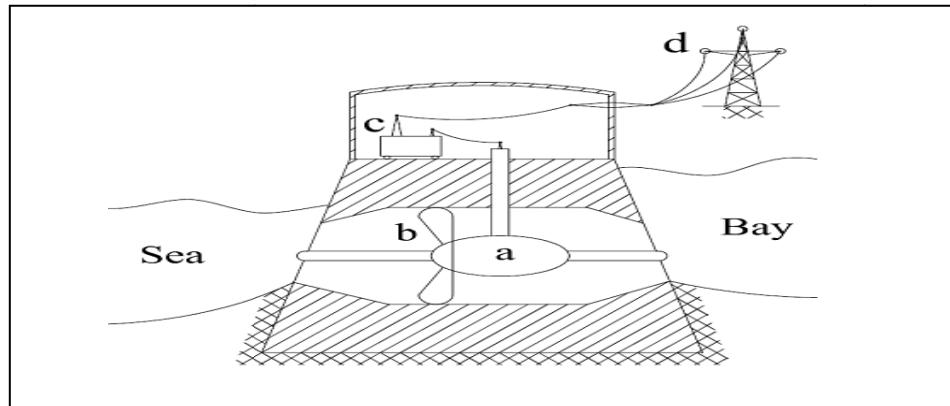


Fig.2 Tidal Power plant with Kaplan turbine in horizontal position. a – generator, b – hydro-turbine, c – transformer, d – electrical network.

Marine energy devices are generally classified first by their resource type and next by their method of energy capture. The wave devices that have been demonstrated so far are subdivided into several categories including, point absorbers, attenuators, and two kinds of terminators; overtopping and oscillating water column. Point absorbers and attenuators are installed in the wave field and extract a portion of energy from waves that pass through. Terminators stop the wave, absorbing most of the wave's energy. A small fraction of the energy is reflected back to sea. Because the different types of devices are described in various references [13, 14], only brief descriptions are provided below.

A point absorber typically comprises a buoyant float that heaves up and down with waves relative to a moored component that is stationary in the heave direction. Energy generation is associated with this relative motion through a conversion device. Conversion devices can be various forms of linear electric generators, or hoses and pumps that create high fluid pressure to be converted later in a central generating station. Wave attenuators are very similar in principle, but the energy is captured over a surface area. Motions are resisted by hydraulic systems in each module that convert hydraulic flow and pressures to electricity. In overtopping terminators, the wave is first concentrated by wings and then focused toward a central reservoir. The amplified waves surge up a ramp and fill a reservoir at a level above sea level. The reservoir drains down through a hydro-electric type turbine device where electricity is generated. Oscillating water column (OWC) terminators use wave motion to trap a volume of air and compress it in a closed chamber where it is exhausted at high velocities through a specialized ducted air turbine device. The kinetic energy of the moving air is converted to electricity. When the wave recedes, the airflow fills the chamber generating a second burst of energy. Conversion efficiencies of OWC air turbine device can be quite high because the flow must pass through the turbine unlike a free stream wind turbine. Although there are some devices under development for river and ocean currents, tidal turbines are the most common water current devices. The main difference between tidal and river/ocean current devices is that river and ocean currents flow in a single direction while tidal turbines reverse flow direction four times per day for ebb and flow cycles. Many of the marine technology designs resemble wind turbine technology, but marine technologies must account for reversing flow, cavitations, and underwater marine material performance. Common rotor designs are either axial flow (similar to modern horizontal-axis wind turbines) or cross flow (similar to early vertical-axis wind turbines). Axial flow turbines must be physically oriented in the direction of flow while cross flow turbines can operate with flow from any direction. There are also several designs that incorporate shrouds around the outer diameter of the rotor. Shrouds can help incrementally improve hydrodynamic performance and may provide some environmental protection, but their benefits have not yet been proven. Ocean current devices are primarily designed for open ocean currents and can provide continuous base-load power because of the nearly constant unidirectional current flow.

III. THE PHYSICS OF TIDAL POWER

Tidal energy is derived from the gravitational forces of attraction that operate between the earth and moon, and between the earth and sun. It is known that the gravitational force that mutually attracts any two bodies is directly proportional to the product of their masses and is inversely proportional to the square of the distance that separates the masses. The attractive force exerted by the moon on a molecule of water is given by [1]:

$$f = K \times m \times \frac{M}{d^2} \quad (1)$$

where,

M = the mass of the moon;

m = the mass of the molecule of water;

d = the distance of the water molecule from the moon;

K = the universal constant of gravitation.

The attractive force exerted by the sun obeys the same law, but the effect (M/d^2) is about 2.17 times less due to the mass and the much greater distance that separates the earth and sun. As the earth rotates, the distance between the molecule and the moon will vary. When the molecule is on the dayside of the earth relative to the moon or sun, the distance between the molecule and the attracting body is less than when the molecule is on the horizon, and the molecule will have a tendency to move away from the earth. Conversely, when the molecule is on the night side of the moon; the mass of the molecule of water; the distance of the water molecule from the moon; the universal constant of gravitation. of the earth, the distance is greater and the molecule will again have a tendency to move away from the earth. The separating force therefore experiences two maxima each day due to the attracting body. It is also necessary to take into account the beating effect caused firstly by difference in the fundamental periods of the moon- and sun-related gravitational effects, which creates the so-called spring and neap tides, and secondly the different types of oscillatory response affecting different seas. If the sea surface were in static equilibrium with no oscillatory effects, lunar forces, which are stronger than solar forces, would produce tidal range that would be approximately only 5.34 cm high.

IV. GLOBAL TIDAL ENERGY MARKET

The tidal energy market is currently in its infancy stage. Table 1 represents the top ten potential locations for Tidal Energy. Markets across the world are trying to adapt to the latest technologies, and are building tidal plants to increase their output. Fig. 3 represents the ocean energy technology maturity curve. The European market is ahead of the Americas in generating tidal energy. Asian countries such as South Korea, India and Japan have also started developing this form of energy. The global tidal energy market is mainly driven due to its predictability. With growing environmental concerns, the low emissions associated with tidal energy are proving to be major market drivers. However the possible adverse effect on marine life will prove to be a challenge to market growth.

Table 1: Top Ten Potential Locations for Tidal Energy

Country	Locations
France	La Rance
Canada	Bay of Fundy – Cumberland Basin,shepody,cobequid
Russia	Mezan Bay and Tugur,penzhisnk
Korea	Sihwa & Garolim,,cheonsu
India	Kambhat,kutch
Australia	Secure Bay & Cape Keraudren,Walcott inlet
Argentina	San Jose / Nuevo,rio Gallegos,santa cruz
UK	Severn & Mersey Yy
Mexico	Rio Colorado
USA	Pasamaquoddy,knik arm,turnagain arm

The first tidal power station was the Rance tidal power plant built over a period of 6 years from 1960 to 1966 at La Rance, France. It has 240 MW installed capacity. 254 MW Sihwa Lake

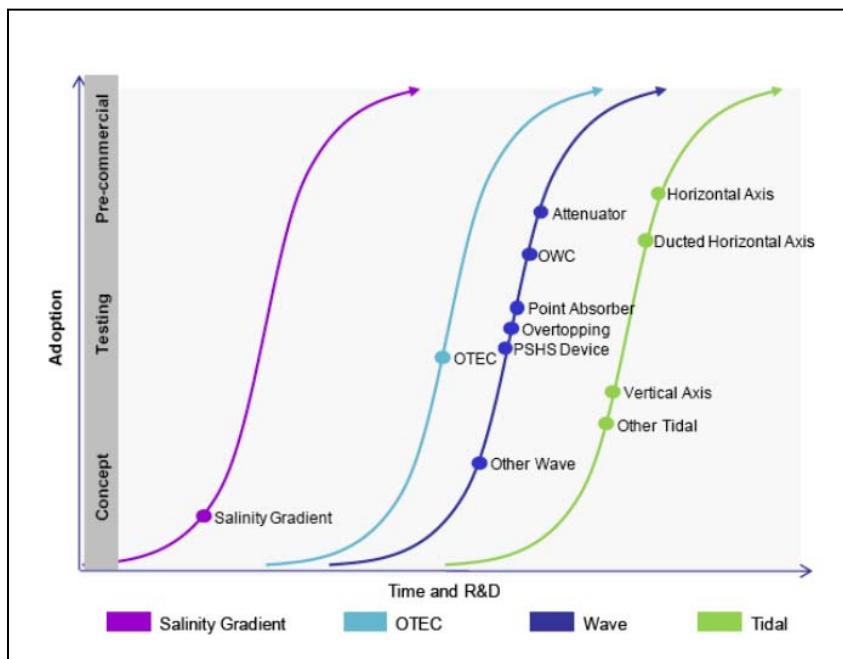


Fig. 3 Ocean Energy Technology maturity curve

Tidal Power Plant in South Korea is the largest tidal power installation in the world. Construction was completed in 2011. A minuscule portion (less than 0.01%) of the world's electricity requirements is currently being generated from tidal sources. Tidal constitutes about 0.02% of the total electricity generated from all renewable energy sources. As of 2009, all electricity from tidal energy is obtained from tidal barrages. Tidal streams and tidal lagoons are yet to have any completed projects that generate electricity.

V. TIDAL ENERGY PROSPECT IN BANGLADESH

Bangladesh is situated between $20^{\circ}34' - 26^{\circ}38'$ North Latitude and $88^{\circ}01' - 92^{\circ}41'$ East Longitude. The country has a 724 km long coast line and many small islands in the Bay of Bengal, where continuously present strong tide & wave of Bay of Bengal. This long coast having strong wave may an admirable source of energy production. The tides at Chittagong, south east of Bangladesh are predominantly semidiurnal with a large variation in range corresponding to the seasons, the maximum occurring during the south-west monsoon occurring during the south-west monsoon. A strong diurnal influence on the tides results in the day time tides being smaller than the night time tides during the wet season and vice-versa during the dry season.

Bangladesh is in the midst of a major energy crisis. It is trying to overcome the problem with costly rental power plants. By this time renewable energy is gaining popularity and contributing to solve energy crisis. Bangladesh is also looking for nuclear power plant to solve the crisis on a long-term basis.

Use of fossil fuels for generation of power contributes to global warming and has demanded the attention toward alternative energy source. In addition, the burning of fossil fuels contributes to the release of carbon dioxide into the atmosphere, thus, causing global warming. Despite all that oil accounts for most of the world energy consumption. Prices of oil are rising. It is also predicted that oil, gas, coal and other global resources will be finished within 40 years. One of the sources of energy that has been overlooked is tidal power. Tide can generate huge amount of electricity.

Ocean covers 75 per cent of the earth and has enormous potentiality of generating electricity. It has been estimated that if less than one per cent of total capacity of tidal electricity is generated, it will cover five times of total global requirements. An acceptable power generation technology must be mechanically sound, environmentally acceptable, and economically viable in order to become a real alternative for builders of new capacity. Renewable energy like tidal power accounts for only 2.5 per cent of the world energy consumption. There are several ways tidal power can be utilized as energy. One of the ways that many tidal power plants harness energy is through construction of tidal barrage. A barrage is a dam that uses potential energy, the difference in height between high and low tides. Water flows through tunnel in a dam enabling it to turn turbines, which then generates electricity.

There are some disadvantages of tidal power. The use of tidal barrage can cause a huge impact to the environment. Barrages block navigation, impede fish migration, and change the size and location of inter-tidal zone. Inter-tidal zone is the areas that are alternatively wet and dry during tidal cycles. Certain plants and creatures inhabited in the inter-tidal zone will disappear with the construction of barrages. In addition, barrages can only provide power up to 10 hours each day when there are ebbs and tides flow in and out. Because of many disadvantages, barrage power plant has lost its popularity, and tidal stream power plant, which has a lesser environmental impact, is now preferred.

VI. FUTURE ASPECTS

Regarding the financial factor, the long construction period for the larger schemes and low load factors would result in high unit costs of energy. This makes tidal projects have relatively high capital cost in relation to the usable output, compared with most other types of power plants. Consequently the capital payback time is longer and rates of return on the capital invested are low. Predicted unit costs of generation are therefore unlikely to change and currently remain uncompetitive with conventional fossil-fuel alternatives. The possible low impact installations are shown in Fig. 4. And Fig. 5 represents the tidal power generation feature with cost effective solution.

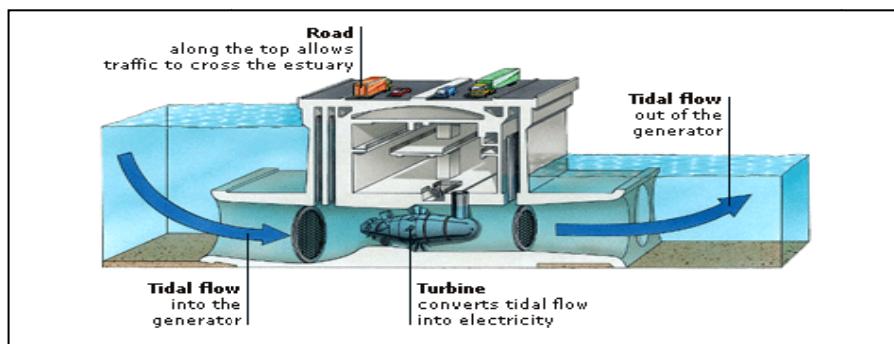


Fig4. Low impact Tidal Power Plant Installation.

However, some non-energy benefits would accrue from the development of tidal energy, which would yield a relatively minor monetary value in proportion to the total scheme cost. These benefits are difficult to quantify accurately and may not necessarily accrue to the barrage developer. Employment opportunities would be substantial at the height of construction, with the creation of some permanent long-term employment from associated regional economic development.

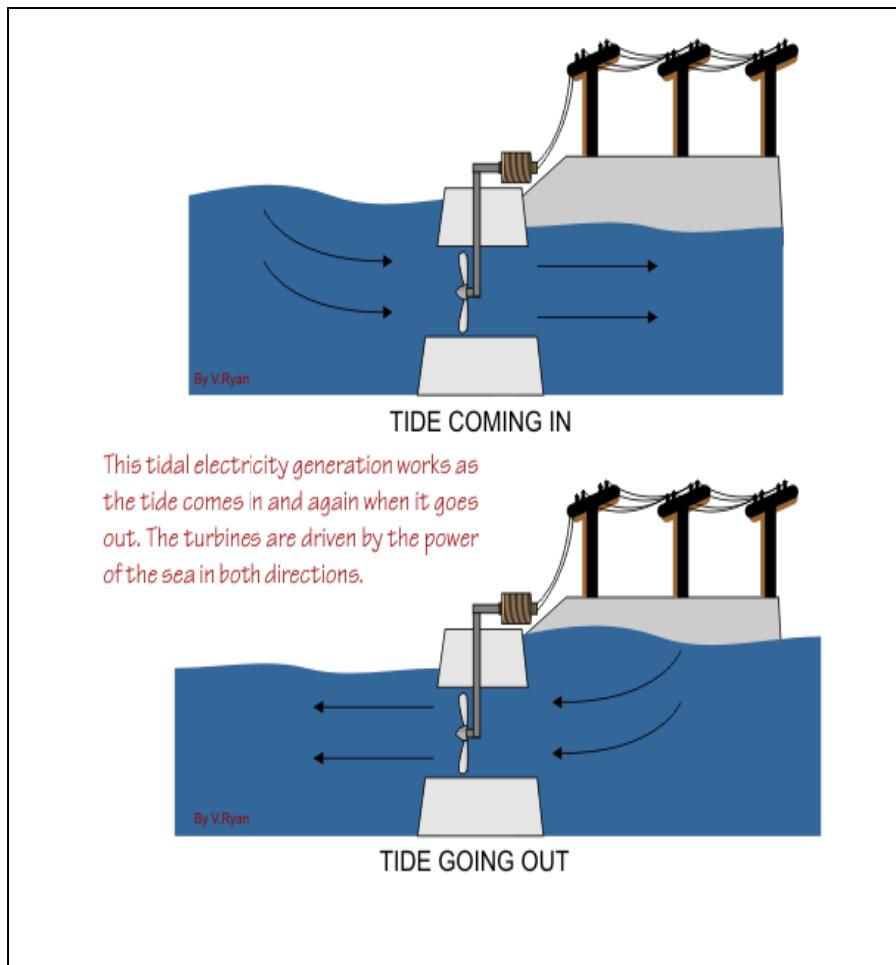


Fig5. Tidal Electricity Generation Feature Using.

Public opinion focuses more and more on these non-energy benefits and that would be an important consideration for the development of the tidal power energy.

VII. CONCLUSION

Renewable energy can not only help solve energy crisis but also contribute to poverty alleviation and fight environmental degradation such as desertification, bio-diversity depletion and climate change effects in Bangladesh. Tidal power plant is a reliable energy source to replace the burning of fossil fuels. In addition, it is a renewable source of energy that produces no greenhouse gases or any type of waste. Tidal stream generator has little environmental impact and can be built offshore. So we can say that with suitable tidal height available, this can be a great source of energy for Bangladesh. Local manufacturing of components should also be encouraged and appropriate tax and VAT rebates should be given to this industry. Duty free import policy should continue for this sector.

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REFERENCES

- [1] T. J. Hammons, "Tidal power", *Proceedings of the IEEE*, v81, n3, pp 419–433. July 26, 2004.
- [2] R. Lecomber, "The evaluation of tidal power projects", in *Tidal Power and Estuary Management*, eds. Severn, R. T., Dineley, D. L. & Hawker, L. E., Henry Ling Ltd., Dorchester, pp 31–39. 1979.
- [3] Ocean Energy Council , "Tidal Energy: Pros for Wave and Tidal Power", 2011.
- [4] W. E. Minchinton, "Early Tide Mills: Some Problems". *Technology and Culture* (Society for the History of Technology) 20 (4): 777–786. doi:10.2307/3103639. JSTOR 3103639. 1979
- [5] Dorf and Richard *The Energy Factbook*. New York: McGraw-Hill. 1981
- [6] J. Di Certo, "The Electric Wishing Well: The Solution to the Energy Crisis" New York: Macmillan, 1976.
- [7] M. Mahbubuzzaman, M. S. Islam, M. M. Rahman, "Harnessing tidal power", News Paper Article, The Daily Star. Available at:http://www.thedailystar.net/newDesign/print_nes.php?nid=146470
- [8] M. S. Kaiser, M. A. Rahman, M. M. Rahman, and S. A. Sharna, "Wind energy assessment for the coastal part of Bangladesh," *Journal of Engineering and Applied Sciences*, vol. 1, no. 2, pp. 87-92, 2009.
- [9] M. Salequzzaman, "Sustainability of Shrimp Aquaculture in Coastal Bangladesh". In: Proceedings of The Fifth International Conference on The Mediterranean Coastal Environment, 23-27 October 2001, Tunisia,
- [10] C.A. Douglas, G. P. Harrison, J. P. Chick, "Life cycle assessment of the Seagen marine current turbine". *Proceedings of the Institution of Mechanical Engineers, Part M: Journal of Engineering for the Maritime Environment* 222 (1): 1–12, 2008.
- [11] J. Khan, G. Bhuyan, and A. Moshref, "An Assessment of Variable Characteristics of the Pacific Northwest Region's Wave and Tidal Current Power Resources, and their Interaction with Electricity Demand & Implications for Large Scale Development Scenarios for the Region - Phase 1" Report No: 17458-21-00 (Rep 3), Prepared for Bonneville Power Administration (BPA), British Columbia Hydro (BCH), British Columbia Transmission Corporation (BCTC), January 2008.
- [12] M. Salequzzaman, and P. Newman, "Integration of Tidal Power with Aquaculture Industry: Case Study of Sandwip, A Remote Coastal Area of Bangladesh". International Coastal Zone Conference 2001 (CZ01), Cleveland, Ohio, USA, 15-19 July 2001
- [13] "Tidal power engineering in the USSR." *Wurer Power und Dam Constr.*, pp. 37-41, Mar. 1986.
- [14] Hagerman, G. "Wave Power" Encyclopedia of Energy Technology and the Environment, Volume Set 4, John Wiley & Sons, Inc, 1995.

BIOGRAPHY

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