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An Objective Analysis on the viability of underwater Turbines and their economic and environmental impacts

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Abstract: The energy crisis and climate crisis are two topics that have been a source of discussion, controversies and interest for global superpowers like America, European Union and China. One of the solutions to solve both is by using renewable source of energy, tidal energy and kinetic hydropower in this instance. This research paper shows an objective analysis on the viability of underwater turbines, their economic benefits, direct or indirect impact on the marine life and environment, their necessity, replaceability over conventional non-renewable and renewable energy sources, and different complications around its small as well as large scale usage. Furthermore, a study is also done to determine the favourable environment in which underwater turbines can be used and the estimated output energy that can be generated using mathematical tools. Also, different alterations are discussed to increase the power density in order to make the technology more feasible.
Keyword: underwater turbines, tidal energy, renewable energy

I. INTRODUCTION

Our energy consumption is at an all-time high and there is no indication that it is going down. To solve this problem oil companies like Royal Dutch Shell, The British Petroleum, Chevron Corporation, ExxonMobil are providing services making around 900 billion USD. In 2019, only 3% of their 115 billion USD investment was in low carbon alternatives. Apart from that, billions of dollars are invested to fund researches that invalidates those alternatives rendering them non-feasible in order to keep the conventional source of energy relevant and in demand.

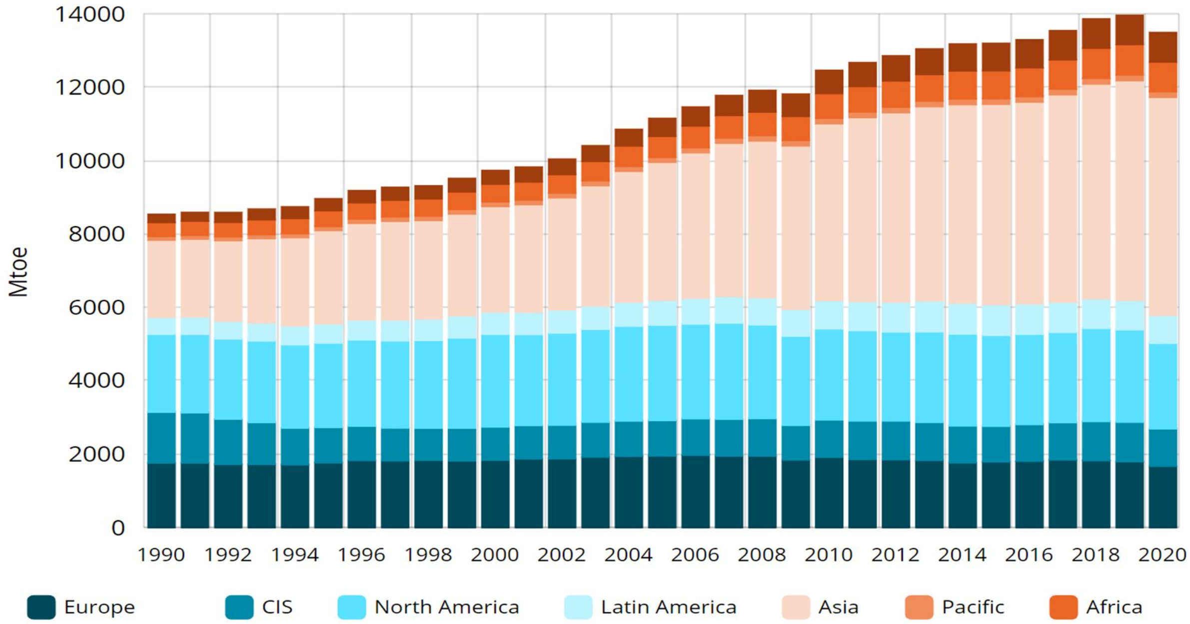
Firstly, a case for renewable energy can be made by analysing that the peak efficiency for oil consumption was attained in 2018 whereas the renewable energy extraction is getting cheaper. Following this, countries like Germany announced that they are going to completely phase out their coal consumption over the next 20 years and invest around 40 billion USD in order to achieve this. In 2017, 45% of total global investments in renewable energy was from China which plans to get 62% of their energy from renewable sources by 2050.

Secondly, a case for increasing the capital and time invested towards harnessing energy using tidal energy can be made simply by factoring the aspect of reliability. The wind flow is very unpredictable throughout the space and time of the year. On the other hand, the flow of tides is far more predictable and have low or avoidable impact on the environment. Despite the fact that the technology has been available for decades, kinetic hydropower has seen limited commercialization compared to wind energy and small hydropower. As a result, another goal is to enhance knowledge of the power densities that may be achieved with this intriguing alternative energy source.

Lastly, the effects of using underwater turbines on the environment has to be discussed in order to determine whether it will be a better alternative to tackle global power consumption need. This study is necessary in order to prevent a similar global degradation rate in future.

II. CURRENT GLOBAL TRENDS

Energy is defined as the ability to do work. It can be harnessed through different means like fossil fuels (coal, petroleum, etc), renewable (wind, tidal, etc) or fissile. The pattern of energy production and consumption also affects the economic growth of any country. Since mid-90s the global energy consumption has been on an exponential rise and it is expected to rise even further as more economies emerge. The key players in today’s global energy scenario are China, United States, European Union. This trend is further increased as more developing countries join and more people are brought in the middle class improving their quality of life and eventually their energy needs.



It is easier to predict the forms in which consumers will demand energy in the future than it is to forecast the absolute volume of energy demand or the energy sources that will provide that demand. People will expect higher levels of more efficient, greener, and environmentally less disruptive energy services as per capita earnings rise around the world. As a result, we believe we have a good understanding of where energy consumers are headed. However, the subject of what kind of businesses would provide energy services and how they will be delivered is still up in the air. [1]

We evaluate the availability and usage of energy resources, in order to address the economic and environmental ramifications of our global energy system. Our reliance on combustible fuels, the environmental concerns connected with their extraction, and the environmental harm caused by their emissions all contribute to problems. Regardless of whether it is renewable or non-renewable, no primary energy source is without environmental or economic constraints.

Conversion to and adoption of environmentally friendly energy technology will be dependent on political and economic realities as developed and developing economies continue to grow. [2]

Energy has an impact on every element of modern life. Because of the exponential growth of the world population, the demand for energy is expanding at an exponential rate. Oil and gas are projected to be key sources of energy in the future. Non-renewable resources such as oil, coal, and nuclear power are used to generate electricity today.

Small-scale renewable energy generation solutions that are both efficient and cost-effective are already commercially available. Renewable energy sources are projected to play a larger role in the future. Many countries are disseminating alternative energy technology with the goal of reducing the use of traditional and commercial energy sources. The choice between the different available solutions in each country is highly dependent on the local situation. [3]

III. WHY IS RENEWABLE ENERGY BECOMING RELEVANT AND VICE VERSA?

There has been a record-breaking rise in the investments and deployment of renewable energy. A reason for this exponential growth could be that the fossil fuel reached its peak efficiency in November 2018. These sources of energy have matured with less exploitable potential left whereas renewable sources are becoming more and more cheap and efficient.

We can deduce another reason by reviewing the New Policy Scenario and Sustainable Development Scenario.

In the New Policies Scenario (**NPS**), renewable energy generation nearly triples by 2040, accounting for over 40% of total generation. Renewables are being used more directly in transportation and heating, although their contribution is still small. In the NPS, the share of renewables in global heat supply rises five percentage points to 15% in 2040. China, the European Union, India, and the United States, who are now the major consumers of renewable-based heat, are predicted to account for over 60% of this growth.

Additional measures to incentivize investment in renewable-based electricity generation, biofuels, solar heat, geothermal heat, and electrification are included in the Sustainable Development Scenario (**SDS**), which pushes renewables to two-thirds of the power mix, 25% of heat, and 22% of transportation in 2040.

IV. WHY WATER TURBINES?

For the entire marine renewables sector, 5,800 MW of installed capacity is projected between 2004 and 2008. Some 99% of that capacity is in the form of offshore wind farms. Wind farms installed capacity of 237 MW is expected in 2004. By 2008, this will grow to 1953 MW – an eight-fold growth within five-years. The value of the market over the next five-years is projected at $9.6 billion, growing from $276 million a year in 2004 to nearly $3 billion a year by the end of the period. Growth between 2004 and 2008 is forecast at more than tenfold. By the end of the period, costs per MW will have fallen noticeably, making offshore renewables increasingly viable. Wave and tidal power will only be a small percentage of the total expenditure in offshore renewables, on the order of $150 million in total expenditure between them. However, wave and tidal power currently attract higher expenditures per megawatt. This indicates higher costs of the immature developing industries. These costs will fall as time goes by and the industries progresses. The leading devices should be comparable with, and in some cases more competitive than offshore wind, by the end of the decade. The dominance of offshore wind does

V. ASSESSING SITE POTENTIAL

In places with high tidal currents, electricity generation utilising underwater turbines can provide a very stable and predictable source of clean and renewable energy, generally with low and/or mitigated environmental impact. Important data such as overall generation potential, input to precise technical design of the underwater turbine system, effects of the turbine system on ambient flow patterns, and potential environmental impact are all determined using 3-D numerical models. ADCP transects were used to take measurements through possible sites.

Special processes are necessary to obtain accurate and reliable maps of the very strong ocean currents due to very strong tidal currents of up to 5.14 meter per second or more.

A. ADCP Profiling

The ADCP operates by sending "pings" of sound into the water at a steady frequency. (The pings are so loud that they can't be heard by people or dolphins.) Sound waves ricochet off particles suspended in running water and reflect back to the instrument as they move. Sound waves bounced back from a particle travelling away from the profiler have a slightly lower frequency when they return due to the Doppler effect. Higher frequency waves are emitted by particles moving toward the instrument. The Doppler shift is the difference in frequency between the waves the profiler sends out and the waves it receives. This shift is used by the sensor to figure out how rapidly the particle and the water around it are moving.

Sound waves that strike particles far away from the profiler take longer to return than waves that strike particles closer to the profiler. With each sequence of pings, the profiler can assess current speed at several different depths by monitoring the time it takes for the waves to bounce back and the Doppler shift.

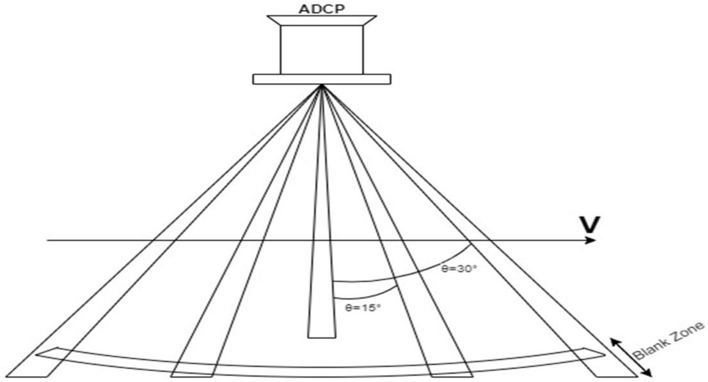


Fig. 1. ADCP Profiling for near bottom current measurement.

VI. CONCLUSIONS

The design of the shroud enclosing turbine generators for kinetic hydropower can be used to increase the performance and economics of this technology. Numerical simulations presented showed the power increases by a factor of 3.1 with a drag increase factor of 3.9. The use of a well-designed shroud increase efficiency that can lead to reduction in the cost per kilowatt-hour of this technology. However, experimentation has not been performed to validate the numerical simulations presented here. Further study is required.

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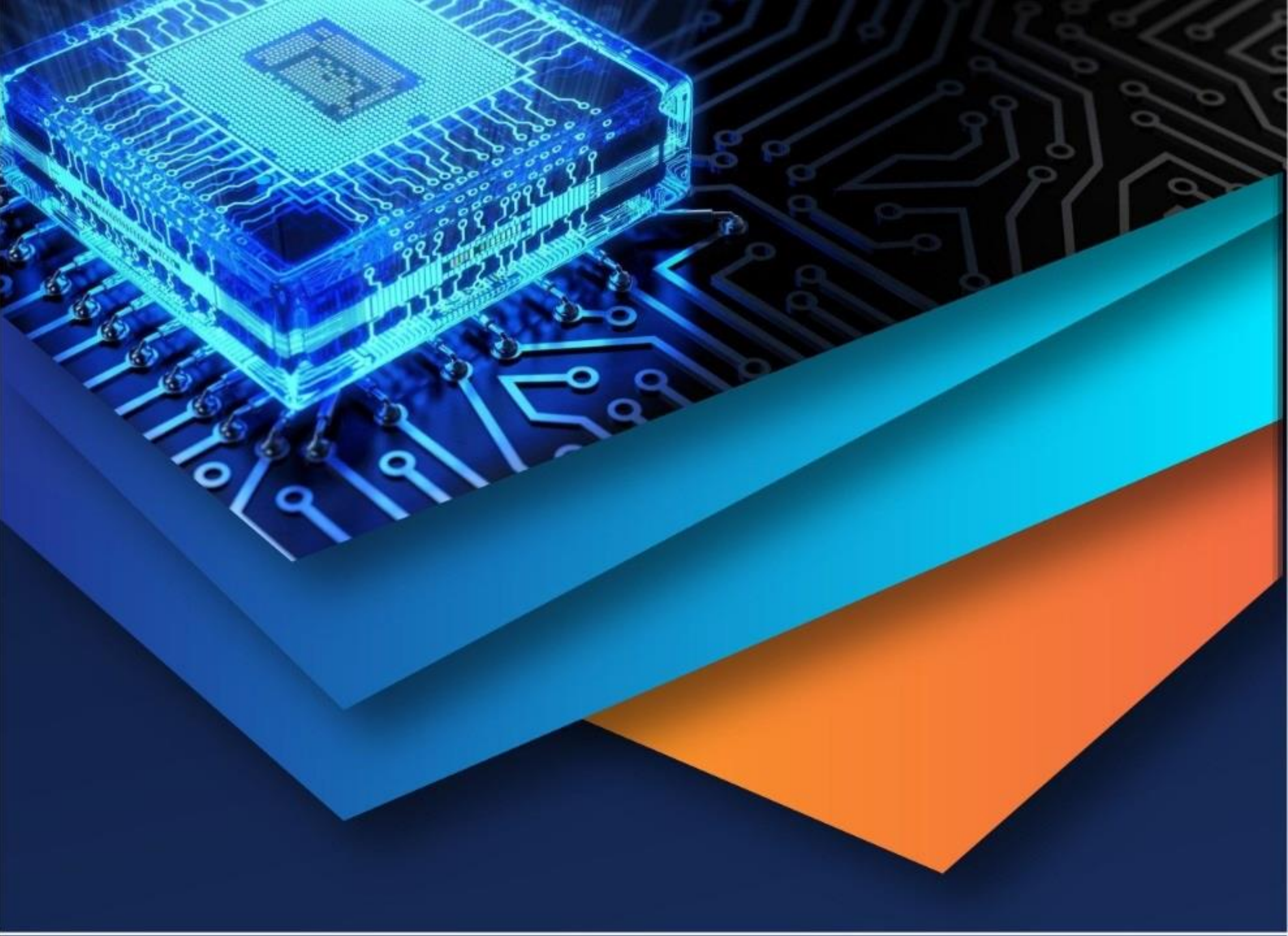

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