Tidal Stream Turbine- Introduction, current and future Tidal power stations

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***Abstract*— The dependence on fossil fuels for energy production has come to an alarming stage. Energy demand continues to increase with growing population. Consequently fossil fuel reserves are continuously draining and the world is confronted with their extinction in near future. This implied the use of non-conventional energy sources. Out of many such sources Tidal is the one which requires high amount of research. Tidal current technologies have salient advantages such as cleaner than fossil fuels, intermittent but predictable, security and diversity of supply, and limited social and environmental impacts. This paper presents the tidal stream turbines' working, types and some information about current and future power stations.**

***Keywords*— Tidal Energy, Current and Future Tidal Power Stations, Tidal Stream Turbines.**

I. INTRODUCTION

Oceans, covering more than 70 % of the earth, have long been appreciated as a vast renewable energy source. The energy is stored in oceans partly as thermal energy, partly as kinetic energy (waves and currents) and also in chemical and biological products [1]. The tidal stream turbines are also known as underwater windmills. They are driven by the kinetic energy of the moving water in similar way that wind turbines use moving air. The generator is placed into a marine current that typically results when water being moved by tidal forces comes up against, or moves around, an obstacle or through a constriction such as a passage between two masses of land. A tidal generator converts the energy of tidal flows into electricity. Greater tidal variation and higher tidal current velocities can dramatically increase the potential of a site for tidal electricity generation. **Zafer Defne et. al. [2]** have devolped a geodatabase of tidal constituents to present the regional assessment of tidal stream power resource in the USA. **Gunwoo Kim et. al. [3]** studied the assessments of the potential of various ocean renewable energy resources in the sea around Korea; potential sources of energy including wave energy, tidal energy, tidal current energy and ocean thermal energy. **Chen, H et. al. [4]** have studied a brief review of state of the art on the marine tidal current generation technology. **Zhibin Zhou et. al. [5]** have described the power fluctuation phenomenon and also presented the state of art of energy storage technologies. **Hong-wei Liu et. al. [6]** presented the distribution of tidal current energy in China.

II. WORKING

Tidal Stream turbines operate on the same principles that wind turbines use. A flow of water moves a set of blades creating mechanical energy which is then converted to electrical energy by the generator. Tidal stream generators (or TSGs) make use of the kinetic energy of moving water to power turbines, in a similar way to wind turbines that use wind to power turbines. Some tidal generators can be built into the structures of existing bridges, involving virtually no aesthetic problems. Tidal Stream turbine uses underwater spinning blades to turn a generator. Underwater turbines rely on tides to push water against angled blades, causing them to spin. As the blades spin, a gearbox turns an induction generator, which produces an electric current. These turbines must be able to swivel 180 degrees to accommodate the ebb and flow of tides. These turbines can be placed in natural bodies of water, such as harbors and lagoons that naturally feature fast-moving flows of water. [13]

III. CONSTRUCTION

The technology consists of rotors mounted on steel piles (tubular steel columns) set into a socket drilled in the seabed. A key requirement for tidal stream devices is the support structure concepts to hold them in place.

Currently there are three options under consideration: Gravity Structure, Piled Structure, and Floating Structure.

A. Gravity Structure

Gravity Structures are massive steel or concrete structures attached to the base of the units to achieve stability by their own inertia.

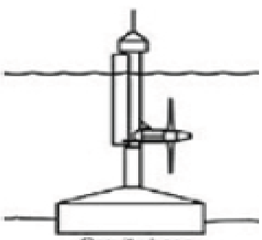

Fig.1 Gravity Structure [9]

B. Piled Structure

Piled Structures are pinned to the seabed by one or more steel or concrete piles. The piles are fixed to the seabed by hammering if the ground conditions are sufficiently soft or by pre-drilling, positioning and grouting if the rock is harder.

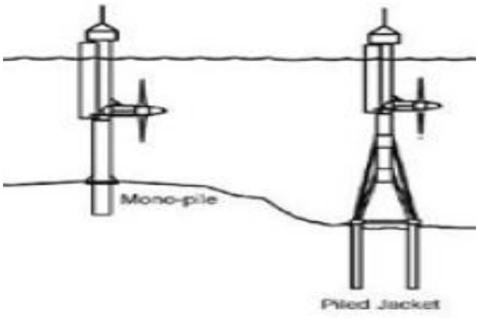

Fig. 2. Piled Structure [9]

C. Floating Structure

The turbine unit is mounted on a downward pointing vertical column rigidly fixed to a flatboat. The flatboat is then fixed to the seabed by chains or wire ropes which hang in a centenary and may be fixed to the seabed by drag, piled or gravity anchors, depending on the seabed condition [9].

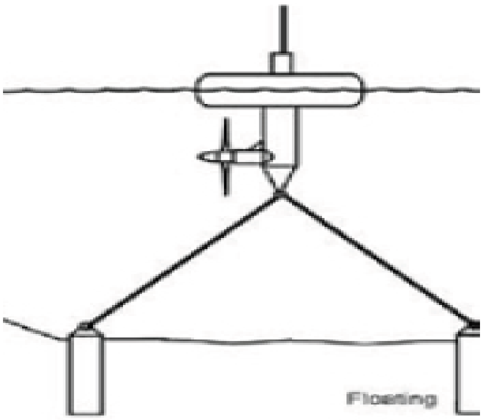

Fig. 3. Floating Structure [9]

IV. TYPES OF TIDAL STREAM TURBINE

A. Horizontal Axis Turbine

Horizontal axis turbines work much the same as a conventional wind turbine and some look very similar in design. A turbine is placed in a tidal stream which causes the turbine to rotate and produce power [15].

A prototype of a 300 KW horizontal axis turbine was installed in kvalsund, south of Hammerfest, Norway (penman, 2009) and connected to the grid on 13 Nov. 2003. A 300 KW horizontal axis turbine, also known as seaflow, was installed by marine current turbines off the coast of Lynmouth, Dxevon, England, in 2003. A prototype project was installed in the East River between Queens and Roosevelt Island in New York City in the United States in April 2007. A prototype, called SeaGen, was installed by Marine Current Turbines in Stangford Lough in Northern Ireland in April 2008 [11].

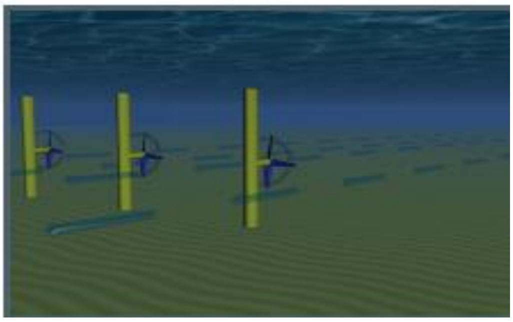

Fig. 4. Horizontal Axis Turbine [15]

B. Vertical Axis Turbine

Vertical axis turbines use the same principle as the horizontal axis turbines only with a different direction of rotation [15].

The Enermar Project developed Kobold turbine. A pilot plant of is moored in the Strait of Messina, close to the Sicilian shore in Italy, in an average sea tidal current of about 2 m/sec [1].

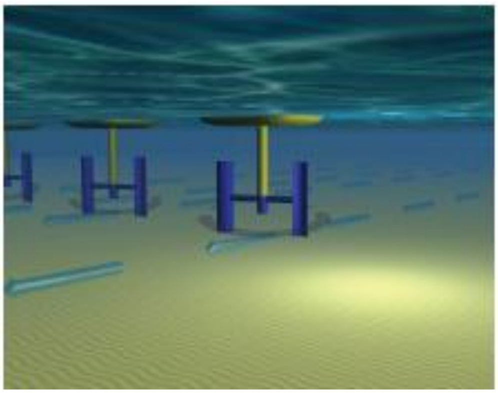

Fig. 5. Vertical Axis Turbine [10]

C. Reciprocating Devices (Oscillating Hydrofoils)

These have hydrofoils which move back and forth in a plane normal to the tidal stream, instead of rotating blades.

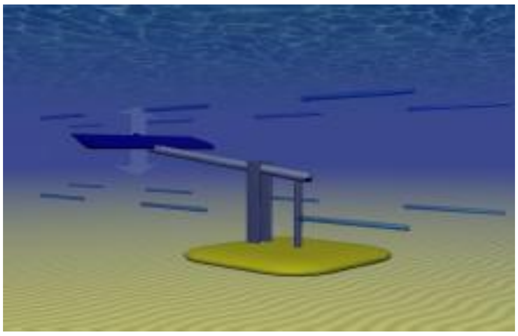

Fig. 6. Reciprocating Devices [15]

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The oscillation motion used to produce power is due to the lift created by the tidal stream flowing in either side of the wing [15].

During 2003, a 150 KW Stingray was tested off the Scottish coast, including a flexible control system to allow the performance of the generator to be accurately controlled and recorded over a longer period [11].

D. Venturi Effect Tidal Stream Devices

The tidal flow is directed through a duct, which concentrates the flow and produces a pressure difference. This causes a secondary fluid flow through a turbine. The resultant flow can drive a turbine directly or the induced pressure differential in the system can drive an air-turbine [15].

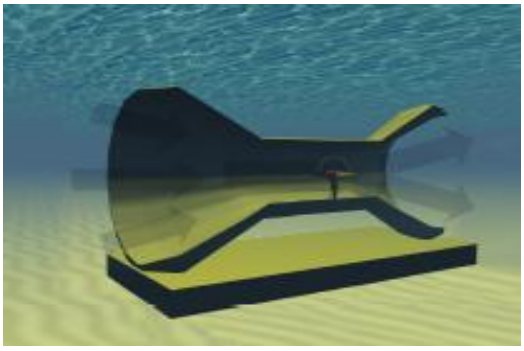

Fig. 7. Venturi Effect Tidal Stream Devices [15]

The tidal Energy installed and tested such shrouded tidal turbines on the Gold coast, Queensland in 2002. Another turbine is planned for deployment as a tidal powered desalination showcase near Brisbane Australia in October 2008. Another device, the hydro Venturi, is to be tested in San Francisco Bay [11].

V. ADVANTAGES & DISADVANTAGES

Because water is far denser than air, spinning blades can potentially be more productive than off-shore wind turbines for the same amount of space. Another advantage, water turbines enjoy over other sources of renewable energy is a predictable tide table.

As wind turbines interrupt bird flights just as water turbines can disturb underwater life. Fishing has to be restricted in the areas of the power plant. Another issue tidal turbine technology faces during active life is chemical pollution due to necessary coatings and lubrications. Chemicals coatings are used on the turbine to control naturally occurring corrosion. Although tidal turbines are inaudible from land, another issue pertaining to the health of the surrounding ecosystem is the level of noise that the turbines produce beneath the ocean surface [1].

VI. CURRENT & FUTURE TIDAL POWER STATIONS

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 Tidal Power Plant in South Korea is the largest tidal power installation in the world. Construction was completed in 2011.

The first tidal power site in North America is the Annapolis Royal Generating Station, Annapolis Royal, Nova Scotia, which opened in 1984 on an inlet of the Bay of Fundy. It has 20 MW installed capacity.

The Jiangxia Tidal Power Station, south of Hangzhou in China has been operational since 1985, with current installed capacity of 3.2 MW. More tidal power is planned near the mouth of the Yalu River.

The first in-stream tidal current generator in North America (Race Rocks Tidal Power Demonstration Project) was installed at Race Rocks on southern Vancouver Island in September 2006.The next phase in the development of this tidal current generator will be in Nova Scotia (Bay of Fundy).

A small project was built by the Soviet Union at Kislaya Guba on the Barents Sea. It has 0.4 MW installed capacity. In 2006 it was upgraded with a 1.2MW experimental advanced orthogonal turbine.

Jindo Uldolmok Tidal Power Plant in South Korea is a tidal stream generation scheme planned to be expanded progressively to 90 MW of capacity by 2013. The first 1 MW was installed in May 2009.

A 1.2 MW SeaGen system became operational in late 2008 on Strangford Lough in Northern Ireland.

The contract for an 812 MW tidal barrage near Ganghwa Island (South Korea) north-west of Incheon has been signed by Daewoo. Completion is planned for 2015.

A 1,320 MW barrage built around islands west of Incheon is proposed by the South Korean government, with projected construction start in 2017.

The Scottish Government has approved plans for a 10MW array of tidal stream generators near Islay, Scotland, costing 40 million pounds, and consisting of 10 turbines – enough to power over 5,000 homes. The first turbine is expected to be in operation by 2013.

The Indian state of Gujarat is planning to host South Asia's first commercial-scale tidal power station. The company Atlantis Resources planned to install a 50MW tidal farm in the Gulf of Kutch on India's west coast, with construction starting early in 2012.

Ocean Renewable Power Corporation was the first company to deliver tidal power to the US grid in September, 2012 when its pilot TidGen system was successfully deployed in Cobscook Bay, near Eastport.

In New York City, 30 tidal turbines will be installed by Verdant Power in the East River by 2015 with a capacity of 1.05MW.

Construction of a 250 MW tidal power plant in Swansea city in UK will begin in 2015. It can generate over 400GWh per year, enough to power over 100,000 homes, the population of Swansea for up to 100 years, by 2017.

VII. ASIA'S FIRST TIDAL POWER PLANT

London-based marine energy developer Atlantis Resources Corporation, along with Gujarat Power Corporation Ltd, has signed a memorandum of understanding (MoU) with the Gujarat government in India to start a 50-Mw tidal power project off the coast of Gujarat in 2013. This will be the first tidal plant in Asia. [13]

The company Atlantis Resources is to install a 50MW tidal farm in the Gulf of Kutch on India's west coast, with construction starting early in 2012.

The facility could be expanded to deliver more than 200MW

The biggest operating tidal station in the world, La Rance in France, generates 240MW, while South Korea is planning several large facilities.

To claim the title of "Asia's first", the Indian project will have to outrun developments at Sihwa Lake, a South Korean tidal barrage under construction on the country's west coast.

Projections indicate that the cost of the initial 50MW farm - to consist of 50 1MW turbines - will come in at about $150m.

As much of the manufacturing as possible will take place in Gujarat, taking advantage of the skills base in India's booming wind turbine industry. [14]

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