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Turbines Reshaped by Physics

This article introduces a creative approach to the generation of electricity with turbines that are shaped by simple physics as one of the 100 innovations that shape "The Blue Economy". This article is part of a broad effort to stimulate entrepreneurship, competitiveness and employment.

The World Turbine Market

The world turbine market was valued in 2010 at +$100 billion. Global demand for turbines is expected to grow at an annual rate of plus 6 percent driven by a strong anticipated expansion in wind turbines. A dramatic drop in demand for gas and steam turbines in the order of 44 percent by the Spanish utilities (€30 billion), 27 percent by ENEL, the Italian market leader, and 17 percent by E.on, the German group (€6 billion) the market suffered its greatest dip in decades. However, the International Energy Agency expects world energy consumption (and demand for turbines) to increase between 2006 and 2030 by 44 percent guaranteeing a stable growth in non-OECD at an average of 2 percent per year. Since Europe needs 275 GW of new capacity by 2020, in part due to the aging of existing power plants, global demand is certain to pick up.

There are two basic types: the impulse and the reaction turbine. The reaction turbines operate with changing pressure, the impulse turbines leave the air or liquid with a lower kinetic energy. The world's largest suppliers of turbines includes General Electric, Siemens, Alstom, and ABB. General Electric operates the world's largest gas turbine manufacturing plant in Greenville, South Carolina. Vestas A/S from Denmark is the world's largest wind turbine maker. However, Sinovel, Goldwind and Dongfang are three Chinese competitors closing in rapidly on all fronts.

The Innovation

The turbine market has undergone numerous innovations to increase efficiency. The combined heat (steam) and power also known as co-generation is one of the low hanging fruits that has been harvested over the past decade. Europe currently generates 11 percent of its electricity using co-generation with Denmark, the Netherlands and Finland taking the lead. Con Edison, the American electric company provides steam to 100,000 buildings in Manhattan, New York using excess heat from 7 energy plants in the area. A lot of effort has been put into blade designs, some moving away from the sleek and smooth shapes. This innovation known as Tubercle Blades is inspired by the whales, and has shown efficiency increases of 20 percent while greatly reducing noise. However, most turbines are meant to operate with steam and gas, while the greatest efficiency can be achieved in water which is - to be precise - 823 times more dense.

Aaron Davidson is an inventor who has a keen interest in fluid dynamics, radio frequency radiation and since 1994 he has been working on venturi turbines. He studied the effect of a venturi-shaped shroud forcing water through a narrowing entrance, which after passing through the throat creates a low pressure vortex behind the turbine, pulling the flow across the turbine. He went on to build large size venturi turbines and tested the efficiency. When he realized that the efficiency could increase by factor 3.8 compared to the same turbine without the shroud he went on to perfect the system through a process of trial and error. Aaron set the world record (that still holds) in 2003 for the highest efficiency ever achieved with a hydraulic turbine, outpacing the Northrop Grumman Aero Space engineers who had set the best record to date in 1978. Based on convincing advances, Aaron went on to create Tidal Energy Pty Ltd (Australia) in 1999 with Craig Hill building a team able to cover civil, structural, mechanical, marine and environmental engineering.

The flow of water into the duct (or shroud) with a turbine located in the narrowing throat is able to achieve higher efficiency and a multiple output. The turbine runs at 20 to 30 revolutions per minute making it safe for aquatic life. The design of the device is simplistic and is dial for mass production with ease of assembly and flat packing for transport. The Queensland Government secured support from the local Sustainable Energy Innovation Fund and the Federal Government of Australia provided a grant to commercialize this emerging technology. By 2005 Aaron and Craig tested their units and concluded that time was ready for commercialization. While the Australian Government never calculated the potential for this type of energy for the whole nation, the UK established that this innovation could provide as much as 59 GW in power to the grid of the British Isles.

The First Cash Flow

The trials succeeded in putting electricity to the grid for as little as one dollar cent per kWh with an investment cost of one million dollars for one MegaWatt in generation capacity. One new shroud turbine supplied by Tidal Energy generates as much as three free flow turbines. The use of high grade extruded materials and a simplification of the design have further reduced capital expenditure. Biofouling, one of the typical problems of any water-based system is overcome thanks to the higher velocity inside the duct.

When the Florida-based Latin Energy investment group learned about the opportunity to mass produce and flat package the turbines shipped per container anywhere in the world for final assembly and installation, they immediately signed an A$18 million purchase order.

The Opportunity

The shroud turbine can be placed in the run of rivers, at the entrance of bays, between islands and the mainland, as well as in open ocean currents. While this system is operating one way, it could include a switching device to follow the reversal of the ocean currents following ebb and tide. The device could also be attached to the outflow of hydro power stations downstream of dams harnessing otherwise wasted energy. This is the co-generation of water flows and the harnessing of the full power of gravity in the future. The obvious application is to locate the shroud turbine into fast flowing ocean currents. These turbines could be considered underwater wind farms more akin to a jet engine since the venturi design accelerates flow across the turbine.

A 15 km/hr flow of water equals the same power as a 380 km/hr wind. This innovation makes the building of wind farms at sea a costly and even uncompetitive option. Instead of large and very expensive highly leveraged investments for offshore wind farms that are at least in the order of 100 million dollars, the Davidson-Hill Venturi Turbine technology caters to the smaller to mid-size investors at a cost of a million dollar per unit, shifting the hurdle one hundred times lower, thus offering hundred times more entrepreneurs the opportunity to embark on a new and efficient form of energy provision.

Perhaps the most appealing argument in favor of the shroud turbine proposed by Aaron and Craig is that it can function in a limited space, and that design can be adjusted to fit available areas. The same technology that could render islands self-sufficient in power could power highlander communities next to cold streams and glacial lakes. A water rich nation like Japan could quickly harness the power of its excess rain running down the mountains, and reduce its dependency on nuclear. A country like Bhutan that has already invested in regular flow turbines could triple its output of electricity with the existing - and due to climate change likely decreasing - flow of water, simply changing over the turbines to shroud designs once the existing ones are written off. Considering that electricity is the major export of the country, it would be the application of the basic principle of the Blue Economy "use what you have" in order to generate development without a need for further material consumption.

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Further information on the 100 innovations at www.theblueeconomy.org.

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