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Essay Question:

In the past 100 years, mankind has made a number of landmark engineering advances in fields such as nuclear energy, space flight, microelectronics, telecommunications, bioengineering, etc. What do you believe will be the most important engineering advance of the next 25 years? Describe why, and detail what you believe will be the resulting benefit to civilization.

Civilization can only continue to advance as far as its ability to harness available energy in a sustainable fashion. It was through the advancement of steam and coal power that fueled the Industrial Revolution, the first time human history has ever seen such a rapid and pervasive growth in technology. However, it has become glaringly apparent that the Earth cannot support our current rate and method of energy consumption. Over 80% of the global power supply comes from the depletion of non-renewable fossil fuels. Burning up such fuel has also produced an unimaginable amount of pollution that ravages the state of this planet. It has become imperative for us to steer our direction towards sustainable energy. Specifically, it must be in a manner that is clean, reliable, cost-efficient, and non-intrusive. The answer to this dilemma lies in the application of Earth's natural ocean and tidal currents. It is for that reason I believe the most important engineering advance of the next 25 years, and even well after that, will be development of novel technology to harness the untapped supply of hydrokinetic energy.

Hydrokinetic energy refers to the energy responsible for the natural movement of waves, tides, rivers and oceans. This kinetic energy differs from the well-known hydropower extracted from dams which rely on gravitational potential energy. Hydropower leads as the most used renewable source of energy, with 16% of the world's electricity being generated from hydroelectricity [1]. However, this energy comes at the cost of large scale dams that result in severe ecological disturbances and damage. On the other hand, hydrokinetic energy is harnessed from the natural flow of water. There is no need to rely on the artificial and intrusive construction of hydraulic head.

It is clear we need to shift our focus onto renewable energy sources, but why do I believe engineering advances in hydrokinetic energy will be more important than other forms of renewable energy such as solar and wind? The answer lies in the potential for innovation; the heart of engineering. Unlike solar and wind technology, hydrokinetic energy is an essentially untapped resource. The International Energy Agency (IEA) estimates a worldwide potential of 29,500 TWh/year in wave power and 1,200 TWh/year in tidal power [2]. That is the equivalent to the yearly power output of 2,600 nuclear power plants [3]. Nevertheless, hydrokinetic energy accountants for only 0.01% of renewable energy produced [2]. While astonishing to learn that such an enormous source of energy has been left unused, it is exciting to think about the future prospects it entails.

Most companies and research groups specializing in hydrokinetic energy formed in the late 2000's. Compared to all other sources of energy, the time spent into the development of this technology is infinitesimal. Thankfully, governments are beginning to realize what amazing potential lies within hydrokinetic energy. The European Commission recently funded MARINET, a €11 million initiative dedicated to the advancement of hydrokinetic energy technologies [4]. The United States Department of Energy also announced funding for future hydrokinetic research and development [5]. It was only in 2012 that the US funded the very first commercial tidal energy project in NYC that will provide power to 9,500 NY residents [6]. In the same year the US also leased the first long-term tidal energy contract with a company specializing in hydrokinetic energy [7]. This is a definitive step towards the commercialization of hydrokinetic technologies and its long overdue application in the coming years. However, what I find much more exciting are the hundreds of startups that are developing their own novel methods of harnessing hydrokinetic energy. Since this is a newly emerging technology, there is no standardized design that projects are restricted to. This freedom for innovation is what engineering is all about.

One such group pioneering this field is WEPTOS, a Danish startup with the vision of becoming the first company to commercially extract wave energy. Starting from just 2007, WEPTOS already designed and manufactured a working model that has produced impressive results (Fig. 1). The WEPTOS wave energy converter (WEC) is an anchored, portable device based on the innovative Salter's Duck model. It consists of numerous rotors on each leg that are connected to a common axle. The rotors use the kinetic energy of incoming waves to turn the axle and then returns to its original position through a ratchet mechanism so it does not apply a reverse torque on the axle (Fig. 2). The common axles are connected to a power take off system that consists of an electrical motor. Furthermore, the WEPTOS WEC has the ability to change its opening angle (Fig. 3). Tests have shown that this mechanism is instrumental in maximizing the efficiency as well as significantly reducing the mooring forces caused by storm conditions [8]. This is the type of ingenuity that makes this field so promising.

Hydrokinetic energy will prove to be the next great revolution in the energy world. It has the ability to provide clean, cost-effective, reliable, non-intrusive, and renewable energy. A concern of renewable energy sources such as solar and wind is that they are intermittent. Weather conditions may blot out the sun for extended periods of time and solar energy is not as effective during the winter. Likewise, wind conditions are difficult to precisely map out and near impossible to predict even a week in advance. On the other hand, tidal forces are so well understood and regulated they can be accurately predicted years into the future. This is a crucial consideration as any unexpected shortage of energy can have disastrous effects. Hydrokinetic energy is also more economical than current hydroelectric dams. The massive structures require large capital investments, the permanent remodeling of ecological systems, and carry the risk of catastrophic failure. Hydrokinetic energy systems can easily be scaled down to accommodate small communities for an affordable price and begin energy generation immediately.

Looking forward, energy will only become a larger issue. The International Energy Outlook Report predicts there will be a 56 percent increase in worldwide energy consumption by 2040 [9]. We will not be able to sustainably support this tremendous demand with our current energy technology. The most viable solution is in the utilization of hydrokinetic energy. It is no overstatement to say that the engineering advances of hydrokinetic energy technology will be the foundation upon which civilization will progress.

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Fig. 1 The WEPTOS WEC model in testing. Thomsen, Kirt. WEPTOS, Pecher, Arthur, Jens P. Kofoed, Tommy Larsen, and Tanguy Marchalot N.d. Web.

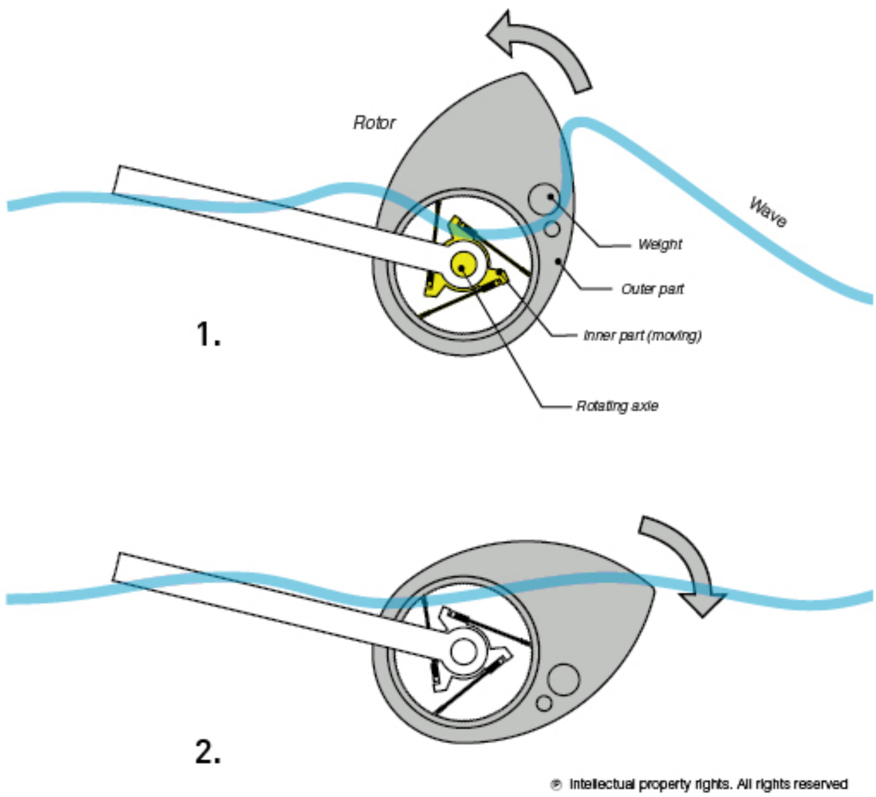

Fig. 2: Side view illustration of the working principle of the ratchet mechanism of each rotor. Thomsen, Kirt. "2 angle". WEPTOS, Pecher, Arthur, Jens P. Kofoed, Tommy Larsen, and Tanguy Marchalot N.d. Web.

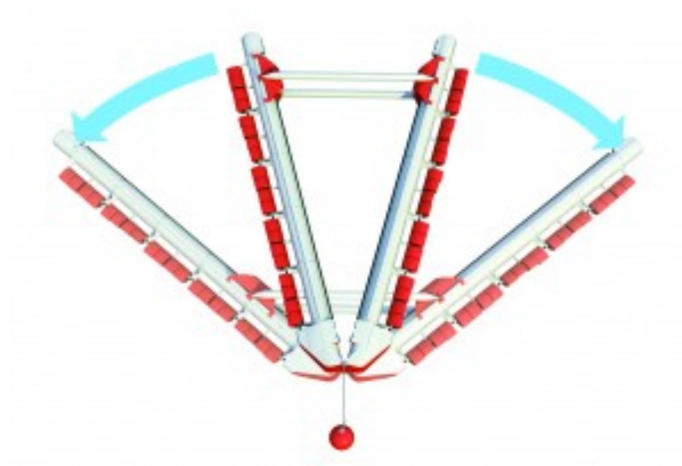

Fig. 3: Illustration of the adaptable opening angle. Thomsen, Kirt. "2 angle". WEPTOS, Pecher, Arthur, Jens P. Kofoed, Tommy Larsen, and Tanguy Marchalot N.d. Web.