Tidal Energy and how it Pertains to the Construction Industry

Armin Latifi
California Polytechnic State University
San Luis Obispo

Renewable Energy is on the forefront of many global discussions. The concern of numerous scientific findings on the impact humanity has had on the environment has grown in recent years. Since alternative energy sources, such as solar and wind, have already made substantial progress, I have decided to focus my attention on tidal energy specifically. This topic will serve as the main focus of this essay. Within this essay, I will examine how tidal energy pertains to the construction industry through four distinguished chapters: (1) What kind of tidal technology exist and what does the construction aspect of these tidal technologies require? (2) What are some of the risks and rewards of building a tidal energy plant and is it profitable for a general contractor? (3) What would make tidal energy a more desirable source of renewable energy when compared to others? (4) What would be considered a good site to develop a tidal energy plant? Hopefully, my research will provide general contractors with a better idea of what tidal energy projects will entail and if it's a viable option to pursue.

Keywords: Tidal Energy, Tidal Energy Plant, Tidal Energy Profitability, Tidal Energy Sites, Renewable Energy

Introduction

Tidal Energy is an underutilized source of energy. Although it is a form of renewable energy, like solar and wind, it differs in that it is produced from hydropower. More specifically, tidal generators convert the energy obtained from the Earth's tides into what we would consider a useful form of power (i.e. electricity). By no means is tidal energy new to the public but its benefits have yet to be widely accepted and taken advantage of.

I believe tidal energy has the potential to be one of the leading renewable energy sources. It has been proven that the ocean's tides are more predictable than wind and solar energy. On the other hand, tidal energy has also proven to be the most challenging types of alternative energy to work with. Its lack of popularity in recent years has been credited to high construction costs and limited availability of legitimate sites that would be able to produce sufficient tidal ranges and

flow velocities required to produce a sufficient amount of energy. However, there have been recent technological advancements with design and turbine technology within tidal energy that is suggesting otherwise. These new improvements indicate that tidal energy can compete with other renewable sources on many levels such as economic costs and energy output.

Within this essay, I explored four main questions. These questions include:
(1) What kind of tidal technology exist and what does the construction aspect of these tidal technologies require?
(2) What are some of the risks and rewards of building a tidal energy plant and is it profitable for a general contractor?
(3) What would make tidal energy a more desirable source of renewable energy when compared to others?
(4) What would be considered a good site to develop a tidal energy plant?
Answering these questions will help others in the construction industry determine whether tidal energy is a viable option to pursue in the construction industry.

Tidal Technologies and Construction

"The worldwide potential for tidal power is estimated to be 700 TWh a year" (Maehlum). There are many ways to capture tidal energy but the three most popular tidal technologies are tidal barrages, tidal fences, and tidal turbines. Each method has its own strengths and weaknesses and we will first better understand the three different methods of capturing the energy before we discuss the construction process.

Tidal Barrages

Tidal barrages have been proven to be the most efficient tidal energy technology. It's engineered like a dam that utilizes the potential energy generated by the change in height between high and low tides. "This energy then turns a turbine, which compresses air and in turn generates electricity" (Kabeya). This electricity is then transported in real-time by a power plant that is stationed on shore. Please refer to Fig. A1.0 below for a graphic of a Tidal Barrage.

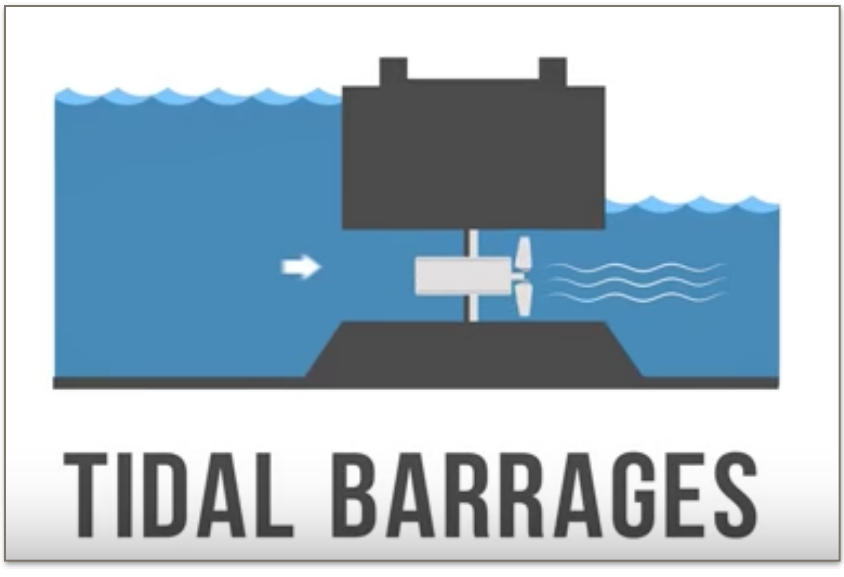
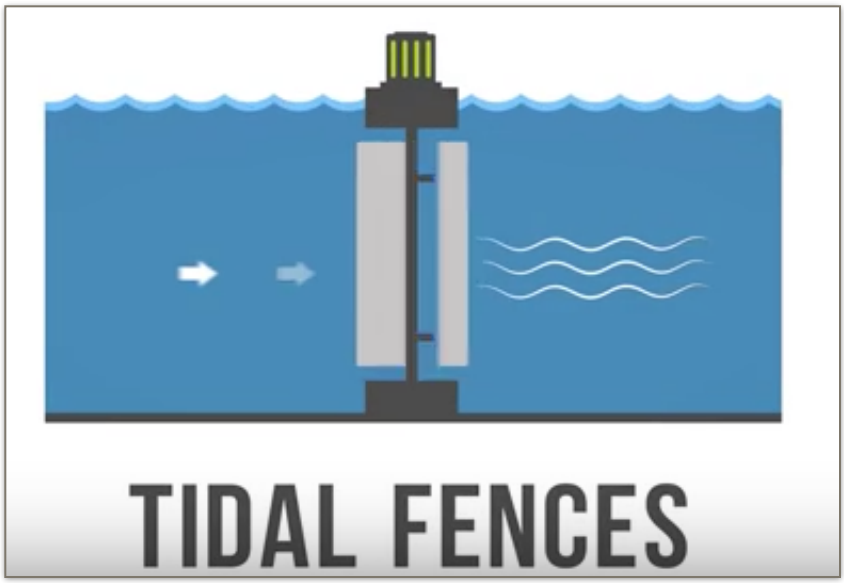


Fig. A1.0
A typical Tidal Barrage in operation.

Tidal Fences

Tidal fences are turbines that operate like giant turn styles. As water passes through the mechanism it pushes the giant turbines and causes them to spin producing electricity (Kabeya). The giant fences allow for more surface area when compared to the other two methods. As displayed in fig. A2.0 below.

Fig. A2.0
A typical Tidal Fence in operation.



Tidal Turbines

Tidal turbines are similar to wind turbines, but they operate under water. Tidal turbines generate electricity when the mechanical energy of tidal currents turns the turbines connected to an electrical generator. The generator then produces electricity. But unlike wind turbines, these tidal turbines are being turned by ocean current versus air currents. It is said that ocean water is 800 times denser than air and therefore applies a greater force on the turbine (Kabeya). Below, in Fig. A3.0 a tidal turbine is shown for your reference.

Fig. A3.0
A typical Tidal Turbine in operation.

Materials

When designing tidal turbines, the engineers must take into consideration all the challenges associated with a dynamic physical environment of a subsea location. The density, pressure, salt and temperature of the water are all major factors in determining the materials used to build the turbines. These materials must be able to withstand all these different variables in order to prove successful in strength and durability. We will take the Andritz Hydro Hammerfest HS1000 for example and look at what materials compose the tidal turbine blades that are manufactured by Gurit. “The blades feature a spar cap molded with unidirectional carbon prepreg and glass prepreg. The shells are all glass prepreg and all components are oven-cured. The blades are 9m/ 29.5-ft long and weigh 2,000 kg (4,409 lb). Source: Gurit” (Sloan). A picture of the design of the turbine blade can be seen below in Fig. B4.0.

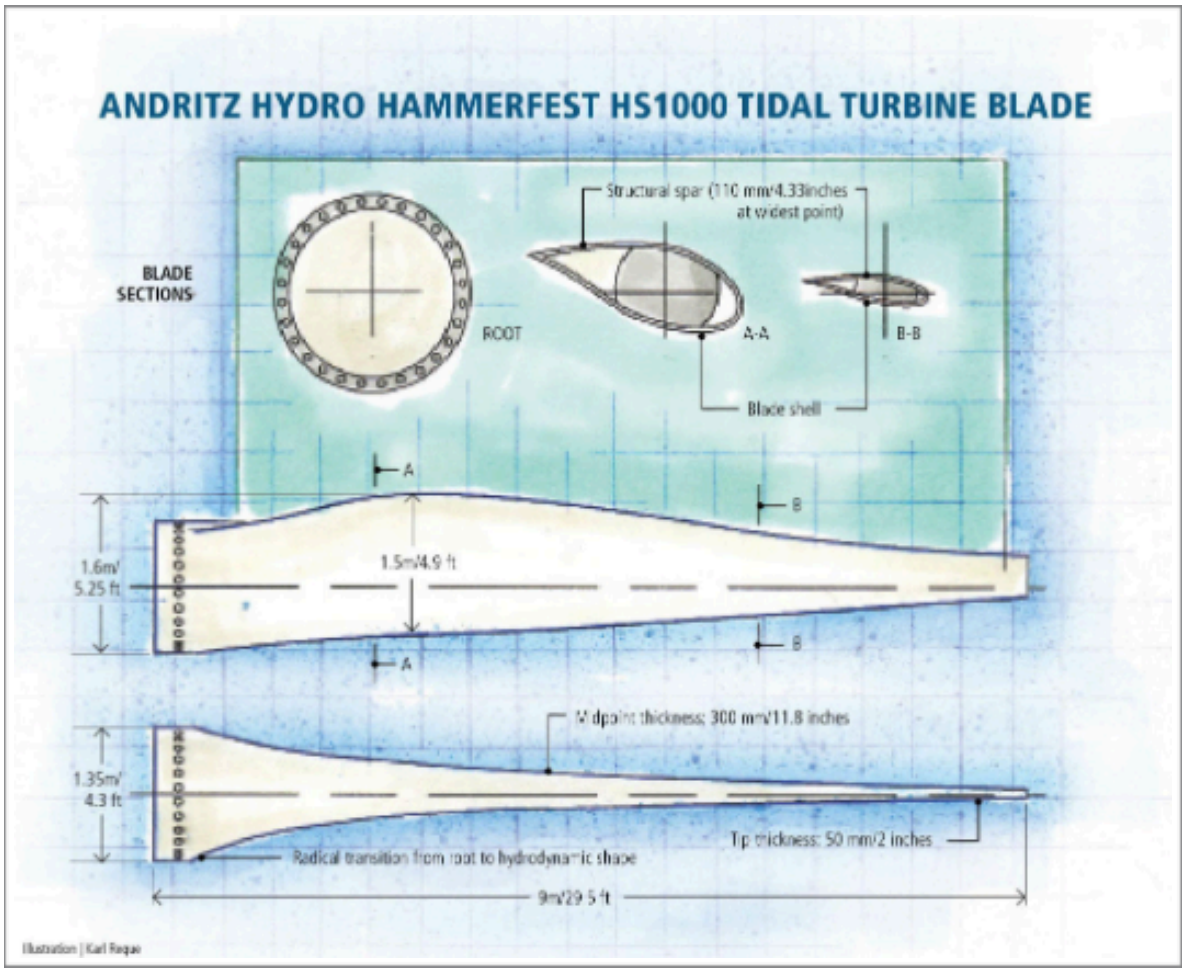


Fig. B4.0
An illustration of the Andritz Hydro Hammerfest HS1000 design by Karl Reque.

Production and Performance

The HS1000 pictured below, is a 1-MW tidal turbine developed by ANDRITZ HYDRO Hammerfest. “The pre commercial model shown below, was installed at the European Marine Energy Centre (EMEC) north of Scotland in December 2011. It features composite blades designed by Gurit (Isle of Wight, U.K.) to withstand an aggressive subsea environment” (Sloan). The composite blades has a life span of 25 years and only require minimal maintenance. Also, the turbine’s 1-MW rating equates to providing sufficient power to approximately 500 homes (Sloan). In result of the environmental challenges, the blades are shorter and stouter than what is found on a wind turbine because they must cope with substantial water pressure and water density challenges (Sloan). Fig. B5.0 shows a photo of the HS1000 installed at the European Marine Energy Centre.

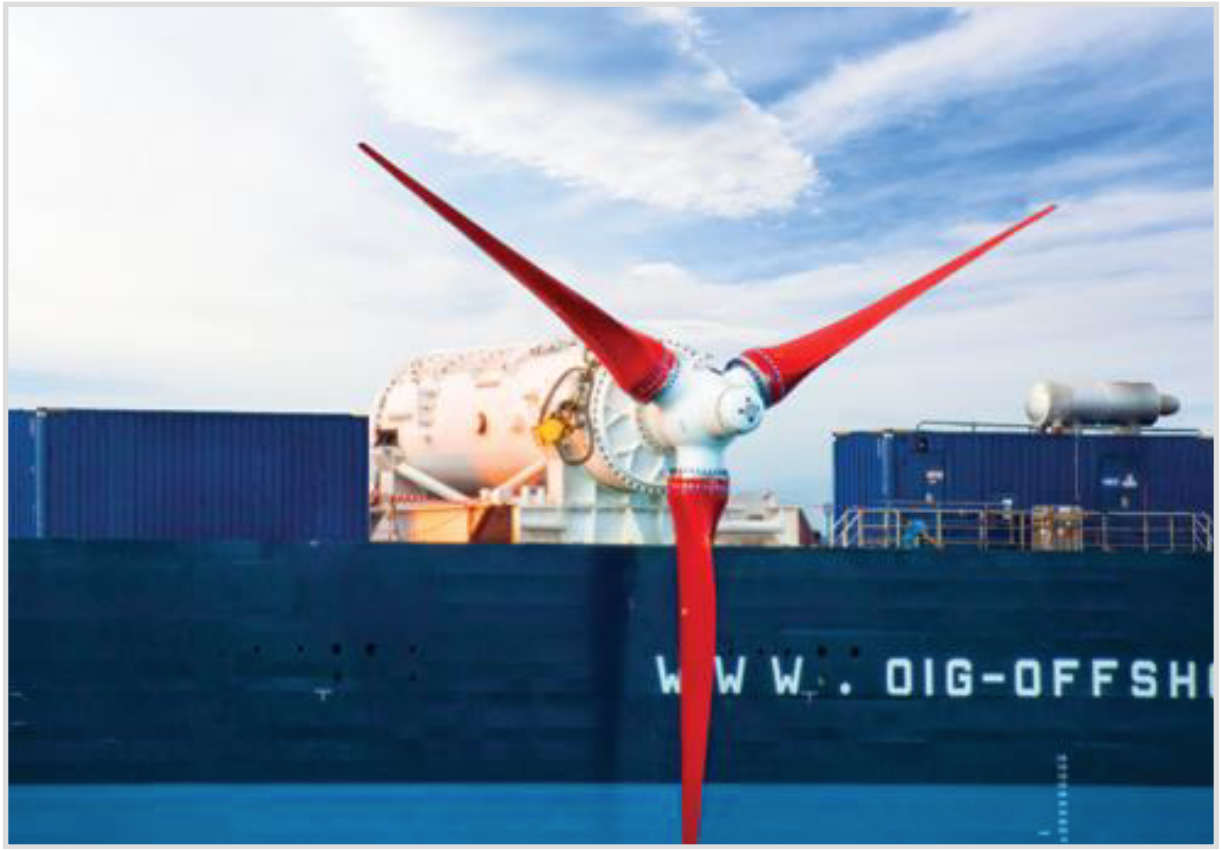


Fig. B5.0
A photo of the HS1000 tidal turbine installed at the European Marine Energy Centre.

Profitability

Determining the profitability of tidal plants is one of the more challenging uncertainties of tidal energy projects. In my opinion there are three main reasons tidal energy has not yet been widely adopted by the public and developers; 1. Tidal Technology has a long way to come and has yet to be perfected and mass produced in order to reduce the price of the equipment involved with tidal plants. 2. Tidal Energy projects are relatively new and lack the “know how” required to complete schedules on time and on budget. 3. There are many variables and not many legitimate sites that can produce sufficient amount of energy output to make the plant profitable. Not much research exists in this field and in result tidal power may be destined to remain a niche player in the U.S. energy portfolio.

Construction

These previously referenced forms of renewable energy aren’t as difficult to construct as suggested in the past. Although a good portion of marine construction activity is required, it is fairly easy. The tidal technology is usually assembled in a factory and then transported to the site. Once on site, you would then load them onto a vessel and haul them out to sea. Once out at sea, you would place them in predetermined locations in the water using a crane. All these tidal technologies mentioned above are fairly light to work with. The tracks and lines would have to be laid down as well, which would require underwater welding. The actual procurement and installation of these systems are not considered to be difficult at all. The plant itself would be located on shore and built like any standard power plant. With the new power plant in place you would also need to lay new power cables to transport the electricity as needed.

Risk and Rewards

Like with most things in construction, you must understand the advantages and disadvantages when pursuing new markets. Although renewable energy isn't necessarily a new market for general contractors, tidal energy somewhat is.

Advantages to Tidal Energy

First, tidal energy is considered to be a renewable source since the energy generated is a result of the gravitational fields from both the sun and the moon, combined with earth’s rotation around its axis, resulting in high and low tides (Maehlum). When compared to fossil fuel or nuclear power generation, tidal energy won’t cease to exist. We will always have tide currents.

The second advantage of tidal energy is that it is considered to be an extremely more environmentally friendly source. It doesn't take a lot of space and a tidal energy plant does not emit any harmful climate gasses.

Third of all, tidal energy is revered for being extremely predictable. It is known that tide currents are highly reliable. High and low tides cycles have been studied and understood for some time now. This ultimately makes it easier to construct the tidal technology systems with the correct dimensions given that we know the amount of power exerted by the oceanic tides at any given time.

A fourth advantage would be that tidal energy is effective even when operating at low speeds. Since water is about 800 times denser than air it allows the turbine to generate electricity at speeds as low as 1 meter per second (Maehlum).

Another advantage is the life span of tidal energy plants. It is believed that with a long life span the cost of the electricity generated is greatly reduced. As a result, tidal energy is more cost competitive and from a developer's point of view, these plants generate revenue on a longer basis on their initial investment. For example, the La Rance power plant located in Brittany, France was constructed in 1966 and is still functioning today. This tidal power plant incorporated the tidal barrage technology and has seen great results (Maehlum).

Disadvantages of Tidal Energy

One disadvantage to tidal energy plants is their possible effect on the environment. For instance, tidal barrages rely on manipulation of the ocean levels and therefore have similar effects on the environment as hydroelectric dams. It can also hinder local ecosystems by disrupting marine animals habitats. The construction aspect of the tidal technologies is challenging in that respect. Although, technological solutions are being developed currently that will help resolve these issues as its relevance becomes greater.

A second disadvantage of tidal power plants is its need to be constructed on or near land. Since these plants require them to be close to land, it disallows the ability to locate these plants further out at sea near the turbines. It is said that in the near future technological advancements will allow tidal plants to be placed out at sea, taking advantage of weaker tidal currents (Maehlum).

Tidal energy's greatest disadvantage is its expense. Since tidal technology is relatively new, it has yet to be perfected and mass produced like solar panels. Given its rapid advancement, tidal power will be commercially profitable within 2020 (Maehlum).

Takeaway

I believe its disadvantages allow tidal energy to be a niche market within renewable energy. General contractors that are proactive in searching for new untapped markets would be striking a gold mine with tidal energy. Since not many general contractors have done work with tidal energy, it would be a good long term investment to learn the job specific requirements for constructing these tidal plants. The earlier general contractors get involved with these special projects, the more of a head start they will have on other competing general contractors. If a

general contractor is successful in doing this, they will then have built a trusting reputation amongst tidal plant developers.

Why Tidal?

Tidal energy has been growing in popularity over other forms of renewable energy for many reasons. Solar and wind have been way more utilized in the US and other countries but tidal is on the rise. Hopefully, by discussing some of the leading renewable energy resources such as solar and wind we can determine why tidal can become more preferred.

Solar Energy

The primary reason solar has seen so much success is because of its fairly cheap installation expense when compared to tidal. But unlike tidal, solar power can only be generated during the day and depending on the climate its production can be greatly hindered by cloud cover. Solar has also been criticized for being inefficient in respect to how much space it takes to produce the amount of power that it does. Solar fields are usually large and take up a lot of space, which means they have to be located in undeveloped areas. That requires general contractors to relocate employees and pay for travel consistently. Also, solar fields demand constant maintenance from the environments affect on them. Dirt, dust and even animals have a tendency to be destructive toward solar panels. Last but not least, solar panels are made of polluting materials and really only have a useful life of about 50 years (Osman).

Wind Energy

Wind energy is commonly critiqued about the noise disturbance associated with it. This is one of the main reasons why wind farms are not constructed near communities. Wind farms, like solar fields, are also commonly located in undeveloped areas. They too are considered to be a threat to wildlife due to large-scale construction of wind turbines in remote locations. It is most harmful to large birds, but studies have also shown it can affect burrowing animals as well since wind turbines require quite a lot of digging to install. Wind is also highly unpredictable making it a tough renewable energy source to rely on. Lastly, in high wind areas wind turbines are threatened by tornadoes and hurricanes.

Tidal Sites

Tidal energy plants have very specific site requirements necessary to produce tidal electricity. Understanding tidal ranges is very crucial in determining tidal energy sites. “Tidal ranges may vary over a wide range anywhere from 4.5 meters to 12.4 meters from site to site. A tidal range of at least 5 to 7 meters is required for economical operations and for sufficient head of water for the turbines” (Meyer).

Geographic Locations

The Pacific Northwest is considered to be an ideal geographical location for tidal energy plants. The tides along the Northwest coast fluctuate dramatically enough to produce a sufficient amount of energy. In particular, the coasts of Alaska, British Columbia, and Washington have high potential. On the Atlantic Seaboard, Maine is also considered to be a valuable potential source of tidal power output (Meyer).

Conclusion

Tidal energy is on the rise. I believe it will be the next thing in alternative energy to takeoff. With all things considered, tidal energy will be a leader in renewable energy. It’s only a matter of time that tidal technology catches up and tidal plants will then be built consistently along coastlines. When this occurs, the construction firms most knowledgeable in this project specific area will reap the benefits. Renewable energy departments within general contracting firms are popping up in many places. For example, the Swinerton Renewable Energy Department in the San Diego division. Swinerton Renewable is the top contractor in terms of revenue in the 2017 ENR report. A good portion of Swinerton’s revenue is generated from renewable energy projects. The most successful general contractors have managed to find untapped markets and exploited them early and often, by being ready when the time comes. Are you ready?

Lessons Learned

A lot of substantial information on tidal energy came in direct result of this project because of the research it required. This research is intended to help answer questions as to why we don't built tidal energy plants and in rebuttal to that, why we should. This paper therefore serves as a place where all the various findings accumulated can be on display and easily accessed by anyone interested in furthering their understanding in why to pursue tidal energy construction. Completing research on a topic thats fairly new is always difficult. That is where I met most of my challenges. Not much quantitive data exists in the world regarding this topic so at times it was difficult to quantify statements to give the reader a better idea by using numbers. To my dismay, I also wasn’t very lucky in finding the construction aspect of tidal energy plants on databases or other literary resources. In these instances, I relied on my connections to personnel in the industry that are working on solar power projects and other renewable energy construction projects.

References

Dorminey, Bruce. "Testing the Waters with Tidal Energy." *Scientific American.* Scientific American, 06 Dec. 2010. Web. 22 Mar. 2017.

Kabeya, Annick. "Tidal Power." *Tidal Power.* Student Energy, 17 May 2015. Web. 03 Mar. 2017.

Maehlum, Mathias Aarre. "Tidal Energy Pros and Cons." *Energy Informative.* Energy Informative, 16 Oct. 2012. Web. 03 Mar. 2017

Meyer, Richard. "Tidal Energy." *Ocean Energy Council*. The Ocean Energy Council, 15 Apr. 2016. Web. 03 Mar. 2017.

Society, National Geographic. "Tidal Energy." *National Geographic Society*. National Geographic Society, 09 Oct. 2012. Web. 22 Mar. 2017.

Osman, Nadia. "Top 7 Disadvantages of Solar Energy." *Understand Solar*. Understand Solar, 19 May 2015. Web. 03 Mar. 2017.

Rinkesh. "Disadvantages of Wind Energy." *Disadvantages of Wind Energy*. Conserve Energy Future, 24 Dec. 2016. Web. 03 Mar. 2017.

Sloan, Jeff. "Tidal Turbine Blade Toughened for Turbulent Salt Sea." *CompositesWorld*. CompositesWorld, 30 Nov. 2012. Web. 21 Mar. 2017.

Taylor, Paul. "Seagen Tidal Power Installation." *AENews*. Alternative Energy News, 6 June 2007. Web. 22 Mar. 2017.