www.susvalleypolicy.org

717-361-8905

PO Box 338, Hershey, PA 17033

AMERICA'S ALTERNATIVE ENERGY SOURCES

Tidal Energy

By Marianne Clay, Research Associate, Susquehanna Valley Center for Public Policy

Part One: Current State of Tidal Energy

A. How much tidal energy is being used, and where?

Currently tidal energy is generating very little electricity anywhere in the world, even though harnessing the power of the tides is hardly a new idea. Back in the 12th century, innovative millers in England and France built along tidal creeks and rivers to take advantage of the water's ebb and flow. They used the change in the tides to turn their waterwheels, which in turn powered the millstones that ground the grain. While you might expect this early use of tidal energy would have led to its widespread use today, tidal energy has not received serious consideration as an alternative energy until very recently.

Currently only one major tidal energy plant is operating, and it is 40 years old. This 240-megawatt station at the mouth of the La Rance river estuary on the northern coast of France, the La Rance Generating Station has been providing nearly 100,000 French households with reliable electricity since it opened in 1966. France originally planned for La Rance to be the first of many tidal power plants, but this nation scuttled plans for other plants and embraced nuclear power instead. In 1968, two years after the La Rance Generating station went into service, the Russians built a tiny .4-megatwatt tidal power plant in Kislaya Bay on the White Sea in Russia, and today, after a 10-year-hiatus, this Russian plant is back in operation. In the late 1950s, China built several small-scale tidal plants for pumping irrigation water and generating electricity, and today about seven tidal power plants, dating back to the 1970s, produce about 11 megawatts of electricity in China.

Closer to home, you find only one tidal power plant has ever operated in North America, and that's the 20-megawatt facility at Annapolis Royal in Nova Scotia's Bay of Fundy. This facility has been reliably producing electricity for 4500 homes since its construction in 1984. Even though this plant is 22 years old, it is the newest tidal power plant operating anywhere in the world. That will soon change.

Spurred by rising fuel costs and a new approach to harnessing the energy of the tides, interest in marine energy is surging like the ocean at high tide. But, instead of building tidal power plants like the ones already operating in France, China, Russia, and Canada, a handful of small and unknown energy companies have been developing underwater turbines that look and operate like windmills or wind turbines that have been submerged in the water. These turbines do not stand some 40 to 400 feet above the ground and do not spin when the winds blow. Instead, the propellers on these underwater tidal turbines turn with the rise and flow of the tides. The tidal flow rotates the underwater turbine blades, and the turning blades power the generators and produce electricity. This new approach, while not completely tested, has set off a search for the best locations to harness energy from the tides.

Currently, scientists, engineers, and investors are examining tidal waters in New York's East River; Cook Inlet and Resurrection Bay in Alaska; Cobscook Bay and the St. Croix River in Maine; under San Francisco's Golden Gate Bridge; around Washington State's Puget Sound; off the coast of South Korea, and a dozen other locations around the world.

B. How does a tidal power plant work?

Neither the 12-century waterwheels that moved when the tide changed nor the tidal power plants already in operation use the technology now being explored. The old-style tidal power plants, currently operating in Nova Scotia, China, France, and Russia, use a system of gates called barrages set up across a narrow inlet, estuary, or bay, where you find at least a ten-foot difference between high and low tide. When the tide comes in, the gates close and trap the water, forcing it through the turbines and thereby generating electricity much like a hydroelectric plant. While these barrage-type of tidal plants generate electricity, they have drawbacks.

Number one: they are very expensive to build for the amount of electricity they produce. According to a 2004 issue of *Tidal Energy* magazine, the average cost to build and run a barrage-style, tidal power plant is about 1.2 billion dollars, which does not include the cost of maintenance and upkeep. Secondly, these barrage plants impede the natural flow of water, reshape the natural landscape, and alter and even destroy natural tidal waterways. Tidal waterways often act as nurseries for marine life, so their destruction has far-reaching impact. Finally, these plants can kill fish and trap marine life. For example, in August 2004 during a low tide, a humpback whale swan through the open sluice gate at the Annapolis Basin Tidal Generating Station in Nova Scotia's Bay of Fundy and remained trapped for several days before finding its way out.

Tidal fences can also harness the energy of tides: a fence mounted with turbines is located in a narrow channel, and the water in the channel is forced through the turbines. While tidal fences are less destructive to the environment than tidal barrages, they still stop large marine animals

and disrupt other marine life. For these reasons, neither the barrage-type tidal power plant nor the tidal fence has taken hold, and the new style of tidal power plant – a tidal farm with hundreds of submerged and slowly spinning windmill-type turbines at the water's bottom – is now being embraced.

These marine turbines generate electricity by spinning as the tides move in and out, much like wind turbines move when the wind blows, and they can be located wherever there is a strong tidal flow. Because water is about 800 times denser than air, tidal turbines have to be very sturdy but they are also able to capture much more energy per spin. Advocates, such as the marine energy lobbying group known as the Ocean Renewable Energy Coalition, cite tidal energy's key advantage over other energy sources: its supply is completely predictable. This D.C.-based lobbying group, which formed in 2005, also notes that water's greater density means tidal turbines can be smaller than wind turbines, and fewer tidal turbines are needed to produce the same amount of electricity as wind turbines.

C. Where are underwater turbine farms being located?

The U.S. has no underwater turbine farms yet but Verdant Power, a Virginia-based energy company and the 2006 winner of the National Hydropower Association's President Award, is installing two on the bottom of New York City's dark and murky East River in an 18-month test program costing $10 million. This $10 million includes $2 million to monitor the effect of the turbines on marine life hardy enough to live in the polluted waters. Despite its pollution, the East River, which is not a river but a tidal channel separating Manhattan and Queens, offers a necessary attribute. It runs fast. In fact, 17th-century Dutch sailors referred to one narrow portion of the East River as "Hell's Gate," because the current reaches speeds of six miles per hour. A fast current is necessary to generate electricity from tidal turbines, but nothing has been fast about the process Verdant Power and its business partner, the New York State Energy Research & Development Authority, have gone through in their efforts for their Roosevelt Island Tidal Energy Project or RITE.

Four years ago, Verdant began testing an underwater turbine in the East River to determine the turbine's environmental impact on marine life and to test the efficiency of its turbine. This November, after finally receiving all the necessary approvals and funding, the company is anchoring the two turbines 40 feet below the river's surface into bedrock. The propeller blades, which span about 16 feet from tip to tip, work in both directions to accommodate reversing tidal currents and turn at a slow 32 rotations per minute. During the coming months, Verdant expects the two turbines to generate enough kilowatts to power a Gristedes supermarket and a parking garage on nearby Roosevelt Island. If the test is successful, Verdant plans to install several hundred more turbines to generate 10 megawatts of electricity or enough to power 8000 homes. Ultimately, the project seeks to make New York City the world's largest major renewable energy city. Then Verdant hopes to install its tidal turbines in other locations as well, and so do other marine energy companies.

In New Hampshire, the New Hampshire Tidal Energy Co. is proposing to produce electricity using the power of tides in the Piscataqua River. The proposal filed with the Federal Energy Regulatory Commission calls for 50 to 100 turbines to be submerged in the river as it passes

through Rockingham and Strafford counties in New Hampshire and York County in Maine. The Massachusetts Tidal Energy Company of Washington, D.C. hopes to install a large-scale underwater generation field off Cape Cod, while another D.C.-based company is eying Maine's Penobscot River for a tidal energy project with as many as 100 underwater turbines. The Ocean Renewable Power Co. of Miami, Florida awaits approval for federal study permits to test tidal turbines in several sites in Alaska including Anchorage's Knik Arm and Resurrection Bay near Seward and the St. Croix River in Maine. Oceana Energy, an investor group based in D.C., has submitted applications for seven tidal energy proposals, including one for the waters underneath the Golden Gate Bridge in the San Francisco Bay.

So far, the Federal Energy Regulatory Commission has received 37 preliminary permit applications for tidal energy around the United States and has approved nearly a dozen permits to study tidal sites. Even big companies, like General Electric and Eon, Germany's power giant, are becoming interested enough to invest too.

D. Costs

The Electric Power Research Institute, a non-profit energy research organization in Palo Alto, Calif., recently completed a $425,000 technological and economic feasibility study of the tidal resources in Maine, Massachusetts, California, Washington, and Alaska, and the Canadian provinces of New Brunswick and Nova Scotia. (Utility companies and various energy agencies in these states and provinces funded this research project.) The study concluded that underwater turbines in California's San Francisco Bay, Maine's Quoddy Bay, and various sites in Washington State and Alaska could produce electricity competitive in cost to the electricity from wind farms and natural gas-powered power plants. In fact, its study concluded that tidal power could produce electricity for 4.2 to 6.5 cents per kilowatt-hour at those U.S. locations. The study also named Nova Scotia's Bay of Fundy, whose waters have some of the highest tides in the world, as the best site in North America for harnessing the power of the tides and urged that the first major tidal farm go into the waters in and around the Minas Basin area of the Bay of Fundy. In the Minas Basin area of the Bay of Fundy, tidal turbines could economically generate enough power to serve 117,000 homes.

Part 2: Outlook for Tidal Energy

A. Pros and Cons

The wind doesn't always blow, the sun doesn't always shine, but the ebb and flow of the tides never stops. Unlike most renewable power sources, tidal power is entirely predictable. It has a cycle slightly longer than 24 hours and is predictable days, weeks, months, years and decades in advance. The Electric Power Research Institute's study concluded, unlike tidal dams and tidal fences, tidal turbines have little harmful impact on the natural landscape or on the marine life. The turbines do not encourage the accumulation of silt nor do they produce toxic by-products. Most marine life easily avoids the slow-turning propellers, and larger marine mammals can be diverted b screens placed in front of the blades. In addition, since tidal turbines are submerged, no part of a tidal farm is visible and so visual blight is not an issue.

Perhaps the biggest factor working against tidal energy is its newness. Because the idea of tidal farms is still in the experimental stage, getting the financing and obtaining the permits requires incredible fortitude. In addition, while Congress has granted tax incentives to lower the cost of producing solar and wind power, it has not enacted legislation providing incentives to developers of tidal projects. So far, the studies of the impact of these turbines on marine life show no adverse effects, but many still express concerns. Fishermen note that energy companies hope to place tidal turbines in narrow channels with fast flowing waters, the same sort of locations that tend to be routes for migrating fish and to offer great fishing. In fact, concerns about the impact on fishing scuttled the plans for a tidal farm in Delaware's Indian River Inlet.

B. Barriers?

Generating electricity from the tides is limited to those sites with the necessary factors. A tidal farm needs large amounts of fast-moving water, enough space to anchor 15-foot turbines without interfering with boat traffic and fishing grounds, and a location close to the power grid. In addition, finding funding and turning years of research and experimentation into viable commercial enterprises offers huge challenges to the small and relatively unknown marine energy companies.

C. Incentives?

While Congress has granted tax incentives to lower the cost of producing solar and wind power, it has not provided such incentives to developers of tidal projects or any ocean energy projects. The Ocean Renewable Energy Coalition, the lobbying group devoted to furthering marine energy, is working to push legislation supportive of marine energy.

III. Costs for energy source

A. Infrastructure?

According to current estimates, designing and installing a full-scale tidal turbine farm will cost about $150 million as compared to more than $1 billion for a barrage-type power plant.

B. Cost per kilowatt hour?

If installed in optimal location, the Electric Power Research Institute study concluded that tidal power could produce electricity for 4.2 to 6.5 cents per kilowatt-hour. At this price, tidal energy is an economical alternative.

C. Environmental costs?

Unlike wind turbines, you cannot see submerged tidal turbines nor can you hear them operate, thus eliminating complaints about noise pollution and visual blight. While most power plants use fossil fuels to generate electricity, tidal farms produce neither pollution nor harmful by-products. In addition, the Electric Power Research Institute's study concluded tidal turbines do not mar the natural landscape or harm marine life. Fish and other life can swim away from the slow-moving

blades on the anchored turbines. In addition, in areas where whales and other large marine mammals swim, screens can be placed in front of the blades. Fishermen, however, are concerned as the same areas optimal for tidal turbines – narrow channels with fast-moving waters – are often good fishing holes. Obviously, marine energy companies will have to be sensitive to these concerns.

IV. Recommendations?

Tidal energy is an idea whose time has finally come. While tidal energy can only provide a percentage of America's energy needs, it does offer a great alternative for some communities. The U.K hopes marine energy will eventually provide 20% of its energy needs, and perhaps we can look forward to a similar outcome here. While still in the experimental stage, tidal energy is worth pursuing. It offers a source of cost-effective electricity, it is non-polluting, and it reduces our dependency on fossil fuels.

Resources
American Chemical Society
Barre-Montpelier Times Argus
Business Week
California Energy Commission
Christian Science Monitor
Federal Energy Regulatory Commission
National Hydropower Association
New York Times
Ocean Renewable Energy Commission
Portland Phoenix
Renewable Energy Access
San Francisco Chronicle
Tidal Energy Magazine
U.S. Department of Energy
World Energy Council