Tidal Energy

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Overview

- Technology
- Cost
- Social and Economic Benefits
- Sustainability
- Negative Impacts
- Policy Challenges and Issues
Ancient Tide Mills

- Tide mills were used during ancient times.
- During the Roman occupation of England, tide mills stored water behind a dam during high tide. As the tide receded, the water was slowly let out to power grain and corn mills.

Nendurm Monastic Site on Mahee Island in Ireland dating back to 787 A.D.
Today’s Tidal Energy Technology

There are two ways to harness of Tidal Energy

1. use of the kinetic energy of moving water similar to wind mills
   • This can be in the form of Tidal turbines that are arrayed underwater in rows.
   • The turbines function best where coastal currents run at between 3.6 and 4.9 knots (4 and 5.5 mph)
Today’s Tidal Energy Technology

2. Use of the potential energy of water using the difference of height in high and low tides
   • Barrage or dams are typically used to convert tidal energy into electricity. The most efficient of these are ebb generators
   • These barrages/dams enclose small estuaries or narrow water channels.
Today’s Tidal Energy Technology

2. Use of the potential energy of water using the difference of height in high and low tides
   - Gates and turbines are installed along the dam and they are opened when there is a significant height difference on opposite sides.
   - The movement of water in essence acts like a regular run-of-the-river hydroelectric dam more commonly seen.
   - This is the most common tidal power plant
Today’s Tidal Energy Technology

- La Rance, France was the first to build a tidal energy plant in 1966 and recently completed its expansion to its 245 MW capacity.
- Other tidal power schemes are being considered in the UK, Russia, China, and Korea.
- Mostly beneficial in providing electricity to coastal residents.
- Should be considered as a good alternative energy source for island nations with large coastlines.
Costs

**Examples for cost of tidal power plants**

<table>
<thead>
<tr>
<th>Tidal power plant and location</th>
<th>Output</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yalu, China (pre-commercial station)</td>
<td>5 MW</td>
<td>$37,000,000</td>
</tr>
<tr>
<td>La Rance, France</td>
<td>240 MW</td>
<td>$125,000,000</td>
</tr>
<tr>
<td>Sihwa Lake, Korea</td>
<td>254 MW</td>
<td>$250,000,000</td>
</tr>
<tr>
<td>Severn, U.K. (proposed)</td>
<td>8 GW</td>
<td>$30,000,000,000</td>
</tr>
</tbody>
</table>

Cost of Tidal power plants vary due to size. The most costly projects are large barrages that try to take careful consideration of marine habitats. Projects like La Rance and Sihwa incorporate existing infrastructure thus have significantly reduced cost.
Cost

- The "Gibrat" ratio is used to measure cost effectiveness of a Tidal power plant
  - This is a ratio of length of the barrage in meters to the annual energy production in kilowatt hours.
  - Smaller Gibrat ratios are more desirable
- Examples of Gibrat ratios are as follows

<table>
<thead>
<tr>
<th>Location</th>
<th>Gibrat Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>La Rance</td>
<td>.36</td>
</tr>
<tr>
<td>Severn</td>
<td>.87</td>
</tr>
<tr>
<td>Bay of Fundy (Canada)</td>
<td>.92</td>
</tr>
</tbody>
</table>
Social and Economic Benefits

- It has an abundant and inexpensive source of fuel, seawater
- Barrages and Dams can serve as roadways as well.

La Rance, France
Social and Economic Benefits

- Since Tidal power plants are not as common as other types of eclectic plants, they can help build tourism in a region.
- The uniqueness of La Rance’s power station has helped to attract 300,000 visitors/year
Social and Economic Benefits

- Sihwa Lake in Korea upon completion, will be Korea’s first tidal energy power plant and opens up the dam to allow water to move from the lake to the sea
Social and Economic Benefits

- Prior to this, the lake was cut off from tidal currents. Pollution and industrial waste from neighboring factories started to build up.
- Water quality had greatly deteriorated.
- Tidal power plant will open the lake to sea water and hopefully improve water quality.
- The tidal plant will improve the lake by circulating 60 billion ton of seawater annually.
Sustainability

- Tidal energy does not create waste or generate emissions like oil or coal power plants do.
- It can reduce the dependency on oil for energy and is considered a clean renewable energy source.
- Tidal energy has some advantages over other renewable energy like wind generated energy:
  - Seawater is denser than air, therefore, ocean currents (including ebbing) can carry more energy than wind.
  - Tides are predictable and reliably generate electricity.
Sustainability

- Energy is produced for free once initial cost are recovered
- Barrages and dams can help protect shorelines from high storm tides
Environmental Impacts

- Barrages block outlets to open water and can create tide level changes, affecting navigation.
- Estuaries that are isolated during construction can have detrimental effects on flora and fauna.
- Species lost habitat due to the La Rance construction, but other species colonized the abandoned space.
Environmental Impacts

- Barrages can affect fish migration. Turbines add a significant impact to fish and even with fish friendly designs, fish mortality per pass is 15%.
- Turbidity and Salinity decrease from the decrease in circulation. This can improve condition for phytoplankton which can propagate up the food chain and cause general changes in the ecosystem.
Technology Problems

- Tidal energy can only be found on coastlines. Furthermore, many of the areas ideal for a tidal energy plant are remote areas where there is little demand for electricity. Transporting the energy then becomes problematic.

- As stated before, Turbines are not 100% safe for fish. This problem is mainly associated with barrages. However, new technology such as open center turbines and tidal fences are working to be marine life friendly to fish as well as large dolphins.
Policy Challenges

- The biggest policy challenge to creating better tidal power infrastructure is lack of public funding as well as private sector investment
  - The payback period on large barrage facilities can take 8-10 years. This long term investment may discourage investors
  - This is especially true in the UK where the Severn project had been proposed for on and off for the past 150 years. The 1970s-80s were the last time the project was given serious consideration. Severn barrage would be 10 mi. long and cost $30 billion to construct.
- The UK has further problems in supplying its own funding for Marine infrastructure
  - £50 million Marine Deployment Fund is not enough to attract investors because the fund can only provide a subsidy for pre-commercial 10 MW projects
Policy Challenges and Issues

- In addition to its cost, the environmental impact on the Severn Estuary presents a serious challenge in protecting wildlife.
  - Severn Estuary contains and array of different habitats including mudflats, salt marshes and rocky islands.
  - Supports some 65,000 birds during the winter.
Policy Challenges and Issues

• Here in the US, states like Maine have already looked into policy review for tidal energy development

• Sample Issues include
  – Inventory and Quantification of Maine’s overall energy cluster
  – Characterizing marine environment and understanding relationship between ocean energy extraction
  – Engaging Canadian counterparts to determine best way to address development opportunities at the Maine and New Brunswick boundary.