Wave and Tidal Energy

By Sarah Meyers

April 15, 2013

Ocean Thermal Energy

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Wave and Tidal Energy

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How it Works

•Wave and tidal energy capture the power of waves and tides using special buoys, turbines, and other technologies and convert it into clean, pollution-free electricity.

•Waves are produced by winds blowing across the surface of the ocean.

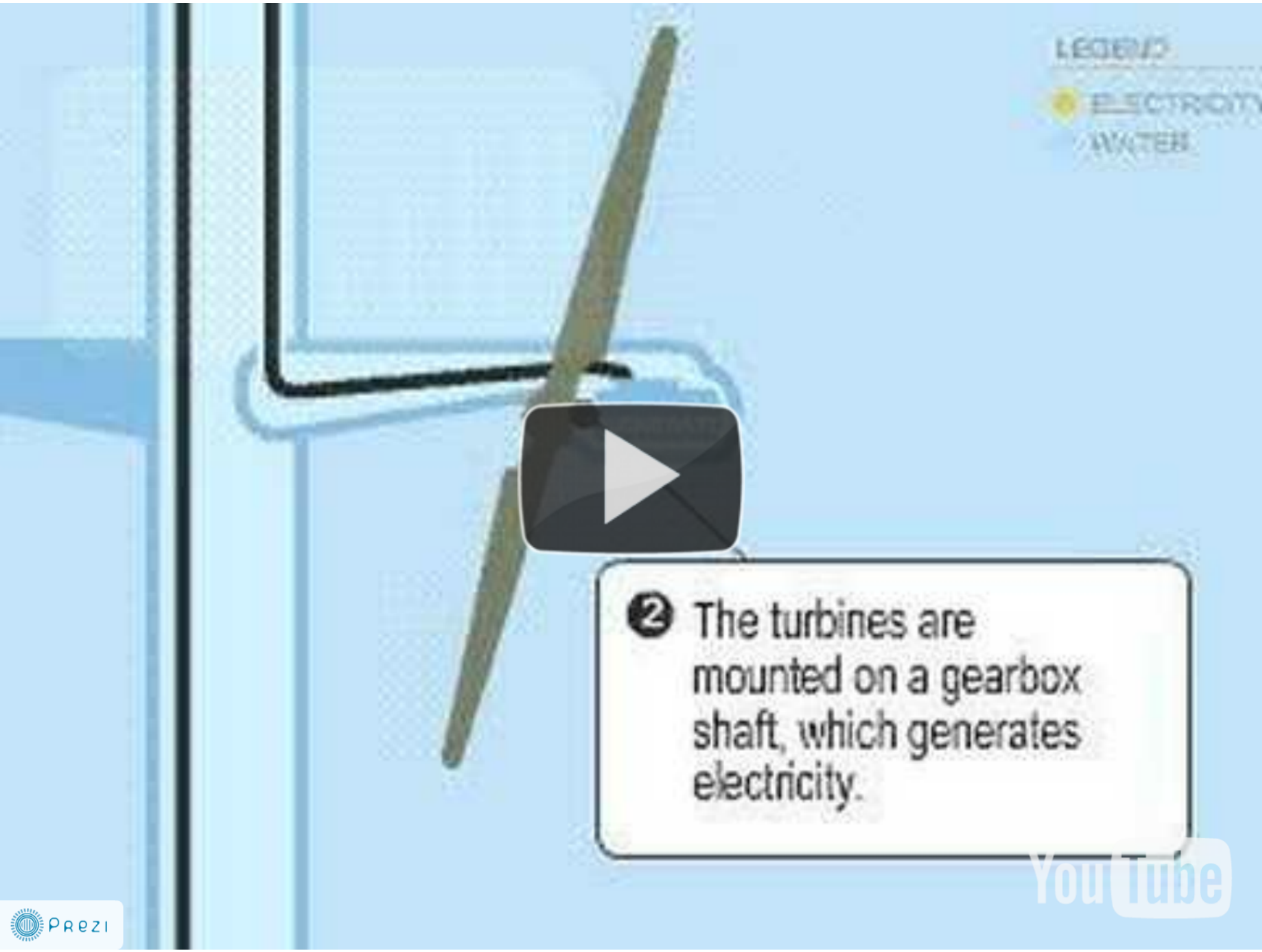
•Ocean Energy

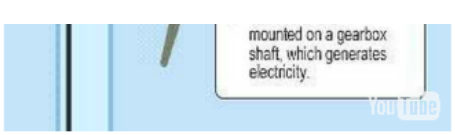
- waves, high and low tides, and temperature differences in the water.

•There are three main types of wave energy technologies.

- Using floats, buoys, or pitching devices to generate electricity using the rise and fall of ocean swells to drive hydraulic pumps.
- Using oscillating water column (OWC) devices to generate electricity at the shore using the rise and fall of water within a cylindrical shaft.
- Lastly, a tapered channel, or overtopping device can be located either on or offshore. They concentrate waves and drive them into an elevated reservoir, where power is then generated using hydropower turbines as the water is released.

- The vast majority of recently proposed wave energy projects would use offshore floats, buoys or pitching devices.


LEGEND
ELECTRICITY
WATER
2 The turbines are mounted on a gearbox shaft, which generates electricity.
YouTube



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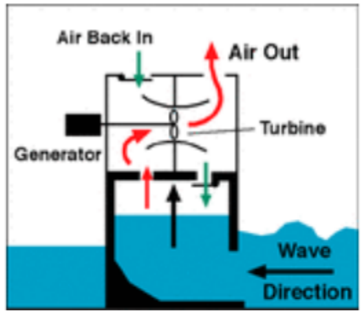
Wave Energy

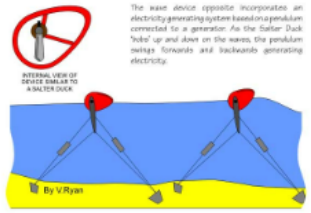
•Wave energy is the transport of energy by ocean surface waves, and the capture of that energy to do useful work
•In harnessing wave power, the back-and-forth or up-and-down movement of waves is captured.
•Wave power devices are categorized by the method used to capture the energy of the waves, by location and by the power take-off system.

- Method types are point absorber or buoy; surfacing following or attenuator oriented parallel to the direction of wave propagation; terminator, oriented perpendicular to the direction of wave propagation; oscillating water column; and overtopping.
- Locations are shoreline, nearshore and offshore.
- Types of power take-off include: hydraulic ram, elastomeric hose pump, pump-to-shore, hydroelectric turbine, air turbine, and linear electrical generator. Some of these designs incorporate parabolic reflectors as a means of increasing the wave energy at the point of capture. These capture systems use the rise and fall motion of waves to capture energy.

HISTORY

•The first known patent to use energy from ocean waves dates back to 1799
•A renewed interest in wave energy was motivated by the oil crisis in 1973
•Stephen Salter's 1974 invention became known as Salter's duck or nodding duck,
•The world's first commercial offshore wave energy facility began operating by the end of 2007 off the Atlantic coast of Portugal.





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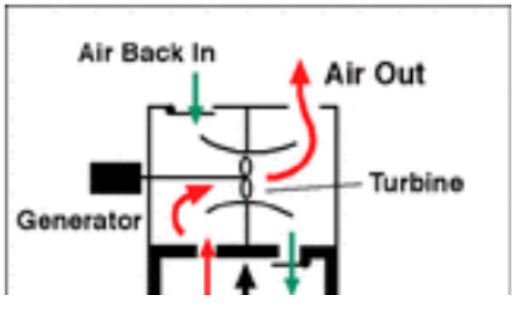

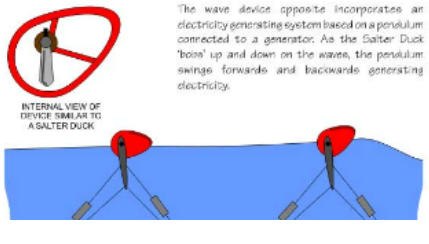

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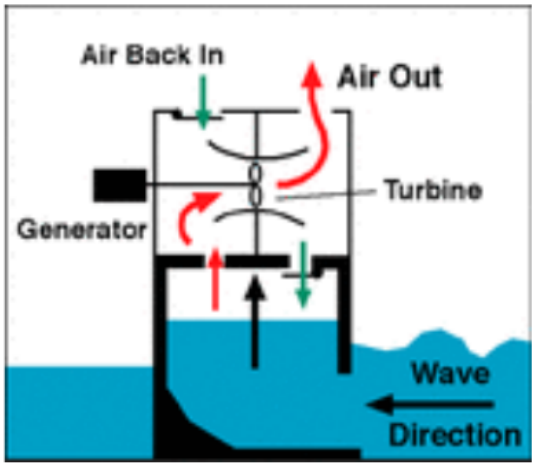
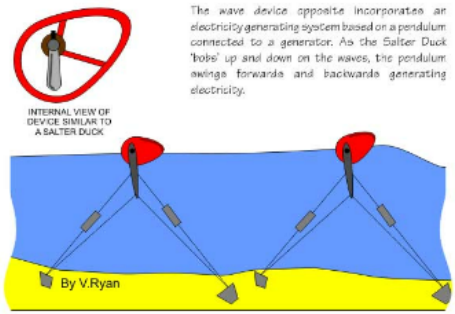
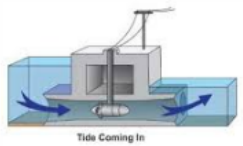
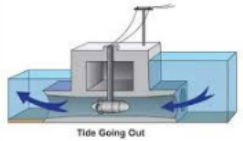




Tidal Energy

- Tidal Wave Energy includes tidal lagoons, tidal fences, and underwater tidal turbines.
- Harnessing tidal energy involves trapping water at high tide and then capturing its energy as it rushes out and drops in its change to low tide.
- Tidal power traditionally involves erecting a dam across the opening to a tidal basin. The dam includes a sluice that is opened to allow the tide to flow into the basin; the sluice is then closed, and as the sea level drops
- Environmental drawbacks
- In order for tidal energy to work well, you need an increase of at least 16 feet between low tide to high tide.
- Tidal turbines
  - can be placed offshore or in estuaries in strong tidal currents
  - Tidal turbines are deployed in underwater 'farms' in waters 60-120 feet deep with currents exceeding 5-6 mph.
- Cost effectiveness





HISTORY

- Tidal energy has been used since about the 11th Century, when small dams were built along ocean estuaries and small streams.
- La Rance Station in France
  - La Rance Station in France began making electricity in 1966.
  - 240 megawatts- power 240,000 homes.
  - It produces about one fifth of a regular nuclear or coal-fired power plant.
  - It is more than 10 times the power of the next largest tidal station in the world, the 17 megawatt Canadian Annapolis station.
- North American tidal turbine facility in New York's East River
  - Built in December 2006 by Verdant Power,
  - 1.05MW capacity
- Three projects (Swansea Bay 30 MW, Fifoots Point 30 MW, and North Wales 432 MW) are in development in Wales where tidal ranges are high, renewable source power is a strong public policy priority, and the electricity marketplace gives it a competitive edge.

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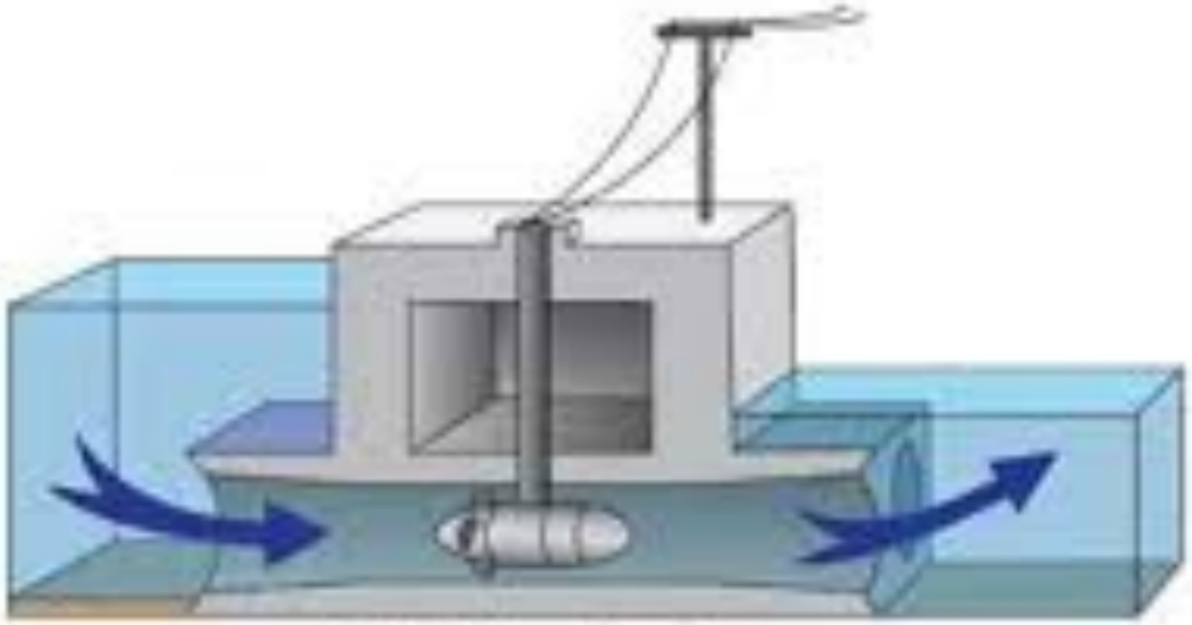
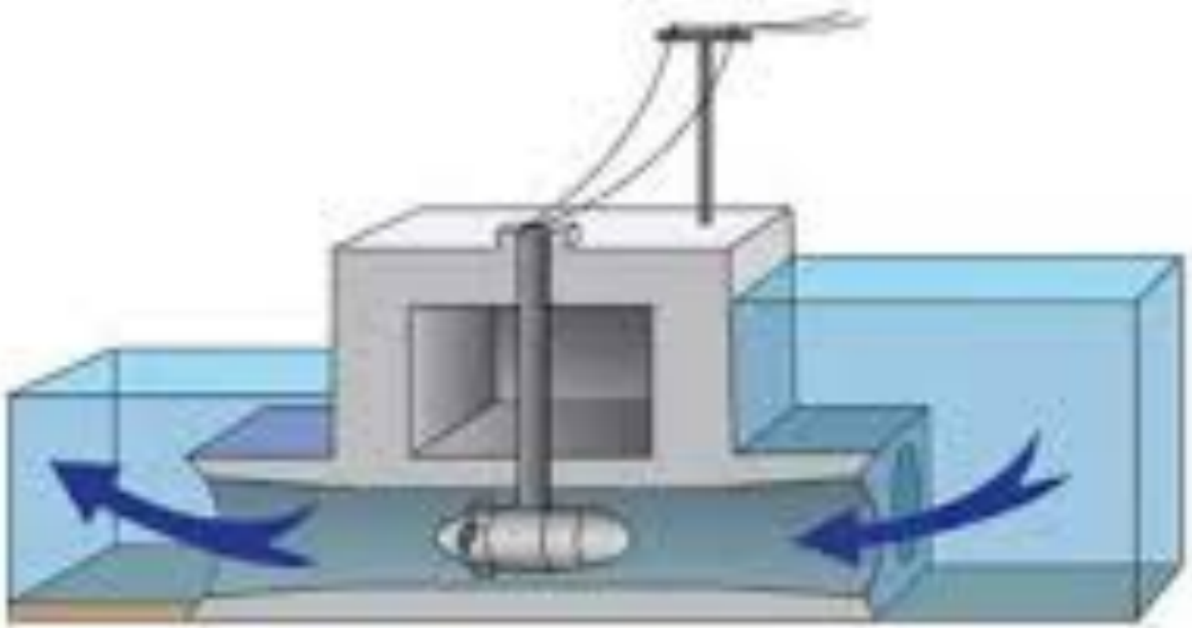


Tide Coming In



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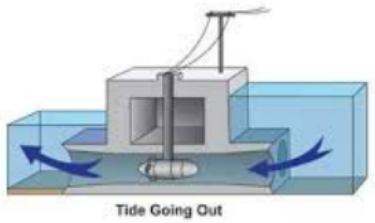

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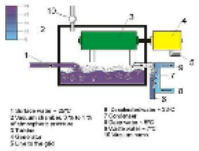
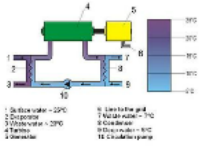
Ocean Thermal Energy

- Ocean Thermal Energy uses temperature differences in the ocean.
- An OTEC system uses temperature differences between deep and surface waters to extract energy from the flow of heat between the two.
- A difference of at least 38 degrees Fahrenheit is needed between the warmer surface water and the colder deep ocean water
- OTEC has the potential to offer global amounts of energy that are 10 to 100 times greater than other ocean energy options such as wave power.
- OTEC systems: closed-cycle, open-cycle, and hybrid.
  - Closed-cycle systems use fluid with a low boiling point to power a turbine to generate electricity.
  - Open-cycle OTEC uses warm surface water directly to make electricity.
  - A hybrid cycle combines the features of the closed- and open-cycle systems. In a hybrid, warm seawater enters a vacuum chamber and is flash-evaporated, similar to the open-cycle evaporation process.
- OTEC is used for air conditioning, desalinization, Chilled-soil agriculture, Aquaculture, Hydrogen production, and mineral extraction



Open-cycle



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History

Using the temperature of water to make energy actually dates back to 1881 with Jacques D'Arsonval.

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- The future

The main technical challenge of OTEC is to generate significant amounts of power efficiently from small temperature differences.
It is still considered an emerging technology.

- Early OTEC systems were 1 to 3 percent thermally efficient.
- , well below the theoretical maximum 6 and 7 percent for this temperature difference.
- For OTEC to be viable as a power source, the technology must have tax and subsidy treatment similar to competing energy sources.
- Because OTEC systems have not yet been widely deployed, cost estimates are uncertain.
- One study estimates power generation costs as low as US $0.07 per kilowatt-hour, compared with $0.05 - $0.07 for subsidized wind systems.

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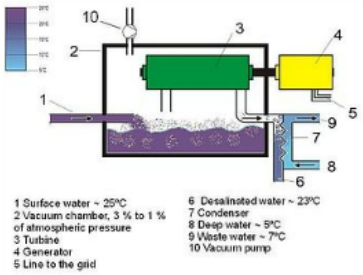

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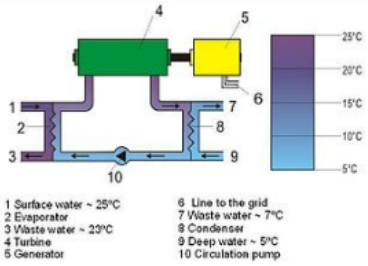

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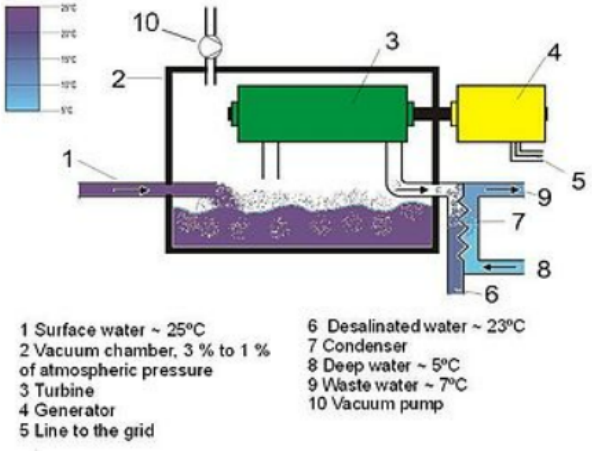

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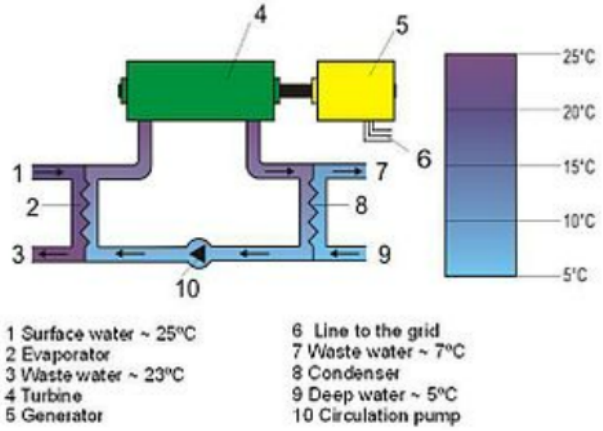

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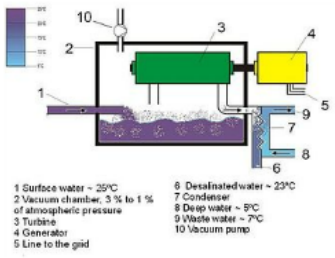

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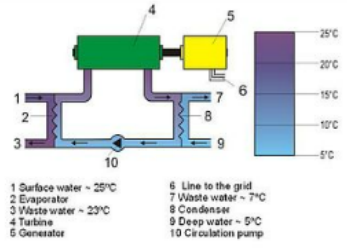

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- The tidal mills largely vanished once we had cheap steam engines.
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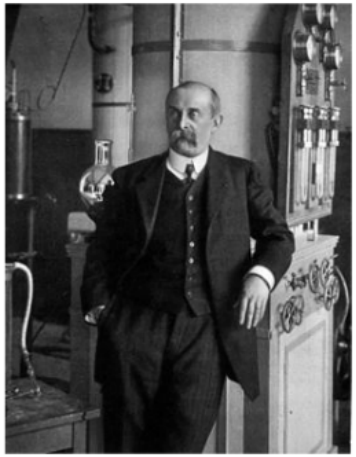
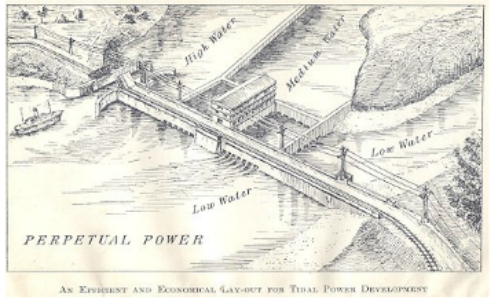
- D'Arsonval's student, Georges Claude, built the first OTEC plant, in Matanzas, Cuba in 1930.
- In 1935, Claude constructed a plant aboard a 10,000-ton cargo vessel moored off the coast of Brazil.
- In 1956, French scientists designed a 3 MW plant for Abidjan, Côte d'Ivoire.





An Efficient and Economical Lay-out for Tidal Power Development

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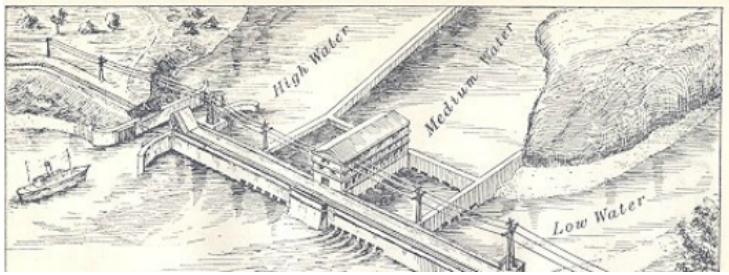

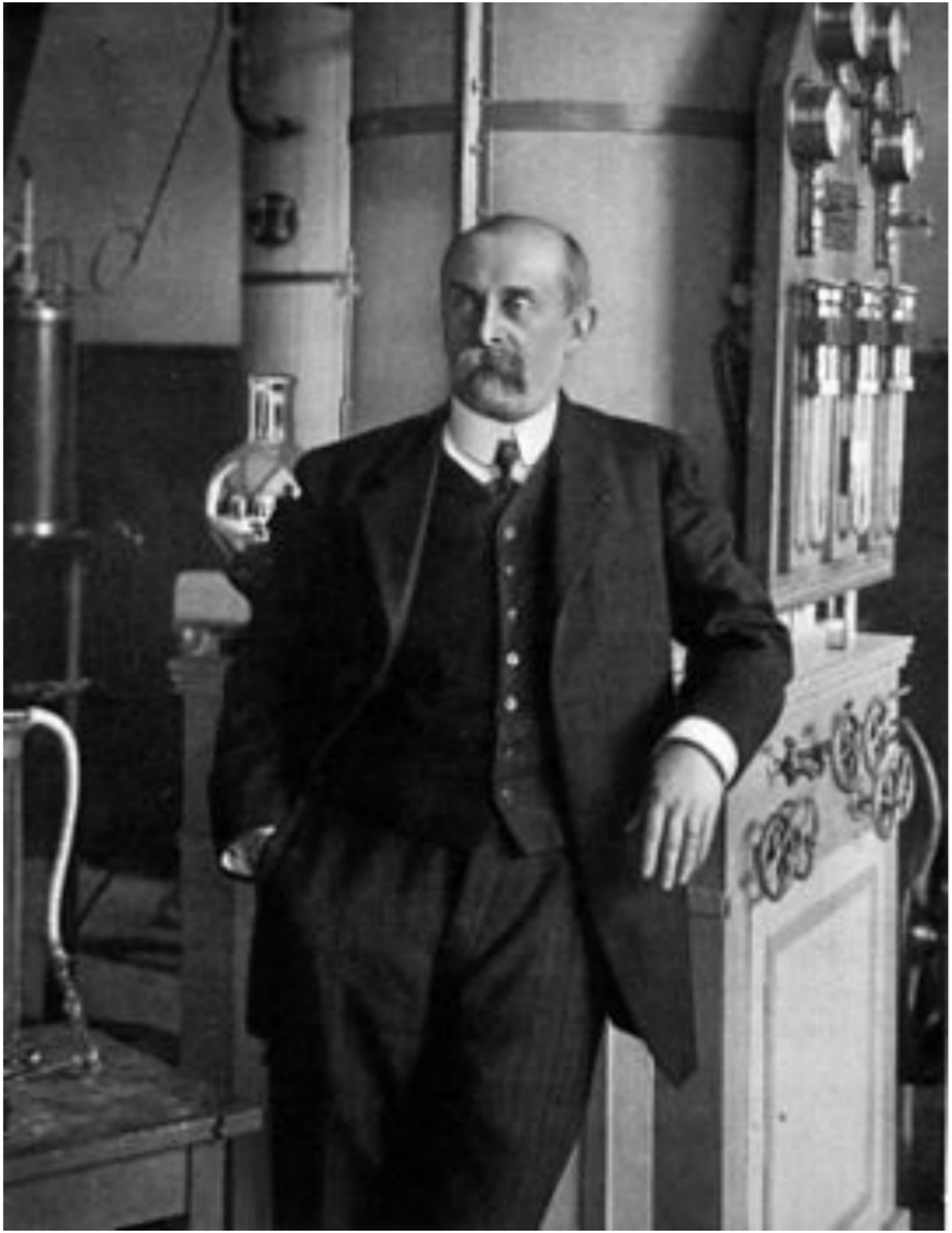

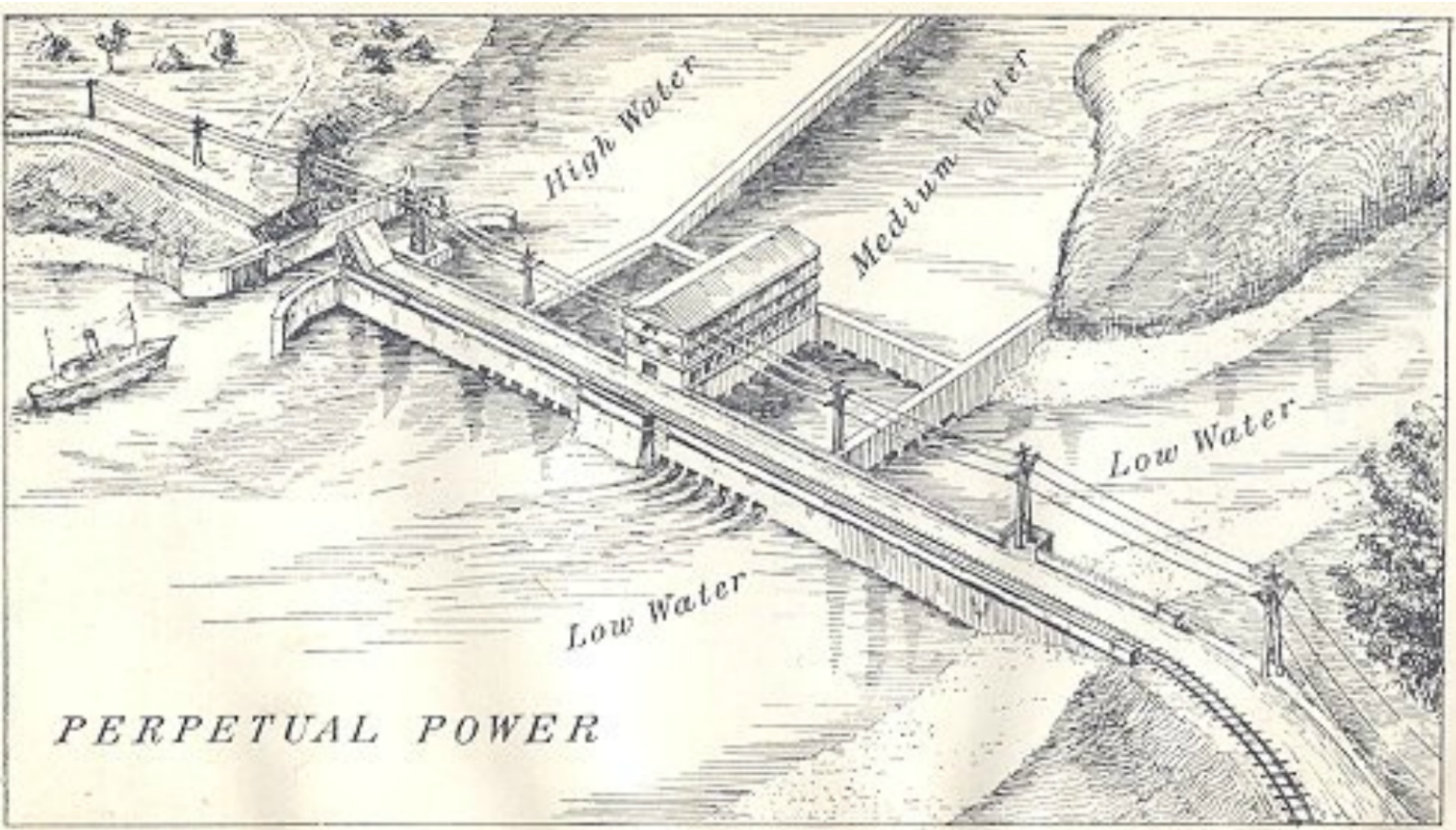

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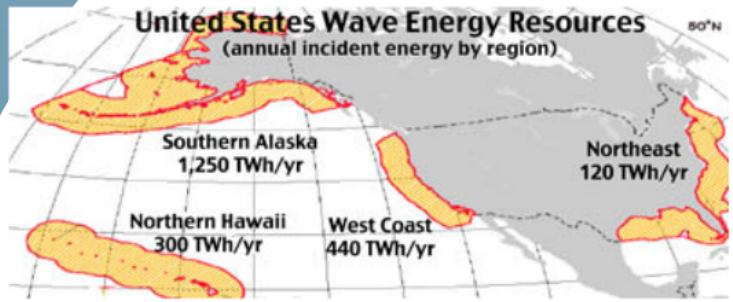
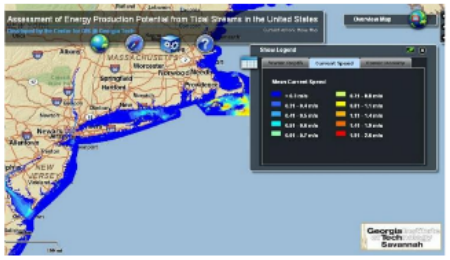
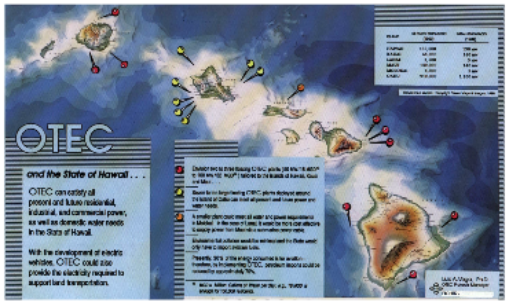
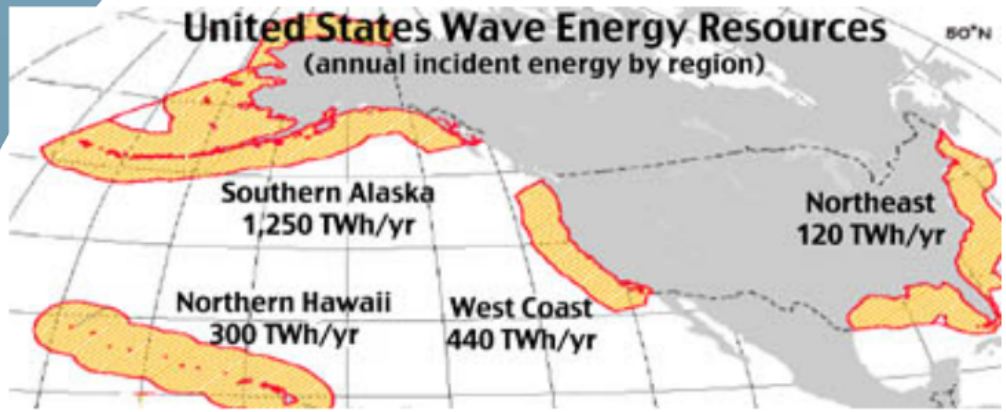




- The total world potential for ocean tidal power has been estimated at 64,000 MWe.
- The 25-30 ft tidal variations of Passamaquoddy Bay (Bay of Fundy) have the potential of between 800 to 14,000 MWe.Wave energy resources are best between 30º and 60º latitude in both hemispheres.The United States receives 2,100 terawatt-hours of incident wave energy along its coastlines each year.Britain has great tidal and wave energy potential
- OTEC in Hawaii
  - present and future residential, industrial and commercial power
  - domestic water needs.
  - electricity for land transportation with the development of electric cars



Distribution



- The total world potential for ocean tidal power has been estimated at 64,000 MWe.
- The 25-30 ft tidal variations of Passamaquoddy Bay (Bay of Fundy) have the potential of between 800 to 14,000 MWe.Wave energy resources are best between 30º and 60º latitude in both hemispheres.The United States receives 2,100 terawatt-hours of incident wave energy along its coastlines each year.Britain has great tidal and wave energy potential
- OTEC in Hawaii
  - present and future residential, industrial and commercial power
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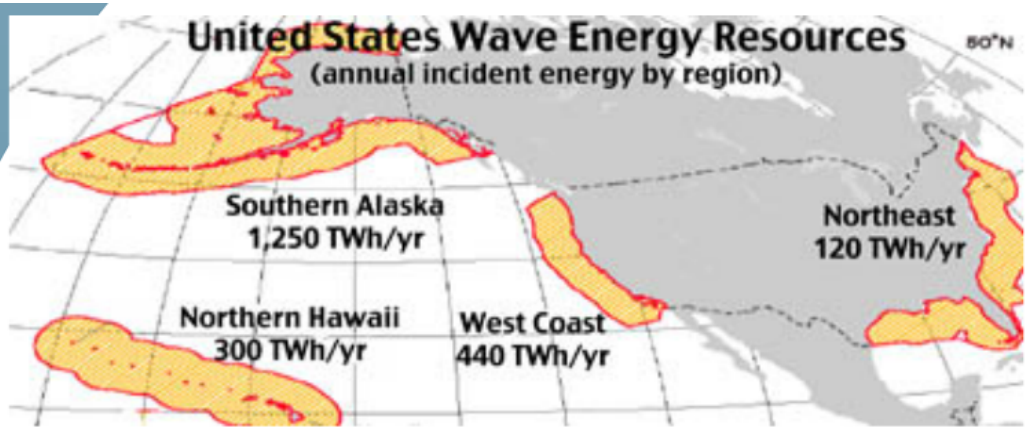
  - electricity for land transportation with the development of electric cars



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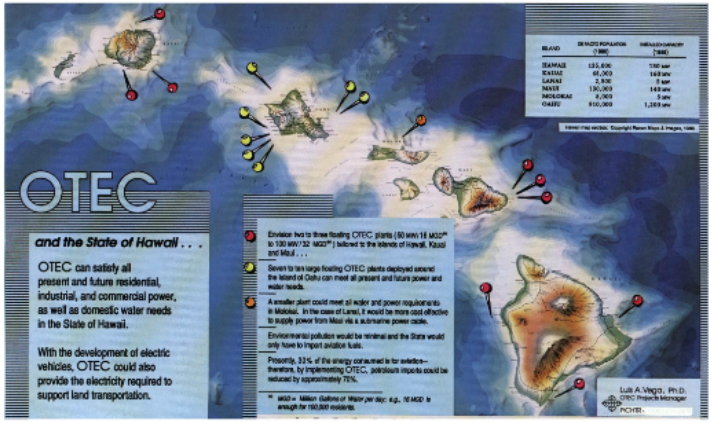
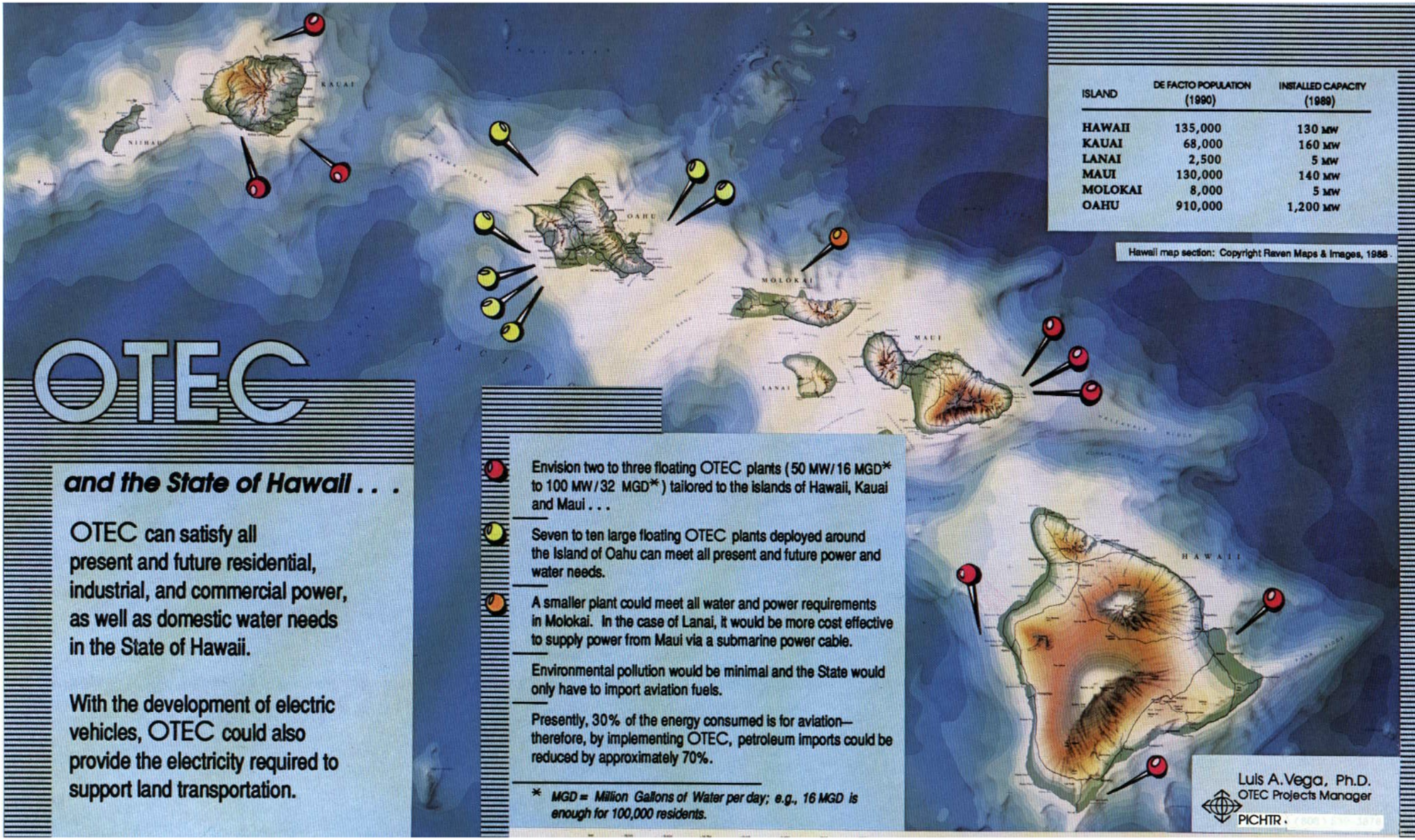
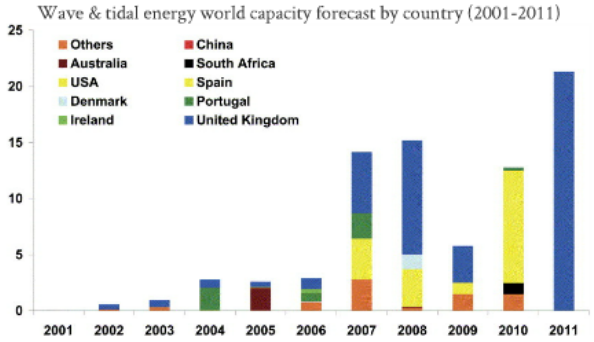


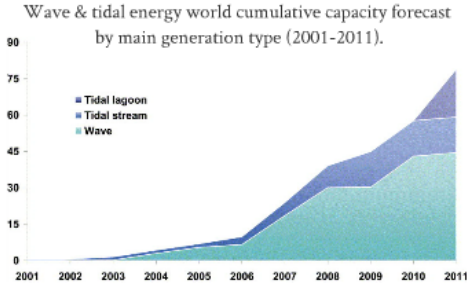
Transportation with the development



Current Use

- Ocean energy V.S. wind
- The United States receives 2,100 terawatt-hours of incident wave energy along its coastlines each year
- French engineers have noted that if the use of tidal power on a global level was brought to high enough levels, the Earth would slow its rotation by 24 hours every 2,000 years.
- Tidal energy systems can have environmental impacts on tidal basins because of reduced tidal flow and silt buildup.





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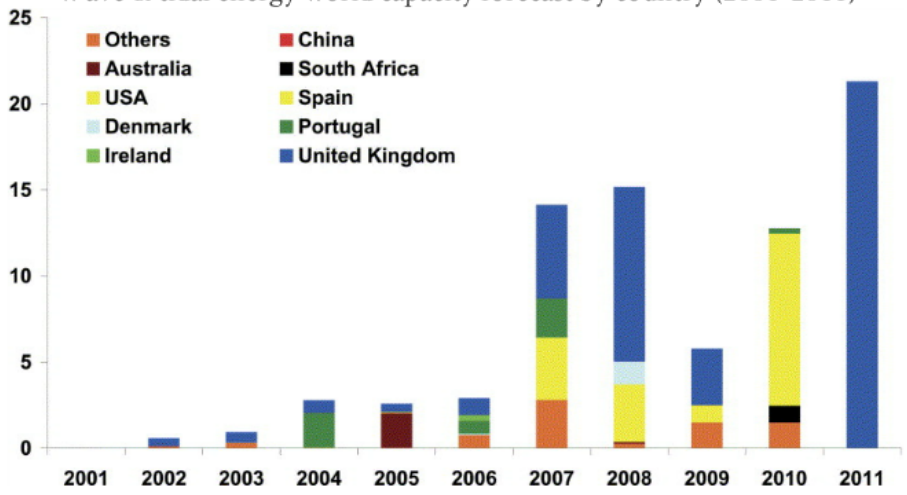
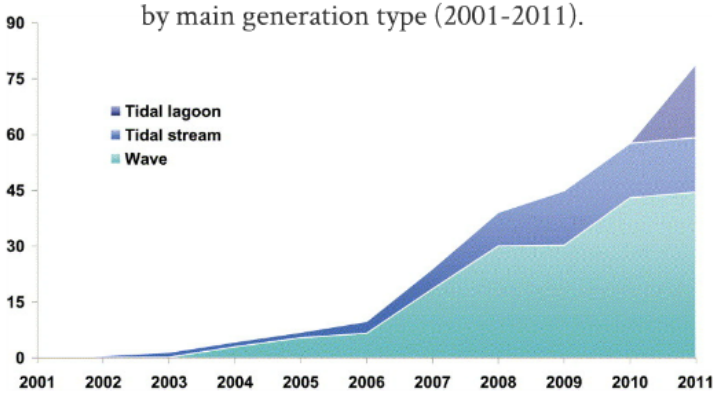
Wave & tidal energy world capacity forecast by country (2001-2011)



Wave & tidal energy world cumulative capacity forecast by main generation type (2001-2011).



Future Use

- Worldwide potential for wave and tidal power is enormous.
- Washington's Puget Sound has excellent tidal resources that could be developed
- It has been estimated that a barrage across the Severn River in western England could supply as much as 10% of the country's electricity needs (12 GW).
- India has an estimated 8,000 MW tidal power potential
- Several sites in the Bay of Fundy, Cook Inlet in Alaska, and the White Sea in Russia have been found to have the potential to generate large amounts of electricity.
- Oregon and Washington have the strongest wave energy resource in the lower 48 states and could eventually generate several thousand megawatts
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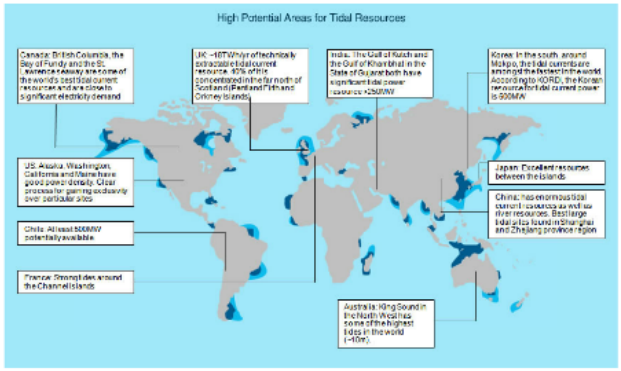

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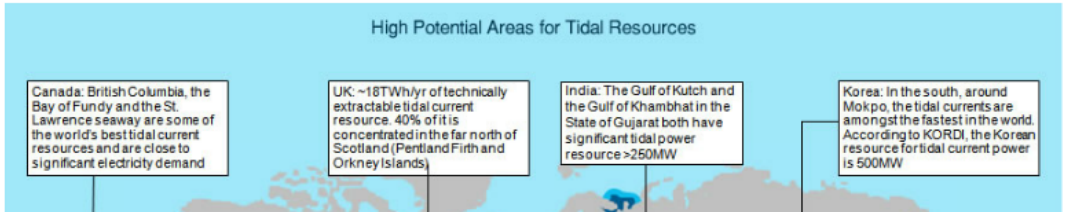

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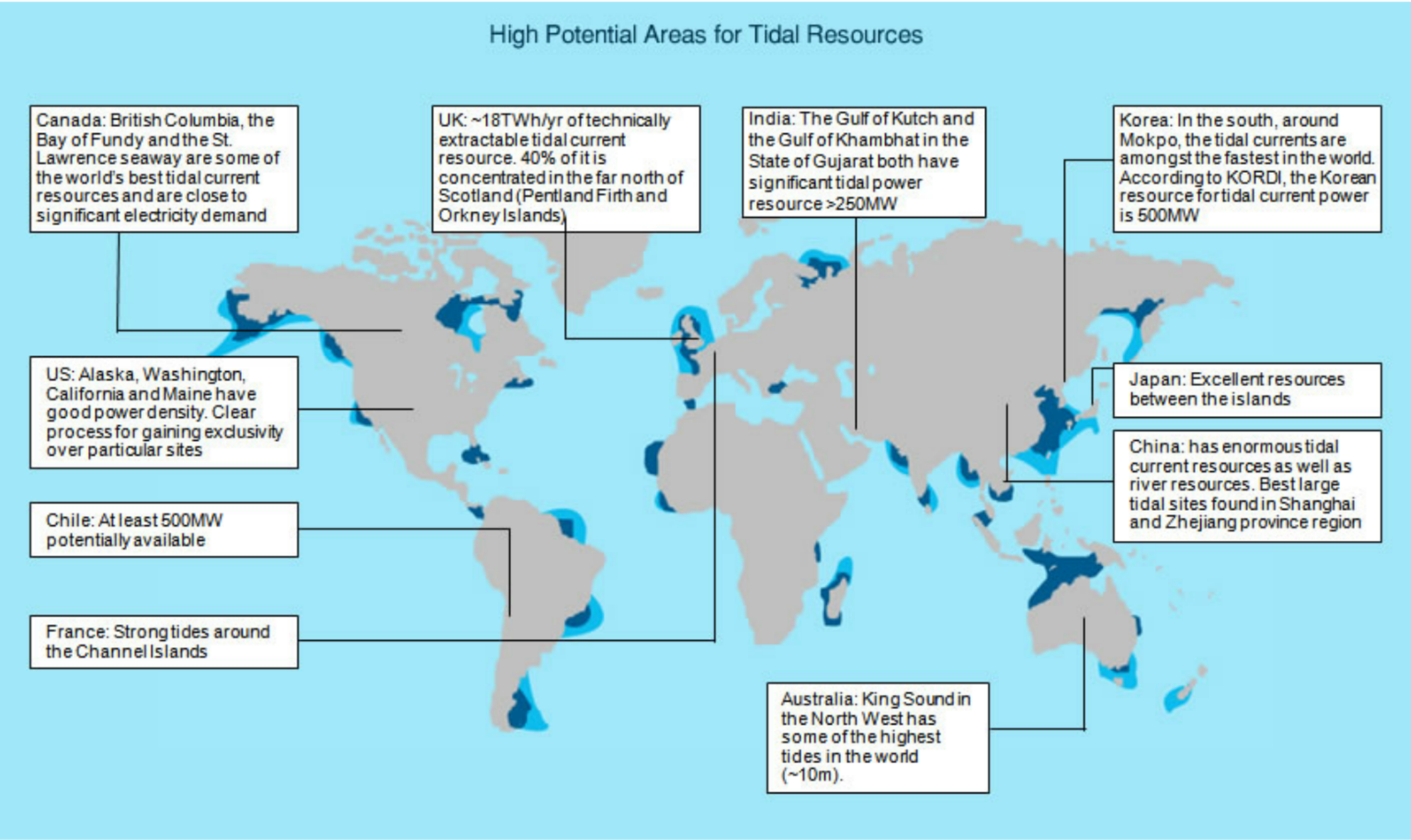

R & D

- Tidal power systems are potentially big and expensive.
- Poorly understood threats to ocean ecosystems.
- The technology
- Construction costs.
    - High capital cost for a tidal energy project, with possibly a 10-year construction period•
- Low capacity factor
- Peak demand times issues because of 12.5 hr cycle of the tides.
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Environmental Impact

- Wave and tidal energy facilities generate electricity without producing any pollutant emissions or greenhouse gases.
- Careful siting should minimize impacts on marine ecosystems, fishing and other coastal economic activities.
- Visual impact, as they are either submerged or do not rise very far above the waterline.
- Each specific site is different and the impacts depend greatly upon local geography.
- Local tides changed only slightly due to the La Rance barrage, and the environmental impact has been negligible, but this may not be the case for all other sites.
- It has been estimated that in the Bay of Fundy, tidal power plants could decrease local tides by 15 cm.
- The turbines can accidentally kill swimming sea life with the rotating blades.
- Some fish may no longer utilize the area if they were threatened with a constant rotating object.
- The Tethys database seeks to gather, organize and make available information on potential environmental effects of marine and hydrokinetic and offshore wind energy development.
- Mixing of deep ocean water with shallower water brings up nutrients and makes them available to shallow water life. This may be an advantage for aquaculture of commercially important species, but may also unbalance the ecological system around the power plant.

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Works Cited

- Bellis, Mary. "How Tidal Power Plants Work." About.com Inventors. About.com, 2013. Web. 15 Apr. 2013.
- California Energy Commission. "The Energy Story - Chapter 14: Ocean Energy." The Energy Story - Chapter 14: Ocean Energy. California Energy Commission, 2012. Web. 15 Apr. 2013.
- Dal Ferro, Benoit. "Wave and tidal energy: Its Emergence and the Challenges it Faces." Refocus, Volume 7, Issue 3, May–June 2006, Pages 46–48. http://dx.doi.org/10.1016/S1471-0846(06)70574-1
- Ocean Energy Council, Inc. "Tidal Energy | Pros for Wave and Tidal Power." Tidal Energy | Pros for Wave and Tidal Power. Ocean Energy Council, Inc., 2012. Web. 15 Apr. 2013.
- Renewable Energy Fact Sheet, Environmental and Energy Study Institute, (May 2006).
- Renewable Northwest Project. "Wave & Tidal Energy Technology | Renewable Northwest Project." Wave & Tidal Energy Technology | Renewable Northwest Project. Renewable Northwest Project, 4 Apr. 2007. Web. 10 Apr. 2013.
- U.S. Department of Energy. "Ocean Thermal Energy Conversion." Energy Basics:. US DOE, 12 Aug. 2011. Web. 15 Apr. 2013.
- Wikipedia. "Tidal Power." Wikipedia. Wikimedia Foundation, 13 Apr. 2013. Web. 15 Apr. 2013.
- Wikipedia. "Ocean Thermal Energy Conversion." Wikipedia. Wikimedia Foundation, 14 Apr. 2013. Web. 15 Apr. 2013.

Questions??