Renewable ocean energy systems becoming more viable

First commercial-scale wave power facility in operation.

More than $200 billion in planned investment worldwide.

Harnessing offshore winds more feasible.

By Anthony T. Jones
Special report

International efforts to reduce fossil fuel emissions have sparked renewed interest in the development of renewable ocean energy systems. Near-shore ocean processes have tremendous potential, boosted by changing worldwide government policies that increasingly focus on alternative energy systems.

Wind farms are another promising technology for offshore energy production, and many offshore wind farms currently are under construction or in the planning stage.

In 1992, the United Nations Framework Convention on Climate Change committed countries to reduce emissions of carbon dioxide and other greenhouse gases to their 1990 levels. Although the United States, among others, has not ratified this approach, the international community is actively engaged in developing renewable energy strategies, including development of offshore resources within their economic zones. In the past 10 years, several developments have demonstrated the potential of the ocean as a source of renewable energy.

Wave power technologies

The first commercial-scale wave power station recently began delivering power to the national grid in Scotland. Due to research and redesign of existing systems, the cost of wave power has declined dramatically over the past 10 years. Several promising projects in tidal power are in the demonstration phase. The focus for tidal power has shifted from estuary barrage systems toward capturing tidal-generated coastal currents.

Development of systems to capture the motion of surface waves has reached a milestone with the commissioning of WaveGen (UK) Limpet, the first commercial-scale power facility. Located on the Isle of Islay in Scotland, WaveGen signed a 20-year power purchase agreement with Scottish Power. (See "Surf's up! Tapping into the renewable power of ocean waves," *Energy Insight, Dec. 13, 2000.*)

Japan Marine Science and Technology Center (JAMSTEC) invested heavily in an experimental wave platform. Dubbed the Mighty Whale, the floating, 50-meter-long, 1,000-ton wave-energy converter produced 110 kW.

JAMSTEC wave energy costs, at about 28 cents/kWh, would provide competitively priced energy for remote communities, environmentally sensitive areas and offshore facilities. As an experimental platform, the cost could be further optimized.

Looking globally, if development programs continue as planned, wave power could exceed 2 TWh/year, according to Tom Thorpe, consultant to the European Thematic Network on Wave Energy. This represents more than $200 billion in planned investment. Dominant technologies include tapering channels, heaving buoys and tidal power.

First developed by Even Mehlum, a Norwegian inventor, tapering channels funnel waves into natural or artificial channels. The water rises and spills into an elevated reservoir, which then flows back to sea through a turbine. Operating systems are in place in Norway and on the island of Java.

Energetech of Australia has combined the tapered channel idea with an oscillating water column in its design of a parabolic wave reflector to concentrate and amplify wave energy. Tests of its system at the University of New South Wales, using a 1:25 scale model, demonstrated the successful design-wave heights were enhanced by two to four times. The predicted power cost is 28 cents/kWh, although the company anticipates its second-generation design could achieve costs in the neighborhood of 10 cents/kWh. A demonstration facility is planned for Port Kembla, Australia.

Heaving buoy technology relies on capturing the energy of an ocean wave with a buoy. While variations exist, essentially heaving buoys use a device that converts the orbital motion of surface waves into electricity using an absorber system. Sea Power & Associates, of Berkeley, Calif., has designed a buoy that is connected to a highly efficient hydraulic pump to generate electricity.

A shift in development focus

Developments in tidal power have taken a paradigm shift. Historically, river estuaries with extreme tidal range were favored as sites for barrier systems to capture the tidal flow and release water during the ebb. Major projects include the Rance River in France, which began producing 240 MW in 1966, and Anapolis, Nova Scotia, which began operating in 1984 to harness 20 MW from the tides of the Bay of Fundy.

Plans for other river estuaries, such as the Severn Estuary in the United Kingdom, are in the planning stages, but are not economically feasible at this time. Because of limited sites with significant tidal range to warrant investing in tidal barrage systems, developers have shifted their focus and now are looking to capture power from tidal-generated coastal currents.

Blue Energy Canada, of Vancouver, British Columbia, designed a tidal fence using a slow-moving vertical turbine. With accessible generator components above the sea surface, maintenance costs are reduced. Another advantage is the system allows fish and silt to move through the system. Demonstration sites are located in the Philippines and British Columbia.

Offshore wind systems

Denmark is leading the effort in northern Europe to harness offshore winds. The first offshore wind farm was constructed in 1991 on a shallow bank a mile off the Port of Vineby. Several small-scale projects followed and a number of commercial wind farms are currently under construction.

By 2008, wind farms are expected to supply 8% of Denmark's electricity. The country also is pushing for 3,300 MW to go on-line by 2030, which would supply 50% of its needs. Conservative estimates peg power costs at about 5 cents/kWh.

Last year, the United Kingdom officially opened its first offshore wind farm, a $10 million project in Northumberland. Located 1 kilometer (about six-tenths of a mile) off the coast where wind speeds can reach 160 kilometers per hour, two 2-MW turbines were installed, with several smaller turbines installed closer to shore. The government is aggressively looking toward developing this technology and expertise for the domestic market and for export.

Meanwhile, feasibility studies for Irish offshore wind energy estimate that nearly a third of the Irish energy demand by 2005 could be met with offshore wind turbines.

In northern Europe, land sites are in short supply, while higher, more stable, wind speeds are available offshore. In the ocean, there is a low surface roughness, so wind speeds do not vary significantly with distance above the water's surface. This is believed to lead to less stress on turbines and longer lifetimes. The engineering challenge lies in creating a foundation for the turbine platform and reducing development costs.

Looking toward the future

The biggest problem in developing renewable ocean energy is obtaining the necessary capital to prove the technology. Most systems require significant amounts of funding to establish their energy efficiency conversion and to ensure reliable delivery of electricity at a unit cost target below 10 cents/kWh.

However, various international efforts focused on climate change have led to a flurry of activities in national and international policies and regulations, including national ceilings on emissions, energy taxes and subsidies for renewable energy, cogeneration targets, energy efficiency agreements and development of "green" certificates. These changes, along with public-private partnerships, tax reform, financing and improved government cooperation, have led to increased activity in alternative energy development.

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