Our Ocean Backyard — *Santa Cruz Sentinel* columns by Gary Griggs, Director, Institute of Marine Sciences, UC Santa Cruz.

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OTEC and offshore wind

Offshore wind farms are now common in Europe and several are under development off Massachusetts and Texas.

Ocean energy has received a lot of space recently, and from the comments posted on-line and emails I've received, it's reassuring to find that people are reading the columns, and to discover their interest and concerns. It's time to move on to other ocean issues but there are two other sources of ocean related energy that I want to cover.

One is Ocean Thermal Energy Conversion (OTEC), a concept that has been around for over a century, but never successfully developed on a commercial scale. It sounds a lot like OPEC, but is clearly worlds apart. The oceans cover 71% of the

Earth's surface and are heated daily by the sun, so there is a vast amount of solar energy stored in warm surface waters. The challenge is how to extract it economically. OTEC generates electricity by taking advantage of the temperature difference between the warm surface water and cold water at depth. As in any heat engine, the greatest efficiency is obtained when the temperature differences are the greatest. Differences of at least 20 degrees Celsius (36 degrees Fahrenheit) are common in tropical latitudes such as Hawaii. However, the relatively small temperature difference means that large flows of both warm and cold water are required.

In a closed OTEC cycle, the warm surface water runs through a heat exchanger to vaporize the working fluid, and the vapor runs through a turbine to generate electricity. The required cold water is brought from the depths up to the surface through the Cold Water Pipe (CWP), and it condenses the working fluid back to liquid. A practical CWP is one of the two key technologies required to commercialize OTEC, and is a huge component, being about 33 feet in diameter and twice as tall as the Empire State Building.

Lockheed Martin is using modern fiberglass and low-cost composite material manufacturing methods to develop a cost-effective, reliable CWP. Workers at their nearby Palo Alto/Sunnyvale location recently completed an initial small-scale "Proof-of-Principle" demonstration of the new fabrication process, and the company recently received a $1.2 million grant from the U.S. Department of Energy to demonstrate it at large scale. OTEC could enable Hawaii to achieve energy independence, ending its almost total reliance on expensive imported oil.

Wind power has been growing at a pace comparable to solar power with the worldwide capacity increasing at 32%/year, on average, for the past decade. Generation costs have fallen by 50% over the past 15 years and modern wind turbines have improved dramatically in their efficiency and reliability. Over 70 countries around the world are now using wind power, with the U.S. in the lead with 21,000 MW of existing capacity (enough to power nearly 17 million homes), and an additional 8,600 MW under construction. California is 2nd behind Texas in wind energy development with 2,500 MW of existing capacity. The growth of new wind farms has been spurred by a modest tax credit, but one that Congress has repeatedly threatened to eliminate, which has slowed investment.
While we usually think of wind turbines on hillsides such as Altamont Pass on the way to Stockton, wind farms can also be sited offshore, which are typically closer to coastal population centers. Depending upon water depths, different foundation systems are required, including floating platforms at greater depths. One of the

largest offshore areas in the U.S. with shallow water is off Cape Cod, where a major wind farm proposal 12 miles offshore is moving forward, despite some local opposition. While local concerns about how wind turbines might affect offshore views may have some merit, they must be balanced against the social costs of other forms of electrical power generation.

Wind turbines can also be built farther offshore in deeper water, although foundation costs increase with greater water depth, and costs of connecting with existing power grids increase with distance offshore. Still, there are advantages to siting wind farms further offshore. Wind speeds tend to be higher and the wind is steadier, which means more energy is available.

A recent study of the offshore wind energy potential along California's coast using existing technologies indicates we have the potential to provide 26 to 112% of the state's total electrical needs, depending upon the height of the wind turbines and wind velocities utilized. This may be our best near-term, renewable ocean energy opportunity.