Marine Energy

Highlights

■ **PROCESS AND TECHNOLOGY STATUS –** Ocean energy encompasses a number of very different technologies that exploit a diverse range of marine energy sources including: ■ Wind-driven waves; ■ Tidal ranges (tidal barrage); ■ Tidal stream (marine currents); ■ Marine salinity gradients; and ■ Thermal gradients between warm surface water and deep (> 1000 m) cold water (also called ocean thermal energy conversion, OTEC)

■ **COSTS –** Most marine energy technologies are in an early stage of development, under demonstration, or have a limited number of applications and commercial installations. As a consequence, their performance and costs vary significantly, depending on technology options, sites and local resource conditions. The investment cost of tidal stream power is currently between \$6,000 and \$7,800/kW$_e$ (US\$ 2008), and is projected to decline to \$5,000/kW$_e$ by 2020, and to \$4,100/kW$_e$ by 2030 as a result of technology learning and larger deployment. The investment cost of wave power is between \$6,800 and \$9,000/kW$_e$ and it is expected to be reduced to \$5,700/kW$_e$ by 2020 and to \$4,700/kW$_e$ by 2030.

■ **POTENTIAL & BARRIERS –** In principle, the potential of marine energy is huge, but the economic potential is much more modest due to current high technology costs. Because of insufficient experience and demonstration, there is a lack of information and understanding regarding performance, lifetime, operation and maintenance of technologies and power plants. For example, the impact of the aggressive marine environment on materials and components, and the consequence on plant lifetime must be established. Significant research investment is still needed as well as government support for market deployment. Policy incentives such as feed-in tariffs may help initial deployment and cost reductions of these technologies by providing improved market certainty.

PROCESS AND TECHNOLOGY STATUS – Ocean (marine) energy includes a diverse range of energy resources and a number of technologies. The energy resources include: ■ Wind-driven waves; ■ Tidal ranges (tidal-range barrage); ■ Tidal stream (marine currents); ■ Ocean thermal energy (conversion), OTEC; and ■ Salinity gradients. Technologies to exploit OTEC and salinity gradients are not addressed in this overview as they presently have a lower level of R&D focus worldwide. Most ocean energy technologies consist of new concepts under demonstration. Power generation from tidal-range barrages is the most known and proven marine technology that has been working reliably in a small number of power plants with a combined capacity of about 500 MW$_e$ (including the 254-MW$_e$ Sihwa tidal barrage in South Korea). Marine wave and tidal stream technologies are in a stage of development similar to that of the wind industry in the 1980s, and commercial systems could become available between 2015 and 2025 (SEI, 2005).

■ **Wave power** - Wave power generation is based on the exploitation of the wind-driven wave energy. The best wave conditions for wave power are found at higher latitudes (away from the equator), with typical conditions of a deepwater power density of 60–70 kW/m of wave crest length declining to 20 kW/m near the shore (Figure 1). About 2% of the world's 800,000 km of coastline exceeds a power density of 30 kW/m, with a technical potential of about 500 GW$_e$ based on a conversion efficiency of 40%. The United States alone holds a technical potential of approximately 100 GW$_e$ (PG&E, 2009), the United Kingdom has an estimated

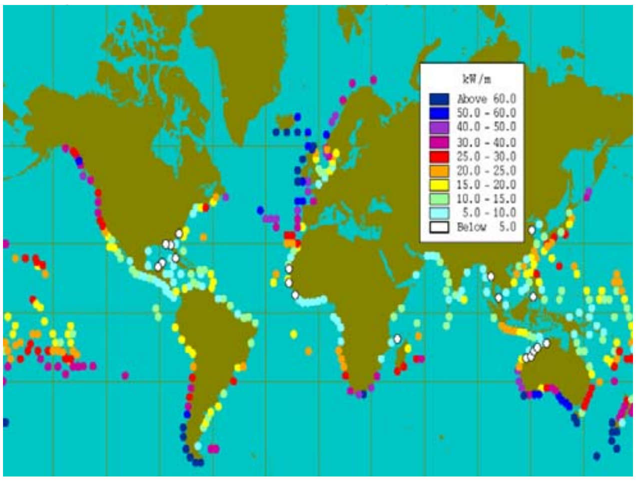

Fig 1 - Global Wave Energy Flux Distribution (Hagerman, 2005)

potential may be well below the technical potential (IPCC, 2007). There is a variety of wave energy technologies, resulting from the different ways in which energy can be absorbed from the waves, and depending on plant location (shoreline, near-shore, offshore) and water depth. A recent review (Falcão, 2008) identified about 100 projects with various working principles and different levels of development. On the basis of the working principle wave energy projects can be grouped as: **a) Oscillating Water Column** (OWC) systems, which use a pneumatic chamber and air turbines (Figure 2), and include onshore plants (e.g. Pico Plant in Azores, www.pico-owc.net and Limpet), near-shore plants (e.g. Mutriku,

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