

## OCEAN ENERGY

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### Summary

The oceans cover more than 70% of Earth's surface. They contain a major portion of our untapped resources, including land space, water resources, food, energy and raw materials. The oceans have a high heat capacity to absorb and retain the solar radiation from the sun, so they are the Earth's greatest heat reservoirs. The incident solar energy is stored either directly or indirectly in various forms within the ocean system. Specifically, this solar radiation is stored directly in the form of thermal heat created by the temperature differences between surface and deep ocean waters, and indirectly as wind, waves, and currents.

The study of temperature gradients with depth in the oceans has led to many experimental schemes for exploiting solar energy via solar pond or farms where solar energy can be stored and then extracted using simple thermodynamic principles, called ocean thermal energy conversion (OTEC) technology. Many such model schemes have proved successful, and this model for solar energy utilization perhaps shows the best promise for future commercial development.

Tidal power is at present restricted to locations where there is sufficient tidal amplitude (water head) to operate turbines economically on tidal flow and ebb. Wave power holds better promise for a truly cosmopolitan exploitation of the movement of water as an energy source. The energy bound up in the movement of a single small wave front in the open sea is very large, but the restrictions are mechanical ones, for it has to be proved that an efficient mechanical device can be designed and constructed to withstand the battering of waves during storm. At the time being, the highly-developed ocean energy systems are ocean thermal energy conversion and tidal, wave and wind energy. The less-developed ocean thermal energy technologies are ocean current turbines and salinity gradient devices.

## 1. Introduction

The world depends on vast quantities of energy in order to maintain its higher standards of living and industrial progress. The main final use of energy is in the industrial sector where 37% of all energy occurs, while transportation accounts for 33%, and the domestic/commercial/agricultural sectors 30%. At present, the main source of energy is the combustion of fossil fuels, followed by nuclear power. Today, fossil fuel and nuclear power comprise over 90% of the total power produced, with the balance of 10% mainly from hydropower and solar-derived energy. World energy consumption is expected to increase by 50% or 60% by 2010, and the global mix use of fuels is to remain substantially the same as today.

Producing electricity is the main use of the primary fuels - accounts for one third of the world's total energy input. The main fuels used are coal (about 29%), oil (about 26%), hydro (about 22%), gas (about 13%) and nuclear (about 10%). In the near future, coal, gas and nuclear will be the three leading fuels for electricity generation.

It has been calculated that burning one ton of carbon in fossil fuels gives rise to more than 3.5 tons of carbon dioxide. Moreover, a global release of 1.6 to 3.5 Giga-tons of carbon as CO<sub>2</sub> per year would result in a safe rate of warming of the order of 0.05°C a decade. In addition, the combustion of fossil fuels, especially coal, accounts for more than 80% of SO<sub>2</sub> and most of the NO<sub>x</sub> released into the atmosphere. Therefore, technologies are now being developed for a long way toward alleviating the regional-scale environmental deterioration associated with fossil-fuel combustion: acid rain and urban smog. Solutions are also being sought for a third and potentially more devastating disturbance: increased global warming caused by rising levels of carbon dioxide and other green house gases in the atmosphere.

As for nuclear power, the public is concerned about the risk of accidents such as Three Mile Island in the United States and Chernobyl in Russia, and the controversies about the safe storage of nuclear waste and spent fuel.

When viewing the world's future energy supply and demand outlook, there is need to exploit alternative energy in order to sustain and further develop the activities of humankind. It is in this sense that attention has come to be focused and high expectations come to be placed on ocean energy because the ocean provides a vast energy resource capable, theoretically, of meeting all our demands if only we can find effective ways to extract it.

Ocean energy is an inexhaustible, non-polluting source that has great potential as an alternative energy source for the future. It requires no fuel cost. Thus, a rise in fuel cost or inflation is not an affecting factor.

The oceans are the world's largest solar energy collector and storage system. The sun's radiant energy at the outer layer of the Earth's atmosphere amounts to a magnitude of 1,353 kw/m<sup>2</sup>, this is called the solar constant. Multiplying the solar constant by the cross-sectional area of the earth results in 173 x 10<sup>12</sup> kw, a value which represents the gross amount of solar energy capable of reaching the earth. Approximately 30% of

this solar energy returns to space because of scatter in the atmosphere and reflection due to clouds and the surfaces of land and ocean. The remaining 70% is absorbed within the atmosphere and converted to other energy forms. The final energy forms may be roughly grouped into kinetic energy such as wind, waves, ocean currents and heat energy stored in the atmosphere, the land mass and the surface layer of the ocean. The former type of energy comprises 23% of the total solar energy, and is deemed as inputs for the electricity generation of wave, ocean current or salinity gradient. The latter type, or heat forms, comprises 47%. Being accumulated energy, the heat energy stored in the ocean is relatively stable among the natural energy forms, and considered to be the world's largest solar energy. If less than one-tenth of one percent of this stored energy could be converted into electric power, it would supply more than 10 times the total amount of electricity consumed in the world on any given day (Vadus, 1999).

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### **Biographical Sketch**

**Kuo-Liang Pan** holds a Bachelor of Science degree from the National Cheng Kung University in Tainan, Taiwan, as well as a Ph. D. conferred by the University of Iowa, Iowa City, U.S.A. He is now the adjunct professor of both Cheng Kung University and Central University at Chung Li. Dr. Pan enjoys a successful career in the field of geotechnical engineering, during which he has been engaged both in research and in consulting. Dr. Pan was with Industrial Technology Research Institute in 1979-1994, where he was the director of Resources Technology Division of the Energy and Resources Laboratories. He received an Award for Technical Innovation in 1982, which was followed two years later by a Distinguished Achievement Award. He was proud to be a coordinator for Oceanology International Conference in 1994. His past positions and responsibilities also include that of a Researcher for the Science and Technology Advisory Group of the Executive Yuan (the Cabinet). Dr. Pan, as senior

vice-present, was involved with Moh and Associates, Inc. in 1994-1999, and then he became senior advisor to the Water Resource Bureau in 1999-2001. A Fellow of the Geological Society of America, Dr. Pan has also been the members of the International Association of Engineering Geology, the International Association of Hydrogeologists, GEO-Institute, the Scientific Research Society of Sigma Xi, and others. He is a council member of the Geological Society of China. Dr. Pan is the author of 4 technical books, mainly on slopeland development and geologic hazards.

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