



Energy Harvesting Systems

OCEAN THERMAL ENERGY CONVERSION (OTEC)

INTRODUCTION

The concept of OTEC was originally introduced in 1881 by a French Scientist Arsene D'Arsonval in Paris. According to D'Arsonval, if you take a liquid with low boiling point such as liquid ammonia and use the warm tropical sea surface water (24°C) to boil the ammonia, the change from a liquid to gas would involve a significant volumetric increase of at least 600:1. This great increase in volume in a confined chamber will create pressurized flow that turns a turbine to generate electric power. When you then take the deep cold water from the ocean at about 1,000 m depth at 4°C to cool the vaporized ammonia, it will return the ammonia gas back to its original liquid form. The cycle is then repeated again with the warm sea surface water boiling and evaporating ammonia to generate more power, etc. This can go on 24 hours a day, year after year, with virtually no workers in attendance or fuel required and involves very little maintenance.

In 1979, our company structurally modified a steel barge on loan from the U.S. Navy to serve as a floating platform to support OTEC facilities off the southern coast of the island of Hawaii. This facility known as MINI OTEC performed a major breakthrough in proving the D'Arsonval Theory by generating 50 KW of electric power while using 40 of the 50 KW generated to operate the system resulting in a net 10 KW output. Dr. Hans Krock, a retired Professor of Ocean Engineering at the University of Hawaii, played a scientific role in these and subsequent studies, and, together with Yee Precast Design Group Ltd. (YPDG), have entered into a strategic relationship to jointly pursue ocean thermal engineering projects. YPDG's role is to design and supervise the construction of ocean platforms required to support the OTEC facility.

This OTEC cycle operates in tropical seas where water depths exceed 1,000 meters and a 20°C or more differential temperature exists between the warm sea surface and the cold deep sea water. In the tropical zone between Tropic of Cancer and Tropic of Capricorn girdling the earth along the equator, the sea water warmed by the sun's rays daily absorbs about 10,000 times the energy consumed by all of mankind in that same 24-hour period. The cold water originates from the Arctic and Antarctic, and because of its cold temperature, it is heavier than the warm water so the cold water sits low along the bottom of the sea.

The areas of the equatorial belt that are deep and cold enough (1,000 m) generally involve a minimum of 20°C+ temperature differential between sea surface and sea bottom and provide a sufficient environment to operate an OTEC facility. The warm sea surface and deep cold water has been there for millions of years and all of this potential energy has remained virtually untapped.

OTEC is the only source of energy that is virtually limitless and sustainable and large enough to replace fossil fuels. The operation of OTEC involves no emissions to our atmosphere. With the energy produced by OTEC we can manufacture hydrogen and oxygen by separating the H₂ from the O in seawater by electrolysis. The H₂ and O can then be liquefied, transported in cryogenic tankers to various destinations for use in space programs, fuel cell cars, industrial manufacturing, power generation, etc. The virtues of the fuel cell cars are well known as these will result in a major reduction in emissions of CO₂, NO_x, CO, etc., into our atmosphere, thus assist in mitigating the impending global warming catastrophe.

With the OTEC process, fresh water can be produced from the seawater by using the generated electric power. The electric power can be used to operate the reverse osmosis desalination process. If we were to substitute seawater for liquid ammonia in the OTEC process (open cycle method) we can vaporize the seawater by simply inducing a vacuum in an enclosed chamber so that the seawater can boil at a lower temperature when activated by the warm surface seawater. When water is vaporized in this manner, there will also be a large change in volume that creates a draft to activate the turbine, generating power

and the subsequent condensation of the water vapor by the cooling effect of deep ocean cold water will become distilled fresh drinking water.

There are many other alternative energy solutions being used such as windmills, wave machines, solar panels, etc., but none have the potential magnitude and capacity to entirely replace fossil fuels to generate sufficient power required by our growing world-wide population and civilization.

MINI-OTEC SYSTEM, Hawaii

A reduced scale OTEC platform (Mini-OTEC) was put into operation off the coast of the Island of Hawaii at Keahole Point in 1979. This facility was able to generate electric power by processing the warm sea surface water and the cold deep ocean water (2,700 ft depth) through the system of heat exchangers and turbines to generate 50 KW of power with a net yield of 10 KW. The platform was constructed by modifying an old navy barge to support the OTEC equipment at a floating off-shore location. This project is recognized as a major break-through in the application of the OTEC concept first published by French scientist Arsene D'Arsonval in 1881.

