

Exploration and Utilization of Energy from Sea

Dr. Antony Joseph,

Senior Scientist, National Institute of Oceanography, Dona Paula, Goa 403 004

Abstract

1. Introduction

The major sources of energy at present are hydrocarbons (oil, gas, and coal), hydroelectric power, and nuclear power. We need to seek alternate sources because of several reasons such as threat of depletion of existing resources, environmental and climatological problems (building up of carbon dioxide layers in the atmosphere, with subsequent global warming and climate change); rise in the mean sea level (inundation of many coastal areas and islands), public concerns about safety of nuclear power together with the problem of nuclear waste disposal. The major sources of energy that can be (and are) extracted from the sea at present are petroleum hydrocarbon, methane gas hydrate, wind, sea surface waves, tide, ocean thermal gradient, and water current. The major advantages of ocean energy resources include their abundance, inexhaustibility, and their non-polluting character (e.g., wind energy, wave energy, tidal energy, etc.).

2. Petroleum hydrocarbons and gas hydrates

Formation of petroleum hydrocarbons and gas hydrates is a complex process. Oil and gas are the remains of the organic matter in the marine environment, which decays under certain physical, chemical and thermal conditions over a period of time. During the decay, the less combustible elements are driven off leaving behind the highly combustible elements such as carbon, hydrogen and oxygen. The elements carbon and hydrogen combine in several ways to form hydrocarbon molecules. Sedimentary rocks, which generate the hydrocarbons, are commonly known as 'source rocks'. As soon as hydrocarbons are formed, they tend to migrate through porous and permeable rocks called 'reservoir rocks' due to their low density. During migration, the hydrocarbons get trapped inside the reservoir rock at times because of surrounding 'obstacles' called 'cap rocks' which are poor in porosity and permeability. If the reservoir is dome/anticline shaped and is capped by an impermeable formation, hydrocarbons get accumulated near the crest of the dome. Prospecting for oil and gas in the present day economic environment requires a synergistic approach based on integration of geophysics, geology and geochemistry. The oil/gas mixture is excavated by drilling a well into the hydrocarbon deposit and transported to land after a series of engineering operations from an offshore platform to which a chain of wells are connected.

Gas hydrate is a crystalline solid consisting of gas molecule (normally methane) each surrounded by a cage of water molecules. On dissociation, 1 unit of "solid" gas hydrate produces 164 unit of gas and about 1 unit of water. Gas hydrates are found in permafrost regions and continental margins. The processes of gas hydrate formation are either biogenic or thermo-genic. Methane hydrates when burned releases less CO₂ and other pollutants to the environment.

3. Offshore wind

Energy, food, and the environment are all involved in both the progress and the decline of a society. A modern civilized society is no exception. On the other hand, greenhouse warming has increased worldwide and has already become a serious environmental challenge. In view of this, maximum utilization of non-polluting energy sources is becoming all the more important. Wind is an important source of energy under this category. Offshore wind energy is used for a variety of applications such as mercantile navigation, and large-scale harvesting of high-pressure hydrogen for manufacture of hydrogen fuel battery and applications in hydrogen-fueled public buses (currently implemented in Germany, Iceland, and a few other countries).

4. Ocean waves

More than 100,000 island communities have fuel energy imported at considerable cost. Ocean wave energy conversion is very attractive for islanders if the minimum sea-state condition required for running the conversion system existed around the islands. Ocean wave energy conversion systems possess several advantages such as (i), availability of renewable energy, (ii) does not require fuel, (iii) does not cause pollution, (iv) relatively inexpensive to build, and (v) affects a small area. A major disadvantage with harvesting of the ocean wave energy on a continuous basis is that except

in some limited regions, wave action is severe for short periods of the year and calm or nearly so for much more of it. In situations where wave energy harvesting is feasible, ocean wave energy converters are used for wave energy extraction.

In an ocean wave energy converter system that produces electric power, the generation of electric power is achieved pneumatically (i.e., by the action of compressed air). In this system, a water body is held within a large chamber (known as "capture chamber"), which is hydraulically connected to the sea. The internal water motions are excited by the external ocean-wave motions. Depending on the volume of the water within the capture chamber, resonance with the external wave may occur. When resonance phenomenon occurs, large motions of the water column also occur. The vertically oscillating water column within the capture chamber produces an oscillating air flow. This air flow is forced past the turbine of a turbo-generating system. Through either a gear system or a pump system, the low rotational speed of the turbine is increased for the high-speed generators. The high-speed generator produces electricity

5. Ocean tides and currents

Generation of electric power from tides and tidal currents requires the following conditions; (i) large tidal ranges (i.e., difference in elevation between successive high tide and low tide is large), (ii) suitable locations having particularly special topographic settings, and (iii) large impoundment basins in the vicinity of the barrage (dam). Locations in the world found suitable for tidal power plants are; Bay of Fundy (Canada), Cook Inlet (Alaska), Inchon (Korea), several locations on the Yellow Sea (China), Kislayaguba (Soviet Union), Gulf of San Jose-Santa Cruz, Argentina, Severn River (England), and Rance River (France). In India, Gulf of Kambhatt and Gulf of Kachchh in Gujarat (north-west coast of India) are potential sites for generation of electric power from tides and tidal currents. Work in this direction has already been initiated at Gulf of Kambhatt.

Tidal power stations operate like hydroelectric schemes. For example, a huge dam (called a "barrage") is built across a river estuary. When the tide flows and ebbs (i.e., when it goes in and out), the water flows through tunnels in the dam. The flow and ebb of the tides can be used to run a turbine, or it can be used to push air through a pipe, which then turns a turbine. Large lock gates, such as the ones used on canals, allow ships to pass.

6. Conclusions

Several sources and techniques used for harvesting energy from the ocean have been addressed. These include offshore hydrocarbons, offshore wind, ocean waves, and ocean tides and currents. In India, Gulf of Kambhatt and Gulf of Kachchh in Gujarat (north-west coast of India) are potential sites for generation of electric power from tides and tidal currents. Engineering work has already been initiated at the former towards extraction of electric energy from the estuary. Taking into account the presence of a vast ocean water body off the western and the eastern regions of the Indian peninsula as well as around the Lakshadweep Island chains in the Arabian Sea and the Andaman Island chains in the Bay of Bengal, wind farm stations onboard of a large-scale linked-cluster of numerous honeycomb-shaped floating structures made of super-light, high strength, and high seawater corrosion resistant materials (such as those used in the Japan Sea) seems to be a viable proposition for extraction of offshore wind-energy for the benefit of the Indian people. Implementation of such a scheme for our island chains would obviate the present use of the greenhouse gas generating diesel-based electricity generation methodology existing at present at these islands. Unlike hydrocarbon based power generation schemes (which emit greenhouse gases), wind farms support people's life and industrial activities (preventing global warming and climate change).

Reference

I. Technological innovation of large-scale ocean wind power station, The SCF Research Group, Kyushu University, Japan.