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Comparative Analysis of Power Generation from Oceans

Sundaresan R [1], Nagaraja M*[2], Sasikumar C[3], Natarajan R[4], Musthaque Muhammad N[5], Charles I[6]

[1,3]Associate Professor, [2]Assistant Professor, [4]Professor, [5]CEO, [6]President
[1]College of Applied Industrial Technology, Jazan University, Baish, Kingdom of Saudi Arabia,
[2]Department of Mechanical Engineering, PSNA College Of Engineering and Technology, Silvarpatti, Tamil Nadu, India,
[3]Department of Mechanical Engineering, Bannari Amman Institute of Technology, Coimbatore, Tamil Nadu, India,
[4]Carbon Dioxide and Green Technologies Centre, Vellore Institute of Technology, Vellore, Tamil Nadu, India,
[5]Department of Mechanical Engineering, NAMS College of Higher Studies, Kinniya, Sri Lanka,
[6]Department of Mechanical Engineering, Ballsbridge University, South Dominica, West Indies
Email: **madurainagaraja@gmail.com*
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Abstract

Solar energy contributes to a reduction of greenhouse gas emissions in comparison to energy generated from fossil fuels. It promotes viable source of energy, being renewable to meet global needs of power. The non renewable energy resources of petroleum and other CO_2 sources are increasing the pollution level and causing the environmental effects. Future scenario coal and oil might not be a source of fuel for power generation. This is due to safeguarding the environment from pollution. The objective of present work is to investigate the feasibility of generating electricity indirectly from solar energy by harnessing the temperature difference between the sun-warmed surface of tropical oceans and the colder deep waters.

Keywords: *Energy from ocean, solar energy*

INTRODUCTION

A significant fraction of solar radiation incident on the ocean is retained by seawater in tropical regions, resulting in average year-round surface temperatures of about 283°C [1]. Literature reviews showed that the temperature of the water in Deep Ocean is about 20°C (36°F). This is an ample heat source to convert the low boiling point fluids like propylene and ammonia to a gas or vapor. This temperature difference is also preferred to be sufficient to operate vapor turbines, which drive generators and produces electricity and fresh water as a byproduct. Jacques Arsene d Arsonval et.al (1881) proposed tapping the thermal energy of the ocean. Georges Claude, et al. (1930), built a 22kw OTEC plant with a low-pressure turbine. Also Claude et al. (1935), built a 10,000-ton cargo vessel moored off the coast of Brazil which was destroyed by waves. In 1956, French scientists designed another 3 MW OTEC plant for Abidjan, Ivory Coast, West Africa. In 1964, J. H. Anderson developed a new closed cycle OTEC plant, which overcomes the weak point of Claude's system. An experimental set up of 50kw OTEC system was built at Keahole Point, Hawaii in May 1983. A vertical-spout evaporator to convert warm seawater into low-pressure steam for open-cycle plants was developed in 1984 by the Solar Energy Research Institute. The Energy conversion efficiencies in the system were reported to be 97%. In 1984

Dr. H. Uehara a Japanese physicist invented more advanced cycle for OTEC system. In 1985 Dr.Alex. Kalina an American physicist invented a new heat cycle, known as Kalina cycle, for thermal energy conversion using ammonia or water mixture as working fluid. A 1 MW closed cycle OTEC demonstration system with a 4-stage axial flow reaction turbine was built in the year 2001 and pioneered by National Institute of Ocean technology (NIOT), Chennai. Compact plate type heat exchangers had been used for both evaporator and condenser side. The working fluid in the system is Ammonia [2]. OTEC is getting importance after the Fukushima nuclear accident in Japan. Faming Sun et al. (2011) reported that the potential of ocean energy is about a million kilowatt-hours per year [3]. Experts suggests it to be one of the most effective thermal conversion way in low temperature applications, which uses an organic fluid as a working medium and offers advantages over conventional rankine cycle with water as the working medium. Gerard C Nihous [4], suggested that OTEC principle is simple and it involves the extraction of mechanical work in a Rankine cycle operated between hot source (warm surface seawater) and sink (deep cold seawater). Soerensen et al. [5], reported that global potential of ocean energy is between 20,000 and 92,000 TWh/year, compared to the world consumption of electricity of around 16,000 TWh/year which is sufficient to meet present energy crisis. Jacob et al. [6] and Cornett et al. [7], investigated the potential for generating 280 TWh per year of ocean energy across Europe. Jacob et al., also had reported a potential of 255 TWh per year in the United States which had been estimated in 2003 by the US Electric Power Research Institute (EPRI). In 1974, the establishment of Natural Energy Laboratory of Hawaii Authority in US becomes one of the world's leading test facilities for OTEC research [6]. A net power output of 255 kWe (gross) was achieved successfully by using a land-based OTEC experimental facility built at Hawaii which had been in operation during 1993−1998. The turbine-generator was designed for an output of 210 kW for 26 °C warm surface water and a deep water temperature 6°C.It was reported that 10% of the steam was diverted to a surface condenser for the production of desalinated water at 0.4l/s.[8, 9].

OPERATION

The general OTEC system constitutes the following (i) Evaporator, (ii) Condenser, (iii) Turbine, (iv) Water pump, (v) Ammonia, (vi) storage tank, (vii) pre deaerator and some others liquefaction unit. The sketch of this cycle is shown in Fig. 1. The principle of operation of an OTEC power plant is as similar to cyclic heat engines. An OTEC plant receives thermal energy through heat transfer from surface sea water warmed by the sun, and transforms a portion of this energy to electrical power. The Second Law of Thermodynamics precludes the complete conversion of thermal energy in to electricity. A portion of the heat extracted from the warm sea water must be rejected to a colder thermal sink. The thermal sink employed by OTEC systems is sea water drawn from the ocean depths by means of a submerged pipeline. A steady-state control volume energy analysis yields the result that net electrical power produced by the engine must equal the difference between the rates of heat transfer from the warm surface water and to the cold deep water [10].

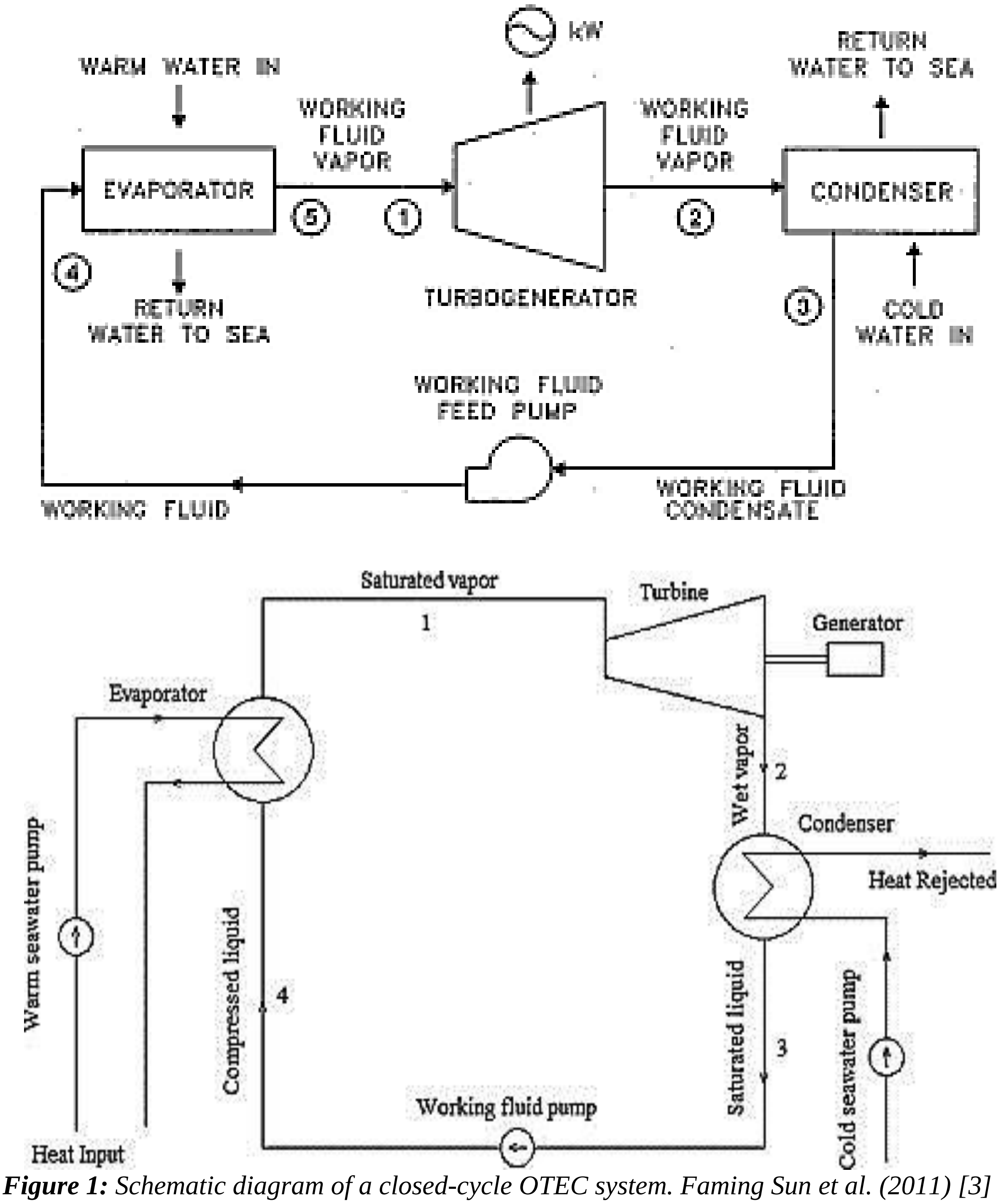

Figure 1: *Schematic diagram of a closed-cycle OTEC system. Faming Sun et al. (2011) [3]*

SOLAR BOOSTED OTEC SYSTEM

A solar-boosted OTEC system was proposed and first-order performance simulation was carried out in a 100kw OTEC system at Kumejima Island in southern part of Japan. Noboru Yamada et al. [11], envisaged that the installation of a solar collector with an OTEC system (Fig. 2) enhanced the thermal efficiency of an OTEC plant. The thermal efficiency of SOTEC operation with 20-K solar boost is reported to be 2.7 times higher than that of OTEC operation. He reported that the utilization of a single-glazed flat-plate solar collector of 5000m^2 effective area boosted the temperature of warm sea water by 20 K.

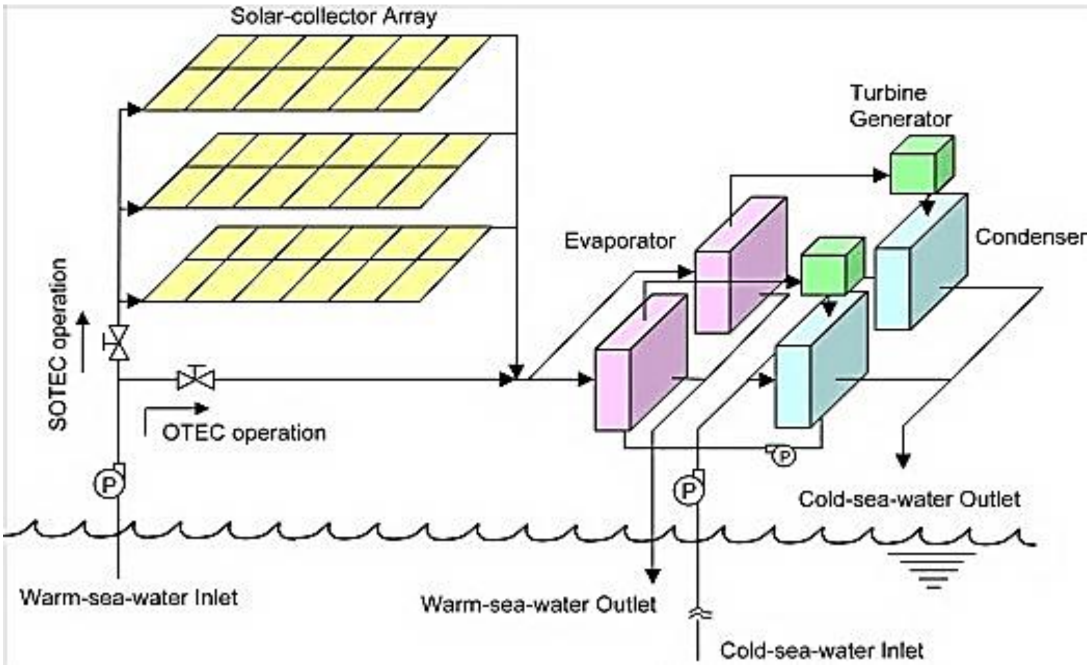

Figure 2: *Solar boosted ocean thermal energy conversion.*

RESULTS AND DISCUSSIONS

Maria Bechtel et al. [12], reported that the energy derived from an OTEC plant is equivalent to the same amount of water passing through a hydroelectric dam with a water height of 56 meters. It is inexhaustible due to the difference in temperature can be maintained constant by the action of ocean currents and sun. It has also been suggested to select corrosion resist materials like Titanium, copper-nickel alloys to protect heat exchangers, platforms and cold-water pipes. (Thomas et al., 1989) reported the problem of biofouling of OTEC heat exchangers due to exposion to surface seawater. So effective heat transfer is to be ensured to protect the heat exchangers from biofouling. During 1981, an analysis performed for the United States Department, pointed out the renewable energy potential of 98 nations and territories with access to the OTEC resource (Temperature difference of 20°C between Deep Ocean and surface water) within their 200 nautical miles. A significant market potential of up to 577,000 MW of new base load electric power facilities was postulated (equivalent to 6% of present day power consumption by humanity). In view of the discussion given above, this volume of power production would represent an environmental impact of significant proportion, primarily due to the movement of massive amounts of seawater [9].

CONCLUSION

The feasibility of extracting energy from the Earth's oceans is envisaged. OTEC technology makes it possible to extract the energy from the suns radiation. Research experts suggest that OTEC plants can be sized to produce from 1 MW to 10 MW of electricity. The area suitable for OTEC ranges around the world from the tropics to semi-tropics. OTEC can be sited anywhere across about 60 million km^2 of tropical oceans-anywhere there is deep cold water lying under warm surface water. Surface water regions, warmed by the sun, generally stays at 25°C or above. Ocean more than 1,000m below the surface is generally at about 4°C. Further innovation research methods are is required in renewable ocean projects as the environmental effects and economic feasibility is shown to exist in most experimental outcomes. OTEC researchers report the unwillingness of private power sectors to make the enormous initial investment. So, government's initiation and financial incentives will attract and draws attention towards the technology. It was also suggested that careful site selection will not cause much impact to environment. OTEC technology has significant potential to provide energy free of greenhouse gas emissions in a cleaner way for the future. OTEC has the potential to produce fuels such as hydrogen, ammonia, and methanol.

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