A REVIEW ON FEASIBILITY OF IMPLEMENTATION OF OCEAN THERMAL ENERGY CONVERSION IN INDIA

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ABSTRACT

India being an aspirant to become a developed nation always requires power to run its large industries and life with its own 120 crore people. The government has established large number of plants in which few runs on renewable source and few on conventional source. Despite India has stepped its foot in all research and achieved several milestones, India has not stepped deep into the field of power from sea water. There are plenty of ways to harness electricity from ocean and one among them is ocean thermal energy conversion.

This paper simply reviews the technology of OTEC and also its implementation in India.

Keywords: Ocean, Power, Thermal, Water

I. INTRODUCTION

Ocean thermal energy conversion (OTEC) is one of the recent trends in energy production. Though it was proposed long back, there is no proper setup all over the world. It ensures the renewable energy production. It can be applicable in most of the world's oceans like the Indian Ocean, Atlantic and the Pacific. The temperature difference between the warm surface water of the ocean the deep cold water is more or less greater than or equal to 20 C which is the basic criteria to produce electricity through this technology.

Recent studies state that the economic evaluation of OTEC plants reveal that future lies with the future of floating plants that have the capability of producing 100 MW for industrialized countries and smaller plants for smaller countries.

Basically there are two types OTEC plants; closed cycle follows the evaporation of working fluid like ammonia or propylene, to drive the turbine generator and the open cycle that follows the evaporation of sea water to run the turbine. Besides the above two, there is another type that is a hybrid one which is the combination if two. The other possible advantage is these plants would cool the ocean as much they produce energy.

Ocean thermal energy is used for many applications, including electricity generation. Ocean mechanical energy is quite different from ocean thermal energy. Another advantage is the tides are influenced by the gravitational pull of the moon and not by the sun and hence the ocean thermal energy is always constant. Besides that the fact is unlike other thermal technologies, the OTEC uses mechanical components too.

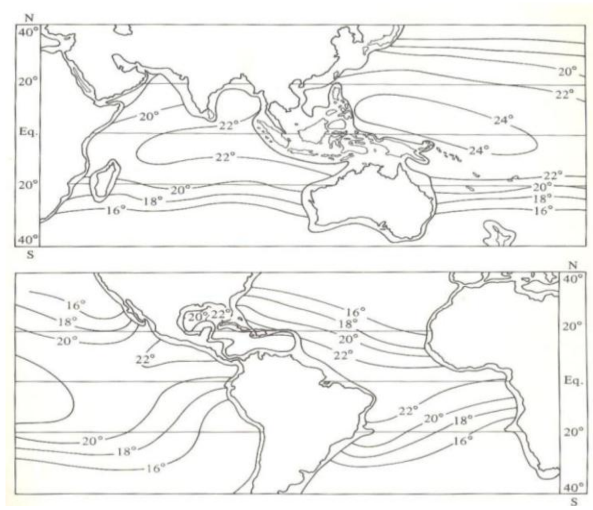

Fig. 1. Temperature difference between the surface and deep sea water in various oceans.

III. LITERATURE REVIEW

The term OTEC was coined by a French scientist Jacques Arsene d'Arsonval (1881).In 1930, a 22 KW open cycle shore based OTEC system was built by Georges Claude in Cuba. In 1956, a set of French designers started working on the development of the OTEC plant in the African coast. But unfortunately they were unable to complete since there was a heavy competition with inexpensive hydroelectric power. An OTEC plant names mini –OTEC was established by NELHA in 1979. It produced power of about 53kW. In 1982, Toshiba & TEPC made a shore-based, OTEC plant that gave a net power of 31.2kW. Further, NELHA installed many plants such as an open cycle plant at Hawaii that produced 210 kW power. The NELHA also produced power for about six years under the government of the US. A Japanese university called Saga university also established its own power plant on behalf of Japan., *National Institute of Ocean Technology* (NIOT), Government of India and Saga University in Japan had a tie-up and involved in the design and development of a 1MW OTEC plant in the coast of Tuticorin, Tamil Nadu. On completion this plant would become the first plant of its kind that produces a MW of electricity. This is one of the prestigious projects of India and it is named as Sagar Shakthi that means the power of water in English. Besides all the above projects, US has proposed a plant that would produce a 13 MW of electricity on completion. This might

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also produce about 1.5 gallons of potable water for the people. A private company in the U.S. has proposed a 10 MW OTEC plant at Guam.

III. INDIAN POWER SECTOR-AT A GLANCE

Since, India had got its independence from the British in 1947, it has a great development in power production. The installed capacity was 1362 MW in 1947 and now it is about more than 2, 00,000 MW and the transmission network has increased from the isolated states to the overall national grid in which power is transmitted all throughout India. But the demand of energy is increasing and the growth of population and industrial development demands more electricity. Even though the country is installed with many power plants under the control of state electricity boards, National Thermal Power Corporation, Nuclear Corporation of India, India still suffers from the lack of power. India is unable to produce as much as electricity it requires every day. The demand of power is increased from 10.2% to 13.6% in the current fiscal says the renewable energy status report of India.

IV. NEED OF AN ALTERNATIVE

India has a severe electricity shortage. It is in the need to increase its production and enhance its capability to increase its power to meet the demands of its rapidly growing economy. A new report states that about 17% of the Indian villages has no electricity till date and remains unelectrified even after 67 years of independence. It also states that 400 million Indians are without any electricity. The additional point is India faces this much deficiency even though it's per capita consumption of electricity is just 640 kWh which is one of the lowest in the world.

An Integrated Energy Policy Report states that India will have to increase its supply by three to four times and power production by five to six times to meet the lifeline per capita consumption needs of its population. Only this will help to sustain a growth rate of 8%. The government failed to increase the per capita consumption of citizens to 1000kWh in 2012. The present government of India is interested in electrifying the villages and bring them into electricity coverage. The weekly report of the power minister of India states that the government electrifies at least 10-20 villages every week. But on the other hand the demand of the electricity still more increases and hence the burden falls on the citizens again due to lack of production.

V. INDIA'S CAPABILITY IN RENEWABLE ENERGY

India is blessed with the renewable energy potential of 150 GW, about half in the form of hydropower, solar, bio-mass as well as wind farm. India has not yet ventured into the field of OTEC efficiently. India is a peninsular country that has large coastline and sea water lashes India by three sides. Thus India has the capability to produce more amount of electricity from sea water using the OTEC technology. When India develops its renewable energy it will help India to increase its energy security and it will also reduce the bad effects on the local environment, lower its carbon intensity and will make India a frontier in the power sector.

Since 2005, the government of India has set ambitious targets to make India a country with self-sufficient power producer. It has also tripled its renewable energy status in the past 8 years. It ranks in the fifth position in the world in total installed renewable energy.

The Indian government has set up an aim to achieve to have generated renewable energy by 40 GW to 55 GW by the end of 2022. Though this may look like a scheme that may not be possible, once if OTEC is established effectively in India, it can develop faster than now. Another major committee named NAPCC has set another target to increase a percent of annual increase in renewable energy installation in India. This will require an additional set up of 40-90 GW by 2017.

VI. TECHNOLOGIES OF OTEC

The power production from the potential available in the ocean is based on the factors such as the thermal system employed that includes all the components like pups, condensers and heat pumps. There are 3 types of cycles in the technology of OTEC. They are discussed briefly and compared in order to find the feasible cycle for Indian coast.

6.1 Closed cycle

D’ Arsonval was the first person to put forth the idea of closed cycle in OTEC. [1]

Usually all cycles works based on a working fluid and the fluid must have a low boiling point. Fluids like propane and ammonia is used in the closed cycle in OTEC technology. The working fluid is sent inside the evaporator where it vaporizes. It is used to run the turbine and that produces power [2]

Closed-cycle operates on Rankine cycle. The first stage of this cycle is an isentropic expansion. It occurs in the steam turbine. Heat rejection at constant pressure takes place at the condenser after the first process. At this stage, the water vapor condenses to liquid and thus the entropy also decreases. The next stage is the isentropic compression in the pump. Due to compression, the temperature rises since the pressure increases. Usually in OTEC systems, warm sea water is pumped into evaporator such that the working fluid could be vaporized easily. The vaporized working fluid will move through the turbine driving it to produce electricity.

The main merit of closed cycle system is that it is more compact compared to that of an open-cycle system and can be used with the existing turbo machinery and heat exchanger designs [3]. The defect is it uses ammonia as a working fluid that might causes the environmental problems.

6.2 Open cycle

This is the cycle that was proposed by Claude. This cycle uses the actual sea water as the working fluid as the working fluid for the heat exchanger. Here the warm sea water is sent into a low pressure evaporator chamber. The water boils in the chamber. The chamber is maintained with valves and serious care is take to avoid leakage. The vapor drives the low pressure turbine to produce electricity. Then the vapor is cooled by using the cold deep sea water. This varies from the open cycle since it uses the sea water instead of ammonia that was used by the closed-cycle process [4].

This cycle do not follow the Rankine cycle but follows the cycle proposed by Claude. It is similar to that of Rankine cycle with very small important differences. The first major difference is that the closed cycle uses complex processes and transfer processes whereas the open cycle does not need it.

In the initial stage, the open cycle sends warm sea water into evaporator through spray spouts [5]. This will increase the water surface area that will allow the water to expose to reduced pressure. This will allow the water to boil. In the close cycle, it is actually used to run the turbine to produce electricity. The next stage is the heat transfer to the thermal sink. This is used to condense the warm water. Then the water is discharged. Since the warm sea water is flash evaporated, all the salinity of the sea water is removed and thus it becomes potable fresh water.

Thus this can be used as a desalination plant also after production of electricity. Secondly, the working fluid used is warm sea water and not ammonia and thus it will not create any problems to environment.

Despite this much advantages, the open cycle has its own disadvantages. The main demerit is that the care taken must be high since it must be sealed to prevent the leakage. It is of low efficiency since it relies always on the pressure gradient to flash evaporate the warm sea water. Also the volume of the working fluid (sea water) is more than that of the closed cycle. Comparing the closed cycle, the efficiency is less.

6.3 Hybrid cycle:

The theoretical concept that is actually not tested is the hybrid cycle. This is the combination of both closed and open cycle. In order to attain high efficiency, this system uses both sea water and the ammonia as the working fluids. In this cycle, the fresh water is evaporated in a vacuum chamber. The ammonia is also evaporated in the same chamber and physically mixed. The evaporated ammonia is removed from the steam and then sent into closed cycle again, the phase change will run the turbine and produces energy.

VII. COMPARISON AND EVALUATION OF TECHNOLOGIES

When we compare all the technologies of the OTEC, all the types has its own pros and cons. But when we consider the coast of India and the feasibility, we can consider the open cycle OTEC plants since they do not harm the environment and can be used as a desalination plant too. Though the closed cycle plant seems to be a better option in terms of efficiency, the utmost care is given for the environment and the ecosystem of the ocean. Though proper measures has to be taken to seal the carriage and considering the technologies vested with India now, the open cycle plant can be prevented from leakage by experts. Another point in consideration is fishery. Most of the people in the Indian coastal

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cities like Chennai, Trivandrum, Kochi, Vizag, Mangaluru etc.… are based on fishery. Hence the proposed plant must not cause any trouble to fishermen community and hence open cycle can be considered.

VIII. ADVANTAGES OF AN OTEC PLANT

The OTEC plants produces variety of products and services. This is the major advantage of the OTEC plants. The ocean thermal energy is relatively clean and do not produce pollutants that are harmful to the environment. The open cycle system does not have the need of a heat exchanger and thus it is simple to construct. The major advantage is the power production is purely renewable. Since there is no use of a fuel, this can be economical in future.

IX. DISADVANTAGES OF OTEC PLANT

1. The cost is high.
2. The efficiency is low.
3. The closed cycle may cause pollution on leakage.
4. Construction of a floating plant is difficult.

X. APPLICATIONS OF AN OTEC PLANT

Besides producing electricity, open cycle plants can produce desalined water that can be used for irrigation as well as drinking purpose. A closed plant can be used to treat the chemicals that can be used as a fertilizers. It can enrich the aquaculture, marine culture, the fishery industry. It can be helpful in the production of hydrogen.

XI. CONCLUSION

This paper thus fulfills the aim and compares the technologies and concludes that the open cycle based OTEC plant can be more feasible to Indian shores.

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