International Journal of Latest Trends in Engineering and Technology
Vol.(17)Issue(4), pp.013-017
DOI: http://dx.doi.org/10.21172/1.174.04
e-ISSN:2278-621X

RENEWABLE ENERGY AND ALTERNATIVE FUELS IN MARITIME FIELD

Pooja C[1], Prof (Dr) Sunil Kumar P G[2]

Abstract- **A major share of present day energy requirements are met from fossil fuels, which are non-renewable. Given the present rate of usage of energy, fossil fuels will not last long. Burning fossil fuels results in global warming and harmful exhaust emissions, leading to environmental pollution and health hazards. Ships are responsible for approximately 3%of global greenhouse gas emissions, in addition to air pollution. Stringent regulatory requirements and environmental concerns call for use of renewable energy and alternate fuels in shipping sector, which include offshore wind, marine biomass, wave, tide, ocean current, osmotic gradient, thermal gradient etc. Various aspects of application of alternative energy resources in marine vehicles are explored in this paper.**

Keywords – Marine Renewable Energy, Tidal Energy, Wave Energy, Ocean Thermal Energy, Offshore Wind, Salinity Gradient.

I. INTRODUCTION

In present day scenario, most of the energy needs of the society are generated by burning fossil fuels. Oil is a finite resource, which means that its supply is limited and cannot be replenished. Probably, the next generation would witness a sharp depletion of oil and natural gas in their lifetime and use of alternate fuels will have to be encouraged. A case study of world energy use indicates that more than 36% of energy is from sources other than petroleum products and coal. IMO has already introduced 2020 low-sulphur standards and upcoming CO_2 emission regulations will reduce the share of conventional oil-based ship fuels with a corresponding increase in the use of alternate fuels.Marine renewable energy sources such as tides, currents, waves etc can play a key role to reduce the consumption of fossil fuel. Lack of availability of data of environmental effects of marine renewable energy devices for commercial development is hindering the progress beyond experimental or trial phases. The renewable energy resources that are used in generating energy from marine filed are offshore wind, wave, tide, tidal and ocean currents, osmotic gradient, thermal gradient and marine biomass.

II. MARINE RENEWABLE ENERGY

A. Offshore Wind Energy

Offshore wind is stronger and steadier than on-shore wind. Wind turbines are used to extract the kinetic energy from offshore winds. It is one of the widely accepted and proven marine renewable energy technologies, which is very cost effective to meet the increasing demand of electricity in a sustainable manner. Surveys have established that coastlines of UK, Norway and Ireland have the strongest offshore wind.

[1] *Department of Naval Architecture and Shipbuilding Engineering, Sree Narayana Gurukulam College of Engineering, Kadayirippu, Ernakulam-682311, Kerala, India*
[2]*Dean (Research), Sree Narayana Gurukulam College of Engineering, Kadayirippu, Ernakulam-682311, Kerala, India*

The European Union leads the world in generating offshore wind energy. In 1991 the first offshore wind farm named Vindely was installed in Denmark and it was decommissioned in 2017.This resulted in large scale commissioning of offshore wind farms. Currently United Kingdom has the largest offshore wind farm named Hornsea 1, commissioned in 2019with a capacity of 1.2GW. It has a life span of 25 years and can generate power for over 1 million households.

Figure 1- Hornsea 1 Offshore Wind Farm [Source:Ørsted]

As per the study conducted by National Institute of Wind Energy [NIWE] it is identified that the coastal area of Gujarat and Tamil Nadu has the potential to generate offshore wind energy. These two regions are subdivided into 8 zones. Gujarat alone can produce a power up to 36 GW and Tamil Nadu region can generate up to 35 GW. Offshore wind assessment for one year in region of Gujarat coast carried out using Light detection and Ranging [LiDARs] system shows that the average wind speed is of 7.52 m/s. At present, survey of oceanographic, geotechnical and geophysical condition of the site is in progress, which would ultimately lead India to develop the first offshore wind farm at Gujarat coast, with an estimated capacity of 1GW.

Offshore wind farms are very expensive in terms of capital, operating and maintenance expenditures. More over the wind actions can even cause damage to wind turbines. The study on the environmental and ecological impacts of offshore wind units, especially on animals and birds are still in progress. Offshore wind energy generators have the potential as a safe marine renewable energy production technology.

B. Wave Energy

Ocean waves are mainly wind generated and the energy content of waves can be used for generating oscillating low frequency electricity, which can be converted to 50 Hz frequency and transmitted to any electric utility grid. One of the most important characteristic of the wave energy is that generation, storage and efficient transmission without much loss can be undertaken on a 24x7 basis. This is one of the most environment friendly methods power generation methods without any harmful byproducts. The power output depends on the selection of site, where the waves generated should be strong enough. Instrumentation for wave power generation include water column oscillator, surface attenuator, point absorber buoy, overtopping device, oscillating wave surge converter etc.

Figure 2 - Wave Energy Converter [Source:OpenEI]

The first wave generating farm ‘Aguçadoura Wave Farm’ was commissioned on September 2008, in Portugal, which was designed using 3 Pelamis wave energy converters with a capacity of 2.25MW. Now this wave farm is undergone shut down due to financial collapse from an economic crisis. The first wave power generator project in India will be commissioned soon at Vizhinjam. Compared to other renewable energy resources, the overall cost for this kind of system is much higher. Research is still continuing for improving the computational tools, optimising the control systems, conducting wave climate forecasting, improving device responses to wave grouping and multi directionality. The environmental impact analysis is yet to be completed.

C. Tidal Energy

The difference between tides and waves is that tides are generated due to the lunar gravitational forces, resulting in high and low tides. Tidal energy is generated using technologies such as tidal turbines, tidal barrages and tidal lagoons. Tidal turbines are also called underwater mills, since it uses similar technology used in wind turbines, but with stronger and shorter blades. Tidal barrages are akin to the dams in hydroelectric plants. These barrages make use of the potential energy due to the difference in heights during high and low tides. However, these are expensive and there is a shortage of viable sites across the oceans.

Figure 3 - South Koreas 254MW Sihwa Lake Tidal Power Station [Source: Power Technology]

Tidal lagoons are similar to barrages but less expensive. World's biggest tidal power plant is Sihwa Lake Tidal Power Plant in South Korea. Proposal to set up a tidal power plant in Gujarat had to be shelved since it was found to cost 20 to 30 times compared to the cost of solar and wind energy projects. The significance of tidal power plant is that the tidal variations are predictable, and so would be the power generation. So the efficiency of the tidal power plants is greater compared to any other method.

D. Osmotic Gradient Energy

Osmotic gradient energy, also known as salinity gradient energy is also a type of marine renewable energy. Here the energy is created from the difference in salinity levels between two fluids. Places such as river mouths where the salinity difference is appreciable can be used for power production using methods like Reverse Electrolysis (RED) and Pressure Retarded Osmosis (PRO) etc. Both processes are carried out by pumping the fresh water through the modules in the membranes to pressurized sea water. In simple terms the seawater and freshwater which are separated by a membrane diffuses through it as a result of difference in osmotic pressure. Power is generated when this pressure drives the turbines. It is possible to ensure production of large amount of steady and predictable power using modular design technology. However, there is a risk of clogging and gradual degradation of semi permeable membranes, necessitating pressure filtering pretreatment of fresh water and periodic membrane replacement every 5 – 7 years.

E. Thermal Gradient Energy

The difference between the temperature gradient of sea surface and deep-water can be used to produce energy called thermal gradient energy. Several thermal energy conversion technologies are available to convert it to power. Though this type of renewable energy is continuously available, research on Ocean Thermal Energy Conversion (OTEC) programs are still under research in countries like Japan, US etc. As per new report China also is developing the world's largest OTEC power plant. Challenges such as designing the heat exchangers, underwater tubes etc are the main challenges faced by OTEC developers. The high cost of production is another disadvantage. The ongoing research initiatives are likely to overcome such roadblocks to make OTEC as the best renewable energy generating technology in near future.

F. Marine Biomass Energy

As the name indicates, the biomass energy from the ocean species such as micro and macro algae's can be converted to energy. Latest research reports reveal that production of methane is possible from marine biomass via anaerobic digestion which can be used for the generation of electricity. This can be beneficial for countries like Japan because of their long coastlines. This is a pollution free, renewable, indigenous source of the energy.

III. ALTERNATIVE MEASURES FOR PROPULSION OF MARINE VEHICLES

Ships account for nearly 3% of global greenhouse gas emissions. Mandatory regulations for such emissions have become the game changer in ship design and operations, leading to intense research into alternatives to conventional fossil fuels for ships.

A number of alternate fuels are being considered for marine vehicles. The most commonly considered options are Liquefied Natural Gas (LNG), Electricity, Biodiesel, and Methanol. Research is in progress regarding other options that could play a role in the future such as Liquefied Petroleum Gas (LPG), Ethanol, Dimethyl Ether (DME), Biogas, Synthetic Fuels, Hydrogen (particularly for use in fuel cells), and Nuclear fuel. Wind energy, solar energy, compressed air, hybrid propulsion etc are also being considered.

Biofuel is a type of fuel which is produced from the animal fats and vegetable oil such as coconut palm soybeans etc. It is generally known as Fatty Acid Methyl Esters (FAME). It is a liquid or gaseous type of fuel which is generated from primary biomass or from residues of biomass. The biofuels are categorized into three types' viz. first generation biofuels which are extracted directly from plants, second generation biofuels which are generated from residues and wastes, woody crops non-food feedstock and third generation biofuels which are generated from aquatics organisms. Biofuels are one of the best alternative fuels which can be used for ship propulsion which has a large potential as a long term solution to reduce emissions. The environmental impact analysis has indicated that the first generation biofuels have certain negative aspects. Research on the storage and handling of these fuels is also reaching the logical conclusions.

Hydrogen is a highly potential alternative fuel for the propulsion of ship. Currently it is produced from natural gases but it can also be generated using wind, hydro-electric and nuclear energies. There are ferries which use hydrogen fuel cells such as "Water-Go-Round" and "HySeas III" which are under construction. The notable advantages of this type of fuel include a considerable reduction is emission of CO_2 and SO_X, versatility for use in both internal combustion engines and fuel cells. This concept is still in research stages and major concerns like safety, hydrogen supply infrastructure etc are to be addressed before commercialization in marine industry.

Anhydrous ammonia is another type of fuel considered in propelling ships, which do not emit carbon dioxide and can be used in both gas turbines and diesel engines. As it is a poisonous gas, it is to be compactly transported by liquefying in a pressurized tank of 30 bar or in unpressurized tanks cryogenically. There is no greenhouse gas and sulphur emission for such ships, but handling difficulties and cost implications are yet to be resolved.

A common feature of all these fuels is that these are sulphur free, rendering them compliant for sulphur content regulations. Another feature is that these may be used along with fossil fuels or as a full scale replacement model for conventional fuels. The type and the proportion of alternative fuel have a deciding impact on the vessel's emissions.

Resolution MEPC 304 (72) of International Maritime Organization (IMO) stipulated the strategies on reduction of GHG emissions from ships through technological innovation and global introduction of alternative fuels or energy sources for international shipping. The strategies are to decline the carbon intensity of the ship by implementing the EEDI (Energy Efficiency Design Index) for the new vessels, to reduce CO_2 emission by 2030 by at least 40%, and 70% by 2050 and to decline the emission of Green-House Gas (GHG) by 2050 by at least 50% compared to 2008 levels. Some of the technical measures for improvising the energy efficiency for the vessel recommended by IMO are improvisation of hull form, engine or propeller, hull appendages for energy saving, recovery of waste heat, utilization of renewable energy, use of LEDs, optimization of trim and draft, speed, hull cleaning, propeller polishing , maintenance of engine etc. Resolution MEPC 323 (74) encourages voluntary cooperation between the port and shipping sectors to towards reducing GHG emissions. The major areas of interest are development of onshore power supply facilities, promotion of port incentives schemes, provision of safe bunkering of alternative low carbon and zero carbon fuels, optimization of port calls including facilitation of just in time arrival of ships etc.

A mix of innovative technical and operational solutions needs to be worked out for achieving the goals of IMO objectives.

IV.CONCLUSION

The ever increasing global warming and pollution are the major issues, which have reflections in the maritime sector also. The fossil fuel reserves across the globe are depleting at a very fast rate. Given the present circumstances, it is inevitable to explore options of alternate fuels and other renewable sources of energy as it can help in creating pollution free world. Some of the modern technologies are already inducted, while some are still under development at various stages. The ongoing research will definitely usher in a great change in the energy production industries. Providing renewable energy technology with lower cost and higher efficiency can bring in new era marine propulsion. Alternate fuels are a necessity and the world needs to more vigorously pursue the use of renewable energy sources like hydro, wind, solar, bio-fuels etc. Alternate fuels can change the face of the future.

REFERENCES

[1] A Azzelino, D Conley, D Vicinanza, J P Kofoed, Marine Renewable Energy: Perspectives and Implications for Marine Ecosystems

[2] M Robinson, W Musail, Offshore Wind Technology Overview

[3] A Marine renewable energy solution for modern ships - Electric vehicles research

[4] An overview of marine renewable energy – Paris Innovation Review

[5] Marine Renewable Energy – European Science Foundation

[6] Offshore Wind – Ministry of new and renewable Energy – Ministry of India

[7] V N Dinh, E McKeogh, ‘Offshore wind energy: technology opportunities and challenges’

[8] M Muchtar, S Manjang, D A Suriamihardja, M A Thaha, ‘Model of Ocean Wave Energy Converter Based on Water Mass Gravity Force as a Renewable Energy Source’

[9] B Chenari, S S Saadatian, A Ferreira, ‘Wave Energy Systems: An Overview of Different Wave Energy Converters And Recommendation for Future Improvements’

[10] Wave Energy – OpenEI

[11] Wave energy technology brief – International Renewable Energy Agency

[12] P Clark, R Clossener, L Kologe - Tidal Power

[13] M Vikas, S Rao, J K Seelam, Tidal Energy: A Review, Proceedings of International Conference on Hydraulics, Water Resources and Coastal Engineering (Hydro2016), CWPRS Pune, India

[14] F L Rashid, A H Mohamad, A Hashim, Power Production using Tidal Energy, British Journal of Science February 2012, Vol. 3

[15] Tidal Energy Technology Brief - IRENA

[16] Salinity Gradient Energy Technology Brief – IRENA

[17] S Yokoyama, K Jonouchi, K Imou, Energy Production from Marine Biomass: Fuel Cell Power Generation Driven by Methane Produced from Seaweed, World Academy of Science, Engineering and Technology 28 2007

[18] Future ship powering options exploring alternative methods of ship propulsion, Royal Academy of Engineering, July 2013

[19] Assessment of selected alternative fuels and technologies, DNV GL– Maritime

[20] Alternative fuels for shipping, DNV GL

[21] IMO Resolution MEPC.304(72), Initial IMO Strategy On Reduction Of GHG Emissions From Ships