Salt Gradient Solar Pond: Future Energy Option for India

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Abstract- **With the tremendous growth in science and technology, followed by the industrialization, the global energy demand is steeply increasing. Presently, mankind is largely dependent upon fossil fuel as a source of energy. Yet its overexploitation has lead to severe environmental concerns. Moreover the resource of fossil fuel is at a vanishing point, therefore global energy researchers are exploring alternative energy options. Salt Gradient Solar Pond (SGSP) is one such alternative which has been successfully applied in many parts of the world. India has vast potential for exploiting this technology. The present paper explores the scope of SGSP in India and its future prospects.**

Keywords- Energy Scenario, Environmental Degradation, Salt Gradient Solar Pond.

I. INTRODUCTION

World energy demand has exceeded 474 exa-joules (Paul 2009). While the global energy demand has increased by 39% in the past decade, that in India has increased by 91% which is more than double of the global rise. This is attributed to the fact that with its rapid industrial growth India is transforming from the developing to developed nation. The renewable energy has a mere share of only 10% in this! On one side the excessive use of fossil fuel has created environmental havocs like global warming and climatic changes and drastically affected the global economics by crop failures, land submergence, mass migrations and class conflicts in society, being a great threat to the very existence to mankind. On the other side, scientists have estimated that the fossil fuels will run out soon. Ancient mankind used wood for burning and the fossil fuels remained untouched until 1200 AD. In 1790, a method that had been devised to extract gas from coal was put to practical use; in England, the first gas lights flared to life. In 1859, in the United States, the world's first commercial oil well was drilled. Through the remaining 1800's and the early 1900's, most people's needs were still met by pre-petroleum technologies. In 1861, a German, Nikolaus Otto, invented the first gasoline-burning engine. In 1882, Carl Benz invented the automobile. By the 1930's, however, cars had become the favorite travel mode of Americans. Airplanes were on the way—in 1920, the first regular airplane passenger service was scheduled. In 1955, 50 million cars were registered; by 1975, over 100 million (Britannica 2007).

Mankind pumped about five percent oil every year. M. King Hubbert, an oil scientist warned that the fossil fuel era would soon be over and urged us to prepare for that inevitable transition. He was ignored, criticized, or denied. But the history proved his estimations correct. The rate of oil field discovery worldwide peaked in 1964. In 1999, oil geologists estimated that ninety percent of global oil deposits had been located. All researchers agree that world oil production will peak before the year 2015. What happens then? Then by 2030, people must manage on 33% less oil; in 2045, they have 50% less; in 2060, they have 75% less. Natural gas may vanish in 2030. Nuclear energy is also non-renewable. At current rate of uranium use, by 2045, sources of fuel for traditional nuclear reactors will be running out (Hubbert 1989).

When conventional energy vanishes, our entire transport sector, security system, even house hold equipments will come to a shut agriculture will become impossible. This creates a very horror-full scene of the future. Apart from this the excessive use of fossil fuel has disturbed the CO_2 balance of the atmosphere and resulted into the consistent rise of mean temperature of earth, called as global warming. Global warming followed by climatic changes has become the greatest challenges to the very existence of mankind (Christopher 2003; Michaels and R C Balling 2000). The solution to all these problems lies in the exploration of alternative sources of energy. Amongst various sources of energy, solar energy is the most viable option due to its abundance and environmentally consistent nature. As one of the various devices developed for the harnessing of solar energy SGSP has an ability to convert solar energy into heat energy and to store it for a long time (Duffie and Beckman 1974). The present paper describes the basic design of a SGSP and its scope in Indian perspective.

II. WHAT IS A SALT GRADIENT SOLAR POND

Typically, a SGSP is a large body of water with dissolved salt. Fig.1 is a schematic diagram of a SGSP (Sukhatme 1996). The overall depth consists of three zones, namely storage zone (STZ), non-convective zone (NCZ) and upper convective zone (UCZ). Solar radiation flux incident at the surface penetrates inside the liquid depth and imparts heat to it by getting attenuated

and absorbed. STZ is meant for storage of heat. If the STZ was exposed to the ambient, it cannot store any heat at all due to evaporation, convection and radiation. Here in order to prevent the heat losses from STZ, a *lid* of non-convective zone (NCZ) is offered, where a salt concentration gradient varies from the maximum possible at STZ interface to the minimum practicable level at the top. The concentration gradient causes a density gradient in the NCZ due to its instability in convection. Hence the convective heat losses through STZ to the ambient are prohibited resulting into a downward increasing temperature profile up in the NCZ. Therefore SGSP is a long term heat storage device and thus can store the heat in summer for winter usage (Hull 1989). The hot water has diversified applications like space heating, boiler preheating and even electricity generation (Amnon 2004). Israel has an ambitious plan to switch over to 100% electricity generation by SGSP by 2020 (Weinberg 1981).

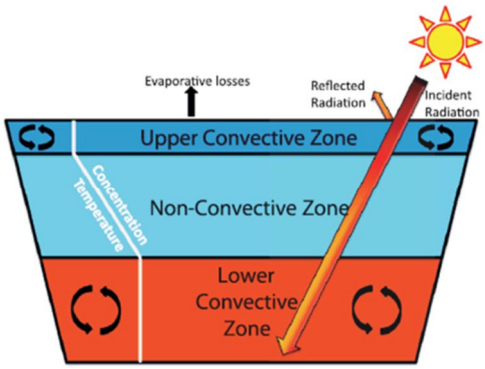

Fig.1 Schematics of a Salt Gradient Solar Pond

III. RESEARCH IN SALT GRADIENT SOLAR PONDS

The SGSP was observed in 1902 by Kalecksinski in Hungarian lakes (Weinberger 1964). Since then a great deal research has been done in the field of this technology as is evident from the bibliography given at end. Weinberger first proposed a mathematical modeling of the pond, which made possible the design and commercial use of the pond. Researchers identified two major aspects of SGSP for research: the thermal aspect and gradient zone stability aspect. Based upon the approach proposed by Tybout (1966), Hull (1980) first proposed a computer simulation of SGSP which was then refined by Husain et al (2002). Kooi (1979; 1981) proposed equations for thermal efficiency of pond for steady state. Husain et al (2003) extended the equation for transient state too. Turner (1973) and Zangrando (1991) did pioneer work in the gradient zone stability aspect of the pond. Husain et al (2012) coupled up both the aspect for the first time and proposed an innovative design of the pond. Another important aspect of the pond research was the bottom and side lining. It has to resist hot saline fluid for prolonged durations. Israeli scientist have worked a lot in this regard and got their work patented.

IV. SCOPE OF SGSP IN INDIA

Salt gradient solar ponds have great scope in India. The resons are as follows: first, the long coastal line in India provides huge sea water resource which is an economical raw material to establish a SGSP; second, solar energy as the driving force for solar pond, is extremely abundance in India due to its geographical placement and clear sky; Over and above this, India is no lack of great scientists and engineers in this field. Thus India has a great scope of harnessing solar energy using an economical and environmental friendly way that is SGSP. In Kutch area of Gujarat one commercial SGSP has worked successfully for several years in the early 19990s. Experimental SGSPs have worked successfully in Indian Institute of Technology, Delhi, Indian Institute of Science, Bangalore and Birla Institute of Technology, Ranchi.

Estimation of SGSP potential in India:

Power requirement of India = 120000 MW (Lalwani, et al 2010)

Solar radiation (Average) = 250 W/m^2 (Mani et al 1982)

Thus land area of SGSP required harnessing desired level of energy

= 120000*10^6/250

= 480 *10^6 m^2. However, SGSP has conversion efficiency around 20%.

Thus actual area required = 480 *10^6/20% = 2400* 10^6 m^2 = 2400 sq. km.

When a thermal or nuclear power plant is established, they occupy the area not only for construction and waste disposal, but also for safety and pollution control purpose. Their effective area coverage is significantly large. As far as the overall cost of SGSP technology is concerned, it is already an established fact that it is quite economical as compared to any other comparable technology (Husain et al 2004).

V. CONCLUSIONS

Evolution is the law of nature. It is the well known theory of Charles Darwin that the species can adapt themselves to the changing environment; if they only persist unchanged they may; get extinct, which can be demonstrated by the extinction of dinosaurs by the end of Mesozoic era and persistence of microorganisms. Mankind is the most physically fragile living creation but has its own supremacy due to its developed intellectual power thus protecting them from the changing environments. With the dawn of a new millennium human civilization has entered into a new era of science and technology. Today the technology needs to be sustainable. Today it needs to be environment friendly. The conventional energy resources have come to a verge of vanishing and are radically agitating the global economy. If the technology for alternative energy is not developed soon the future of civilization will be in dark. The time has come when the research needs to be focused towards the alternative energy; however, the alternative energy technology is very costly and the cost can only reduced by research and investigation. Salt gradient solar technology is already an established technology. India has tremendous scope to harness this technology. In a real sense, Salt Gradient Solar Pond technology is the future of India's energy sector.

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