A Study on Some Other Likely Renewable Sources for Developing Countries

K.A. Khan[1], Mohammad Nazim Uddin[2], Md. Nazrul Islam[3] , Nuruzzaman Mondol[4]& Md.Ferdous[5]

[1]*Department of Physics, Jagannath University, Dhaka-1100, Bangladesh*
[2]*Department of Physics, Uttara University, Bangladesh.*
[3]*Department of Physics, Uttara University, Bangladesh.*
[4]*Department of Physics, Uttara University, Bangladesh.*
[5]*Department of Physics, Uttara University, Bangladesh.*

Abstract

The organized utilization of geothermal energy, from hot springs & underground steam, for the production of electricity, and the supply of domestic and industrial heat, dates from the early years of the twentieth century. Since geothermal energy must be utilized or converted in the immediate vicinity of the resource, to prevent excessive heat-loss, the entire fuel cycle, from resource-extraction to transmission, is located at one site. This reduces costs and the risks of the environmental impacts of fuel cycle, and also facilitates environmental protection-measures (in contrast, the different stages of the coal, oil, natural gas and nuclear fuel cycles are normally located at widely separated sites). Unlike fossil-fuel or nuclearpower production, geothermal energy is not a technology that requires massive infrastructure of facilities and equipment or large amounts of energy input. The capital cost runs around $ 500,000 per M.W. and the electricity thus, costs 15 mils/kwh, which is almost as cheap as hydro-electricity. Both the total quantity of gases in the fluid and the relative concentration of their constituents, depend on the geochemistry of the underground reservoir. Geothermal steam contains carbon dioxide, hydrogen sulphide, ammonia, methane, hydrogen, nitrogen and boric acid. In steam dominated fields (for example, the Geysers, California, and Larderello, Italy), composition of discharged steam corresponds to that at depth. However in high temperature water-dominated fields, the proportion of gas in the steam depends on the extent to which steam has flashed from the original high-temperature water. The gases (except ammonia) are predominantly concentrated in the steam-phase and the gas/steam ratio decreases with increasing steam-proportion in the discharge.

Keywords: *OTEC, Wave Energy, Tidal Energy, Geothermal Energy, Wind Energy*

I. Introduction

Energy flows from many sources, exists in a variety of interchangeable forms, and drives all systems. It is fundamental to the quality of our lives and today, we find ourselves totally dependent on an abundant and uninterrupted supply of energy for living and working. It is undoubtedly the key ingredient in all sectors of modern economies.

Fossil fuels and nuclear technologies, as a core source of global energy production since the beginning of the 1970's, left behind a legacy of thousands of thermal, natural gas and oil fired power plants spread across the world. The carbon gas emissions and non-degradable nuclear waste produced by these plants have caused serious environmental problems such as the greenhouse effect leading to a virtual chain reaction of ozone depletion followed by global warming and climate change. Time and experience have shown that these energy production methods are non-sustainable. Instead, hope for sustainable energy production is to be found in renewable energy sources that are clean, cheap and 'green' Renewable energy resources and technologies have the potential to provide long-lasting solutions to the problems faced by the economic and environmental sectors of a nation. Besides the overall global benefits, renewable energy systems can provide direct benefits at national and local levels, which justify their wide use in developing countries. They can contribute to substantial savings in import bills for fossil fuels. At the local level, availability of electricity contributes to improved productivity, and indirect positive effects are also visible in the form of the creation of new employment opportunities.

II. Methods and Materials

II A. Geothermal Energy

Worldwide development of geothermal electric power and direct heat utilization is given in Table 1. The total power of installed geothermal power-plants by 2000 in the world (Table 2 below) was 7974.06 MWe. Worldwide, geothermal power can serve the electricity need of 865 Million people, or about 17% of world population. Moreover, 39 countries have America and the Pacific. The cost of geothermal energy is 2-10 US Cents per kWh.

Table-1: **Worldwide development of geothermal electric power**

Year	Installed Energy		No. of countries	Participants reporting
	MWth	GWh/year		
1940	130		1	Italy
1950	293		1	Italy
1960	386	2,600 est	4	+NZ, Mexico & USA
1970	678	5,000 est	6	+Japan & USSR
1975	1,310		8	+Iceland and El Salvador
1980	2,110		14	+China, Indonsia, Kenya,Turkey,Philippines & Portugal
1985	4,764		17	+Greece, France & Nicaragua
1990	5,832		19	+Thailand, Argentina & Australia,- Greece
1995	6,797		20	+Costa Rica
2000	7,974	49,261	21	+Guatemala,- Argentina

The source of this Table-1 is: Source: John W. Lund, "World Status of Geothermal Energy Use Past and Potential" REW July-Aug 2000, p. 123.

A planned survey of the geothermal potential of the relevant countries should be carried out; in which the programme should A planned survey of the geothermal potential of the relevant countries should be carried out; in which the programme should include: collection and tabulation of data on the hot springs of the country, as well as analysis of the fluids produced by these springs. Appropriate RD&E studies can then be initiated.

II B. Ocean-energy

Ocean-energy has only recently received serious attention, most study work has been done only in the last ten years or so. Although energy-generation from water currents is not a new concept, the technology needed for large scale energy-generation has now become feasible. The energy of ocean offers a number of possibilities for commercial exploitation and developments have been picking up pace. Estimates suggest that there is some 2-3 million MW worth of power in the waves, breaking on all the coastlines of the world. Although it would not be feasible to exploit all of this, coastlines facing the open ocean to their west are particularly good sites for wave energy and therefore, there is significant development of the technology in Northern Europe and North America.

Fig.-1: Installed Geothermal Generating Capacities in the Year 2000

Computer-generated image of an array of axil flow tidal current turbines of a kind under development by Marine Current Turbines Ltd in the UK, showing how a system might be maintained by raising it above the sea surface Image: Marine Current Turbines Ltd

Table-2: Installed Geothermal Generating Capacities in the Year 2000 [3]

Country	Installed Mwe	GWh generated
Australia	0.17	0.90
China	29.17	100.00
Costa Rica	142.50	592.00
El Salvador	161.00	800.00
Ethiopia	8.52	30.05
France	4.20	24.60
Guatemala	33.40	215.90
Iceland	170.00	1138.00
Indonesia	589.50	4575.00
Italy	785.00	4403.00
Japan	546.90	3532.00
Kenya	45.00	366.47
Mexico	755.00	5681.00
New Zealand	437.00	2268.00
Nicaragua	70.00	583.00
Philippines	1909.00	9181.00
Portugal	16.00	94.00
Russia	23.00	85.00
Thailand	0.30	1.80
Turkey	20.40	119.73
USA	2228.00	15,470.00
Total	**7974.06**	**49,261.45**

There have been many systems proposed for utilizing the energy from the oceans, but perhaps the greatest potential for ultimate utilization exists in OTEC, i.e. Ocean Thermal Energy Conversion OTEC which utilizes the fact that the ocean's surface-water is warmer than water in its depths (an OTEC plant works like a heat engine, but with a small temperature differential of 15o to 20o, compared with 500o C or more for a steam turbine or internal combustion engine). Fig.1 (page 223, REW/July - August 2002) is a computer generated image of an array of axil flow tidal current turbines of a kind under development by Marine Current Turbines Ltd in the UK, showing how a system might be maintained by raising it above the sea surface image : Marine Current Turbines Ltd.

II C. OTEC (Ocean Thermal Energy Conversion):

Development work and demonstration units are needed for both types of plant, viz closed-cycle, using a volatile working fluid, and open-cycle, in which the warm surfacewater is turned into steam by lowering the pressure, and after driving a generator, it is later condensed by the colder water. (The second type also produces fresh water as a by-product).

The process depends on the difference of temperature between deep-sea layers, where the temperature is 7-8° C at a depth of 1,000 meter, and sea-surface layer, where it is 30° C. This difference in temperature is employed to generate electricity. The technology of OTEC is based on the Ocean's functioning as both absorber and heat-sink for solar radiation. Because of incomplete mixing, temperature-differences of upto 40°F (or 22°C) exists between surface and deep waters near the equator. The basic idea of OTEC is to use this absorbed heat and this temperature-difference to drive a large heat engine. Usually, the heat-engine proposed is a closed- cycle, latent-heat absorber, using a suitable working fluid, like ammonia, propane or a chlorofluorocarbon (cfc).

III. Results and Discussion

Some idea about the capital cost and the energy-cost for large plants can be estimated. For a power-generating station of 250 Mega-Watt size, the capital cost would be around dollars 3,500 per kWe, but this can come down to dollars 2,500 if more plants are built. This compares unfavourably with capital cost of around dollars 450 per kWe, for coalwaste power plants and dollars 575 per kWe for nuclear plants. But if energy-costs are compared, these OTEC costs compare favourably with oil and are only slightly above the cost of coal and nuclear power generation. Energy cost was estimated in 1984 at 39 to 43 mils/kWh for OTEC-generated electricity versus 28 mils for nuclear, 36 mils for coal and 90 mils for oil. Development work and demonstration units are needed for both types of plants, viz closedcycle, using a volatile working-fluid, and open-cycle, in which the warm surface-water is turned into steam by lowering the pressure and, after driving a generator, is later condensed by the colder water. The second type also produces fresh water as a bye-product. The National Institute of Oceanography, in Karachi, had considered some plans to undertake a survey of likely sites for OTEC plants off the Pakistan coast. The biggest advantage of OTEC systems is that the heat is absolutely free. Probably the biggest disadvantage is the necessity for large heat-exchangers and cold-water conduits. Both these requirements are due to the enormous quantities of water that must be handled by any productive system. The process of converting the difference of temperature between deep and surface water-layers of ocean into electricity has been studied for several decades by the Department of Energy in U.S.A. and is being pushed for warm coastal regions, such as Florida, Hawaii and Guam. This process is now feasible in various islands and peninsular areas along the earth's tropical belt, which have the highest and the most efficient thermal gradients. Such areas are the most potential places for the initial OTEC development. To give a few examples, Puerto Rico is one such place; Hawaii is another. Potential sites exist in the continental shelf off the shores of many countries all over the world.

IV. Conclusions

The first land-based OTEC plant has been built at Nauru, a small island in the South Pacific. A consortium of three Japanese firms has undertaken to build this plant on the island, at a cost of 4.3 million dollars, and it was expected to deliver 1.5 Mega Watt after 1983. The Nauru plant uses Freon gas as its working fluid in titanium heat-exchangers as its working fluid. Cold bottom-water is drawn from a 900 meter long, 70cm. diameter, polyethylene pipe; 30oC water is drawn directly from the ocean surface. The U.S. Department of Energy is thinking of constructing a 40 Mega-Watt plant, which was expected to be completed in the late nineties at an estimated cost of 250 million dollars, but this figure is bound to rise considerably due to inflation.

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