

A MULTI-PURPOSE RURAL DEVELOPMENT PROGRAMME FOR COASTAL REGIONS UTILISING SOLAR ENERGY AND THE SEA

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ABSTRACT

A project primarily designed to meet the energy and fresh-water requirements of isolated coastal communities is presented. It will also help to increase the production of salts and marine chemicals and fish (by aquaculture). The design involves the construction of a solar pond which supplies hot brine at 85°C. This is used as heat source for the power and desalination plants. The sea water of temperature approximately 15°C, brought up from a depth of about 250 m, is used as heat sink for the plants. The temperature difference between the source and the sink is used for production of power. The hot and the cold waters rejected by the power plant are utilised for production of fresh water by vacuum evaporation of sea water. The coolant water, being rich in nutrients, is further utilised for aquaculture and production of marine living resources. We present the details of the concept and examine the relevant technologies and benefits of the project.

INTRODUCTION

The development of rural areas largely increases with the availability of power, freshwater and employment opportunities, in addition to other basic factors. The energy demand of many rural areas can be met from a central power station. However, there are many areas which are too remote to reach. In some remote coastal areas, it is possible to generate electric power utilising the solar energy and the sea. There are many marine sources that can deliver power. Tidal power, for example, is ideally suited for the Gujarat regions. The ocean coupled solar pond power station (Gopinathan and Sastry, 1983) may be ideal for the coastal areas of Tamil Nadu. This power generation method is similar to the Ocean Thermal Energy Conversion (OTEC) where a temperature difference of about 21°C is utilised for the power production. In an Ocean Coupled Solar Power Pond Station (OCSPPS), the temperature difference utilised is more than 70°C, resulting in higher efficiency of thermal energy conversion. Since the power plant is based on shore, many complicated problems encountered in OTEC programme can be avoided.

We examine how an OCSPPS may be designed to supply both power and freshwater and the coolant water may be utilised for aquaculture and production of salt and marine chemicals. We present the details of the concept and examine the relevant technologies/ capabilities available in India for its implementation.

DETAILS OF THE PROJECT

A salt gradient solar pond is the basic requirement of the project. It is a large tank, lined with a special black material, containing layers of water of density increasing from surface to bottom. The density layering can be achieved by a number of ways. When exposed to solar radiation, the bottom layer of the pond becomes progressively warmer. The temperature build-up at the bottom layer can be as high as 100°C (see Tabor and Weinberger, 1981) while the surface temperature may be only 25° to 30°C . The warm water from the bottom of the pond can be pumped through the heat exchanger/evaporator of the thermal energy conversion plant, and when cooled, can be re-circulated to the pond where it regains heat. We plan for a solar pond that will supply hot water at a steady temperature of about $80\text{-}85^{\circ}\text{C}$ to the thermal energy conversion and desalination plants.

The cold water needed to condense the working fluid of the plant will be obtained from the sea. Gopinathan and Sunder (1986) observed a temperature of about 15°C at a depth of 200 m off the east coast of India. Such cold water sources are found within a range of 10-20 km from the shore along the Tamil Nadu coast. A heat insulated pipeline will bring this water to the power plant. The technology for manufacture of such pipes and its laying are available within India.

It is proposed to use a closed cycle power plant for the thermal energy conversion. In such plants, water at high temperature is circulated through the heat exchanger/evaporator of the plant (see Fig. 1). A working fluid of low boiling temperature (like ammonia) is evaporated and the vapour at high pressure is supplied to the turbine. The turbine is coupled to a generator and electric power is produced by the rotation of the turbine. The working fluid after leaving the turbine is condensed by the cold water pumped through another heat exchanger. The condensed working fluid is pumped back into the evaporator. Repetition of the process results in continuous power production. Such power plants of 10 kW_e net capacity were developed at the Indian Institute of Technology, Madras (Murthy and Murthy, 1987). Recently, similar power plants have also been fabricated at the National Aeronautical Laboratory, Bangalore.

The production of freshwater is an important aspect of the project. Many areas along the east coast of India which are ideally suited for such plants, have freshwater scarcity problems. In our programme for production of freshwater, sea water will be heated to about 75°C with the help of the hot water rejected by the power plant. This will be introduced to the first stage of a two-stage vacuum evaporation plant (see Fig. 1), where about 68% vacuum is maintained. The sea water splashes and the vapour produced is condensed by the incoming sea water. The sea water left after splashing is then passed to the second stage of the plant where about 89% vacuum is maintained and the water is again splashed. The evaporated water vapour is condensed by the coolant water rejected by the power plant. The left over sea water is rejected and fresh sea water is admitted for further splashing. The process is repeated and freshwater is continuously produced. In India, this technol-

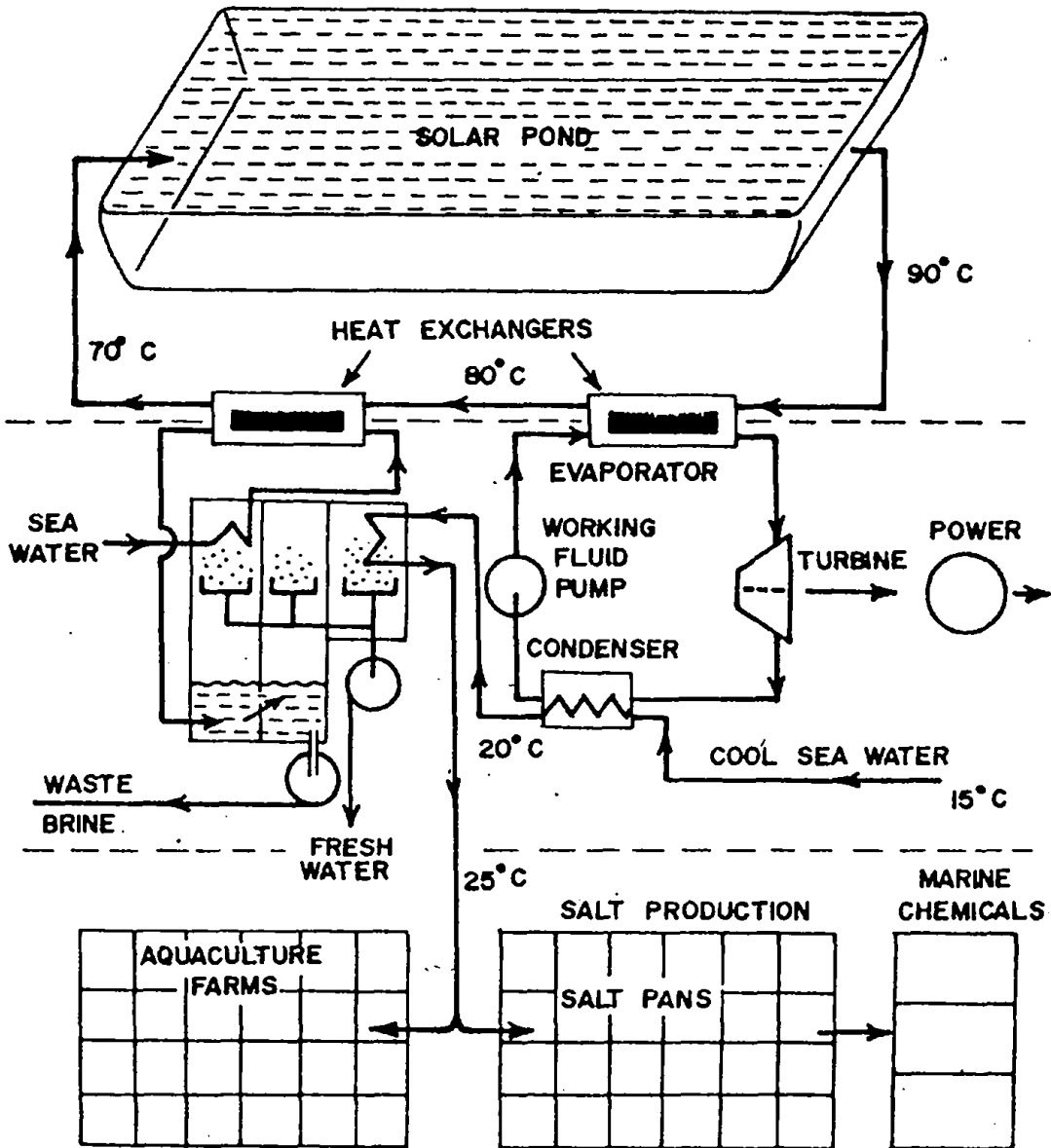


Fig. 1 The solar pond (top) absorbs solar energy. The hot water from the lower layers of the pond is circulated through the power plant (middle right) and the desalination plant (middle left). The coolant water is utilised for aquaculture and salt production (bottom).

ogy has been developed by the Bhabha Atomic Research Centre, Bombay (Hanra et al., 1984).

The sea water that is proposed to be brought from a depth of about 200 m is rich in plant nutrients and has a low dissolved oxygen content and can be utilised for the improvement of coastal aquaculture. The water warms up nearly to the ambient temperature as it passes through the power and desalination plants. The oxygen content of the water can be improved either by aeration or by passing over large bed of seaweeds. The use of this water to fertilise the coastal waters will improve the productivity of the coastal aquaculture many fold. Some more R & D work may be required to optimise the productivity of the aquaculture fields by the use of this water.

A schematic representation of the project is shown in Fig. 1. Some typical specifications of the project are given below:

1.	Solar pond area for a 100 kW _e plant	2.13	hectares
2.	Cooling water requirements of the plant	35	litres/sec
3.	Area for conventional salt pans	231	hectares
4.	Amount of salt produced per year	22 x 10 ³	tonnes
5.	Fresh-water to be produced	100	m ³ /day
6.	Major chemicals to be produced	Br, Mg etc.	
7.	Major marine living products from aquaculture	Shrimps, Fishes, Artemia, Algae	

REFERENCES

- Gopinathan, C.K. and Sastry, J.S. (1983), Thermal energy conversion by coupling solar pond and sea. Proceedings of the Second Conference in Ocean Engineering, CWPRS, Pune, 14-16, December, Vol. II, 1226-1239.
- Gopinathan, C.K. and Sunder, D. (1986), Seasonal variations in the OTEC potential off the Indian coasts. Proceedings of the Third Indian Conference on Ocean Engineering, IIT, Bombay, 11-13, December, Vol. II, F43-F49.
- Hanra, M.S., Varma, R.K. and Ramani, M.P.S. (1984), Operational experience with a 15,000 litre/day multistage flash (MSF) distillation facility. Proceedings of the Third National Conference on Water Desalination, CSMCRI, Bhavnagar 10-12, February, 18-29.
- Murthy, S.S. and Murthy, M.V.K. (1987), Experimental studies on a solar thermal power plant. *Applied Energy*, 27, 305-319.
- Tabor, H. and Weinberger, Z. (1981), Non convecting solar ponds. In *Solar Energy Handbook*, McGraw Hill Book Co. N.Y. Chapter 10, 1-29.