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EVALUATION OF SOLAR POND PERFORMANCE

MONSANTO RESEARCH CORPORATION

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OBJECTIVE

This project is directed toward data collection and evaluation of the thermal performance and operational characteristics of the largest, functional, salt-gradient solar pond in the United States. Also, firsthand experience is being obtained regarding the maintenance, adjustments and repairs required of a large, operational solar pond facility. This evaluation will provide engineering knowledge for the future design of similar large ponds in the U. S.

BACKGROUND

The City of Miamisburg, Ohio, constructed during 1978 a large, salt-gradient solar pond as part of its community park development project. The thermal energy stored in the pond is being used to heat an outdoor swimming pool in the summer and an adjacent recreational building during part of the winter. This solar pond, which occupies an area of 2020 m^2 (22,000 sq. ft.), was designed from experience obtained at smaller research ponds located at Ohio State University, the University of New Mexico and similar ponds operated in Israel.

The solar pond (shown schematically in Figure 1) combines low-cost solar energy collection with the annual storage of low temperature heat. The installation cost to the city for this pond was ∿70,000. The cost of this type of combined solar collector and heat storage system is, therefore, only $35/$m^2$ ($3.20/ sq. ft.). Because the pond is an annual storage system, it may require two to three years to reach a steady-state condition at which time it is projected to deliver annually 300,000 kWH (1 billion BTU) of heat. If the cost of the pond is amortized over ten years, the cost of this heat will be only 1.8¢/kWH ($5.45/million BTU)

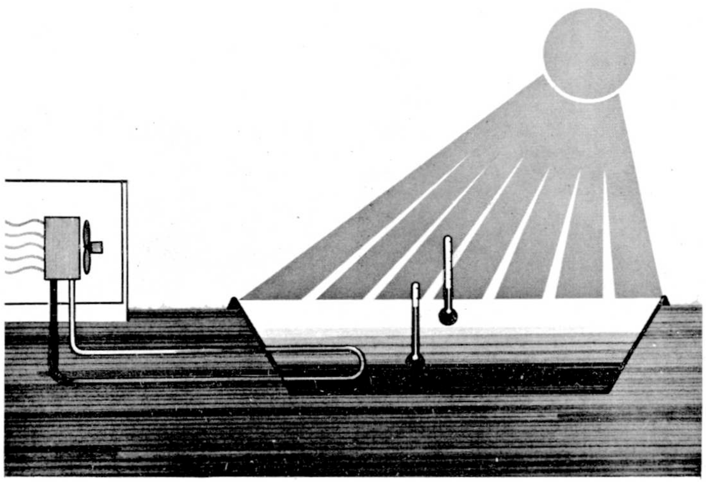

Figure 1. A schematic representation of the salt-gradient solar pond. The darker shading near the bottom of the pond represents higher salt concentrations and, consequently, higher water temperatures.

SUMMARY

During the summer of 1979, the initial heat (40,000 kWH, 136 million BTU) was withdrawn from the solar pond to heat the outdoor swimming pool. All of the data collection systems were installed and functioned as designed so that operational data were obtained. The observed performance of the pond was compared with several of the predicted models for this type of pond.

TECHNICAL ACCOMPLISHMENTS

- During July, August, and September 1979, useful heat (40,000 kWH, 136 million BTU) was withdrawn for the first time from the solar pond to maintain the outdoor swimming pool at ∿80°F. Because of very poor solar insolation during August 1979 and some readjustments required to the solar pond, the test of heat extraction for space heating during the winter of 1979-80 could not be conducted.

- Instrumentation was installed to measure the total solar insolation, the solar radiation penetration into the water, air temperature, wind speed and direction, and temperatures at numerous depths and locations in the water and in the earth beneath the pond. All of these sensors are automatically read and recorded on a pre-determined schedule by the use of a small computer. The seasonal variation in the temperature of the storage layer is illustrated, Figure 2.

- A simple heat flow model was constructed for the pond and tested by comparison between the observed and predicted temperature for the storage layer during each month of 1979. These predicted values were in good agreement with the observed values except for March and April when a large amount of heat is probably consumed to heat the ground. Based upon this model, the pond is predicted to deliver 300,000 kWH/yr (1 billion BTU/yr) of heat when it has reached a steady-state condition.

- Water quality was determined frequently by measurements of salinity and acidity on samples extracted from various depths of the pond. Copper sulfate, in the 1-2 ppm concentration range, served

successfully as an algaecide; however, the acidity of the water had to be readjusted several times during the year with hydrochloric acid to maintain a pH of 5-6 so that the copper sulfate remained in solution.

- Corrosion of the solder joints of the copper tube heat exchanger caused by the hot, concentrated saline solutions become severe. All of the original solder joints, composed of 95% tin-5% antimony, were subsequently refabricated with a brazing alloy of high silver content.

- A 25 cm length along one seam of the plastic liner in the pond separated and some of the saline water leaked from the pond. This seam was successfully patched under eight feet of water.

FUTURE ACTIVITIES

Contract Activities Continuous data collection from all the installed instrumentation will continue. This information will be used to improve the thermal performance model of the pond, which will permit greater reliability in the prediction of pond performance. Several maintenance operations will be instituted to improve or maintain water clarity, acidity and salinity of the various layers of the pond. Corrosion tests of metallic specimens will be initiated to determine the preferred materials for the construction of the heat exchanger. Several techniques will be tested to locate small leaks in the large pond of water. Analytical and experimental studies will be conducted to improve the thermal efficiency of the solar pond.

Post Contract Activities No current plans exist for marketing this system. The cost and performance information derived from this project will be given wide circulation, because it is the largest, functional pond in the U. S. For low-temperature process heat and certain types of community development projects, such ponds have the potential for displacing significant amounts of fossil fuels. Based upon such interest and need, a more formal marketing/industrial information strategy may be proposed.

PUBLICATIONS

1. R. S. Bryant, R. P. Bowser, and L. J. Wittenberg, "Construction and Initial Operation of the Miamisburg Salt-Gradient Solar Pond," Proc. International Solar Energy Congress, Atlanta, GA, May 28 - June 1, 1979, pp. 1005-1009, Pergamon Press, New York, 1979.

2. L. J. Wittenberg and M. J. Harris, "Evaluation of a Large Non-Convective Solar Pond," Proc. Solar Energy Storage Options, San Antonio, March 19-20, 1979, pp. 193-202, CONF 790328-P1 (1979).

3. L. J. Wittenberg and M. J. Harris, "Performance of a Large Salt-Gradient Solar Pond," Proc. 1979 Intersociety Energy Conversion Engineering Conference, Boston, August 5-10, 1979, pp. 49-52, American Chemical Society Publ., 1979.

4. M. J. Harris and L. J. Wittenberg, "Heat Extraction from a Large, Salt Gradient Solar Pond," Proc. Solar Heating and Cooling Operational Results Conf., Colorado Springs, Nov. 27-30, 1979, pp. 161-163, SERI/TP-245-30 (1979).

5. "Solar Ponds," Solar Age Magazine, p. 37, January 1980.

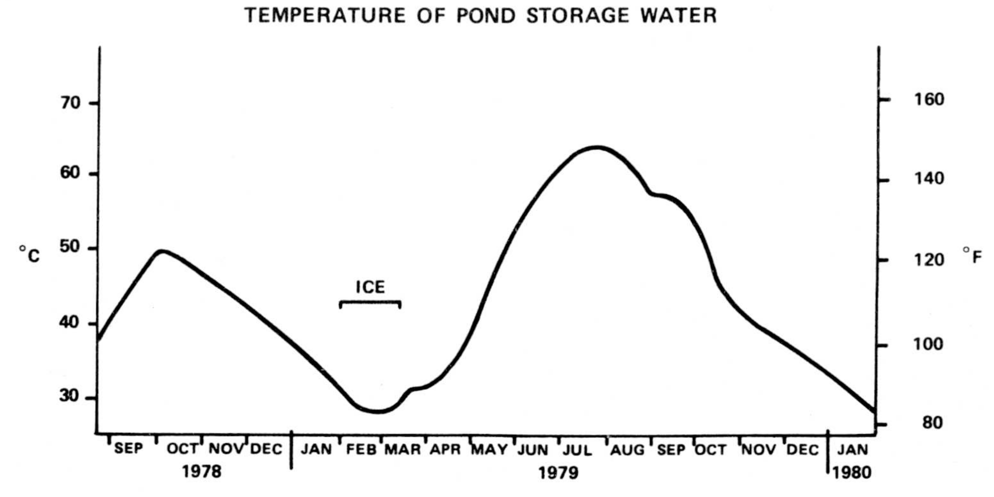

Figure 2. The seasonal variation in the temperature of the storage layer of the solar pond since its completion in August 1978.