Abridgment

Solar Energy: Hedge Against the Future

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If solar energy has an answer to some of the transportation industry's problems, both economic and energy oriented, we need to find it out. Solar is already a $75 million a year industry in California, and nationwide it involves nearly 6000 manufacturers and distributors.

The major problems encountered in solar applications seem to stem from simple mechanical problems of leakage and control malfunctions. Many engineers with solar experience stress the importance of simplicity in designing controls and layout (1,2). All of this means that any solar commitment should be made with well-researched performance specifications and carefully and specifically designed integration of solar into the existing structural plans. It is recommended that an engineering consultant with current experience in solar systems be employed whenever a solar system is being designed. Also, cost estimates for solar should compensate for the tendency of contractors to bid conservatively in this unfamiliar field.

FUEL COSTS

A general industry rule of thumb predicts a 10 percent increase in energy costs per year during the next 20 years. The U.S. Army Corps of Engineers uses a 20 percent increase per year until 1983, when it drops to 5 percent a year.

Use of gas and electricity has exhibited a fairly consistent pattern according to a five-year analysis of three Oklahoma field divisions. Cost of that use is a different matter, however, when the average annual increase in fuel bills over the five-year period is 17 percent or 30 percent as it was in 1976 and 1977. When cost is computed according to increases per million kilojoules, the increase is even greater—from 22 to 36 percent each year.

MUSKOGEE ASPHALT STORAGE TANK

The Oklahoma Department of Transportation (DOT) Research Division has been investigating solar energy for three years. With state funding only, a heated asphalt storage tank was designed for one of Oklahoma DOT's field division headquarters in Muskogee (3). The first in the nation, it began operation in April 1977. The 38 m^3 (10 000 gal) tank has successfully maintained the asphalt emulsion at an 18-60°C (65-140°F) temperature for two years. In fact, the temperature has never dropped below 23°C(75°F). The emulsion is about 65°C (150°F) when it is delivered from the supplier, so only six flat-plate solar collectors [10 m^2 (108 ft^2)] were required.

The Muskogee solar tank uses a 45.4-dm^3 (12-gal) fluid system to circulate the solar heat from the collector to a heat exchanger inside the storage tank. The fluid used is a combination of 40 percent ethylene flucol and 60 percent water (similar to antifreeze). It flows in 18.4-mm (0.75-in) copper pipes directly from the collectors to the heat exchanger unless the solar radiation drops or the collector temperature is less than that of the asphalt. In that case it automatically circulates through the auxiliary heater, which is a regular 22.7-dm^3 (6-gal) camper hot-water heater, into the asphalt tank.

The heat exchanger used copper tubing at Muskogee but later installations will use finned aluminum on copper to provide better heat distribution.

In summer the fluid remains in the solar system with a 103.4-kPa (15-lbf/in^2) pressure-relief valve for safety purposes. A 6.2-W ($^1/_{12}$-hp) pump circulates the fluid.

A feature added later involves an electric heat tape with a 15-min timer. It was placed on the take-out valve to heat the asphalt that coagulates at cold temperatures. This improvement was made after the discovery that the 51 mm (2 in) of sprayed-on urethane foam insulation on the tank was flammable when a torch was used to heat the valve.

The $4600 cost of the solar part of the installation, which includes insulation, solar system, and labor but not the tank itself, has been recovered in less than two years through reduced operating expenses. Heating a similar tank in 1977 cost $2900 and used 32 m^3 (8500 gals) of propane. Cost of heating the solar tank during 1978 was $70, which is the cost of the fuel used by the electric hot-water heater that is the standby heat source on cold and/or cloudy days. In February 1977 the auxiliary heater operated 16 days in a row at full capacity at a cost of $12.

The contrast between those two costs is striking, and the winter of 1978 was exceedingly severe. The benefits of solar energy need to be compared to the cost of the local source of energy. At Muskogee, propane costs $0.11/dm^3 ($0.40/gal), whereas the electricity costs approximately $0.035/kW·h. If one's storage tanks are presently heated by a cheaper fuel, the savings realized from a solar system may not be as dramatic and will take more years before payoff is achieved.

Solar savings at Muskogee are not all monetary. Maintenance crewmen are enthusiastic about not having to get up in the middle of a January night to check the pilot light on the propane burner. The dependability of the solar system has saved uncounted hours of labor and time and has helped morale.

The insulation of the 38-m^3 storage tank was a most important part of the solar system in Muskogee. As in all solar designs, the use of "passive" solar is the first consideration. Solar heat or energy is hard earned and every effort must be made to keep and treasure each unit: Plumbing runs should be as short as possible; all piping should be heavily insulated; solar collectors should not leak.

An optimum 51-76 mm (2-3 in) of spray-on urethane foam will provide important savings. To prevent ultraviolet deterioration, a Hypalon coating over the insulation is used.

The success of the Muskogee installation has led Oklahoma DOT to start construction on three additional solar-heated tanks with six retrofits planned for 1979. The use of solar to heat MC asphalt tanks involves the use of higher-temperature solar collectors of the evacuated-tube or concentrating type. Such collectors can produce temperatures in the 149°C (300°F) range.

The Oklahoma emulsion storage tank is designed to maintain the asphalt within specified temperature ranges rather than heat it quickly. It has a much lower capital investment than the Texas and Arizona solar asphalt storage tanks, which cost two to three times as much (4).

FIELD DIVISION HEADQUARTERS

In a more venturesome solar research project, the Oklahoma DOT plans to supply heat, hot water, and air conditioning to a new \$1.7 million 2880-m^2 (32 000-ft^2) field division headquarters building scheduled to be let in May 1979. The plans also call for solar heating in the 2592-m^2 (28 800-ft^2) warehouse and shop area. Auxiliary heat will be natural gas.

The present estimate is approximately \$300 000 above the cost of a normal heating and cooling system. As a means of sharing the cost of the solar system at the Buffalo, Oklahoma, field headquarters, Oklahoma DOT applied to the U.S. Department of Energy (DOE) for an award under their demonstration projects program for commercial solar applications. The project was one of 83 DOE awards made under the 1978 offering and involves a 50 percent sharing of the solar cost. The remaining half will be provided by state transportation funds. It also provides Oklahoma with the benefit of DOE experiences in the previous 222 demonstration projects.

The Buffalo project design calls for about 450 m^2 (5000 ft^2) of liquid flat-plate collectors arrayed on the ground near the two-story office structure. The mechanical room will be located in the warehouse along with a 38-m^3 (10 000-gal) above-ground storage tank. A 22.5-t (25-ton) reciprocating chiller and a 22.5-t (25-ton) absorption chiller will be used. One way or the other, the transportation industry has to cut its fuel and overhead costs. Be it pioneering solar research or plain ingenuity, there are a multitude of ways to save money and energy. Now is the time to start these projects.

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