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DEFINITIVE DESIGN OF THE SOLAR TOTAL ENERGY LARGE-SCALE EXPERIMENT AT SHENANDOAH, GEORGIA*

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ABSTRACT

The U.S. Department of Energy, with Sandia National Laboratories providing technical support and management, is now starting construction of a Solar Total Energy Large Scale Experiment at Shenandoah, Georgia. The Solar Total Energy System (STES) is designed with capacity to supply electricity and thermal energy to a knitwear plant at the Shenandoah site. The system will provide 400 kilowatts electrical and 3.5 megawatts thermal energy.

The STES is a cascaded total energy system configuration. It uses parabolic dish collectors and a steam turbine-generator. The electrical system will be grid-connected to the Georgia Power Company system.

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INTRODUCTION

The Solar Total Energy Project at Shenandoah, Georgia, (Figure 1) is a prototype of a cascaded energy system using solar energy. Through system operation, definitive performance, cost, and O&M data will be obtained and an industrial solar total energy capability evaluated.

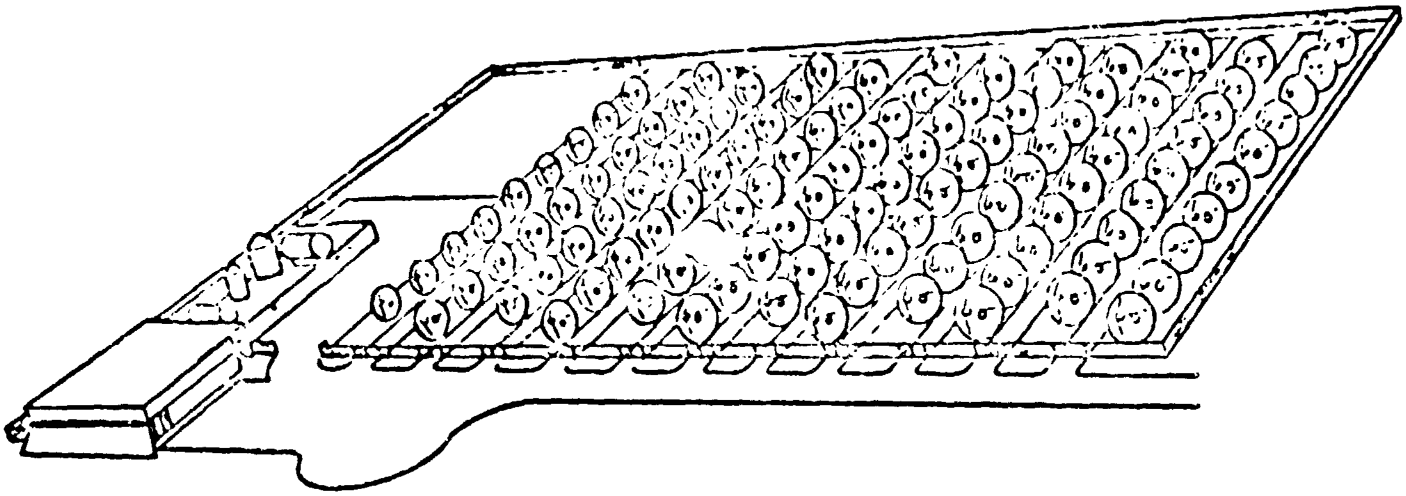

FIGURE 1. ARTIST'S CONCEPT, SOLAR TOTAL ENERGY PROJECT, SHENANDOAH, GA

A silicone heat transfer fluid is used to transport solar energy from the parabolic dish collectors to thermal storage or a steam generator. The power conversion system employs a high speed, steam, Rankine cycle turbine.

The system has the flexibility to operate in either a stand-alone or peak shaving mode while providing the electrical, steam, and heating and cooling needs of the nearby Bleyle Knitwear plant. Shenandoah, about 35 miles south of Atlanta, is an industrial-residential planned community. Sun right easements have been obtained on the land bounding the STES site to prevent future shading of the collector field.

SYSTEM DESCRIPTION

The STES consists of three major loops: solar collection and storage, power conversion, and thermal utilization, Figure 2.

One hundred and fourteen parabolic dish solar collectors, in parallel branches, form the collector field with a peak energy delivery rate of 1.2×10^4 MJ/hr (11×10^6 BTU/hr). Energy is either transported to storage or supplied to a steam generator by a high temperature silicone heat transfer fluid. The temperature range of the solar collector field is 260°C (500°F) inlet, 400°C (750°F) outlet. To permit operation during transient weather conditions, a thermal storage capacity

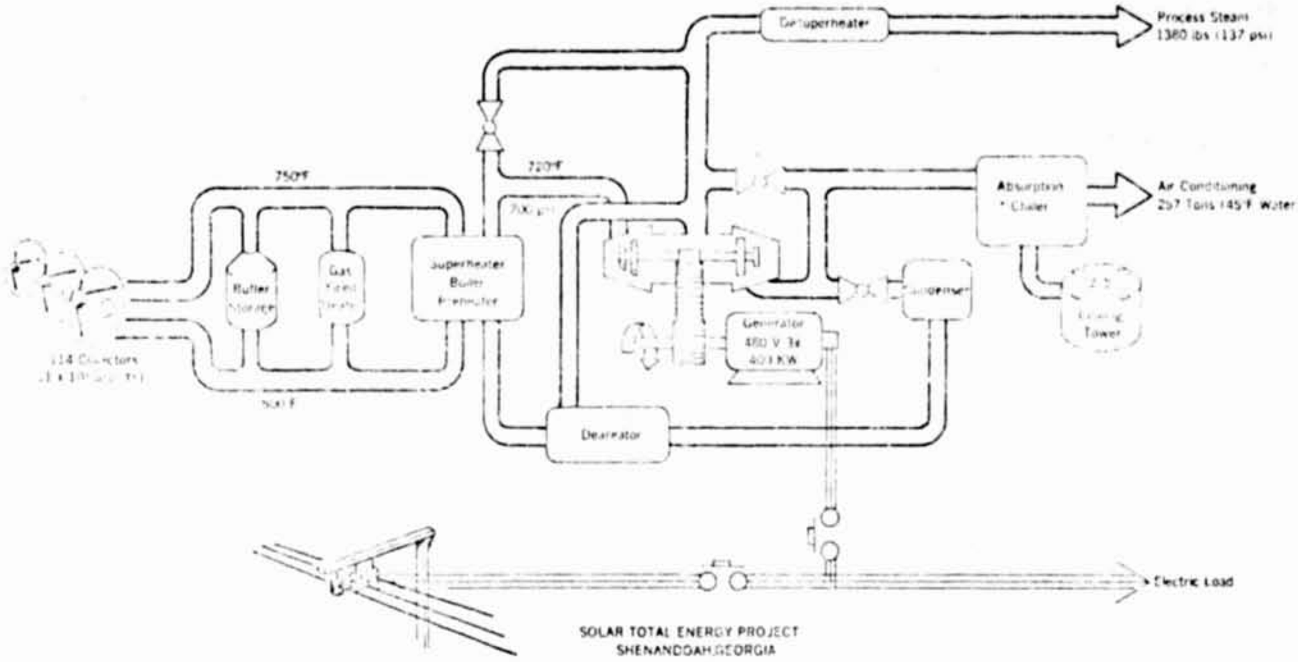

FIGURE 2. BLOCK DIAGRAM, SOLAR TOTAL ENERGY PROJECT, SHENANDOAH, GA

of 1.2×10^4 MJ (11×10^6 BTU) has been incorporated in the system. The solar collector is a 7-meter diameter paraboloid with a cavity receiver. Reflected solar energy is focused onto a coil of blackened stainless steel tubing within the receiver. The total field temperature rise occurs in each receiver (250°F).

The power conversion loop employs a high efficiency/high speed (42,500 RPM) steam Rankine cycle turbine, capable of providing 400 KW_e. Process steam at 630 Kg/hr (1380 lbs/hr) for the knitwear plant is extracted at an intermediate turbine stage. Thermal energy from the turbine exhaust is transferred to the thermal utilization loop for cooling of the Bleyle plant. An absorption air conditioner operating on 230°F steam provides chilled cooling water. In the peak shaving mode, the STES operates with a baseload provided by the Georgia Power Company. Table 1 lists the energy capabilities of the STES.

TABLE 1. STES ENERGY OUTPUT CAPACITY

Electrical:	400 kW_e	
Cooling:	22,000 MJ	174 tons
Process Steam:	630 Kg/hr	1380 lbs/hr (114 psia, 377°F)

High temperature storage is provided in an ASME code carbon steel tank. The tank is 3.04 meters (10 feet) in diameter and 5.47 meters (18 feet) high with a capacity of 41.6 cubic meters (11,000 gallons). Thermal energy storage is provided in 400°C (750°F) heat transfer fluid in a thermocline mode. Approximately

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one hour of storage is provided for solar transient conditions. Storage for extended operation is not intended.

The Control and Instrumentation Subsystem initiates, regulates, and terminates collector tracking, energy storage, power generation, and thermal utilization for heating and cooling of the Bleyle plant. When operating in the peak shaving mode, the CAIS will monitor and regulate the generation of power to satisfy system requirements.

The CAIS consists of a central control console, a central minicomputer, and two remote microprocessor control units. The control system has the flexibility to be operated in a manual or automatic mode, and permits the operator to monitor or control the system functions from the control panel. Color graphic CRTs are employed for data display. Data archiving is performed with magnetic storage tapes and in hard copy form on the computer line printer. The remote microprocessors are programmable from the central minicomputer to allow a high degree of system control and versatility.

SUMMARY

A solar total energy system that uses parabolic dish collectors is being constructed that will have the capability to provide various energy forms, electrical and thermal, to a contemporary industrial facility with 25,000 square feet of floor space. Collector tests have demonstrated that existing fabrication techniques could produce an efficient parabolic dish solar collector. Performance measurements on the 7-meter dish have shown that the specified fabrication tolerances and performance of the full-scale unit can be realized in hardware.