ALO-3994-83/2
(DE84004770)

SOLAR TOTAL ENERGY PROJECT, SHENANDOAH, GEORGIA SITE

Annual Technical Progress Report for July 1, 1982—June 30, 1983

Work Performed Under Contract No. FC04-77ET20216

Georgia Power Company
Atlanta, Georgia

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U. S. DEPARTMENT OF ENERGY

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SOLAR TOTAL ENERGY PROJECT
Shenandoah, Georgia Site

Annual Technical Progress Report for the Period
July 1, 1982 through June 30, 1983

Coordinated by

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for

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Prepared For The United States Department of Energy
Division of Solar Energy
Under Cooperative Agreement No. DE-AB04-77ET20216
(Formerly EG-77-A-04-3994)

CONTENTS

FOREWORD

Although summary and abstract information for the period July 1, 1977 through June 1982 is included, the detailed data in this Report reflect progress and status of the Shenandoah Solar Total Energy Project (STEP) only for the period July 1, 1982 through June 1983.

The following publications, available from the National Technical Information Service (see back of Title Page), contain detailed progress and status reports for the first three years of the Project. They also contain additional information on the socio-economics of the Shenandoah area; weather and insolation statistics; and technical details concerning the factory application, energy-usage monitoring instrumentation; interface drawings; and Solar Easements. This information was crucial to the Site Selection and Design Phases that preceded construction activity in 1981.

- Solar Total Energy—Large-Scale Experiment, Annual Report, July 1, 1977 through June 1978 (ALO-3994-77/3)
- Solar Total Energy—Large-Scale Experiment, Annual Report, July 1, 1978 through June 1979 (ALO-3994-77/4)
- Solar Total Energy—Large-Scale Experiment, Annual Report, July 1, 1979 through June 1980 (ALO-3994-77/5)
- Solar Total Energy—Large-Scale Experiment, Annual Reports, July 1, 1980 through June 1982 (ALO-3994-83/1)

General information on the Shenandoah STEP also can be obtained by writing to:

Manager, Solar Operations
Georgia Power Company
7 Solar Circle
Shenandoah, Georgia 30265

Section 1
CHRONOLOGICAL SUMMARY OF PROGRESS

Following is a chronological summary of key events that occurred throughout the first six years of the Cooperative Agreement. A detailed progress report for the subject reporting period appears in Section 3 of this Report.

1977

May	Cooperative Agreement award announced.
June	Formal meetings—Site Team; Sandia; and Conceptual Design Teams (G.E., Stearns Roger, Acurex).
July	Energy-saving features incorporated into Bleyle plant design.
August	GPC participates in design review as Utility Advisor.
	Concrete flooring for Bleyle Plant poured, insulated roof completed.
	Government-furnished meteorology station installed, operation initiated.
	First set of design interface drawings submitted to Sandia.
September	GPC Team attends design reviews at Albuquerque.
	Interconnection piping task added to Cooperative Agreement.
October	First coordination meeting held with G.E. Design Team.
	Energy measurement program defined; measurement points selected.
	Formal change procedures (Master Index Sheet) instituted for interface drawings.
November	Interconnection Piping System inspected.
December	Knitwear Plant completed, keys presented to Bleyle.
	Plant side of interconnection piping system activated.

1978

January	Bleyle plant begins operation.
February	Mobile Instrument and Visitor Center installed at site.
March	Plans submitted to Sandia for adding eight instruments to Meteorology Station.
	Electrical data collection lines installed.
April	Site surveys completed.
	Solar easement document drafted.
	Initial kilowatt hour data recorded.
May	Rough grading bid package submitted.
	Instrumentation wiring completed, tested.
June	Meeting held to discuss planned expansion of Bleyle Plant.
	Legal document drafted to transfer 5.7-acre tract to GPC.
	Site tour and presentation made to Nevada Power Company and State of Nevada personnel.
	Testimony presented to House Sub-Committee on Government Relations.
	First Energy Data Report submitted, reflecting kWh consumption in Bleyle plant.
July	Groundbreaking ceremony for collector field and open-house held at site.
	Tours and presentations conducted for several groups including Georgia Professional Engineering Society and Governor's honor students.
August	Contract validation and approval of site grading and TTO programs received from DOE.
	Monthly energy data and first computer data tape submitted.
September	Final review conducted for land transfer and solar easement documents.
	Technical Interchange Meeting held.
October	DOE approval received for grading work—bids received for evaluation.
	Site Team meets with WBS-TV (Channel 2) to discuss Met Station; two-minute presentation broadcast on news programs on two consecutive days.
	Bleyle Plant wins Southeastern Electric Exchange competition in Industrial Building Category.
November	New data logger installed by EG&G and GIT personnel; channel capacity expanded from 8 to 16.
	Site clearing work begins: sediment fence installed, drainage trench begun, topsoil stockpiled.
December	Presentations made to Texas Utilities Service Company and other groups.
	Construction of energy dissipator completed.

1979

January	Presentations made to DOE representatives.
	Land Transfer and Solar Easement documents officially recorded in Coweta County Court House.
February	"Energy Challenge" show presented to IEEE, Power Generation Division of Atlanta. Presentation made at meeting of Southern Company Services System Research Advisory Committee.
	Earth moving activities completed at STES site.
March	Series of meetings conducted with GPC and H&H engineers to evaluate Bleyle Plant HVAC system and Energy Measurement and Reporting Programs.
April	Presentations made to several Swedish engineers, Gulf States Utility Company, and representatives from Federal and State governments.
	Grassing of steep slope areas completed at site.
May	Site Team participates in 1979 International Solar Energy Society (ISES) convention; more than 600 attendees from 60 nations tour STES site.
	Grassing of entire site completed.
June	Presentations made to several groups including heating/air conditioning students at Atlanta Federal Penitentiary.
	Scope of Project is reduced and total number of collectors drops from 192 to 120.
July	Meteorology Station in full operation with 16 weather parameters being recorded.
August	Doe-requested soil and pier tests completed.
	STEP personnel participate in Energy Technology Conference at Georgia Tech.
	General Accounting Office conducts Management Audit of STEP site.
September	Final Power Supply Interface System Specifications completed.
October	Final correct operating mode for Bleyle economizer systems determined.
	Efforts started to make all data channels operational.
November	STEP Technical Paper presented at the American Nuclear Society Meeting.

1980

February	Figures for connected load and demand power are agreed upon.
	Mr. R. Hunke of Sandia Laboratories establishes office at STEP Site.
	Bleyle Plant Instrumentation Measuring Program terminated.
March	Location for Power Supply Interface System selected, north of the STEP Mechanical Equipment area.
April	Scope of Project is further reduced: collector field is reduced from 120 (originally 192) to 114, thermal storage system is reduced to a one-hour buffer system, and heating of the Bleyle Plant is removed from the requirements to be met with solar energy.
May	Design of Interconnecting System deferred due to program rescoping.
	Cooperative Agreement Access Road to Site provided.
June	Bleyle purchases building and 2.3 acres of adjacent land for expansion.
	STEP Construction Office and Visitor Center established.
	Weather Station moved to southeast corner of site.
July	Discussions between Sandia and Georgia Power Company resolve schedule changes for installation of equipment in power supply interface.
August	Proposals received for fabrication and installation of collectors.
	System Integration contract placed with Lockwood-Greene, Inc.
	Contract for Construction Inspection Services awarded to Heery and Heery, Inc.
September	Interface meeting held to discuss technical details of solar energy system.
	Plans and specifications for Mechanical Equipment Area received for review.
	Bids opened for Collector Field construction.
October	Modifications made to Cooperative Agreement to provide additional office space and to provide utility services to the trailers.
	Suppliers chosen for major equipment in substation.
November	Bids opened for Mechanical Equipment Area; recommendations made for suppliers.
December	Surveying and other pre-construction activities initiated at the Site.
	Contracts awarded for Collector Field Work and for purchase of collectors.

1981

January	First underground caissons put into place to support collectors.
February	Contract awarded to construct Mechanical Equipment Area.
March	All caissons are completed, and installation of underground piping begins.
	First cost proposal submitted for STEP operations.
April	Work begins to place lower base support frames on caissons; installation of underground piping completed.
May	All support frames installed on caissons; rock and asphalt roads completed.
	Walls of Mechanical Equipment Area erected, and steel roof deck put into place.
June	Collector field is nearly complete, bids taken for high temperature insulation work.
July	Permanent gas lines and phone cables installed, and personnel trailer moved to new location.
	Access roads paved while work on Mechanical Equipment Building nears completion.
August	Work begins for installation of equipment inside the Mechanical Equipment Building.
	Mr. J. Zimmerman of Sandia Laboratories arrives on Site to supervise operation activities.
	Electrical interface substation completed.
September	Cost proposal for STEP operations submitted.
	High Temperature Fluid piping is completed.
	Steam generator arrives at Site.
October	Five-day HTF conditioning tests conducted.
	Large storage tank is jacketed and insulated.
November	Cooling tower, condenser water pump, and chilled water pump installed. Other piping completed.
	Last of 114 collectors is installed, and stripping of protective coating begins.
December	Procedure prepared for conducting steam tests.
	Absorption chiller received, and piping, wiring and equipment installation proceeds.
	DOE and Georgia Power sign Agreement in Principle regarding STEP operations.

1982

January	Steam System Integrity Tests culminate with first generation of electricity to 100 kW level.
February	Insulation of steam generator completed.
	Initial steam is flowed to the Bleyle Plant to condition the insulation.
	Adjustment of collectors to meet acceptance criteria continues, but most are accepted.
March	Two-day inspection of STES conducted by Readiness Review Committee—no problems found.
	Mechanical Equipment Area contractor completes work.
April	Operational status review conducted by DOE, Sandia, and Georgia Power. Provisional acceptance is granted.
May	More than 500 people attend Site dedication ceremonies—generator synchronized to 200 kW and electricity from solar energy is produced for 44 minutes. All collectors are brought into focus for the first time.
June	Absorption chiller is started, leading to cogeneration with 250 kW (electric) and 50 tons of air conditioning (thermal).
	Final 'punch list' work completed by all primary contractors.
	Contract amendment for STEP operations is completed by Georgia Power.
July	Amended Cooperative Agreement is received from DOE. Two-shift STEP operations are initiated.
August	STES provides 600 ton-hours of air conditioning and 5600 pounds of process steam to Bleyle Plant.
September	Control and Instrumentation Subsystem (CAIS) auto-tracks simulated solar conditions and then stowes the collectors.
October	Operations are limited by various anomalies, especially cavitation problems in the Heat Transfer Fluid (HTF) pumps.
November	Water contamination is determined to be the cause of the HTF pump problem, and efforts begin to find the source.
December	Source of HTF water contamination is found in the steam generator, and leaks at the tube-tubesheet interface are welded.

1983

January	Turbine generator operation is resumed, producing 6,700 kWh of electricity, and 27,750 pounds of process steam.
February	At mid-month, 113 collectors operate continuously under CAIS control; 400 kWe generation level is reached.
March	CAIS continues to operate with various levels of success while anomalies are identified and corrected.
April	Two-shift work schedule resumes for the spring and summer, while work continues on updating as-built drawings and writing a system description.
May	Plans for the new Solar Center building are finalized.
June	Significant preparations are made regarding objectives and procedures for the Test Operations Phase.

Section 2
PROJECT OVERVIEW

The Solar Total Energy Project (STEP) at Shenandoah, Georgia, is a cooperative effort between the United States Department of Energy (DOE) and the Georgia Power Company to further the search for new sources of energy.

A part of the National Solar Thermal Energy Program, initially funded by DOE, the Shenandoah Project, shown in Figure 2-1, is the world's largest industrial application of the solar total energy concept. The objective of the Project is to evaluate a solar total energy system that provides electrical power, process steam, and air conditioning for a knitwear factory (operated by Bleyle of America, Inc.). During normal operation, solar energy generates a large part of the electricity and displaces part of the fossil fuels normally used to run the factory and produce the clothing.

Construction of the system was completed early in 1982, when operations were initiated. Solution of unexpected electrical and mechanical problems produced significant information for subsequent system designs. This Section presents an overview of the Project and a brief System Description. A discussion of various anomalies, together with subsequent high quality solar and thermodynamic system performance results, is included in Section 3.

History

In 1977, DOE declared Georgia Power Company the winner among 16 competitors from 14 states for the location and application of the Solar Total Energy Project. The Georgia Power site most nearly met all project requirements regarding weather, accessibility, energy requirements, and other important considerations.

Design work for the solar energy system was completed between 1978 and 1980. Georgia Power provided cost-sharing support and coordination throughout the design and construction stages, and assumed responsibility for operation of STEP in July 1982. It is anticipated that ownership will be transferred to the Georgia Power Company near the end of DOE operational funding in July 1984. The complete STEP schedule is shown in Figure 2-2.

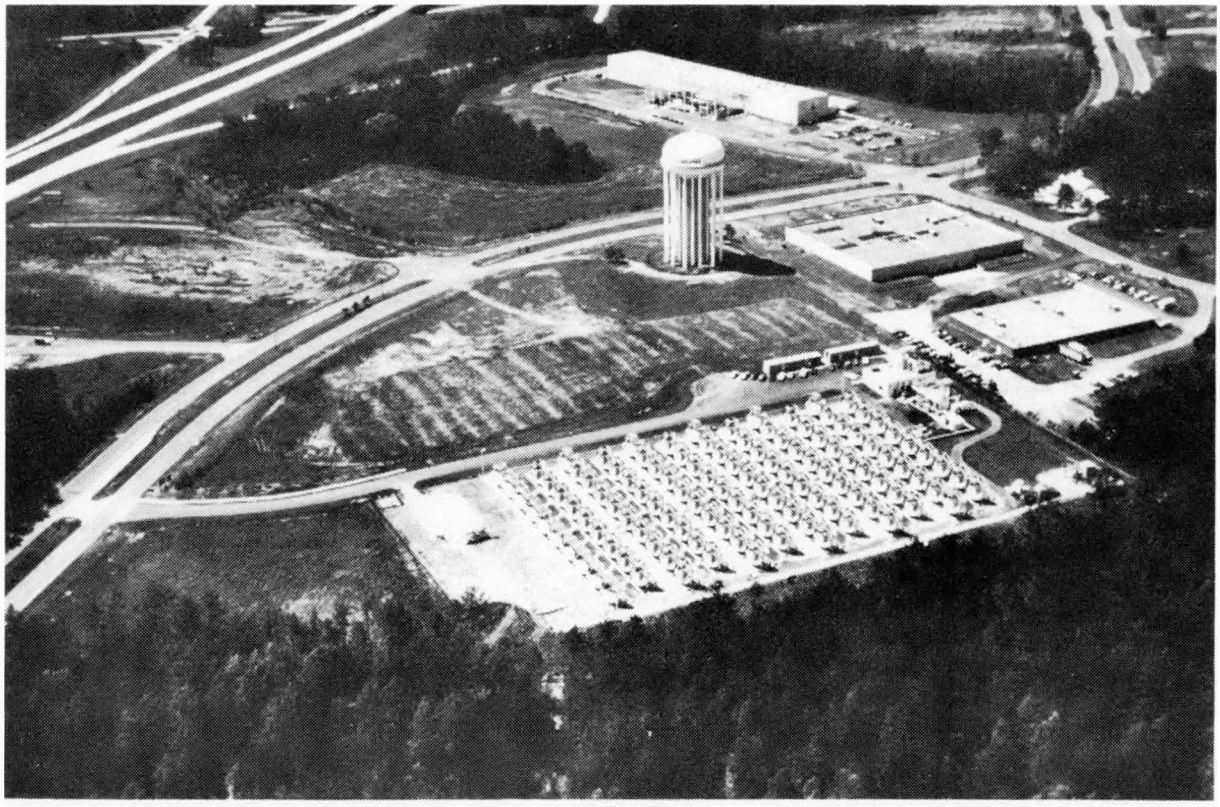


Figure 2-1. Aerial View of Completed STEP Site

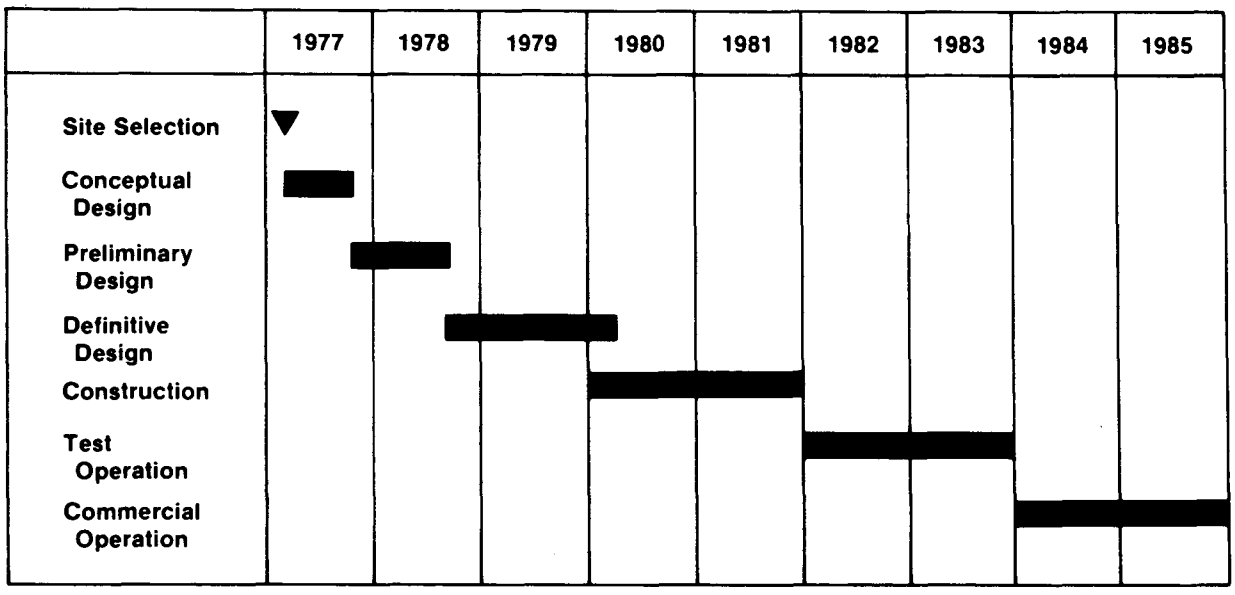


Figure 2-2. STEP Program Schedule Toward Commercial Operation by 1984

In the future, as full owner of the Project, Georgia Power will operate the facility as part of a Solar Center that will include further land acquisitions, additional offices, visitor space, exhibits, and test facilities for research and development of solar energy technology.

The seven-year period comprising site selection, design, construction, operation, and dissemination of cost and performance data (shown in Figure 2-2) will culminate with a period of commercial operation that will complete the original ten-year cooperative agreement signed with Georgia Power in May 1977.

Total Energy Concept

The total energy concept—also called cogeneration—makes maximum use of waste heat from electrical power generation to meet other energy requirements. Combined with a solar energy system, the total energy concept offers these benefits:

1. It provides energy from a renewable source.
2. It makes maximum use of collected energy.
3. Its closed-loop system releases no pollution.
4. It is compatible with existing utility services.

Commercial Application

The 25,000-square-foot Bleyle Knitwear Factory has been operating since 1978 with conventional energy sources. The fully operational solar system is capable of generating 11 billion Btu annually, or 11 million Btu per hour peak thermal energy. This can be translated into 400 kW of electricity, 1380 pounds per hour of process steam at 350°F and 120 psig, and 257 tons of air conditioning, which can be supplied to the knitwear factory. Energy needs beyond the solar derived portion required by the Bleyle Plant are supplied by conventional sources.

The Bleyle Plant building was designed to incorporate DOE and Georgia Power recommendations for achieving energy efficiency:

1. Reduced height to minimize volume of building and wall area
2. Four-foot insulating earth berm as thermal buffer around the building
3. North-south orientation
4. Air conditioning economizer cycle
5. Super insulated walls and roof
6. High efficiency fluorescent lighting
7. Energy efficient equipment

Energy-conserving features alone, exclusive of the solar equipment, have reduced the factory's energy needs by 46%, thus saving more than $25,000 a year (at 1982 utility rates). Data gathered by Georgia Power instruments in the factory were used to determine the building's energy requirements, and this information was used to design the solar energy system.

Figure 2-3. Layout of Completed STEP Site

Site Description

The aerial photograph in Figure 2-3 shows the physical layout of the project site. A field of 114 parabolic solar dish collectors—each 23 feet in diameter—tracks the sun and concentrates the rays to heat a circulating fluid. An easement obtained from adjacent landowners guarantees unobstructed sunlight for the collectors.

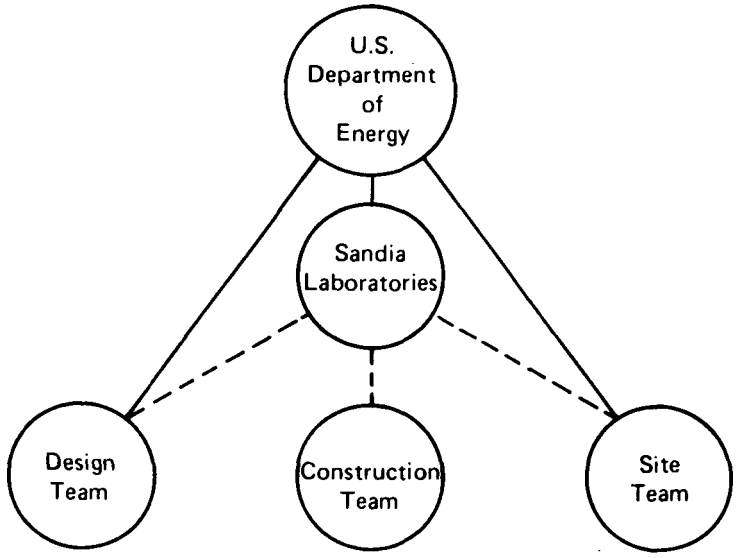
The Bleyle Knitwear Plant is shown in the upper left corner of the photo. Below the plant are the two trailers being used for offices and Visitor Center. The white building at the upper left corner of the collector field houses the operations and control equipment, and the area to the right of the building contains the steam generator, high temperature storage tank, and other mechanical equipment.

A meteorological station at the Site, operated by the Georgia Institute of Technology, constantly monitors the amount of solar energy available. The solar insolation and surface weather instruments make it one of the most sophisticated stations in America for gathering data about the sun. Information collected by the station was used in designing the solar total energy system and will continue to be used to support the national weather network.

A Georgia Power electrical substation (upper right) designed for the Shenandoah project is providing new technology and engineering experience for integrating the electrical output of the cogeneration solar system with the company's 15,000-plus megawatt system.

Participants

The organizations shown in Figure 2-4 participated in the development of the Shenandoah Solar Total Energy Project over the first six years of planning, designing, construction, initial operation, and testing. The diagram illustrates the relationships among the participants.



DESIGN TEAM
General Electric (Valley Forge)
Lockwood-Greene
Scientific Atlanta
Dow Corning Corp.
Mechanical Technology

CONSTRUCTION TEAM
Dow Corning Corp.
L.B. Samford
B&W Mechanical Contractors
Joe North, Inc.
General Electric (Daytona Beach)
Solar Kinetics

SITE TEAM
Georgia Power
Georgia Institute of Technology
Heery & Heery, Architects and Engineers
Shenandoah Development
Owens-Corning Fiberglas Corp.
Westinghouse Electric Corp.
Bleyle of America

Figure 2-4. Overall Organizational Relationship Among Participants in Solar Total Energy Project

Program Objectives

The overall U.S. Department of Energy (DOE) objectives for the National Solar Total Energy Project at Shenandoah, Georgia are to:

1. Produce engineering and development experience on large scale solar total energy systems as preparation for subsequent commercial size applications.
2. Assess the interaction of solar energy technology with the application environment.
3. Narrow the prediction uncertainty of the cost and performance of the Solar Total Energy System (STES).
4. Expand solar engineering capability and experience with large-scale hardware systems.
5. Disseminate information and results.

Site Objectives

The primary objective of the STEP Site/Application effort at Shenandoah is to provide a commercial facility to utilize solar-derived electrical and thermal energy, as well as a suitable area for erecting a solar energy system to provide the required energy to the facility. This includes data acquisition and analysis, as well as design interface.

The objectives of the Georgia Power Company within these parameters are to:

1. Evaluate the significance of an emerging alternate energy technology in an industrial application.
2. Promote the utilization of energy conservation and load management.
3. Consider the applicability of cogeneration facilities.
4. Analyze the economic potential of solar total energy in an industrial application.

The achievement of these objectives will allow Georgia Power Company to better provide reliable, economic and environmentally acceptable energy to the consumers of the State of Georgia and help lead the nation to a partial solution of the energy dilemma.

Project Description and System Design

The Solar Total Energy Project is in Shenandoah, Georgia, 25 miles southwest of Atlanta International Airport, at Exit

Figure 2-5. Geographic Location of STES Site

9 of Interstate 85, as shown in Figure 2-5. The Site consists of 5.72 acres in the Shenandoah Industrial Park adjacent to and east of the Bleyle Knitwear Plant.

A solar total energy system uses collected solar energy to supply high-grade electrical and mechanical energy and low-grade thermal energy for selected applications. The Solar Total Energy Project (STEP) at Shenandoah supplies electric power to a utility grid, and process steam and air conditioning to a knitwear manufacturing facility. Excess power from the STEP is supplied to the Georgia Power Company electricity distribution network.

The STEP is a fully cascaded total energy system with parabolic dish solar collectors and steam Rankine cycle power conversion system capable of supplying 100-400 kWe output with process steam extraction. The design includes the Solar Collection Subsystem, the Power Conversion Subsystem, the Thermal Utilization Subsystem, and the Control and Instrumentation Subsystem, which are monitored to provide the data necessary to evaluate the STEP. Figure 2-6, a simplified schematic diagram of the STES, illustrates the overall concept of cogeneration with solar energy.

Operation: Operation of the system begins with circulation of a heat transfer fluid through the receiver tubes of the parabolic dish solar collectors. Solar radiation is focused in the receivers by the collector reflector and heats the silicone heat transfer fluid (HTF) to 750°F. The heat transfer fluid is then pumped to a heat exchanger. In the heat exchanger, the heat transfer fluid boils water and superheats the steam; the heat transfer fluid then returns to the collectors and the cycle is repeated. The superheated steam drives a turbine that in turn drives an alternator. Steam at 350°F is extracted from the turbine for knitwear pressing. The low-pressure steam exhausted from the turbine is used to produce chilled water for air conditioning, or is cooled as it passes through an air-cooled condenser.

Solar Collection Subsystem: The Solar Collection Subsystem (SCS) consists of an array of 114 parabolic dish collectors, each 23 feet in diameter, shown in Figure 2-7. The heat transfer fluid flowing through the collectors, whose receivers are connected in parallel, is heated from the inlet temperature at 500°F to 750°F. The receiver is a cavity type capable of receiving an incident concentrated solar flux equal to 235 suns. The concentrated solar flux impinges upon the receiver coil's absorptive surfaces enclosed within the insulated cylindrical shell.

Each parabolic dish is made up of die-stamped aluminum petals and was assembled in the field. The aluminum petal is laminated with a second surface—aluminized acrylic reflective film—prior to forming. Each collector tracks individually in polar and declination axes to follow the sun from morning to evening, and from season to season. The para-

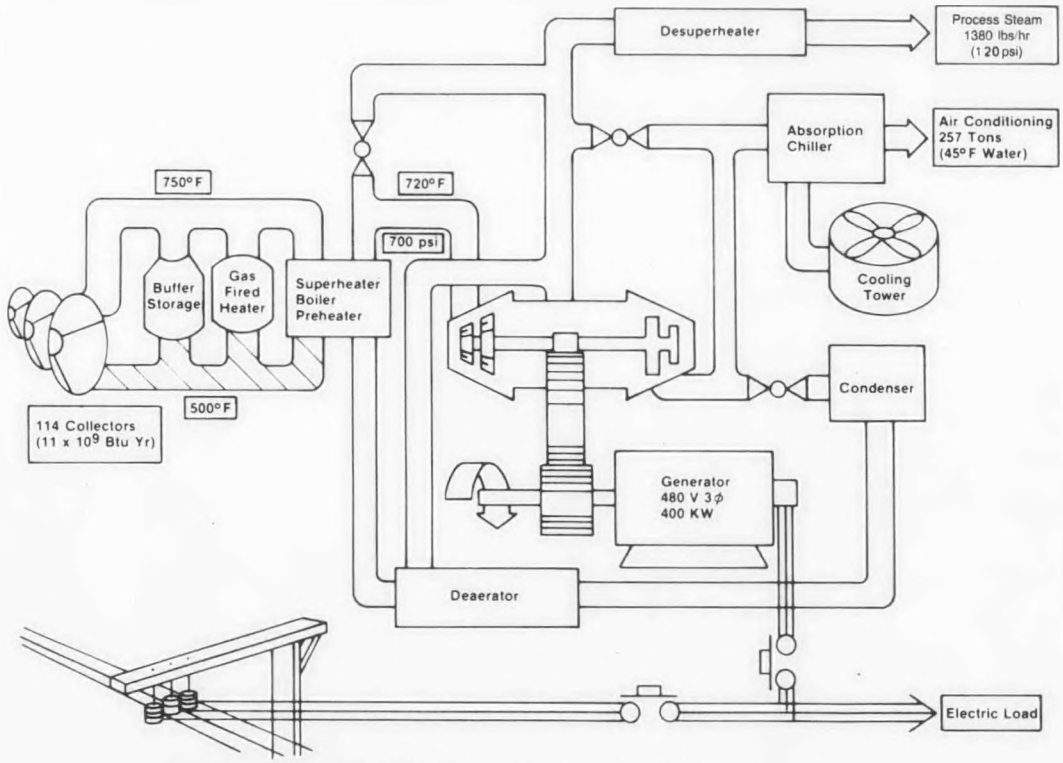


Figure 2-6. Illustration of STES Concept

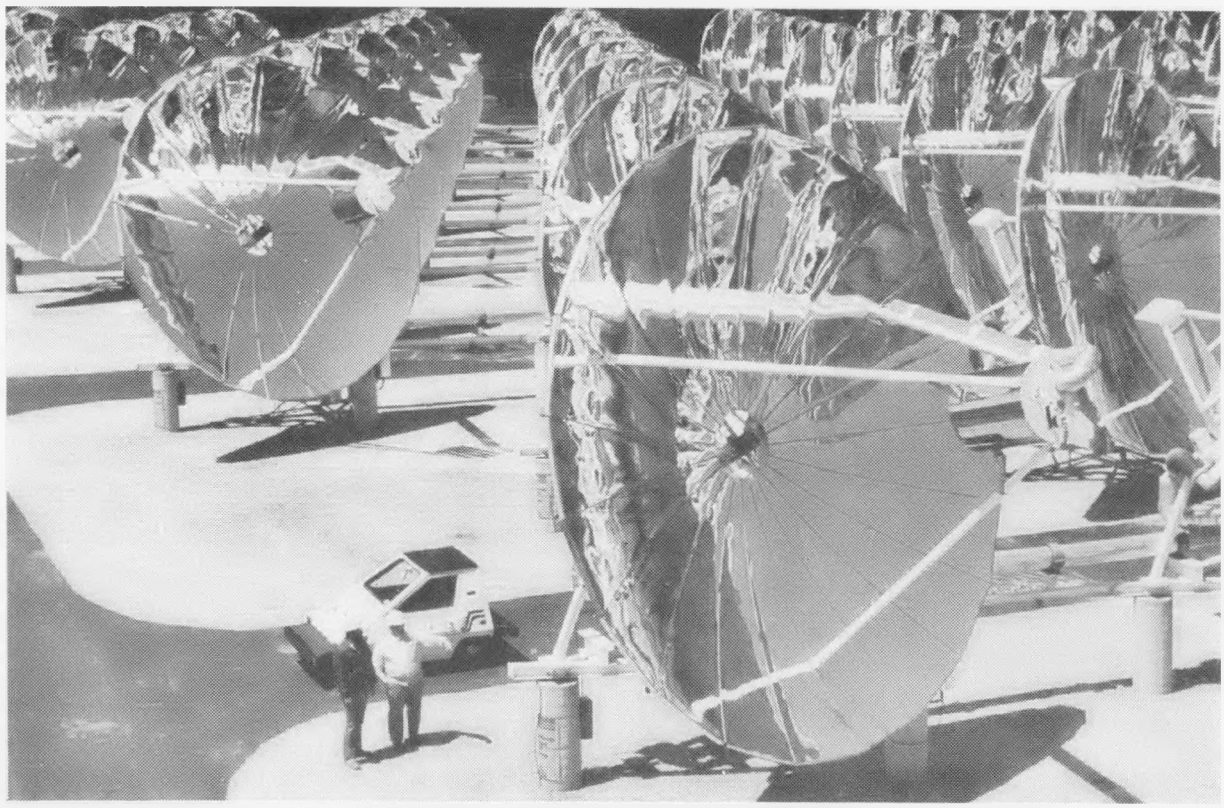
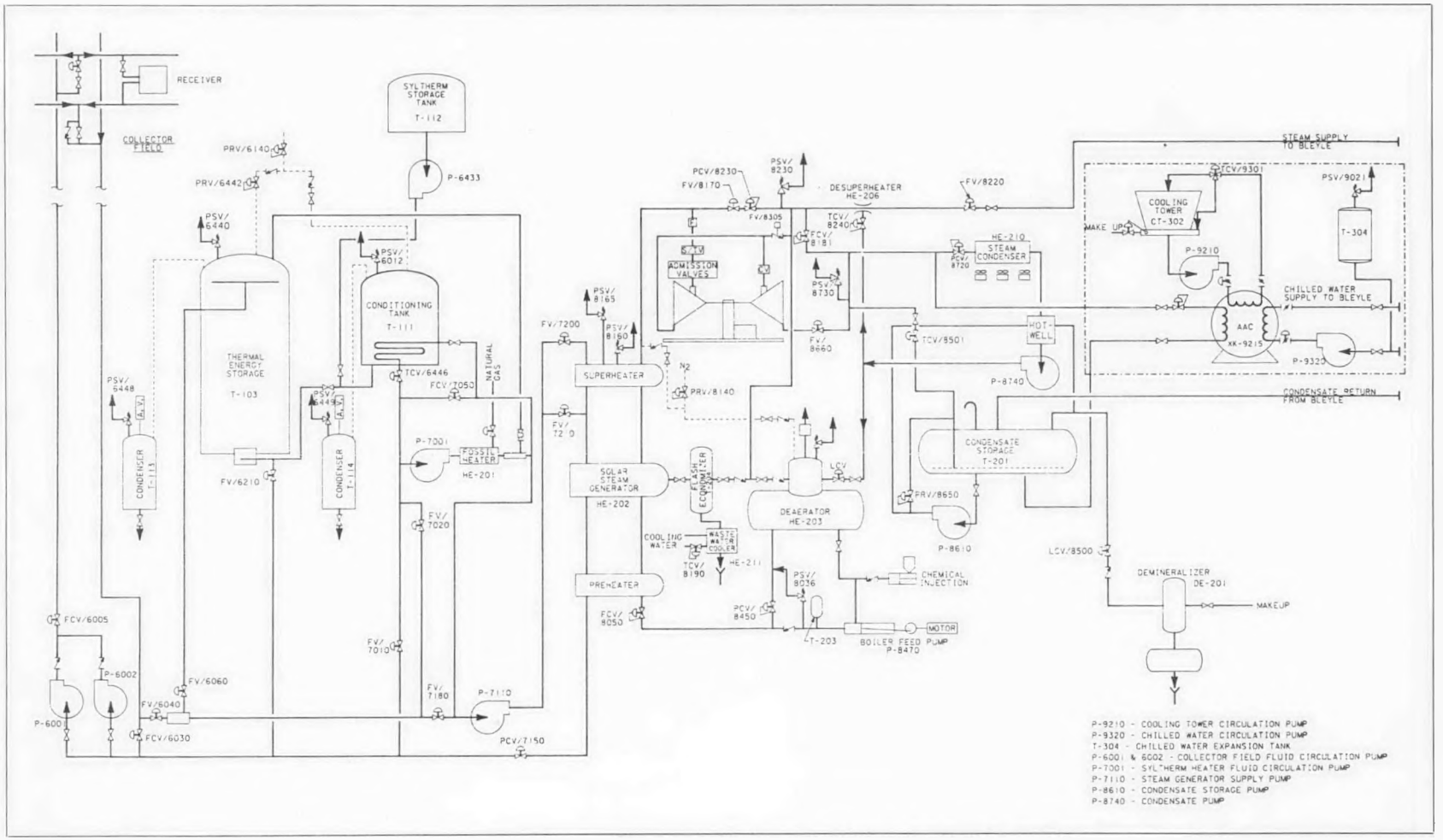


Figure 2-7. STEP Parabolic Solar Collectors

Simplified Schematic Diagram of STES



bolic dish collectors are arrayed on the Shenandoah collector field in a repeating diamond pattern.

The field piping network consists of welded pipes in the main manifolds, and steel tubing in the branches. All are covered with a high-temperature insulation. The SCS provides one hour of thermal storage at 750°F as a buffer against transient solar conditions. Energy is stored in the silicone heat transfer fluid in a thermocline tank. A natural gas fired heater capable of supplying the power conversion subsystem energy input requirements is used during startup and to supplement the solar energy system as necessary.

Power Conversion Subsystem: The Power Conversion Subsystem (PCS) consists of a three piece pool-type boiler with preheater, boiler and superheater, a steam turbine-alternator rated at 500 KVA, an air-cooled condenser and condensate storage tank, make-up demineralizer, deaerator, and necessary pumps. In normal operation, steam at 720°F and 700 psig is generated in the boiler-superheater and delivered to the turbine inlet.

The turbine alternator consists of a four-stage, high-speed (42,450 rpm) turbine, a gearbox that reduces the speed to 1800 rpm, and a 60 Hz alternator. The low pressure side of the high pressure turbine stages has an extraction port for process steam and steam for regenerative feed water heating. The low pressure turbine stages exhaust into an air cooled condenser at 230°F and provides steam to the Thermal Utilization Subsystem (TUS).

Thermal Utilization Subsystem: The Thermal Utilization Subsystem serves as the condensing medium for the steam and the heat source for the cooling of the Bleyle Plant. The exhaust heat from the steam turbine provides the heat input to the Thermal Utilization Subsystem. When the turbine is out of service, steam is provided directly to the Thermal Utilization Subsystem.

The steam from the turbine or the turbine by-pass is routed to the absorption air conditioner. The chilled water produced by the absorption air conditioner cools the cooling water supply to the Bleyle Plant. Any excess steam is circulated through the air-cooled condenser. The condensed water from the condenser and the absorption air conditioner is then placed in the hot well and the condensate storage tank.

Control and Instrumentation Subsystem: The STEP control system provides a full range of operations covering minimum operator control to extensive data collection for analysis of experimental operations. The control system partitions control functions between a minicomputer and its peripheral equipment and micro-processors distributed through the system. These micro-processors exercise some control functions locally. The Collector Control Units (CCU) located at each collector and the Control and Instrumentation Subsystem (CAIS) are connected by redundant serial links. This allows communication among the distributed control system components by a single pair of leads. Other sensors, including the weather instruments, interact with the central control computer through the Energy Utilization Processor (EUP).

The CAIS provides the following:

1. Control of all subsystems and components for normal and fail-safe operation.
2. All control logic for operational modes as selected by the operator.
3. Collection, monitoring of data and processing of information for:
   - Automatic decisions
   - System status information
   - Stored information for subsequent system analysis and evaluation
   - Automatic initiation of safety measures to prevent hazards to personnel, damage to equipment and property, and loss of data

In addition, operator control is provided for experimental modes to characterize system and component performance over ranges of operational parameters and to identify operating strategies for more effective electric and thermal energy displacement. The switch to the experimental modes allows the operator to initiate solar collection experiments, and to monitor and record data. Diagnostic routines may be initiated in the event of a malfunction.

The CCUs perform the following functions:

1. Receive system control information from the CAIS and provide signals to collector field control equipment, such as drive motors and valves.
2. Interpret local data to identify potential hazards and initiate control actions to preclude damage to the collector.
3. Maintain proper sun tracking automatically once sun acquisition by central computer has been established.
4. Relay data from local instruments to the CAIS for further processing or storage.

System Loads: The STEP loads include electric loads and process steam and cooling for the knitwear manufacturing facility. The design loads used to size the STEP are summarized in the following table. Except for lunch and shift breaks, the knitwear manufacturing facility electrical load profile is relatively constant over a one-shift operation.

Process steam at saturated conditions is required during all working hours.

	Peak Load Requirements For Knitwear Manufacturing Facility	STEP Capacity
Electrical	161 kW	400 kW
Cooling	1420 Mj (113 tons)	3260 Mj (257 tons)
Process Steam (177°C, 350°F)	626 Kg/hr (1380 lbs/hr)	626 Kg/hr (1380 lbs/hr)

The cooling loads consist primarily of internal heat generated by the process steam, machinery, people, and building lighting and are relatively constant during plant operating hours. The plant's heating, ventilating, and air conditioning (HVAC) system incorporates an economizer cycle that supplies a portion of the cooling load during the winter months. The cooling loads are met by a chilled water system supplied by an absorption chiller.

The total number of heating degree days for Atlanta is 3,095, and the total number of cooling degree days is 1,595 (using 65°F as a base). The heating season generally extends from October to April, with occasional heating required in May and September. The cooling season extends from May through September with occasional cooling required during March, April and October. This balanced situation allows research data gathered at Shenandoah to be generalized for much of the United States.

Collector Field: Portions of the collector field are surfaced with blacktop for vehicular access. The main collector supply and return lines are constructed of ASTM-A106 Schedule 40 welded pipe and run in an east-west direction. The branch lines to the individual collectors, constructed of ASTM A-192 seamless steel tubing (welded), run in a north-south direction.

The Mechanical Building is in the southwest corner of the Site. The building contains the control room, motor control center, absorption air conditioning unit, and turbine alternator. Located north of the building is the heat transfer fluid storage and conditioning equipment, including the large thermal energy storage tank, the fossil-fuel-fired heater for the fluid, the steam generator (unfired boiler), and the collector field circulating and boiler pumps. The hardware is on a concrete pad with provisions for containing spills, and the drain system contains a separator for reclaiming the fluid. Also contained in this area is the unfired boiler's ancillary equipment. All the equipment is insulated and sealed for outdoor application.

Knitwear Manufacturing Application

The Bleyle Knitwear Manufacturing application for the STES at the Shenandoah Site offers a high degree of rapid and widespread commercialization, it requires energy beyond the sunlight hours, and it provides a usage for any desired degree of thermal storage incorporated into the STES. In addition to its use of electrical energy and cooling requirements, the plant requires approximately 1000 lb/hr of low temperature process steam for pressing clothes.

Meteorology Station

In the design of advanced-concept solar energy systems such as the Solar Total Energy System in Shenandoah, it is important that a comprehensive and accurate solar data base be available. This is important since many of the design decisions are based on estimates of system performance in specific modes of operation under representative "normal" and "extreme" conditions. In addition, concentrating solar collectors such as those in the Shenandoah Total Energy System can effectively collect only the direct component of solar radiation, which to date has been measured at only a few research sites across the United States.

The original weather station, installed at ground level, consisted of eight solar radiation and surface weather instruments, appropriate mounting or support structures, and a compact, portable, cassette tape data logger. Figure 2-8 shows the meteorology station as it exists today. The following table lists the original instruments and the variables they measure:

Instrument	Variable
1. Pyranometer (horizontal)	Global radiation
2. Pyrheliometer	Direct normal radiation
3. Pyrheliometer	Direct normal radiation
4. Resistance thermometer	Dry bulb temperature
5. Humidity cell	Relative humidity
6. Cup anemometer	Wind speed
7. Wind vane	Wind direction
8. Pressure transducer	Barometric pressure

Each variable is measured at one minute intervals, 24 hours per day, and the results are stored on small digital magnetic tape cassettes.

The station was originally installed on a fenced concrete pad located at ground level at the center of the southwest quadrant of the Total Energy System collector field (it has since been moved to the southeast corner).

The logger operates from a common power source but is capable of operation from batteries for up to 45 minutes. At

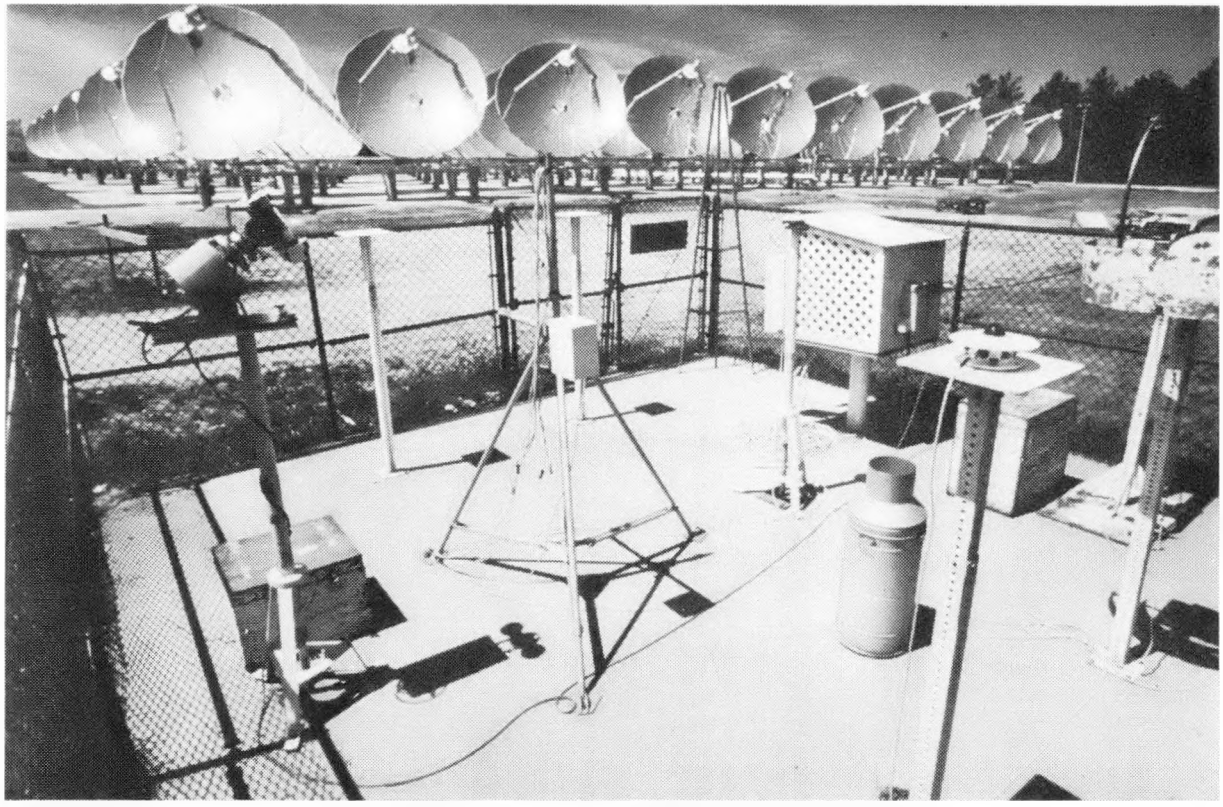


Figure 2-8. Shenandoah STEP Meteorology Station

a recording interval of one minute, the logger can record data from the eight instruments for a little more than ten days before a cassette is filled.

The following table describes new equipment added to the Meteorology Station as part of the Southeastern Regional Solar Meteorological Research and Training Project at Georgia Tech, and under subcontract to GPC.

Instrument	Variable
1. Pyranometer (unshaded)	Global radiation
2. Pyranometer (shaded)	Diffuse radiation
3. Pyranometer (tilted 34°)	Global radiation on latitude plane
4. Pyranometer (CSIRO)	Net radiation
5. Rain gauge	Rainfall
6. UV pyranometer	Ultra-violet radiation
7. Nephelometer	Turbidity

Section 3
DETAILED PROGRESS REPORT

This section contains a detailed, chronological record of activities at the Shenandoah Solar Total Energy Project over the subject reporting period (July 1, 1982 through June 30, 1983). This information is provided under the terms of Co-operative Agreement No. DE-AB04-77ET20216 in fulfillment of requirements for reporting and information dissemination.

Progress is reported in each of the primary task areas (where appropriate) under the terms of the Agreement:

- Acceptance Testing
- Test Operations
- System Performance Analysis
- Maintenance
- Personnel and Training Services
- Information Dissemination/Technology Transfer

Following is a summary of STEP energy production, energy usage in the Bleyle Knitwear Plant, and insolation data for the entire reporting period. This information is provided as a frame of reference for the summary of activities that makes up the remainder of Section 3.

STEP ENERGY PRODUCTION

Month	kW/hr generated	Ton Hrs produced	Process Steam (lb) produced	Therms Nat. Gas For Fossil Fired Heater
July	4600	2500	—	6194
August	3400	6000	50700	6824
September	0	8600	121500	9887
October	0	4048	61040	7093
November	0	665	10925	1430
December	0	0	0	1734
1982 Total	17852	21813	244165	53777
1983				
January	7295	0	30500	6112
February	27757	629	79021	15110
March	31028	3593	85208	11559
April	45226	4551	104038	18720
May	34249	7517	91857	16279
June	42203	12655	118291	28435

BLEYLE KNITWEAR PLANT

Month	kWh (Total)	kWh (HVAC)	Therms Nat. gas for process heat
July 1982	53680	29690	1779
August	31840	14996	914
September	36400	14600	546
October	32240	12386	788
November	36560	13222	1533
December	34800	11075	1867
January 1983	28000	3301	898
February	32800	4965	799
March	30160	7716	912
April	32000	7782	388
May	43920	14794	816
June	46960	19768	505

STEP Year-To-Date Monthly Direct Insolation

	Empirical		Solar Model Year	
	Avg (Btu/ft^2/day)	Sigma	Avg (Btu/ft^2/day)	Sigma
January 1983	947	842	926	833
February	839	956	1328	1020
March	1059	1012	1444	879
April	1492	1099	1602	925
May	1098	955	1675	895
June	991	822	1547	788

ACTIVITIES FOR JULY, 1982

Test Operations

During July, the DOE/GPC amended cooperative agreement was received and reviewed by Georgia Power Legal and Equal Opportunities Departments, and comments were transmitted to DOE for resolution.

Two-shift STEP operations were initiated (6 a.m. to 10 p.m.) to maximize training operations time and to control final checkout and optimization for the balance of plant systems. Extracted steam was supplied to the Bleyle Plant system for a major blowdown and flush with STEP steam at 1500 lb/hr. Samples were taken and analyzed at Plant Yates to validate that STEP water chemistry is compatible with polyester and wool fabrics.

General Electric provided several man-days of support in correcting anomalies of the Control and Instrumentation Subsystem (CAIS), and continued software analysis on site and at other locations to provide a workable collector control program.

A recommendation for instrumentation calibration was developed by Georgia Power Company instrument technicians, as a basis for a Standard Operating Procedure (SOP). An Auburn University proposal for support of analytical work during Test Operations was presented to DOE for approval.

Lockwood Greene completed and delivered the first draft of the three volume Operating and Maintenance Manual set for comments from Sandia, DOE, and the Georgia Power Company, while the STEP System Description was being prepared by Sandia.

Differential pressure transmitters were installed in the field supply and return manifolds just north of the mechanical building area, and wiring to the Control Room was planned for the following month.

Also during July, a lightning strike near the STEP momentarily interrupted power and damaged a Buffer Control Unit, but the damage was repaired and all systems operated properly. During startup the next day, several items had to be reset: variable speed on auxiliary cooling water; safety devices on fossil fired heater; absorption chiller power; and cooling tower fan.

The following anomalies were experienced and corrected during July:

- The steam generator sight glass, which cracked after two days of cooling, was replaced.
- A boiler feedwater pressure relief valve failed for a second time on July 26, effectively shutting down steam operations for the last five days of the month. The problem was in the design (positive displacement pump and its rapid pressure fluctuations), and the valve was repaired and reinstalled.
- A coupling on a waste water pump failed and had to be replaced.
- The computer system failed to respond several times due to excessive heat in the Control Room, and correction action was taken.
- A problem developed with potentiometer coupling pins falling out of the declination shafts of the solar collectors. Four were reinstalled, and the others were monitored. These nongrooved pins were replaced with superior, grooved pins.
- The solar collectors were moved to an offset track position (on the sun declination and 15° from the sun in polar) for the first time by CAIS program, but further computer control was limited by potential hardware and software problems.
- The reflective film on 15 solar collectors was damaged when stray concentrated light from adjacent collectors focused on the backs of the affected collectors. Operation of all collectors was modified to prevent recurrence, and all collectors with melted film were repaired.
- A redesigned accumulator was installed, but the error associated with the original Vitron bladder caused the steam system to be down for 17 days (June 22 to July 9).
- A control anomaly that prevented the successful tracking of the sun was eliminated; a failed microprocessor was repaired off-site; and a transducer, which failed for a second time, was replaced.

In other events during July, the roadway above the French drain at the north end of the collector field was sealed, and subsequent rainfalls were adequately handled. Grass was planted east of the collector field, all construction contractors completed work, and construction files were turned over to Sandia. Fire extinguishers and breathing apparatus were being checked on a regular basis, and various filters were replaced during routine maintenance.

Information Dissemination/Technology Transfer

In July, activity continued at a high level as the STEP neared operational status. Representatives of Georgia Power visited the site for information before preparing a proposal for a 10-minute audio/visual presentation to re-

July, 1982

place the outdated "Energy Challenge" slide show, and the GPC Publications department completed a photographic layout for a high-quality brochure to be given to special visitors.

Also in July, a representative of the Southern Solar Energy Center was given a tour and presentation. With the change of status of the SSEC (from a DOE-funded operation to a private corporation), its emphasis becomes stronger in soliciting business programs from private organizations. Insights West also visited as part of a Gas Research Institute-funded study on the impact and business potential of solar industrial process heating systems relative to the gas industry.

Following is a summary of additional site visits and presentations for July:

- Meridian Corporation was provided material for use in a STEP energy report per DOE request.
- Walter Kidde Company was provided with information, as requested by phone, and a site visit was arranged.
- Six textile manufacturers visited and participated in a discussion of solar energy applications in their industries.
- Mississippi Power visited for a tour and discussion of solar energy.
- *Gwinnett Daily News* visited in preparing a newpaper article: "Shenandoah—A City for Sale in Georgia."
- A Chinese scientist, visiting Georgia Tech, toured the facility.
- Commercial Systems Laboratories visited and was given a presentation (interest was expressed).
- Ebasco visited relative to STEP operations support and analysis.
- Twenty-eight minority engineering students from Auburn University were given a presentation and tour.
- BDM Corporation visited as part of another solar energy project.
- Lester Laboratories visited to discuss water treatment.
- Women of Georgia Power were given a presentation and tour as part of their monthly meeting.
- Enertec, which was planning to announce the development of a line of parabolic trough collectors, received a tour.
- Nagai Asbestos Co. and Kumamoto University were given presentations and tours, as was a second Japanese group.

ACTIVITIES FOR AUGUST, 1982

During August, 1982, a Georgia Power Executive Vice President and three associates were given a presentation and tour in preparation for a visit by Wall Street analysts to the STEP site in September. A DOE representative also visited the site to discuss a broad range of activities including system document requirements, status of operating manual, and resolution of remaining issues of the contract amendment for operations.

Significant progress was made in STEP computer programming for both new and modified programs, and efforts continued to achieve computer control of the collectors.

On August 26, the Solar Total Energy System provided 600 ton-hours of air conditioning and 5600 pounds of process steam by semi-manual operation of the collectors. During August, thermal energy was provided on 13 days. The Power Conversion Subsystem and the Thermal Utilization Subsystem were operating well.

Considerable work was done by the Georgia Power Company Human Resources Department, Legal Department, and Solar Operations group to provide DOE with an acceptable Small Business Plan.

Georgia Power Company's Telecommunications Department made a recommendation for a communication system to be used within the STEP collector field. Temporary units were provided, and a permanent set was ordered from the Columbus Division.

Also during August, the following anomalies were addressed and resolved:

- A deaerator developed a leak that prevented steam generation. Failure of the deaerator level valve was determined to be the problem, and it was resolved.
- The refractory ring in Fossil Fired Heater (FFH) was replaced; the unit failed because of inadequate heatup time in the programming cycle. Georgia Power Operations provided a necessary line truck for removing and reinstalling the 800 pound FFH cover.
- The continuing problem of cavitating pumps was determined to be due to cyclics formation within the heat transfer fluid. A solution from Dow Corning was implemented.
- Collector 1209 developed an alignment problem with solar evacuator No. 2; the cause was unknown, but a repair was made by Sandia.
- Following boxing of collectors, 18 polar or declination potentiometers were checked for slipping or calibration. Following repair, all collectors responded satisfactorily.
- During computer checkout operations, relief valves on the FFH operated when field pumps operated with an abnormal valve lineup that resulted in an overpressure. No damage was experienced, and only a few gallons of oil were lost.
- Permanent piston packing was replaced on the boiler feedwater pump to replace temporary packing that was utilized to reduce a leak.
- The boiler feedwater pump pressure relief valve failed and was repaired, and a microprocessor, which failed twice, was returned to the supplier for repair.
- A leak in Bleyle's condensate tank on August 12th made the STEP process steam the only source for 1.5 days. Because of this leak, the tank had to be replaced.

Progress on resolving CAIS anomalies picked up considerably toward the end of August with development of total collector field simulation and better initiation of auto tracking. The following new programs and program modifications to the CAIS software were completed by the STEP team:

New Programs

1. Heating the High Temperature Storage Tank

File Name: HTSBTU

This program heats the High Temperature Storage Tank (T-103) fluid to a desired temperature specified by the operator. It configures the system properly for heating the tank. Then, after the desired temperature is reached, it allows a one hour cool down period for the fossil fired heater. Also, it monitors the pressure of T-103 and gives a high pressure alarm to indicate over pressure of the tank.

2. Cooling the Steam Generator and Fossil Fired Heater

File Name: COOLT

The operator is given the option of cooling the steam generator or the fossil fired heater or both. This program monitors the area to be cooled and determines the most efficient operating times to cool the desired area. Through operator and computer interaction, the system is configured, then cooling begins. The purpose of this program is to aid the operators when plant maintenance demands cool equipment.

3. Equipment Operating Data Points

File Name: DATA

Analysis of plant efficiencies and equipment trouble is aided by this program. It provides current readings of

operating conditions with a brief description beside the data point. Both the analog and digital signals are provided.

4. Bringing the Plant to a Shutdown State

File Name: SHUTDN

This program shuts down the plant in an orderly fashion. It shuts down both the Slytherm/steam systems and the collector field system. It is the coordinating program for several smaller tasks.

Note: Shutdown of the collector field system has not been tested.

5. Steam System Normal Shutdown

File Name: BOPNSD

This task terminates steam production in an orderly fashion. It also uses any latent energy in the steam generator to continue to provide Bleyle with process steam and chilled water. The operator is updated and appropriate alarms are active during this phase.

6. Collector Field Coefficients

File Name: 115

This basic program, written for the Tektronics 4054, computes the calibration constants for each collector. The program requires tracking data from each collector.

Program Modifications

1. Due to the location of temperature transmitter TT6600, a thermal siphoning program exists before the collector field pumps are started. This causes the computer to request solar derived steam too early. Corrections were made to programs MODEA, BOPSEQ, and FISUP to correct this problem.

2. Corrections were made to the programs MODEF and MOSTPR to follow the steam system pressure change response time more closely. Before the changes, the computer would simply request a steam pressure, then continue to ramp to a new set pressure. Now, it waits until the system has reached the set pressure before continuing.

3. The program print, which prints alarm messages, was reworked to clarify alarm conditions. Before the changes, it simply told the operator that a particular transmitter had an alarm condition. Now, it informs the operator of the alarm set point, which system the transmitter is associated with, and the time of the alarm in most cases.

4. The turbine trip routines TETRIP and TRIP2C were modified to prevent over pressurization of the steam generator.

Also during August, Crane Packing assisted in replacing bearings and seals on the steam generator pump and instructed personnel in the proper method of aligning the pump and motor. A new graphite type seal was ordered to replace the previously used tungsten carbide seals. A problem with P-7110 leaking at high temperatures (above 700°F) continued.

Instrumentation wiring was installed for the differential pressure transmitters for the flow nozzles in the field supply and return manifolds just north of the mechanical building area.

At month's end, 200 gallons of heat transfer fluid were conditioned and added to the Thermal Storage Tank to replace losses. The fluid was being conditioned in T-103 at night, following normal operation of the system in thermal Mode C during the day.

A DC voltmeter was installed to monitor electric power generation as a function of Woodward controller operation, fiber optic cables were replaced on solar collector No. 205, an acid pump on the demineralizer was cleaned to attain proper operations, and fire extinguishers and breathing apparatus were checked in accordance with the monthly inspection schedule.

All Heery & Heery Construction Inspection activity was concluded when the construction files were officially accepted by Sandia.

Information Dissemination/Technology Transfer

In August, a presentation on STEP status and outlook was given to 140 attendors of the EPRI Wind and Solar Power Conference. EPRI reiterated a desire to finalize a cooperative effort with Georgia Power to gather technical data for assessment by the U.S. electric industry.

A new brochure, with the latest photography, was completed in August by the Georgia Power Company. This material will be used to further develop solar industrial applications in Georgia as a part of the commitment to DOE to pursue solar thermal systems.

Following is a summary of additional STEP presentations and tours:

- Southern Mississippi University toured the facility in preparation of a solar industrial process heating book that will include the Shenandoah solar cogeneration system.

- The Southern Company End Use Research Committee held a meeting on site, 27 senior citizens were given a

presentation and tour, and Southern Tech visited relative to a research paper.

- Eleven new Georgia Power Residential Marketing Representatives toured the facility.
- Georgia Power Company Power Generation was on site to discuss additional areas of support to STEP from within the Department.
- A presentation was given to the American Solar Energy Society's Passive Conference at the request of Georgia Tech.
- Solar Energy Economics visited to discuss the economic feasibility of STEP as compared to various generic types of solar thermal systems, as part of a DOE study.
- An alcohol producer visited to discuss possible alcohol production using excess solar thermal energy that results from no operation at the Bleyle Plant on weekends.
- YKK research and energy management personnel were given a presentation and tour.
- The General Manager of Georgia Power Company's Management Information Systems visited for a briefing and to make arrangements to hold a staff meeting on site.

ACTIVITIES FOR SEPTEMBER, 1982

Test Operations

On September 12th, 1982, under computer simulated solar conditions, the Control and Instrumentation Subsystem (CAIS) auto-tracked and stowed the collectors. On the 17th, one branch of the collector field was brought into focus by the PDP 11-03 Buffer Control Unit under control of the CAIS.

Analog simulator and switchable DIPs and DOPs (digital inputs and digital outputs) were installed at the terminal board panel and computer interface panel. These controls, developed by Sandia National Labs, manually operate the Balance of Plant (BOP) so that the CAIS can run separately without being involved with the BOP operation. The controlled device can be "off" (closed), "on" (open), or under automatic control.

Discussion continued with Auburn University on two research proposals to increase the scope of university participation to achieve the major goals of performance analysis and information dissemination.

On September 23rd, 1982, 112 of the 114 solar collectors manually auto-tracked. For 7.5 hours that day, solar energy was produced and used for chilled water production for air conditioning and process steam for pressing clothes. With a nominally bright sun, 10 x 10^6 Btu/hr of solar steam was produced by the auto-tracking collector field. Potentiometer correction factors were obtained for about 30 solar collectors, and significant progress was made in generating correction factors for all solar collector potentiometers.

The heat transfer fluid in T-103 was conditioned to 750°F, as approximately 2,000 gallons of cyclics were removed. Dow Corning provided 60 gallons of additives for use in the heat transfer fluid conditioning, but the cavitation problem continued occasionally on all four oil pumps.

Also in September, DOE representatives visited STEP for final contract discussions and observation of collector field control operations, and Newnan Computer Services met with the STEP staff to discuss potential computer programming service.

The following anomalies were addressed and corrected:

- Eleven collector control units failed and were repaired. Defective repeaters and cracked pots were the major sources of failure.
- The Digital Equipment Corporation DEC PDP 11-34 computer overloaded, and real time control and display were slowed to the point that the operators were unaware of changes that occured in the system until minutes after they occurred. A change from this computer to a DEC PDP 11-44 system with a larger memory allowed operation of the entire system safely and efficiently. Sandia handled necessary planning and implementation.

Air conditioning and process steam provided by the STEP increased significantly, but no kilowatt hours were generated because of problems associated with heat transfer fluid and seal leakage on P-7110, and interference with the effort to resolve the CAIS anomalies to allow operation of the collector field.

Also during September, the following activities took place:

- The spring was changed in the nitrogen regulator increasing setting of T-103, High Temperature Storage Tank, to 10 psig.
- Lockwood-Greene completed the hand valve identification design. Permanent micarta tags were installed to identify all hand valves and other valves.
- Two covers for the upper basins of the HVAC cooling tower were installed to prevent algae formation.
- Mode C Operation (thermal energy only) was demonstrated under control of the Control and Instrumentation Subsystem.
- A manifold was added to condense the cyclics removed from the High Temperature Storage Tank.
- Samples of condensate return from Bleyle were taken and sent to Georgia Power's Plant Yates for analysis. Because the results indicated satisfactory condition, the condensate was returned to the condensate storage tank.

Georgia Power Company discussed possible computer programming assistance at STEP to support updating the Program Design Listing, computer upgrading, and future maintenance.

At the end of the month, Georgia Power signed Cooperative Agreement No. DE-FC04-77ET20216 (formerly DE-AB04-77ET20216) with the U.S. Department of Energy. DOE's signature finalized arrangements at the Solar Total Energy Project for completion of the test operations program.

Information Dissemination/Technical Transfer

In September, a representative of Grumman visited the site to discuss a presentation of STEP system operation to the Solar Energy Industries Association (SEIA) meeting, the 8th Annual Conference and Exhibition, to be held in Atlanta

on November 7-10. Other visits and activities included the following:

- M & E Contractors visited to discuss solar business opportunities.
- The NRECA in Washington requested slides.
- Fritz Kleine, a German journalist attending the World Energy Engineers Conference (WEEC) in Atlanta, visited the site.
- Four members of the Nashville Power Board were given a tour.
- A presentation was given to Wall Street Security Analysts as part of a Southern Company meeting.
- A review of Shenandoah activities were presented to 25 Korean industrialists visiting this country relative to possible business ventures.
- Marketing Masters International discussed use of its display boards at the Shenandoah site.
- The Solar Lobby in Washington was provided requested information concerning STEP operations.
- Material and slides were given to Dow Corning for a presentation to a technical meeting in Michigan.

ACTIVITIES FOR OCTOBER, 1982

During October, 1982, operation of the Power Conversion Subsystem was limited due to: (a) the leaking Heat Transfer Fluid (HTF) seal on the steam generator pump (P-7110); (b) the CPU limitation of the DEC PDP 11-34 computer; and (c) the HTF pumps' cavitation problems.

A newly designed seal resolved the leak problem at P-7110, and a PDP 11-44 was ordered to eliminate the operational limitation with its larger memory capacity (twice the size of the 11-34). Dow Corning worked closely with the STEP staff to take care of the HTF fluid problem. In an attempt to eliminate cavitation problems, a third barrel of inhibitor was added to HTF system.

Discussions were held with representatives of Westville Oil (Indiana), a user of Syltherm 800 HTF in a heat transfer system. They indicated the need to use the HTF at a higher pressure for prevention of pump cavitation, which would require a major mechanical change for the STEP. Four engineers from Dow Corning investigated the problem.

The Balance of Plant operated for significant time in Mode C (thermal energy mode). On October 15th, a typically good autumn day in Georgia, the solar collectors autotracked for 9 hours, 23 minutes and provided 38 x 10^6 Btu/hr of energy. Sandia utilized the data as part of a presentation to DOE's Solar Thermal Technology Semi-Annual Review at Livermore, California.

Acceptance Testing

Acceptance testing was limited in October. The Balance of Plant (BOP) was operated in a Mode C configuration during the month. Since the leaking seal on the steam generator pump (P-7110) prevented the generation of high temperature steam, the turbine-generator was inoperable. With the CPU limitation of the PDP 11-34, it was impossible to run more than the BOP on Mode C, the turbine-generator, or the solar collector field under control of the computer. Performance of the system acceptance tests for the remaining four acceptance tests under control of the computer were not possible until the PDP 11-44 was operational. These four acceptance tests are:

a. Mode A—turbine-generator and process energy (steam and chilled water) to Bleyle with the fossil fired heater (FFH) as a heat source.

b. Mode B—turbine-generator only—with FFH as a heat source.

c. Mode A—with the solar collector field as a heat source.

d. Mode C—thermal energy only—with the solar collector field as a heat source.

Test Operations

Three members of Georgia Power Company's Power Generation Department visited the STEP site to consider support of computer debugging and maintenance. Hiring of a full-time person with computer experience was recommended.

An in-depth analysis of the HTF and steam system was completed in October, and 75 oil samples were analyzed by Dow Corning. Water samples were closely checked by Mogul and Georgia Power Company (Plant Yates).

System Performance Analysis

Shenandoah operations for October 15th are summarized in the following table. During this typical day, 72 percent of the air conditioning and 71 percent of the process steam were provided to the Bleyle Plant by solar derived energy. Figures 3-1 and 3-2 illustrate the distributions.

Collectors in Focus	9 Hours 23 Minutes
Sunlight	11 Hours 22 Minutes
Constant Flow in Collector Field	235 GPM
Collector Temperatures	Up to 650°F
Collectors Operating	104/5
Thermal Energy at Edge of Field	11,300 kWh

Energy to Bleyle Plant

	Fossil	Solar	% Solar
Chilled Water Ton-Hrs.	95	242	72%
Process Steam Lbs.	1800	4300	71%

Balance of Solar Energy

High Temp Storage	60°F Rise, 435 kWh
Steam Condenser	

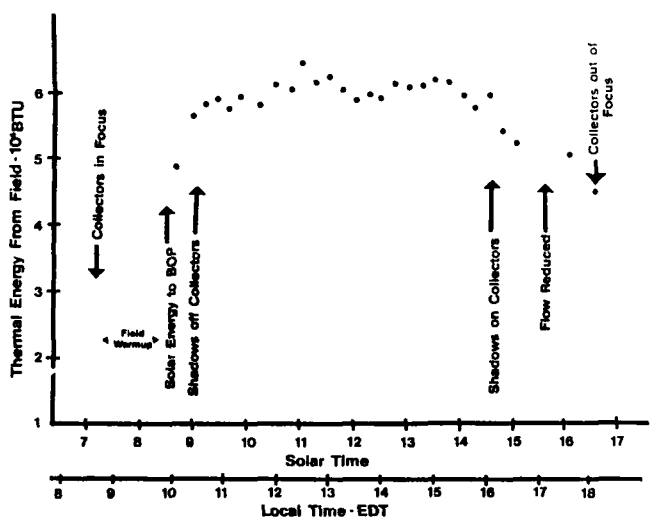


Figure 3-1. Thermal Energy from Solar Field (10/15/82)

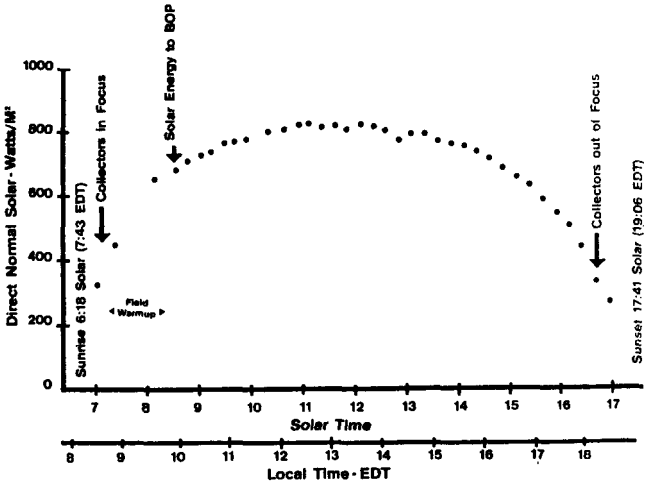


Figure 3-2. Direct Normal Solar Insolation (10/15/82)

Following is a summary of progress on the Met Station and on the technical support activities for October:

- The Met Station suffered several failures during the month, and the entire data logger and most of the instruments were removed and returned to the Georgia Tech campus for repair. This work was completed and the station was restarted.
- During the time the Met Station was down for repair, all solar radiometers were returned to Georgia Tech for an annual recalibration against the regional reference instruments (at the Geophysics Department).
- Met Station data for June, July, and September 1982 were processed. No data were available for August and early September due to data logger failure.
- Progress on the research tasks was satisfactory, but problems with instruments and support equipment delayed the optical efficiency measurements and the collector parameter estimation tests. Progress with the solar radiation model study increased when the student began to master the CYBER main-frame computer. Preparation of the biannual report write-ups was underway.

Also during October, three members of Auburn University's Electrical Engineering Department met with the STEP staff to discuss Statements of Work for two studies to support STEP analysis. Approval of Georgia Power Company and U.S. Department of Energy was pending.

Maintenance of Solar Total Energy System (STES)

A barrel truck/fork lift was rented to safely and efficiently handle the cyclics removed from the HTF system, and to move other heavy loads.

Lockwood-Greene submitted the electrical portion of the Operating and Maintenance Manual for review, and Digital Equipment Corporation (DEC) repaired the DEC-writer, which had been blowing fuses from a faulty power supply.

Four short fiber optic cables on collector 906, which fused together as a result of insufficient insulation within the receiver, were corrected.

The solar collectors were extensively rain washed during October, and a computer program, needed to prevent water collection on the dishes, was being developed.

Electrical safety gloves were exchanged for new ones, and the fire extinguishers and air packs were checked for proper operation as part of routine monthly maintenance procedures.

Personnel and Training Services

After the proper use of air packs was demonstrated, the Georgia Power Safety Department conducted CPR training for the STEP Staff. Planning was also progressing to develop computer control system training requirements.

Mogul was scheduled to provide classroom training for the STEP staff on proper water quality testing and control, and to monitor results.

Administrative Support for STES Operation

The Federal audit of the first stages of the U.S. Department of Energy/Georgia Power Company Cooperative Agreement was nearly complete. Total costs to July 1, 1982 (date of new amendment for Test Operations) were $1,359.95 less than the amount authorized by DOE.

The fourth quarterly report (1982) was submitted to DOE relative to subcontracting with small business concerns owned and controlled by socially and economically disadvantaged individuals. This was the first Small Business Minority Report required under the new Cooperative Agreement.

The Georgia Power Company Accounting Department was in the final stages of preparation of a new monthly financial reporting system for budget control of the recently signed test operational contract amendment.

Information Dissemination/Technology Transfer

In October, a STEP exhibit was set up at the Sunbelt Agricultural Exposition in Moultrie, Georgia, which 200,000 people attended. STEP personnel participated in the planning and exhibit operations. Following is a summary of other activities:

October, 1982

- Fisher and Porter, Inc. visited to discuss a possible instrument service contract, and Federal Products Corporation reviewed STEP activities for possible use of their devices to measure physical dimensions.
- The 18-member Citizens Advisory Committee on Energy was given a presentation and tour.
- Thirteen members of the IEEE Pulp and Paper Industry Committee reviewed STEP status as part of their meeting in Atlanta.
- American Technical Services was on site to take pictures that denoted their instrumentation efforts during construction. These pictures will be used in their marketing efforts.
- A 15-member computer users group, representing several electric utilities throughout the United States, was given a presentation and tour.
- Shore Publications was given information for an article.
- The Project Director of Small Solar Power Systems Project of DFVLR reviewed STEP as part of his visit from Almeria, Spain.
- The October issue of the "ASHRAE Journal" included a detailed article on the STEP solar cogeneration plant.
- Georgia Power Company Industrial Marketing participated in DOE's Solar Thermal Technology Semi-Annual Review.
- Georgia Power Company was planning STEP participation in the Solar Energy Industries Association Annual Conference and Exhibition.
- Planning and budgeting meetings were held within Georgia Power Company regarding facilities for visitors, solar thermal training, and testing.

ACTIVITIES FOR NOVEMBER, 1982

A significant event during November, 1982, was the confirmation that water was contaminating the heat transfer fluid. Following a systematic search, it was determined that the leak was occurring within the superheater section of the steam generator (see *Test Operations*).

As-built drawings were updated and returned to Lockwood-Greene for preparation of final drawings for the permanent STEP plant file.

Acceptance Testing

Progress in acceptance testing was limited during November due to efforts to resolve the HTF anomally and continuing planning for replacement of the DEC PDP 11-34 with a DEC PDP 11-44.

Test Operations

Dow Corning personnel gathered information for use on the Analytic Trouble Shooting Technique developed by Kepner-Tregoe as a part of the investigation of the HTF pump cavitation problem. When it was determined that water was contaminating the HTF, subsequent operations traced the general source to the steam/HTF heat exchanger. Tests using freon, nitrogen, and water failed to pinpoint the exact source, and the three heads to the pre-heater, steam generator, and superheater were removed.

A feed pump hydrostatic pressure test to 550 psig showed leaks at seven of the 45 HTF inlet tubes. Three of the leaks were large. The location, pattern, and specific nature of the leaks pointed to a common cause, probably a cold thermal shock where a cold fluid (~100°F) from the solar collector field is introduced into the seal.

A weld metallurgist consultant (Law Engineering) was called to verify a weld failure, or to suggest another cause for the leaks. Since the leaks were at the tube-tubesheet interface and not down the length of the tube inside the heat exchanger, the leaks could be repaired by TIG (Tungsten Inert Gas) welding. The 1/16-1/8" deposit, caused by the steam breakdown of the Syltherm 800, was removed with a steam cleaner.

On November 4th, a problem developed with the high temperature storage tank (T-103) during normal startup. With a fossil fired heater control setting of 570°F and the actual heater outlet temperature being 470°F, the graphic display showed that the inlet temperature to T-103 was 800°F. The oil pump (P-7001) was found to be cavitating. It was determined that the flow valve (FY-6060) was closed due to either a sticky valve stem or a control malfunction. When the valve was reopened, pressure rose to 16 psig in T-103, blowing the pressure safety valve. The hand valve on the T-103 condenser was opened to reduce the pressure, and P-7001 was restarted. The temperature and pressure returned to normal, and operations were continued.

General Electric personnel provided computer support for most of November in debugging the Control and Instrumentation Subsystem (CAIS). The DEC PDP 11-44 computer, delivered on schedule on November 8th, was powered up and was functional.

DEC personnel performed a System Generation (initialization and definition of operating units) on the PDP 11-44, and the STEP Staff continued to support changeover of the 11-34 to 11-44, debugging efforts, checkout of the operation programs, and creation of data analysis programs.

The graphic display files were upgraded and refiled. The hardware aspects of archive reduction of magentic tape was completed, but software efforts continued.

A purchase order was issued to Auburn University to assist the STEP Staff in several areas:

- Update Program Design Listing for computer system
- Assist in changeout of DEC PDP 11-34 with DEC PDP 11-44
- Assist with debugging efforts
- Recommend and implement a training program for System Operators in use of computer system

System Performance Analysis

Progress by Georgia Tech on Met Station operation and on the technical support activities for the month of November were:

- The Met Station operated throughout the month without any serious problems.
- Met Station data for October and November were not processed by Georgia Tech. Personnel were analyzing the instrument calibration results from the annual recalibration program completed in late October, and reports were to be provided when this task was complete.
- Solar Model Year (SMY) data and supporting text were provided as input to the STEP Annual Report.

Progress on the Georgia Tech research tasks was satisfactory, and optical efficiency testing on Solar Collector No. 110 was conducted. The units tracked the moon for several hours and obtained a significant amount of data. Some problems were encountered with the operation of the

photodiodes used for measurement of the radiation. Modifications were initiated to make operation easier.

Use of air conditioning and process steam from conventional sources increased at the Bleyle Plant due to the reduced operation of the STEP. Operations were terminated on November 15th to resolve the HTF anomally.

Maintenance of STES

With continued inclement weather, computer upgrading, and major disassembly of the Steam Generator System, it was appropriate to consider other maintenance items of significance. Close examination of the burner tile of the fossil fired heater showed cracking in the same manner as the failure of the burner tile in August. A stainless steel extender ring, built by Eclipse, was to be welded to the present burner tile support ring. The burner tile would then be supported along its full length instead of at half its length.

The pressure safety valve (PSV-6440) from the high temperture storage tank (T-103) was refurbished and reinstalled. The instrument air compressor developed a high intermediate pressure indicative of a valve failure, and disassembly maintenance was planned. Georgia Power's Operating Department provided a line truck and personnel support to remove the door from the fossil fired heater, and to remove and install PSV-6440.

On October 28th, the solar collector field was brought up under computer control, but the question "Is daylight savings in effect?" was improperly answered negative. This caused the collectors to come to the stopping point of offset track (normally 15° off the sun in polar) with the sun focused on the east fiber-optic cable. All the collectors were defocused.

When the collectors were brought into focus the following day, 24 collectors had trouble auto-tracking the sun with fiber optics. Nineteen of the collectors required replacement of the east fiber optic, and five required only a recalibration of the optics. A computer subroutine to determine whether daylight savings is in effect was written, and would be included in the Control and Instrumentation Subsystem (CAIS) program.

Digital Equipment Corp. visited the STEP site to discuss a service contract that could provide equipment maintenance service, training, and software support. DEC also provided preventative maintenance on the 11-34, 1103, T503 Tape Drive, RX01 Floppy Drives, and 2RL01 Hard Disk Drives. A floppy disk drive for PDP 11-34 was replaced.

Woods' Mechanical installed a control valve at the Bleyle Plant, in the chilled water return line, and installed flanges in HTF piping to the steam generator heads to allow easier maintenance. Four pressure flow transmitters were calibrated, and a permanent high pressure (100 psig) air line was installed to the steam generator to aid in cleaning the system during tear down maintenance.

A Georgia Power Company manlift truck was secured for maintenance, eliminating the need to continue renting the Fabtek manlift, which had been leased under a Sandia contract.

Since the cost for nitrogen was averaging more than $1,500 per month, significantly higher than budgeted, this item was reviewed for a possible reduction of use or a reduction of cost through another supplier.

Personnel and Training Services

Mogul held two training sessions for STEP personnel. Water testing requirements were delineated for steam system and HVAC operation, and tests were developed that would be part of the daily routine when the steam system is in full operation. These include tests for hydrazine, conductivity, P&M, alkalinity, and hardness.

Upon receipt of the Georgia Power Company manlift truck, a safe operation training session was given by Georgia Power Company automotive maintenance personnel. Further reviews and training were required by the Georgia Power Company Safety Department. Operational anomalies, maintenance, and computer upgrading limited additional formal training sessions.

Information Dissemination/Technology Transfer

During November, additional Georgia Power Company support of the SEIA conference was provided, and Georgia Power Company's Chief Executive Officer provided the Keynote address. Tours and presentations also were given at Future I, the Georgia Power Company Office Building, and Passive Solar Home applications. Other activities in November included the following:

- Georgia Power Public Information visited relative to future STEP and Shenandoah Solar Center media coverage.
- A STEP status report was given to 37 people attending the Southeastern Electric Exchange meeting held in St. Petersburg, Florida.
- Clemson University students from the School of Architecture were provided a briefing and tour of the solar cogeneration facility.

- Detailed information on solar collectors was mailed to Southeastern Massachusetts University students who were doing a solar research project.
- The Georgia Power Company-funded STEP solar display was used at a Solar Energy Industrial Association (SEIA) meeting in Atlanta and at a Macon museum.
- Georgia Power Company Retail Marketing Department Administrative Support personnel toured STEP and discussed potential economic studies.
- Florida Power and Light was given briefing and tour of solar site.
- Slides were provided to Georgia Solar Coalition.
- Georgia Power Company Retail Marketing personnel visited STEP for a briefing and discussion of public relations.
- Information on STEP status was sent to *Electrical World* for use in future publication.

ACTIVITIES FOR DECEMBER, 1982

A signficant development during December, 1982, was the resolution of the water contamination of the heat transfer fluid (HTF) within the steam generator. The leaks at the tube-tubesheet interface were repaired by Tungsten Inert Gas (TIG) welding. The steam generator heads were then reinstalled, the HTF piping was reconnected to the steam generator, and steam was generated with no further leaks. The steam generator was reinsulated and jacketed and made ready for operation.

Midway in the month, after the leaks in the steam generator were repaired, time was spent over a two-week period conditioning the HTF. Student interns were utilized during their Christmas break, since the conditioning required 24-hour per day effort for several days per batch.

All the Syltherm 800 on hand that had been contaminated by the steam generator water leak was reconditioned to 750°F. Also, 4,000 gallons of new HTF, needed to make up for the fluid loss caused by breakdown of oil when exposed to water at temperatures of 500 to 700°F, were conditioned. Twenty-two barrels of fluid were produced during this operation. At the end of the month, 154 barrels of oil that had been condensed from the thermal energy storage condenser were shipped to Dow Corning for credit.

Considerable progress was made in achieving full operation of the DEC PDP 11-44. STEP personnel worked with DEC, GE and Auburn University in moving this activity forward.

DEC installed the Direct Memory Access (DMA) into the PDP 11-44 and conducted part of the system generation. GE spent a great deal of time with the STEP Staff in debugging the computer, including helping complete system generation. Auburn modified the computer program to regulate the flow of data from the 11-44 to the graphic terminal to enable it to work as it had with the 11-34, and continued work with the STEP Staff to modify the DMA program.

At the conclusion of December, the DMA program and all necessary changes had been accomplished, and the CAIS was ready for final checks and system operation.

Acceptance Testing

Progress was limited for acceptance testing during December because the HTF/steam system was under repair and the CAIS system was under modification for the expanded capacity PDP 11-44. Reinitiation of system operation was scheduled for January.

Test Operations

Ten solar collectors were auto-tracked to dry out resistance temperature devices as a result of a great amount of rain and minimal collector operation.

Changeover of the computer system from a PDP 11/34 to a PDP 11/44 was completed during December. Individual system interfaces between the computer, balance of plant, and the energy utilization processor were tested. DEC, GE and STEP personnel were involved with this compatibility testing.

The interfaces between the PDP 11/44, the Datum digital clock, and the PDP 11/03 were installed, debugged, and operated. Hardware and software anomalies were encountered when the direct memory accessing feature of the PDP 11/34 was incorporated in the PDP 11/44. DEC and STEP personnel replaced or repaired the hardware, while individuals from Auburn University were called upon to correct the software irregularities.

The computer equipment was finally made operational, with full system compatibility. The change from a PDP 11/34 to a PDP 11/44 was initiated because limited memory problems were detected in the PDP 11/34. The PDP 11/44 was tested in regard to the memory limitations, and the anomaly was solved. Remaining work included establishing maintenance agreements with DEC and resumption of debugging the Control and Instrumentation Subsystem.

After the steam generator heads were installed, the steam generator was run at temperatures up to 680°F and pressures up to 670°F psig. The steam generator was insulated, but special metal cladding elbows were needed before the necessary piping could be insulated.

System Performance Analysis

No energy was supplied to the Bleyle Plant during December because of a steam leak in the steam generator and modifications to the CAIS. The table on the following page summarizes STEP production and Bleyle Plant usage during the last two quarters of 1982.

Progress was made during December by the Georgia Tech students in their thesis work. One study was proceeding on the development of an improved solar radiation model for determining the amount of beam radiation present when only data for the global irradiation for a particular site are available. Decomposition of global irradiation is expressed by presenting the fraction of global irradiation that is scattered as a function of the clearness index. A non-parametric presentation attempts to preserve the statistical nature of a relationship between the scattered fraction and the clearness index.

The other research project involved the optical performance of the solar collectors. A computerized literature survey was made to determine previous work in related fields.

A scanner for the receiver aperature was designed and built during December, as well as electronic circuitry for inter-

Month	STEP ENERGY PRODUCTION STEP kWh generated	Ton Hrs produced	Process Steam (lb) produced	Therms Nat. Gas for Fossil Fired Heater
July 1982	4600	2500	—	6194
August	3400	6000	50700	6824
September	0	8600	121500	9887
October	0	4048	61040	7093
November	0	665	10925	1430
December	0	0	0	1734

Month	BLEYLE PLANT USAGE BLEYLE kWh (Total)	kWh (HVAC)	Therms Nat. Gas For Process Heat
July 1982	53680	29690	1779
August	31840	14996	914
September	36400	14600	546
October	32240	12386	788
November	36560	13222	1533
December	34800	11075	1867

facing this scanner with the portable data system. Several tests were made while tracking the moon, and a three-dimensional computerized plot of the receiver irradiation distribution, shown in Figure 3-3, was generated.

Georgia Tech weather data were analyzed by the STEP Staff to gain additional insights relative to characteristics of solar radiation.

Maintenance of STES

The Staff successfully overhauled an air compressor head, and it was operating satisfactorily. The teardown revealed that the compression rings on all three cylinders were broken (each low pressure piston has a single compression ring). The high pressure piston has two 3-piece rings, with a metal expander ring inside; both carbon rings were broken

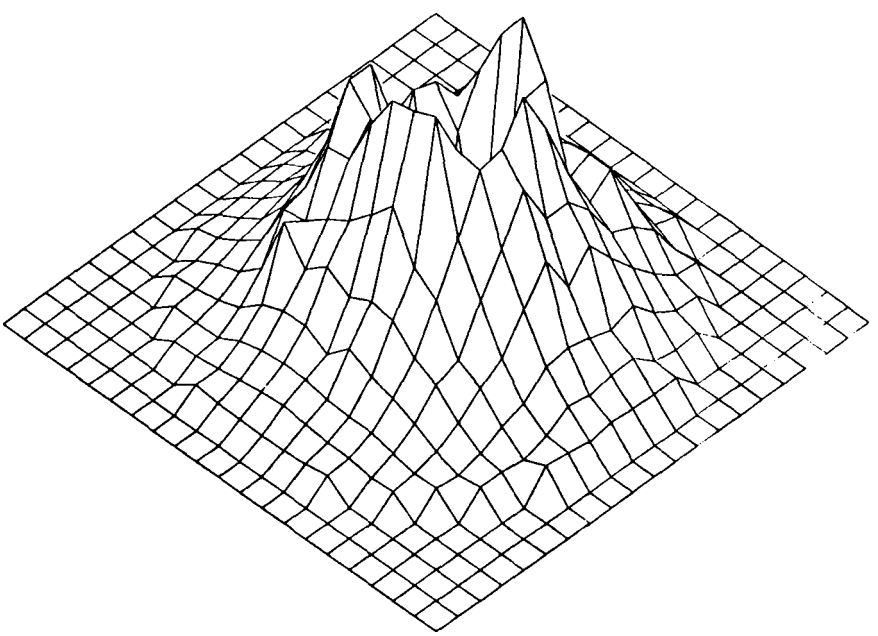


Figure 3-3. Receiver Irradiance Distribution (Collector No. 110)

into several pieces, and one of the expander rings also was broken. Three people performed the work in 11 hours; with the experience gained, the job could be repeated by two people in eight hours.

The tankometer on T-112 was cleaned to permit further use and the strainer was cleaned for the steam generator pump (P-7110), although very little cleaning was necessary.

A locking pin was installed on solar collector no. 902 to prevent slippage between the solar collector yoke and the declination potentiometers, and packing for the boiler feedwater pump was replaced to stop the leak.

With the beginning of cold weather, interface problems with the Bleyle Plant began to surface. Five enthalpy controllers on the roof top units developed various problems preventing reliable and complete operation. In addition, dirty, unreliable potentiometers, used to control the ventilation from 100 percent down to 10 percent of outside air, needed maintenance. These problems were resolved by the Bleyle Staff with advisory support from the STEP Staff. The control circuitry for the Bleyle STEP interface was redrawn and corrected by the STEP Staff.

Personnel and Training Services

The Georgia Power Company Safety Department presented a safe operation training session on use of the manlift truck. The safety procedures in the Safety Operating Manual were revised, and all personnel were requalified on the new Georgia Power Company manlift.

Georgia Power Company presented a training program on "Georgia Power Company Energy Research Projects." This was part of a series that gives the Shenandoah Staff a better understanding of solar energy in general and the operation of the STEP in particular.

Newer employees were given a demonstration on effectively changing the Collector Control Unit (CCU) boards, and the Georgia Power Company summer interns returned to provide additional support during the heavy maintenance period.

Administrative Support for STES Operations

A new STEP accounting system was initiated during December by the Georgia Power Company as part of company-wide change, but the present reporting format to DOE was not affected.

A new method of purchasing nitrogen, using a 315 gallon bulk liquid tank, and the acquisition of a new supplier, resulted in an operating cost savings of $10,000 per year. System engineering drawings were redlined to reflect the change, and a contract was secured for one year.

Information Dissemination/Technology Transfer

In December, STEP personnel visited Terrora Park and Visitors Center in northeast Georgia to investigate the Park's procedures for handling visitors. During a 2.5 year period, more than 100,000 people have visited the Shenandoah Solar Center, and an increase is expected once a permanent building is completed at the STEP site. The STEP Visitor Center project was initiated through two formal planning sessions with the designer, Heery & Heery.

A 1983 Planner, produced by Georgia Power Company Industrial Marketing, was provided to various solar industry contacts. The month of June in the Planner featured a STEP picture and notes efforts that are being made by Georgia Power to use alternate energy sources such as solar energy.

Following is a summary of other activities for December:

- Approximately 30 Georgia Power Company employees from the Manchester District and their spouses were given a presentation and tour.
- 3M visited to see how well its reflective film was performing on solar collectors.
- A final report indicated that 7,733 people viewed the STEP exhibit during its showing at Macon Museum of Arts and Sciences. The total included 3,477 in school groups and 1,201 senior citizens.
- Houston Power and Light visited to coordinate solar efforts.

ACTIVITIES FOR JANUARY, 1983

In January, 1983, turbine-generator operation was resumed. During five consecutive days, the T-G produced 6,700 kW/hr of electricity, and 27,750 pounds of process steam. On one day, the turbine ran for nine hours with no tripping, producing 1,603 kW/hr. On another day, the turbine operated for almost eight hours reaching a level of 410 kw with solar and fossil fired heater boost. During this period, process steam was typically available ten hours per day.

On two occasions, the generator tripped. Once, the generator "J" breaker operated at a power level of 400 kW. The apparent cause was a malfunction in the breaker, and Georgia Power was asked to evaluate the problem. Then the T-G tripped because of phase imbalance at a generated level of approximately 350 kW, also for undetermined reasons.

STEP was unable to operate for 11 days because of a pressure regulating valve (PCV 8230) failure. PCV 8230 reduces the steam pressure from 700 psig to 100 psig in the extraction line of turbine bypass, and the system cannot operate without it. Parts were not shipped from the supplier in an adequate manner, and this procurement problem was resolved. Consideration also was being given to purchasing a spare valve.

Considerable effort was expended during the report period on the Control and Instrumentation Subsystem (CAIS). Although progress was made, additional minor hardware and software problems prevented operations in Modes A and B.

Acceptance Testing

Progress was limited in acceptance testing during January due to continued anomalies in the mechanical and control systems.

Test Operations

Progress continued in the CAIS. The correction for the DMA interface made in December proved to be unreliable because the DMA driver program and the computer system were using the upper memory registers. A new system generation of the PDP 11-44 computer increased the number of upper memory registers. The DMA driver program was rewritten to use the additional upper memory registers.

Operation of the solar collector field and the balance of plant were checked out in Mode C operation under PDP 11-44 computer control. A modification was made to the solar collector program to prevent defocuses from being sent to a collector if the collector is in the stow position. This will prevent a solar collector from defocusing to a point where it is near focus early on a winter morning.

Significant effort was expended on computer software changes to enhance the interpretation of system data. Effort continued on the mechanical, electrical, and computer software to operate the system in Mode A and Mode B.

STEP experienced a three-hour planned power outage from the GPC grid due to substation maintenance. The emergency generator performed as designed for this period.

The solar collector field was brought up and shut down under automatic computer control several times during the month with no problems. On one occasion, 15 collectors exceeded normal temperature and required an adjustment in the hand valves.

While autotracking the collector field, correction factors were updated and inserted into the computer software to ensure proper tracking of individual collectors.

Sandia ordered a new air compressor—better matched for operation at 20 hp and 200 psig—for installation outside the mechanical building (connected to a 240 gallon receiver). The original unit was kept for standby.

The PDP 11-44 computer was made operational, without the memory limitations that existed with the PDP 11-34, and five collector field communication radios were received from GPC.

Beginning January 17th, steam production resumed at a significant level using solar energy, when available.

A purchase order was issued for installation of a concrete spill and drain for the west access road, and installation of a shelter for the new air compressor to be installed at the northwest end of the Mechanical Building.

System Performance Analysis

There was no demand for air conditioning from STEP during January because of cold, dry weather and use of enthalpy-controlled outside air. The STEP Staff assisted Bleyle Plant personnel in determining operational problems with the enthalpy controllers.

A meeting was held with Auburn University Electrical Engineering Department personnel and STEP personnel as they began a reliability evaluation of STEP performance.

Dow Corning worked with STEP in analyzing the performance of the Syltherm 800 Heat Transfer Fluid (HTF) and associated problems. A trouble shooting system determined that the earlier problem with the excessive chemical cracking rate (the production and condensing of cyclics) was caused by water contaminating the HTF in the steam generator. They used site logs as the major source of data to complete the study. It was agreed that the cracking rate

should be tracked and studied further by Dow, and several steps were taken by STEP personnel:

- Take more detailed data for later analysis.
- Dry HTF additions in conditioning tank, T-111, to 650°-700°F.
- Check daily for water contamination HTF in cyclics being condensed.
- Track stability of system by measuring daily cyclic formation rate at steady state conditions.
- Take base HTF samples as required for analysis by Dow.

Georgia Tech continued to update its solar meteorological year (SMY) data. Following is a summary of data collected for direct insolation at Shenandoah in 1981:

Month	Measured Direct Insolation Btu/ft²/Day	Solar Model Year
Jan	1501	926
Feb	1175	1328
Mar	1552	1444
Apr	1458	1602
May	1520	1675
Jun	1646	1547
Jul	1245	1602
Aug	Bad Data	1543
Sep	1456	1471
Oct	1222	1587
Nov	1102	1511
Dec	976	1163

The weather at the site during the period was about equal to the long term average for January. Special attention was given to the direct insolation recording by a strip recorder. Following is a summary of the data yielded by the pyreheliometer:

Date (Jan. 83)	Direct Insolation Btu/ft²/Day	Peak W/m²	Time of Peak
1	Cloudy		
2	Cloudy		
3	Cloudy		
4	1851.75	776.76	1:15 pm
5	1568.97	805.52	1:15
6	1099.19	747.99	12:00
7	1222.34	776.76	1:00
8	1491.43	776.76	12:30
9	77.54	690.45	1:15
10	Cloudy		
11	1540.60	805.52	1:30
12	196.25	747.99	1:45
13	2119.25	863.06	12:30
14	2016.70	805.52	1:00
15	1991.93	805.52	2:30
16	1957.82	834.29	1:00
17	2054.7	863.06	1:00
18	2207.5	920.60	12:30
19	1085.5	747.99	11:00
20	Cloudy		
21	Cloudy		
22	Cloudy		
23	Cloudy		
24	Cloudy		
25	1359.2	747.99	12:45
26	1158.5	805.52	12:00
27	Cloudy		
28	1537.0	747.99	12:00
29	560.9	776.76	12:30
30	373.9	747.99	12:30
31	Tape did not function properly		
Average	886 Btu/ft²/Day		
Long Term Avg.	926 Btu/ft²/Day		
From	SMY		

The data logger operated without serious problems during the month, but problems developed with the pyrheliometer, which was not accurately tracking the sun. The north-south alignment had been disturbed so that the unit tracked properly either during the morning or afternoon. Adjustments were made, but the amount of direct radiation data for the month was low.

Progress on the graduate research tasks was satisfactory in most cases, and the optical efficiency task was in the final stages of measurement and evaluation. The parameter estimation task was slowed by difficulty in setting up the measurement instrumentation in the field, and sensor problems delayed the work. The model year data evaluation task, which was behind schedule, was reassigned to a new graduate student.

Maintenance of STES

A failure of the seal on P-7001 in conjunction with a low oil level shutdown of the air compressor allowed approximately 100 gallons of HTF to flow onto the patio floor.

A leak in the demineralizer (DE-201) was repaired. The water leak in the piping resulted from a mixture of water and acid in Column A due to an operator error, which also caused acid damage to the underdrain. A new underdrain was installed to eliminate resin losses.

Replacement resins for Column A of the demineralizer were obtained from Plant Wansley. These anions and cations were installed, but the column was not yet operative. Additional operational conditioning was expected to restore normal operation. No down time was experienced because of availability of Column B for conditioning makeup water to condensate storage tank.

The dry bulb temperature/relative humidity meter from the meteorological station on the roof of the Mechanical Building was shipped to the manufacturer for repair.

For undetermined reasons, lack of antifreeze in the auxiliary cooling water resulted in freezing and shutdown of systems for several hours. The system was flushed, and 40 gallons of (presumed) ethylene glycol were added. Following a second freezing, a new automobile type anti-freeze solution was purchased and 60 gallons were installed. The previous replacement solution that worked unsatisfactorily was analyzed for content.

Following is a summary of other maintenance actions during January:

- The turbine oil, which had become contaminated since the last turbine operation, was replaced.
- HTF piping to the steam generator was insulated as the last item associated with the repair of leaks to the steam generator superheater section.
- A new solenoid was electrically connected to flow control valve (FCV-8181).
- A wall cabinet was installed in the control room to keep instruments and other materials needed for water analysis of steam system.
- Activated alumina was secured from Plant Yates, and silica gel was obtained to be used in an air dryer. This was used to change out old dessicants at the end of the month when the air dryer valve needed minor repair.
- Manual control switches were installed to the flow valve (FV-8170) and flow control valve (FCV-8181).

At the conclusion of the report period, a solar collector operational status was performed. Five collectors (506, 507, 906, 1202, and 1208) were inoperative because of fiber optic problems. One (1203) had an inoperative declination potentiometer; one (710) had a bad declination motor; and one (1008) had an inoperative CCU board. Several balance of plant instruments were not working at the end of January.

Personnel and Training Services

The STEP Staff reviewed the proper method on installing flanges prior to removing the HTF pump. To emphasize the potential consequences of heated oil injury, GPC Safety presented a comprehensive program on treatment of burns. GPC Skills Development visited the site to support efforts in solar training at STEP.

Section 11.0 of the Safe Operating Procedures (SOP-1) was updated to reflect the replacement of the Fabtek with the GPC Manlift Truck. These revised safety procedures were distributed to all STEP personnel.

During January, three new engineers-in-training joined the STEP team, and Dow Corning presented a training session to the STEP Staff on HTF characteristics, problems encountered, and resolution.

Information Dissemination/Technology Transfer

In January, an Israeli professor from Ben Gurion University and an Israeli engineer visited STEP to discuss how solar energy might replace expensive, imported coal and oil in their country. A significant amount of Georgia Power Company and Sandia time was spent in answering the detailed questions that were asked.

Following is a summary of other activities for January:

- Information was provided to a *Technology Review* editor for an article.
- A discussion was held with a CH2M Hill group relative to their alternate energy project.
- Foster-Miller Associates visited to discuss use of their steam engines.
- STEP slides were given to Southern Company Services for use in a presentation to Southern Company System Marketing Group.
- Erich Weber-Bleyle, owner of Bleyle of America, visited the STEP site for the first time in five years. The *Newnan Times Herald* used the occasion for pictures and an updated STEP status report.
- Toccoa Falls College (President Bill Alford and Trustee Paul Carpenter) visited Shenandoah facilities to discuss potential solar applications at their Georgia college.
- Two GPC research engineers from Forest Park Research Laboratory toured the site and offered future assistance.
- U.S. Army representatives visited for discussions on items of mutual interest in alternate energy use.
- Gulf Oil discussed possible arrangements for turbine oil purchases at Shenandoah.
- Students from the University of Delaware and their professor were given a tour and presentation.
- Two representatives from Bleyle's West German operations toured the facility.
- The cover story for the last issue of *Georgia Professional Engineer* magazine was an article on STEP activities.

ACTIVITIES FOR FEBRUARY, 1983

During February, 1983, the Control and Instrumentation Subsystem (CAIS) operated smoothly. For the first time, the CAIS demonstrated its ability to operate the balance of plant and collector field subsystems simultaneously. This was not possible previously because the computer was able to control only one subsystem at a time. Maintenance on the CAIS was limited to one RL01 hard disk drive. The hard disk drive needed a head realignment, and Digital Equipment performed this task.

Mogul reviewed the results of the STEP water sampling analysis and the cooling tower operation. It was recommended that (a) the plant acquire an all organic tester, (b) that city water be tested once a month for fluctuation in makeup, (c) pH test be modified, and (d) the test point for flash economizer be changed, and three new test points be added.

Operating Experience

On Tuesday, February 1st, the packing was replaced on the boiler feed pump. The plant began operations at 9:00 a.m. and completed operations at 4:30 p.m. Bleyle was provided with 3739 pounds of process steam, and 947 kilowatt-hours were produced.

Components of the flow control valve FCV-6030 also were replaced to facilitate remote operation of the valve, the level switches in the deaerator were inspected and lubricated.

Following startup of the system on February 3rd, water was allowed into the Bleyle steam system. This situation originated inadvertently when TCV-8240, the desuperheater control valve, was opened in an unknown manner. The problem was rectified in approximately 45 minutes. This was the first time that Bleyle pressing operations had been interrupted by the STEP interface. Also, a new loop isolator was installed and calibrated for flow control valve FCV-8181 on February 3rd.

On February 7th, the generator interconnect circuit breaker was removed and sent to the repair shop for calibration and inspection, and modifications were made to the boiler feed pump to increase maximum flow from 22 GPM to 25 GPM.

Georgia Power Company personnel checked the operation of several protective relays on February 11th. They found that the phase imbalance relay would not calibrate, and it was removed and sent to Atlanta for repair.

On February 15th, 113 of the solar collectors operated continuously under CAIS control A 400 kWe generation level was achieved producing a total of 1714 kW/hr that day along with 3775 pounds of process steam. A total of 77 kW/hr (net) was provided to the grid by 4 p.m. The boiler feed water pump maintained the needed flow rate with no difficulty.

Also tested were the branch and shadow flow control valves. Anomalies in the software prevented the valves from operating properly, and modifications were made to help correct the problems.

On February 17th, the turbine-generator produced the largest single-day electrical generation to date: 2797 kW/hr in nine hours at levels from 250 to 400 kW. The solar collector field was operated in a solar/fossil boost mode, providing more than half the energy to the steam-generator while at 390 to 400 kW level.

At approximately 12:00 p.m., the collector field defocused. The problem was determined to be software anomalies in the Buffer Control Unit (BCU). The field was refocused by 1:00 p.m. Subsequent modifications to the software solved this problem. Computer consultants from Auburn visited the site to discuss continuation of their work on the Program Design Language (PDL) listing. They also began work on software for data collection and reduction.

A water leak developed in the boiler feedwater pressure safety valve PSV-8036 on February 18th. The valve was replaced with a spare, and the plant was back in operation at 7:30 a.m. During operation that day, the steam generator sight glass developed a small leak. Since the leak wasn't severe, plans were made to replace the sight glass the following Monday.

The system began operations at 11:00 a.m. Monday, February 21st. The delay on startup was caused by the planned replacement of the steam generator sight glass. Process steam, chilled water, and electricity were provided by Bleyle for the remainder of the day.

Operations on February 22nd were interrupted at 1:11 p.m. due to the loss of city water for the industrial park. Operations were restored approximately 45 minutes later.

At 11:28 a.m. on February 23rd, a severe steam leak from the steam generator sight glass dictated an early shutdown of operations. This unit failed after two days of operation. The cause of the failure was determined to be an incorrectly seated gasket. The sight glass was replaced with a rebuilt unit that afternoon.

Performance

The performance levels and total operational time for the STEP were high during February:

27,747 kWh of electricity
79,021 pounds of process steam
629 ton-hours of air conditioning

Insolation in February averaged 839 Btu/ft^2/day. This figure was approximately 30 percent lower than the predicted normal for February. However, even with the low amount of energy, STEP was still able to provide more energy to the Bleyle Plant than in any previous month.

Reflectometer readings from five sample collectors were taken, and the percentage reflectivity readings ranged from 82.55 to 80.88.

No further acceptance tests were performed during February, but progress with system anomalies indicated resumption of activity during March.

Planned Activities

The Georgia Power Company Skills Development Department began working with the STEP Staff in developing a formal six-month training course that will be used to qualify people as solar cogeneration plant operators.

A request was made to Atlanta Gas Light Company to provide a recording meter for the natural gas service to the boiler used in heating the heat transfer fluid (HTF). There was a need for the same type of pulsing equipment that is used at Bleyle to transmit information to the CAIS. This equipment will be used to carry out some of the analytical studies.

The Electric Power Research Institute (EPRI) presented a preliminary draft for a joint test program for STEP. The objective of the EPRI proposal was to disseminate performance results of solar cogeneration to the electric utility industry. The program is being designed to complement the efforts of the DOE/Sandia and GPC. A meeting was scheduled for March between DOE, Sandia, EPRI and GPC to discuss this program.

Also planned for March was installation of a new high temperature pump on the conditioning tank T-111 to facilitate conditioning and transfer of the Slytherm 800™ Heat Transfer Fluid (HTF). When the pump is operational, approximately 1,000 gallons of HTF would be conditioned. Installation and conditioning were not expected to cause any plant down time.

Information Dissemination/Technology Transfer

In February, a STEP display, an electric car, and handout materials were sent to the Energy Expo, Georgia Southern College, in Statesboro. The objective of this exposition was to explore future energy ideas.

A comprehensive presentation was provided for the GPC Annual Meeting of the Retail Marketing Organization. The Operational history of STEP was covered, as well as progress on the Shenandoah Solar Center. Nearly 500 people attended this meeting, which included marketing and management personnel from throughout the state. The first three Solar Plant Operators were certified and recognized at this meeting.

Following is a summary of other activities for February:

- A presentation and tour was provided to 11 GPC Augusta Division Retail Marketing Representatives.
- An invitation was given to GPC to participate in the "Solar 83" exhibition at the Belgrade (Yugoslavia) Fair in September.
- STEP literature was provided to the Chemical Engineering Department at the University of South Florida.
- A presentation and tour of the Shenandoah solar cogeneration plant was given to ten Georgia Tech Georgia Society of Professional Engineers (GSPE) student chapter members.
- STEP was featured in an exhibit at Atlanta's Perimeter Mall as part of Engineers' Week activities.
- Sandia spoke to the Georgia Solar Energy Association meeting on progress at STEP.
- Symmes Systems was given a tour.

ACTIVITIES FOR MARCH, 1983

In March, 1983, the STEP Staff was represented at the distributed Solar Collector Summary Conference in Albuquerque sponsored by DOE and Sandia. The latest STEP annual report and a technical paper detailing the status and progress of STEP were distributed, and STEP operations were highlighted with a poster presentation.

Discussions were held with the Electric Power Research Institue (EPRI), DOE, Sandia, and GPC relative to coordinating participation at STEP.

Operating Experience

On March 1st, the branch six temperature control valve software was succesfully implemented. The following day, valve control of the entire field by CAIS was achieved with marginal success. A new computer program was developed to control this system. The old control logic worked fairly well on clear days, but variable cloudiness caused problems.

Difficulty existed in controlling the collector field under cloudy and transiently cloudy conditions, resulting from tracking correction factors, but these were updated for successful operation.

The solar collector field, once at temperature, provided 64 percent of energy to the steam generator on March 8th. An attempt was made to trip the turbine on March 9th (by manual computer control), but it failed because of a wiring anomally, which was corrected.

Also on March 9th, preliminary measurements indicated that the solar collector field thermal losses were between 8 and 10 percent, within 1 percent of the original designed value.

STEP was not operational on March 21st, allowing a check of leak detection and thermal line insulation on the newly installed bleed line to the thermal storage tank (T-103). The weather proofing on top of the tank also was verified.

The pipe strainers for fossil fired heater pump (P-7001) and steam generator pump (P-7110) were cleaned on March 25th to help eliminate pump cavitation. A problem developed when the line between the thermal storage tank (T-103) and the cyclic overhead condenser (T-113) clogged with solidified heat transfer fluid condensate. The line was unclogged but was clogged again later due to poor insulation on the pressure regulating valve atop T-103.

On March 22nd, the steam generator sight glass started to leak and broke. A ½" x ½" piece of glass was ejected, releasing a large volume of steam. This was the fourth such instance of sight glass failure. The sight glass operational ratings were reviewed, and a new sight glass with higher operating design points was ordered.

Mogul suggested during the monthly review with the STEP Staff that the feed of chemicals to HVAC cooling tower should be modified. Excessive water treatment chemicals were found in cooling tower samples, and corrective actions were taken. Also, water samples from normal test points were taken and sent to Mogul's laboratories for analysis. STEP daily water sampling tests were validated with an emphasis on pH tests, viewed by Mogul as the most important test.

The Met Station operated without serious instrument problems during March, and Georgia Tech continued to process data for the Met Station from January and February. Delays occurred due to the turnover in students, but improvements in processing and analysis efficiency in this area was expected.

Two graduate students were completing the final drafts of work done at STEP for their theses. A third met with site personnel to review plans for his graduate research in the operation of the thermal storage subsystem and parameter estimation methods to assess performance.

In an attempt to calibrate branch temperatures with the test program, an erroneous signal was sent to the collector field, preventing 13 collectors from autotracking. This action resulted in the "east" fiber optics of all 13 being damaged. During a two day period, the damaged sensors were replaced.

Performance

The performance levels and total operational time of the STEP were high during March:

31,028 kWh of electricity
85,208 pounds of process steam
3,593 ton-hours of air conditioning

Insolation in March averaged 1059 Btu/ft^2/day. This figure was approximately 27 percent lower than the predicted normal.

Reflectometer readings from five sample collectors were taken. The percentage reflectivity readings ranged from 83.7 to 77.8 (the low reading was due to HTF mist that coated collector No. 110; after it was washed, the reflectivity is expected to return to approximately 80 percent.

No further acceptance tests were performed during March. Progress with system anomalies was expected to allow resumption of this activity during April.

Planned Activities

Arrangements were finalized with Atlanta Gas Light Company to provide the necessary metering equipment for natural gas service to the boiler used in heating the heat transfer fluid (HTF). The pulsing equipment that transmits information to the CAIS was scheduled for installation during April.

Beginning on Monday, April 4th, STEP operations were scheduled to expand to include the hours from 6:00 a.m. to 9:00 p.m. weekdays, plus other hours as required under special conditions.

Information Dissemination/Technology Transfer

During March, Flambeau Southeast Corporation visited to gather information to help make a decision relative to using a solar installation in conjunction with plant expansion in Monroe, Georgia.

Other activities during March included the following:

- Western Electric visited to discuss potential solar system applications at the Norcross, Georgia and other Western Electric plants.
- Fort Benning engineering personnel visited and were given a comprehensive tour.
- Lockwood-Greene was on site with a photographer to take pictures for internal use.
- Clemson University professors were on site to discuss possible participation at STEP. They were accompanied by Georgia Power and Southern Company Services personnel.
- Kuwait Institute for Scientific Research visited and discussed potential participation of their organization.
- Southern Tech toured the facilities.

ACTIVITIES FOR APRIL, 1983

In April, 1983, Lockwood Greene personnel returned to the STEP site to update as-built drawings. Following a thorough review of mechanical and electrical systems, they estimated the work to be completed within a month. Work also resumed to develop a suitable STEP system description. The updated, as-built, and earlier iterations were used.

A two-shift STEP work schedule resumed to allow coverage of the increased daylight hours, and maintenance logs were modified to accomodate the DOE and the Auburn Reliability Study.

Operating Experience

Auburn University was on site to assist the Staff in CAIS work, and progress was being made in archiving data. Meanwhile, the solar collector field provided solar thermal energy in a constant-flow, fossil-boost mode. The turbine-generator was operated at a 400 kW level and at a 300 kW level.

A change was necessitated to the CAIS program to ensure the start of the wind speed monitor before the solar collectors are moved from stow. On the 13th, the collectors continued to operate with winds gusting to 50 mph and exceeding the 30-mph-for-30-seconds winds speed limit that normally stows the field.

600 gallons of heat transfer fluid were transferred and conditioned. Also, the solid state relay that controls computer-start of the turbine was replaced by a conventional relay. All turbine functions were performed by manual control through the computer.

All 114 collectors operated in focus for eight hours and 23 minutes on the 21st. The heat transfer fluid boiled out of T-111 because of an excessive quantity of fluid being heated, and Loss of power in the Shenandoah Industrial Park grid caused the STEP turbine-generator to trip.

During the last two days of April, the collector field was inoperative because of a problem with DEC PDP 11-03. The buffer control unit programs would not load and run.

Performance

The peak level of performance and total operational time at STEP highlighted this reporting period:

42,226 kWh of electricity
104,038 pounds of process steam
4,500 ton-hours of air conditioning

Insolation during April averaged 1492 Btu/ft^2/day. This figure was approximately 7 percent lower than the predicted normal for April.

Planned Activities

A new Out-of-Service Log was developed to satisfy DOE needs and the Auburn University reliability assessment of STEP. These log forms were used as part of the May report period, although additional minor modifications were expected.

Work was scheduled toward automatic control of the turbine generator by the Control and Instrumentation Subsystem (CAIS). Startup and shutdown of the T-G, under this automatic control, has not been fully realized. The control of collector field branch temperatures also remained to be validated.

Additional progress was anticipated during May in production of a suitable STEP System Description. This document would reflect the changes made during the past year, and would use the updated as-built drawings from Lockwood Greene. Earlier iterations on system description would also be utilized.

Significant progress was being made on the STEP Training Manual, which was planned to be ready for use by the end of the summer.

Information Dissemination/Technology Transfer

In April, the STEP Staff participated in Denver at the Solar Thermal Collectors Workshop sponsored by the U.S. Department of Energy and Saudi Arabian Center for Science and Technology. In addition, both the Southern Company and Georgia Power Company Annual Reports featured solar activities at Shenandoah. The Georgia Power Company report stated that "at Georgia Power, 1982 was the year of the sun."

Following is a summary of activities for April:

- Marketing personnel from Alabama Power Company were given a presentation and tour.
- A solar presentation was provided to the Auburn Dean of Engineering and several members of his staff.
- Ten members of an IEEE committee in Atlanta toured Shenandoah facilities.
- the STEP Staff was given a presentation on development, status and potential of photovoltaics.
- Lange International was given a briefing and tour.
- Helionetics was given briefing and tour.
- Plans began to include STEP tours as part of the ASHRAE national meeting activities in Atlanta next January.
- Electricite De France was given a tour of the facilities.

ACTIVITIES FOR MAY, 1983

In May, Lockwood-Greene was on site to continue updating As-Builts. Completion was expected within a month.

The plan for the new Shenandoah Solar Center building was proceeding. The exterior design was approved, and work was continuing on the interior. Construction of this building, with its numerous active and passive solar characteristics, was scheduled to begin this fall.

A serious design problem on the demineralizer surfaced during May. The plastic pipe in the system could not safely handle concentrated sulfuric acid used for regeneration, and replacement parts were provided by the vendor. Sufficient parts and the required 10 percent acid solution were received for continuing operation. However, after the condensate storage tank had been depleted of its demineralized water, the total operation was curtailed for four days.

EPRI notified the STEP Staff that it will participate in testing planning studies of solar cogeneration operation. An engineer was expected on site during June to begin this support.

Work continued on setting up the Control and Instrumentation Subsystem (CAIS) control program and data collection/reduction program. Mode "A" software was rewritten; STEP CAIS now starts the BOP when process steam and the turbine/generator are required.

Operating Experience

The STEP system incorrectly shut down under emergency conditions when power was interrupted to the Shenandoah Industrial Park.

Auburn University was on site to review the Reliability Study. Data were collected in support of this Study, which is on schedule and progressing satisfactorily.

Following are additional operational items for May:

- The uninterrupted Power Supply (UPS) was repaired following earlier malfunction during power failure.
- The Georgia Power Safety Department inspected the STEP facility; no major problems were found.
- New packing was installed at boiler feedwater pump.
- The shadow valve on Collector No. 210 would not close and required repair.
- Atlanta Gas Light installed pulsing metering equipment that transmits natural gas service information to the CAIS.
- The STEP pyrheliometer stopped tracking the sun and was repaired when parts became available.
- The demineralizer was run with 10 percent sulfuric acid solution for the first time.
- A software anomaly with PDP 11-44 prevented operation of solar collector field for three days in May.
- Wiring was corrected for turbine trip signal.
- The system in Mode A was brought up under computer control.

Performance

The peak level of performance and total operational time at STEP highlighted this reporting period:

34,249 kWh of electricity
91,857 pounds of process steam
7,517 ton-hours of air conditioning

Insolation during May averaged 1098 Btu/ft^2/day. This figure was approximately 34 percent lower than the predicted normal for May.

Information Dissemination/Technology Transfer

Georgia Power and Georgia Solar Coalition worked together on activities for Sun Day, including an Open House at STEP. Other activities in May included the following:

- Solarex visited for discussions of mutual interest.
- Five members of IEEE power committee meeting in Atlanta toured facilities.
- A STEP review and status was presented to DOE Solar Thermal Semi-Annual Review.
- Seven Egyptian engineers were provided presentation and tour.
- A STEP report was provided to the Exchange Club of Tri-Counties, Georgia.
- A presentation was made at a monthly STEP staff meeting by Southern Company Services.
- PG&E was given a briefing and tour as information was exchanged on solar acitivities at each company.
- Thirty Agricultural Engineering students from the University of Georgia visited.
- During this report period, approximately 72 walk-on visitors were provided information and tours as appropriate.

May, 1983

- An ITT representative visited the site to gather information as a prospective for financing solar ventures.
- A comprehensive STEP report was presented at the American Solar Energy Society annual conference in Minneapolis.
- Photographs were taken for the STEP training manual, which is in production and should be available by the end of August.
- Three Boston Edison representatives, three engineers from West Point Pepperell, and an Energy Management and Analysis company representative visited the site.
- American City Corp. in Columbia, Maryland had three representatives visit STEP.
- Georgia Power Company Economic Services staff held a meeting at Shenandoah and were provided STEP presentation and tour.

ACTIVITIES FOR JUNE, 1983

In June, 1983, the Electric Power Research Institute (EPRI) contracted with Engineering Technology Energy Center (ETEC) to provide six man months of support for test planning studies of solar cogeneration operation. ETEC was scheduled to participate at site during July.

The computer stopped processing software on several occasions during one week in June. After a thorough check of the DEC 11-44 computer, software modifications were determined to be causing the problem. Appropriate changes were made, and there were no further problems

A review of water samples demonstrated that water management is controlling the content to recomended levels. With the recent conversion from 93 percent sulfuric acid to 10 percent, the water sample data improved considerably. Results were very close to the 7.0 pH balance. The "p" and "m" alkalinity test results were steady at 20 ppm or less. The conductivity levels were low, and hardness was constantly zero for all samples.

A ramp scanner was installed near the thermocouple junction box at the thermal storage tank (T-103), and was transmitting data to the PDP 11-34 computer. This scanner provides 128 temperature readings throughout the heat transfer fluid in T-103. Once the thermocouple data are available to the Control and Instrumentation Subsystem (CAIS), the quality of the energy and power measurements were expected to increase significantly.

Development of productive relations with area universities continued. A master's theses, "Optical Performance of Paraboloidal Solar Concentrating Collectors," was completed during June. The objective of this STEP study was to devise an accurate means of collector field measurements for determining concentrator efficiency frequently and easily. The paper concluded that "although no conclusive results can be drawn yet due to the poor angular response of the detector, the state of the art has been advanced through kinetic design, electronic control, and dynamic location detection."

Also during June, a site project progressed in discussion with Clemson and Auburn relating to a photovoltaic system for the new Shenandoah Center building.

Plant operation was curtailed on two occasions as the nitrogen supply was depleted. A leak at the safety valve of the nitrogen bulk storage tank was discovered and was repaired at the second curtailment. (Repair was accomplished when the tank was empty.) A billing adjustment was made by the supplier.

Operating Experience

The turbine generator tripped three times in June as a result of high lube oil temperature. The auxiliary water condenser fans were not operating at maximum speed due to temporary control problem. Following are additional operational items:

- The automatic VAR controller was wired and is fully operational.
- Spare parts (collector components) were delivered from Sandia in Albuquerque.
- The Control Room heat pump coils froze and freon was added.
- Bolts in the evacuators of each collector motor were inspected and tightened as needed. Approximately 20 percent of the bolts were loose.
- A fan belt was replaced on the mechanical building heat pump.
- The DEC 11-44 computer shut down abornormally. Originally, a hardware fault was suspected, and DEC service was called. After all the hardware passed diagnostic testing, a software problem was discovered and corrected.
- 4,000 gallons of heat transfer fluid was delivered for needed inventory.
- On 6/20, STEP was the sole source of Bleyle's steam, as their steam system was inoperative.
- Gaskets in the flange between the boiler feedwater pump and steam generator were replaced.
- Metal housing fell off of polar motor one on collector 709.
- Moisture condensation inside the pyrheliometer required removal and drying of the instrument.
- The wind direction indicator required rewiring and calibration after its potentiometer was replaced.

Performance

Insolation for June averaged 991 Btu/ft^2/day. Following is a summary of STEP production and Bleyle usage for the entire reporting period (7/82 through 6/83):

STEP ENERGY PRODUCTION

Month	kW/hr generated	Ton Hrs produced	Process Steam (lb) produced	Therms Nat. Gas For Fossil Fired Heater
July	4600	2500	—	6194
August	3400	5000	50700	6824
September	0	8600	121500	9887
October	0	4048	61040	7093
November	0	665	10925	1430
December	0	0	0	1734
1982 Total	17852	21813	244165	53777
1983				
January	7295	0	30500	6112
February	27757	629	79021	15110
March	31028	3593	85208	11559
April	45226	4551	104038	18720
May	34249	7517	91857	16279
June	42203	12655	118291	28435

BLEYLE KNITWEAR PLANT

Month	kWh (Total)	kWh (HVAC)	Therms Nat. gas for process heat
July 1982	53680	29690	1779
August	31840	14996	914
September	36400	14600	546
October	32240	12386	788
November	36560	13222	1533
December	34800	11075	1867
January 1983	28000	3301	898
February	32800	4965	799
March	30160	7716	912
April	32000	7782	388
May	43920	14794	816
June	46960	19768	505

STEP Year-To-Date Monthly Direct Insolation

	Empirical		Solar Model Year	
	Avg (Btu/ft^2/day)	Sigma	Avg (Btu/ft^2/day)	Sigma
January 1983	947	842	926	833
February	839	956	1328	020
March	1059	1012	1444	879
April	1492	1099	1602	925
May	1098	955	1675	895
June	991	822	1547	788

Planned Activities

Test Operations were planned with Georgia Power, EPRI, and Sandia during July report period.

Needed changes in CAIS software for more automatically controlled operations would be continued, and needed programming for data recording would be added.

Information Dissemination/Technology Transfer

The emphasis at the June 1983 STEP staff meeting was on safety. The Georgia Power Company Safety Department demonstrated high and low voltage uses, and the consequences of faults and mistakes associated with each, to illustrate ways to avoid electrical accidents and injuries. Other activities in June included the following:

- Several industry representatives were at the site during the month relative to PV activities. These included Solarex, Westinghouse, Hughes, and M. Hutton.
- Some 22 MITE (Minorities Interested Toward Engineering) high school students participating in a two week program at Auburn received a presentation and tour.
- A STEP staff member participated in the ASHRAE Annual Meeting in Washington and reviewed STEP status with the DOE.

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