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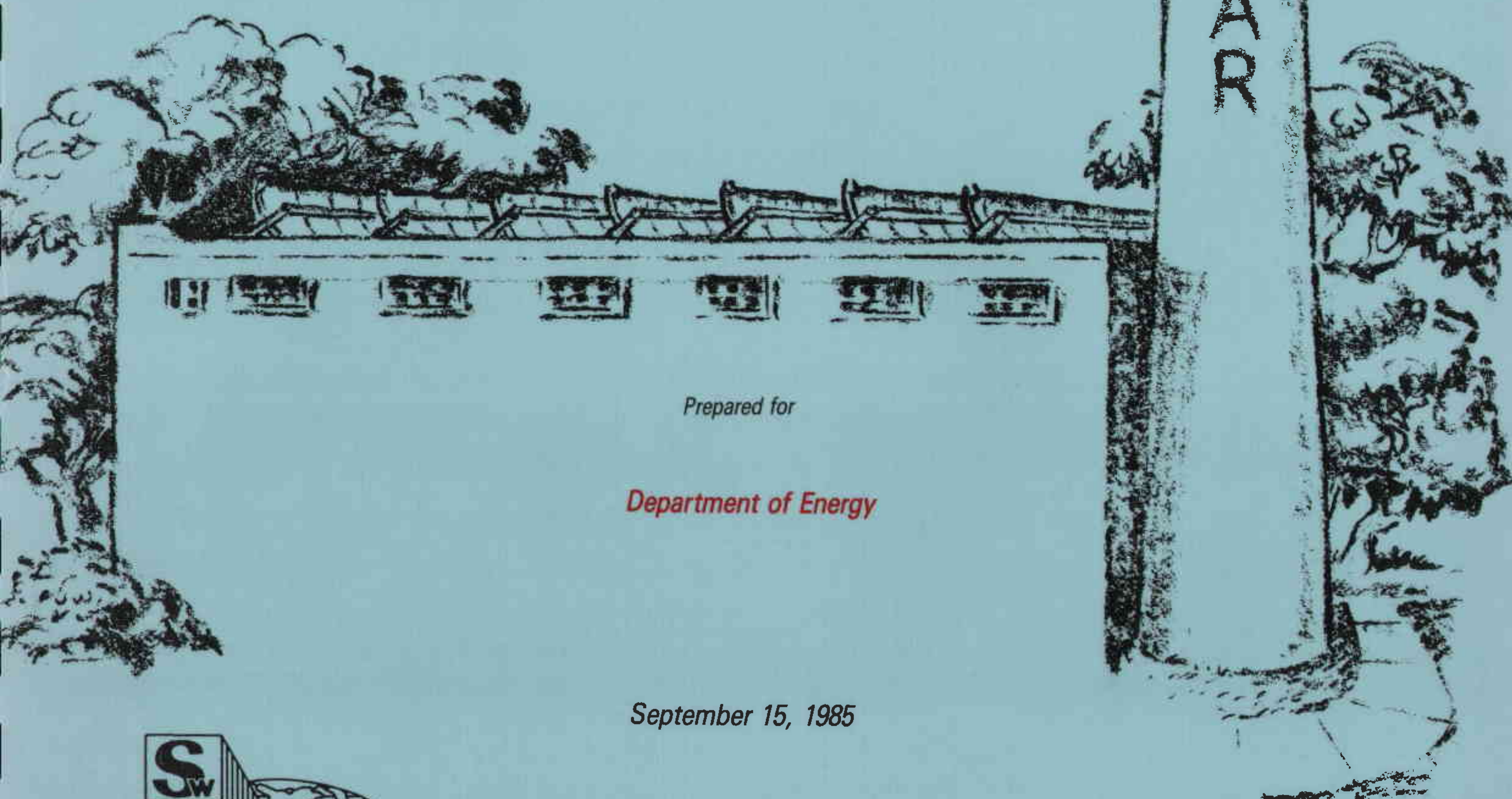
SOLAR PRODUCTION OF INDUSTRIAL PROCESS STEAM FOR THE LONE STAR BREWERY

FINAL REPORT



Prepared for

Department of Energy

September 15, 1985

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SOLAR PRODUCTION OF INDUSTRIAL PROCESS STEAM FOR THE LONE STAR BREWERY: FINAL REPORT

by
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Project No. 06-5476

Prepared for
Department of Energy

September 15, 1985

Approved:

Robert L. Bass, Director
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EXECUTIVE SUMMARY

This report summarizes the fourth and final phase of a multi-year program to investigate the feasibility of a solar industrial process heat system. The project was initiated in September 1978, the design was completed in June 1979, and the construction was completed in June 1981. This initial system was a process steam system generating 125 psig steam. This steam system was evaluated over a two-year period ending in June 1983. The primary objectives of these three phases were to resolve all of the technical issues required to integrate prototype solar collector equipment into an industrial environment and to determine the technical and economic feasibility. The net result was a successful experimental program. The conclusion was that the system was technically feasible, but was not reliable enough and was not economically feasible. Based on these three initial phases it was recommended that the system be further modified to produce hot water at 200°F with the addition of new modular receivers, new low-temperature hoses, hot water pumps, heat exchanger and piping, and upgrade the drive/control system with a mechanical drive and search mode control system. A fourth phase was initiated in November 1983 to make the hot-water modification, and an additional contract modification was initiated in May 1984 to include the mechanical drives and search mode controls. The schedule was to have the drives and controls installed by November 15, 1984 with a six month experimental evaluation period. Due to delays at the solar collector manufacturer, the drive and control systems were not installed until April 23, 1985. An operational extension was granted to allow operation until August 14, 1985.

The conclusion from the fourth phase of the project was that the hot water modification doubled the thermal output of the system over the steam system. The new mechanical gear box drives were a significant improvement over the original hydraulic drives. The function of providing a search mode to the tracker controls eliminated the prior problems of acquiring the sun in cloudy conditions and was a needed improvement.

However, due to the poor reliability of the new controls, the system required a fulltime operator to provide acceptable operation. Unattended system operation in an automatic mode requires an additional upgrade of the control components from commercial grade to industrial grade. With this added improvement the system most probably would be reliable, but the initial cost would still render the system economically unfeasible. The initial purchase price must be reduced by a factor of three or four before economical feasibility can be reached at current energy prices.

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I. INTRODUCTION

This document summarizes the work performed during the final operational phase of a project conducted for the U. S. Department of Energy under Contract No. DE-AC04-78CS32198, Southwest Research Institute Project Number 06-5476. The objective of this phase of the program was to convert the existing solar process heat system at the Lone Star Brewery in San Antonio, Texas from a high temperature steam system to a lower temperature water preheat system and monitor the system performance after the conversion. For more detailed information on the original design and construction of the system, consult the previous reports published for this project.

The system was converted to a lower temperature system for several reasons. One reason was to eliminate the heat transfer oil that circulated through the collectors and replace it with water. Since the collectors are mounted on a tar based roof the heat transfer oil would damage the roof when a leak in a flex hose or receiver tube seal occurred. Other reasons to convert the system to a lower temperature system were improved solar system performance, improved system reliability, and increased component life for flex hoses and receiver tube seals. The existing collector drive units and the collector controls were also replaced with new equipment manufactured by the collector manufacturer. The new collector controls were installed to provide each collector row with the capability to search for the sun in the event that the row looses focus on the sun. The old control units experienced problems in tracking the sun under the partly cloudy sky conditions that exist throughout the year in San Antonio, Texas. If the old control system lost track of the sun at any time during the day it would not require the sun. The new control system had a built-in search mode that would indicate a search if the collector lost track of the sun.

Along with the new control systems, new collector drives based on a gear box and a variable speed DC motor were installed on each row of collectors. The new drive systems replace the existing hydraulic based drive systems that had low reliability and caused damage to the tar based roof when hydraulic fluid leaks occurred.

This report describes the modified solar system, the solar system performance, system maintenance and operation, and the economic aspects of the solar system.

II. SOLAR SYSTEM DESCRIPTION

II.1 System Overview

The Lone Star Brewery utilizes large quantities of process heat for product processing and product packaging. The majority of the process heat is provided in the form of steam at 353°F (125 psig). The steam is generated with three natural gas fired boilers that have a total steam generating capacity of 110,000 lb/hr. The boiler makeup water for each of the boilers comes from a common deaerator that not only removes corrosive noncondensible gases from the water but also preheats the water to 210°F. Makeup water fed into the deaerator comes from condensate return water and treated raw water. After the deaerator makeup water is injected into the deaerator it is heated by directly injecting steam from the boilers.

The upgraded solar system at the Lone Star Brewery is used to preheat the treated raw water before it is injected into the deaerator. By preheating the deaerator makeup water the heating load at the deaerator is decreased and, therefore, operating costs are reduced through reduced fuel consumption. The Brewery requires relatively large quantities of makeup water because several of the processes at the plant require live steam injection and, therefore, no condensate is returned from these processes. The large relatively low temperature thermal load is fairly constant and is therefore ideally suited to the use of solar heating. A description of the solar system mechanical components and control system follows.

II.2. Solar System

The solar heating system consists of a collector fluid loop and a process water loop. The collector loop is a closed loop where the working fluid (treated water) is circulated through 15 parallel rows of solar collectors, through a shell and tube heat exchanger, and then pumped back to the collector field. Figure II.1 presents a schematic representation

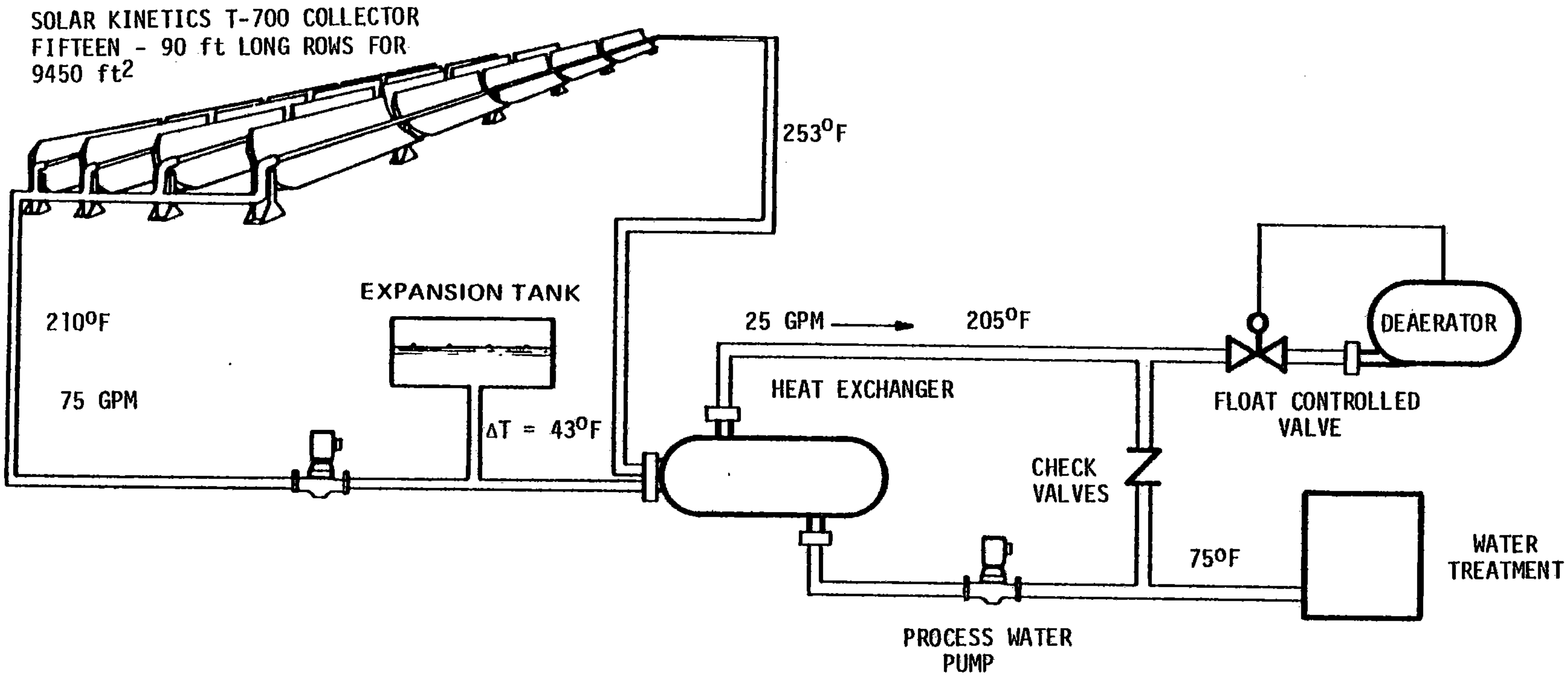


FIGURE II.1. SCHEMATIC OF SOLAR SYSTEM

of the solar system. The process water loop is an open loop that passes treated process water through the shell side of the solar heated heat exchanger where it is heated and then it flows to the deaerator through a float activated valve. If the deaerator is not calling for water, the process water is returned to the heat exchanger where it is further heated.

Under clear sky conditions with the collector plane radiation equal to 250 Btu/hr-ft^2 the collector field inlet temperature is 210°F and the outlet temperature is 253°F. The energy collection rate is 1.6 MBTU/hr and the solar collector efficiency, based on test stand performance data [1], is 69%. The flow rate through the collector loop is 75 gpm while the flow in the process water loop is 25 gpm. The process water temperature rise through the solar heated heat exchanger is 130°F.

Figure II.2 shows the system piping and instrumentation diagram (P&ID) and Figure II.3 shows the piping details in the solar equipment room. The piping in the solar collector field was not substantially changed when the system was converted to a water preheat system so the details of the collector field piping are presented in Reference 2.
The collector field consists of 15 rows of Solar Kinetics, Inc. Model T-700A parabolic trough solar collectors with a total area of 9450 ft^2. The collectors were originally installed on the roof of the can warehouse at the brewery in 1981. The original receiver tubes, collector drives, and control systems were replaced with the manufacturer's newest equipment when the system was converted to a water preheat system. The collectors are piped in a parallel configuration with the flow through each collector equal to 5 gpm. Since the collectors are not piped in a reverse return configuration the flow through the collector rows is balanced by adjusting a valve at the outlet of each collector row (see Figure II.2). An aerial photograph of the collector field is presented in Figure II.4. Figure II.5 and II.6 shows a single collector drive pylon and the collector drive consisting of a 1/4 hp DC motor and a gear box that provides a speed reduction of 8000:1. Figure II.7 shows a collector control panel that consists of a fused disconnect, a DC motor controller, and a search mode

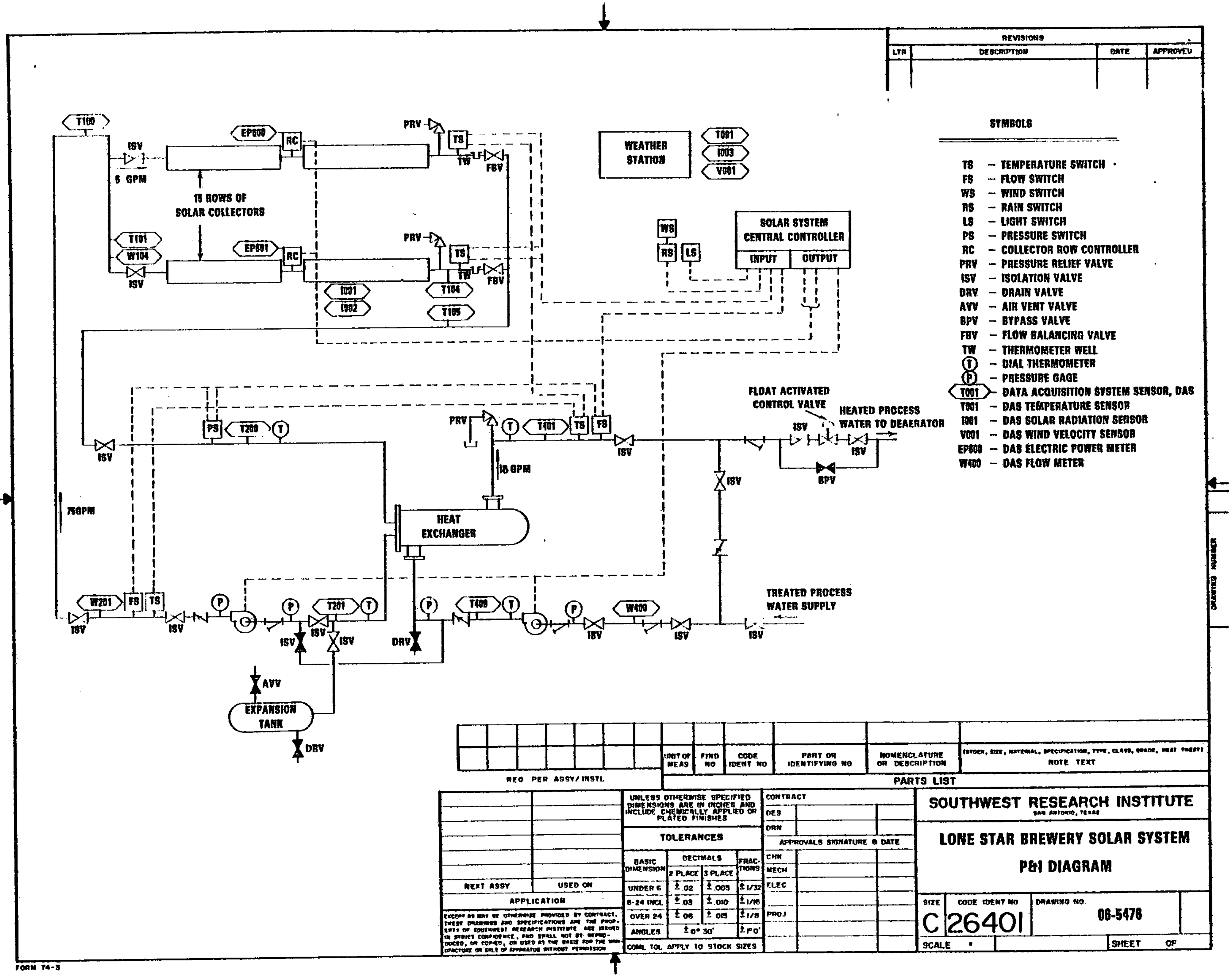
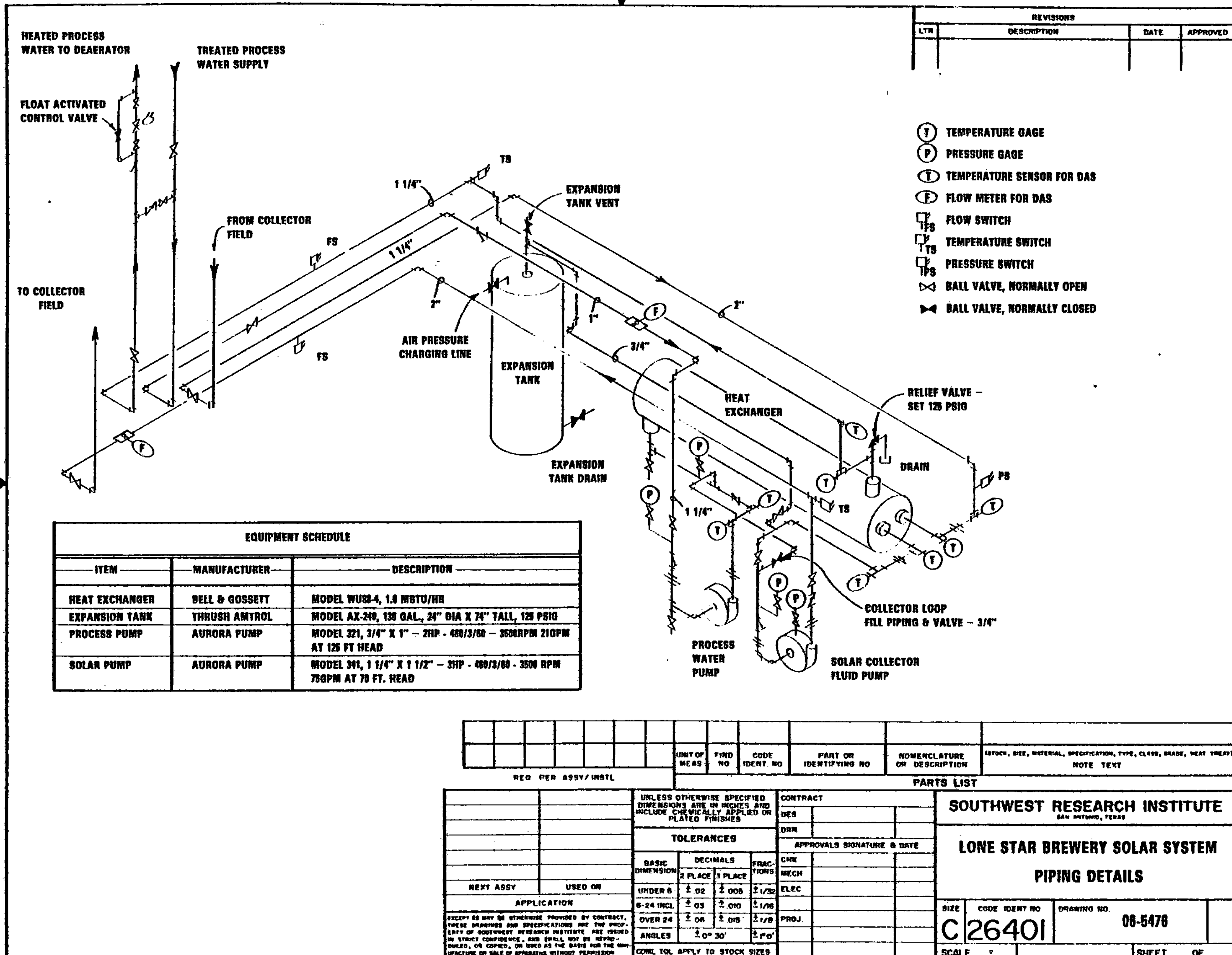


FIGURE II.2. SYSTEM PIPING AND INSTRUMENTATION DIAGRAM



EQUIPMENT SCHEDULE		
ITEM	MANUFACTURER	DESCRIPTION
HEAT EXCHANGER	BELL & GOSSETT	MODEL WU88-4, 1.8 MBTU/HR
EXPANSION TANK	THRUSH AMTROL	MODEL AX-240, 130 GAL., 24" DIA X 74" TALL, 125 PSIG
PROCESS PUMP	AURORA PUMP	MODEL 321, 3/4" X 1" – 2HP - 460/3/60 – 3500RPM 21GPM AT 125 FT HEAD
SOLAR PUMP	AURORA PUMP	MODEL 341, 1 1/4" X 1 1/2" – 3HP - 460/3/60 - 3500 RPM 75GPM AT 78 FT. HEAD

FIGURE II.3. EQUIPMENT ROOM PIPING DETAILS

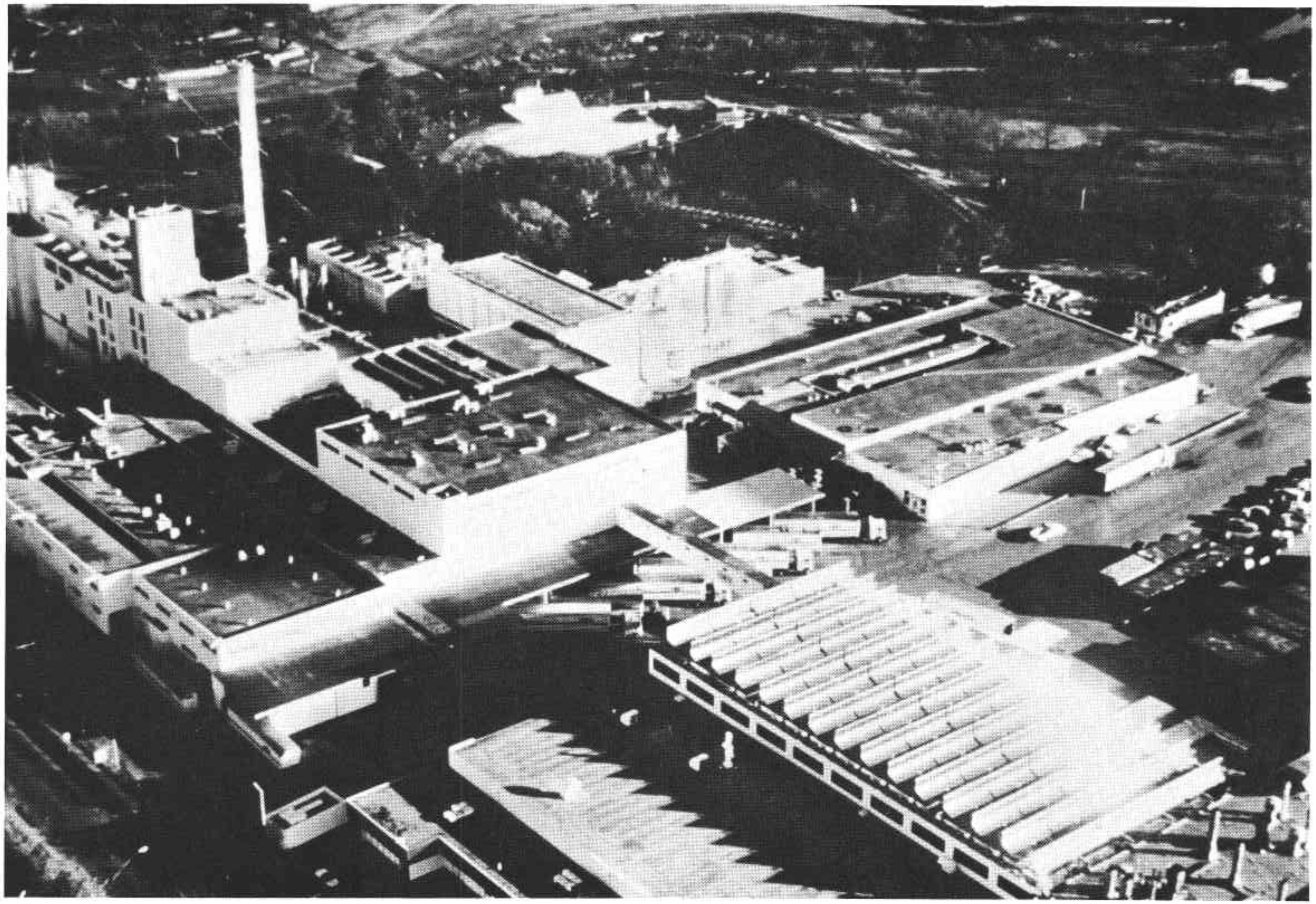


FIGURE II.4. SOLAR COLLECTOR FIELD AT LONE STAR BREWERY

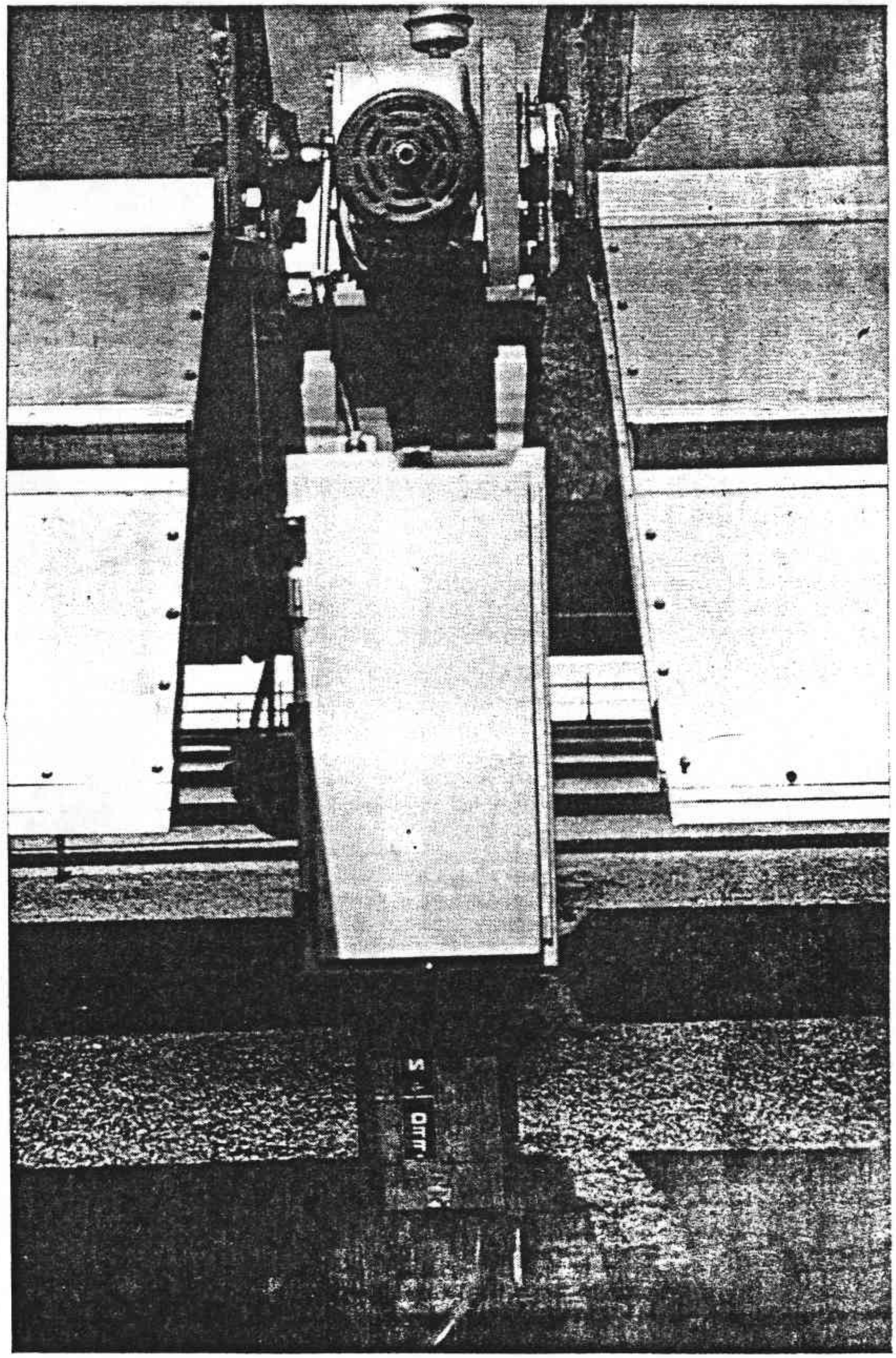


FIGURE II.5. COLLECTOR DRIVE PYLON

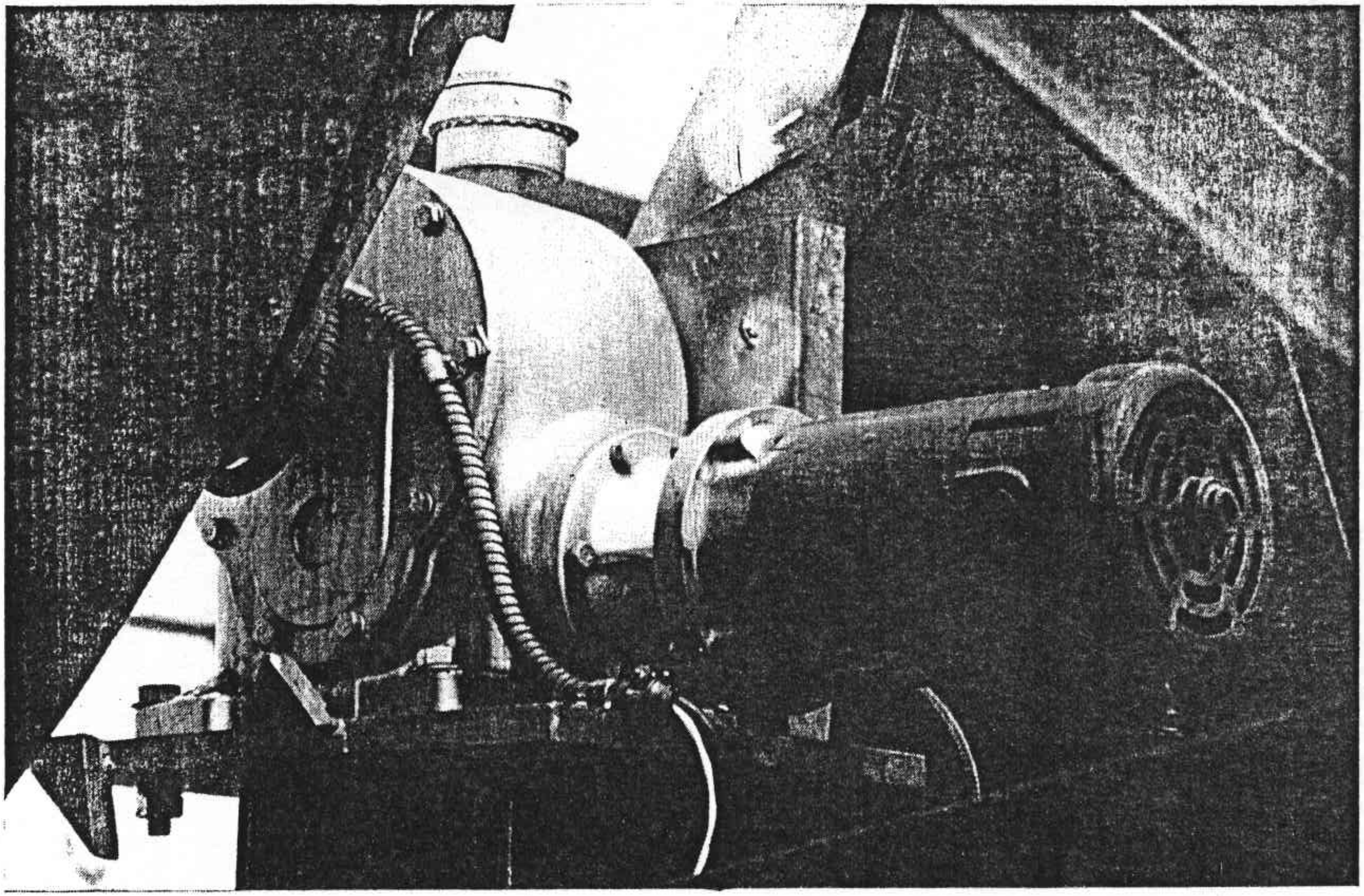


FIGURE II.6. COLLECTOR DRIVE GEAR BOX AND D.C. MOTOR

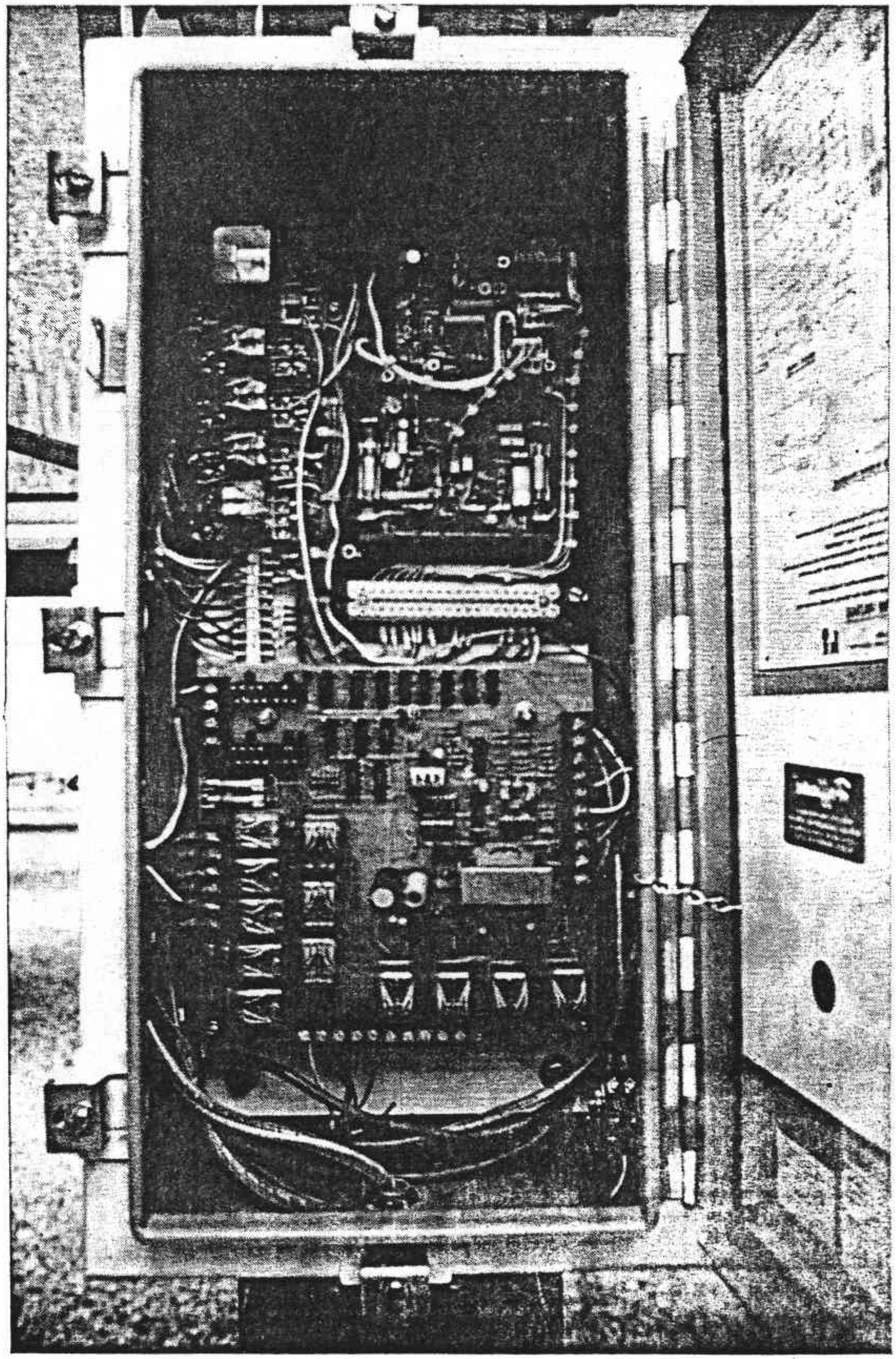


FIGURE II.7. COLLECTOR DRIVE CONTROL PANEL control board. Figure II.8 shows the collector tracker head, tracker head mounting on the receiver tube and the over temperature protection switch. Also shown in the picture are the new receiver tube supports, receiver tube clamps, and the receiver tube glass cover seal. Figure II.9 shows the piping configuration at the collector row outlet. The solar system central control panel is shown in Figure II.10. To provide for stowing the collector field in the event of an electrical power failure a back up generator was installed. The generator and the automatic power transfer switch are shown in Figures II.11 and II.12. The circulating pumps, heat exchanger, and equipment room piping are shown in Figure II.13.

II.3. System Controls

The solar control system is designed to provide completely automated system operation. The control system monitors ambient conditions, controls pump operation, activates the collector controllers, and monitors the system for hazardous conditions. The control system is centered around the Minarik Electric Company Model WP6000 programmable microprocessor controller (shown in Figure II.10). A copy of the program entered into the controller is listed in Appendix A.

The central controller continuously monitors the status of the light switch circuit to determine if enough solar radiation is available to initiate system operation. If enough radiation is available and the wind switch, rain switch, and system temperature switches indicate no hazardous conditions exist, then the fluid pumps are turned on. The controller then confirms flow has been established by checking the status of the two flow switches before activating the collector row controllers. The controller continues to monitor the hazard sensors during system operation and immediately stows the system if a hazard condition exists. If the light level switch indicates a low level of solar radiation the collector trackers are sent the deadband (halt) signal until the light level increases (cloud passes) or a time period of 15 minutes has passed and the system is stowed.

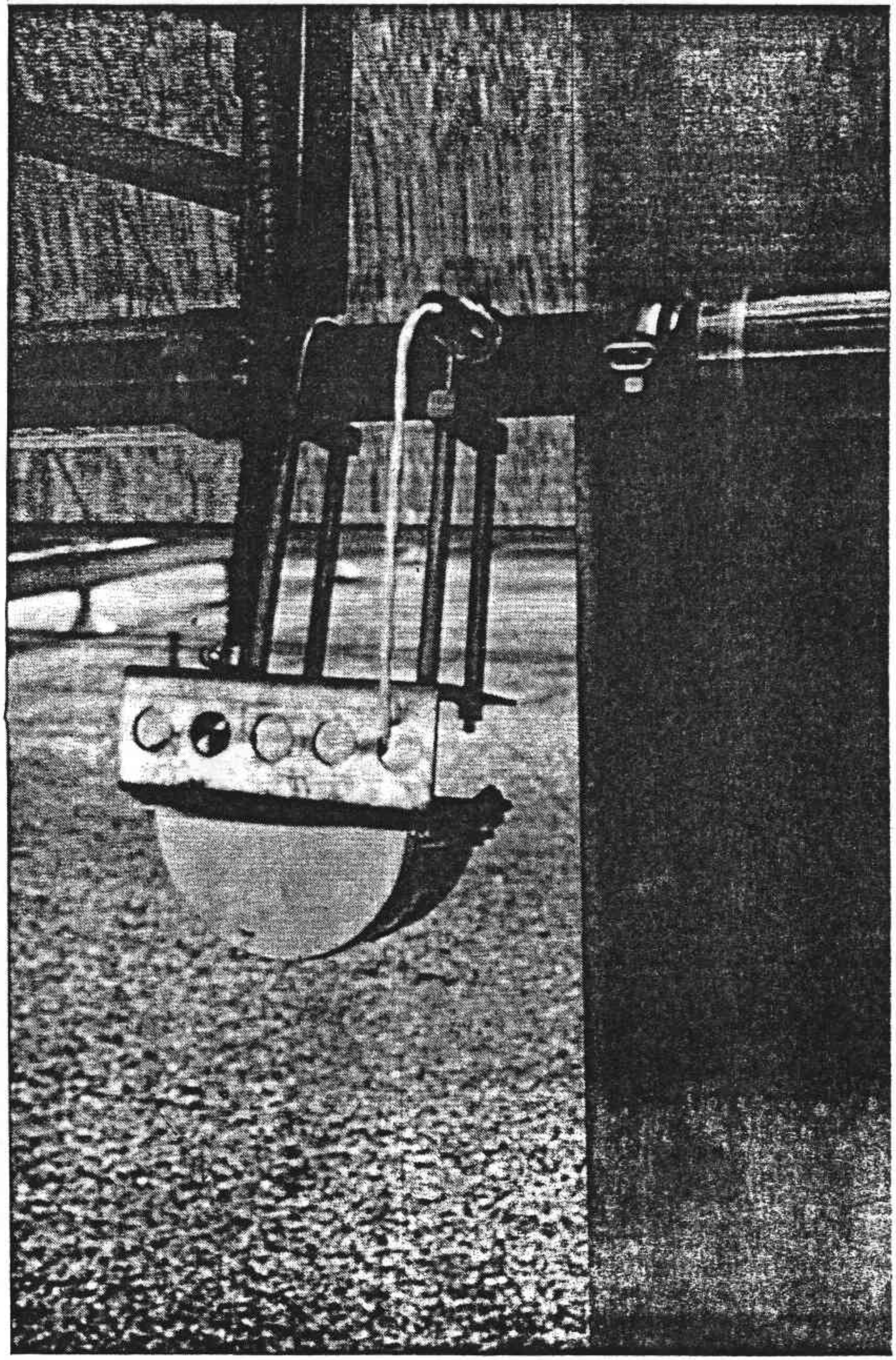


FIGURE II.8. COLLECTOR ROW TRACKERHEAD AND TEMPERATURE SWITCH

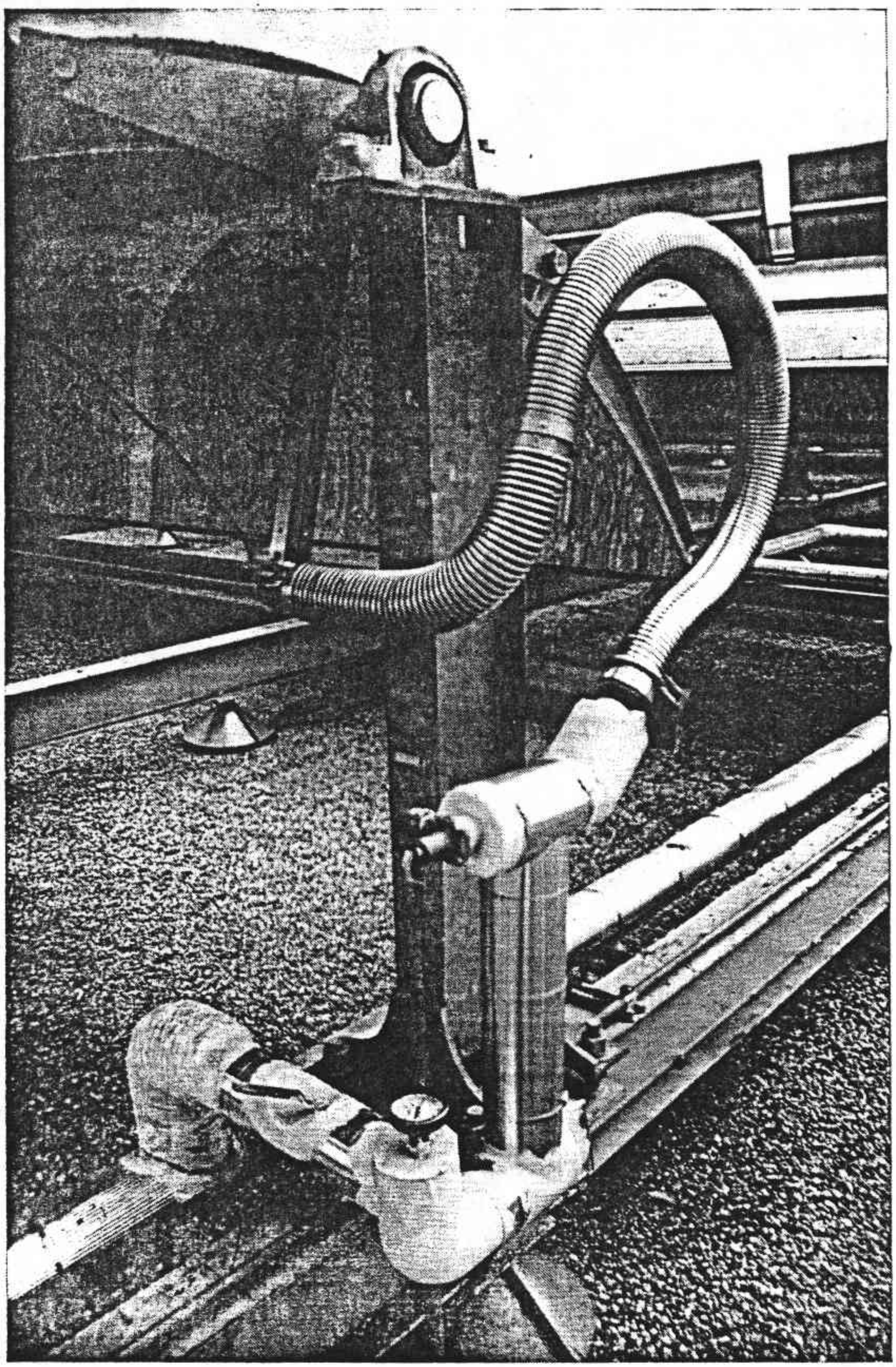


FIGURE II.9. COLLECTOR ROW OUTLET PIPING AND FLEX HOSE

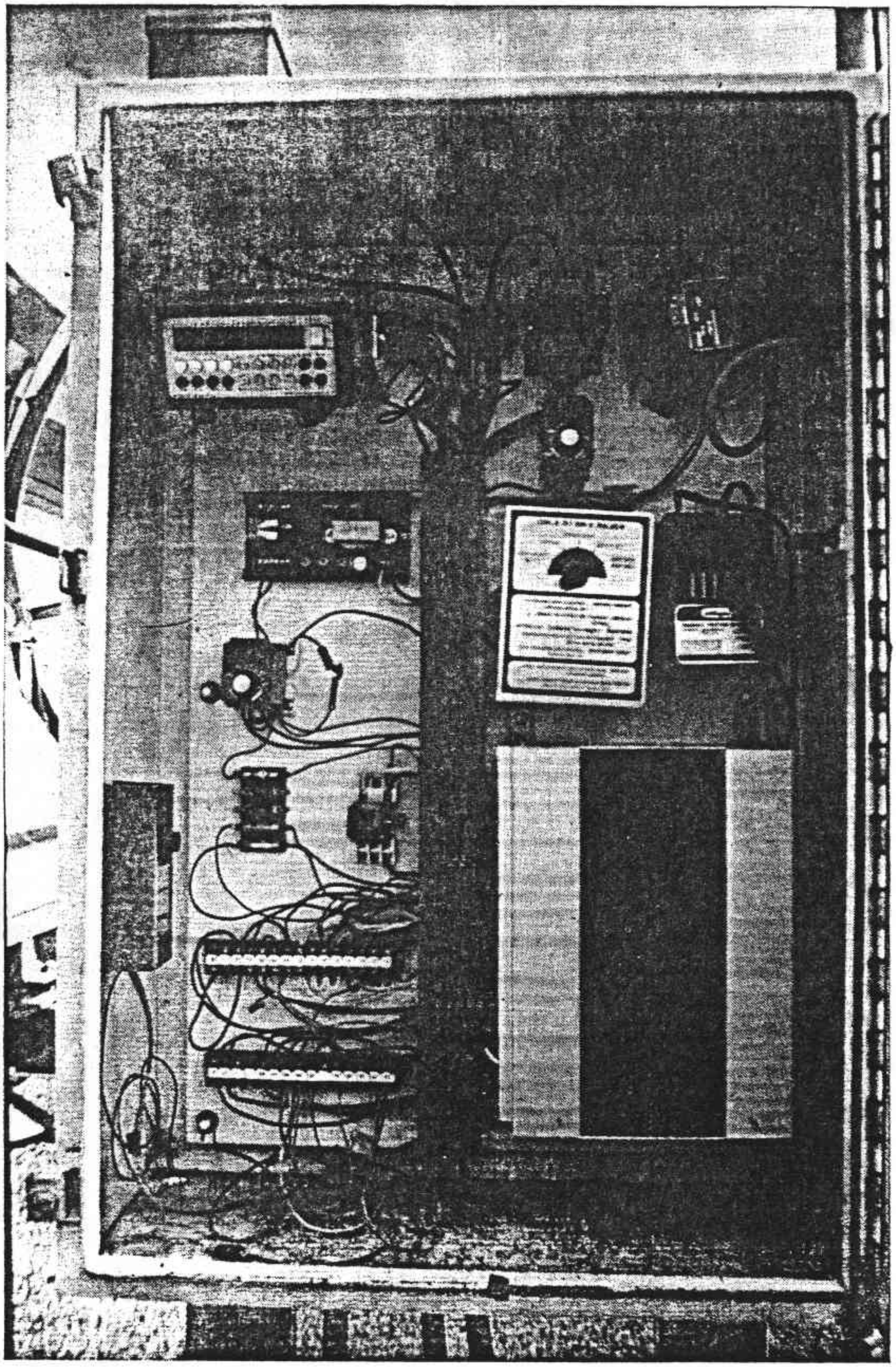


FIGURE II.10. SOLAR SYSTEM CENTRAL CONTROL PANEL

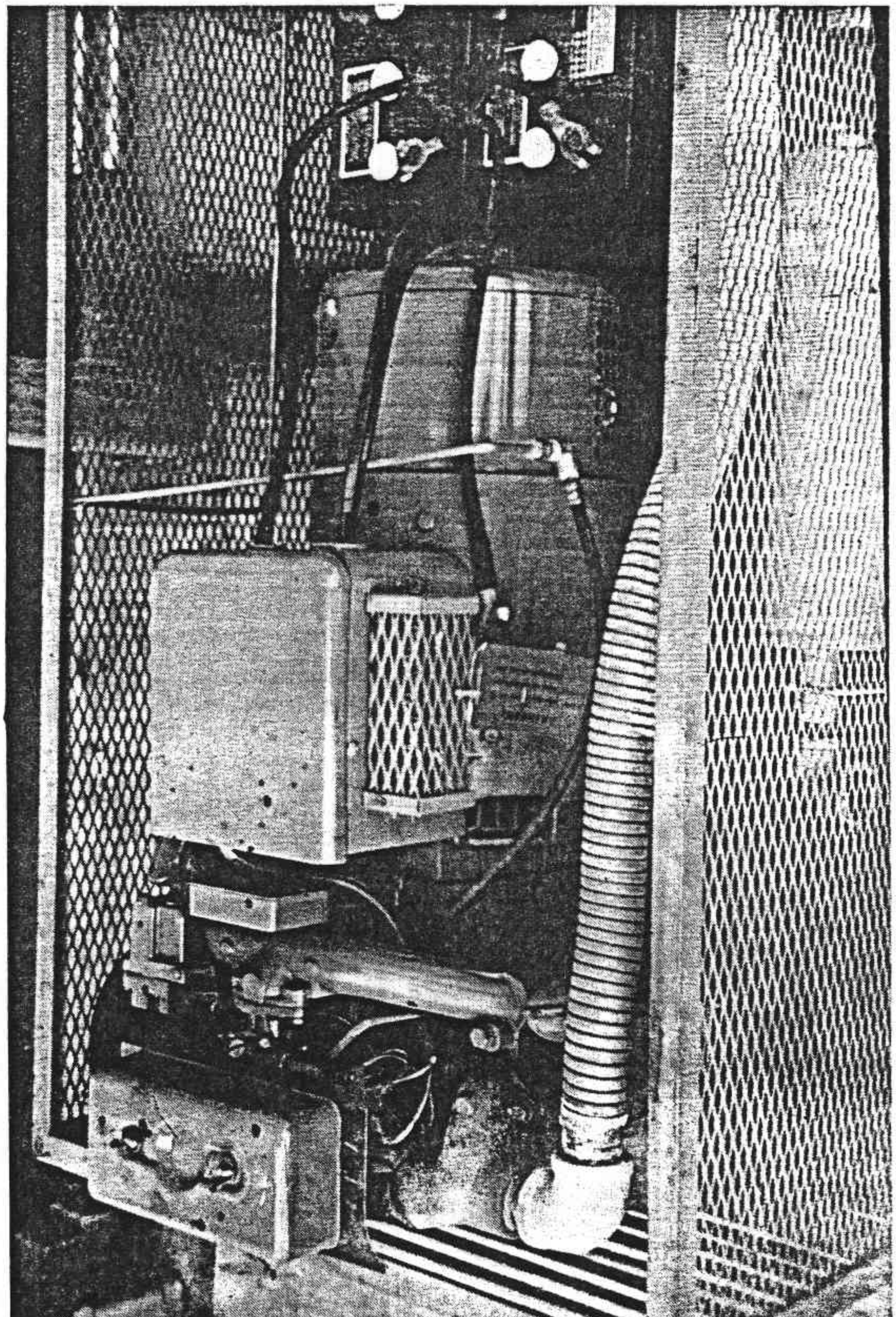


FIGURE II.11. SOLAR SYSTEM BACKUP GENERATOR

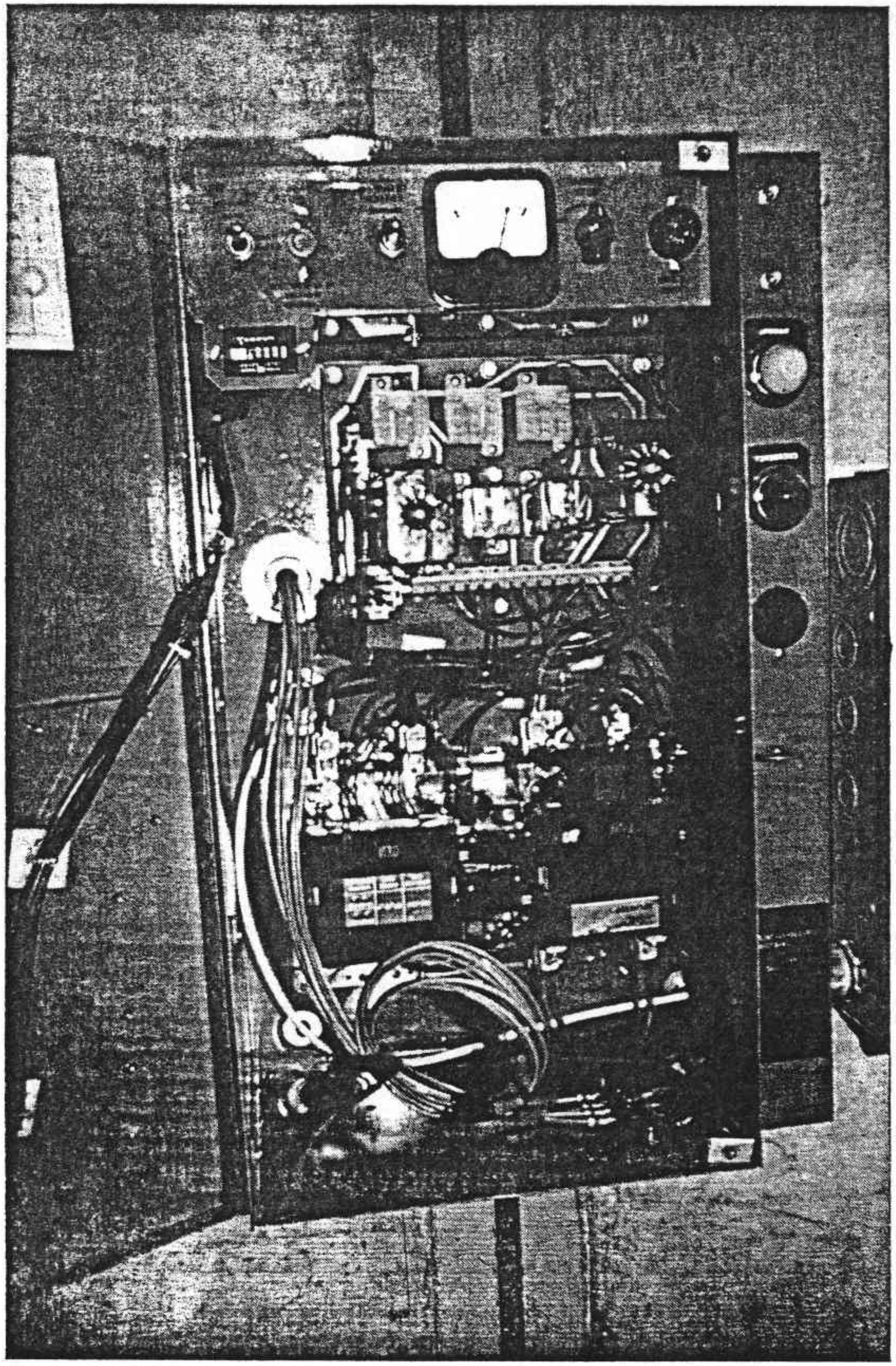


FIGURE II.12. AUTOMATIC TRANSFER SWITCH FOR BACKUP GENERATOR

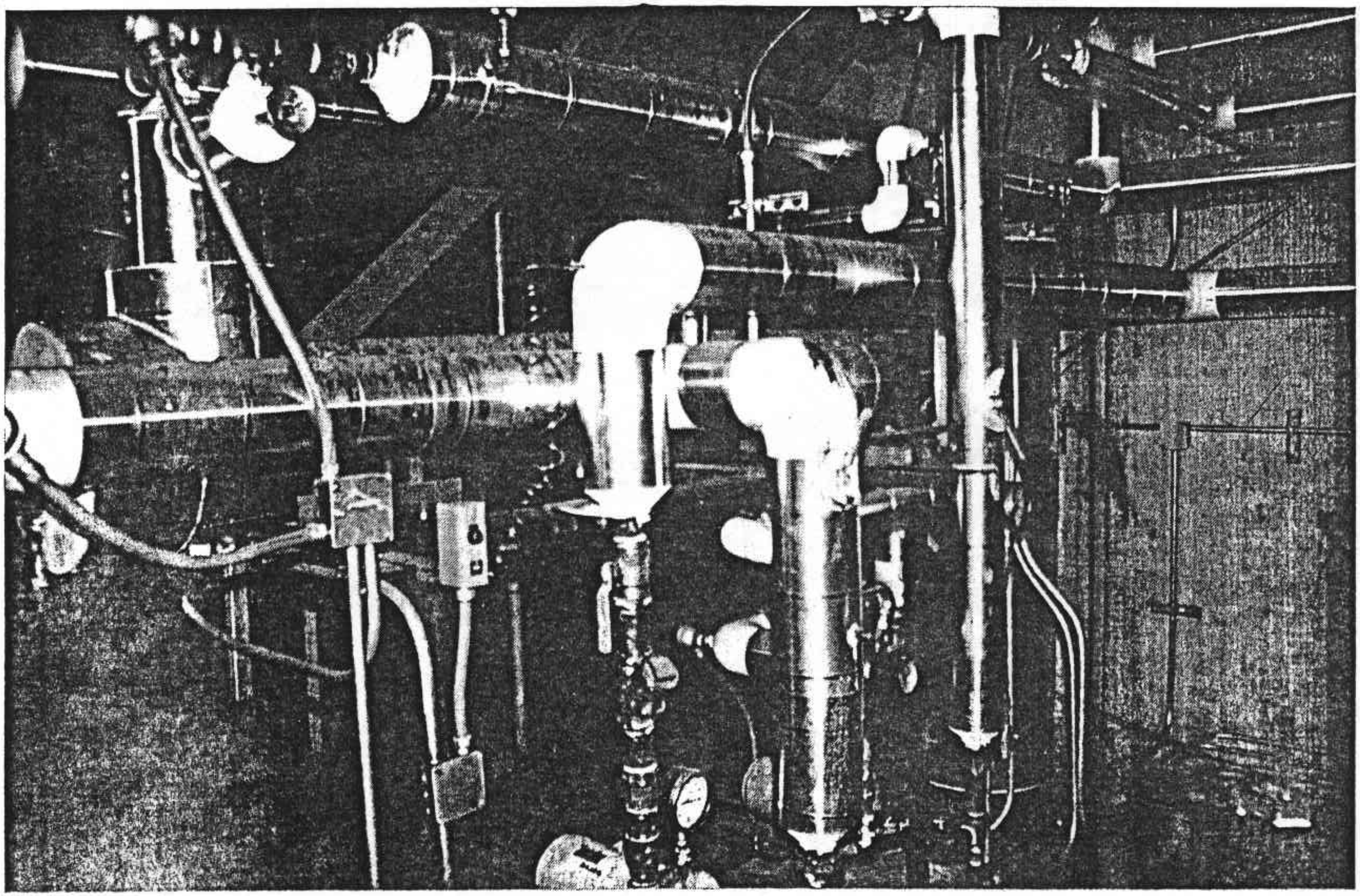


FIGURE II.13. SOLAR SYSTEM EQUIPMENT ROOM

The controller will defocus the collector field any time one of the temperature switches indicates an overtemperature condition exists. The collectors will remain out of focus until the temperature drops to a safe level. This allows the system to operate safely during time periods when the deaerator is not calling for feed water.

Each of the 15 individual collector rows is equipped with its own search mode control board and DC motor controller. The only interface between the central controller and the row controller is a two wire control signal that directs the row controller to stow the collector, track from the stowed position, track in the automatic mode, or deadband the collector (hold collector in the present location). When the collector row receives the track from stow signal the row will drive westward until it finds the sun and begins tracking or the row reaches the west limit. The collector controller will continue the search for the sun for two cycles before going to the stow position. If the collector looses track of the sun the controller will initiate the search mode to track west and then east until the collector relocates the sun or completes two complete cycles and goes to the stow position.

III. DATA ACQUISITION SYSTEM

A data acquisition system is installed at the solar system site to monitor the performance of the solar system. The data system records temperature readings, flow rates, and ambient weather condition data so the solar system energy collection rates and efficiencies can be calculated. The data system consists of an Acurex Autodata Ten/10 Calculating Datalogger, an MFE Model 2500 digital cassette recorder, and a number of primary sensors and signal conditioners. The datalogger is programmed to sample each of the primary sensors at a 15 second interval and to average the data over a ten minute period. At the end of a ten minute period the averaged values of data are dumped to the digital cassette recorder where they are stored. The datalogger also averages the data over a one hour period and writes the data out to a line printer. This hard copy of the data averaged at one hour intervals serves as a backup to the cassette recorder. Data reduction and analysis are performed by transferring the data contained on the digital cassettes to a Digital Equipment Company PDP 11/70 minicomputer located at Southwest Research Institute.

The primary sensors used to provide the input to the datalogger include RTD thermometers, turbine flow meters, pyranometers, wind anemometer, and AC power meters to monitor parasitic power consumption. Table III.1 presents a summary of the primary sensors and signal conditioners.

For each of the primary sensors used to monitor the solar system performance Table III.2 presents a typical operating value and the uncertainty of the reading. The tabulated uncertainties include the uncertainties in the primary sensor, signal conditioner, and the uncertainty in the reading introduced by the datalogger as it converts the analog signal to a digital value. Based on the uncertainties shown in Table III.2 the uncertainties in the calculated values of energy collected by the solar system and solar system efficiency can be determined. The overall uncertainty in the energy collected calculation is 5.0% and the calculation of solar system efficiency has an uncertainty of 6.3%.

TABLE III.1. SENSOR DESCRIPTION

Measured Parameter	Sensor Type	Manufacturer	Model
Fluid and Ambient Temperature	RTD Thermometer	Omega	PR12-2-100-1/4-5 1/2-E
Solar Radiation	Pyranometer	Epply	PSP
Fluid Flow	Turbine Meter	ITT Barton	7200
AC Power Consumption	AC Power Meter	Ohio Semitronics	PC5-28
Ambient Wind Velocity	3-Cup Wind Anemometer	Vaisala	WAA 12
Flow Meter Signal Conditioner	Freq to DC	Moore Inst.	FDX/D/4-20/14-42/11

TABLE III.2. SENSOR UNCERTAINTY

Parameter	Units	Typical Value	Total Uncertainty
T001 - Ambient Temperature	°F	75	± 0.5
T100 - Field Inlet Temperature	°F	200	± 1.1
T101 - Row 15 Inlet Temperature	°F	200	± 1.1
T104 - Row 15 Outlet Temperature	°F	235	± 1.2
T105 - Field Outlet Temperature	°F	235	± 1.2
T200 - Solar HX Inlet Temperature	°F	235	± 1.2
T201 - Solar HX Outlet Temperature	°F	200	± 1.1
T100 - Process HX Inlet Temperature	°F	75	± 0.5
T401 - Process HX Outlet Temperature	°F	200	± 1.1
I001 - Total POC Radiation	$\frac{BTU}{Hr/Ft^2}$	300	±10.0
I002 - Diffuse POC Radiation	$\frac{BTU}{Hr/Ft^2}$	45	±10.0
I003 - Total Horizontal Radiation	$\frac{BTU}{Hr/Ft^2}$	300	±10.0
W104 - Row 15 Flow	GPM	5	± 0.10
W201 - Collector Loop Flow	GPM	75	± 1.51
W400 - Process Flow	GPM	21	± 0.40
E600 - Collector Drive Power	KW	2.5	±0.05
E601 - Collector Driver Power	KW	3.0	±0.06
V001 - Wind Velocity	MPH	10	±0.30

IV. SOLAR SYSTEM MAINTENANCE AND OPERATION

The construction modifications required to convert the existing steam system to a deaerator water makeup preheater were completed on November 12, 1984. At this time the system was activated and the solar system performance monitoring began. The solar system operated until November 19, 1984 when a failure in some plant equipment made it necessary to cut off the deaerator makeup water supply and, therefore, the solar system had to be turned off. The plant water supply and the solar system were turned back on December 13, 1984. The solar system was operational from December 13, 1984 through February 13, 1985. On February 13, 1985 the system was shut down so the tracker heads from each collector row could be removed and sent to the manufacturer (Solar Kinetics) for installation on the drive systems that were to be installed at Lone Star. The construction and complete checkout of the new mechanical drives and control systems was completed on April 23, 1985 at which time the solar system was put into the automatic operation mode. The system continued to operate until June 14, 1985 when the system was shut down. The system was restarted on July 10, 1985 and operated until August 14, 1985. During this time period, personnel from Solar Kinetics, Inc. were on-site to repair the collector drive systems. The data collection system was shut down on August 14, 1985. A summary of the solar system operation is presented in Table IV.1.

A summary of the maintenance performed during the period of system operation is presented in Table IV.2. A more detailed description of the maintenance performed is contained in the monthly reports that are in Appendix B. The relatively short list of maintenance performed shown in Table IV.2 would lead one to believe the system was relatively trouble free. The majority of the system, such as the pumps, piping system, heat

TABLE IV.1. SOLAR SYSTEM OPERATION SUMMARY

Time Period	Solar System Status
11/12/84 - 11/19/84	System operational with hot water modification
11/20/84 - 12/12/84	System shut off because of plant equipment failures
12/13/84 - 2/13/85	System operational
2/14/85 - 4/22/85	System shut down for installation and check-out of new mechanical drives and new controls
4/23/85 - 6/14/85	System operational
6/14/85	System shut down due to control reliability problems
7/10/85 - 8/14/85	System operational after control repairs
8/14/85	System shut down

exchanger, and central controller was very reliable and required only minimal maintenance. The only component of the system that provided continuing problems was the collector control system. Table IV.3 presents a summary of the collector drive status for each of the 15 drive rows. The entries in the table correspond to the times that a person was on site and the solar system was operational. From November 12, 1984 through February 13, 1985 the only collector drive to experience a failure was row 1. During this period of operation the drive systems were hydraulic based and the control boards did not have the capabilities to search for the sun if they did not acquire the sun during startup. While the hydraulic drive systems were fairly reliable, problems with leaking hydraulic fluid (on to the tar-based roof) and control problem with acquiring the sun made a change to a mechanical drive system and a control system with search mode capabilities desirable.

TABLE IV.2. MAINTENANCE SUMMARY

Date	O & M Activity	Hours	Labor $	Materials $	Total $
Nov.1984	Collector Washed 11-7-84 (Subcontract)		197.00		197.00
Dec.1984	Replaced row 1 hydraulic	1	25.00	90.00	115.00
Dec.1984	Cleaned strainers at inlet	0.25	6.00	--	6.00
Dec.1984	Drained water from collector Wash water piping (to keep from freezing)	0.25	6.00	--	6.00
Jan.1985	Charged hydraulic accumulator on row 7 (1-11-85)	0.5	12.50	--	12.50
Jan. 1985	Reprogrammed the microprocessor used as the collector controller (1-21-85)	0.5	12.50	--	12.50
Feb.1985	No maintenance performed				
Mar.1985	No maintenance performed				
Apr.1985	Replaced microprocessor used for the solar system central controller (4-5-85)	1.0	25.00	--	25.00
Apr.1985	Traced down and solved cause of process water flow stoppage (4-15-85)	2.0	50.00	--	50.00
Apr.1985	Replaced row 11 flex hose (4-23-85)	1.0	25.00	--	25.00
Apr.1985	Solar Kinetics repair	NO COST - WARRANTY WORK			
May 1985	Solar Kinetics repaired collector drive	NO COST - WARRANTY WORK			
June 1985	No maintenance performed				
July 1985	Maintenance performed by Solar Kinetics	NO COST - WARRANTY WORK			
Aug. 1985	Maintenance performed by Solar Kinetics	NO COST - WARRANTY WORK			
				TOTAL	$449.00

TABLE IV.3. SUMMARY OF COLLECTOR DRIVE STATUS

								ROW								
Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Remarks
1984																
11/12																All rows operational
11/19	D															
12/13																All rows operational
12/31																All rows operational
1985																
1/3																All rows operational
1/25																All rows operational
1/30	D															Row 1 down
2/27	D															
2/13	D															System shut down for change to mechanical drives and new controls
4/1														D		
4/2																SKI on site, adjust trackers
4/5		I						I							D	
4/15															D	Solved problem of low process water flow rate
4/17								I					I		D	
4/23		I						D						D	D	
4/24																SKI on site (4 rows down)
4/25															D	SKI on site, Row 8 had water in limit switch

D = ROW DOWN
I = INTERMITTENT OPERATION

TABLE IV.3. SUMMARY OF COLLECTOR DRIVE STATUS (Continued)

Date	ROW 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Remarks
5/1										D				D		2 rows down
5/3					D				D						D	3 rows down
5/6					D				D		D				D	4 rows down
5/9					D				D		D				D	4 rows down
5/10					D				D						D	4 rows down
5/15				D	D				D	D	D				D	6 rows down
5/21				D	D	I		D	D	D	D				D	7 rows down
5/24		D		D	D			D	D	D	D				D	8 rows down
5/29		D		D	D	D		D	D	D	D			D	D	10 rows down
5/30	---SKI ON SITE---															
5/31				D	D	D				D						4 rows down
6/10				D	D	D				D	D					Row 15 brought up (isolation valves opened)
6/14				D	D	D				D	D					Turned off system
7/9				D	D	D				D	D					SKI on site, system re-reactivated
7/12																SKI on site, all rows operational
8/13																All rows operational, data collection system shut off

D = ROW DOWN
I = INTERMITTENT OPERATION

Table IV.3 shows the collector drive/control system reliability to be significantly lower after the installation of the new units (after 2/13/85). A number of collector drive/control failures occurred soon after the new units were installed (on March 21, 1985 only 3 of the 15 rows were functioning properly). The cause of the initial problems was probably due to rain water leaking into the control boxes during installation. After the initial failures were repaired other failures occurred. The causes of the failures were not known for certain but some could be traced to water that leaked into the limit switch enclosures. Some design problems with the DC motor control board were found and new boards were installed on May 30, 1985. During the system operating period from July 12, 1985 through August 14, 1985, personnel from Solar Kinetics, Inc. were on-site to repair the collector drive units. For this reason there was almost no collector downtime during this period since the collectors were repaired soon after they failed.

After the data system was turned off on August 14, 1985 the system continued to run. Two collector drive units failed and were repaired on August 21, 1985. By August 28, 1985 two different collector drives failed. Even after the period of close supervision by Solar Kinetics personnel the system continued to have extremely poor reliability. The current assessment for the poor reliability of the control system is that while the basic design seems to be adequate, the quality of the components is not sufficient. The manufacturer's evaluation is that the limit switches should be upgraded to a higher quality switch and the DC motor control board should be upgraded from a commercial grade to an industrial grade.

Since there was not a person at the solar system site every day to document the status of each collector drive row, it is difficult to document the performance of the solar system since the number of active rows is not known. The system was checked once or twice a week for a period of about one hour. During this time the status of the system was recorded. The solar system status between these periods can only be

Hell of a way to run an experiment.

guessed at considering the relatively unreliable collector drive units. Besides requiring a considerable amount of maintenance the control unit failures also represent a lost potential to collect solar energy while they are down. This reduces the yearly energy savings and, therefore, reduces some of the economic benefits of the system. Collector control failures therefore drastically effect the economic viability of a solar system by reducing benefits (fuel cost reductions) and increasing costs (parts and labor for repair).

V. SOLAR SYSTEM THERMAL PERFORMANCE

V.1. Actual System Performance

A summary of the Lone Star Brewery solar system performance is shown in Table V.1. The table presents the monthly totals for energy collected by the solar collectors, the amount of energy "delivered" as hot process water, and the measured values of collector plane and horizontal plane radiation. The data in Table V.1 are taken from the monthly performance reports contained in Appendix B. It is important to relate the system operation and maintenance history presented in the previous section (and in the monthly reports contained in Appendix B) with the performance data. During several months of the monitoring period the solar system was turned off for several days during the month. This obviously has a negative impact on the quantity of energy collected during the month.

To provide insight into the daily system performance, the solar system performance for a single clear day of operation (August 5, 1985) is presented in Table V.2 and Figure V.1. From the plot of solar radiation on the horizontal surface in Figure V.1 it can be seen that the day was completely clear after the solar system began operation. The solar system began operation at 9:50 A.M. CDT and continued to operate until 6:05 P.M. when the system shut down. The system operating period is limited to this time period by placing "blinders" on the central controller light switch that prevented the light switch from "seeing" the sun before 9:00 A.M. or after 6:00 P.M. Partly cloudy conditions in the early morning prevented the system from activating until 9:50 A.M. The daily total energy collected was 6.66 MBTU and the total energy delivered as hot process water was 6.46 MBTU. During the peak system operating period average collector fluid temperature at the inlet to the collector field was about 172°F while the average temperature leaving the field was 197°F. The collector array efficiency during this period was 36%. It should be noted that the solar collectors were extremely dirty on August 5, 1985. A nother example of poor performance by the experimenter, SWRI.

TABLE V.1. MONTHLY PERFORMANCE SUMMARY

Month	Solar Radiation Horizontal Plane BTU/FT²	Solar Radiation Collector Plane BTU/FT²	Energy Collected KBTU	Energy Delivered KBTU	Notes
11/84	4014	1833	4543	4499	1
12/84	13031	2282	6794	6508	2
1/85	23518	13766	47608	44669	-
2/85	11048	6911	24157	23909	3
4/85	11898	-	9715	8270	4,5
5/85	58347	-	57499	55579	5
6/85	25392	-	24965	23751	5,6
7/85	25681	-	56454	55048	5,7
8/85	28038	21121	70809	68687	8
		45913		148,272 MBtu	

x 9450

433.9 MBtu

34%

NOTES:
(1) Solar system turned on only 8 days during month.
(2) Solar system turned on only 19 days during month.
(3) Solar system turned on only 12 days during month.
(4) Solar system turned on only 8 days during month.
(5) No collector plane radiation data available because collector drive with radiation measuring data mounted on it was not operational.
(6) Solar system turned on only 13 days during month.
(7) Solar system data for 15 days during July.
(8) Solar system data for 13 days during August.

TABLE V.2. CLEAR DAY SOLAR SYSTEM PERFORMANCE SUMMARY TABLE FOR AUGUST 5, 1985

DAILY PERFORMANCE TABLE AUG 5, 1985
COLLECTOR FIELD AREA = 9450. [SQ-FT]
COLLECTOR REFLECTANCE =53.5%

Not explained

HR	AMBIENT TEMP. DEG F	WIND SPEED MPH	INCIDENT SOLAR RAD: ON A HORIZ. SURFACE (1) BTU/SF	INCIDENT SOLAR RAD: IN THE COLLECTOR PLANE (2) BTU/SF	COLLECTOR ARRAY FLOW RATE GPM	COLLECTOR ARRAY TEMPERATURE: INLET DEG F	COLLECTOR ARRAY TEMPERATURE: OUTLET DEG F	ENERGY COLLECTED KBTU	COLLECTOR ARRAY EFFIC. BASED ON (1) %	COLLECTOR ARRAY EFFIC BASED ON (2) MEAS %	COLLECTOR ARRAY EFFIC BASED ON (2) CALC %	ENERGY DELIVERED KBTU	THERMAL LOSSES KBTU	PARASITIC ENERGY KBTU
1	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
2	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
3	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
4	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
5	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
6	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
7	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
8	75.6	0.7	18.	0.	0.0	85.9	82.0	0.0	0.0	0.0	0.0	0.	0.	0.
9	76.5	3.0	33.	0.	0.0	86.7	81.8	0.0	0.0	0.0	0.0	0.	0.	0.
10	78.5	4.5	112.	9.	6.9	87.9	82.5	0.0	0.0	0.0	33.1	7.	-7.	2.
11	82.1	4.8	198.	223.	75.4	148.4	164.3	588.7	31.5	28.0	31.2	540.	48.	14.
12	85.8	5.4	254.	236.	75.6	174.4	196.0	796.4	33.2	35.6	30.2	770.	27.	14.
13	89.3	6.0	291.	244.	75.7	175.3	197.8	829.2	30.1	36.0	30.2	806.	24.	14.
14	93.3	6.1	304.	262.	75.7	172.4	196.8	899.0	31.3	36.4	30.5	877.	22.	14.
15	95.5	6.2	308.	271.	75.7	170.3	196.2	953.3	32.7	37.2	30.7	934.	20.	14.
16	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
17	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
18	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
19	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
20	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
21	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
22	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
23	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
24	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
TOT			1519.	1245.				4066.5				3933.	134.	72.

DAILY COLLECTOR ARRAY EFFICIENCY BASED ON (1) 28.3%
DAILY COLLECTOR ARRAY EFFICIENCY BASED ON (2) 34.6%
DAILY SYSTEM THERMAL EFFICIENCY BASED ON (1) 27.4%
DAILY SYSTEM THERMAL EFFICIENCY BASED ON (2) 33.4%

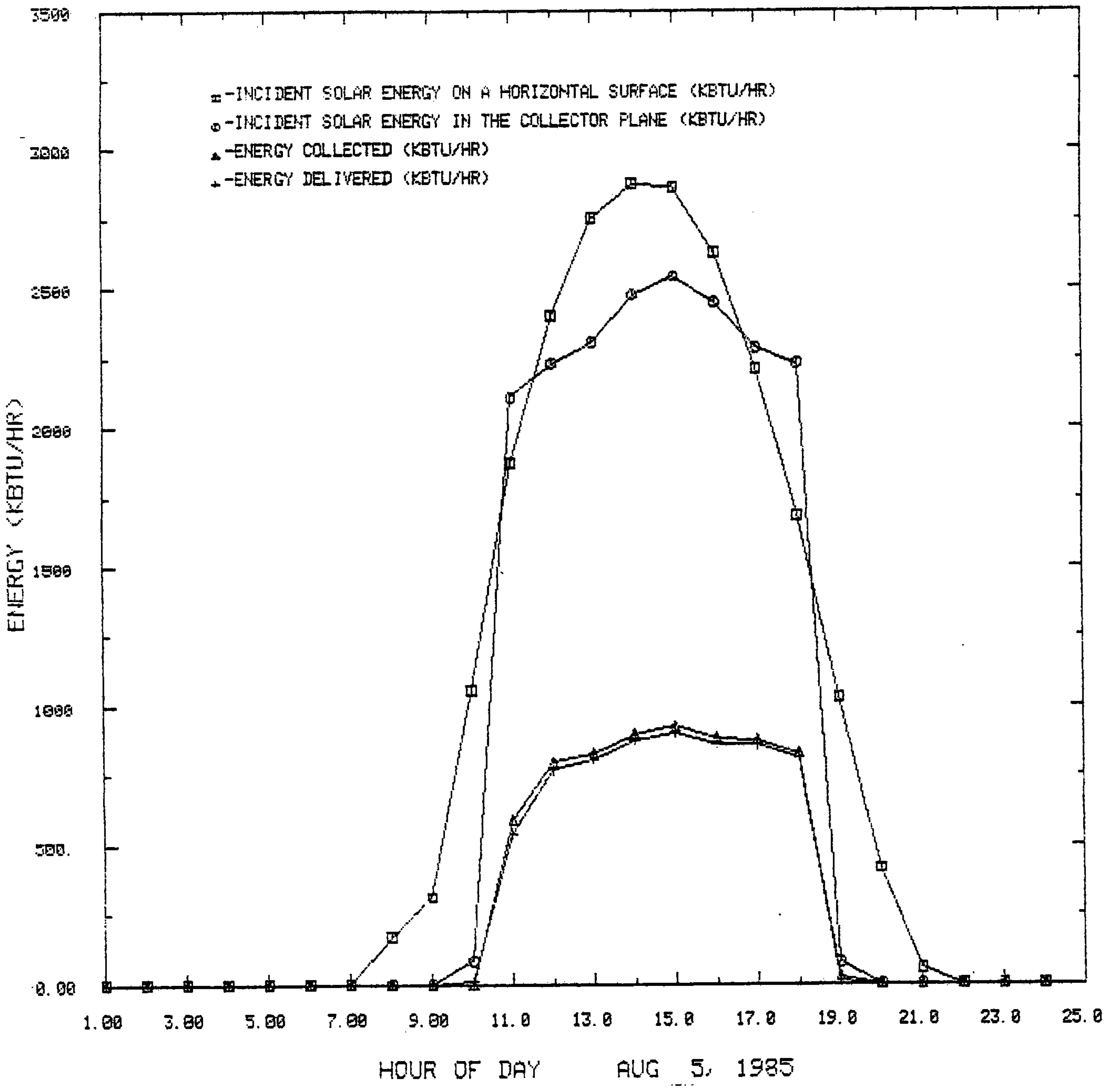


FIGURE V.1. CLEAR DAY PERFORMANCE SUMMARY PLOT FOR AUGUST 5, 1985

The relatively low system efficiency (36%) is caused by the dirt and debris that accumulated on the reflector surface and the glass receiver tube cover. The measured reflectance of the collector reflectors was only 50% compared with a new and clean reflector that has an 84% reflectance.

I wouldn't have the nerve to report this evidence of my poor performance or neglect

V.2. System Performance Prediction

As part of the solar system design effort a prediction of the solar system performance was calculated. The performance model utilized in the performance prediction was developed by Treat, et al. [3]. The computer code simulation model is a quasi-steady state routine that utilizes hourly weather data compiled by the National Climatic Center [4]. The computer code simulates the operation of the solar system through software that simulates the solar system controls, parabolic trough solar collectors, piping (thermal losses) and the solar system heat exchanger. The results of the solar system simulation for an entire year of simulated operation is presented in Table V.3.

The performance predictions summarized in Table V.3 are based on the assumption that there is no solar system "down time" caused by failure of any of the components in the system. This assumption is obviously optimistic and results in an upper bound for the solar system performance. The degradation of the solar collector reflective surface due to the buildup of debris was modeled in the performance simulation by degrading the collector reflectance by a factor of .0025 per day. The reflectance was restored to the "clean" collector reflectance at a 60 day interval to simulate the effect of collector washing every 60 days.

A comparison of the actual system performance (Table V.1) and the predicted performance (Table V.3) is difficult because of the intermittent operation of the solar system and the high failure rate of the solar collector drive systems. During January 1985 the system was turned on the entire month but power failures caused loss of operational data so the data presented in Table V.1 represents only 26.5 days of operation. A

TABLE V.3. PREDICTED SOLAR SYSTEM PERFORMANCE FOR ONE YEAR OF OPERATION

	Solar Radiation			
Month	Horizontal Plane BTU/FT^2	Collector Plane BTU/FT^2	Energy Collected KBTU	Energy Delivered KBTU
Jan	28900	39400	114300	109600
Feb	31600	34300	103000	99200
Mar	46200	42300	168200	161600
Apr	46800	33000	122900	118100
May	57400	44200	207900	201300
Jun	62200	49900	217400	210700
Jul	67300	58800	288200	279700
Aug	58600	51300	222100	216400
Sep	49800	46000	197500	191800
Oct	40900	44800	148400	143600
Nov	29700	36400	110600	106800
Dec	26000	34500	87100	83300
TOTAL	545000	515000	1985000	1918000

$\eta = 39\%$

comparison of measured and predicted daily energy delivery during January shows the measured energy delivered to be 1.69 MBTU/day compared to the predicted value of 3.54 MBTU/day (measured energy collected is 48% of the predicted). The difference between the actual and the predicted can partly be due to less than average solar radiation but the majority of the difference is primarily due to collector control related problems. Intermittent clouds can cause the solar system central controller to keep the collector field stowed when there is enough solar radiation present to warrant operation. The other effect of intermittent clouds on system operation is to cause individual collector rows to fail to properly track the sun. During January the search mode tracker boards were not yet installed, so a collector row that failed to acquire the sun at start up would remain out of focus for the entire day.

The measured system operation during June 1985 showed the solar system delivered 1.83 MBTU/day compared with the predicted value of 7.02 MBTU/day. During June 1985 only 10 of the 15 collector rows were operational so a comparison based on a per square foot of active collector would be more meaningful. The per unit area measured and predicted energy delivered are 0.29 KBTU/day-ft^2 and 0.74 KBTU/day-ft^2, respectively. The actual energy delivered is still only 40% of the predicted value. Approximately 5% of the difference between the measured and predicted values can be accounted for by lower than average solar radiation during June. Another small portion of the difference is due to increased thermal losses because 5 rows of collectors had hot fluid flowing through the unfocused collector receiver tubes. The rest of the difference is probably due to collector control related problems and to inaccuracies in the simulation model.

During August 1985 personnel from Solar Kinetics were on-site for part of the month. When someone was on-site he made certain that all the rows remained focused on the sun. The average daily energy delivered by the system during August was 5.28 MBTU/day. This is compared to the predicted value of 6.98 MBTU/day. The measured value is 76% of the predicted value. Comparing this value with the above 40% (for June) shows that the unattended system apparently experiences many problems with the collector control systems.

VI. ECONOMIC ANALYSIS

To perform an economic analysis on the solar system, the system purchase price, yearly maintenance costs, and the system benefits (through reduced energy costs) must be known. The cost of the solar system is difficult to determine since the water preheat system is a modification of the earlier steam generating solar system. The difference between the installed cost of a new water preheat system and a steam system is negligible, so for the purpose of an economic analysis the installed cost will be assumed to be the same as the cost to install the steam system or $51 per square foot of collector area. An estimate of the yearly maintenance costs can be obtained from Table IV.2. The total maintenance cost for a period of approximately six months was $449 so an estimate of $900 per year ($0.095 per square foot of collector area per year) for maintenance is reasonable.

Except that the system was not maintained in a fully operable manner.

Since an entire year of solar system performance data is not available the predicted system performance data will be used to provide an estimate of the solar system benefits. Based on a yearly energy delivery of 1918 MBTU (Table V.3) and a fuel cost of $6 per MBTU (natural gas) and a boiler efficiency of 75%, the yearly energy cost savings are $15,300 per year.

An economic analysis of the solar system was performed based on the method recommended by Dickinson and Brown [5] with the following input parameters:

Corporate tax rate	= 50%
Investment tax credit	= 20%
General inflation rate	= 5%
Fuel escalation rate	= 5%
System life	= 20 years
Zero year fuel cost	= $6/MBTU
Boiler efficiency	= 75%
Salvage value	= $0
Depreciation period	= 7 years

The resulting economic analysis shows the solar system has a 13 year payback period and a 3.4% internal rate of return (based on 20 year life).

VII. ENVIRONMENTAL IMPACT

The solar system at the Lone Star Brewery was designed to have a minimum environmental impact from every standpoint except energy consumption. Each of the pertinent issues from an environmental impact stand point are discussed below where it is shown that the overall impact is a favorable one.

Air Quality: The only impact the solar system has on air quality is a positive one by displacing a portion of the fossil fuel that is burned in the industrial process. By reducing the amount of fuel burned there is less polluting exhaust gas introduced into the environment.

Water Usage: The only water required for use (and discarded) in the solar system is the water required to wash the collector field. The collectors as are washed at an interval of approximately two months. The water required for one washing is estimated to be about 300 gallons so the amount of water used by the solar system on a yearly basis is about 1800 gallons. This is a small fraction of the plant's annual water load.

Noise Impact: The predominant industrial activities at the site generate a relatively high noise level compared to the noise generated by the heat transfer fluid pump and the collector drive systems. Therefore, the noise generated by the solar system has a negligible impact.

Energy Impact: The impact of the proposed action on the energy usage of the industrial plant is the major reason for constructing this system. This system is estimated to conserve about 2.6 million cubic feet of gas per year for the industrial plant, which is a very positive impact.

Land Usage: Since the collector field is roof-mounted, no long-range impact on land usage will be felt and the surrounding valuable urban land can be used for more productive purposes.

VIII. CONCLUSIONS

A number of important conclusions can be drawn from this phase of the solar industrial process heat experiment conducted at the Lone Star Brewery. The conversion to a hot water preheat system not only eliminated the prior problems with the receiver tube and flex-hose leaks, but it also significantly improved the thermal output of the system. The thermal performance was increased by a factor of two. The upgrade drive/control system exhibited improvement in some areas and disappointments in others. The new Windsmith gear box appears to be significantly more reliable and requires less maintenance than the previous hydraulic system. The search mode feature in the control system solved the solar acquisition problem under cloudy startup conditions. While the control system passed a functional test, a severe reliability problem does exist. A post test evaluation by the vendor indicated that the source of the problem is the quality of the limit switches and motor control boards. Both are commercial grade components that need to be upgraded to industrial grade in order to provide the required reliable service.

This source has not been verified as the cause of the problem. It is conjecture

The overall conclusion from this solar industrial process heat experiment is that while this technology is technically feasible, it is not yet reliable for the industrial environment and is not cost effective at current energy prices.

REFERENCES

1. Dudley, V.E. and R. M. Workhoven, "Performance Testing of the Solar Kinetics T-700A Solar Collector," SAND81-0984, Sandia National Laboratories, Albuquerque, New Mexico, October 1982.

2. Deffenbaugh, D.M., et al., "Solar Production of Industrial Process Steam for the Lone Star Brewery: Construction Final Report," SwRI Project No. 06-5476, Southwest Research Institute, San Antonio, Texas, October 1982.

3. Treat, C.H. et al., "A Design Procedure for Solar Industrial Process Heat Systems," Proceeding of the ASME Solar Energy Division Fourth Annual Conference, Albuquerque, New Mexico, April 26-29, 1982, pp. 249-255.

4. Typical Meteorological Year User's Manual: Hourly Solar Radiation-Surface Meteorological Observations, National Climatic Center, Asheville, North Carolina, May 1981.

5. Dickinson, W.C. and K. C. Brown, "Economic Analysis of Solar Industrial Process Heat Systems," UCRL-52814, Lawrence Livermore Laboratory, Livermore, California, August 1979.

APPENDIX A

SOLAR SYSTEM CENTRAL CONTROLLER PROGRAM

The program listed here is for the Minarik Electric Company Model WP6000 programmable microprocessor that is used to automatically control the solar system operation.

Step No.	Function	Output Status	Remarks
1.	L = 30	----	Loop requires light switch on for 5 min
2.	IF 0 4	----	
3.	Go to 01	----	
4.	SS 10.00	----	
5.	L 2	----	
6.	IF 0 8	----	
7.	SS 15.00	----	
8.	IF 0 10	----	
9.	Go to 01	----	
10.	IF 1 12	----	Check hazard loop
11.	GO TO 06	----	
12.	IF 2 14	----	Check enable
13.	GO TO 06	----	
14.	SS 00.05	++--	Hydraulic pump start
15.	L = 1075	----	Fluid pump start (30 sec.)
16.	IF 0 18	---+	
17.	SS 15.00	---+	
18.	IF 0 20	---+	
19.	GO TO 06	---+	
20.	IF 1 22	---+	
21.	GO TO 06	---+	
22.	If 2 24	---+	
23.	GO TO 06	---+	
24.	L 16	---+	
25.	IF 3 27	---+	Check flow switch
26.	TO TO 01	---+	
27.	IF 0 29	++++	Start Auto track
28.	SS 15.00	-+++	
29.	IF 0 31	++++	
30.	GO TO 40	++++	Branch to deadband
31.	IF 1 33	++++	
32	GO TO 56	++++	STOW
33.	IF 2 35	++++	
34.	GO TO 58	++++	Defocus collectors
35.	IF 3 37	++++	
36.	SS 15.00	++++	Flow switch delay
37.	IF 3 39	++++	
38.	GO TO 56	++++	Stow
39.	Go TO 27	++++	End Auto track loop
40.	L = 870	++++	
41.	IF 0 43	-+++	Begin deadband subroutine (15 min)
42.	GO TO 46	-+++	
43.	SS 15.00	-+++	Light on delay
44.	IF 0 27	-+++	Return to Auto track

Step No.	Function	Output Status	Remarks
45.	GO TO 46	-+++	
46.	IF 1 48	-+++	
47.	Go to 56	-+++	Stow
48.	IF 2 50	-+++	
49.	TO TO 58	-+++	Stow
50.	IF 3 52	-+++	
51.	SS 15.00	-+++	
52.	IF 3 54	-+++	End deadband subroutine
53.	GO TO 56	-+++	
54.	SS 1.00	-+++	
55.	L 41	-+++	
56.	MS 5.00	----	Stow command
57.	TO TO 01	----	Return to start
58.	SS 5.00	--++	Defocus collectors for over temperature
59.	L = 100	-+++	Deadband over temperature (15 min)
60.	IF 1 62	-+++	
61.	GO TO 56		
62.	IF 2 40	-+++	
63.	IF 3 65	-+++	
64.	GO TO 56	-+++	
65.	SS 9.00	-+++	
66.	L 60	-+++	
67.	GO TO 56	-+++	

Input 0 = light switch - close with light
Input 1 = wind and rain hazard sensors - NC
Input 2 = equipment room and row outlet (15 ea) temperature switches - NC
Input 3 = flow switches - close with flow

Output 0 = collector control line
Output 1 = collector control line
Output 2 = not used
Output 3 = pump control line

Collector control status (+ indicates control line activated)

	Output 0	Output 1
Stow	-	-
Track from stow	+	+
Deadband	-	+
Automatic track	+	-

APPENDIX B

MONTHLY PERFORMANCE REPORTS

The monthly performance reports contained in this Section present a complete account of the system, operation, maintenance, and performance on a monthly basis.

MONTHLY REPORT #12

REPORT PERIOD:	October 27, 1984 through November 28, 1984
REPORT NO.:	LS-12
DOE CONTRACT NO.:	DE-AC04-78CS32198
CONTRACT TITLE:	Solar Production of Industrial Process Steam for the Lone Star Brewery
CONTRACTOR:	Southwest Research Institute P. O. Drawer 28510 San Antonio, TX 78284 Contact: D. Deffenbaugh, (512) 684-5111, Ext. 2384
PROJECT SITE:	Lone Star Brewery 600 Lone Star Blvd. San Antonio, TX 78204

II. Project Description

Application	Preheat boiler feed water.
Site:	29° 32' N Latitude, 98° 28' W Longitude Elevation = 794 ft.
Process Schedule:	Average steam requirement is 50,000 lb/hr.
Auxiliary Fuel:	Natural gas; boiler efficiency = 70%.
Collectors:	9450 ft^2 of Solar Kinetics tracking, parabolic, T-700 collectors. Roof mounted: Horizontal with N-S axis of rotation; 15 rows at 90 ft per row; Packing factor = .46.
Fluid Type, Flow Rate:	Treated water flowing at a fixed rate of 75 gpm.
Design Energy Delivery:	1.9×10^9 Btu/yr.
Phase 1 Cost (Design):	$107,795
Phase 2 Cost (Construction):	$690,900

Description:

The solar system at the Lone Star Brewery provides solar heated makeup water for the deaerator that feeds the plant's boilers. By providing hot makeup water to the deaerator, the fossil fuel consumption is reduced through a decreased requirement for steam injection into the deaerator. Cool, treated makeup water is heated prior to injection into the deaerator as it flows through a solar heated shell-and-tube heat exchanger. Solar heating is provided by 15 rows of parabolic trough solar collectors that are plumbed in a parallel configuration. The solar collectors heat the treated water as it passes through the collectors. The hot water is cooled as it flows through the heat exchanger (to heat the makeup water) and is then pumped back to the collector field in a closed piping loop.

III. Operating Experience

The solar system was reactivated on November 12, 1984. The system remained in operation until November 19, 1984 when the deaerator makeup water supply was valved off because some plant equipment failed. The solar system remained shutdown through the remainder of November while the plant equipment was being repaired. The only maintenance activities during November was to wash the solar collector field. The tracking system on collector Row 1 failed on November 19th and was not repaired until the entire system was reactivated in December. A summary of maintenance activities is given in Table IV.

IV. System Performance

A. Monthly Summary

The system operation for November is summarized in Tables I and II and Figure 1. Table II shows several days where the Data Acquisition System (DAS) was not operational between November 12 and November 19. Power failures during that time period caused the cassette recorder to drop out of the data "receive" mode and, therefore, data was lost. Readings from the "BTU computer" indicates 1,343 KBTU's of energy was delivered as hot water between the 16th and the 19th when the data system was restarted. Below are the readings taken off the BTU totalizer during November.

Date	BTU Computer Totalizer (KBTU)
11-16-84	0
11-19-84	1343
11-21-84	2756
11-27-84	2756

B. Clear Day Performance

The system performance for a clear day is presented in Figure 2 and Table III. The solar system was manually shut down early in the afternoon because of plant equipment failures. In Table II the "energy delivered" is greater than the "energy collected" during hour 13, and the "thermal losses" are negative. This apparent inconsistency is probably caused by a combination of sensor uncertainty, extremely low thermal losses, and some energy recovery from piping as the average collector loop fluid temperature dropped from hour 12 to hour 13.

TABLE I. LONE STAR BREWERY - SYSTEM OPERATION SUMMARY TABLE
NOVEMBER 1984

Date	Status Code	Solar System Availability %	Weather	Remarks
3/1	2	100		
3/2	2	100		
3/3	2	100		
3/4	2	100		
3/5	2	100		
3/6	2	100		
3/7	2	100		
3/8	2	100		
3/9	2	100		
3/10	2	100		
3/11	2	100		
3/12	1	100	F	SOLAR SYSTEM TURNED ON
3/13	1	100	P	
3/14	1	100	P	
3/15	1	100	C	
3/16	1	100	C	
3/17	1	100	C	
3/18	1	100	C	
3/19	1	93	F	ROW 1 TRACKING SYSTEM FAILED
3/20	2	93		SOLAR SYSTEM SHUT DOWN BECAUSE OF PLANT EQUIPMENT FAILURE
3/21	2	93		
3/22	2	93		
3/23	2	93		
3/24	2	93		
3/25	2	93		
3/26	2	93		
3/27	2	93		
3/28	2	93		
3/29	2	93		
3/30	2	93		

Weather Codes:

F - Fair
P - Partly Cloudy
C - Fog or Overcast
R - Rain

Solar Status Codes:

1 Normal operation
2 Solar system down
3 Solar system not turned on
4 Energy collected but not delivered to the process
5 Solar system and plant both down
6 Plant down, solar system idle
7 Solar system and plant both operational but DAS down

REMARKS: Solar system availability is computed from the sum of each row's availability (availability = 1 if row is available all day, availabaility = .5 if row is available for half of the day) divided by the total number of rows (15 rows).

TABLE II. LONE STAR BREWERY MONTHLY PERFORMANCE SUMMARY TABLE - NOV. 1984

DATE	INCIDENT SOLAR ENERGY: HORIZONTAL SURFACE (1) BTU/SFT	INCIDENT SOLAR ENERGY: COLLECTOR PLANE (2) BTU/SFT	ENERGY COLLECTED KBTU	COLLECTOR ARRAY EFF.: BASED ON (1) %	COLLECTOR ARRAY EFF.: BASED ON (2) %	ENERGY DELIVERED KBTU	THERMAL LOSSES KBTU	SYSTEM THERMAL EFFIC. %	PARASITIC ENERGY USED KBTU	ACTIVE COLLECTOR AREA SFT
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
2	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
3	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
4	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
5	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
6	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
7	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
8	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
9	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
10	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
11	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
12	745.	797.	2210.	31.	29.	2255.	-33.	30.	72.	9450.
13	946.	86.	196.	2.	24.	199.	3.	25.	24.	9450.
14	723.	0.	0.	0.	0.	0.	0.	0.	1.	9450.
15	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
16	292.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
17	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
18	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
19	1308.	950.	2137.	19.	25.	2045.	92.	24.	66.	8820.
20	SOLAR SYSTEM SHUT DOWN BECAUSE OF PLANT EQUIPMENT FAILURE.									
21				"						
22				"						
23				"						
24				"						
25				"						
26				"						
27				"						
28				"						
29				"						
30				"						
	4014.	1833.	4543.			4499.	62.		163.	

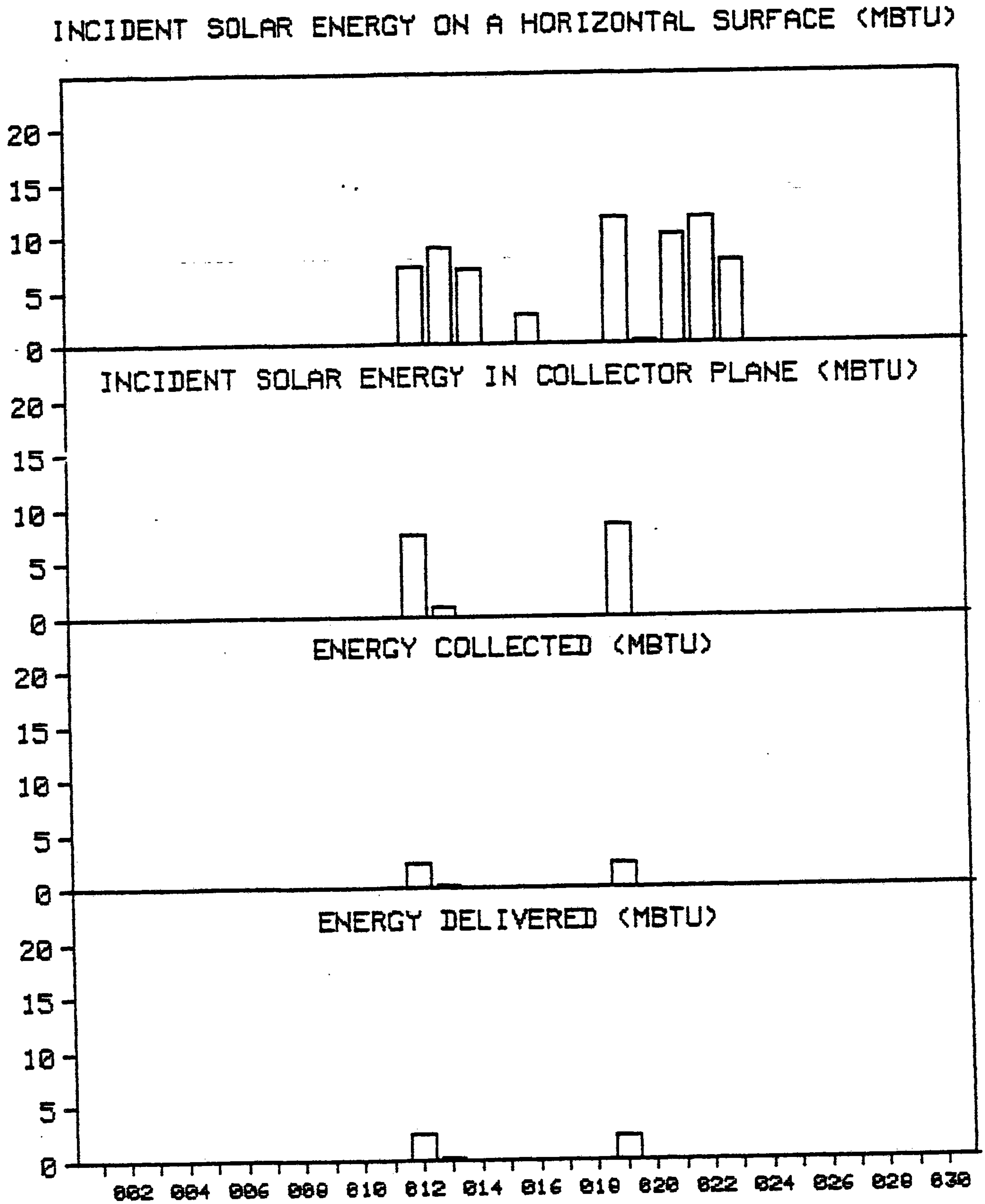


FIGURE 1. LONE STAR BREWERY MONTHLY PERFORMANCE SUMMARY GRAPH FOR NOVEMBER 1984

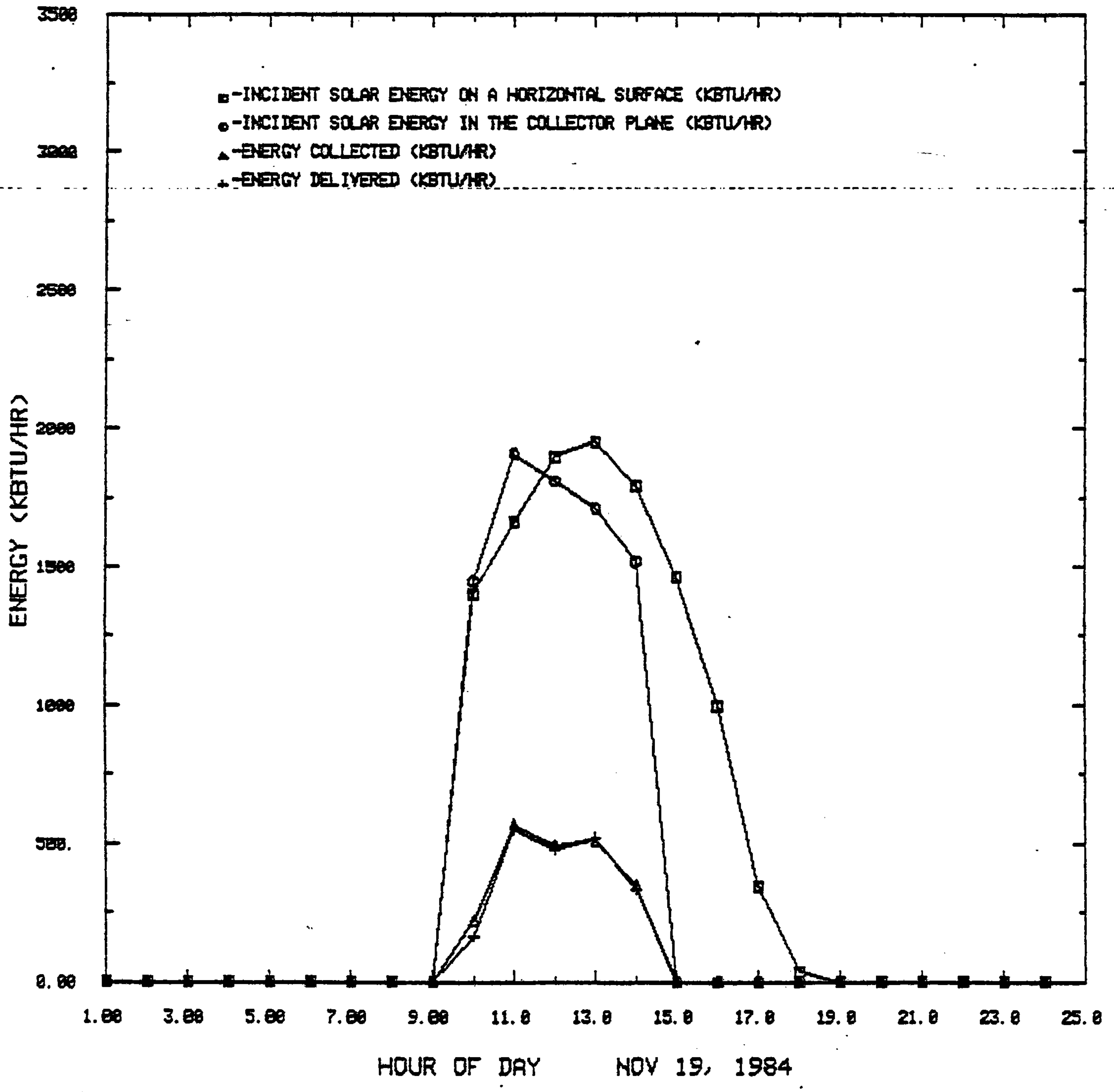


FIGURE 2. CLEAR DAY PERFORMANCE GRAPH FOR NOVEMBER 19, 1984

TABLE III. DAILY PERFORMANCE TABLE - NOVEMBER 19, 1984

COLLECTOR FIELD AREA = 8820. [SQ-FT]
COLLECTOR REFLECTANCE =72.7%

HR	AMBIENT TEMP. DEG F	WIND SPEED MPH	INCIDENT SOLAR RAD: ON A HORIZ. SURFACE (1) BTU/SF	INCIDENT SOLAR RAD: IN THE COLLECTOR PLANE (2) BTU/SF	COLLECTOR ARRAY FLOW RATE GPM	COLLECTOR ARRAY TEMPERATURE: INLET DEG F	COLLECTOR ARRAY TEMPERATURE: OUTLET DEG F	ENERGY COLLECTED KBTU	COLLECTOR ARRAY EFFIC. BASED ON (1) %	COLLECTOR ARRAY EFFIC. BASED ON (2) MEAS	COLLECTOR ARRAY EFFIC. BASED ON (2) CALC %	ENERGY DELIVERED KBTU	THERMAL LOSSES KBTU	PARASITIC ENERGY KBTU
1	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
2	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
3	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
4	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
5	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
6	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
7	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
8	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
9	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
10	53.1	8.8	159.	164.	58.3	95.4	102.4	221.1	15.8	15.3	52.9	161.	60.	12.
11	54.6	8.9	188.	216.	69.9	157.7	174.3	568.1	34.3	29.8	50.0	550.	17.	13.
12	58.1	6.8	215.	205.	69.8	158.5	172.9	491.7	25.9	27.2	49.0	478.	13.	13.
13	61.1	6.7	221.	194.	69.6	156.1	171.0	508.3	26.1	29.8	48.3	520.	-11.	13.
14	61.9	7.0	203.	172.	64.1	144.8	155.4	347.5	19.4	22.9	48.1	336.	12.	12.
15	61.6	8.4	166.	0.	0.0	147.5	153.3	0.0	0.0	0.0	0.0	0.	0.	1.
16	60.1	8.0	113.	0.	0.0	132.2	136.2	0.0	0.0	0.0	0.0	0.	0.	1.
17	57.5	8.9	37.	0.	0.0	121.3	123.7	0.0	0.0	0.0	0.0	0.	0.	1.
18	53.6	8.7	4.	0.	0.0	112.3	113.6	0.0	0.0	0.0	0.0	0.	0.	0.
19	49.7	8.4	0.	0.	0.0	104.5	104.9	0.0	0.0	0.0	0.0	0.	0.	0.
20	48.1	8.6	0.	0.	0.0	97.5	97.6	0.0	0.0	0.0	0.0	0.	0.	0.
21	47.3	8.5	0.	0.	0.0	91.7	91.7	0.0	0.0	0.0	0.0	0.	0.	0.
22	46.9	6.2	0.	0.	0.0	86.9	86.7	0.0	0.0	0.0	0.0	0.	0.	0.
23	46.9	6.4	0.	0.	0.0	83.1	82.7	0.0	0.0	0.0	0.0	0.	0.	0.
24	46.7	6.6	0.	0.	0.0	79.9	79.3	0.0	0.0	0.0	0.0	0.	0.	0.
TOT			1308.	950.				2136.7				710.	92.	66.

DAILY COLLECTOR ARRAY EFFICIENCY BASED ON (1) 18.5%
DAILY COLLECTOR ARRAY EFFICIENCY BASED ON (2) 25.5%
DAILY SYSTEM THERMAL EFFICIENCY BASED ON (1) 6.2%
DAILY SYSTEM THERMAL EFFICIENCY BASED ON (2) 8.5%

TABLE IV. LONE STAR BREWERY MAINTENANCE SUMMARY - NOVEMBER 1984

O & M Activity	Hours	Labor $	Materials $	Total $
Collector Washed 11-7-84 (Subcontract)		197.00		197.00

MONTHLY REPORT #13

REPORT PERIOD:	November 24, 1984 through December 21, 1984
REPORT NO.:	LS-13
DOE CONTRACT NO.:	DE-AC04-78CS32198
CONTRACT TITLE:	Solar Production of Industrial Process Steam for the Lone Star Brewery
CONTRACTOR:	Southwest Research Institute P. O. Drawer 28510 San Antonio, TX 78284 Contact: D. Deffenbaugh, (512) 684-5111, Ext. 2384
PROJECT SITE:	Lone Star Brewery 600 Lone Star Blvd. San Antonio, TX 78204

II. Project Description

Application	Preheat boiler feed water.
Site:	29 32' N Latitude, 98 28' W Longitude Elevation = 794 ft.
Process Schedule:	Average steam requirement is 50,000 lb/hr.
Auxiliary Fuel:	Natural gas; boiler efficiency = 70%.
Collectors:	9450 ft^2 of Solar Kinetics tracking, parabolic, T-700 collectors. Roof mounted: Horizontal with N-S axis of rotation; 15 rows at 90 ft per row; Packing factor = .46.
Fluid Type, Flow Rate:	Treated water flowing at a fixed rate of 75 gpm.
Design Energy Delivery:	1.9×10^9 Btu/yr.
Phase 1 Cost (Design):	$107,795
Phase 2 Cost (Construction):	$690,900

Description:

The solar system at the Lone Star Brewery provides solar heated makeup water for the deaerator that feeds the plant's boilers. By providing hot makeup water to the deaerator, the fossil fuel consumption is reduced through a decreased requirement for steam injection into the deaerator. Cool, treated makeup water is heated prior to injection into the deaerator as it flows through a solar heated shell-and-tube heat exchanger. Solar heating is provided by 15 rows of parabolic trough solar collectors that are plumbed in a parallel configuration. The solar collectors heat the treated water as it passes through the collectors. The hot water is cooled as it flows through the heat exchanger (to heat the makeup water) and is then pumped back to the collector field in a closed piping loop.

III. Operating Experience

The solar system was shut down from December 1st through December 12th because a broken check valve in a condensate return line was dumping water directly into the deaerator. This excess flow of water was causing the deaerator to overflow and dump water down the drain. Because the plant could not shut down the process with the broken check valve, the deaerator makeup water supply was valved off. For this reason the solar system had to be shut down until the replacement parts for the check valve could be shipped to the plant and installed. During November and December there were several nights of below freezing ambient temperatures. The freeze protection switch turned on the circulating pumps when the temperature approached 32°F and maintained the fluid temperature above 50°F. On November 27th the heat loss rate in the collector field was about 5.6 KBtu/hr when the ambient temperature was 32°F and the wind speed was less than 1 mph. A summary of the maintenance activities during December is given in Table IV.

IV. System Performance

A. Monthly Summary

The solar system operation for the month of December is summarized in Table I and II and Figure 1. Cloudy weather caused the solar system to be idle for 13 of the 19 days that the solar system was activated. The combination of cloudy weather and plant equipment failures resulted in a low monthly total energy delivered to the process. The total amount of energy delivered to the process was 6.5 MBtu's. This is compared to the predicted energy delivery of 83 MBtu's. The performance predictions generated by SERI, for the Lone Star Brewery, called for a total monthly energy delivery of 102 MBtu's. SERI's simulation showed the system delivering energy as hot process water on 24 of the 31 days in December. The average daily total horizontal solar radiation measured at the Lone Star Brewery was 537 Btu/ft^2 (for the period from December 14 through December 31). This demonstrates the unusually cloudy conditions for San Antonio, Texas that has a long term average daily total horizontal radiation of 850 Btu/ft^2.

B. Clear Day Performance

The solar system performance for December 31, 1984 is presented in Figure 2 and Table III. The daily total energy collected and delivered are 1935 and 1840 KBtu's, respectively. The daily average collector efficiency is 22% which is about half of the efficiency calculated from the performance curves for the Solar Kinetics T-700 collector operating at the same conditions as the solar collector field. The cause of this large difference between the measured and predicted efficiencies is not known.

TABLE I. LONE STAR BREWERY - SYSTEM OPERATION SUMMARY TABLE
December 1984

Date	Status Code	Solar System Availability %	Weather	Remarks
12/1	2	93		
12/2	2	93		
12/3	2	93		
12/4	2	93		
12/5	2	93		
12/6	2	93		
12/7	2	93		
12/8	2	93		
12/9	2	93		
12/10	2	93		
12/11	2	93		Repaired Row 1, Average Collector Reflectance = 68.4%
12/12	2	100		
12/13	1	100	F	Plant equipment repaired, solar system reactivated
12/14	1	100	C	
12/15	1	100	C	
12/16	1	100	C	
12/17	1	100	C	
12/18	1	100	P	
12/19	1	100	P	
12/20	1	100	P	
12/21	1	100	P	
12/22	1	100	P	
12/23	1	100	C	
12/24	1	100	P	
12/25	1	100	P	
12/26	1	100	C	
12/27	1	100	C	
12/28	1	100	P	
12/29	1	100	P	
12/30	1	100	P	
12/31	1	100	F	

Weather Codes:

F - Fair
P - Partly Cloudy
C - Fog or Overcast
R - Rain

Solar Status Codes:

1 Normal operation
2 Solar system down
3 Solar system not turned on
4 Energy collected but not delivered to the process
5 Solar system and plant both down
6 Plant down, solar system idle
7 Solar system and plant both operational but DAS down

REMARKS: Solar system availability is computed from the sum of each row's availability (availability = 1 if row is available all day, availability = .5 if row is available for half of the day) divided by the total number of rows (15 rows).

TABLE II. LONESTAR BREWERY MONTHLY PERFORMANCE SUMMARY TABLE - DECEMBER 1984

DATE	INCIDENT SOLAR ENERGY: HORIZONTAL SURFACE (1) BTU/SFT	INCIDENT SOLAR ENERGY: COLLECTOR PLANE (2) BTU/SFT	ENERGY COLLECTED KBTU	COLLECTOR ARRAY EFF.: BASED ON (1) %	COLLECTOR ARRAY EFF.: BASED ON (2) %	ENERGY DELIVERED KBTU	THERMAL LOSSES KBTU	SYSTEM THERMAL EFFIC. %	PARASITIC ENERGY USED KBTU	ACTIVE COLLECTOR AREA SFT
1	1288.	-3.	0.	0.	0.	1.	0.	0.	102.	8820.
2	1223.	-1.	1.	0.	0.	5.	0.	0.	104.	8820.
3	788.	1.	0.	0.	0.	0.	0.	0.	26.	8820.
4	36.	0.	0.	0.	0.	0.	0.	0.	0.	8820.
5	0.	0.	0.	0.	0.	0.	0.	0.	0.	8820.
6	0.	0.	0.	0.	0.	0.	0.	0.	0.	8820.
7	0.	0.	0.	0.	0.	0.	0.	0.	0.	8820.
8	0.	0.	0.	0.	0.	0.	0.	0.	0.	8820.
9	0.	0.	0.	0.	0.	0.	0.	0.	0.	8820.
10	0.	0.	0.	0.	0.	0.	0.	0.	0.	8820.
11	0.	0.	0.	0.	0.	0.	0.	0.	0.	8820.
12	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
13	52.	120.	315.	64.	28.	1943. *	31.	25.	22.	9450.
14	415.	0.	0.	0.	0.	2.	0.	0.	4.	9450.
15	324.	0.	0.	0.	0.	0.	0.	0.	4.	9450.
16	387.	0.	0.	0.	0.	0.	0.	0.	3.	9450.
17	258.	0.	0.	0.	0.	0.	0.	0.	3.	9450.
18	636.	0.	0.	0.	0.	1.	0.	0.	2.	9450.
19	729.	0.	0.	0.	0.	1.	0.	0.	2.	9450.
20	853.	412.	783.	10.	20.	717.	65.	18.	73.	9450.
21	606.	291.	655.	11.	24.	601.	54.	22.	58.	9450.
22	719.	419.	1224.	18.	31.	1168.	57.	29.	33.	9450.
23	348.	0.	0.	0.	0.	0.	0.	0.	2.	9450.
24	692.	127.	253.	4.	21.	229.	23.	19.	22.	9450.
25	557.	0.	0.	0.	0.	0.	0.	0.	1.	9450.
26	215.	0.	0.	0.	0.	0.	0.	0.	1.	9450.
27	240.	0.	0.	0.	0.	0.	0.	0.	1.	9450.
28	598.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
29	497.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
30	586.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
31	1020.	916.	1935.	20.	22.	1840.	96.	21.	94.	9450.
	13031.	2282.	5166.			6508. *	326.		556.	

* DATA TAKEN FROM "BTU COMPUTER"

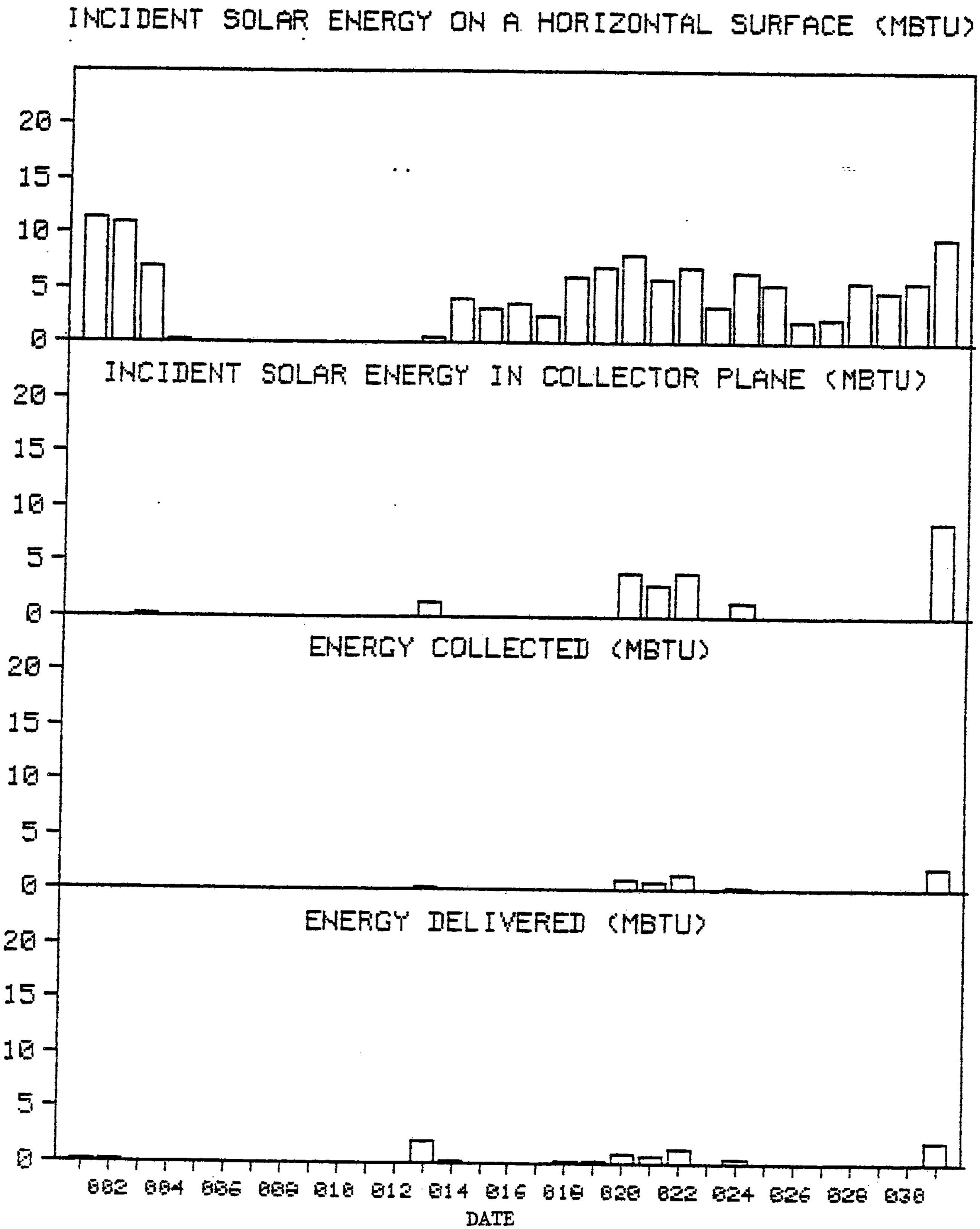


FIGURE 1. LONE STAR BREWERY MONTHLY PERFORMANCE SUMMARY PLOT FOR DECEMBER 1984

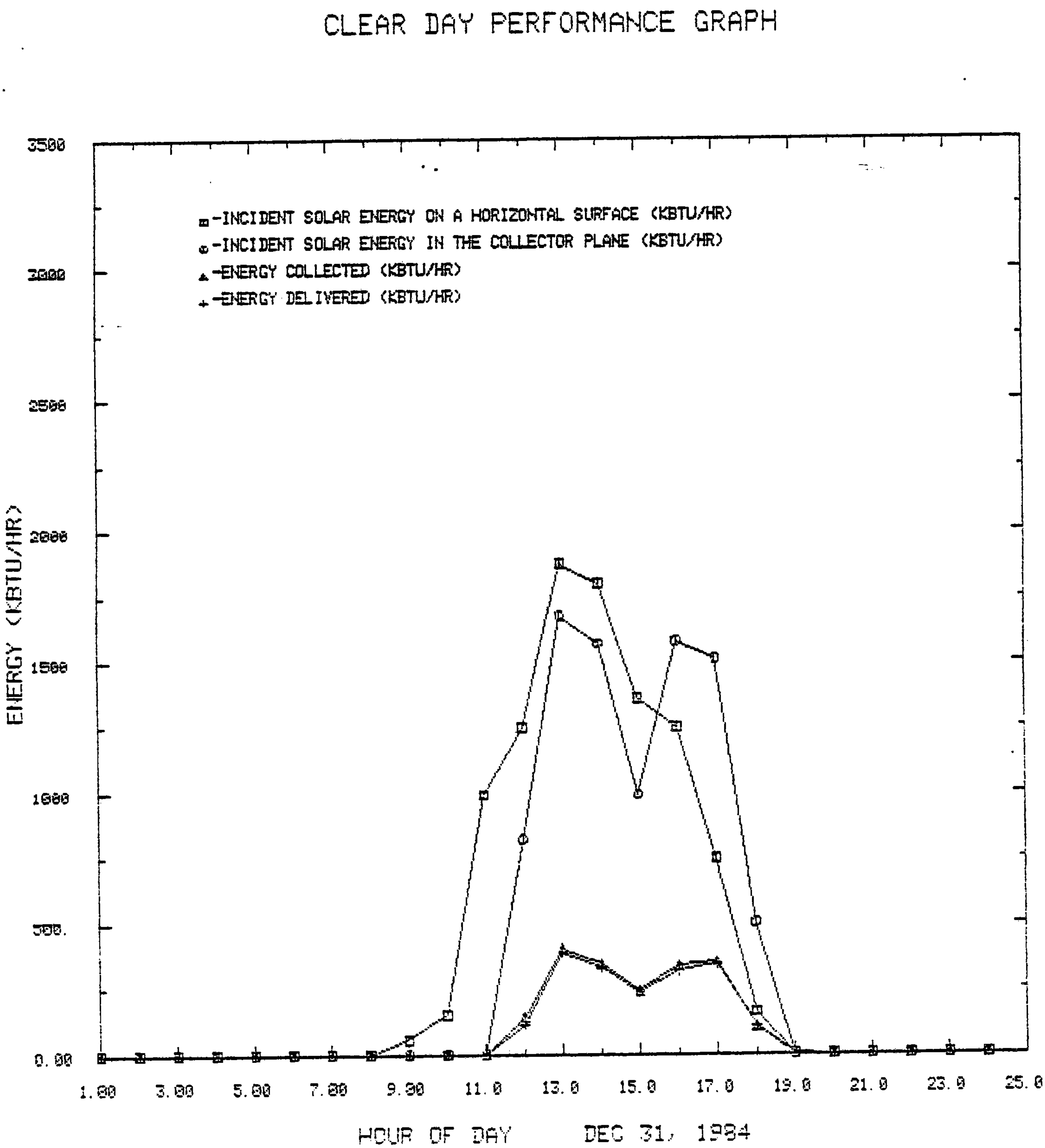


FIGURE 2. CLEAR DAY PERFORMANCE FOR DECEMBER 31, 1984

TABLE III. DAILY PERFORMANCE TABLE - DECEMBER 31, 1984

DAILY PERFORMANCE TABLE DEC 31, 1984
COLLECTOR FIELD AREA = 9450. [SQ-FT]
COLLECTOR REFLECTANCE =68.4%

HR	AMBIENT TEMP. DEG F	WIND SPEED MPH	INCIDENT SOLAR RAD: ON A HORIZ. SURFACE (1) BTU/SF	INCIDENT SOLAR RAD: IN THE COLLECTOR PLANE (2) BTU/SF	COLLECTOR ARRAY FLOW RATE GPM	COLLECTOR ARRAY TEMPERATURE: INLET DEG F	COLLECTOR ARRAY TEMPERATURE: OUTLET DEG F	ENERGY COLLECTED KBTU	COLLECTOR ARRAY EFFIC. BASED ON (1) %	COLLECTOR ARRAY EFFIC. BASED ON (2) MEAS	COLLECTOR ARRAY EFFIC. BASED ON (2) CALC %	ENERGY DELIVERED KBTU	THERMAL LOSSES KBTU	PARASITIC ENERGY KBTU
1	67.2	11.3	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
2	67.1	11.7	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
3	66.7	12.6	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
4	66.8	15.1	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
5	67.2	25.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
6	64.6	13.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
7	65.2	11.7	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
8	65.0	13.7	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
9	64.4	9.0	6.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
10	63.7	7.6	16.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
11	64.5	7.6	105.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
12	66.2	7.5	132.	87.	69.3	87.3	93.5	144.1	11.6	17.6	45.5	116.	28.	13.
13	69.1	10.7	198.	177.	69.8	112.0	123.7	403.1	21.5	24.1	44.8	390.	13.	13.
14	70.0	10.3	190.	166.	69.4	107.4	117.5	344.6	19.1	21.9	44.3	332.	13.	13.
15	70.0	10.0	144.	105.	69.2	99.6	106.7	242.3	17.8	24.4	44.2	234.	9.	13.
16	69.9	5.7	132.	167.	69.3	105.8	115.7	338.7	27.3	21.4	45.2	318.	21.	13.
17	70.6	4.9	79.	160.	69.3	107.9	118.2	354.0	47.4	23.4	46.2	344.	10.	13.
18	68.7	3.1	17.	53.	69.0	89.2	92.3	105.4	64.0	20.9	47.0	105.	1.	13.
19	65.8	1.9	0.	0.	10.0	80.1	80.7	2.6	0.0	0.0	0.0	0.	2.	3.
20	63.2	2.5	0.	0.	0.0	78.3	79.1	0.0	0.0	0.0	0.0	0.	0.	0.
21	61.1	1.5	0.	0.	0.0	76.7	77.7	0.0	0.0	0.0	0.0	0.	0.	0.
22	59.3	1.8	0.	0.	0.0	75.2	76.2	0.0	0.0	0.0	0.0	0.	0.	0.
23	57.0	4.1	0.	0.	0.0	72.8	74.5	0.0	0.0	0.0	0.0	0.	0.	0.
24	54.2	6.7	0.	0.	0.0	69.5	72.4	0.0	0.0	0.0	0.0	0.	0.	0.
TOT			1020.	916.				1934.8				1840.	96.	74.

DAILY COLLECTOR ARRAY EFFICIENCY BASED ON (1) 20.1%
DAILY COLLECTOR ARRAY EFFICIENCY BASED ON (2) 22.4%
DAILY SYSTEM THERMAL EFFICIENCY BASED ON (1) 19.1%
DAILY SYSTEM THERMAL EFFICIENCY BASED ON (2) 21.3%

TABLE IV. LONE STAR BREWERY MAINTENANCE SUMMARY - DECEMBER 1984

O & M Activity	Hours	Labor $	Materials $	Total $
Replaced Row 1 Hydraulic Pressure Switch	1	25.00	90.00	115.00
Cleaned Strainers at Inlet to Circulating Pumps	0.25	6.00	--	6.00
Drew Water from Collector Wash Water Piping	0.25	6.00	--	6.00
				127.00

MONTHLY REPORT #14

REPORT PERIOD:	December 22, 1984 through January 18, 1985
REPORT NO.:	LS-14
DOE CONTRACT NO.:	DE-AC04-78CS32198
CONTRACT TITLE:	Solar Production of Industrial Process Steam for the Lone Star Brewery
CONTRACTOR:	Southwest Research Institute P. O. Drawer 28510 San Antonio, TX 78284 Contact: D. Deffenbaugh, (512) 684-5111, Ext. 2384
PROJECT SITE:	Lone Star Brewery 600 Lone Star Blvd. San Antonio, TX 78204

II. Project Description

Application	Preheat boiler feed water.
Site:	29 32' N Latitude, 98 28' W Longitude Elevation = 794 ft.
Process Schedule:	Average steam requirement is 50,000 lb/hr.
Auxiliary Fuel:	Natural gas; boiler efficiency = 70%.
Collectors:	9450 ft^2 of Solar Kinetics tracking, parabolic, T-700 collectors. Roof mounted: Horizontal with N-S axis of rotation; 15 rows at 90 ft per row; Packing factor = .46.
Fluid Type, Flow Rate:	Treated water flowing at a fixed rate of 75 gpm.
Design Energy Delivery:	1.9×10^9 Btu/yr.
Phase 1 Cost (Design):	$107,795
Phase 2 Cost (Construction):	$690,900

Description:

The solar system at the Lone Star Brewery provides solar heated makeup water for the deaerator that feeds the plant's boilers. By providing hot makeup water to the deaerator, the fossil fuel consumption is reduced through a decreased requirement for steam injection into the deaerator. Cool, treated makeup water is heated prior to injection into the deaerator as it flows through a solar heated shell-and-tube heat exchanger. Solar heating is provided by 15 rows of parabolic trough solar collectors that are plumbed in a parallel configuration. The solar collectors heat the treated water as it passes through the collectors. The hot water is cooled as it flows through the heat exchanger (to heat the makeup water) and is then pumped back to the collector field in a closed piping loop.

III. Operating Experience

During January there were a large number of days with unusually cold weather for the San Antonio, Texas area. The cold weather caused the freeze protection system to operate for 10 days during January. The most severe weather encountered from a heat loss standpoint was 24°F air temperature and 20 mph winds. During these weather conditions, the heat loss rate in the collector field and insulated piping were 26 KBTU/HR and 16 KBTU/HR respectively. The water circulating through the collectors was maintained at a temperature of 73°F.

Performance data is not available for January 5, 6, 9, and 10 because the power to the data system was turned off at the circuit breaker. This problem has now been corrected so that the power to the data system will not be cut off again. The microprocessor used as a central controller for the solar system lost its program on January 20th. The solar system, therefore, did not operate on January 20th and part of January 21st. The microprocessor was reprogrammed on January 21st and it has since operated properly. The maintenance activities for January are summarized in Table IV.

IV. System Performance

A. Monthly Summary

The solar system operation for January is summarized in Tables I and II and Figure 1. Table II shows the operational data for January 5, 6, 9, and 10 were lost. The horizontal radiation data for January 20th shows the day was a clear day and the solar system did not operate for the above discussed reasons. Table II also shows three days where the collector row with the collector plane radiation instrumentation did not track the sun. Other collector rows may have "missed" the sun during collector startup but no one is on site every day to document tracking problems. The thermal losses shown in Table II are higher than would normally be expected because of the thermal losses encountered due to the use of the freeze protection system.

The total energy delivered as hot process water during January was 44670 MBTU's. The following table presents the actual system performance and compares it to the predictions of system performance calculated at SwRI and SERI. The differences between the solar system performance predictions are primarily due to differences in the method of modeling dust buildup on the solar collector. The method utilized by SwRI allows the collector reflectance to decrease a small amount each day for a 60 day wash cycle. The method incorporated by SERI utilizes an average collector performance degradation factor for every day of the simulation. The actual energy delivered as hot process water was 40% of the predicted value while the measured total horizontal radiation measured at the solar system site was 94% of the average solar radiation for San Antonio, Texas for January. This shows that the poor performance during January cannot be attributed to lower than normal solar radiation. The average collector reflectance on January 25th was measured at 65.0% which is 77% of the new and clean reflectance.

	Energy Delivered to Process (MBTU)			Horizontal Radiation $\left(\frac{BTU}{Ft^2 Day}\right)$		
Month	Measured	Prediction	Prediction	Measured	TMY*	Notes
Dec	6.5	83.2	96.2	499.0	839	1
Jan	44.7	109.6	110.6	876	932	2

Notes: 1. Solar system turned off from December 1 through December 12. Weather was unusually cold and cloudy.

2. Performance data was lost for January 5, 6, 9, 10 and parts of January 7, 11 (power failures caused data system failures). Number of days of operation where data vailable - 26.5.

* - Typical meteorological year data used in simulation

B. Clear Day Performance

The solar system performance for January 25, 1985 is shown in Figure 2 and Table III. The daily total energy collected and delivered are 4966 and 4724 KBTU's, respectively. Table II shows the measured collector array efficiency is very close to the collector efficiency calculated from the performance curves for the Solar Kinetics T-700 collector operating at the same ambient conditions as the solar system.

TABLE I. LONE STAR BREWERY - SYSTEM OPERATION SUMMARY TABLE
January 1984

Date	Status Code	Solar System Availability %	Weather	Remarks
1/1	1	100	C	
1/2	1	100	C	
1/3	1	100	F	
1/4	1	100	F	
1/5	1	100	P	Performance data lost
1/6	1	100	P	Performance data lost
1/7	1	100	F	
1/8	1	100	P	
1/9	1	100	P	Performance data lost
1/10	1	100	P	Performance data lost
1/11	1	100		Row 7 hydraulic accumulator recharged
1/12	1	100	C	
1/13	1	100	C	
1/14	1	100	P	
1/15	1	100	P	
1/16	1	100	C	
1/17	1	100	F	
1/18	1	100	F	
1/19	1	100	F	
1/20	2	100	F	Central controller down
1/21	1	100	F	Reprogrammed central controller microprocessor
1/22	1	100	C	
1/23	1	100	C	
1/24	1	100	F	
1/25	1	100	F	Measured collector reflectance, AVG = 65.0%
1/26	1	100	P	
1/27	1	100	F	
1/28	1	100	P	
1/29	1	100	C	
1/30	1	93	P	Row 1 down
1/31	1	93	C	

Weather Codes:

F - Fair
P - Partly Cloudy
C - Fog or Overcast
R - Rain

Solar Status Codes:

1 Normal operation
2 Solar system down
3 Solar system not turned on
4 Energy collected but not delivered to the process
5 Solar system and plant both down
6 Plant down, solar system idle
7 Solar system and plant both operational but DAS down

REMARKS: Solar system availability is computed from the sum of each row's availability (availability = 1 if row is available all day, availability = .5 if row is available for half of the day) divided by the total number of rows (15 rows).

TABLE II. LONESTAR BREWERY MONTHLY PERFORMANCE SUMMARY TABLE - JANUARY 1985

DATE	INCIDENT SOLAR ENERGY: HORIZONTAL SURFACE (1) BTU/SFT	INCIDENT SOLAR ENERGY: COLLECTOR PLANE (2) BTU/SFT	ENERGY COLLECTED KBTU	COLLECTOR ARRAY EFF.: BASED ON (1) %	COLLECTOR ARRAY EFF.: BASED ON (2) %	ENERGY DELIVERED KBTU	THERMAL LOSSES KBTU	SYSTEM THERMAL EFFIC. %	PARASITIC ENERGY USED KBTU	ACTIVE COLLECTOR AREA SFT
1	488.	0.	0.	0.	0.	0.	92.	0.	17.	9450.
2	208.	0.	0.	0.	0.	0.	850.	0.	299.	9450.
3	1264.	**	3588.	30.	**	3232.	356.	**	208.	9450.
4	1213.	1228.	3223.	28.	28.	2934.	289.	25.	175.	9450.
5	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
6	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
7	1017.	1070.	3197.	33.	32.	2983.	59.	29.	91.	9450.
8	1193.	1126.	2893.	26.	27.	2707.	98.	25.	98.	9450.
9	126.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
10	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
11	475.	0.	0.	0.	0.	0.	195.	0.	52.	9450.
12	220.	0.	0.	0.	0.	0.	833.	0.	300.	9450.
13	269.	0.	0.	0.	0.	0.	651.	0.	301.	9450.
14	1172.	**	1324.	12.	**	1210.	278.	**	190.	9450.
15	805.	33.	24.	0.	8.	13.	31.	4.	11.	9450.
16	239.	0.	0.	0.	0.	0.	0.	0.	1.	9450.
17	1368.	1491.	4264.	33.	30.	4024.	103.	29.	109.	9450.
18	1359.	1550.	4929.	38.	34.	4624.	141.	32.	113.	9450.
19	1362.	1489.	4774.	37.	34.	4541.	126.	32.	114.	9450.
20	1327.	0.	0.	0.	0.	0.	618.	0.	178.	9450.
21	1494.	1008.	3221.	23.	34.	3072.	485.	32.	211.	9450.
22	580.	0.	0.	0.	0.	0.	267.	0.	119.	9450.
23	240.	0.	0.	0.	0.	0.	0.	0.	1.	9450.
24	1280.	1257.	4478.	37.	38.	4260.	125.	36.	106.	9450.
25	1313.	1399.	4966.	40.	38.	4724.	121.	36.	111.	9450.
26	828.	308.	973.	12.	33.	910.	78.	31.	53.	9450.
27	1221.	1200.	4003.	35.	35.	3839.	104.	34.	90.	9450.
28	1264.	607.	1691.	14.	30.	1548.	137.	27.	94.	9450.
29	232.	0.	0.	0.	0.	3.	0.	0.	0.	9450.
30	694.	**	60.	1.	**	48.	12.	**	9.	8820.
31	267.	0.	0.	0.	0.	0.	696.	0.	223.	8820.
	23518.	13766.	47608.			44669.	6745.		3276.	

** - COLLECTOR ROW WITH SOLAR INSTRUMENTATION MOUNTED ON IT WAS NOT FOCUSED ON SUN.

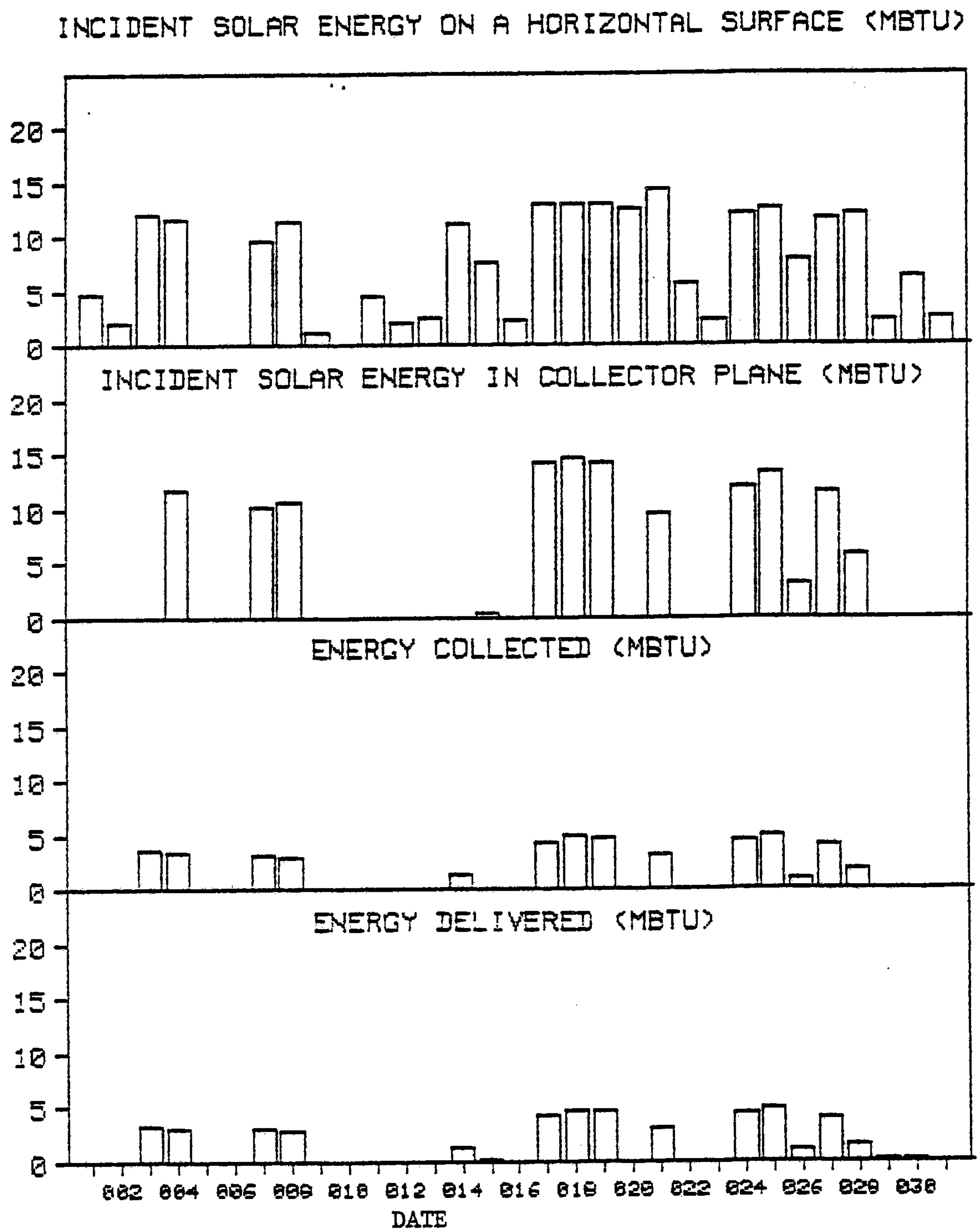


FIGURE 1. LONE STAR BREWERY MONTHLY PERFORMANCE SUMMARY PLOT FOR JANUARY 1985

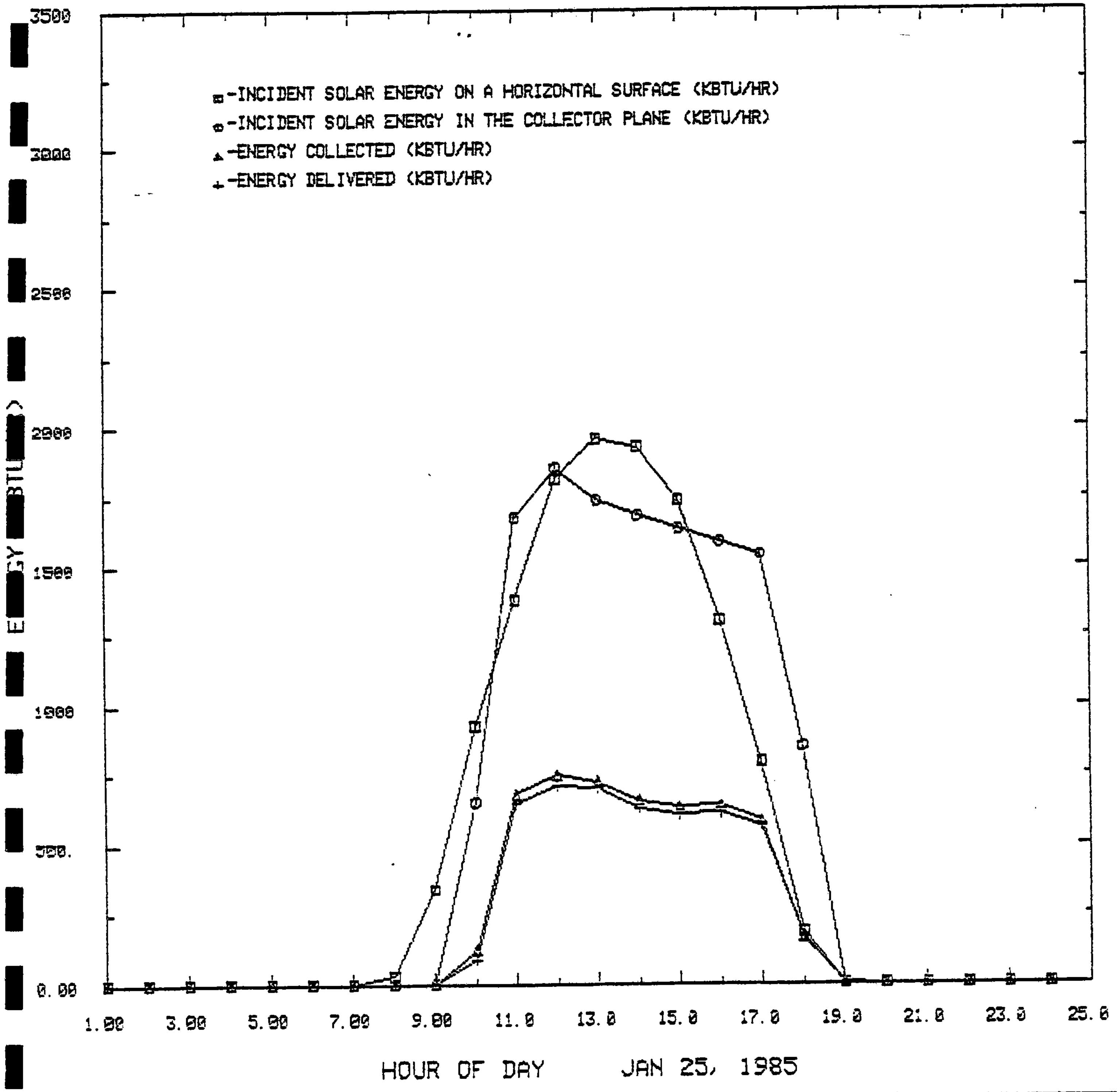


FIGURE 2. CLEAR DAY PERFORMANCE FOR JANUARY 25, 1985

TABLE III. DAILY PERFORMANCE TABLE - JANUARY 25, 1985

COLLECTOR FIELD AREA = 9450. [SQ-FT]
COLLECTOR REFLECTANCE =65.0%

			INCIDENT SOLAR RAD			COLLECTOR ARRAY TEMPERATURE				COLLECTOR ARRAY EFFIC. BASED ON (2)				
HR	AMBIENT TEMP. DEG F	WIND SPEED MPH	ON A HORIZ. SURFACE (1) BTU/SF	IN THE COLLECTOR PLANE (2) BTU/SF	COLLECTOR ARRAY FLOW RATE GPM	INLET DEG F	OUTLET DEG F	ENERGY COLLECTED KBTU	COLLECTOR ARRAY EFFIC. BASED ON (1) %	MEAS	CALC %	ENERGY DELIVERED KBTU	THERMAL LOSSES KBTU	PARASITIC ENERGY KBTU
1	53.5	0.6	0.	0.	0.0	71.0	72.4	0.0	0.0	0.0	0.0	0.	0.	0.
2	51.8	0.6	0.	0.	0.0	67.4	70.4	0.0	0.0	0.0	0.0	0.	0.	0.
3	50.5	1.1	0.	0.	0.0	64.9	68.5	0.0	0.0	0.0	0.0	0.	0.	0.
4	48.7	0.5	0.	0.	0.0	63.1	67.1	0.0	0.0	0.0	0.0	0.	0.	0.
5	47.8	0.7	0.	0.	0.0	61.6	65.8	0.0	0.0	0.0	0.0	0.	0.	0.
6	47.0	0.9	0.	0.	0.0	60.4	64.5	0.0	0.0	0.0	0.0	0.	0.	0.
7	46.7	0.5	0.	0.	0.0	59.3	63.1	0.0	0.0	0.0	0.0	0.	0.	0.
8	46.4	0.4	3.	0.	0.0	58.4	61.9	0.0	0.0	0.0	0.0	0.	0.	0.
9	50.0	1.0	36.	0.	0.0	57.9	60.8	0.0	0.0	0.0	0.0	0.	0.	0.
10	55.7	4.7	78.	69.	28.5	74.2	79.1	121.8	13.1	18.7	44.0	89.	29.	6.
11	61.0	5.3	146.	177.	69.8	137.9	157.8	680.6	49.2	40.6	41.6	646.	18.	13.
12	66.2	4.5	192.	196.	69.8	141.1	163.0	749.6	41.4	40.5	41.0	709.	19.	13.
13	69.4	5.2	207.	184.	69.7	140.1	161.4	727.4	37.1	41.7	40.3	701.	9.	13.
14	71.7	6.9	204.	178.	69.7	134.6	153.8	657.4	34.1	39.2	40.2	629.	13.	13.
15	73.9	6.4	184.	173.	69.7	132.7	151.2	634.4	36.5	38.8	40.4	604.	14.	13.
16	74.3	7.7	138.	168.	69.7	133.7	152.4	642.1	49.3	40.4	40.9	611.	15.	13.
17	74.2	7.1	84.	163.	69.6	129.9	147.0	586.8	73.8	38.1	41.9	567.	6.	13.
18	72.6	7.0	20.	90.	69.2	95.9	100.7	162.5	85.9	19.1	43.6	167.	-4.	13.
19	69.8	3.3	0.	0.	9.2	82.2	83.0	3.6	0.0	0.0	0.0	3.	1.	3.
20	67.3	3.4	0.	0.	0.0	81.1	82.1	0.0	0.0	0.0	0.0	0.	0.	0.
21	64.2	2.9	0.	0.	0.0	80.0	80.8	0.0	0.0	0.0	0.0	0.	0.	0.
22	61.8	2.4	0.	0.	0.0	78.7	79.5	0.0	0.0	0.0	0.0	0.	0.	0.
23	60.4	7.3	0.	0.	0.0	77.2	78.2	0.0	0.0	0.0	0.0	0.	0.	0.
24	56.9	10.5	0.	0.	0.0	75.3	76.4	0.0	0.0	0.0	0.0	0.	0.	0.
TOT			1313.	1399.				4966.3				4724.	121.	111.

DAILY COLLECTOR ARRAY EFFICIENCY BASED ON (1) 40.0%
DAILY COLLECTOR ARRAY EFFICIENCY BASED ON (2) 37.6%
DAILY SYSTEM THERMAL EFFICIENCY BASED ON (1) 38.1%
DAILY SYSTEM THERMAL EFFICIENCY BASED ON (2) 35.7%

TABLE IV. LONE STAR BREWERY MAINTENANCE SUMMARY - JANUARY 1984

O & M Activity	Hours	Labor $	Materials $	Total $
Charged hydraulic accumulator on Row 7 (1-11-85)	0.5	12.50	--	12.50
Reprogrammed the microprocessor used as the collector controller (1-21-85)	0.5	12.50	--	12.50
				25.00

MONTHLY REPORT #15

REPORT PERIOD:	January 19, 1985 through February 15, 1985
REPORT NO.:	LS-15
DOE CONTRACT NO.:	DE-AC04-78CS32198
CONTRACT TITLE:	Solar Production of Industrial Process Steam for the Lone Star Brewery
CONTRACTOR:	Southwest Research Institute P. O. Drawer 28510 San Antonio, TX 78284 Contact: D. Deffenbaugh, (512) 684-5111, Ext. 2384
PROJECT SITE:	Lone Star Brewery 600 Lone Star Blvd. San Antonio, TX 78204

II. Project Description

Application	Preheat boiler feed water.
Site:	29 32' N Latitude, 98 28' W Longitude Elevation = 794 ft.
Process Schedule:	Average steam requirement is 50,000 lb/hr.
Auxiliary Fuel:	Natural gas; boiler efficiency = 70%.
Collectors:	9450 ft^2 of Solar Kinetics tracking, parabolic, T-700 collectors. Roof mounted: Horizontal with N-S axis of rotation; 15 rows at 90 ft per row; Packing factor = .46.
Fluid Type, Flow Rate:	Treated water flowing at a fixed rate of 75 gpm.
Design Energy Delivery:	1.9×10^9 Btu/yr.
Phase 1 Cost (Design):	$107,795
Phase 2 Cost (Construction):	$690,900

Description:

The solar system at the Lone Star Brewery provides solar heated makeup water for the deaerator that feeds the plant's boilers. By providing hot makeup water to the deaerator, the fossil fuel consumption is reduced through a decreased requirement for steam injection into the deaerator. Cool, treated makeup water is heated prior to injection into the deaerator as it flows through a solar heated shell-and-tube heat exchanger. Solar heating is provided by 15 rows of parabolic trough solar collectors that are plumbed in a parallel configuration. The solar collectors heat the treated water as it passes through the collectors. The hot water is cooled as it flows through the heat exchanger (to heat the makeup water) and is then pumped back to the collector field in a closed piping loop.

III. Operating Experience

From February 1 through February 4 the ambient temperature at the solar system site was below freezing or just slightly above freezing. The freeze protection system caused the collector fluid pumps to circulate water through the collector during the freezing weather. Table II shows unusually high parasitic power consumption and thermal loss for the first four days of February because the freeze protection system was operating.

The solar system was deactivated on February 13 so the solar collector tracker heads could be removed and sent to Solar Kinetics, Inc. The tracker heads will be installed and checked out on the new mechanical drive systems that are going to replace the hydraulic drive units at the solar system site.

IV. System Performance

A. Monthly Summary

The solar system operation during February is summarized in Tables I and II and Figure 1. The total energy delivered as hot process water during February was 23.9 MBTU's. The following table presents a comparison of the actual solar system performance with predictions of the system calculated by SwRI and SERI.

COMPARISON BETWEEN ACTUAL AND PREDICTED SYSTEM PERFORMANCE

Energy Delivered (MBTU)				Horiz. Rad. (Btu/Ft^2 Day)		
Month	Actual	Predicted SwRI	Predicted SERI	Measured	TMY	Notes
Dec 1984	6.5	83.2	96.2	499	839	1
Jan 1985	44.7	109.6	110.6	876	932	2
Feb 1985	23.9	99.2	116.3	921	1129	3

Notes: 1. Solar system turned off from December 1 through December 12. Weather was unusually cold and cloudy.

2. Performance data was lost for January 5, 6, 9, 10 and parts of January 7, 11 (power failures caused data system failures). Number of days of operation where data available - 26.5.

3. Solar system deactivated on February 13, 1985 to begin modification of collector drive units. Twelve days of system operation during month. One collector row was not operational for the entire month.

* - Typical meteorological year data used in simulation

TABLE I. LONE STAR BREWERY - SYSTEM OPERATION SUMMARY TABLE
February 1984

Date	Status Code	Solar System Availability %	Weather	Remarks
2/1	1	93	C	
2/2	1	93	F	
2/3	1	93	C	
2/4	1	93	C	
2/5	1	93	P	
2/6	1	93	P	
2/7	1	93	F	
2/8	1	93	P	
2/9	1	93	P	
2/10	1	93	C	
2/11	1	93	F	
2/12	1	93	F	
2/13	3			Solar system deactivated so tracker heads could be removed and sent to SKI for installation on new drive pylons.
2/14	3			
2/15	3			
2/16	3			
2/17	3			
2/18	3			
2/19	3			
2/20	3			
2/21	3			
2/22	3			
2/23	3			
2/24	3			
2/25	3			
2/26	3			
2/27	3			
2/28	3			

Weather Codes:

F - Fair
P - Partly Cloudy
C - Fog or Overcast
R - Rain

Solar Status Codes:

1 Normal operation
2 Solar system down
3 Solar system not turned on
4 Energy collected but not delivered to the process
5 Solar system and plant both down
6 Plant down, solar system idle
7 Solar system and plant both operational but DAS down

REMARKS:

Solar system availability is computed from the sum of each row's availability (availability = 1 if row is available all day, availability = .5 if row is available for half of the day) divided by the total number of rows (15 rows).

TABLE II. LONE S T AR BREWERY MONTHLY PERFORMANCE SUMMARY TABLE - FEBRUARY 1985

DATE	INCIDENT SOLAR ENERGY		ENERGY COLLECTED KBTU	COLLECTOR ARRAY EFF.		ENERGY DELIVERED KBTU	THERMAL LOSSES KBTU	SYSTEM THERMAL EFFIC. %	PARASITIC ENERGY USED KBTU	ACTIVE COLLECTOR AREA SFT
	HORIZONTAL SURFACE (1) BTU/SFT	COLLECTOR PLANE (2) BTU/SFT		BASED ON (1) %	BASED ON (2) %					
1	290.	1.	0.	0.	0.	0.	925.	0.	299.	8820.
2	1558.	1672.	5423.	39.	37.	5302.	572.	36.	288.	8820.
3	235.	2.	0.	0.	0.	0.	749.	0.	299.	8820.
4	232.	1.	0.	0.	0.	0.	330.	0.	136.	8820.
5	970.	**	1542.	18.	**	1529.	10.	**	60.	8820.
6	446.	**	965.	25.	**	962.	15.	**	44.	8820.
7	1206.	838.	2346.	22.	32.	2352.	41.	32.	99.	8820.
8	1111.	693.	2252.	23.	37.	2212.	20.	36.	51.	8820.
9	778.	0.	0.	0.	0.	1.	0.	0.	0.	8820.
10	631.	4.	26.	0.	73.	33.	0.	90.	22.	8820.
11	1714.	1901.	5788.	38.	35.	5748.	23.	34.	113.	8820.
12	1695.	1799.	5815.	39.	37.	5769.	184.	36.	167.	8820.
13	SOLAR SYSTEM DEACTIVATED FOR COLLECTOR DRIVE MODIFICATIONS									
14	SOLAR SYSTEM DEACTIVATED FOR COLLECTOR DRIVE MODIFICATIONS									
15	SOLAR SYSTEM DEACTIVATED FOR COLLECTOR DRIVE MODIFICATIONS									
16	SOLAR SYSTEM DEACTIVATED FOR COLLECTOR DRIVE MODIFICATIONS									
17	SOLAR SYSTEM DEACTIVATED FOR COLLECTOR DRIVE MODIFICATIONS									
18	SOLAR SYSTEM DEACTIVATED FOR COLLECTOR DRIVE MODIFICATIONS									
19	SOLAR SYSTEM DEACTIVATED FOR COLLECTOR DRIVE MODIFICATIONS									
20	SOLAR SYSTEM DEACTIVATED FOR COLLECTOR DRIVE MODIFICATIONS									
21	SOLAR SYSTEM DEACTIVATED FOR COLLECTOR DRIVE MODIFICATIONS									
22	SOLAR SYSTEM DEACTIVATED FOR COLLECTOR DRIVE MODIFICATIONS									
23	SOLAR SYSTEM DEACTIVATED FOR COLLECTOR DRIVE MODIFICATIONS									
24	SOLAR SYSTEM DEACTIVATED FOR COLLECTOR DRIVE MODIFICATIONS									
25	SOLAR SYSTEM DEACTIVATED FOR COLLECTOR DRIVE MODIFICATIONS									
26	SOLAR SYSTEM DEACTIVATED FOR COLLECTOR DRIVE MODIFICATIONS									
27	SOLAR SYSTEM DEACTIVATED FOR COLLECTOR DRIVE MODIFICATIONS									
28	SOLAR SYSTEM DEACTIVATED FOR COLLECTOR DRIVE MODIFICATIONS									
TOTAL	11048.	6911.				23909.	2870.		1578.	

** - COLLECTOR ROW WITH SOLAR RADIATION INSTRUMENTATION MOUNTED ON IT WAS NOT FOCUSED ON SUN.

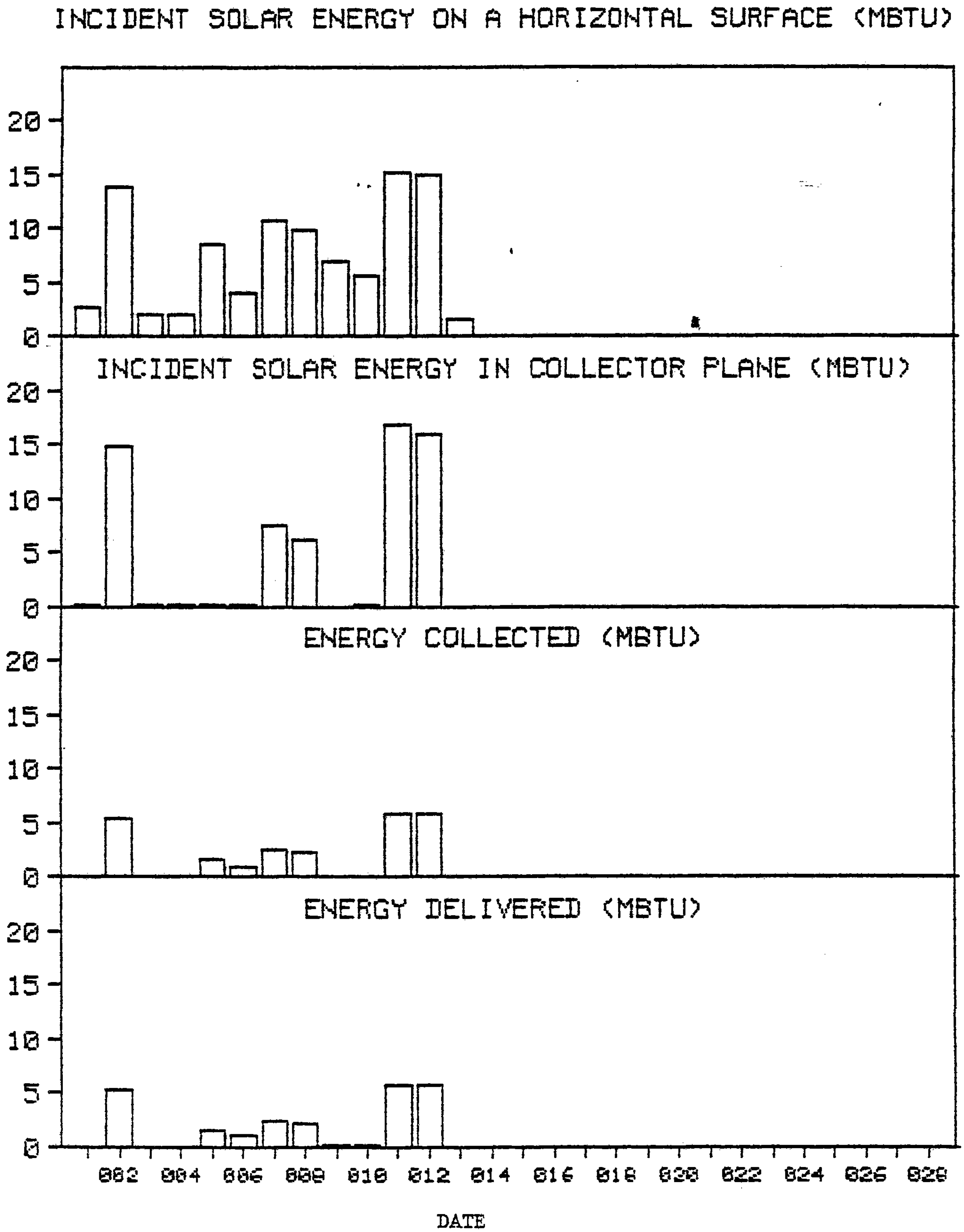


FIGURE 1. LONE STAR BREWERY MONTHLY PERFORMANCE SUMMARY PLOT FOR FEBRUARY 1985

The actual energy delivered during February is about 23% of the predicted values. Most of the difference is due to the solar system being turned off for 16 out of 28 days in the month. Another factor that reduced the energy output was one collector drive unit was not operational during February (Row 1). A comparison of average daily energy delivery shows the actual system provided 2.0 MBTU/day (12 days) compared to a predicted value of 3.6 MBTU/day (28 days with one of the 15 collector rows deactivated). This comparison shows the system provided only 56% of the energy that was predicted during the days that it was operational. A small portion of the difference may be attributed to slightly less than typical radiation during the month (see above table). The remainder of the reduced performance can probably be attributed to collector control related problems.

B. Clear Day Performance

The solar system performance for February 12, 1985 is presented in Figure 2 and Table III. The daily total energy collected and delivered were 5.82 MBTU and 5.77 MBTU's, respectively. Table III shows the collector array efficiencies are slightly less than the calculated "test stand" collector efficiency calculated from the measured ambient temperature and available solar radiation.

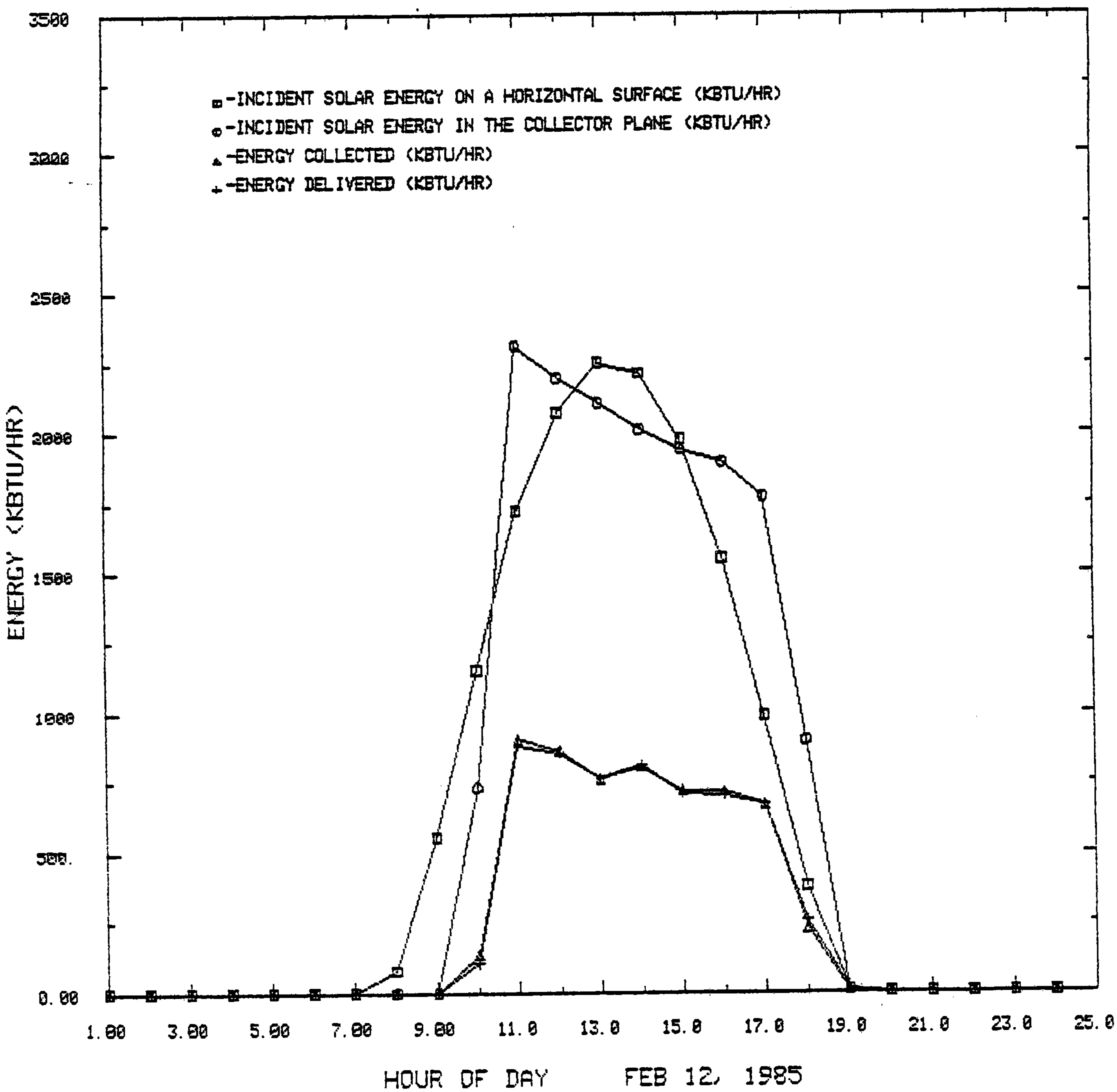


FIGURE 2. CLEAR DAY PERFORMANCE FOR FEBRUARY 12, 1985

TABLE III. DAILY PERFORMANCE TABLE - FEBRUARY 12, 1985

COLLECTOR FIELD AREA = 8820. [SQ-FT]
COLLECTOR REFLECTANCE =65.0%

			INCIDENT SOLAR RAD			COLLECTOR ARRAY TEMPERATURE								
HR	AMBIENT TEMP. DEG F	WIND SPEED MPH	ON A HORIZ. SURFACE (1) BTU/SF	IN THE COLLECTOR PLANE (2) BTU/SF	COLLECTOR ARRAY FLOW RATE GPM	INLET DEG F	OUTLET DEG F	ENERGY COLLECTED KBTU	COLLECTOR ARRAY EFFIC. BASED ON (1) %	COLLECTOR ARRAY EFFIC. BASED ON (2) MEAS-CALC %		ENERGY DELIVERED KBTU	THERMAL LOSSES KBTU	PARASITIC ENERGY KBTU
1	39.5	1.1	0.	0.	0.0	68.7	67.0	0.0	0.0	0.0	0.0	0.	0.	0.
2	38.0	0.4	0.	0.	0.0	66.9	64.9	0.0	0.0	0.0	0.0	0.	0.	0.
3	36.4	0.4	0.	0.	0.0	65.4	62.7	0.0	0.0	0.0	0.0	0.	0.	0.
4	35.1	1.1	0.	0.	66.7	72.9	70.3	0.0	0.0	0.0	0.0	0.	79.	12.
5	33.9	0.4	0.	0.	68.4	78.5	77.7	0.0	0.0	0.0	0.0	0.	23.	12.
6	33.3	0.7	0.	0.	68.4	77.6	76.8	0.0	0.0	0.0	0.0	0.	23.	12.
7	33.3	0.4	0.	0.	68.4	78.3	77.5	0.0	0.0	0.0	0.0	0.	26.	12.
8	33.3	0.4	9.	0.	43.4	78.4	77.6	0.0	0.0	0.0	0.0	0.	16.	8.
9	41.4	0.8	63.	0.	0.0	75.7	74.7	0.0	0.0	0.0	0.0	0.	0.	0.
10	48.5	5.3	131.	83.	25.9	87.4	90.7	135.4	11.7	18.4	43.7	103.	28.	5.
11	52.0	8.7	195.	262.	69.2	152.6	179.4	905.9	52.6	39.2	41.8	882.	10.	13.
12	56.2	6.9	235.	247.	69.1	158.1	183.7	862.4	41.6	39.3	41.0	856.	3.	13.
13	59.1	7.9	255.	239.	69.1	161.5	184.1	762.0	33.9	36.1	40.4	762.	11.	13.
14	60.5	10.2	251.	228.	68.9	148.6	172.5	806.0	36.4	40.2	40.5	811.	-9.	13.
15	61.9	10.0	224.	220.	69.0	145.0	166.3	720.0	36.4	37.1	40.7	712.	4.	13.
16	62.2	10.0	176.	215.	69.1	144.4	165.6	716.8	46.2	37.8	41.1	704.	4.	13.
17	62.4	9.1	112.	201.	68.9	136.8	156.7	673.0	68.3	38.0	41.9	674.	-9.	13.
18	61.2	8.9	43.	102.	68.4	104.7	111.4	227.2	60.3	25.4	42.7	256.	-21.	12.
19	58.9	5.7	1.	1.	18.4	82.5	83.0	6.5	52.8	0.0	0.0	10.	-2.	4.
20	56.2	4.8	0.	0.	0.0	80.0	80.1	0.0	0.0	0.0	0.0	0.	0.	0.
21	53.6	6.1	0.	0.	0.0	78.2	77.7	0.0	0.0	0.0	0.0	0.	0.	0.
22	50.7	7.6	0.	0.	0.0	76.1	75.4	0.0	0.0	0.0	0.0	0.	0.	0.
23	48.2	10.4	0.	0.	0.0	73.9	72.9	0.0	0.0	0.0	0.0	0.	0.	0.
24	46.3	7.8	0.	0.	0.0	71.7	70.4	0.0	0.0	0.0	0.0	0.	0.	0.
TOT			1695.	1799.				5815.4				5769.	184.	167.

DAILY COLLECTOR ARRAY EFFICIENCY BASED ON (1) 38.9%
DAILY COLLECTOR ARRAY EFFICIENCY BASED ON (2) 36.7%
DAILY SYSTEM THERMAL EFFICIENCY BASED ON (1) 38.6%
DAILY SYSTEM THERMAL EFFICIENCY BASED ON (2) 36.4%

MONTHLY REPORT #17

REPORT PERIOD:	March 16, 1985 through April 12, 1985
REPORT NO.:	LS-17
DOE CONTRACT NO.:	DE-AC04-78CS32198
CONTRACT TITLE:	Solar Production of Industrial Process Steam for the Lone Star Brewery
CONTRACTOR:	Southwest Research Institute P. O. Drawer 28510 San Antonio, TX 78284 Contact: D. Deffenbaugh, (512) 684-5111, Ext. 2384
PROJECT SITE:	Lone Star Brewery 600 Lone Star Blvd. San Antonio, TX 78204

II. Project Description

Application	Preheat boiler feed water.
Site:	29 32' N Latitude, 98 28' W Longitude Elevation = 794 ft.
Process Schedule:	Average steam requirement is 50,000 lb/hr.
Auxiliary Fuel:	Natural gas; boiler efficiency = 70%.
Collectors:	9450 ft^2 of Solar Kinetics tracking, parabolic, T-700 collectors. Roof mounted: Horizontal with N-S axis of rotation; 15 rows at 90 ft per row; Packing factor = .46.
Fluid Type, Flow Rate:	Treated water flowing at a fixed rate of 75 gpm.
Design Energy Delivery:	1.9×10^9 Btu/yr.
Phase 1 Cost (Design):	$107,795
Phase 2 Cost (Construction):	$690,900

Description:

The solar system at the Lone Star Brewery provides solar heated makeup water for the deaerator that feeds the plant's boilers. By providing hot makeup water to the deaerator, the fossil fuel consumption is reduced through a decreased requirement for steam injection into the deaerator. Cool, treated makeup water is heated prior to injection into the deaerator as it flows through a solar heated shell-and-tube heat exchanger. Solar heating is provided by 15 rows of parabolic trough solar collectors that are plumbed in a parallel configuration. The solar collectors heat the treated water as it passes through the collectors. The hot water is cooled as it flows through the heat exchanger (to heat the makeup water) and is then pumped back to the collector field in a closed piping loop.

III. Operating Experience

On April 1 the solar system was brought up for further checkout of the new drive systems. Solar Kinetics personnel were on site repairing several of the collector drive units. The collectors that were operational were brought up and the fluid flow through these rows was balanced (by measuring the temperature at the row outlet and adjusting the flow balancing valves). Solar kinetics remained on site until April 2 when the weather turned cloudy so no further checkout work could be performed. During the initial checkout period the collector loop would heat up quickly and have to be defocused since the process water flow was very low. The problem was originally thought to be caused by a faulty float activated valve, but the cause was finally traced to debris that had collected in several locations in the process water pipe. The process water flow problem was resolved on April 22 with the installation of another strainer in the process water piping. The microprocessor used as the solar system central controller failed and was replaced with a spare on April 5.

The solar system was manually brought up to checkout system operation several days during April. The system was put into automatic control on April 23 and the data acquisition system reactivated. The system performance for the period from April 23 until the end of the month is summarized below. Maintenance activities during April are summarized in Table IV.

IV. System Performance

A. Monthly Summary

The solar system operation from April 23 through April 30 is summarized in Tables I and II and Figure 1. When the system was set in the automatic operation mode on April 23, 1985, collector rows 8, 11, 14, and 15 were not functioning properly. Solar Kinetics personnel were on site April 24 and 25 to repair several collector drives. When Solar Kinetics left, all the collector rows were functional except row 15. The system did not operate on April 25 and 26 because the water level in the collector loop was too low. The low water level caused the fluid pump to cavitate so the solar system never came up. Apparently there is a leak in the collector loop piping that is causing the system to lose water, but it has not yet been located. One source of water leakage, that has been repaired was the flex hose on the outlet end of row 11. This hose was replaced on April 23. Since the collector row that has the instrumentation for measuring the collector plane radiation was not operational (row 15) during the month, no collector plane radiation was measured during April.

B. Clear Day Performance

The solar system performance for April 24 is shown in Figure 2 and Table III. The daily total energy collected was 5207 KBTU and the total energy delivered was 4403 KBTU. On April 24 there were four collector drive rows that were not operational so only 73% of the solar collector field was available.

TABLE I. LONE STAR BREWERY - SYSTEM OPERATION SUMMARY TABLE
April 1984

Date	Status Code	Solar System Availability %	Weather	Remarks
4/23	1	73	P	Rows 4, 8, 11, and 15 not operational.
4/24	1	73	F	Solar Kinetics on site.
4/25	2	93	P	Solar Kinetics on site. Row 15 still down.
4/26	2	93	P	Low collector loop water level.
4/27	1	93	C	
4/28	1	93	C	
4/29	1	93	C	
4/30	1	93	C	

Codes:

F - Fair
P - Partly Cloudy
C - Fog or Overcast
R - Rain

Solar Status Codes:

1 Normal operation
2 Solar system down
3. Solar system not turned on
4. Energy collected but not delivered to the process
5. Solar system and plant both down
6. Plant down, solar system idle
7. Solar system and plant both operational but DAS down

REMARKS:

Solar system availability is computed from the sum of each row's availability (availability = 1 if row is available all day, availability = .5 if row is available for half of the day) divided by the total number of rows (15 rows).

TABLE II. LONE STAR BREWERY MONTHLY PERFORMANCE SUMMARY TABLE - APRIL 1985

DATE	INCIDENT SOLAR ENERGY HORIZONTAL SURFACE (1) BTU/SFT	INCIDENT SOLAR ENERGY COLLECTOR PLANE (2) BTU/SFT	ENERGY COLLECTED KBTU	COLLECTOR ARRAY EFF. BASED ON (1) %	COLLECTOR ARRAY EFF. BASED ON (2) %	ENERGY DELIVERED KBTU	THERMAL LOSSES KBTU	SYSTEM THERMAL EFFIC. %	PARASITIC ENERGY USED KBTU	ACTIVE COLLECTOR AREA SFT
1			SOLAR SYSTEM DEACTIVATED							
2			SOLAR SYSTEM DEACTIVATED							
3			SOLAR SYSTEM DEACTIVATED							
4			SOLAR SYSTEM DEACTIVATED							
5			SOLAR SYSTEM DEACTIVATED							
6			SOLAR SYSTEM DEACTIVATED							
7			SOLAR SYSTEM DEACTIVATED							
8			SOLAR SYSTEM DEACTIVATED							
9			SOLAR SYSTEM DEACTIVATED							
10			SOLAR SYSTEM DEACTIVATED							
11			SOLAR SYSTEM DEACTIVATED							
12			SOLAR SYSTEM DEACTIVATED							
13			SOLAR SYSTEM DEACTIVATED							
14			SOLAR SYSTEM DEACTIVATED							
15			SOLAR SYSTEM DEACTIVATED							
16			SOLAR SYSTEM DEACTIVATED							
17			SOLAR SYSTEM DEACTIVATED							
18			SOLAR SYSTEM DEACTIVATED							
19			SOLAR SYSTEM DEACTIVATED							
20			SOLAR SYSTEM DEACTIVATED							
21			SOLAR SYSTEM DEACTIVATED							
22			SOLAR SYSTEM DEACTIVATED							
23	2181.	***	4405.	29.	***	3783.	86.	***	145.	6930.
24	2317.	***	5207.	32.	***	4403.	171.	***	148.	6930.
25	1988.	***	102.	1.	***	79.	42.	***	25.	8820.
26	1181.	0.	1.	0.	0.	1.	1.	0.	7.	8820.
27	1111.	0.	0.	0.	0.	0.	0.	0.	7.	8820.
28	1186.	0.	0.	0.	0.	0.	0.	0.	8.	8820.
29	639.	0.	0.	0.	0.	0.	0.	0.	7.	8820.
30	1295.	0.	1.	0.	0.	4.	1.	0.	8.	8820.
	11898.	0.	9715.			8270.	300.		355.	

*** - COLLECTOR ROW THAT HAS THE INSTRUMENTATION FOR MEASURING COLLECTOR PLANE RADIATION WAS NOT OPERATIONAL.

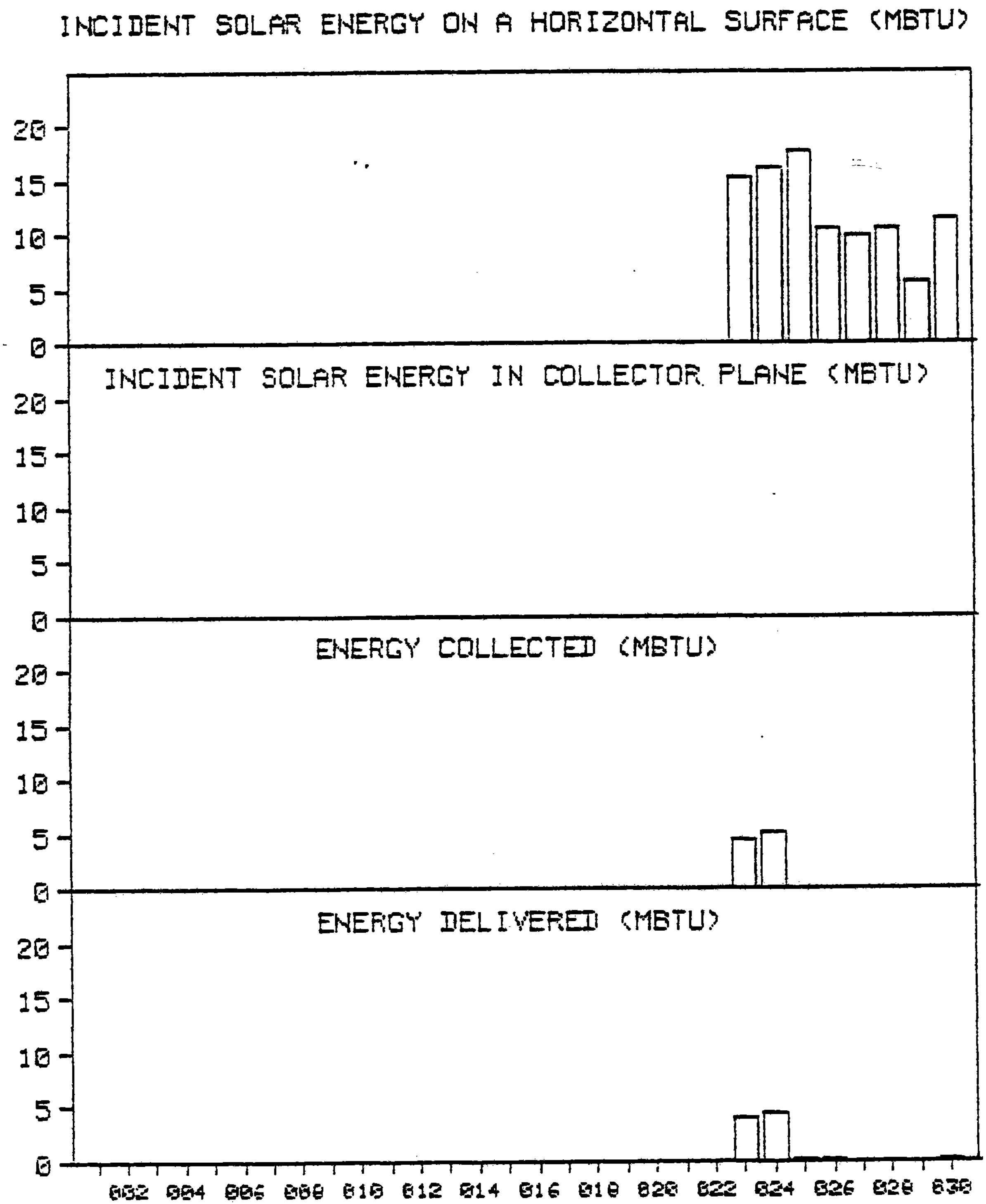


FIGURE 1. LONE STAR BREWERY MONTHLY PERFORMANCE SUMMARY PLOT FOR APRIL 1985

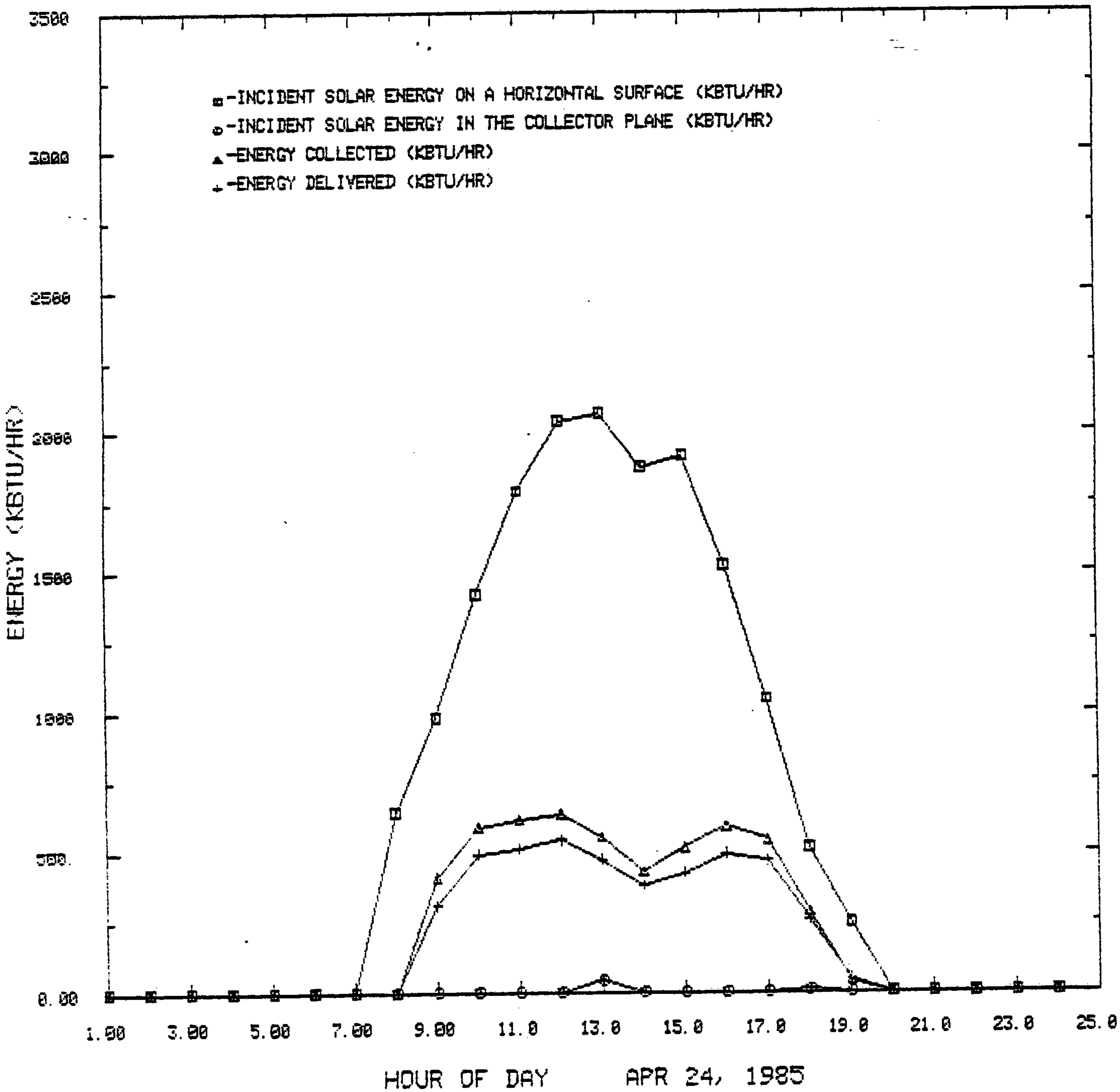


FIGURE 2. CLEAR DAY PERFORMANCE FOR APRIL 24, 1985

TABLE III. DAILY PERFORMANCE TABLE - APRIL 24, 1985

COLLECTOR FIELD AREA = 6930. [SQ-FT]
COLLECTOR REFLECTANCE =59.3%

HR	AMBIENT TEMP. DEG F	WIND SPEED MPH	INCIDENT SOLAR RAD: ON A HORIZ. SURFACE (1) BTU/SF	INCIDENT SOLAR RAD: IN THE COLLECTOR PLANE (2) BTU/SF	COLLECTOR ARRAY FLOW RATE GPM	COLLECTOR ARRAY TEMPERATURE: INLET DEG F	COLLECTOR ARRAY TEMPERATURE: OUTLET DEG F	ENERGY COLLECTED KBTU	COLLECTOR ARRAY EFFIC. BASED ON (1) %	COLLECTOR ARRAY EFFIC. BASED ON (2) MEAS-CALC %		ENERGY DELIVERED KBTU	THERMAL LOSSES KBTU	PARASITIC ENERGY KBTU
1	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
2	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
3	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
4	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
5	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
6	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
7	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
8	68.3	5.1	93.	0.	0.0	72.9	73.3	0.0	0.0	0.0	0.0	0.	0.	0.
9	71.4	3.8	142.	0.	74.2	126.8	137.9	411.1	41.7	****	***	310.	43.	14.
10	76.2	4.4	205.	0.	76.3	168.3	184.1	587.6	41.4	****	***	493.	20.	14.
11	78.6	5.1	258.	0.	76.3	171.7	188.3	615.0	34.4	****	***	512.	25.	15.
12	82.4	4.4	294.	0.	76.3	168.9	186.1	637.5	31.3	****	***	544.	15.	15.
13	85.4	4.5	298.	0.	76.2	171.4	186.3	552.7	26.8	****	***	473.	14.	15.
14	86.0	3.7	270.	0.	75.4	145.8	157.4	428.3	22.9	****	***	381.	-2.	15.
15	85.7	4.5	276.	0.	75.0	151.0	165.1	515.1	26.9	****	***	423.	28.	14.
16	86.2	3.5	220.	0.	74.6	170.7	187.0	592.8	38.9	****	***	494.	21.	14.
17	85.1	.4.2	151.	0.	74.4	172.4	187.4	543.8	51.8	****	***	467.	9.	14.
18	83.1	4.6	74.	0.	71.7	136.1	144.2	284.8	55.4	0.0	0.0	258.	-9.	14.
19	80.6	5.1	36.	0.	12.1	111.7	117.5	37.7	15.2	0.0	0.0	48.	7.	3.
20	76.9	3.5	0.	0.	0.0	104.8	108.5	0.0	0.0	0.0	0.0	0.	0.	0.
21	73.8	2.4	0.	0.	0.0	102.0	105.4	0.0	0.0	0.0	0.0	0.	0.	0.
22	71.5	3.5	0.	0.	0.0	99.0	102.5	0.0	0.0	0.0	0.0	0.	0.	0.
23	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
24	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
TOT			2317.	0.				5206.7				4403.	171.	148.

DAILY COLLECTOR ARRAY EFFICIENCY BASED ON (1) 32.4%
DAILY COLLECTOR ARRAY EFFICIENCY BASED ON (2) 0.0%
DAILY SYSTEM THERMAL EFFICIENCY BASED ON (1) 27.4%
DAILY SYSTEM THERMAL EFFICIENCY BASED ON (2) 0.0%

TABLE IV. LONE STAR BREWERY MAINTENANCE SUMMARY - APRIL 1985

O & M Activity	Hours	Labor $	Materials $	Total $
Replaced microprocessor used for the solar system central controller (4-5-85)	1.0	25.00	-	25.00
Traced down and solved cause of process water flow stoppage (4-15-85)	2.0	50.00	-	50.00
Replaced row 11 flex hose (4-23-85)	1.0	25.00	-	25.00

MONTHLY REPORT #18

REPORT PERIOD:	April 13, 1985 through May 10, 1985
REPORT NO.:	LS-18
DOE CONTRACT NO.:	DE-AC04-78CS32198
CONTRACT TITLE:	Solar Production of Industrial Process Steam for the Lone Star Brewery
CONTRACTOR:	Southwest Research Institute P. O. Drawer 28510 San Antonio, TX 78284 Contact: D. Deffenbaugh, (512) 684-5111, Ext. 2384
PROJECT SITE:	Lone Star Brewery 600 Lone Star Blvd. San Antonio, TX 78204

II. Project Description

Application	Preheat boiler feed water.
Site:	29 32' N Latitude, 98 28' W Longitude Elevation = 794 ft.
Process Schedule:	Average steam requirement is 50,000 lb/hr.
Auxiliary Fuel:	Natural gas; boiler efficiency = 70%.
Collectors:	9450 ft^2 of Solar Kinetics tracking, parabolic, T-700 collectors. Roof mounted: Horizontal with N-S axis of rotation; 15 rows at 90 ft per row; Packing factor = .46.
Fluid Type, Flow Rate:	Treated water flowing at a fixed rate of 75 gpm.
Design Energy Delivery:	1.9×10^9 Btu/yr.
Phase 1 Cost (Design):	$107,795
Phase 2 Cost (Construction):	$690,900

Description:

The solar system at the Lone Star Brewery provides solar heated makeup water for the deaerator that feeds the plant's boilers. By providing hot makeup water to the deaerator, the fossil fuel consumption is reduced through a decreased requirement for steam injection into the deaerator. Cool, treated makeup water is heated prior to injection into the deaerator as it flows through a solar heated shell-and-tube heat exchanger. Solar heating is provided by 15 rows of parabolic trough solar collectors that are plumbed in a parallel configuration. The solar collectors heat the treated water as it passes through the collectors. The hot water is cooled as it flows through the heat exchanger (to heat the makeup water) and is then pumped back to the collector field in a closed piping loop.

III. Operating Experience

Solar system operation continued through May 1985. On May 1st collector rows 11 and 15 were not operating because of collector drive system problems. By May 5th rows 5 and 9 were also down due to drive failures. By May 15th the collector drives on rows 4 and 10 had also failed so 6 collector rows out of 15 were down. The drive system on row 8 failed around May 21st and row 2 was not operational on May 24th. By May 29th rows 4 and 14 were not tracking properly so 10 of the 15 rows were down. The collector drive failures exhibited many different modes of failure with some rows stuck in the stow position, some stuck facing the west horizon, some would intermittently track and lose focus on the sun, and some rows would drive in a rapidly cycling on-off manner. Table I presents a summary of the collector field's availability. Solar Kinetics, Inc. (SKI) was on site to repair collector drives on May 30th, and after they left 6 rows had been repaired and 4 rows remained down. The repair work done by SKI included replacing rectifiers on 3 motor control boards, replacing both the motor control board and the search mode board on 3 rows, and finding failed drive motors on 3 rows. At this time the cause of these failures is not known.

During May there was no maintenance performed on the solar system except for the work done by SKI as warranty work on the new mechanical drive systems.

IV. System Performance

A. Monthly Summary

The solar system performance during May 1985 is summarized in Tables I and II and Figure 1. No collector plane radiation data is reported in Table II or Figure 1 because the instrumentation for measuring the collector plan radiation is mounted on row 15 and the drive system on that row was not functioning during May. During May the total energy collected was 57.5 MBTU and the energy delivered to the process was 55.6 MBTU.

B. Clear Day Performance

The solar system performance for May 6, 1985 is presented in Table III and Figure 2. The daily total energy collected was 4.5 MBTU and the energy delivered was 4.3 MBTU. On May 6, 1985 there were 4 of the 15 collector drive rows down or 73% of the collectors were available.

TABLE I. LONE STAR BREWERY - SYSTEM OPERATION SUMMARY TABLE
May 1985

Date	Status Code	Solar System Availability %	Weather Code	Remarks
5/1	1	86	F	Rows 11 and 15 down
5/2	1	86	F	
5/3	1	80	F	Rows 5 and 9 stuck facing west horizon
5/4	1	80	F	
5/5	1	80	F	
5/6	1	73	F	
5/7	1	73	F	
5/8	1	73	F	
5/9	1	73	P	
5/10	1	73	F	
5/11	1	73	P	
5/12	1	73	C	
5/13	1	73	C	
5/14	1	73	P	
5/15	1	60	P	Rows 4 and 10 down
5/16	1	60	P	
5/17	1	60	C	
5/18	1	60	F	
5/19	1	60	F	
5/20	1	60	P	
5/21	1	53	P	Row 8 down
5/22	1	53	F	
5/23	1	53	P	
5/24	1	47	P	Row 2 down
5/25	1	47	F	
5/26	1	47	P	
5/27	1	47	P	
5/28	1	47	P	
5/29	1	33	F	Row 4 down, Row 14 tracking erratically
5/30	1	33	F	Solar Kinetics, Inc. on site to repair collector drives
5/31	1	73	F	Rows 4,5,6, and 11 still down

TABLE I (Continued)

Codes:

F - Fair
P - Partly Cloudy
C - Fog or Overcast
R - Rain

Solar Status Codes:

1 Normal operation
2 Solar system down
3. Solar system not turned on
4. Energy collected but not delivered to the process
5. Solar system and plant both down
6. Plant down, solar system idle
7. Solar system and plant both operational but DAS down

REMARKS:

Solar system availability is computed from the sum of each row's availability (availability = 1 if row is available all day, availability = .5 if row is available for half of the day) divided by the total number of rows (15 rows).

TABLE II. LONE STAR BREWERY MONTHLY PERFORMANCE SUMMARY TABLE - MAY 1985

	INCIDENT SOLAR ENERGY			COLLECTOR ARRAY EFF.						
DATE	HORIZONTAL SURFACE (1) BTU/SFT	COLLECTOR PLANE (2) BTU/SFT	ENERGY COLLECTED KBTU	BASED ON (1) %	BASED ON (2) %	ENERGY DELIVERED KBTU	THERMAL LOSSES KBTU	SYSTEM THERMAL EFFIC. %	PARASITIC ENERGY USED KBTU	ACTIVE COLLECTOR AREA SFT
1	2305.	0.	3188.	17.	0.	2966.	222.	0.	140.	8190.
2	2329.	0.	3628.	19.	0.	3416.	213.	0.	158.	8190.
3	2391.	0.	3771	21.	0.	3493.	279.	0.	155.	7560.
4	2362.	0.	2575.	14.	0.	2378.	198.	0	113.	7560.
5	2466.	0.	78.	0.	0.	36.	42.	0	13.	7560.
6	2371.	0	4550.	28.	0.	4348.	202.	0	147.	6930.
7	2212.	0.	3751.	24.	0.	3590.	162.	0.	136.	6930.
8	2038.	0.	2399.	17.	0.	2361.	39.	0	110.	6930.
9	1977.	0.	1021.	7.	0.	1038.	-17	0.	91.	6930.
10	2127.	0.	2674.	18.	0.	2612.	62.	0.	160.	6930.
11	1677.	0	1110.	10.	0.	1097.	12.	0.	89.	6930.
12	698.	0.	0	0.	0.	0.	0	0.	7.	6930.
13	909.	0	29.	0.	0.	25.	4.	0.	16.	6930.
14	1671.	0.	1251	11.	0.	1205.	47.	0.	76.	6930.
15	1465.	0	813.	10.	0.	775.	38.	0.	57.	5670.
16	1766.	0.	1269.	13.	0.	1262.	7.	0.	102.	5670.
17	1067.	0.	1160.	19.	0.	1151.	9.	0.	64.	5670.
18	2129.	0.	2238.	19.	0.	2180.	58.	0.	128.	5670.
19	2066.	0.	2025.	17.	0.	1952.	73.	0.	135.	5670.
20	1368.	0.	986.	13.	0.	963.	24.	0	92.	5670.
21	1761.	0.	1341.	20.	0.	1330.	11.	0.	123.	3780.
22	2194.	0.	1536.	19.	0.	1539.	-3.	0.	117.	3780.
23	1929.	0.	1199.	16.	0.	1221.	-23.	0.	100.	3780.
24	1237.	0	604.	13.	0.	619.	-15.	0.	63.	3780.
25	2368.	0.	2488.	28.	0.	2447.	41.	0.	131.	3780.
26	1992.	0.	1088.	14.	0.	1110.	-21.	0	117.	3780.
27	1224.	0.	478.	10.	0.	492.	-14.	0.	58.	3780.
28	1421.	0	682.	13.	0.	698.	-16.	0.	69.	3780.
29	2226.	0.	2486.	35.	0.	2451.	36.	0.	115.	3150.
30	2159.	0.	3108.	46.	0.	2997.	111.	0.	118.	3150.
31	2444.	0.	3974.	26.	0.	3826.	148	0.	120.	6300.
	58347.	0.	57499.			55579.	1927.		3119.	

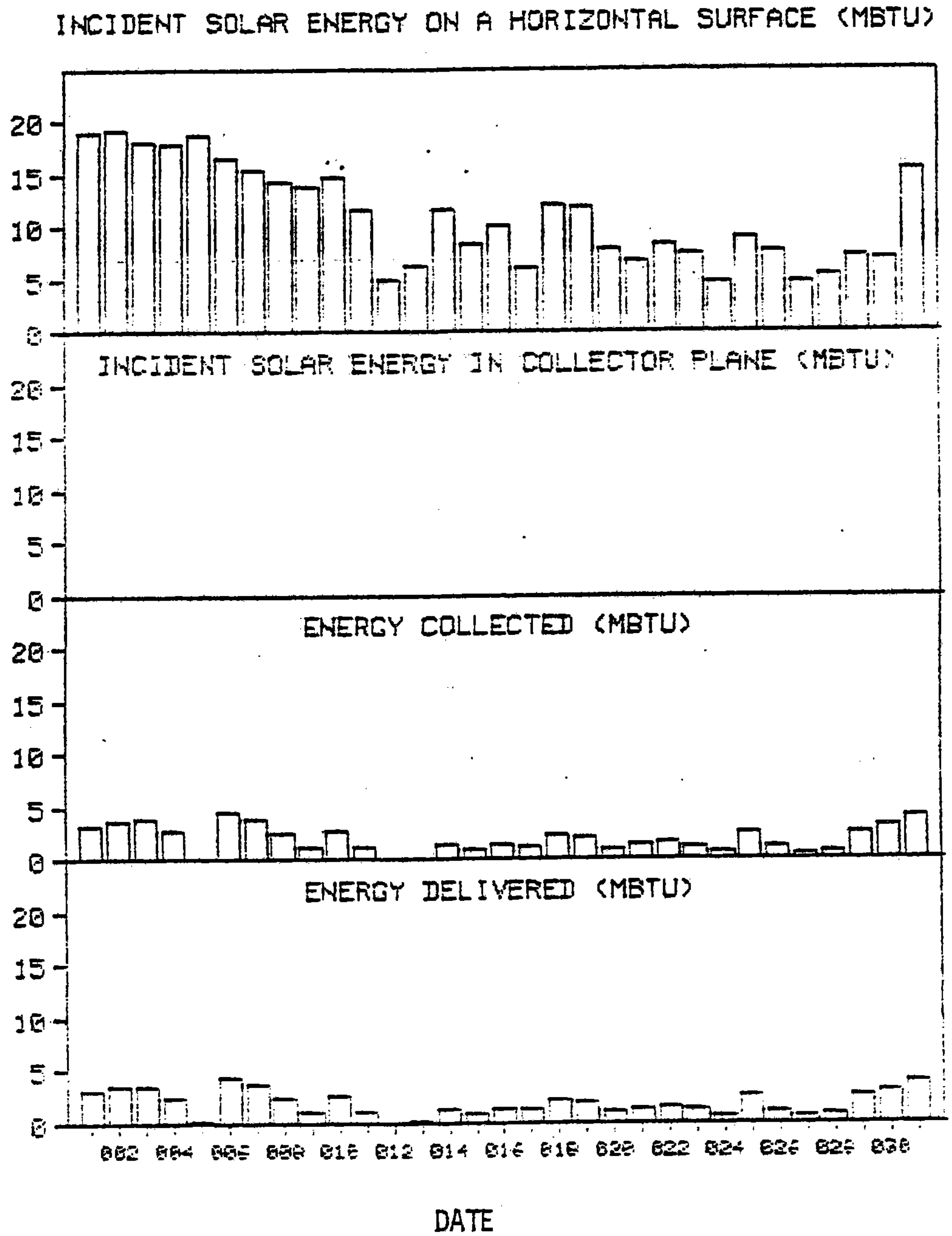


FIGURE 1. LONE STAR BREWERY MONTHLY PERFORMANCE SUMMARY PLOT - MAY 1985

TABLE III. DAILY PERFORMANCE SUMMARY TABLE - MAY 6, 1985

COLLECTOR FIELD AREA = 6930. [SQ-FT]
COLLECTOR REFLECTANCE =96.1%

HR	AMBIENT TEMP. DEG F	WIND SPEED MPH	INCIDENT SOLAR RAD ON A HORIZ. SURFACE (1) BTU/SF	INCIDENT SOLAR RAD IN THE COLLECTOR PLANE (2) BTU/SF	COLLECTOR ARRAY FLOW RATE GPM	COLLECTOR ARRAY TEMPERATURE INLET DEG F	COLLECTOR ARRAY TEMPERATURE OUTLET DEG F	ENERGY COLLECTED KBTU	COLLECTOR ARRAY EFFIC. BASED ON (1) %	COLLECTOR ARRAY EFFIC. BASED ON (2) MEAS	COLLECTOR ARRAY EFFIC. BASED ON (2) CALC %	ENERGY DELIVERED KBTU	THERMAL LOSSES KBTU	PARASITIC ENERGY KBTU
1	0.0	0.0	0	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
2	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
3	0.0	0.0	0	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
4	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
5	0.0	0.0	0	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
6	0.0	0.0	0	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
7	0.0	0.0	0	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
8	68.7	6.7	89.	0.	0.0	76.3	78.9	0.0	0.0	0.0	0.0	0.	0.	0.
9	71.4	8.0	140.	0.	50.6	104.1	105.3	120.0	12.3	0.0	0.0	84.	36.	10.
10	73.6	10.6	200	0.	74.9	161.3	173.7	452.1	32.6	0.0	0.0	422.	30.	14.
11	77.2	10.9	223.	0.	74.7	149.1	158.9	343.8	22.2	0.0	0.0	340.	4.	14.
12	79.5	11.1	272	0.	74.3	169.0	181.6	456.5	22.5	0.0	0.0	423.	34.	14.
13	82.0	10.9	320.	0.	75.1	162.3	176.8	530.9	24.0	0.0	0.0	507.	24.	14.
14	83.7	10.5	309	0.	74.9	173.1	188.6	564.9	26.4	0.0	0.0	538.	27.	14.
15	84.6	10.4	279	0.	74.7	176.8	191.8	543.9	28.1	0.0	0.0	518.	26.	14.
16	85.6	10.2	230	0.	74.8	177.5	192.5	547.5	34.4	0.0	0.0	522.	25.	14.
17	85.0	10.7	165.	0.	75.0	175.8	189.9	515.8	45.1	0.0	0.0	494.	22.	14.
18	84.0	11.0	92	0.	75.1	151.7	161.6	362.0	56.7	0.0	0.0	363.	-1.	14.
19	82.4	10.4	31	0.	40.7	114.5	119.1	112.5	52.8	0.0	0.0	135.	-23.	8.
20	80.0	8.0	1.	0.	0.0	104.1	106.3	0.0	0.0	0.0	0.0	0.	0.	0.
21	77.6	9.5	0	0.	0.0	98.2	99.2	0.0	0.0	0.0	0.0	0.	0.	0.
22	75.0	9.6	0	0.	0.0	92.1	99.6	0.0	0.0	0.0	0.0	0.	0.	0.
23	0.0	0.0	0	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
24	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
TOT			2371.	0.				4549.7				4348.	202.	147.

DAILY COLLECTOR ARRAY EFFICIENCY BASED ON (1) 27.7%
DAILY COLLECTOR ARRAY EFFICIENCY BASED ON (2) 0.0%
DAILY SYSTEM THERMAL EFFICIENCY BASED ON (1) 26.5%
DAILY SYSTEM THERMAL EFFICIENCY BASED ON (2) 0.0%

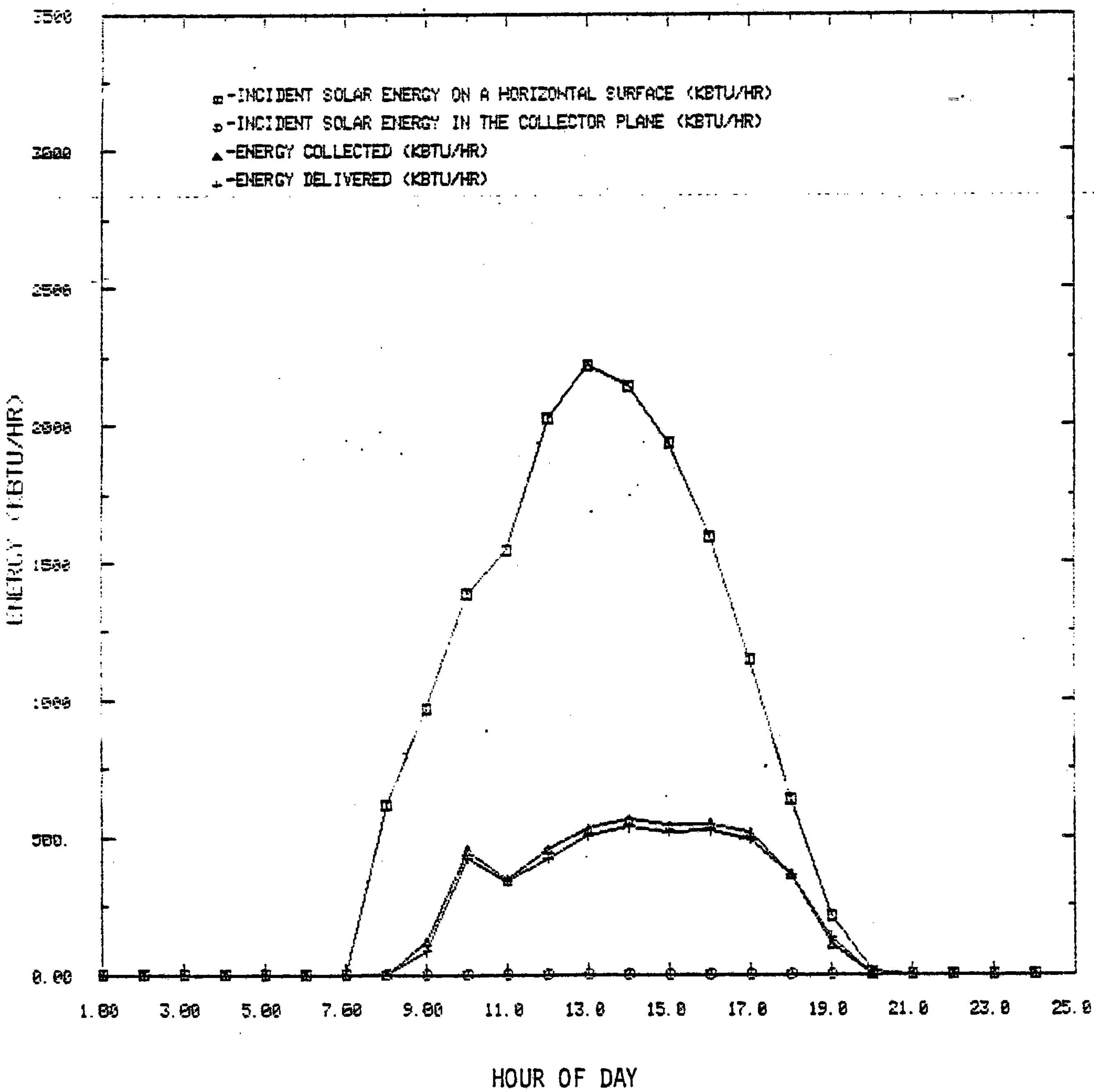


FIGURE 2. CLEAR DAY PERFORMANCE PLOT FOR MAY 6, 1985

MONTHLY REPORT #19

REPORT PERIOD:	May 11, 1985 through June 14, 1985
REPORT NO.:	LS-19
DOE CONTRACT NO.:	DE-AC04-78CS32198
CONTRACT TITLE:	Solar Production of Industrial Process Steam for the Lone Star Brewery
CONTRACTOR:	Southwest Research Institute P. O. Drawer 28510 San Antonio, TX 78284 Contact: D. Deffenbaugh, (512) 684-5111, Ext. 2384
PROJECT SITE:	Lone Star Brewery 600 Lone Star Blvd. San Antonio, TX 78204

II. Project Description

Application	Preheat boiler feed water.
Site:	29° 32' N Latitude, 98° 28' W Longitude Elevation = 794 ft.
Process Schedule:	Average steam requirement is 50,000 lb/hr.
Auxiliary Fuel:	Natural gas; boiler efficiency = 70%.
Collectors:	9450 ft^2 of Solar Kinetics tracking, parabolic, T-700 collectors. Roof mounted: Horizontal with N-S axis of rotation; 15 rows at 90 ft per row; Packing factor = .46.
Fluid Type, Flow Rate:	Treated water flowing at a fixed rate of 75 gpm.
Design Energy Delivery:	1.9×10^9 Btu/yr.
Phase 1 Cost (Design):	$107,795
Phase 2 Cost (Construction):	$690,900

Description:

The solar system at the Lone Star Brewery provides solar heated makeup water for the deaerator that feeds the plant's boilers. By providing hot makeup water to the deaerator, the fossil fuel consumption is reduced through a decreased requirement for steam injection into the deaerator. Cool, treated makeup water is heated prior to injection into the deaerator as it flows through a solar heated shell-and-tube heat exchanger. Solar heating is provided by 15 rows of parabolic trough solar collectors that are plumbed in a parallel configuration. The solar collectors heat the treated water as it passes through the collectors. The hot water is cooled as it flows through the heat exchanger (to heat the makeup water) and is then pumped back to the collector field in a closed piping loop.

III. Operating Experience

On June 1 collector rows 4, 5, 6, 11, and 15 were not up. Rows 4, 5, and 6 had failed collector drive motors; row 11 had a failed search mode tracker board; and row 15 was operational, but not activated (row 15 was repaired by Solar Kinetics on May 30 but left in stow because the rows isolation valves were closed). Row 15 was reactivated on June 10. The collector drive system on row 12 failed some time between May 31 and June 10. The cause of the failure of row 12 is unknown. The solar system was turned off on June 14.

During June there was no maintenance performed.

IV. System Performance

A. Monthly Summary

The Lone Star Brewery solar system performance during June is summarized in Tables I and II, and Figure 1. Table I shows the solar system availability during June was 67% or only two-thirds of the collector drives were available. Table II and Figure 1 present a summary of the daily total energy collected, energy delivered, and solar radiation in a horizontal plane. Collector plane radiation data are not available because the instrumentation for measuring the collector plane radiation is mounted on row 15 which was not brought up until June 10. After row 15 was brought up it was discovered that the pyranometer was providing an erroneous reading. The solar system was turned off before the problem was discovered. During the period from June 1 through June 14, 25.0 MBTUs of energy were collected and 23.8 MBTUs were delivered to the industrial process.

B. Clear Day Performance

The solar system performance for June 8, 1985 is shown in Table III and Figure 2. The daily total energy collected was 4.25 KBTU and the daily total energy delivered to the process was 4.07 KBTU. The thermal losses in the system piping account for approximately 4% of the energy collected.

TABLE I. LONE STAR BREWERY - SYSTEM OPERATION SUMMARY TABLE
June 1985

Date	Status Code	Solar System Availability %	Weather Code	Remarks
6/1	1	67	F	Rows 4,5,6, and 15 down
6/2	1	67	F	
6/3	1	67	F	
6/4	1	67	P	
6/5	1	67	C	
6/6	1	67	C	
6/7	1	67	P	
6/8	1	67	F	
6/9	1	67	F	
6/10	1	67	F	Row 15 brought up, row 12 down
6/11	1	67	F	
6/12	1	67	P	
6/13	1	67	P	
6/14	1	67	P	Solar system shut down

Codes:

F - Fair
P - Partly Cloudy
C - Fog or Overcast
R - Rain

Solar Status Codes:

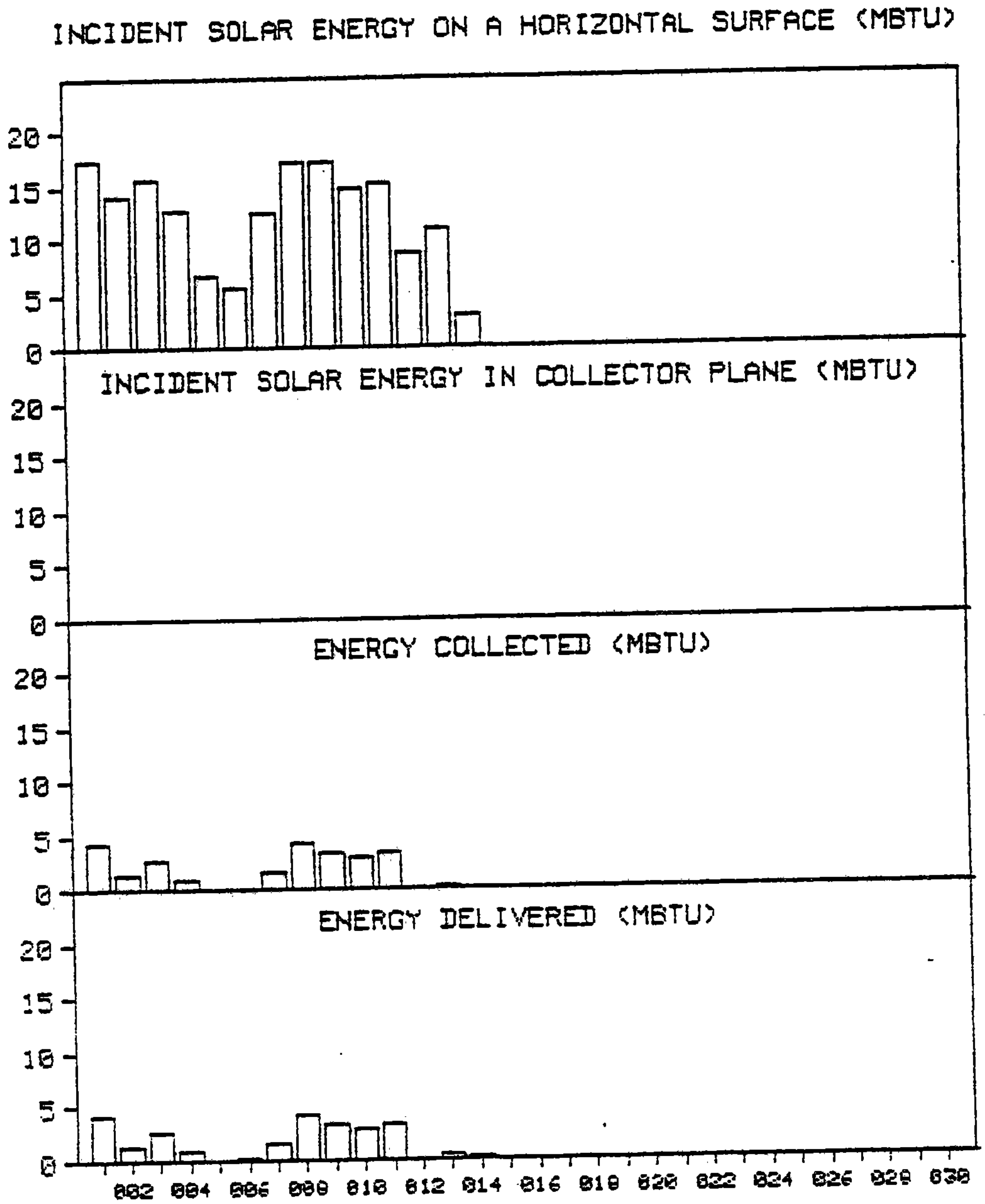
1 Normal operation
2 Solar system down
3. Solar system not turned on
4. Energy collected but not delivered to the process
5. Solar system and plant both down
6. Plant down, solar system idle
7. Solar system and plant both operational but DAS down

REMARKS:

Solar system availability is computed from the sum of each row's availability (availability = 1 if row is available all day, availability = .5 if row is available for half of the day) divided by the total number of rows (15 rows).

TABLE II. LONE STAR BREWERY MONTHLY PERFORMANCE SUMMARY TABLE - JUNE, 1985

	INCIDENT SOLAR ENERGY			COLLECTOR ARRAY EFF.						
DATE	HORIZONTAL SURFACE (1) BTU/SFT	COLLECTOR PLANE (2) BTU/SFT	ENERGY COLLECTED KBTU	BASED ON (1) %	BASED ON (2) %	ENERGY DELIVERED KBTU	THERMAL LOSSES KBTU	SYSTEM THERMAL EFFIC. %	PARASITIC ENERGY USED KBTU	ACTIVE COLLECTOR AREA SFT
1	2494.	0.	4279.	27.	0.	4118.	162.	0.	126.	6300.
2	2036.	0.	1254.	10.	0.	1129.	125.	0.	53.	6300.
3	2237.	0.	2726.	19.	0.	2628.	98.	0.	112.	6300.
4	1833.	0.	821.	7.	0.	816.	5.	0.	80.	6300.
5	975.	0.	0.	0.	0.	0.	0.	0.	5.	6300.
6	807.	0.	1.	0.	0.	1.	-1.	0.	6.	6300.
7	1791.	0.	1575.	14.	0.	1501.	74.	0.	65.	6300.
8	2479.	0.	4255.	27.	0.	4072.	183.	0.	136.	6300.
9	2482.	0.	3432.	22.	0.	3250.	182.	0.	109.	6300.
10	2339.	0.	2930.	20.	0.	2757.	173.	0.	111.	6300.
11	2386.	0.	3324.	22.	0.	3167.	158.	0.	118.	6300.
12	1363.	0.	0.	0.	0.	0.	0.	0.	6.	6300.
13	1727.	0.	279.	3.	0.	250.	29.	0.	22.	6300.
14	444.	0.	91.	3.	0.	61.	29.	9.	9.	6300.
15	0.	0.	0.	0.	0.	0.	0.	0.	0.	6300.
16	0.	0.	0.	0.	0.	0.	0.	0.	0.	6300.
17	0.	0.	0.	0.	0.	0.	0.	0.	0.	6300.
18	0.	0.	0.	0.	0.	0.	0.	0.	0.	6300.
19	0.	0.	0.	0.	0.	0.	0.	0.	0.	6300.
20	0.	0.	0.	0.	0.	0.	0.	0.	0.	6300.
21	0.	0.	0.	0.	0.	0.	0.	0.	0.	6300.
22	0.	0.	0.	0.	0.	0.	0.	0.	0.	6300.
23	0.	0.	0.	0.	0.	0.	0.	0.	0.	6300.
24	0.	0.	0.	0.	0.	0.	0.	0.	0.	6300.
25	0.	0.	0.	0.	0.	0.	0.	0.	0.	6300.
26	0.	0.	0.	0.	0.	0.	0.	0.	0.	6300.
27	0.	0.	0.	0.	0.	0.	0.	0.	0.	6300.
28	0.	0.	0.	0.	0.	0.	0.	0.	0.	6300.
29	0.	0.	0.	0.	0.	0.	0.	0.	0.	6300.
30	0.	0.	0.	0.	0.	0.	0.	0.	0.	6300.
	25392.	0.	24965.			23751.	1217.		961.	



MONTHLY PERFORMANCE SUMMARY PLOT - JUNE 1985

FIGURE 1

TABLE III. DAILY PERFORMANCE TABLE - JUNE 8, 1985

COLLECTOR FIELD AREA = 6300. [SQ-FT]
COLLECTOR REFLECTANCE =53.5%

HR	AMBIENT TEMP. DEG F	WIND SPEED MPH	INCIDENT SOLAR RAD: ON A HORIZ. SURFACE (1) BTU/SF	INCIDENT SOLAR RAD: IN THE COLLECTOR PLANE (2) BTU/SF	COLLECTOR ARRAY FLOW RATE GPM	COLLECTOR ARRAY TEMPERATURE: INLET DEG F	COLLECTOR ARRAY TEMPERATURE: OUTLET DEG F	ENERGY COLLECTED KBTU	COLLECTOR ARRAY EFFIC. BASED ON (1) %	COLLECTOR ARRAY EFFIC. BASED ON (2) MEAS-CALC %		ENERGY DELIVERED KBTU	THERMAL LOSSES KBTU	PARASITIC ENERGY KBTU
1	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
2	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
3	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
4	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
5	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
6	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
7	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
8	80.1	1.4	23.	0.	0.0	89.7	92.7	0.0	0.0	0.0	0.0	0.	0.	0.
9	81.8	1.1	71.	0.	0.0	94.1	92.9	0.0	0.0	0.0	0.0	0.	0.	0.
10	85.7	1.2	143.	0.	27.9	101.0	98.9	60.3	6.7	0.0	0.0	44.	17.	6.
11	88.7	2.9	208.	0.	75.4	159.1	169.1	369.8	28.2	0.0	0.0	338.	31.	14.
12	91.9	3.1	257.	0.	75.5	184.3	197.3	478.7	29.6	0.0	0.0	456.	23.	14.
13	93.3	5.7	293.	0.	75.4	189.6	203.3	500.9	27.1	0.0	0.0	480.	21.	14.
14	95.7	4.9	312.	0.	75.5	189.1	202.9	503.8	25.6	0.0	0.0	483.	20.	14.
15	97.7	4.8	316.	0.	75.4	188.4	201.8	489.2	24.6	0.0	0.0	470.	20.	14.
16	99.6	3.9	287.	0.	75.5	188.9	202.0	482.4	26.7	0.0	0.0	464.	18.	14.
17	100.0	4.3	237.	0.	75.5	190.0	203.3	488.2	32.6	0.0	0.0	468.	21.	14.
18	98.5	5.9	174.	0.	75.5	186.2	198.9	465.0	42.5	0.0	0.0	450.	15.	14.
19	97.7	6.0	109.	0.	75.6	171.3	181.6	380.1	55.3	0.0	0.0	378.	2.	14.
20	96.4	4.8	43.	0.	12.3	139.7	145.3	36.1	13.2	0.0	0.0	42.	-5.	3.
21	94.5	3.0	5.	0.	0.0	128.9	136.6	0.0	0.0	0.0	0.0	0.	0.	0.
22	91.5	7.4	0.	0.	0.0	119.0	127.2	0.0	0.0	0.0	0.0	0.	0.	0.
23	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
24	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
TOT			2479.	0.				4254.5				4072.	183.	136.

DAILY COLLECTOR ARRAY EFFICIENCY BASED ON (1) 27.2%
DAILY COLLECTOR ARRAY EFFICIENCY BASED ON (2) 0.0%
DAILY SYSTEM THERMAL EFFICIENCY BASED ON (1) 26.1%
DAILY SYSTEM THERMAL EFFICIENCY BASED ON (2) 0.0%

CLEAR DAY PERFORMANCE GRAPH

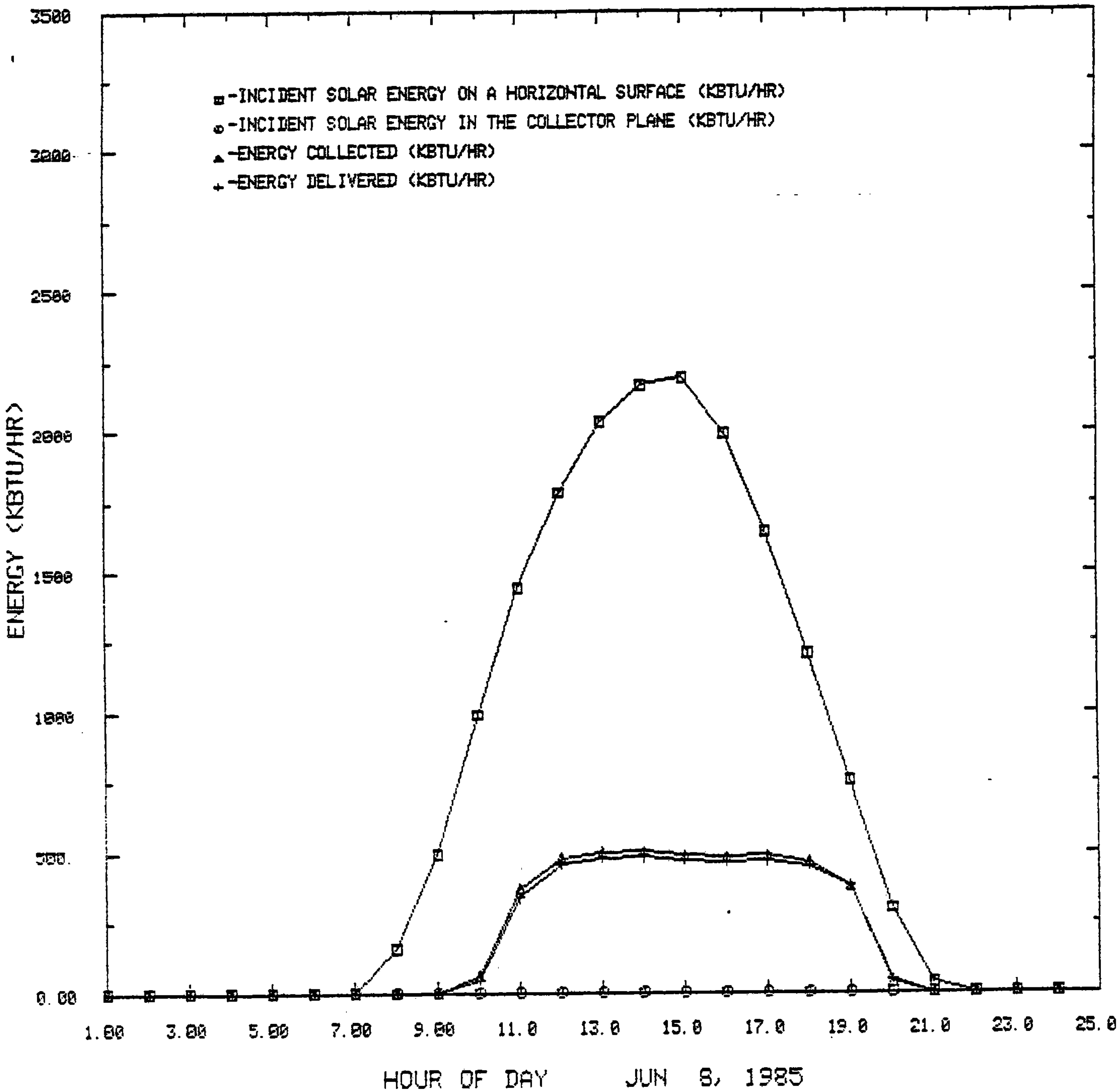


FIGURE 2

MONTHLY REPORT #20

REPORT PERIOD:	June 15, 1985 through July 19, 1985
REPORT NO.:	LS-20
DOE CONTRACT NO.:	DE-AC04-78CS32198
CONTRACT TITLE:	Solar Production of Industrial Process Steam for the Lone Star Brewery
CONTRACTOR:	Southwest Research Institute P. O. Drawer 28510 San Antonio, TX 78284 Contact: D. Deffenbaugh, (512) 684-5111, Ext. 2384
PROJECT SITE:	Lone Star Brewery 600 Lone Star Blvd. San Antonio, TX 78204

II. Project Description

Application	Preheat boiler feed water.
Site:	29° 32' N Latitude, 98° 28' W Longitude Elevation = 794 ft.
Process Schedule:[7]	Average steam requirement is 50,000 lb/hr.
Auxiliary Fuel:	Natural gas; boiler efficiency = 70%.
Collectors:	9450 ft^2 of Solar Kinetics tracking, parabolic, T-700 collectors. Roof mounted: Horizontal with N-S axis of rotation; 15 rows at 90 ft per row; Packing factor = .46.
Fluid Type, Flow Rate:	Treated water flowing at a fixed rate of 75 gpm.
Design Energy Delivery:	1.9×10^9 Btu/yr.
Phase 1 Cost (Design):	$107,795
Phase 2 Cost (Construction):	$690,900

Description:

The solar system at the Lone Star Brewery provides solar heated makeup water for the deaerator that feeds the plant's boilers. By providing hot makeup water to the deaerator, the fossil fuel consumption is reduced through a decreased requirement for steam injection into the deaerator. Cool, treated makeup water is heated prior to injection into the deaerator as it flows through a solar heated shell-and-tube heat exchanger. Solar heating is provided by 15 rows of parabolic trough solar collectors that are plumbed in a parallel configuration. The solar collectors heat the treated water as it passes through the collectors. The hot water is cooled as it flows through the heat exchanger (to heat the makeup water) and is then pumped back to the collector field in a closed piping loop.

III. Operating Experience

The solar system was reactivated on July 9, 1985. Collector rows 4, 5, 6, 11, and 12 were not functional when the system was brought up. Solar Kinetics, Inc. personnel were on site on July 9, 1985 and repaired each of the malfunctioning rows by July 12, 1985. The process water flow rate was fairly low when the system was restarted so the strainers in the process water piping were flushed out. This did not increase the water flow rate. The strainers were flushed out several times between July 9 and July 18 when the strainers were finally disassembled and cleaned. This allowed the process water flow rate to increase and eliminated the solar system defocusing that occurs when the process water is heated above 200°F.

There were a number of problems encountered with the Data Acquisition System (DAS) during July. From July 9 through July 25 the data system experienced several failures. Each time the data system was restarted it would appear to be functioning properly, but for some unknown reason would later fail. A replacement datalogger was installed on July 25 and no further problems were encountered.

The list on the following page summarizes the service work performed by Solar Kinetics, Inc. personnel during July. Not all of the component part replacements listed represent a part failure since more than one part may have been replaced before the failed part was located.

IV. System Performance

A. Monthly Summary

Tables I and II and Figure 1 summarize the solar system performance during July. Table I shows that all of the collector drive rows were operational from July 12 through the end of the month. Problems with the data system caused loss of performance data on July 9, 15, 16, 17, and 19 through 25. After the datalogger was replaced on July 26 there were no more problems with the data system. The collector plane radiation values shown in Table II from July 10 through July 15 are not correct since the tracker head on the row with the solar instrumentation was not properly focused on the sun. The incorrect values of solar radiation result in incorrect calculations of collector and system efficiencies.

B. Clear Day Performance

The solar system performance for July 27 is presented in Table III and Figure 2. The daily total energy collected and energy delivered were 7.0 and 6.8 MBTUs. The low collector array efficiency of 38% is caused by the dirty collector reflectors that have a measured reflectance of approximately 55% (new and clean reflectance is 85%).

MAINTENANCE SUMMARY - July 1985

Row 4	Replaced blown fuse (6-1/4 amp)	7-9-85
	D.C. motor replaced (water in box)	7-9-85
	Replaced motor control board and search mode board as a reference row with new parts (nothing wrong with existing boards)	7-9,10-85
	Replaced East limit switch	7-13-85
	Replaced West unit switch	7-15-85
Row 5	Replaced D.C. motor control board	7-10-85
Row 6	Replaced D.C. motor control board	7-10-85
Row 7	Replaced D.C. motor control board	7-16-85
Row 11	Replaced D.C. motor control board	7-10-85
	West limit switch switch replaced	7-11-85
	Replaced D.C. motor	7-11-85
	Replaced search mode board	7-11-85
	Replaced D.C. motor control board	7-12-85
	Replaced search mode board	7-15-85
Row 12	Replaced search mode board	7-12-85
	Replaced West limit switch	7-12-85
Row 13	Replaced East and West limit switches	7-15-85
Row 15	Replaced East limit switch	7-16-85

TABLE I. LONE STAR BREWERY - SYSTEM OPERATION SUMMARY TABLE
July 1985

Date	Status Code	Solar System Availability %	Weather Code	Remarks
7/9	7	67		System reactivated, Row 4, 5, 6, 11, 2 down
7/10	1	87	P	Row 4, 5 and 6 repaired
7/11	1	87	P	
7/12	1	100	F	Row 11 and 12 repaired
7/13	1	100	P	
7/14	1	100	P	
7/15	1	100	P	Row 15 focus adjusted
7/16	7	100		
7/17	1	100	P	
7/18	1	100	F	
7/19	7	100		
7/20	7	100		
7/21	7	100		
7/22	7	100		
7/23	7	100		
7/24	7	100		
7/25	1	100	P	Replacement Datalogger installed
7/26	1	100	F	
7/27	1	100	F	
7/28	1	100	F	
7/29	1	100	F	
7/30	1	100	P	
7/31	1	100	P	

Codes:

F - Fair
P - Partly Cloudy
C - Fog or Overcast
R - Rain

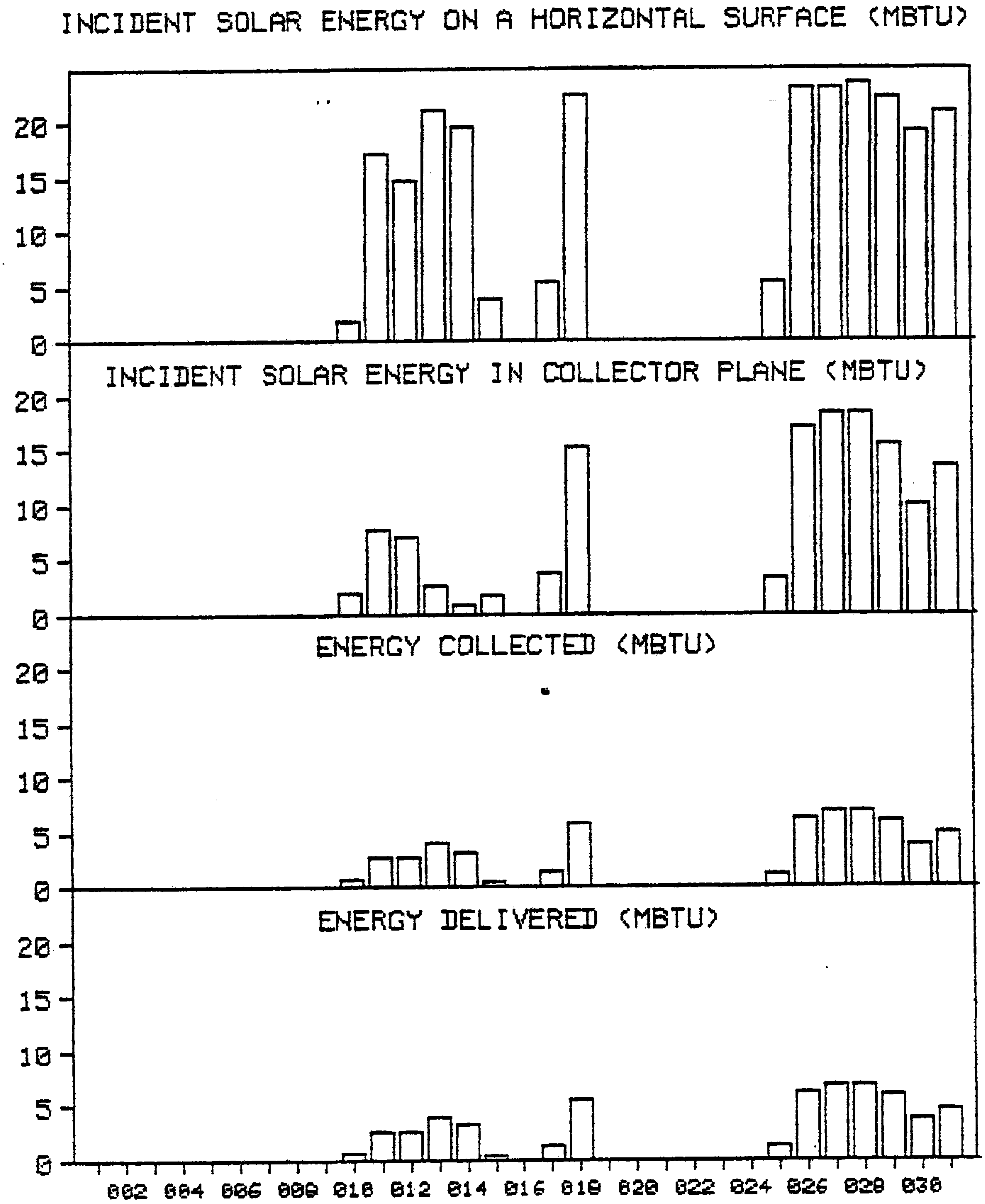
Solar Status Codes:

1 Normal operation
2 Solar system down
3. Solar system not turned on
4. Energy collected but not delivered to the process
5. Solar system and plant both down
6. Plant down, solar system idle
7. Solar system and plant both operational but DAS down

REMARKS: Solar system availability is computed from the sum of each row's availability (availability = 1 if row is available all day, availability = .5 if row is available for half of the day) divided by the total number of rows (15 rows).

TABLE II. LONESTAR BREWERY MONTHLY PERFORMANCE SUMMARY TABLE - JULY 1985

	INCIDENT SOLAR ENERGY			COLLECTOR ARRAY EFF.						
DATE	HORIZONTAL SURFACE (1) BTU/SFT	COLLECTOR PLANE (2) BTU/SFT	ENERGY COLLECTED KBTU	BASED ON (1) %	BASED ON (2) %	ENERGY DELIVERED KBTU	THERMAL LOSSES KBTU	SYSTEM THERMAL EFFIC. %	PARASITIC ENERGY USED KBTU	ACTIVE COLLECTOR AREA SFT
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
2	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
3	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
4	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
5	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
6	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
7	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
8	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
9	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
10	193.	197.	636.	35.	34.	628.	9.	34.	14.	9450.
11	1803.	800.	2593.	15.	34.	2572.	21.	34.	196.	9450.
12	1555.	729.	2679.	18.	39.	2639.	41.	38.	198.	9450.
13	2228.	266.	3948.	19.	**	3886.	63.	**	203.	9450.
14	2068.	71.	3187.	16.	**	3163.	25.	**	200.	9450.
15	394.	168.	402.	11.	25.	362.	39.	23.	57.	9450.
16	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
17	561.	380.	1304.	25.	36.	1263.	42.	35.	29.	9450.
18	2383.	1616.	5777.	26.	38.	5549.	229.	36.	130.	9450.
19	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
20	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
21	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
22	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
23	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
24	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
25	554.	345.	1203.	23.	37.	1190.	13.	37.	28.	9450.
26	2440.	1792.	6266.	27.	37.	6092.	175.	36.	122.	9450.
27	2441.	1945.	6982.	30.	38.	6808.	175.	37.	123.	9450.
28	2493.	1941.	6917.	29.	38.	6721.	197.	37.	123.	9450.
29	2343.	1640.	6008.	27.	39.	5842.	166.	38.	117.	9450.
30	2021.	1047.	3752.	20.	38.	3672.	80.	37.	102.	9450.
31	2204.	1412.	4800.	23.	36.	4662.	139.	35.	108.	9450.
	25681.	14349.	56454.			55048.	1413.		1750.	



MONTHLY PERFORMANCE SUMMARY PLOT - JULY 1985

FIGURE 1

TABLE III. DAILY PERFORMANCE TABLE JULY 27, 1985

DAILY PERFORMANCE TABLE JUL 27, 1985
COLLECTOR FIELD AREA = 9450. [SQ-FT]
COLLECTOR REFLECTANCE =53.5%

HR	AMBIENT TEMP. DEG F	WIND SPEED MPH	INCIDENT SOLAR RAD ON A HORIZ. SURFACE (1) BTU/SF	INCIDENT SOLAR RAD IN THE COLLECTOR PLANE (2) BTU/SF	COLLECTOR ARRAY FLOW RATE GPM	COLLECTOR ARRAY TEMPERATURE INLET DEG F	COLLECTOR ARRAY TEMPERATURE OUTLET DEG F	ENERGY COLLECTED KBTU	COLLECTOR ARRAY EFFIC. BASED ON (1) %	COLLECTOR ARRAY EFFIC. BASED ON (2) MEAS	COLLECTOR ARRAY EFFIC. BASED ON (2) CALC %	ENERGY DELIVERED KBTU	THERMAL LOSSES KBTU	PARASITIC ENERGY KBTU
1	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
2	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
3	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
4	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
5	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
6	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
7	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
8	75.9	2.9	15.	0.	0.0	87.2	81.9	0.0	0.0	0.0	0.0	0.	0.	0.
9	76.9	3.5	66.	0.	0.0	88.0	81.2	0.0	0.0	0.0	0.0	0.	0.	0.
10	79.5	3.5	139.	71.	55.1	113.2	118.6	282.0	21.5	42.1	28.8	254.	28.	10.
11	82.4	3.6	203.	196.	75.7	156.1	176.0	738.4	38.6	39.8	29.7	714.	25.	14.
12	86.3	4.0	256.	249.	75.7	167.2	190.6	862.1	35.6	36.7	30.6	841.	22.	14.
13	88.9	4.0	294.	261.	75.8	170.0	194.9	916.4	33.0	37.1	30.6	896.	21.	14.
14	91.8	4.3	311.	265.	75.8	171.8	197.3	938.3	31.9	37.4	30.6	917.	22.	14.
15	93.9	4.5	310.	261.	75.8	172.8	197.8	923.9	31.5	37.5	30.6	903.	21.	14.
16	95.6	4.5	273.	226.	75.8	165.0	188.0	848.9	33.0	39.7	30.8	841.	8.	14.
17	96.2	4.4	234.	219.	75.8	157.3	177.8	761.1	34.4	36.7	31.2	744.	17.	14.
18	96.5	4.4	179.	196.	70.7	158.4	178.4	710.4	41.9	38.3	31.0	699.	11.	13.
19	96.0	4.3	114.	0.	0.0	135.0	145.5	0.0	0.0	0.0	0.0	0.	0.	0.
20	94.1	4.2	40.	0.	0.0	127.3	135.7	0.0	0.0	0.0	0.0	0.	0.	0.
21	92.5	4.0	7.	0.	0.0	121.3	129.6	0.0	0.0	0.0	0.0	0.	0.	0.
22	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
23	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
24	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
TOT			2441.	1945.				6981.5				6808.	175.	123.

DAILY COLLECTOR ARRAY EFFICIENCY BASED ON (1) 30.3%
DAILY COLLECTOR ARRAY EFFICIENCY BASED ON (2) 38.0%
DAILY SYSTEM THERMAL EFFICIENCY BASED ON (1) 29.5%
DAILY SYSTEM THERMAL EFFICIENCY BASED ON (2) 37.0%

CLEAR DAY PERFORMANCE GRAPH

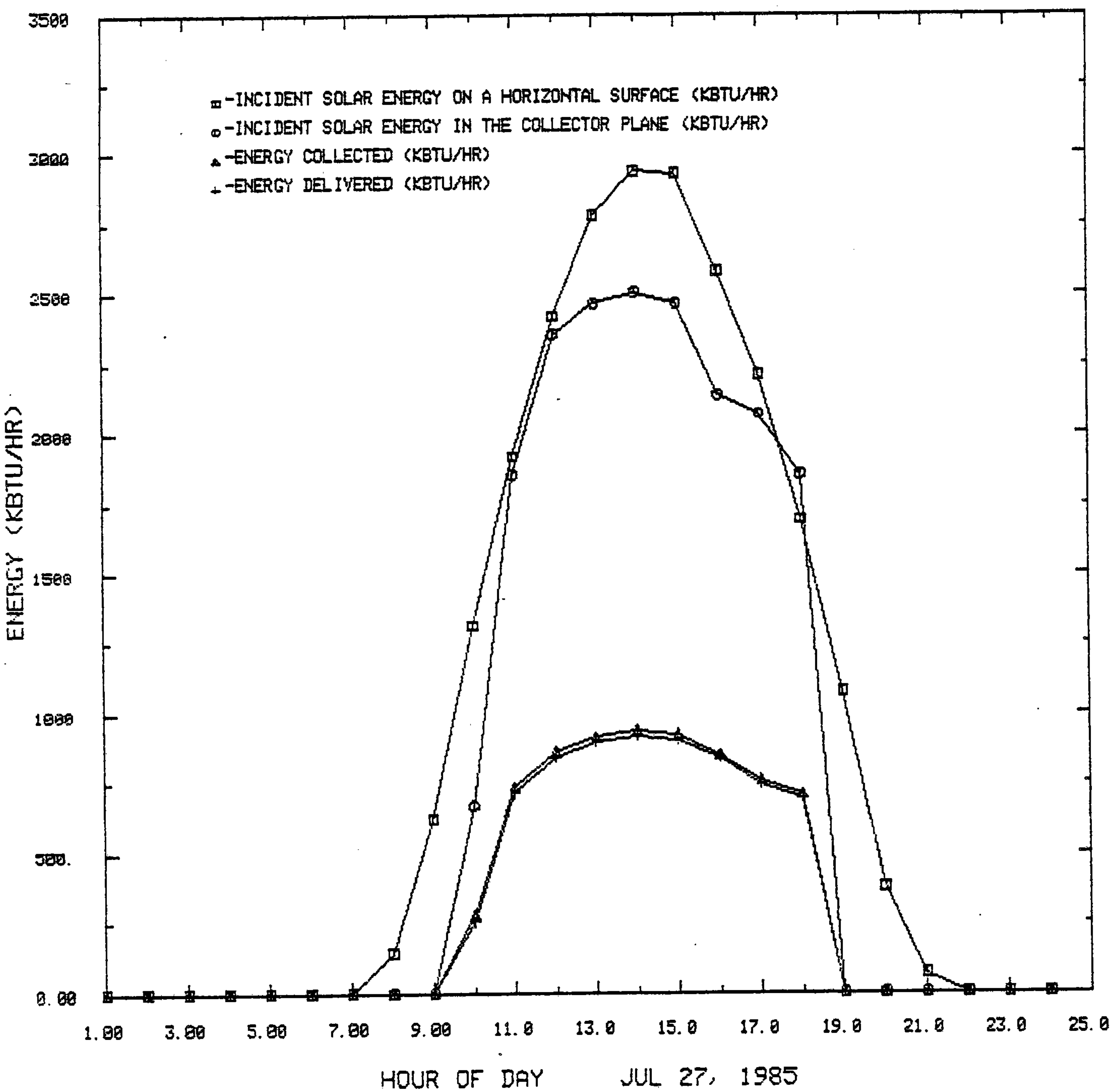


FIGURE 2

MONTHLY REPORT #21

REPORT PERIOD:	July 20, 1985 through August 16, 1985
REPORT NO.:	LS-21
DOE CONTRACT NO.:	DE-AC04-78CS32198
CONTRACT TITLE:	Solar Production of Industrial Process Steam for the Lone Star Brewery
CONTRACTOR:	Southwest Research Institute P. O. Drawer 28510 San Antonio, TX 78284 Contact: D. Deffenbaugh, (512) 684-5111, Ext. 2384
PROJECT SITE:	Lone Star Brewery 600 Lone Star Blvd. San Antonio, TX 78204

II. Project Description

Application	Preheat boiler feed water.
Site:	29° 32' N Latitude, 98° 28' W Longitude Elevation = 794 ft.
Process Schedule:?	Average steam requirement is 50,000 lb/hr.
Auxiliary Fuel:	Natural gas; boiler efficiency = 70%.
Collectors:	9450 ft^2 of Solar Kinetics tracking, parabolic, T-700 collectors. Roof mounted: Horizontal with N-S axis of rotation; 15 rows at 90 ft per row; Packing factor = .46.
Fluid Type, Flow Rate:	Treated water flowing at a fixed rate of 75 gpm.
Design Energy Delivery:	1.9×10^9 Btu/yr.
Phase 1 Cost (Design):	$107,795
Phase 2 Cost (Construction):	$690,900

Description:

The solar system at the Lone Star Brewery provides solar heated makeup water for the deaerator that feeds the plant's boilers. By providing hot makeup water to the deaerator, the fossil fuel consumption is reduced through a decreased requirement for steam injection into the deaerator. Cool, treated makeup water is heated prior to injection into the deaerator as it flows through a solar heated shell-and-tube heat exchanger. Solar heating is provided by 15 rows of parabolic trough solar collectors that are plumbed in a parallel configuration. The solar collectors heat the treated water as it passes through the collectors. The hot water is cooled as it flows through the heat exchanger (to heat the makeup water) and is then pumped back to the collector field in a closed piping loop.

III. Operating Experience

The solar system was operational from August 1 through August 13 when the data acquisition system was turned off. While the solar system was left on there were no performance data recorded. During the period from August 1 through August 7 a solar system operator was on site (Solar Kinetics, Inc. personnel).

The collector reflectance was measured on August 1, 1985 with a Devices & Services Company Portable Specular Reflectometer. The reflectometer measured an average reflectance of 49.8% (reflectometer acceptance angle set at 2.6 degrees). This low reflectance (reflectance of a new and clean reflector is 85%) is due to the dust and dirt buildup and a considerably higher reflectance could be obtained if the reflectors were washed.

On August 1 a temperature switch that is used to signal the central controller to defocus the collector field was adjusted from a setting of 200°F to 220°F to decrease the amount of time the collector field was out of focus and, therefore, increase the total energy collected.

IV. System Performance

A. Monthly Summary

The solar system performance for the period from August 1 through August 13 is presented in Table I and II and Figure 1. For the 12 full days of operational data the average daily energy collected was 5.78 MBTU, and the average daily energy delivered was 5.61 MBTUs. The average system thermal efficiency was 34%. The system efficiency shown in Table II for August 8 is considerably higher than the efficiencies for the other days. The reason for this is that collector row 15 (the row that has the solar radiation measuring instrumentation mounted on it) lost focus on the sun during the middle of the day. This caused the total collector plane radiation value shown in Table II to be lower than the actual value and, therefore, the efficiency of 41% is an incorrect value.

B. Clear Day Performance

The solar system performance for August 5, 1985 is summarized in Table III and Figure 2. On August 5 the solar system came up at 9:55 A.M. CDT and stowed at 6:05 P.M. CDT. The daily total energy collected was 6.66 MBTU and the daily total energy delivered as hot process water was 6.45 MBTU. At steady state the temperature of the collector fluid entering the collector array was about 173°F and the fluid was heated to about 197°F as it passed through the collector field. On the process water side of the heat exchanger the water entered at a temperature of 84°F and was heated to 167°F. The collector array efficiency based on the collector plane radiation was about 36% during this period. This low efficiency is due to the dirty collector reflectors and receiver tubes.

TABLE I. LONE STAR BREWERY - SYSTEM OPERATION SUMMARY TABLE
August 1985

Date	Status Code	Solar System Availability %	Weather Code	Remarks
8/1	1	100	F	Adjusted temperature switch in collector loop piping
8/2	1	100	F	
8/3	1	100	P	
8/4	1	100	P	
8/5	1	100	F	
8/6	1	100	F	
8/7	1	100	F	
8/8	1	100	F	
8/9	1	100	F	
8/10	1	100	P	
8/11	1	100	F	
8/12	1	100	P	
8/13	1	100	P	

Codes:

F - Fair
P - Partly Cloudy
C - Fog or Overcast
R - Rain

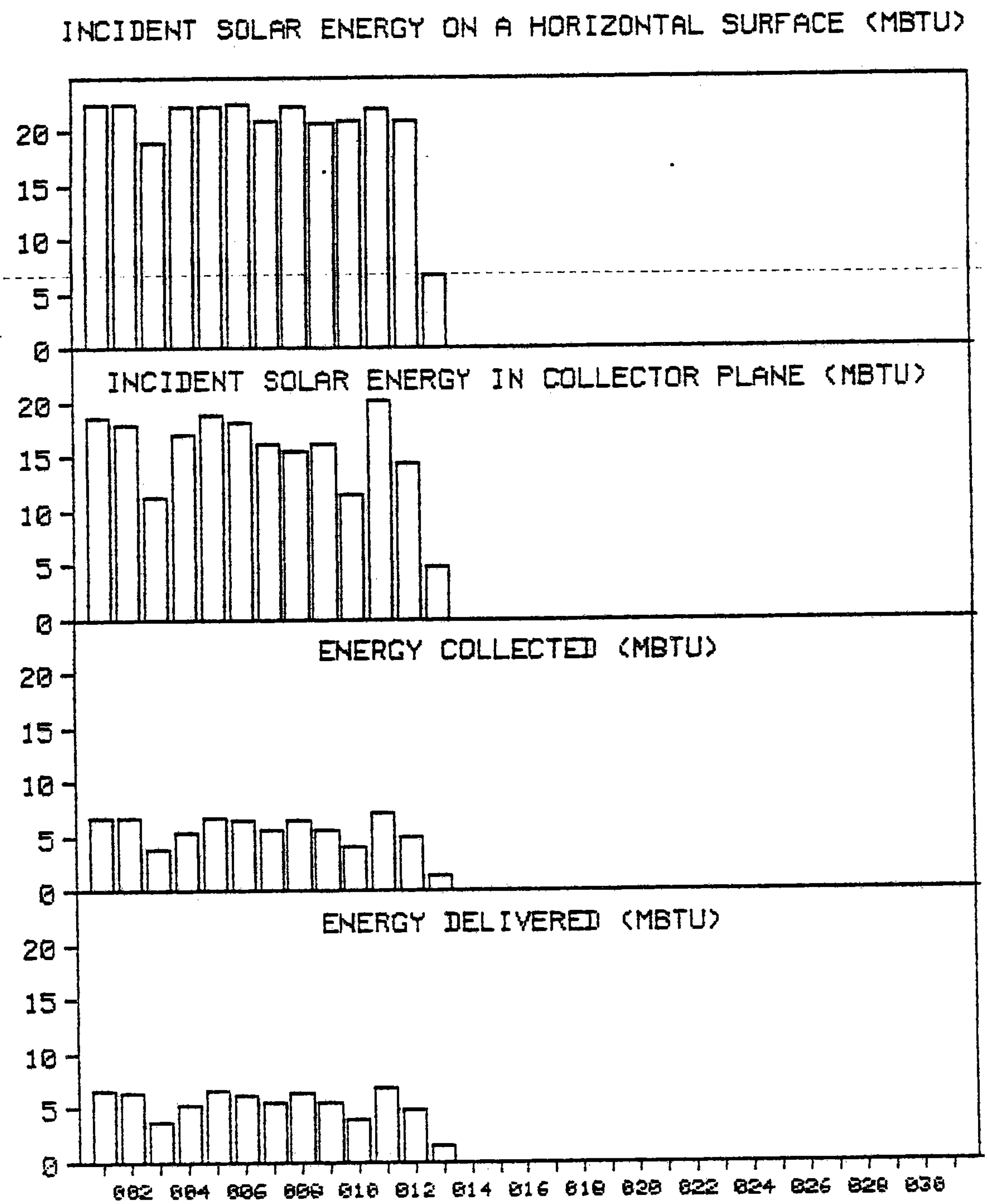
Solar Status Codes:

1 Normal operation
2 Solar system down
3. Solar system not turned on
4. Energy collected but not delivered to the process
5. Solar system and plant both down
6. Plant down, solar system idle
7. Solar system and plant both operational but DAS down

REMARKS: Solar system availability is computed from the sum of each row's availability (availability = 1 if row is available all day, availability = .5 if row is available for half of the day) divided by the total number of rows (15 rows).

TABLE II. LONESTAR BREWERY MONTHLY PERFORMANCE SUMMARY TABLE - AUGUST 1985

DATE	INCIDENT SOLAR ENERGY HORIZONTAL SURFACE (1) BTU/SFT	INCIDENT SOLAR ENERGY COLLECTOR PLANE (2) BTU/SFT	ENERGY COLLECTED KBTU	COLLECTOR ARRAY EFF. BASED ON (1) %	COLLECTOR ARRAY EFF. BASED ON (2) %	ENERGY DELIVERED KBTU	THERMAL LOSSES KBTU	SYSTEM THERMAL EFFIC. %	PARASITIC ENERGY USED KBTU	ACTIVE COLLECTOR AREA SFT
1	2370.	1967.	6706.	30.	36.	6491.	217.	35.	115.	9450.
2	2381.	1882.	6618.	29.	37.	6414.	205.	36.	125.	9450.
3	1992.	1194.	3716.	20.	33.	3603.	114.	32.	94.	9450.
4	2354.	1797.	5395.	24.	32.	5268.	128.	31.	123.	9450.
5	2362.	1989.	6658.	30.	35.	6455.	204.	34.	116.	9450.
6	2365.	1913.	6375.	29.	35.	6177.	198.	34.	107.	9450.
7	2209.	1702.	5627.	27.	35.	5464.	163.	34.	101.	9450.
8	2361.	1631.	6525.	29.	42.	6354.	172.	41.	119.	9450.
9	2187.	1711.	5642.	27.	35.	5478.	164.	34.	102.	9450.
10	2209.	1209.	4079.	20.	36.	3934.	145.	34.	111.	9450.
11	2326.	2120.	7043.	32.	35.	6828.	216.	34.	117.	9450.
12	2207.	1511.	4991.	24.	35.	4855.	137.	34.	109.	9450.
13	715.	496.	1434.	21.	31.	1366.	68.	29.	40.	9450.
14	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
15	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
16	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
17	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
18	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
19	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
20	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
21	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
22	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
23	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
24	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
25	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
26	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
27	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
28	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
29	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
30	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
31	0.	0.	0.	0.	0.	0.	0.	0.	0.	9450.
	28038.	21121.	70809.			68687.	2132.		1377.	



MONTHLY PERFORMANCE SUMMARY-AUGUST 1985

FIGURE 1

TABLE III. CLEAR DAY SOLAR SYSTEM PERFORMANCE SUMMARY TABLE FOR AUGUST 5, 1985

DAILY PERFORMANCE TABLE AUG 5, 1985
COLLECTOR FIELD AREA = 9450. [SQ-FT]
COLLECTOR REFLECTANCE =53.5%

HR	AMBIENT TEMP. DEG F	WIND SPEED MPH	INCIDENT SOLAR RAD ON A HORIZ. SURFACE (1) BTU/SF	INCIDENT SOLAR RAD IN THE COLLECTOR PLANE (2) BTU/SF	COLLECTOR ARRAY FLOW RATE GPM	COLLECTOR ARRAY TEMPERATURE INLET DEG F	COLLECTOR ARRAY TEMPERATURE OUTLET DEG F	ENERGY COLLECTED KBTU	COLLECTOR ARRAY EFFIC. BASED ON (1) %	COLLECTOR ARRAY EFFIC. BASED ON (2) MEAS-CALC %		ENERGY DELIVERED KBTU	THERMAL LOSSES KBTU	PARASITIC ENERGY KBTU
1	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
2	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
3	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
4	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
5	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
6	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
7	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
8	75.6	0.7	18.	0.	0.0	85.9	82.0	0.0	0.0	0.0	0.0	0.	0.	0.
9	76.5	3.0	33.	0.	0.0	86.7	81.8	0.0	0.0	0.0	0.0	0.	0.	0.
10	78.5	4.5	112.	9.	6.9	87.9	82.5	0.0	0.0	0.0	33.1	7.	-7.	2.
11	82.1	4.8	198.	223.	75.4	148.4	164.3	588.7	31.5	28.0	31.2	540.	48.	14.
12	85.8	5.4	254.	236.	75.6	174.4	196.0	796.4	33.2	35.6	30.2	770.	27.	14.
13	89.3	6.0	291.	244.	75.7	175.3	197.8	829.2	30.1	36.0	30.2	806.	24.	14.
14	93.3	6.1	304.	262.	75.7	172.4	196.8	899.0	31.3	36.4	30.5	877.	22.	14.
15	95.5	6.2	308.	271.	75.7	170.3	196.2	953.3	32.7	37.2	30.7	934.	20.	14.
16	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
17	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
18	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
19	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
20	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
21	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
22	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
23	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
24	0.0	0.0	0.	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.
TOT			1519.	1245.				4066.5				3933.	134.	72.

DAILY COLLECTOR ARRAY EFFICIENCY BASED ON (1) 28.3%
DAILY COLLECTOR ARRAY EFFICIENCY BASED ON (2) 34.6%
DAILY SYSTEM THERMAL EFFICIENCY BASED ON (1) 27.4%
DAILY SYSTEM THERMAL EFFICIENCY BASED ON (2) 33.4%

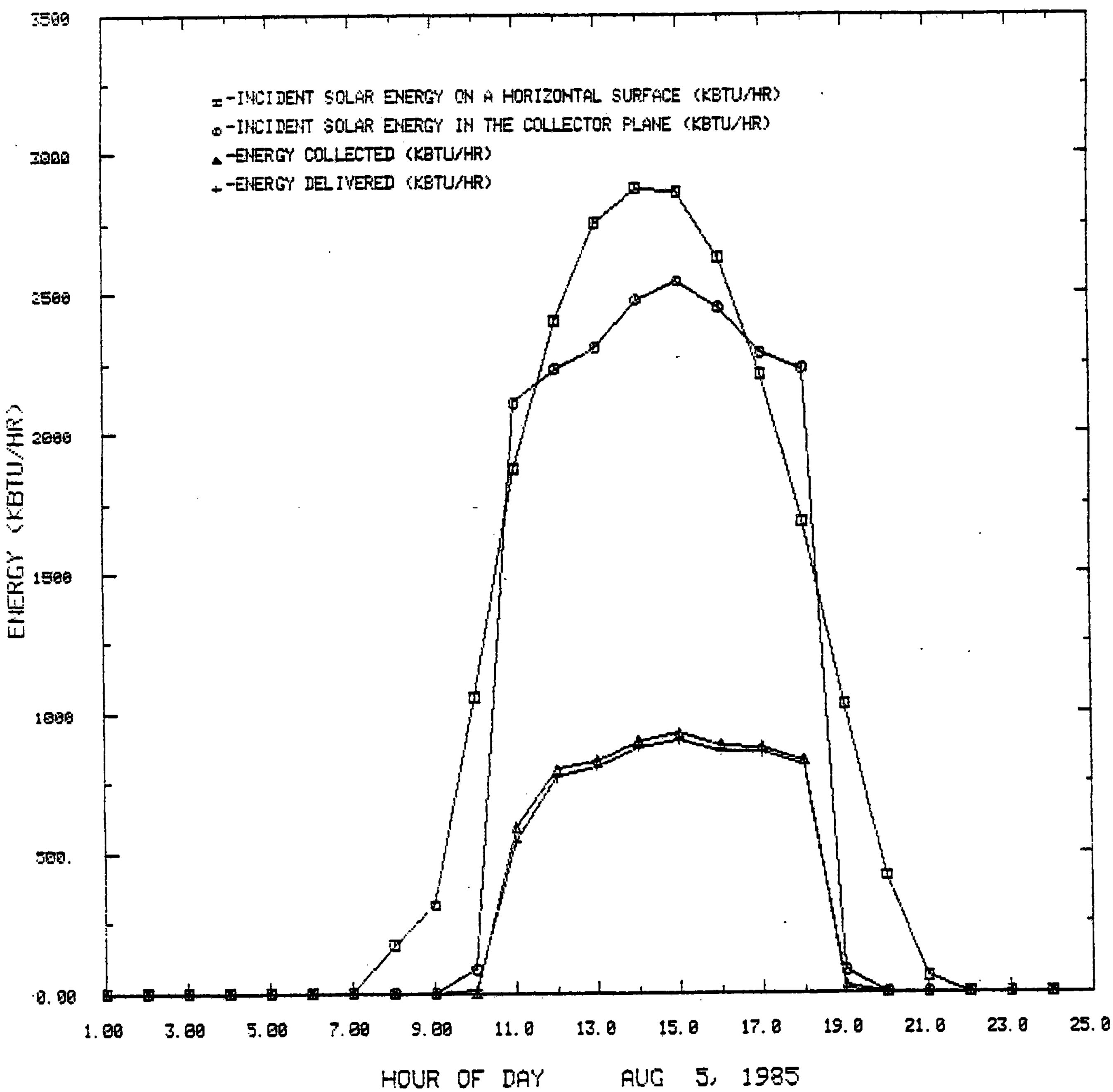


Figure 2. CLEAR DAY PERFORMANCE SUMMARY PLOT FOR AUGUST 5, 1985