

Solar Total Energy Project Construction Cost History

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Abstract

A solar energy project using parabolic dish collectors was designed, fabricated, and installed near Shenandoah, GA. A cost history of the construction of the Solar Total Energy Project is presented. Costs are broken down into the various project elements.

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Solar Total Energy Project Construction Cost History

Introduction

The Solar Total Energy Project (STEP) (Figure 1) located near Newnan, GA, about 35 miles southwest of Atlanta, is currently the largest solar total energy facility in the world.

Operated by Georgia Power Company for the US Department of Energy (DOE) under the technical direction of Sandia National Laboratories, Albuquerque, NM (SNLA), the STEP is capable of delivering simultaneously 400 kW of electrical energy, 627 kg/h (1380 lb/h) 175°C (347°F) saturated process steam, and 3250 MJ/h (257 tons) of 7°C (45°F) water for air conditioning. The electrical energy generated is supplied to a nearby knitwear factory (shown in Figure 1) and to the Georgia Power Company grid through the substation located in the northeast corner of the site. The thermal energy is delivered to the knitwear factory through underground pipes.

A field of 114, two-axis tracking 7-m (23-ft)-diameter paraboloidal collectors concentrate the solar energy on receiver coils where a silicone base oil is heated to 400°C (750°F). The collector field can provide more than 3 MW of thermal energy to the power conversion

system. The energy from the heat transfer fluid is transferred to steam, and the steam drives a turbine alternator to produce electricity. The exhausted steam is fed to the absorption chiller which cools water for air conditioning the factory. Steam is also directly provided to the factory for pressing fabric. Figure 2 shows a simplified schematic of the STEP.

The project began in 1976 as a major element of the DOE's Solar Thermal Program. The site was selected in April 1977 from an unrestricted, national, competitive solicitation. Design and component development started in May 1977 and was completed in March 1980. Construction started in December 1980 and was essentially completed in June 1982. Checkout and acceptance of the system was initiated in January and completed in August 1982.

This report documents and details the construction costs of the STEP. Major equipment items were provided as Government-Furnished Equipment (GFE) by SNLA.

These items are also identified as long-lead procurement in sections of this report.

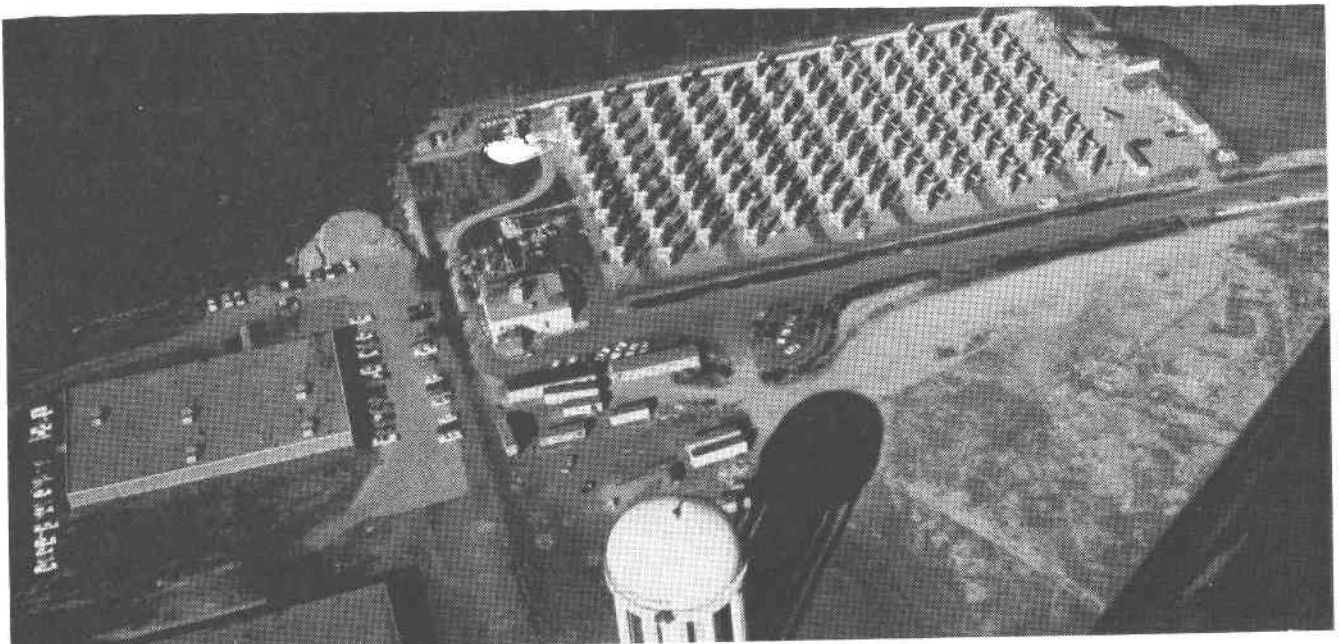


Figure 1. Solar Total Energy Project, Shenandoah, GA, March 1982

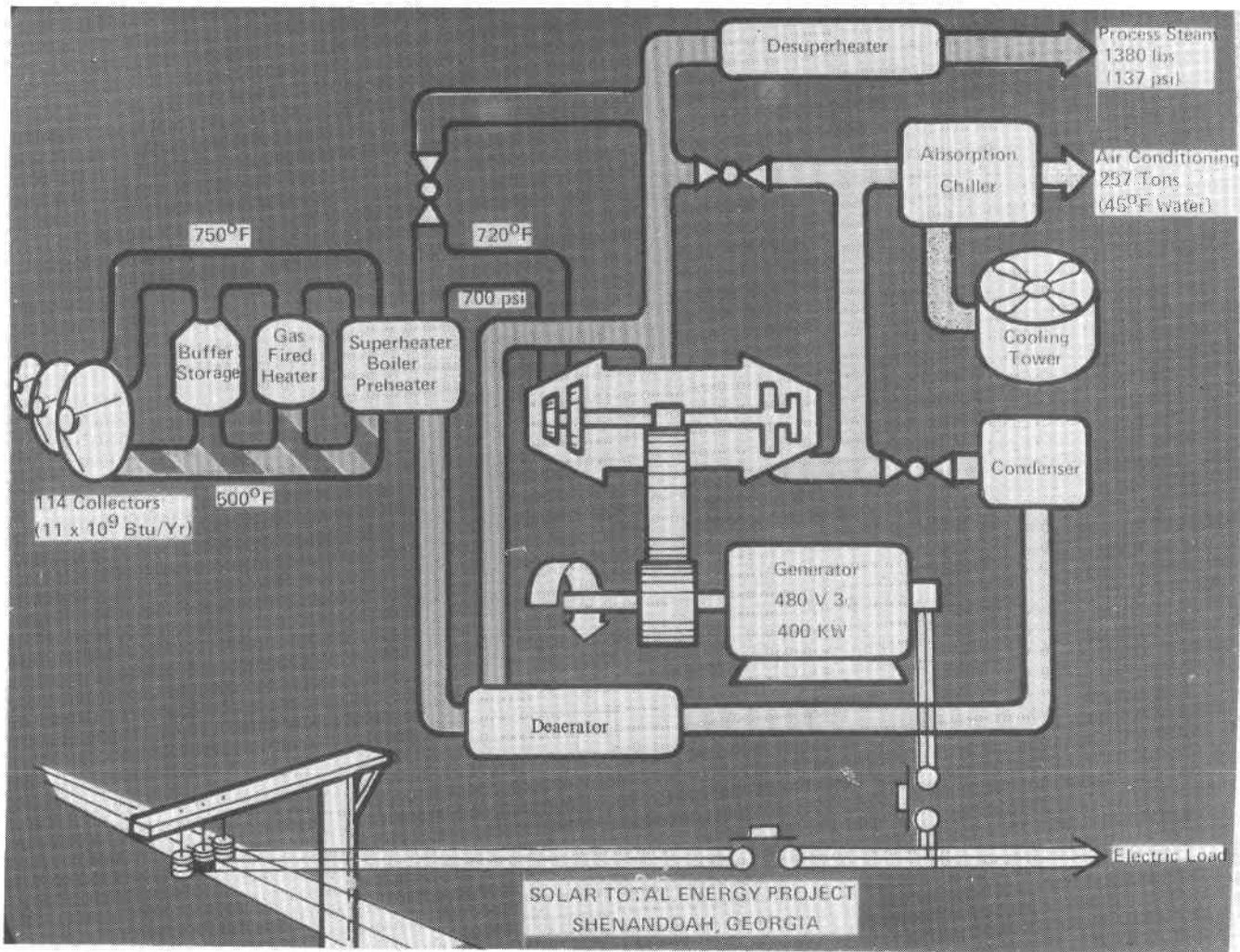


Figure 2. Simplified Schematic

Summary of Construction Costs

Figure 3 is a view looking northwest of the STEP site in 1978 shortly after the time of site selection. Figure 4 is an aerial view of the site following cut and fill to provide a collector field with 2% north and 1% east sloping grade.

Expenditures to construct the STEP were divided into seven main categories (contractors):

- Collector Field Construction (L. B. Samford, Inc)
- Building and Mechanical Area Construction (B&W Mechanical Contractors)

- Insulation (Joe North, Inc)
- Control and Instrumentation System (General Electric, Simulation and Controls Division)
- Collectors (Solar Kinetics, Inc)
- Long-Lead Procurement (GFE and various suppliers)
- Construction Inspection (Heery)

All contracts were fixed-price, competitively bid except the Control and Instrumentation Subsystem, which was a fixed-price, sole-source procurement. Figure 5 shows the percentage of costs encompassed in each of the seven categories identified above and costed in Table 1.

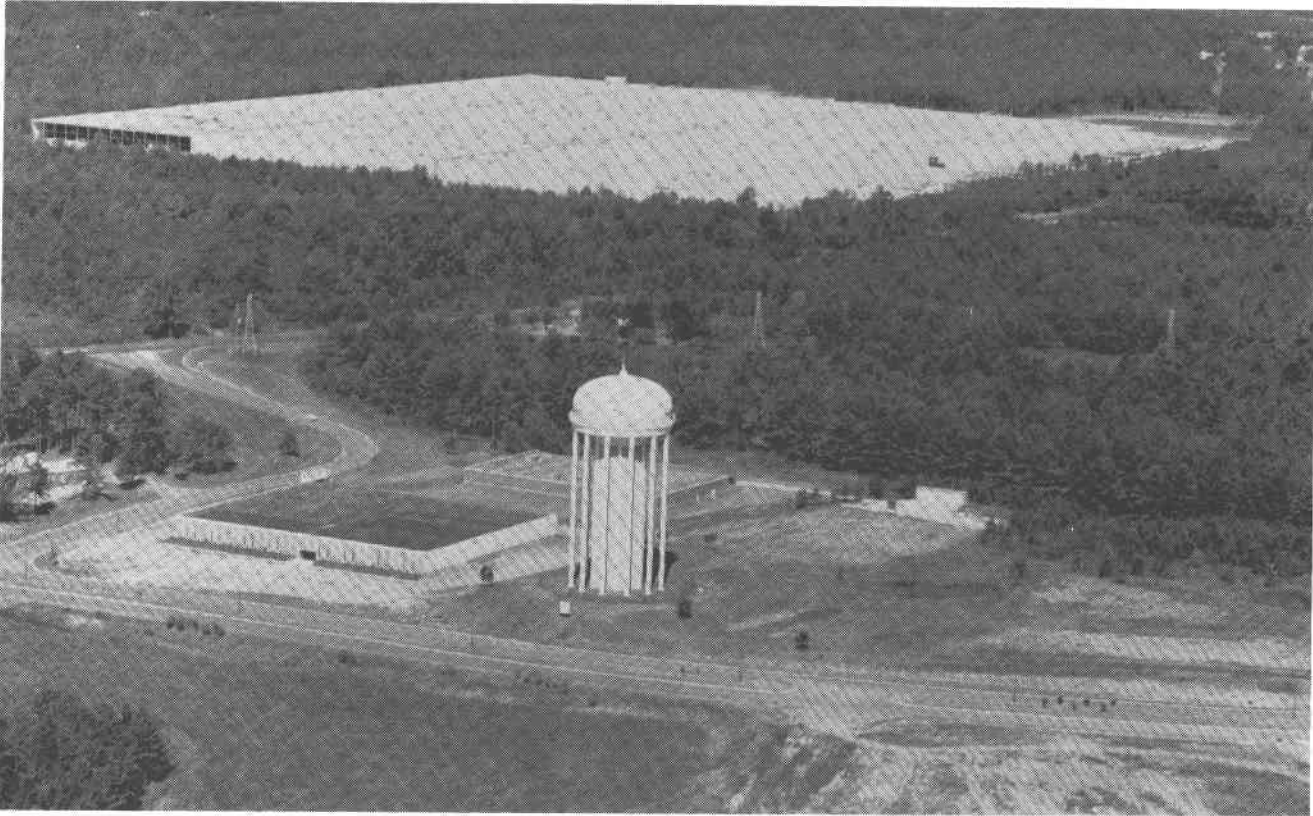


Figure 3. Site Prior to Construction, October 1978



Figure 4. Site Initial Preparation, March 1980

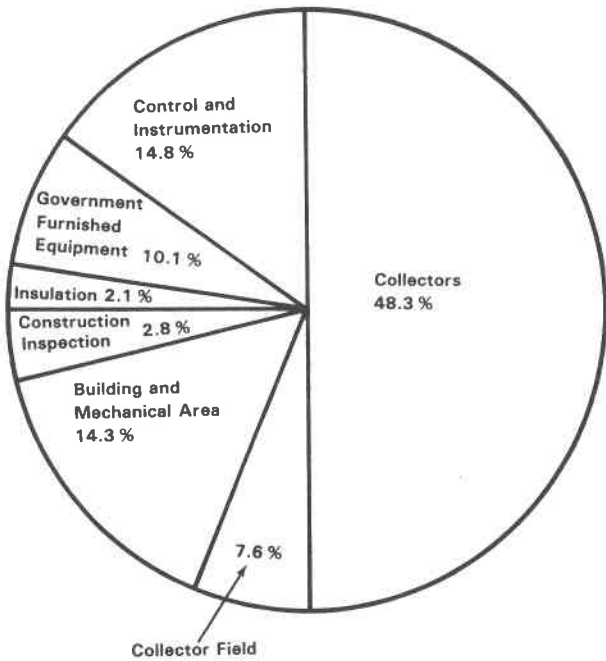


Figure 5. Construction Cost (\$12 030 000) Distribution for STEP

Table 1. Construction Costs

Item	Cost (\$Thousands)	% of Cost
Collectors	\$ 5 807	48.3
Collector Field	916*	7.6
Building and Mechanical Equipment Area	1 721	14.3
Control and Instrumentation	1 779	14.8
Government-Furnished Equipment	1 213†	10.1
Insulation	252	2.1
Construction Inspection	342	2.8
	<u>\$12 030</u>	<u>100.0</u>

*Includes \$100 000 for initial site grading

†Includes \$500 000 for MTI Turbine-Alternator

Collector Field Construction Costs

Figure 6 depicts the collector field under construction in April 1981. The collector foundations are in place, and placement of the stone paving is underway.



Figure 6. Collector Field Under Construction, April 1981

Figure 7 shows a view of the completed collector field. The white triangular collector base frames are a part of the collector procurement and are not costed in this section. The east-west local heat transfer fluid lines are visible as are the guides and anchors for the branch piping. Collector support frames are installed on several stations. The Building and Mechanical Area is seen in the foreground. Costs for the collector field construction are divided into seven categories. The total cost of \$916 000 is distributed as follows:

- Site work
- Collector foundations
- Electrical
- Instrumentation
- Piping
- Steel
- Miscellaneous

Figure 8 depicts the distribution of the costs by discipline excluding the collectors. Costs of each item are given in Table 2.

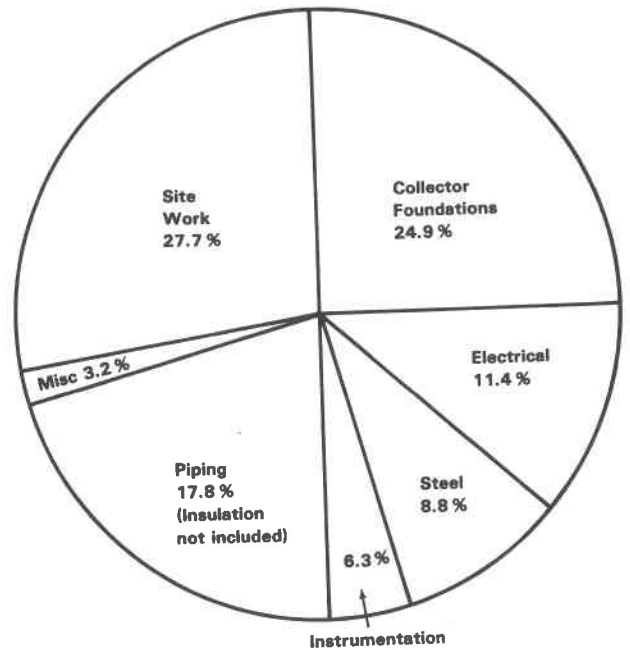


Figure 8. Construction Costs (\$916 000) for Collector Field

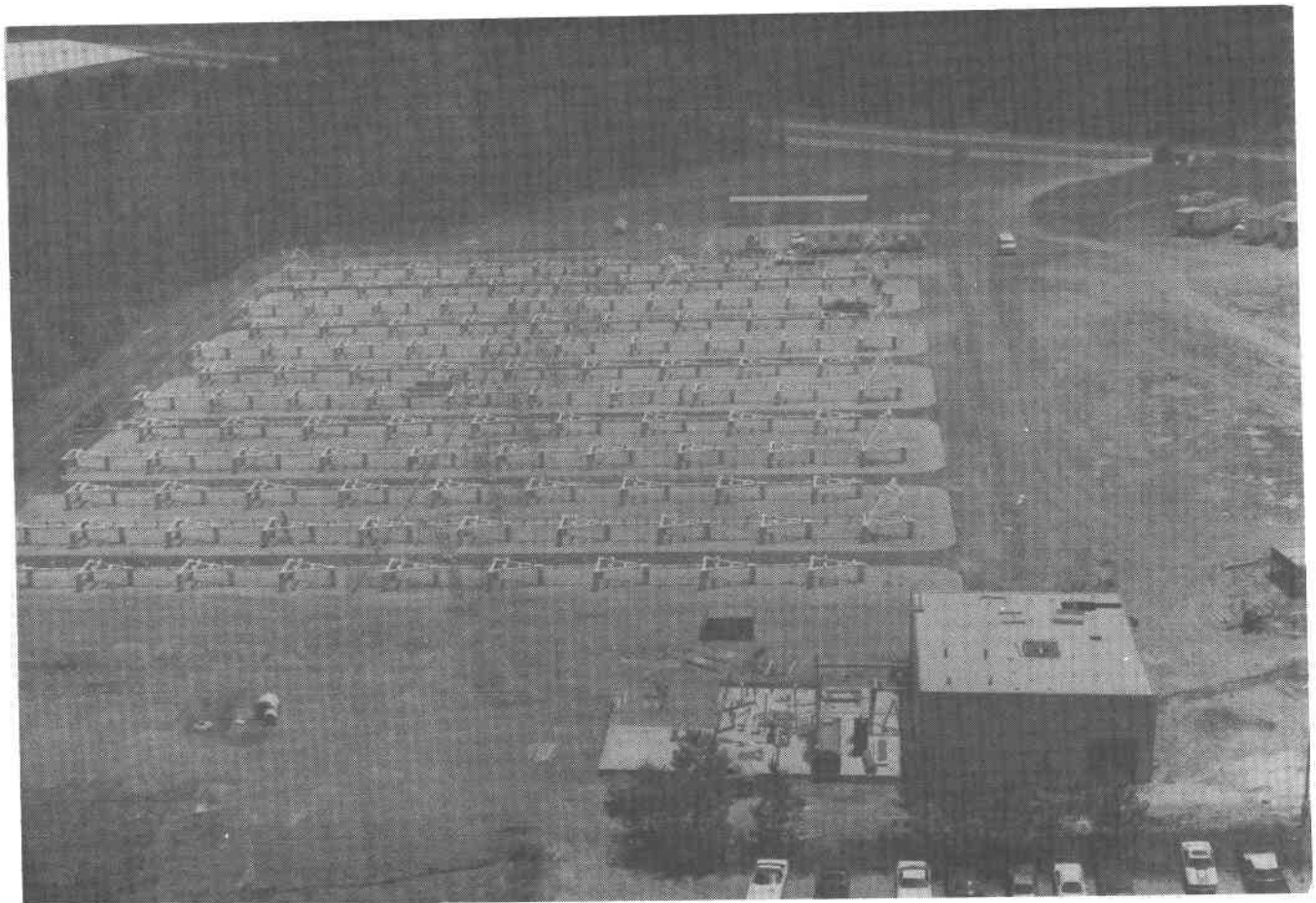


Figure 7. Collector Field June 1981 (Building and Mechanical Area in foreground)

Table 2. Collector Field Construction Costs

Item	Cost (\$Thousands)	% of Collector Field Costs
Collector foundations	228	24.9
Electrical	104	11.4
Instrumentation	58	6.3
Piping	163	17.8
Site preparation	253	27.7
Steel	81	8.8
Miscellaneous	29*	3.2
	<u>916</u>	<u>100.0</u>

*Includes service water system.

Building and Mechanical Area Construction Costs

Figure 9 shows the nearly completed Building and Mechanical Area (B and MA) in January 1982. The absorption chiller cooling tower is located in the foreground. Atop the building is the auxiliary water cooling unit, a small building housing the deaerator and the air-cooled steam condenser. The high-temperature storage tank is clearly visible. Figure 10 is a closer view of the mechanical area showing the heat transfer fluid piping in the process of being insulated. The Georgia Power Company substation is visible in the background.

Costs for the B and MA are divided into six categories:

- General construction
- Mechanical
- Insulation
- Instrumentation
- Electrical
- Equipment

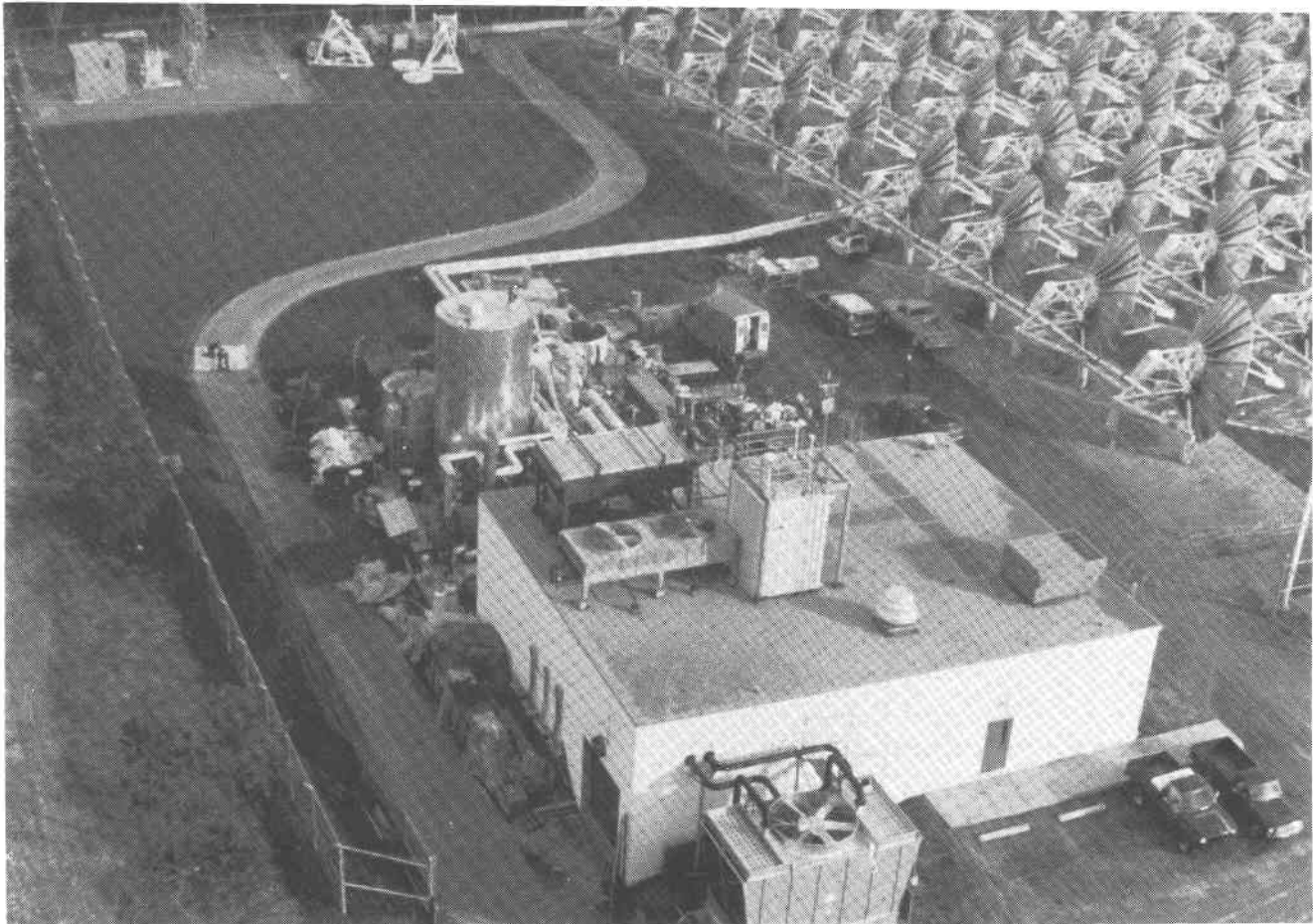


Figure 9. Building and Mechanical Area, February 1982

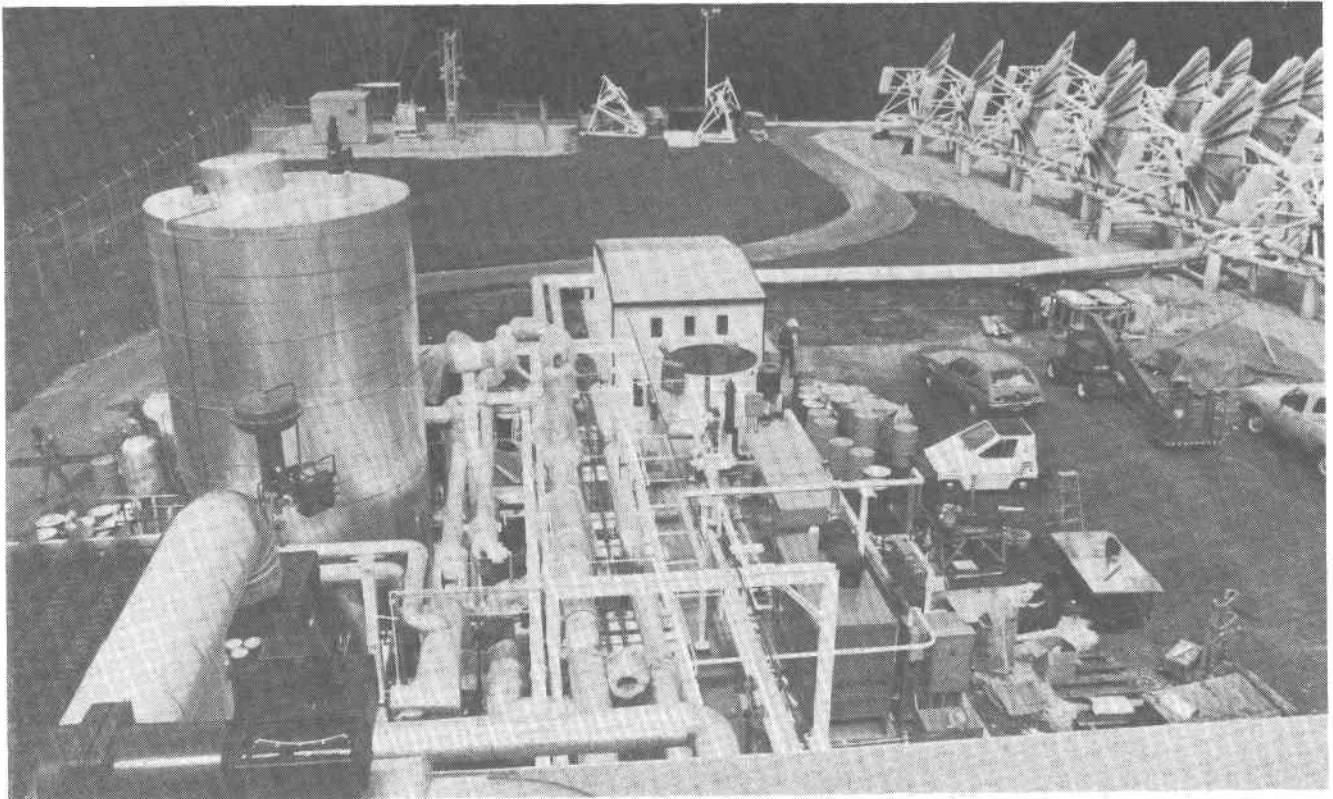
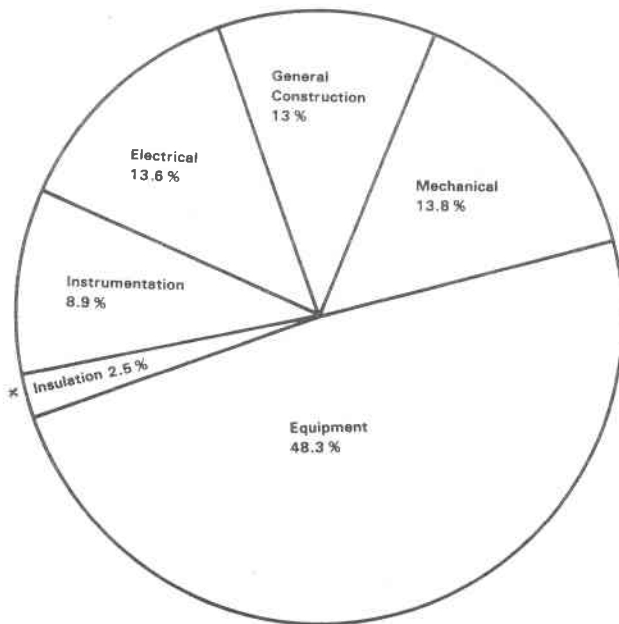


Figure 10. Mechanical Area, February 1982

Figure 11 shows the distribution of the B and MA costs listed in Table 3.



*Does not include heat transfer fluid piping insulation in the Mechanical Area.

Figure 11. Construction Costs (\$2 934 000) for Building and Mechanical Area

Table 3. Building and Mechanical Area Construction Costs

Item	Cost (\$Thousands)	% of B and MA Cost
General construction	380	13.0
Mechanical	404	13.8
Insulation	73	2.5
Instrumentation	261	8.9
Electrical	400	13.6
Equipment	1 416*	48.3
	2 934	100.0**

*Includes \$500 000 for MTI Turbine-Alternator

**Does not equal 100.0 because of rounding

Heat Transfer Fluid Pipe and Equipment Insulation Costs

Figures 7 and 10 show the piping in the collector field and the piping and equipment in the Mechanical Area.

Costs for insulating the heat transfer fluid pipes and equipment are illustrated in Figure 12. The insulation costs are broken down into four categories:

- Collector Field branch lines
- Collector Field feeder lines
- Mechanical Area equipment
- Mechanical Area pipes

These costs are listed in Table 4.

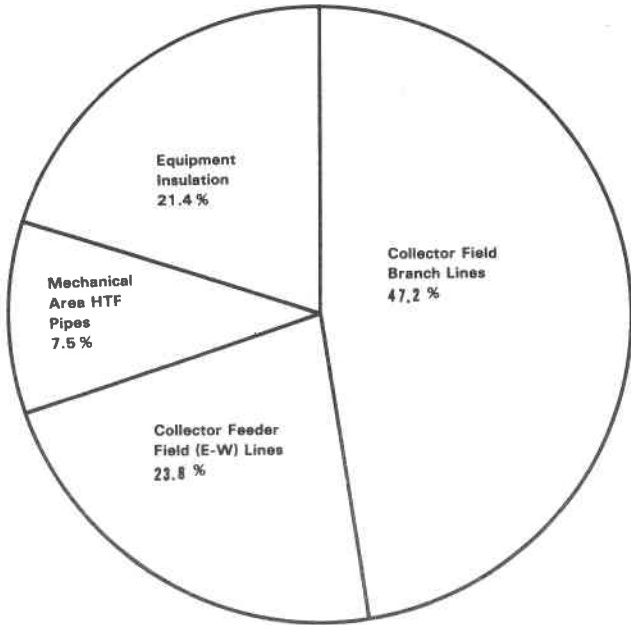


Figure 12. Construction Costs (\$252 000) for Insulation HTF Equipment and Pipe Lines

Table 4. Heat Transfer Fluid Piping and Equipment Insulation Costs

Item	Cost (\$Thousands)	% Insulation Costs
North-South Branches	119	47.2
East-West Mains	60	23.8
Equipment Area Pipes	19	7.5
Equipment in Mechanical Area	54	21.4
	252	100.0*

*Does not equal to 100.0 because of rounding.

Collector Costs

Figure 7 depicts the collector field nearing completion and readiness to accept the collectors. Figure 13 shows the east-west progression of collector assemblies across the field. The collector base frames (white triangular structures) are all in place. Many of the collector support frames are in place waiting the reflector assembly. White, polyolefin, strippable masking is seen on all the assembled reflectors except for one reflector in the eastern sector. This film was removed when the field was activated as can be seen in Figure 1.

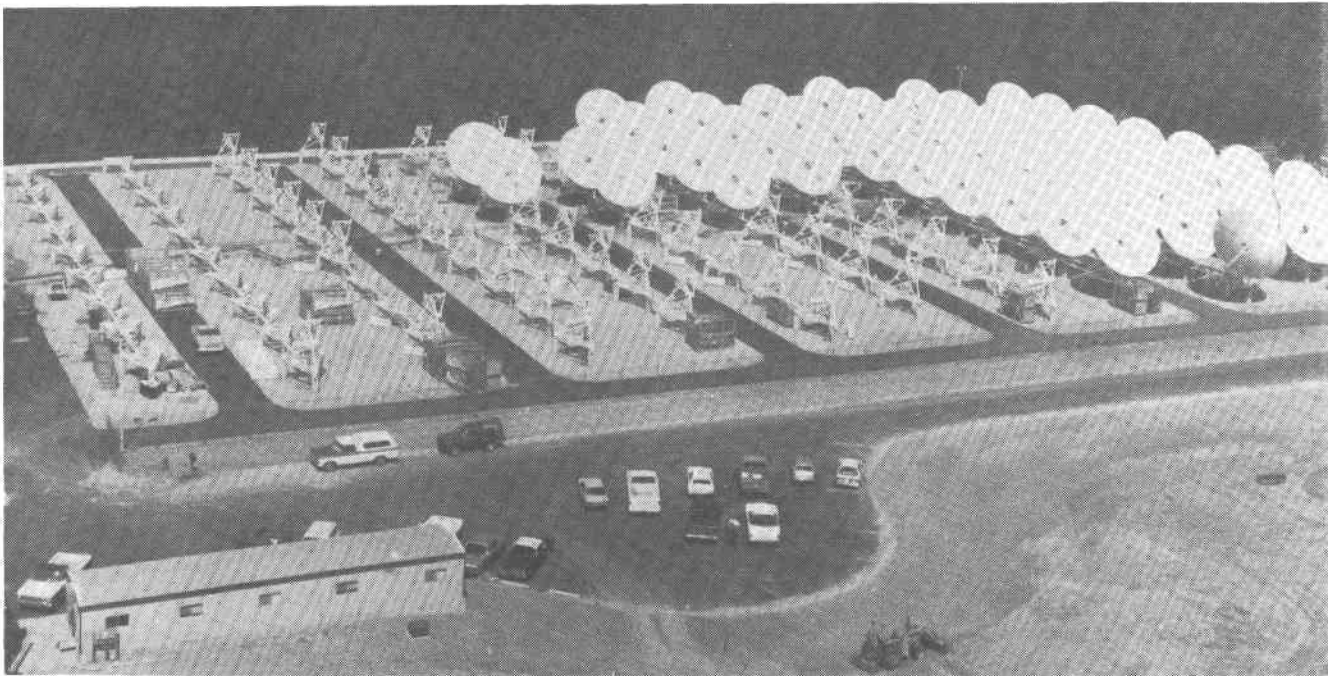


Figure 13. Collector Field With Assembled Collectors

The collectors for the STEP were purchased through a fixed-price, competitively bid procurement that included delivery and installation at STEP; delivery, installation, and testing of a production collector at SNLA; and provision of spare parts. Table 5 lists the costs by category for the collectors. The distribution is depicted by category in Figure 14.

Table 5. Collector Costs

Item	Cost (\$Thousands)	% of Cost
114 Base assemblies, installed	317	5.5
Test collector	320	5.5
114 Collectors installed	4 626	79.7
Spare parts/manuals	124	2.1
Subtotal	5 387	
Sandia-furnished aluminum with premask	420	7.2
	5 807	100.0

Control and Instrumentation Costs

The Control and Instrumentation System (CAIS) for STEP is shown in Figure 15. The control system consists of two control color CRT consoles, floppy discs on the table in the foreground, line printer; and in the background, located in three vertical racks, are the PDP-11/34 main computer, tape drive, and the microprocessor-based Buffer Control Unit (BCU), which monitors and commands the 114 collector control units. The Energy Utilization Processor is also mounted in the vertical rack with the BCU. Also shown in the picture (but not a part of the CAIS) is the uninterruptible power supply (right background) and the large grey switchgear and protective relay system for the electrical generation subsystem. The control units, one mounted at each collector, are defined as parts of the control system. The control system was procured as a sole-source procurement on a fixed-price contract.

Costs for the STEP Control and Instrumentation System have been apportioned as follows:

Collector control units	\$ 774 000
Control system	<u>\$1 005 000</u>
	\$1 779 000

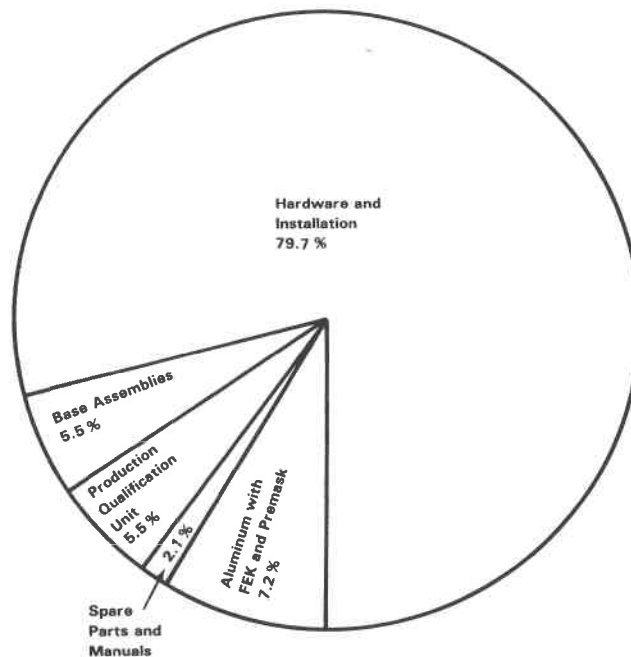


Figure 14. Collector Costs for STEP



Figure 15. Control Room

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