SOLAR/2018-78/60
DISTRIBUTION CATEGORY UC-59

Solar Project
Cost Report

REEDY CREEK UTILITIES CO., INC.
OFFICE BUILDING
Walt Disney World, Florida
July 11, 1978

U.S. Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

MASTER

SOLAR/2018-78/60
DISTRIBUTION CATEGORY UC-59
(MODIFIED)

SOLAR PROJECT

COST REPORT

for

REEDY CREEK UTILITIES CO., INC.

OFFICE BUILDING

WALT DISNEY WORLD, FLORIDA

Prepared for
DEPARTMENT OF ENERGY
OFFICE OF ASSISTANT SECRETARY
FOR CONSERVATION AND SOLAR APPLICATIONS
NATIONAL SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

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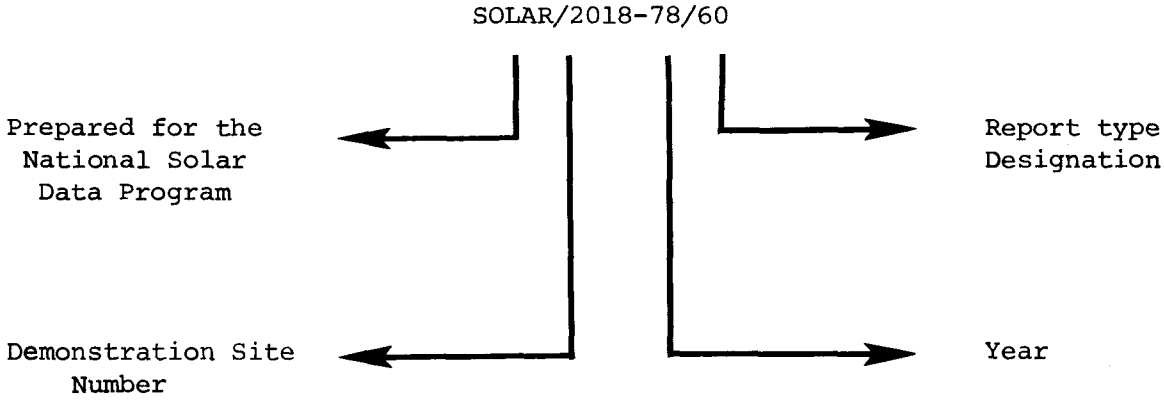
NATIONAL SOLAR DATA PROGRAM REPORTS

Reports prepared for the National Solar Data Program are numbered under a specific format. For example, this report for The Reedy Creek Utilities project site is designated as SOLAR/2018-78/60. The elements of this designation are explained in the following illustration:



- Demonstration Site Number:
  Each project site has its own discrete number - 1000 through 1999 for residential sites and 2000 through 2999 for commercial sites.
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  - o Solar Project Cost Reports are designed by the number 60

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I. FOREWORD

The National Program for Solar Heating and Cooling is being conducted by the Department of Energy as mandated by the Solar Heating and Cooling Demonstration Act of 1974. The overall goal of the Federal Demonstration Program is to assist in the establishment of a viable solar industry and to stimulate its growth. An analysis and synthesis of the information gathered through this program will be disseminated in site-specific reports and summary documents as part of the National Solar Data Program. This cost report is a component of a larger data gathering effort to determine the costs and cost factors to satisfy the data requirements of the following:

- DOE planning and management
- Economic projections and analysis
- The solar industry infrastracture

The focus of this report is the initial installation cost of the system. No design, start-up, operating or maintenance costs are provided nor are costs for the solar data acquisition system (SDAS) or display system that may be installed in conjunction with the solar system.

Associated reports prepared by others for this specific solar Demonstration Project describe the system in greater detail, provide reliability and maintenance information, and describe system performance.

A similar series of reports is being developed for other solar deomonstration program projects to assure widespread dissemination of project data. Detailed analysis of this report will require reference to the "Solar Project Description" for this project, report number SOLAR/2018-78/50.

II. EXECUTIVE SUMMARY

This report provides detailed cost information for the Reedy Creek Utilities solar space heating, cooling and service water heating project located in Walt Disney World, Florida.

This Demonstration Project was funded by the U.S. Energy Research and Development Administration (ERDA, now the U.S. Department of Energy, DOE) in the Program Opportunity Notice (PON) Cycle 1. The PON request was issued in the Autumn of 1975. Buena Vista Construction Company was the general contractor for the project construction.

The solar energy system cools, heats and supplies service hot water for approximately 5625 ft^2 of office space in a general office building. The system was designed as an integral part of the building at the time the building was designed. The 3840 ft^2 of collectors were manufactured by the AAI Corporation and serve as both the roof of the building and the solar collectors. For cooling, water is chilled by a 25 ton Arkla packaged water chiller. Chilled water is also stored in a 10,000 gallon tank from which it can be circulated to the central air handler for space cooling.

Solar heated water for use in space cooling, heating, and service water is stored in a separate 10,000 gallon hot water storage tank.

The construction costs of this solar project are presented in this report. Category costs are listed by materials, direct labor, and subcontract costs. The subcontract costs include both materials, labor, overhead and profit for electrical, control and other minor subcontractors. No further breakdown of these costs could be obtained. Most costs incurred by the mechanical subcontractor could be disaggregated into materials and labor and were reported accordingly. The installed cost of the system was $582,920 not including general contractor overhead and profit and general and administrative costs. Subsequent sections, especially Sections VI through VIII, provide a more detailed account of the data base and category cost components.

III. INTRODUCTION

The approach to assembling the data into solar system cost categories for every installation is to resolve the data into elements at two levels of detail, primary and secondary. Table III-1 provides an indication of the level of disaggregation associated with primary and secondary cost breakdowns.

TABLE III-1. SITE SPECIFIC COST BREAKDOWN

PRIMARY	SECONDARY
Collector Array	• Materials • Delivery • Mounting on Support Structure • Collectors Connecting to Manifold
Collector Support Structure	• Materials • Labor
Piping	• Collector Distribution System o Materials o Labor • Other Piping o Materials o Labor
Ductwork	• Collector Distribution System o Materials o Labor • Other Ductwork o Materials o Labor
Insulation	• Collector Distribution System o Materials o Labor • Other Piping/Ductwork o Materials o Labor
Heating/Cooling Equipment	• Materials • Delivery • Installation
Storage	• Materials • Delivery • Installation • Insulation
Controls	• Materials • Labor
Electrical Power	• Total
General Construction	• Roofing • Equipment Room • Architectural • Excavation • Painting

In general, the primary cost breakdown follows work categories typically performed by different trades or subcontractors on building systems construction projects and are often separable, identifiable costs. The secondary cost categories represent a more detailed breakdown of the primary categories and are more difficult to obtain. This information is sought through discussions with subcontractors and suppliers, and by reviewing their records.

The following are typical examples of components comprising the cost breakdown categories listed in Table III-1.

- Collector Array: all materials provied by collector manufacturer (including tracking mechanisms, attachment fittings, hoses), labor to install collectors on support structure, labor and materials to connect collectors to supply and return manifolds, and miscellaneous specialties required for a complete array.
- Collector Support Structure: all framing, beams and columns, roof connections, fasteners and brackets required to receive collectors.
- Piping: all collector distribution and major supply and return piping, external collector manifolds, if required, pumps, expansion tanks, valves, interconnecting piping, hangers, and miscellaneous piping specialties.
- Ductwork: all ductwork connecting collectors to air handling equipment, dampers, interconnection with auxiliary systems and filter boxes.
- Insulation: all insulation - both interior and exterior - for piping and ductwork, chillers, and miscellaneous equipment, except energy storage containers.
- Heating/Cooling Equipment: absorption chillers, heat pumps, air handling units or heat exchangers used to interface with auxiliary system or to deliver energy directly to load.

- Storage: vessel or container, lining, supports, pads, internal piping, nozzles, and insulation.
- Controls: solid state controllers, thermostats, alarms, switches, wiring and miscellaneous pneumatic or electrical devices.
- Electrical: normally an identifiable subcontract including power wiring, motor controllers, starters, conduits, disconnect switches, and miscellaneous high voltage electrical devices.
- General Construction: excavation, crane, tool and equipment rental, permits, painting, architectural modifications or additional space requirements, roofing and services such as clean-up, field offices, and temporary telephone and electrical service.

Auxiliary energy system costs are not included as part of the solar energy system costs.

Obtaining accurate total project construction cost is the focus of the data gathering effort. The costs presented do not include the contractor's overhead and profit (OH&P) or general and administrative costs. There is a general sensitivity to the publication of OH&P costs among corporations in a competitive market. Also, the bare costs (without overhead and profit) are more useful to other project planners and contractors since they could include their own overhead and profit figures.

General contractors are the main source of data since they have the most cost information for each project. Major subcontractors are interviewed where possible to obtain more specific information pertaining to respective subsystems. Interviews are pursued with the personnel from the contracting firms who were actually on site performing the work and those that kept the cost records.

For each cost category the following types of information are sought:

- Labor type utilized
- Number of workers utilized
- Number of hours required
- Time per unit of equipment installed
- Materials cost
- Labor rates
- Delivery costs of major items
- Overhead factors
- Total costs

This information is obtained from cost files, invoices, time logs, government payment request vouchers, monthly progress reports, bills-of-materials, and the interviews.

In addition to the above data, each contractor and subcontractor is questioned concerning cost estimating techniques employed to date, recommended areas for cost reduction, final engineering cost estimates, and any other pertinent cost information.

It must be emphasized that this cost information can only be assessed in relation to the detailed system description report, SOLAR/2018-78/50.

IV. SYSTEM DESCRIPTION SUMMARY

The following is a brief summary of the Reedy Creek Utilities Co., Inc. Office Building solar installation. Highlights of this site include:

- COLLECTOR TYPE: Concentrating, Liquid, Tracking
- FREEZE PROTECTION: Circulation
- APPLICATION: Space Heating, Space Cooling, Domestic Water Heating
- STORAGE TYPE: Exterior Tank
- NEW OR RETROFIT: New
- INSTRUMENTED FOR PERFORMANCE EVALUATION: Yes

The solar energy system heats and cools approximately 5,625 square feet of office area in this two story, modern office building in Walt Disney World, Florida.

The system utilizes 16 AAI Corporation concentrating collectors which provide an effective aperture area of 3,840 square feet. The collectors are cylindrical mirrors which form the structural roof of the building. The axes of the mirrors are perpendicular to the meridian and the foci point to the zenith. A single tracking mechanism keeps the absorber assembly at the mirror focus throughout the day.

All 16 absorbers are connected in parallel with flex hoses to the steel manifold piping. The water is pumped between the collectors and the storage tank. The 10,000 gallon insulated steel storage tank is located on the concrete floor of a dike within a protected porch of the building.

Three of the system pumps are located adjacent to the storage tank, and two are mounted near the central air handler above the roof. The chiller condenser water circulator is located in the central chiller plant building. All exterior piping is insulated with fiberglass covered by an aluminum jacket.

The cooling equipment for the system is an Arkla 25-ton packaged water chiller located on grade adjacent to the storage tank. The chilled water from the Arkla unit is stored in a separate 10,000 gallon tank from which it is circulated to the

central air handler for space cooling.

Auxiliary cooling is provided by standby chilled water from the central chilled water plant. There is no auxiliary system for space or domestic water heating.

The solar system has been fully instrumented for data acquisition and is included in the National Solar Data Network.

V. PROJECT BACKGROUND

The Reedy Creek Utilities Company solar project was constructed as a result of a PON I proposal to ERDA in November, 1975. The contract with ERDA which committed the Government to funding 75% of the estimated project cost was awarded in March, 1976. Construction of the system began in October, 1976, with the system reaching substantial completion by March, 1978 when acceptance testing was performed.

Project responsibilities were as follows:

- Owner: Reedy Creek Utilities Co., Inc.
- Architect: WED Enterprises, Inc.
- Engineer: AAI Corporation
- General Contractor: Buena Vista Construction Co., Inc.

Three subcontractors performed major portions of the solar system construction.

- Collector Fabrication and Installation Supervision: AAI Corporation
- Mechanical Subcontractor: S.I. Goldman Company
- Electrical Subcontractor: Robbins Electric Company

All work was performed by union labor.

VI. DATA SOURCES

Cost data for the Reedy Creek Utilities Company solar energy system were collected during a visit to the site made on July 11, 1978 and as a result of subsequent follow-up communications.

Cost data were collected from representatives of Reedy Creek Utilities Company, Buena Vista Construction Company, and the S.I. Goldman Company. The primary source materials were:

- Mechanical Contractor receipts and invoices
- Owner invoices to DOE
- Supplier invoices
- Owner and General Contractor accounting records of project costs

A secondary source of data was personal communication with a representative of the collector supplier. The Mechanical Contractor provided the breakdown of installation and labor requirements that could not be obtained from the owners' data sources. This information was the basis for the apportionment of the materials and labor components attributable to certain categories. The Electrical Contractor was contacted by telephone for information concerning the breakdown of electrical and controls work performed by him.

VII. COST ANALYSIS BY CATEGORY

A. Introduction

In the ten subsections that follow, cost information is provided for the following categories of the solar system.

- Collector Array
- Support Structure
- Piping
- Ductwork
- Insulation
- Heating/Cooling Equipment
- Storage
- Controls
- Electrical Power
- General Construction

In each subsection, descriptions of the category are presented along with the cost components. A tabular presentation of the cost data actually obtained then follows. All cost data are rounded to the nearest five dollar increment. The data sources used for each cost item and any unique aspects are discussed along with detailed information related to the basis for the costs. This includes the identification of costs that were either unavailable or impossible to separate from the other categories.

B. Collector Array

The collector category includes cost associated with the purchase of collector materials, delivery, handling and mounting, and piping of the collectors. For the Reedy Creek project, the collector category includes the 16 reflecting solar panels; each designed as a 7-1/2' x 32' sandwich of aluminum and isocyanurate foam which reflects energy to a moveable collector bar.

The collector array for Reedy Creek was designed to also serve as the roof of the building. As a result it is important to consider that there was no roofing for the Reedy Creek site. This can be considered as a credit to the cost of the solar array.

The purpose of this report is to present actual construction costs incurred in building the system. However, the credit for

roofing cost is important in analyzing the cost data. The value of roofing compatible with this structure is estimated to be $\$4/ft^2$.

The credit applied for not having a roof structure in addition to the solar array is quantified as:

$$\$4/ft^2 \times 3,840\ ft^2 = \$15,360$$

Table VII-1 presents the actual construction cost breakdown for this category and include the roof credit.

TABLE VII-1. COLLECTOR ARRAY CATEGORY COSTS - REEDY CREEK

COMPONENT	COST, $		
	Materials	Labor	Subcontractor
Materials			None
Collector Panels and Concentrating Bar Assembly	360,445		
Miscellaneous Materials	990		
Piping	*		
Collector Assembly and Mounting			
Installation of Collectors		6,705	
Collectors Connected to Manifold		10,245	
Delivery	N/A**		
SUBTOTALS	361,435	16,950	None
COLLECTOR ARRAY CATEGORY TOTAL	$378,385		

* Piping materials cost included in piping category.
**Not available, typical notation, all tables. Delivery costs included in Material Costs.

- Collector Array Materials
  - o Data sources - Suppliers invoices, discussion with Reedy Creek and collector supplier and Mechanical Contractor.
  - o Cost components - 16 Reflecting Panels, factory constructed cylindrical sandwich of aluminum, 3" of isocyanurate foam and aluminum backing approximately 32' long, each.
    - 16 Absorbers, aluminum extrusion with "U" shaped copper tube housed in an aluminum extrusion with a glass cover, insulated with high temperature foam, approximately 40' long, each.
    - Insulation - 250 lineal feet of 3" fiberglass wrapped around header pipes.
- Collector Mounting
  - o Data source - Mechanical Contractor records.
  - o Cost components - Collector mounting, 137 man-days
    - Piping, 90 man-days

C. Support Structure

Since the solar collector array was integrated at Reedy Creek as the roof, a structure of support members, designed and installed for the sole purpose of carrying the solar array was not required. However, at the top of the longer walls of the building, a steel support base forming a series of 16 arcs was provided to receive the curved solar reflecting panels. The cost of these steel members and associated masonry work, required to achieve the architectural integration was included as the support structure cost. Cost data for this category are presented in Table VII-2.

TABLE VII-2. SUPPORT STRUCTURE CATEGORY COSTS - REEDY CREEK

COMPONENT	COSTS, $		
	Materials	Labor	Subcontract
Structural Steel	None	None	13,040
Masonry			3,270
SUBTOTALS	None	None	16,310
SUPPORT STRUCTURE CATEGORY TOTAL	$16,310		

- Subcontract
  - o Data source - Owner records of project costs.
  - o Cost components - Structural steel members, approximately 240 lineal feet specially manufactured to accept curved reflecting panels.
    - Masonry, concrete block work in preparation for structural steel.

D. Piping

The piping category includes piping, pumps, valves, and miscellaneous components used to transport the system fluid. Costs are shown in Table VII-3.

TABLE VII-3. PIPING CATEGORY COSTS - REEDY CREEK

COMPONENT	COST, $		
	Materials	Labor	Subcontract
Piping - all systems	24,525	23,910	None
Miscellaneous Hardware	3,660	1,240	
SUBTOTALS	28,185	25,150	None
PIPING CATEGORY TOTAL	$53,335		

- Piping Materials
  - o Data source - Mechanical Contractor records.
  - o Cost components - Piping - all systems, includes fittings and all piping materials costs for all piping loops in the solar system.
    - Miscellaneous hardware, pumps and most valves incorporated in piping systems.
- Labor
  - o Data source - Mechanical Contractor records.
  - o Cost components - Piping systems labor, installation of pipes and fittings, 231 man-days.
    - Miscellaneous hardware, labor required for installation (other than piping) of pumps, valves, and other piping hardware, 12 man-days.

E. Ductwork

No costs are attributable to the solar system in this category. All ductwork is used also by the auxiliary energy system.

F. Insulation

The insulation category includes all insulation used in the solar system except that employed in the solar collectors and for the storage tanks. In practice, piping insulation comprises the major portion of this category. Costs are listed in Table VII-5.

TABLE VII-5. INSULATION CATEGORY COSTS - REEDY CREEK

COMPONENT	COSTS, $		
	Materials	Labor	Subcontract
Pipe insulation	3,020	6,155	None
Collector piping insulation	1,265	2,275	
SUBTOTALS	4,285	8,430	None
INSULATION CATEGORY TOTAL	$12,715		

- Materials
  - o Data source - Mechanical Contractor records.
  - o Cost components - Fiberglass pipe insulation.
- Labor
  - o Data source - Mechanical Contractor records.
  - o Cost component - Installation, 75 man-days.

G. Heating/Cooling Equipment

This category include the ARKLA chiller and air handling unit and coils. Costs are shown in Table VII-6.

TABLE VII-6. HEATING/COOLING EQUIPMENT CATEGORY COSTS - REEDY CREEK

COMPONENT	COST, $		
	Materials	Labor	Subcontract
ARKLA chiller	14,375	620	
Heat Exchanger	1,045	350	
SUBTOTALS	15,420	970	None
HEATING/COOLING EQUIPMENT CATEGORY	$16,390		

- Materials
  - o Data source - Mechanical Contractor records.

- o Cost components - ARKLA chiller, 25 tons (cooling)
  - Heat exchanger, one located in storage tank (water to water), for domestic hot water. The air handler and its coils are not included in the solar cost because they are part of the auxiliary system also.

- Labor
  - o Data source - Mechanical Contractor records.
  - o Cost components - ARKLA chiller installation: 6 manhours.

H. Storage

The storage category consists of the tanks or other devices used to store thermal energy. At Reedy Creek, two, 10,000 gallon steel tanks were used. The tanks were mounted outside of the building adjacent to the main entrance in an area that constitutes a solar equipment display. Costs are shown in Table VII-7.

TABLE VII-7. STORAGE CATEGORY COSTS - REEDY CREEK

COMPONENT	COST, $		
	Materials	Labor	Subcontract
Tank	23,140	1,655	
Insulation	4,675	8,630	None
SUBTOTALS	27,815	10,285	None
STORAGE CATEGORY TOTAL	$38,100		

- Materials
  - o Data sources - Mechanical Contractor records.
  - o Cost components - Tanks: Two 10,000 gallon, steel, cylindrical.
- Labor
  - o Data source - Mechanical Contractor records.
  - o Cost components - Tank installation, 16 man-days.
    - Insulation, 100 man-days.

I. Controls

The controls category includes all equipment in the system installed for the purpose of automatically regulating system operation. See Table VII-8 for controls cost. The cost of the automatic control valves is not included here, but is included in the piping category.

TABLE VII-8: CONTROLS

COMPONENT	COST, $		
	Materials	Labor	Subcontract
Pneumatic Piping & Controls	None	None	$ 1,545
Electrical Controls	None	None	$10,020
SUBTOTALS	None	None	$11,565
CONTROLS CATEGORY TOTAL	$11,565		

* Does not include cost of automatic control valves.

- Subcontract
  - o Pneumatic Piping
    - o Data Source - Mechanical Contractor's records.
    - o Cost Component - Materials $850,
      - Labor, 6 man-days
  - o Electrical Controls
    - o Data Source - Discussion with electrical subcontractor.

J. Electrical Powers

The electric power category includes all components, materials and labor required to install the power distribution system for the electrical energy needed for the system. Costs are shown in Table VII-9.

TABLE VII-9. ELECTRICAL POWER CATEGORY COSTS - REEDY CREEK

COMPONENT	COSTS, $		
	Materials	Labor	Subcontract
Electrical Subcontract	None	None	$ 6,340
SUBTOTALS	None	None	$ 6,340
ELECTRICAL POWER CATEGORY TOTAL	$ 6,340		

- Electrical Subcontract
  - o Data source - Subcontractor invoice to General Contractor.
  - o Cost component - Materials and labor charged by Subcontractor for wiring and connecting pumps and other equipment.

K. General Construction

The general construction category includes all materials and labor consumed in the project but not directly attributable to other specific categories. No costs for building space requirements are included because most of the solar equipment was located exterior to the building. However, some site work was required to prepare the mechanical display area. This included the excavation of a pit with a drainage line. Items such as concrete bases for the pumps and chillers were also required. As a result it was not possible to charge any system category with the site work costs. Direct supervision provided by the General Contractor for all categories of the system are also charged as general construction. Site work and supervision constitute a major portion of the General Construction Category costs. Equipment and miscellaneous labor expended in association with collector mounting and the piping category were also included. Costs are given in Table VII-10.

TABLE VII-10. GENERAL CONSTRUCTION CATEGORY COSTS - REEDY CREEK

COMPONENT	COSTS, $		
	Materials	Labor	Subcontract
General Contractor Supervision	None	$23,490	None
Miscellaneous	$2,385	$ 1,655	$ 5,205
SUBTOTALS	$2,385	$25,145	$ 5,205
GENERAL CONSTRUCTION CATEGORY TOTAL	$32,735		

- Materials
  - o Data sources - General Contractor and Mechanical Contractor records.

- o Cost components - Miscellaneous, charges for use of ancilliary equipment for collector mounting, heating and cooling equipment installation, and piping installation.

- Labor
  - o Data sources - General Contractor records and Mechanical Contractor records.
  - o Cost component - General Contractor supervision, time spent in supervising solar system construction, 200 man-days.

VIII. TOTAL SYSTEM CONSTRUCTION COST

Table VIII-1 presents the total system construction cost summary based on costs presented in Section VII. No allowance for General Contractor overhead and profit (OH&P) or general and administrative (G&A) has been made. It is important to note that at Reedy Creek, subcontractors, especially the Mechanical Contractor were major participants in the system construction. All subcontractor costs include OH&P and G&A charges. The labor and materials breakouts presented in Section VII and in Table VIII-1 represent the costs of the major contractors and suppliers such as the Mechanical Contractor and collector supplier. Subcontractor costs are those due to minor subcontractors such as electrical and controls.

TABLE VIII-1. TOTAL SYSTEM CONSTRUCTION COST SUMMARY-REEDY CREEK

CATEGORY[a]	MATERIALS	LABOR	SUBCONTRACT	TOTAL
Collector Array	$361,435	$16,950	None	$378,385
Support Structure	None	None	$16,310	16,310
Piping	28,185	25,150	None	53,335
Ductwork	None	None	None	None
Insulation	4,285	8,430	None	12,715
Heating/Cooling Equipment	15,420	970	None	16,390
Storage	27,815	10,285	None	38,100
Controls	None	None	11,565	11,565
Electrical Power	c	c	6,340	6,340
General Construction	2,385	25,145	5,205	32,735
SUBTOTAL	$439,525	$86,930	$39,420	
TOTAL MATERIALS, LABOR AND SUBCONTRACT	$565,875[d]			

[a]For a complete description of items included in each category, see Section VII.

[b]Includes only automatic controls. Does not include automatic or manual valves, shown in piping category.

[c]Electrical power wiring was performed by an electrical subcontractor and a breakdown of materials and labor was not available.

[d]Does not include overhead and profit or general and administrative expenses for general contractor.

IX. DISCUSSION

In this section, the data are presented in formats to facilitate comparisons and further analysis of data collected at the various demonstration sites.

Table IX-1 presents the proportional composition of the total system costs and the costs per square foot of collector area for each category. It is useful to analyze the cost data unitized and apportioned in this manner, especially in comparing the costs of different systems.

TABLE IX-1. CATEGORY COSTS PER UNIT COLLECTOR AREA AND AS A PERCENT OF TOTAL COST - REEDY CREEK

CATEGORY[a]	UNIT COST, $/FT^2 COLLECTOR AREA		PERCENT OF TOTAL SYSTEM COST	
	BARE COSTS, WITHOUT OH&P	WITH OH&P[b]	BARE COSTS, WITHOUT OH&P	WITH OH&P
Collector Array	98.50	108.40	67	67
Supporting Structure	4.20	4.70	3	3
Piping	13.90	15.30	9	9
Ductwork	None	None	None	None
Insulation	3.30	3.60	2	2
Heating/Cooling Equipment	4.30	4.70	3	3
Storage	9.90[c]	10.90	7	7
Controls	3.00	3.30	2	2
Electrical Power	1.70	1.90	1	1
General Construction	8.50	10.30	6	6
TOTAL	147.40	163.00	100	100

[a] For a complete description of items included in this category, see Section VII.

[b] See Section X for the procedure used to add overhead and profit.

[c] Equates to $1.91/gallon storage.

Another item of interest in discussing the cost experience of a solar project is a comparison of cost estimates prior to construction to actual costs experienced.

For Reedy Creek, the general contractor conducted a "Financial Post Mortem" comparing the budgeted costs to the final costs. While this analysis did not consider the system in exactly the

same categories as used in this report, it is still possible to ascertain the areas of cost variation. This information is presented in Table IX-2.

TABLE IX-2. COMPARISON OF ESTIMATED AND ACTUAL CONSTRUCTION COSTS - REEDY CREEK

	Estimated Costs, $[a]	Actual Costs,[a] $
Collector Array	133,551	360,447
Support Structure	16,580	16,312
Electrical Power	29,467	15,898
Other o piping, ductwork o insulation, htg/clng equipment o storage	92,045	140,464
TOTAL SYSTEM COST	$271,643	$533,121

[a]Note that this cost breakdown differs from the one used elsewhere in this report. Some items included in the total system cost are not included here so that the totals in Table IX-2 are not equal to those reported in Section VIII.

X. SYSTEM COST FOR USE IN ANALYSIS

Detailed performance data is being acquired for this solar energy system through the National Solar Data Network. The assessment of this system's economic performance (cost/unit of energy delivered) requires a total construction cost figure that should include an overhead and profit (OH&P) factor. However, a constant OH&P factor will be applied to all bare costs in this series of reports to normalize the great variation of OH&P percentages encountered in the program.

To illustrate the necessity for this adjustment, consider two systems. System A performs well, but was installed by a contractor with a high OH&P factor. System B does not perform as well, but was installed by a contractor with a low OH&P factor. It would not be appropriate to penalize System A in an economic performance comparison of the two systems because of the installer's OH&P factor. Major variations in OH&P factors are expected due to the diversity of business firm types that contracted to install the solar demonstration systems. These include colleges and universities, engineering firms, and construction contractors. The comparison discussed above represents the extremes of conditions that can be encountered.

As a result, a need exists to "normalize" the treatment of OH&P in analysis of the cost data. For this reason, an OH&P factor of 25% will be added to all general contractor bare costs (materials and labor) and 10% will be added to all subcontract costs to represent the cost that a general contractor would charge. The only materials or labor supplied directly by the general contractor was supervision ($23,490).

The equivalent total construction cost thus determined for the solar energy system of the Reedy Creek Utilities Company Office Building is $625,985 in 1977 dollars. To allow equivalent comparisons among sites, all cost data must account for the effects of inflation. Adjustment of data from all sites to a common year will eliminate inflation biases. The base year selected is 1977, the same year in which the Reedy Creek system was constructed. Hence, no modification is required.