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Manufacturing and Cost Analyses of Heliostats Based on the Second Generation Heliostat Development Study

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MANUFACTURING AND COST ANALYSES OF HELIOSTATS BASED ON THE SECOND GENERATION HELIOSTAT DEVELOPMENT STUDY

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ABSTRACT

The manufacturing processes and users' costs were analyzed for the Second Generation Heliostats. Mass production scenarios are examined by comparison and manufacturing analysis, including facility site selection and design, operations, equipment and tooling, and labor. Different transportation scenarios are compared, as are the site assembly and installation procedures. Users' costs are allocated to the central manufacturing facility, to transportation from the central manufacturing facility to the field, and to the field sites. Costs are also compared for these major components: reflective assembly, drive mechanism, controls and field wiring, foundation/pedestal, and support structure. Breakdowns are given for direct materials, direct labor, and other expenses including an estimate of the gross profit. A contractor-estimated capital price to the utility is shown for each heliostat design as well as estimated operations and maintenance (O & M) expenses.

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Summary

The Second Generation Heliostat program produced several results, including manufacturing and cost analyses for the mass production of heliostats at the rate of 50,000 units per year. Installed prices of all of the designs fall in the \$100 to \$150/m^2 range in April 1980 dollars.

The manufacturing analysis considered numerous factors which resulted in the following:

- Facilities designs were provided by the contractors for a central manufacturing facility (CMF) producing 50,000 heliostats per year; land areas ranged from 40 to 95 acres, while production facilities occupied from 260,000 to 620,000 square feet.

- Capital costs were estimated for the land, buildings, equipment, and tooling associated with such a manufacturing facility. Totals varied among contractors from \$71M to \$102M.

- The nature of the CMF operations ranged from a low to a high degree of vertical integration.

- The direct labor hours required to manufacture a heliostat (excluding controls and foundation/pedestal) varied among the contractors from 14 to 44 hours, with a majority of hours spent on drive mechanisms. Estimated factory labor efficiencies varied from 0.80 to 0.92.

- The direct labor hours per heliostat and the associated efficiencies were a strong function of the degree of automation. The fewest hours per heliostat and the highest efficiencies were associated with highly automated facilities, and the most hours per heliostat and lowest efficiencies with less automated facilities.

The four contractors provided transportation scenarios in which the heliostat components were shipped from the CMF to the site. The shipping procedure varied somewhat among three of the contractors and was quite different for the fourth. For three contractors, components were shipped by truck or rail to a site assembly building for subsequent assembly and installation. The fourth contractor elected to ship nearly complete heliostats to the site for installation, with no site assembly operations

required. The shipping densities for the fourth contractor were significantly lower than those for the other three contractors (1.8 compared with 2.8 to 5.0 heliostats per truck) because of the shipment of bulky components in a volume-limited rather than weight-limited manner.

Two contractors elected to assemble and install about fifty heliostats per day at each of four sites. The other two contractors planned to assemble and install about half as many heliostats per day at about twice as many sites. The hours spent per heliostat in on-site assembly/installation procedures vary from 4 to 23 for the four contractors, excluding the controls and foundation/pedestal.

The four contractors investigated the cost of "mass producing" heliostats at a rate of 50,000 per year. Cost estimates by the contractors were based on summing all of the individual costs of the many heliostat parts of a detailed design. The level of detail in the designs included bolts, locknuts, lockwashers, gaskets, seals, pins, plugs, screws, adhesive, paint, primer, studs, cable, connectors, diodes, resistors, capacitors, switches, grease, oil, thread compound, and sealants. A condensation of the contractors' detailed cost estimates appears in Appendix B, while the actual cost data sheets are part of the contractors' final reports (References 1-4).

Estimates of the capital price range from about $\$100/m^2$ to $\$150/m^2$ in 1980 dollars. These estimates are significantly lower than previously produced heliostats and reflect not only the increased reflective areas of the Second Generation Heliostat designs but also the advantages of mass production (bulk purchasing, use of dedicated equipment and laborers, etc). While heliostats would probably not be initially produced at rates approaching 50,000 units per year, the Second Generation Heliostat designs have been proof-tested and could be produced at prices significantly lower than past heliostats. Two of the designs are estimated to be priced at about $\$105/m^2$. The other two designs could be reduced in price by increasing reflective area and by making other design changes. As a result, the competitive price range could be close to $\$100/m^2$ for all the Second Generation Heliostat designs.

The user's cost consists of the fixed capital price paid for an installed heliostat and the recurring operations and maintenance (O & M) costs. The user's cost is not stated in this report since the assumptions required to arrive at a levelized O & M cost are best left to the reader. The components of user's cost shown in Figure 1 outline the levels of detail provided by the contractors and those presented and discussed in this report.

The estimated installed heliostat prices are composed of about 75 percent reflective assembly, drive mechanism, and support structure costs; about 12 percent controls and field wiring costs; and about 13 percent foundation/pedestal costs. Further breakdown of the reflective assembly, drive mechanism, and support structure costs reveals that about 85 percent of the costs are incurred at the CMF, 5 percent in transportation to the site, and 10 percent at the site. A different viewpoint of the reflective assembly, drive mechanism, and support structure costs is that about 63 percent of the incurred cost is for direct materials, another 9 percent is for fully loaded direct labor, about 5 percent is for capital replacement, about

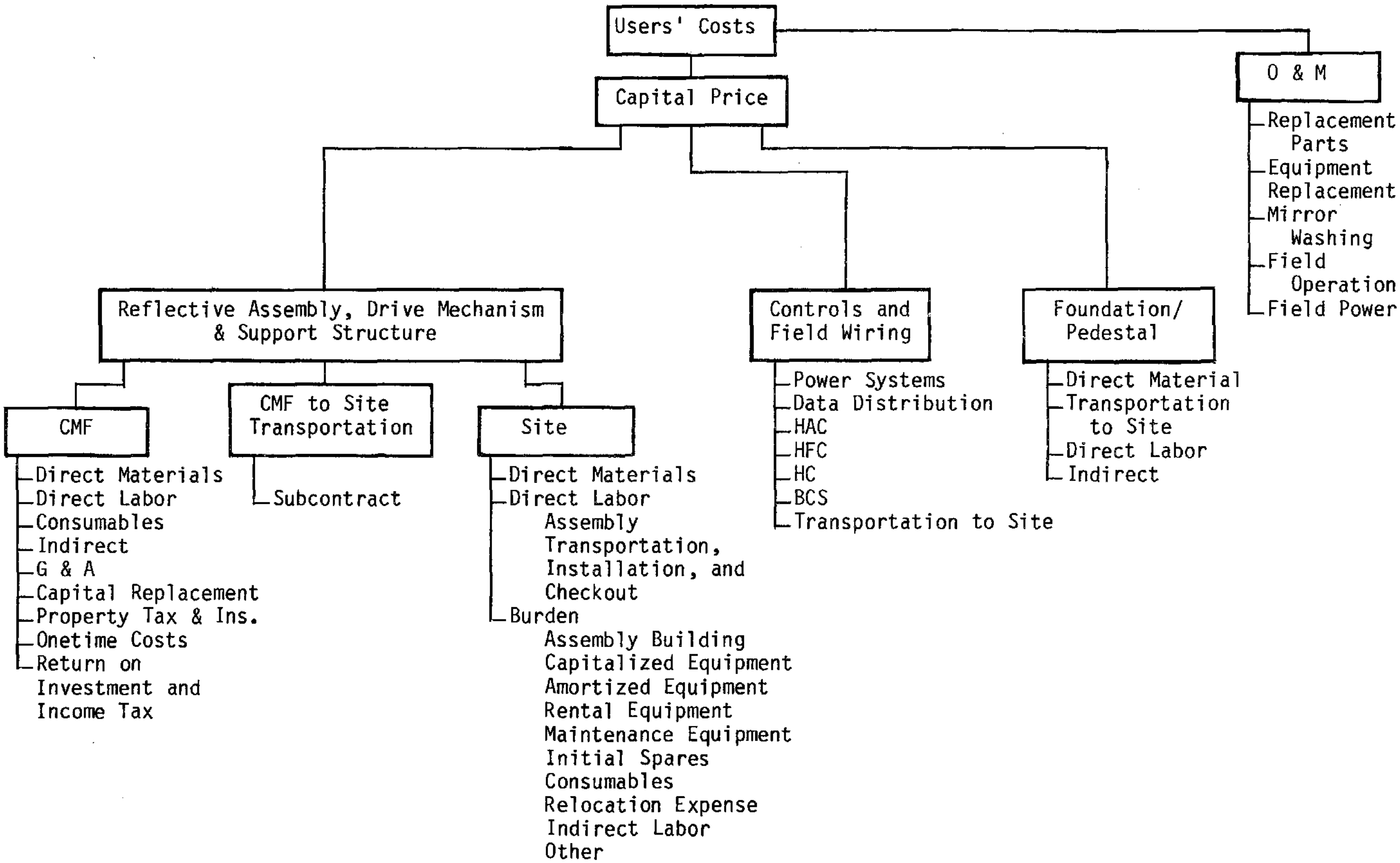

Figure 1. Components of Users' Costs

6 percent is for gross profit, and the remainder is for consumables, indirect expenditures, general and administrative (G & A) costs, property tax and insurance, transportation to the site, and other expenses.

The annual operations and maintenance costs were also estimated. The estimates ranged from 1.2 percent to 1.8 percent of the installed heliostat price, with an average of 1.4 percent.

The contractors projected that the costs would increase by 4 to 14 percent if the production rate were cut in half in the same factory; they would decrease slightly (1 to 3 percent) if the production rate of 50,000 heliostats per year were increased to 67,500 heliostats per year.

The contractors continue to improve their designs and have projected cost reductions beyond those incorporated into the \$100 to 150/m^2 installed heliostat prices. These cost savings could reduce the installed heliostat prices by 7 to 21 percent. In addition, the effects of learning could further reduce installed heliostat prices by as much as 10 to 15 percent over a ten-year production period. Learning was not included in the \$100 to 150/m^2 installed heliostat price.

Sandia National Laboratories, Livermore, California, did not make an independent heliostat price estimate. However, the data are displayed and discussed so that an adjusted price--which considers appropriate additions and deletions--can be estimated by the reader. The real price will be determined in the marketplace.

INTRODUCTION

Introduction

Sponsored by the Department of Energy (DOE), a Second Generation Heliostat program was undertaken by Sandia National Laboratories Livermore (SNLL) to develop cost-effective heliostats and multiple potential heliostat suppliers. Four contractors were involved: Atlantic Richfield Company (ARCO), Boeing Engineering and Construction (BEC), Martin Marietta Corporation (MMC), and McDonnell Douglas Astronautics Company (MDAC). Each of these contractors provided a detailed heliostat design, fabricated and tested two prototype versions of the detailed design, provided a preliminary design of a factory that would produce the detailed design in mass quantities, and provided a price estimate of an installed heliostat field with the subsequent operations and maintenance expenses of field operation over a period of time.

To allow comparisons of the designs, Sandia specified the mass production rate, total quantity of heliostats, and size of the electrical power plants that would consume the entire heliostat production output. Although the eventual growth of solar central receiver energy production in this country probably will not follow these specifications, they do provide a useful basis for comparison.

This report covers the mass manufacturing, installation at power plant sites, and cost estimates made by the contractors. Each contractor has published the results of its design, analysis, and cost estimates (References 1-4). The manner in which these results have been reported varies in level of detail, completeness, clarity, and method, making comparison of the results somewhat difficult.

This report attempts to help the reader compare the contractors' results. The report also contains comments regarding omissions, discrepancies, differences of approach, apparent underestimates or overestimates, and areas for potential cost savings not already discussed by the contractors.

Ground Rules

Sandia provided a number of cost-estimating ground rules for Second Generation Heliostat development. The contractors were to provide a production design of a heliostat which would be manufactured at a rate of 20,000 units during the first year (June 1984 - June 1985) and installed in 50 MW_e (peak) plants. After start-up production, the heliostats would be built at a rate of 50,000 heliostats per year for ten years for a total build of 520,000 units. All of these heliostats would be installed in 50 MW_e (peak) electric power generation plants within a 400-mile radius from the central manufacturing facility (CMF), which was to be located in one of the eight southwestern states (Arizona, California, Colorado, Nevada, New Mexico, Oklahoma, Texas, and Utah). The electric power plants would be uniformly distributed in the 800-mile diameter circle around the CMF.

A single CMF would be located within the eight states and would service electric power plants in a 400-mile radius. The facility would operate at 100 percent output with two shifts. The daily output would be about 200 heliostats per working day, based on 50,000 heliostats completed per year. Heliostats would be transported to the electric power generation sites and installed by the heliostat manufacturer.

The costs of all activities would be based on April 1980 dollars. All costs incurred--from the initial manufacture of the heliostats through the final installation at the sites, along with the annualized operations and maintenance (O & M) costs over a 30-year life--would be included. The cost of the installed heliostat would be itemized according to a cost breakdown structure that included the reflective assembly, drive mechanism, controls and field wiring, foundation/pedestal, and support structure.

The field layout for the 50 MW_e (peak) electric power generation plants was provided by SNLL. The number of heliostats needed for each plant was determined using the DELSOL I computer code with the heliostat dimensions, mirror reflective area, and reflectivity provided by the contractors; specification values were used for pointing accuracy and mirror quality. Default values in DELSOL I were used for nominal costs of the land, tower, receiver, wiring, and heliostats.

Cost Tasks

The contractors' estimates were to include the following:

- CMF capital cost.
- Installed heliostat capital price (i.e., cost plus gross profit).
- Annual O & M costs.
- Heliostat price difference for production at the same facility at 50 percent of the nominal production rate (25,000 heliostats per year) and at 135 percent of the nominal production rate (67,500 heliostats per year).
- Potential reductions in price identifiable after completion of the Second Generation Heliostat development program.

The contractors were encouraged to design the most cost-effective heliostat, even to the point of challenging any of the Sandia guidelines. Such challenges were used effectively by some contractors to provide reductions in manufacturing and transportation costs.

SNLL Manufacturing Analysis

The manufacturing and costing analyses are closely related. The goals of the SNLL manufacturing analysis, which are similar in scope to those of the cost analysis, are to:

- Understand the manufacturing scenarios provided, including the strategies used to select a site for a facility, types of facilities incorporated, use of colocated facilities, equipment and tooling used, degree of automation used in manufacture, make/buy decisions for components, and direct/indirect labor requirements.

- Understand the interrelation between manufacturing and resultant heliostat costs.
- Compare manufacturing scenarios in a similar format.
- Evaluate production plans for completeness and feasibility and point out omissions or errors.
- Point out what SNLL feels may be wise or judicious decisions on the part of the contractors and SNLL's rationale for recommending them.

In analyzing the contractors' manufacturing scenarios, SNLL studied each portion of the plans, examined the rationale for certain contractor choices, and compared plans. Assessments were made concerning the site location of the CMF plant layout and associated facilities, tradeoffs involved in production plans, actual manufacturing approach and plans, labor requirements (both direct and indirect), efficiency of labor, and interrelation of these factors to manufacturing cost (Reference 5).

SNLL Cost Analysis

The objectives of the SNLL cost analysis are to:

- Understand a complete set of costs defining the total installed heliostat price and the recurring O & M expenses incurred by a site owner.
- Provide a format for those costs that allow comparative analyses. These cost-displays are incorporated by SNLL in HELCAT, a Heliostat Cost Accounting Tool (Reference 6).
- Resolve differences that are apparent within the individual or among the contractors' results.
- Provide SNLL with an understanding of heliostat costs.
- Compare the price estimates.

The basic approach taken by SNLL in the cost analysis was to break down the profit centers into three areas: the central factory, the transportation from the central factory to the site, and the on-site assembly, transportation, and installation. The recurring O & M costs were treated separately. Because of the structure of the contract and the manner of contractor response, two exceptions were made. The controls and field wiring and the foundation/pedestal costs were separated from the other costs. The contract did not emphasize controls and field wiring; therefore, one contractor did not estimate any costs, while the other contractors made incomplete estimates or based them on previous studies. Furthermore, the foundation/pedestals were produced by a wide variety of methods making comparison difficult.

The bulk of the manufacturing costs incurred at the factory are for the reflective assemblies, drive units, and support structures. These items are transported to the individual sites where they are assembled (if applicable), transported from the site assembly building to the foundation/pedestal location, installed, and checked out before turnover to the site owner. The initial capital investment for maintenance equipment and spares represents additional costs. Any recurring costs are included in O & M.

Each profit center is subdivided to separate the costs of direct materials, direct labor, and all other cost charges to the center. Where possible, the other costs are broken down into burden categories and gross profit, which includes the return to investors and income tax.

The SNLL cost analysis is not intended to provide a bottom-line Second Generation Heliostat price, since this is only one possible manufacturing/deployment scenario. Rather, it will highlight all the cost component areas. In the end, the contractors' results can be reevaluated for use in other scenarios, or the format can be employed in future studies.

COMPARISONS

Comparative Formats

Comparative formats can be used to examine and contrast the different heliostat characteristics. Both manufacturing and cost comparisons are made using these formats in this report.

Comparative formats for the manufacturing of heliostats vary widely in the items contrasted. Both qualitative and quantitative comparisons are made on subjects ranging from capital costs to make/buy decisions to labor efficiencies. The total installed heliostat prices are broken down to comparable categories. These comparisons highlight the costs of major heliostat parts, costs associated with the location where they were incurred, and costs independent of the location or the major parts. In this report, baseline comparisons are normally given in $\$/m^2$. (Cost comparisons could be given in \$/heliostat; however, since each of the four Second Generation Heliostats is a different size, $\$/m^2$ comparisons are more meaningful.) Most cost comparisons exclude those costs associated with controls and field wiring and foundation/pedestals. These two categories were handled quite differently by each of the contractors, and more meaningful comparisons can be made by their exclusion.

Manufacturing Comparisons

Comparative formats can be used to contrast various manufacturing scenarios for Second Generation Heliostats. Both qualitative and quantitative comparisons are possible. Items that can be compared include space requirements for the various manufacturing facilities, make/buy decisions, production operations at the plants, installation operations in the field, direct labor hours spent in heliostat manufacture and installation, personnel requirements, efficiency of laborers, transportation scenarios, capital costs for manufacturing facilities (including land, buildings, equipment, and tooling), and plans for various production rates. Each contractor handled the capital costs incurred at each site quite differently; these costs are discussed more fully in the section on site installation.

Space Requirements--Table 1 compares the various space requirements for each CMF and site. Required acreage for a CMF varies from 40 to 95 acres. Enclosed floorspace also varies widely, from 260,000 square feet to over 600,000 square feet. The CMF floorspace requirements should be a strong function of the make/buy decisions for heliostat components. Further breakdowns of floorspace at the CMF are included in the manufacturing section of this report. Site floorspace requirements vary widely as well, depending on the types of activities that occur within each site building.

Make/Buy Decisions--Each contractor decided which heliostat components it would make and which it would buy. A synopsis of major make/buy decisions for mass-produced Second Generation Heliostats is given in Table 2. All the contractors elected to fabricate certain assemblies (such as reflective assemblies, drive mechanisms, and support structures) either at a CMF or on site. Furthermore, they all elected to buy controls components and either to perform some minimal assembly or to subcontract controls assembly. Foundation/pedestals were provided as purchased parts and through

TABLE 1

SPACE REQUIREMENTS FOR CMF AND SITE

Facility Location	ARCO	BEC*	MMC*	MDAC
Central Manufacturing Facility				
Land Area, acres	60	75	95	40
Manufacturing Floorspace, ft^2 (not including aislespace)	482,000**	281,000	186,000	155,000
Total Enclosed Floorspace, ft^2 (includes support facilities)	620,000	638,000	507,000	260,000
Site Facility				
Total Enclosed Floorspace, ft^2	7,500	6,000***	28,500	4,000***

*Space requirements for colocated facilities not included here.
**Aislespace included.
***Building not costed in capital estimates.

TABLE 2

MASS PRODUCTION OF SECOND GENERATION HELIOSTATS
MAJOR MAKE/BUY DECISIONS

Heliostat Major Parts	ARCO	BEC	MMC	MDAC
Reflector Assembly	M	M	M	M
Float/Fusion Glass	B	B	B*	B
Mirroring	M	B**	M	B**
Core/Backing	M/M	B*/B	M/M	B
Drive Assembly	M	M	M	M
Motors	B	B	B	B
Gears/Shafts	M	B	M	B
Finished Castings	M	M	M	B
Bearing Assembly	M	M	B	B
Support Structure	M	M	M	M
Torque Tubes/Main Beams	M	B	M	B
Cross Beams	M	B	M	B
Controls Assembly	B	B	B	B
Foundation/Pedestal	M	B	B	M/B

M-Make
B-Buy
*Colocated captive facility.
**In-line mirroring at Corning Glass Works.

subcontracts in the BEC and MMC scenarios. ARCO and MDAC, however, provided their own labor and materials to produce all or a portion of their foundation/pedestals.

Production Operations--Each contractor performs a variety of production operations at its CMF. A synopsis of these CMF operations is provided in Table 3. While major operations are itemized in this table, not every production operation is included. Details of the full operation can be found in the corresponding final reports. The required operations vary widely depending on the make/buy strategies discussed earlier and on the planned site activities. The use of purchased parts results in fewer required manufacturing operations.

Each contractor assembles a reflective unit from parts that are produced by colocated facilities or the CMF, or that are purchased from outside suppliers. Similarly, the drive mechanism and support structure are assembled by each contractor from purchased parts, or from parts manufactured at its CMF or at colocated facilities. Three of the four contractors perform some assembly of controls or fabrication of controls packages. Three of the four contractors also perform some manufacturing operations related to the foundation/pedestal, ranging from complete fabrication to simple tapering of a purchased pedestal.

In addition to comparing the contractors' manufacturing operations, comparisons can also be made for on-site assembly operations. Each contractor considered various labor costs and transportation cost tradeoffs before deciding which operations would be performed in the field and which would be performed at the CMF. Labor rates for site laborers are generally higher than those for laborers at a manufacturing facility. The manufacturing operations performed at each CMF were discussed earlier. The operations performed at each site are compared in Table 4. MDAC elects not to perform any assembly operations on site but rather to have preassembled units shipped to the site for immediate installation. The other three contractors assemble support structures on site and then mount either half the reflective panels onto a half-frame or all the panels onto a full frame. After the mirror modules are mounted, they are canted before installation.

Labor Requirements--A comparison is made of direct labor hours per heliostat or per square meter that are spent by each contractor both at the CMF and on site. This comparison is shown, using first-year manhours, in Table 5. The numbers in Table 5 do not include direct labor hours spent on the controls and field wiring or foundation/pedestal since these two areas were treated differently by each of the contractors. (MDAC performed its own controls and field wiring and foundation/pedestal installation. The other three contractors used subcontracts for foundation/pedestal installation. BEC did not include controls and field wiring in its planning, and the other two contractors subcontracted controls and field wiring installation.) Further breakdowns of direct labor hours are given in the manufacturing section of this report.

ARCO, which makes most of its heliostat components, expends the most direct labor hours per heliostat and per square meter. MDAC, which makes the most use of automated facilities and purchased parts, expends the least direct labor hours per heliostat and per square meter. The next fewest

TABLE 3

CENTRAL MANUFACTURING FACILITY MAJOR PRODUCTION OPERATIONS

Heliostat Parts	ARCO	BEC	MMC	MDAC
Mirroring	Edge glass Clean and silver glass Copper coat glass Paint glass		Clean and silver glass Copper coat glass Paint glass PIB coat glass	
Mirror Module	Fabricate steel parts Assemble steel substrate Assemble mirror module Mount edge molding	Clean mirrors and backsheets Machine core blocks Join core blocks Assemble mirror module Seal edges	Fabricate paper honeycomb core Shear facesheet Machine doublers Fabricate edge frame Assemble mirror module	Clean mirrors Adhesive coat glass Laminate glass Assemble into reflective units of 7 panels each
Drive Mechanism	Machine 14 major parts Gear cover Bearing ring Elevation gear Az gear Worm Elevation housing Frame, cover Housing, web Ring gear Planetary gear Pinion Assemble drive Paint	Machine azimuth casting Machine elevation casting Assemble azimuth bearing assembly Assemble elevation drive assembly Paint	Machine 14 major parts Stow lock Worm gear Intermediate gear Pinion Motor bracket Caps, open and closed Encoder shaft mount Gear housing Elevation shaft Elevation/azimuth gear Elevation cover Azimuth cover Azimuth shaft Assemble drive Paint	Fabricate azimuth drive housing Fabricate elevation drive support Machine 5 major parts Drive shaft Flex spline Wave generator Bearing retainer Circular spline Assemble azimuth and elevation drives
Support Structure	Roll tubes Fabricate flanges Weld torque tube Fabricate trusses Fabricate braces Paint	Form stampings except for Z beams and torque tube Galvanize	Fabricate bar joists Fabricate hat sections Roll torque tube Weld torque tube Paint Fabricate controls cover	Form braces Support structure frames Fabricate main beam Join main beam to drive
Foundation/ Pedestal	Fabricate pile for foundation Paint	Subcontracted	Fabricate interface tube Paint	Taper steel cap for foundation Join pedestal to drive Paint
Controls	Inspect purchased parts Assemble board, submodule, cable Perform final assembly Test Fabricate control box	Not addressed	Form electronics cover/package	Fabricate electronics and power cable

TABLE 4

SITE ASSEMBLY BUILDING OPERATIONS

ARCO	BEC	MMC	MDAC
Assemble two half-frame support structures. Join half-frames to drive. Mount 12 facets. Cant facets.	Assemble two half-frame support structures. Mount 12 facets, 6 per unit. Cant facets.	Assemble one drive/support structure unit. Mount 10 full-size facets, and one half-size facet. Cant facets.	None

TABLE 5

DIRECT LABOR HOURS COMPARISON
(Excludes Controls and Field Wiring, and Foundation/Pedestal)

Direct Labor Requirements	ARCO	BEC	MMC	MDAC
CMF Direct Labor, Hours/Heliostat	23.06	18.19	10.18	10.28
Site Direct Labor, Hours/Heliostat	21.17	14.17	9.6	3.24
Total Direct Labor, Hours/Heliostat	44.23	32.36	19.78	13.52
Total Direct Labor, Hours/m^2	0.84	0.74	0.34	0.24

direct labor hours per square meter are expended by MMC; this is somewhat surprising because MMC, like ARCO, makes many of its components. MMC may have underestimated direct labor hour requirements for its heliostat. On the other hand, ARCO's estimates may be conservative. BEC expends the second-most direct labor hours on its heliostat; this is also somewhat inconsistent since BEC purchases many of its heliostat components. BEC may have overestimated direct labor hour requirements for its heliostats.

Personnel requirements of each contractor for its central plant and at each field site can also be compared. Personnel can be considered as either direct or indirect labor. Those accounted for under "direct" labor actually make the heliostat components. All other support personnel are considered "indirect." A comparison of daily personnel requirements for the contractors is given in Table 6, excluding those laborers involved with controls and field wiring or foundation/pedestals. In some cases approximate numbers are given because exact values were not provided in the reports. Again, some apparent inconsistencies exist when labor requirements are contrasted to manufacturing activities. BEC employs the most CMF personnel but buys many of its components. MMC makes many of its components, yet its total CMF personnel requirements are about the same as those of MDAC, which purchases many of its components. ARCO employs a large number of employees both at its CMF and on site; this is consistent with its manufacture of most of its components.

Each contractor provided efficiency estimates for its laborers, both at its CMF and on site. "Inefficiency" is defined here to be the fraction of planned and unplanned downtime in a normal workday. "Efficiency," or the productive work fraction, is defined as one minus the inefficiency. Table 7 compares the efficiencies projected by the contractors at the CMF and on site. ARCO, BEC, and MMC predict efficiencies in the 80 to 90 percent range at their CMFs, while MDAC predicts 92 percent efficiency in its more automated facility. On site, the predicted efficiencies vary more widely from 67 to 84 percent. In a site assembly building, efficiency would probably be higher than in the field itself during heliostat installation. In general, ARCO may be conservative in its overall efficiency estimates, while MMC appears to be optimistic in its on-site efficiency projections.

Transportation Scenarios--Various transportation schemes were proposed to ship heliostat components from the CMF to the sites. Each contractor provided a tractor-trailer shipping scenario, although trucking was considered the alternate transportation scenario for MMC. The average number of heliostats that could be transported on one truckload is compared in Table 8. In addition, the table compares the nominal number of truckloads leaving the CMF each day, based on an average production rate of 200 heliostats per day. Dividing the truckloads leaving the CMF by the number of sites in progress gives the number of trucks arriving per day at any given site. ARCO has the highest packing density of heliostats in transport and is thus more than three times as efficient as MDAC, which ships nearly complete heliostats. As a result, far fewer trucks need to leave ARCO's CMF each day to supply the nominal sites in progress. MDAC has many trucks per day leaving its CMF and many arriving at each site. Logistics problems may result for MDAC from the many transportation-related activities at the CMF and associated sites. Further discussion related to various transportation scenarios follows in the manufacturing, transportation, and site activities sections.

TABLE 6

DAILY PERSONNEL REQUIREMENTS*
(Number of Employees)

Labor Location	ARCO	BEC	MMC	MDAC
Central Manufacturing Facility				
Direct	~688	476	~254	~271
Indirect	~157	536	~232	~212
Total CMF Personnel*	~845	1012	~486	~483
On Site				
Direct	126	54	30	~33**
Indirect	21	26	6	~8**
Total Site Personnel*	147	80	36	~41
Heliostats installed/day/site	48	27	20	52

*Not including laborers associated with controls and field wiring or foundation/pedestal.
**Some laborers are on site for the duration of only one specific task.

TABLE 7

LABOR EFFICIENCIES COMPARISON*

Labor Location	ARCO	BEC	MMC	MDAC
Central Manufacturing Facility				
Shift 1	0.80	0.89	0.85	0.92
Shift 2	0.80	0.88	0.85	0.92
Shift 3	0.80	0.83	**	**
Site				
Assembly				
Shift 1	0.75	0.83	0.84	N/A
Shift 2	0.67	0.79	0.84	N/A
Shift 3	0.58	0.63	**	N/A
Installation				
Shift 1	0.75	0.81	0.84	0.67
Shift 2	**	**	0.84	**

*Efficiency = productive work fraction.
**Not used.

TABLE 8

TRANSPORTATION COMPARISON*

CMF To Sites Transportation Results	ARCO	BEC	MMC	MDAC
Average Packing Density (Heliostats/Truckload)	6.06	2.74	4.07	1.80**
Truckloads From CMF/Day	33	73	50	112
Truckloads to Nominal Site/Day***	9	11	6	28

*Excludes controls and field wiring and foundation/pedestal.
**Special 10 ft wide oversize truck used.
***Based on nominal sites in progress/year: ARCO (~4), BEC (~7), MMC (~9), and MDAC (~4).

Manufacturing Facility Capital Costs--Each contractor provided costs for manufacturing facilities. These capital costs include land, improvements, buildings, equipment, and durable tooling. A comparison of the capital expenses predicted by each contractor is given in Table 9. Further capital expense breakdowns are provided in the manufacturing section. It is likely that the improved land for a CMF will cost in the $1 million to $2 million range. The cost estimates for a suitably constructed CMF and its associated facilities (but not colocated captive facilities) range from nearly $20 million to almost $40 million. Durable tooling and equipment cost estimates range from about $30 million for MMC to over $70 million for ARCO. ARCO, which manufactures most of its heliostat components, would be expected to spend the most money on equipment and tooling. MMC also makes many of its heliostat components and yet spends the least money on equipment and durable tooling. MMC appears to be somewhat optimistic in this area of its capital expense estimates.

Planning for Variable Production Rates--Each contractor provided production planning for the manufacture of heliostats at a rate of 50,000 per year. In addition, they provided alternate plans for a 50 percent production rate of 25,000 per year and a 135 percent production rate of 67,500 per year. A comparison of the production plans is given in Table 10. The advantage of using fewer shifts but paying higher wages for overtime or flextime is that additional fulltime workers need not be hired. The addition of more workers to a payroll would be more costly in benefits and

TABLE 9

CMF CAPITAL EXPENSE COMPARISON (M$)

Capital Requirements	ARCO	BEC	MMC	MDAC
Improved Land	0.7	2.4	2.5	0.6
CMF Buildings	19.8	31.9*	38.0	36.0
CMF Equipment & Durable Tooling	72.5	67.9	30.3	47.7
Total Capital Investment, M$	93.0	102.2	70.8	84.5

*BEC itemizes the $31.9M into costs for buildings plus normally associated building costs such as fencing, roads, parking lots, lockers, light fixtures, utility substation, permits, turnover costs, etc.

TABLE 10

PLANNING COMPARISON FOR VARIABLE PRODUCTION RATES
(Number of Shifts Required)

Production Rate (Heliostats/Year)	ARCO	BEC	MMC	MDAC
25,000	2*	1	1	1
50,000	3*	2	2	2
67,500	3*a	3	2a	2b

*Limited operations on second and/or third shifts.
a = plus some overtime.
b = plus work weekends using flextime.

fringes than would overtime for on-roll employees. Employment of low-cost labor, however, could warrant the use of additional workers rather than overtime by regular employees.

Cost Comparisons

The use of three comparative formats allows the total installed price breakdown to be viewed from different angles. One format may be of more interest to some audiences than others, but all of the formats are meaningful to an understanding of the total installed heliostat price.

The three formats address costs by (1) a cost breakdown structure into major heliostat parts, (2) location, and (3) components of required revenue. An associated cost table, using the contractors' estimates where possible, follows each format. Strict adherence to the format was not always possible because of the form or omission of detail in the data provided (Reference 7).

Costs by Cost Breakdown Structure--In order to compare the costs of similar heliostat parts, a division of the heliostat into five categories, or the cost breakdown structure (CBS), was developed. Table 11 shows the heliostat parts of each contractor's design that are included by SNLL in the five categories of the CBS. The content of each category is not necessarily the same as that shown in the contractor's report, and caution should be exercised in directly comparing costs. The contractors' estimates of first-year costs by the CBS are given in Table 12. According to this breakdown structure, the majority of costs are spent on drives and reflective assemblies for all of the contractors.

TABLE 11

SNLL COST BREAKDOWN STRUCTURE

Heliostat Major Parts	ARCO	BEC	MMC	MDAC
Reflective Assembly	Mirror Assy. Substrate Assy. Edge Molding	Mirror Modules Facet Attachment Brackets,Pads,Plates	Mirror Modules Doubler Attachments	Mirror Modules w/Hel. Support Structure
Drive Mechanism	Az Drive Stepper Motors, Limit Switches	Az Drive, Motor El Drive, Motor	Az/El Drive, Motors Stow Lock, Encoders Limit Switches, Cabling, Power	Az Drive, Motor El Drive, Motor POS/LIM Indicators Power Supply,Distr.
Controls and Field Wiring	HC/HFC HAC Power & Data Cabling, BCS	HC, HFC, HAC Field Power, Data Distr., BCS	HC, HFC, HAC Field Power, Data Distr., BCS	HC, HFC, HAC Field Power, Data Distr. Center, BCS
Foundation/ Pedestal	Foundation/ Pedestal	Foundation/Pedestal	Foundation/Pedestal Pedestal Interface Access Cover	Foundation/Pedestal
Support Structure	Torque Tube Truss Assy.	Torque Tubes Z-Beams Struts, Bars, Flanges Elevation Arms	El Beam Barjoists, crossbar Control Arms/Caps Stow Disc Mirror Mount Brackets	Main Beam Crossbeams Diagonal Beams

TABLE 12

COSTS BY COST BREAKDOWN STRUCTURE
(Contractors' Estimates, $\$/m^2$)

Heliostat Major Parts	ARCO	BEC	MMC	MDAC
Reflective Assembly - Factory* & Transportation	21.86	38.37	28.44	29.95
Drive Mechanism - Factory* & Transportation	36.76	33.90	27.49	23.17
Support Structure - Factory* & Transportation	10.90	15.79	8.74	13.62
Other** Reflective Assembly, Drive Mechanism & Support Structure - Factory	11.09	5.85	7.35	8.04
Reflective Assembly, Drive Mechanism, Support Structure - Site	14.97	9.16	7.15	3.98
Subtotal Reflective Assembly, Drive Mechanism & Support Structure, $\$/m^2$	95.58	103.07	79.17	78.76
Controls and Field Wiring	13.63	***	14.31	10.24
Foundation/Pedestal	11.40	23.72	10.46	16.90
Total Installed Heliostat Price, $\$/m^2$	120.61	126.79 (w/o controls and field wiring)	103.94	105.90

*Includes direct materials, direct labor, replacement allowance, and gross profit.
**Includes indirect costs, consumables, property tax and insurance, G & A, other.
***Not addressed.

Costs by Location--The costs can alternately be broken down in terms of the location with which they are associated. The three locations would be the CMF, the transportation from the CMF to the individual field sites, and the individual field sites. SNLL provides a cost-by-location analysis with two exceptions: costs associated with the controls and field wiring and the foundation/pedestal--whether at the CMF, during transportation, or during on-site activities--are accounted for in two independent categories.

This SNLL cost format appears as follows:

- Central Manufacturing Facility
  - Reflective Assembly
  - Drive Mechanism
  - Support Structure

- Transportation from CMF to Site
  - Reflective Assembly
  - Drive Mechanism
  - Support Structure

- Site
  - Reflective Assembly
  - Drive Mechanism
  - Support Structure

- Controls and Field Wiring

- Foundation/Pedestal

The contractors' estimates of costs by the above location breakdown are listed in Table 13. When costs are allocated in this fashion, the majority of costs for all the contractors are incurred at their CMFs.

Costs by Components of Required Revenue--The revenue required by the heliostat manufacturer to recover his costs and to provide a return on investment can be broken down into the following components:

- Direct Costs - materials and labor
- Site-Retained Capital
- Subcontracts
- Consumables
- Indirect Costs - plant and other
- G & A
- Capital Replacement Allowance
- Property Tax and Insurance
- Annualized One-Time Capital Costs
- Return to Investors - equity holders, bondholders
- Income Taxes

Each of these cost elements is discussed in the following section. A comparison of the costs incurred in these categories is also shown for the four contractors, based on their own estimates, in Table 14.

TABLE 13

COSTS BY LOCATION
(Contractors' Estimates, $\$/m^2$)

Location of Incurred Cost	ARCO	BEC	MMC	MDAC
Central Manufacturing Facility*	79.89	90.03	68.69	67.26
To-Site Transportation*	1.82	4.22	3.33	7.47
Site*	14.97	9.16	7.15	3.98
Subtotal Reflective Assembly, Drive Mechanism, & Support Structure, $\$/m^2$	96.68	103.41	79.17	78.71
Controls and Field Wiring	13.63	**	14.31	10.24
Foundation/Pedestal	11.40	23.72	10.46	16.90
Total Installed Heliostat Price, $\$/m^2$	121.71	127.13 (w/o controls and field wiring)	103.94	105.85

*Includes reflective assembly, drive mechanism, and support structure.
**Not addressed.

TABLE 14

COSTS BY COMPONENTS OF REQUIRED REVENUE
(Contractors' Estimates, $\$/m^2$)

Required Revenue Components	ARCO	BEC	MMC	MDAC
Direct Materials	52.11	68.50	53.97	49.16
Direct Labor	11.71	10.36	4.66	4.48
Consumables	1.42	0.63	2.33	3.57
Indirects	4.38	3.07	2.28	1.43
G & A*	6.48	2.65	3.27	2.90
Capital Replacement & Capitalization	6.01	5.31	4.96	3.34
Property Tax & Insurance*	0.46	1.45	0.17	0.43
Other	1.16	1.06	-0-	1.14
Transportation to Site	1.82	4.22	3.33	7.47
Gross Profit*	10.02	4.49**	4.20	4.79****
Subtotal Installed Price for Reflective Assembly, Drive Mechanism, Support Structure, $\$/m^2$	95.57	101.74	79.17	78.71
Controls and Field Wiring	13.63	***	14.31	10.24
Foundation/Pedestal	11.40	23.72	10.46	16.90
Total Installed Heliostat Price, $\$/m^2$	120.60	125.46 (w/o controls and field wiring)	103.94	105.85

*Incurred only at CMF.
**BEC has $\$2.73/m^2$ described as profit on material, labor, etc. included in those accounts; see text.
***Not addressed.
****Estimate by SNLL to reflect MDAC stated 15% internal rate of return at end of 10th year.

Direct Materials--The direct materials account includes charges for purchased materials and raw materials, plus an allowance for scrap on each. Purchased materials are those that are assembled without further processing. Already included in their costs are material, labor, transportation, and indirect charges, and a profit associated with the previous manufacture of these parts. However, at the entry to the CMF or the site, the entire cost is considered as a purchased material cost. Raw materials at the CMF undergo one or more manufacturing steps before assembly into the next higher level. Raw materials costs include shipping costs to the CMF or to the site location if applicable.

Direct materials costs can also be incurred in subcontracts. A subcontract can include direct materials (purchased and raw materials), delivery, assembly or installation labor, indirect charges, and a profit. These separate costs are not normally itemized by the subcontractor, so the direct materials portion may be difficult to determine.

Each contractor uses varying amounts of raw materials, purchased materials, and subcontracts, but the direct materials cost comprises at least 50 percent and as much as 70 percent of the total heliostat installed price. Nominal scrap fractions are 1 percent for purchased materials and 3 percent for raw materials, but these fractions vary among contractors. Factory scrap (and rework) is caused by either defective supplier parts or defective operations in the factory. Charges can result from returned products, parts under guarantee repaired by customers, and parts repaired at the sites. Factory scrap and rework charges could result from design changes made during the production year. The losses from theft, storm damage, etc., not covered by insurance must also be included.

Direct Labor--The direct labor account includes the costs incurred by all production employees whose working time is dedicated to the manufacture or assembly of a particular component or its parts. Transportation labor, and installation and checkout labor at the site, are considered direct labor. Employees that load and unload conveyors in the CMF or site assembly building are also included in the direct labor account.

The direct labor cost is based on the direct labor hours expended at a fully loaded direct labor cost rate. This rate should account for the base wage, Social Security payments, unemployment insurance, Workmen's Compensation, company contributions to insurance policies and pension funds, vacations, holidays, premiums (overtime, shift, cost of living allowance), and other fringes. Labor productivity is not normally included in direct labor rates and hence should be factored into the number of labor hours required.

Typical labor productivity fractions are about 0.8 to 0.9 in the CMF and about 0.65 to 0.85 in the field. The factory productivity rate depends on the degree of automation as well as many other factors. Some reasons for inefficiency--besides planned downtime from normal breaks--could be unplanned downtime resulting from power failures, machine or tool failures, accidents, meetings, and waiting for delivery of parts or stock.

The direct labor hours and fully loaded direct labor rates vary among contractors. The direct labor cost is roughly 6 to 12 percent of the total required revenue.

Site-Retained Capital--Certain facilities, equipment, and tooling used for assembly, site transportation, and installation at the site were then left at the site for the owner's use in field maintenance. Other equipment was provided specifically for site use in heliostat maintenance. Another site-retained cost, but not an annual expense such as O & M, is the cost for initial spares. These costs are capitalized over the number of heliostats at the site. The costs incurred by the contractors varied from about 4 to 6 percent of the installed heliostat price for site-retained capital equipment and for capital replacement.

Subcontracts--Subcontracts are expenses for manufacturing, transportation, or installation services that are purchased rather than provided or performed by the heliostat manufacturer. The allowance should include all costs for materials, labor, equipment use or rental, and profit. The heliostat manufacturer could also add a profit of its own to a subcontracted purchase. Subcontracts were used by most of the heliostat manufacturers. Examples included transportation from the factory to the site, as well as the manufacture or installation of foundations, power and cabling, and the beam characterization system (BCS). The number of subcontracts per contractor varies from none to several; therefore no typical subcontract cost is meaningful.

Consumables--The consumables account includes charges for all purchased supplies and materials that are necessary during the manufacturing, assembly, or installation processes but do not appear in the finished product. Consumables include utilities, operating and processing supplies, and perishable or nondurable tooling and equipment.

Utilities include the direct costs of purchased electricity, natural gas, fuel oil, water, and sewage disposal. Operating and processing supplies include the following: fuel oil, natural gas, or coal used in ovens, heat treating furnaces, and steam generators; lubricants, cutting compounds, and coolants for machinery and equipment; brooms, rags, and cleaning supplies (except maintenance supplies); office stationery and supplies; testing chemicals and supplies; packing and shipping supplies (except for reusable crates); tempering and quenching oils, process cleaning materials, fluxes, acids, etc.; and sundry supplies for drafting, engineering, dispensary, etc. Perishable or nondurable tooling includes cutters, drill bits, files, punches, grinding wheels, etc., that wear out in less than a year. Perishable or nondurable equipment includes special handling devices, spacers, etc., that do not last over a year.

Although consumable costs are design dependent, they typically represent about 1 to 5 percent of the installed cost of the heliostat. Some consumable costs are already included in subcontract costs, especially at the site, and in purchased material costs.

Indirects--Indirect costs include those incurred by plant maintenance, plant engineering, and all other nondirect labor functions. The indirect costs can be calculated as a fraction of direct labor costs, a fraction of direct material costs, a fraction of facility, equipment, and tooling costs, or any combination of them. Each contractor estimated indirect costs differently, but the indirect costs for all of the contractors were about 2 to 3 percent of the installed heliostat costs.

The plant maintenance and engineering costs include labor and material costs for land improvements, maintenance, and replacement of paving, sidewalks, sewers, fences, etc.; building maintenance and replacement, such as rearrangement of walls, plumbing, heating, lighting, and painting; maintenance and replacement of machinery, equipment, tooling, and fixtures, including oiling and cleaning; and rearrangement of plant processes, offices, and equipment. The costs associated with the plant upkeep are included as a fraction of the facility, equipment, and tooling costs.

The other indirect labor costs include charges for functions related closely to direct labor, direct materials, or capital costs. Those indirects associated with direct labor are the supervision personnel, foremen, and superintendents; inspectors and quality control personnel (line or repetitive inspections are included under direct labor); factory clerks and office typists; material handlers such as truckers and crane operators (handlers that load and unload conveyors, etc., are considered direct labor); production control and scheduling personnel; machine tool and die setting personnel; and other support personnel such as medical attendants, tool crib attendants, personnel services employees, and cafeteria workers.

Indirect laborers more closely allied to direct materials are purchasing and accounting personnel, and shipping and receiving personnel.

Other indirect costs are closely associated with capital costs (e.g., facility, equipment, and tooling costs) and are calculated as a fraction of them. These indirect costs include charges for property attendants such as janitors, yardmen, and security personnel.

General and Administrative (G & A)--The general and administrative cost account includes marketing costs and administrative costs. The marketing costs are for advertising, sales and promotion expense, sales engineers, traffic personnel, and billing and customer accounting personnel. A heliostat producer would deal with a limited number of customers and probably in a limited region but for extended periods of time.

The administrative costs are for overall corporate management, consultants, public relations, legal services, research and development, and contingency.

Every company treats the content of G & A differently; the grouping presented here is only one of many possible collections of costs. The G & A value should be representative of the restricted marketing expenses associated with manufacturing and installing heliostats in large fields. The contractors' G & A estimates range from about 2 to 8 percent of the installed heliostat price. An estimate of nominal G & A costs is difficult to predict with no comparable industries.

Capital Replacement Allowance--The capital replacement allowance account includes the cost for depreciation of capital equipment, facilities, tooling, and land improvements. The capital replacement allowance is the difference between book values of successive years that is not attributable to differences in working capital. For comparative purposes, the capital replacement allowance is annualized.

Typical contractor-supplied depreciation schedules for buildings, equipment, and tooling recovery periods using straight-line, 150 percent declining balance, or sum-of-years digits are as follows:

- Buildings - 12.5 years to 40 years
- Equipment - usually 10 years
- Durable Tooling - usually 5 years

New accelerated depreciation schedules shorten the recovery periods from 3 to 15 years. These costs were added to the site-retained capital expenses for a total of 4 to 6 percent of the installed heliostat price.

Property Taxes and Insurance--The property tax and insurance account includes the cost of city and county property taxes and the cost of insurance to protect against loss or damage to property, equipment, and materials from fire, flood, tornado, sprinkler malfunctions, etc., as well as from public liability. The cost depends on the book value, which changes each year. The book value includes the value of land, working capital, facilities, equipment, and tooling.

A nominal property tax and insurance rate might be about 4 percent per year; however, many large corporations have blanket insurance policies that may reduce or eliminate the need for the insurance portion. The property tax alone would be about 1 to 3 percent of the book value. The contractors' property tax estimates vary from much less than 1 percent to somewhat over 1 percent of the installed heliostat price.

Annualized Onetime Costs--Certain costs associated with the CMF construction and start-up are collected as onetime costs and annualized over the entire production run. These costs include an allowance for land and factory financing during construction, an allowance for excess factory costs during start-up, and a credit for an investment tax credit on equipment and tooling.

The cost of financing land before start-up is based on the land price and the length of time between the purchase and CMF start-up. The interest during construction is determined for the cost of the facility, the equipment, and the tooling--and the time between the expenditures and CMF start-up.

The investment tax credit applies only to equipment and tooling. The onetime credit is 10 percent.

The excess CMF cost during start-up (compared to steady-state operation) is annualized over the life of the CMF.

Return to Investors and Income Tax--The capital investment is financed totally by a combination of bond and common stock issues. The bond-to-stock ratio varies with each company. The bondholders are repaid from an interest account, while the stockholders are rewarded with both dividends paid and retained earnings that are used to increase the equity value. For comparison purposes, the cost of interest, dividends, and retained earnings are annualized to provide a single cost that accounts for the changing book value and inflation.

Income required to pay the return to equity, dividends, and interest must also be sufficient to pay federal and state income taxes. The income tax portion can be decreased on an annualized basis if an accelerated write-off method is employed. If straight line depreciation is used, then no tax reductions occur.

The working capital is costed as a fraction of the annual costs of direct materials, direct labor, consumables, and indirect charges; it changes each year depending on inflation. It corresponds to the fraction of a year that, on an average, the heliostat manufacturer awaits payment for his product. Since the book value is increased by working capital, the amount of income required to pay investors, property taxes, and insurance, if applicable, also is increased.

An average fraction for working capital used in this study was 0.17, or a two-month delay of payment for inventory required. This average accommodates normal billing, pipelines, and time between field installation and field checkout and turnover. None of the contractors' estimates considered working capital.

CMF

Central Manufacturing Facility

Each of the Second Generation Contractors provided a detailed scenario for mass producing heliostats. The manufacturing analysis section examines manufacturing plans, including choices and tradeoffs made by the contractors, and justifications for them.

The manufacturing cost analysis section examines the costs incurred by a heliostat manufacturer. The analysis includes costs for direct materials, direct labor, and various burden categories, and their effects on overall heliostat price. In this section, the costs incurred at the CMF are only for the reflective assembly, the drive mechanism, and the support structure.

Manufacturing Analysis

In this report, the rationales for the mass-manufacturing scenarios for Second Generation Heliostats are evaluated for completeness and feasibility. Each contractor provided a unique scenario that considered the following aspects of the CMF:

- Site selection
- Facilities design
- Production equipment and tooling
- Manufacturing operations
- Labor requirements

The contractors determined the land requirements, building types, specific manufacturing and support tasks to be performed, types of equipment and tooling needed, process flow, number and types of direct and indirect personnel required, space necessary for specific tasks, and types of handling and packaging necessary.

The manufacturing tradeoffs considered in the contractors' production scenarios include:

- Colocation of a captive manufacturing facility vs. use of outside suppliers for heliostat parts
- Vertical vs. horizontal integration
- Automation vs. manual labor
- CMF assembly vs. site assembly of major heliostat parts

Tradeoff decisions varied among the contractors as a result of differing cost assumptions (detailed in the cost section of this report) and diverse company policies.

Site Selection--In selecting a CMF site, the contractors considered the cost and availability of a variety of factors: labor, land, buildings, taxes, transportation to market, utilities, natural resources, and municipal financial incentives. Other influential factors included state business climate ranking, insolation, topography, market potential, unemployment, and community population.

Final selections were based on different combinations of all these factors. The choices also depended on both the importance that the contractor placed on each factor and the way it typically conducted business.

Two contractors, ARCO and MMC, chose Albuquerque, New Mexico, as the site for the CMF. ARCO selected Albuquerque because of the available natural resources; adequate labor supply; favorable costs for labor, taxes, and transportation; and access to highways and railways. MMC selected Albuquerque for similar reasons, as well as municipal financial incentives and the favorable ranking of New Mexico's business climate.

Phoenix, Arizona, was the site selected by BEC for its CMF and colocated cellular glass plant. Among the reasons BEC gave for its choice were the city's proximity to potential electric plants; adequate supplies of land, labor, and energy; access to highways and railways; and the high insolation and suitable topography around Phoenix.

MDAC chose Tuscon, Arizona, for the site of its CMF. Reasons cited for the selection were its centralized shipping location, adequate labor and supporting industries, and favorable building and labor costs.

During the course of the Second Generation Heliostat contract, SNLL performed a site selection analysis. Results of that analysis appear in Appendix A.

Facility Design--Each contractor provided a conceptual design of a CMF that would produce 50,000 heliostats per year. Factors considered in the design included land requirements, building type, space allocation for different heliostat parts, plant processes, equipment and tooling necessary for processing, support facilities to accommodate the plant processes and the employees, and colocated facilities to supply materials.

ARCO proposes to locate its CMF on 60 acres. The improved land cost is $0.72 million, or $12,000 per acre. Its CMF contains 620,000 square feet of space. Included in the building costs are areas for administrative personnel, a parking lot, support activities, and the various production processes, including a high bay overhead area for a paint line. The facility cost is about $19.8 million, or about $32 per square foot. ARCO has recently constructed similar buildings equipped with heating, cooling, and auxiliary equipment for other purposes for only about $20 per square foot. Therefore ARCO believes that its building cost estimate is a conservative one.

BEC proposes to locate its CMF on 75 acres. The improved land cost is $2.4 million, or $32,000 per acre. An independent cellular glass manufacturing plant is adjacent to the CMF but not within the 75 acres. The CMF includes two separate manufacturing facilities, one for mirror facets and the other for gimbals and frames. It also includes parking lots and fencing, administration and support facilities, and a separate building for galvanizing. Total enclosed floorspace (including administrative and employee facilities) is about 638,000 square feet. The CMF costs about $50 per square foot, for a total facility construction cost of $31.9 million. Building materials include structural steel frames, concrete walls, reinforced concrete floors, and an insulated roof. Some of the facility's features are fire protection sprinklers, air conditioning, and high bay areas.

MMC would build its CMF on approximately 80 acres. The operation would require about 15 more acres for miscellaneous facilities (such as an electrical substation) and would consume the output of colocated captive facilities on an adjacent 30 acres. The cost of 95 acres of improved land is $1.9 million, or $20,000 per acre. MMC does not provide a plant layout but does allocate floorspace to various categories such as processing heliostat parts, aislespace, and support facilities. The cost of the 507,000-square-foot facility is about $38 million, or $75 per square foot.

MDAC requires 40 acres for its CMF. The improved land cost is $0.8 million, or $20,000 per acre. This facility contains floorspace for processing various heliostat parts, administrative services, and other support needs. Total enclosed floorspace is about 260,000 square feet, for a total of $36 million, or $138 per square foot. Building costs include such features as high bay construction, air conditioning, reinforced concrete flooring, basic support utilities and equipment, site fencing, a power substation, fire sprinklers and a firehouse, and a 450,000-square-foot outside staging area.

The wide variations noted for land and building costs are a function of company practice, quotations received from outside sources, and other factors. Capital cost of the improved land (from $0.7 million to $2.4 million) is small when compared to building costs. Building costs will likely be in the $20 million to $40 million range depending on building size and features. The space allocated by the contractors for manufacturing operations seems reasonable, particularly when the various make/buy decisions are considered. The actual manufacturing space allotted for different tasks is shown in Table 15. Aislespace has been removed from square footage allotments where possible, and the total floorspace used for manufacturing activities has been contrasted to the total building area. Depending on the contractor, actual manufacturing activities, excluding aislespace, occupy from about 40 percent to 60 percent of the total building area.

Production Equipment and Tooling--Each contractor provided detailed breakdowns of the equipment and tooling required for the various process steps in heliostat manufacture. The costs of necessary equipment and tooling were estimated on the basis of past experience, vendor quotes, and engineering judgment. Table 16 summarizes capital equipment dollars for equipment and tooling at the CMF. In the cases of BEC and MMC, plant equipment costs designated as "support" or "miscellaneous" were allocated either as drive and support structure equipment costs or included in capital building costs if such costs were normally associated with the purchase of a building. Although BEC and MDAC reported shipping crates as equipment, those costs are not included here; they have been accounted for under transportation costs. In some cases, MMC and ARCO did not classify items as equipment

TABLE 15

CMF SPACE ALLOCATIONS (ft^2)

Heliostat Major Parts	ARCO	BEC*	MMC*	MDAC
Reflective Assembly	30,000 Mirroring 120,000 Assembly	134,400**	79,000	61,400
Drive Mechanism	170,000	94,500	85,000	46,700
Support Structure	54,800	39,900	22,000	38,300
Controls and Field Wiring	22,100	Not Included	***	2,200
Foundation/Pedestal	24,800	0	***	6,300
Other	60,000 Painting Penthouse	12,600 Galv. Bldg.		
Mfg Floor Space, ft^2	482,000**	281,000	186,000	155,000
Total Enclosed Space, ft^2	620,000	638,000	507,000	260,000

*Floorspace in colocated captive facilities not included.
**Includes aislespace. Otherwise aislespace is excluded.
***Included in total.

TABLE 16

CMF CAPITAL COST FOR EQUIPMENT AND TOOLING (M$)

Heliostat Major Parts	ARCO	BEC	MMC	MDAC
Reflective Assembly	9.2	15.2	6.9	7.2
Drive Mechanism	54.3	40.8	19.6	17.6
Support Structure	6.6	3.3	2.4	9.2
Controls and Field Wiring	0.7	*	0.1	4.3
Foundation/Pedestal	1.5	**	0.6	1.5
Equipment Cost, M$	72.2	59.4	29.6	39.8
Special and Durable Tooling Cost, M$	0.3	8.5	0.8	7.9
Total Equipment and Special and Durable Tooling Cost, M$	72.5	67.9	30.3	47.7

*Estimate not included.
**Subcontracted.

or durable tooling; SNLL therefore categorized them as such according to their functional description, estimated lifetimes, and costs.

MMC spends the least dollars on equipment and durable tooling at about $30 million. ARCO spends the most at about $72 million. Costs for the BEC and MDAC durable tooling and equipment are between those for ARCO and MMC. The MMC tooling and equipment costs seem somewhat low, especially considering that MMC makes quite a few of its heliostat parts. The other estimates seem consistent with the types of operations performed at the respective CMFs.

Table 17 summarizes the direct labor hours associated with the production of the various heliostat parts, including controls and foundation/pedestal. The more direct labor hours spent in producing a heliostat, the more equipment used by the laborers in the heliostat's production. However, the use of more equipment does not necessarily imply that more direct labor hours are spent in production. For an example, automated equipment may reduce direct labor hours but might require a capital investment equivalent to or greater than that for nonautomated equipment. Dollar values in Table 16 for special and durable tooling do not include any nondurable tooling costs which may have been provided by the contractors. These costs are instead accounted for under consumable item costs.

Drive equipment represents the greatest capital equipment expense. In all cases, the dollar amount for drive equipment and the hours spent per heliostat total over half of the capital equipment expense and direct labor hours at the CMF. Generally, the next most expensive machinery and second greatest number of hours spent per heliostat are attributed to mirror module production, followed by support structure production. The exception to this generalization is MDAC, which spends more time and equipment dollars on its support structure than on its mirror modules. The hours per heliostat spent on controls and foundation/pedestal are small for BEC and MMC when compared to their total hours per heliostat. For ARCO and MDAC, however, about 10 percent of total direct labor hours is spent on controls. In addition, MDAC spends about 10 percent of its total capital equipment cost on control-designated equipment. ARCO and MMC spend much smaller dollar amounts in this area. BEC does not estimate the capital expense required to purchase the equipment or the labor hours to assemble controls.

The final line of Table 9 (Comparative Formats section) sums all capital expenses required for land, equipment, special and durable tooling, and buildings for a CMF. Surprisingly close, the totals seem to indicate that a viable CMF could be funded and operating for a capital investment of $70 million to $100 million.

<u>Manufacturing Operations</u>--Each contractor designed a conceptual manufacturing plan for producing 50,000 heliostats per year. Contractors considered such variables as types of tasks performed, hours required per task, equipment and tooling, number of direct laborers to operate machinery, efficiency of laborers, and support personnel. In addition, the contractors provided production planning for a 50 percent production rate of 25,000 units per year and a 135 percent production rate of 67,500 units per year.

TABLE 17

CMF DIRECT LABOR SUMMARY
(First-Year Direct Labor Hours per Heliostat)

Heliostat Major Parts	ARCO	BEC	MMC	MDAC
Reflective Assembly	3.51	4.53	2.84	1.94
Drive Mechanism	17.11	11.06	5.61	6.22
Support Structure	2.44	2.60	1.73	2.12
Controls and Field Wiring	2.33	*	Purchased	1.32
Foundation/Pedestal	1.00	Purchased	0.17	0.54
Total CMF Direct Labor, Hours/Heliostat	26.39**	18.19	10.35	12.14

*Estimate not included.
**Estimate does not include inefficiency of 20% and should total 31.67 hours/heliostat.

Summaries of the major production operations conducted at the contractors' CMFs are given in Table 3 (Comparative Formats section). Detailed descriptions of many specific operations are provided in the contractors' final reports. Capital equipment dollars and direct labor hours spent at the CMF on the specific heliostat parts were discussed in the previous section and are compared in Tables 16 and 17.

Labor Considerations--Each contractor determined the number of direct laborers needed at its CMF. In addition to those laborers required for the actual hands-on production of heliostats, various support service personnel such as secretaries, janitors, buyers, and supervisors are also required. Thus, indirect personnel requirements were determined based on current experiences or projected business practices. Synopses of labor requirements at the CMF, efficiencies, and work shifts for various production rates are provided in Tables 6, 7, and 10 (Comparative Formats section).

To produce 50,000 heliostats per year, ARCO employs 787 direct laborers and 180 indirect (including salaried) workers at its CMF. The ratio of indirect workers to direct workers is very low for ARCO as compared to the other three contractors.

BEC employs 456 direct laborers and 536 indirect workers at its CMF. This information was presented in an informal review with BEC and is not contained in BEC's detailed design or final reports. Some of the indirect labor force estimated by Ford for BEC's gimbal and frame manufacturing plant and by Pittsburgh Corning for BEC's facet assembly plant were combined to eliminate redundancy in certain areas, e.g., administrative tasks. Hence, the Ford and Pittsburgh Corning work force total does not equal the number presented by BEC at its informal review.

MMC proposes to use 258 direct laborers and 236 indirect and salaried workers in its CMF. It is somewhat surprising that MMC's total CMF work force is the smallest of all the Second Generation Heliostat contracts, since MMC anticipates making many of its heliostat parts.

MDAC employs about 320 direct laborers and 250 indirect or salaried workers in its CMF. Its total labor force includes workers estimated by General Motors for the majority of the heliostat production and workers added by MDAC for controls production. Fixed and variable indirect costs were calculated as an annual burden. SNLL estimated manpower allotments based on MDAC indirect cost estimates and private communication with MDAC.

BEC, MMC, and MDAC use two shifts of workers to produce 50,000 heliostats per year. ARCO has limited operations on an additional third shift because it makes so many of its heliostat parts. For a 50 percent production rate of 25,000 heliostats per year, each contractor except ARCO proposes to cut back to one shift per day; ARCO has limited operations on a second shift. For 135 percent production, ARCO and BEC use three shifts. ARCO again has operations on the third shift but plans to use some overtime as well. Although MMC and MDAC use only two shifts, MMC uses some overtime labor, and MDAC has its laborers work weekends using flextime.

CMF efficiencies were estimated by each contractor. ARCO estimated a nominal efficiency, or productive work fraction, of 80 percent. BEC estimated an 89 percent worker efficiency on the first shift, 88 percent on the second shift, and 83 percent on the third shift. MMC estimated a nominal 85 percent efficiency, while MDAC estimated a 92 percent efficiency. ARCO's estimate of 80 percent is probably reasonable since its manufacturing operations are quite labor intensive. MDAC's estimate of 92 percent may also be reasonable since its operations are automated and do not depend as much on human-related factors.

Manufacturing Tradeoffs--Each contractor followed one particular strategy for the manufacture and installation of heliostats. To decide that strategy, the contractors considered using colocated facilities vs. outside suppliers, horizontal vs. vertical integration (i.e., buying vs. making components), manual labor vs. automation, subcontracts vs. in-house labor, and on-site labor vs. central plant labor to accomplish similar tasks. Decisions concerning these tradeoffs were based on a unique set of assumed premises for each contractor. These premises would include, for instance, the manner in which the company normally conducts business, the labor rates assumed for factory and site, and the quotes and estimates provided by suppliers or other outside sources. If one premise were changed, the entire manufacturing scenario might change.

Colocated Facilities vs. Outside Suppliers--Both BEC and MMC locate support manufacturing facilities adjacent to their CMF. BEC uses cellular glass in its mirror modules. Because the composition and processing of this material are proprietary, Pittsburgh Corning, the manufacturer, would produce this glass in a factory located adjacent to BEC's CMF.

A captive fusion glass plant and a captive casting foundry are colocated with MMC's CMF. Both facilities are sized to produce only enough materials for 50,000 heliostats per year. MMC's rationale for using colocated facilities is an assured supply of castings; cost savings in the areas of transportation, packaging, handling, and storage facilities; and rapid mirroring of glass. (Delays in mirroring glass have sometimes been associated with stains which appear on the mirrors.)

Although the use of colocated captive facilities might necessitate partial capital funding by the CMF, BEC and MMC concluded that such facilities are still cost effective. Costs of colocated facilities are amortized in the costs of castings ($/lb) and glass ($/ft^2) for MMC and in the cost of cellular glass ($/board ft) for BEC.

Benefits of colocated facilities include increased yield (as a result of less breakage in transit) and more rapid feedback about product quality (because of easier communication between the CMF and the captive plant). Also, material supply is guaranteed since the product is always available from the nearby captive facility; no contingency plans need be made to obtain it from other sources. On the other hand, should the colocated facility shut down unexpectedly, no other suppliers exist to step in rapidly and meet the demand for the product. The heliostat manufacturer is therefore quite dependent on its colocated facility as a sole source supplier.

The colocation of certain manufacturing facilities with the CMF may be cost effective, especially when a great demand for or an uncertain supply of a product exists. For example, the output from U.S. casting foundries is being consumed rapidly, and backorders are not uncommon.

The colocation of a fusion glass plant with the CMF, however, may not be warranted. Corning Glass Works, the producer of fusion glass, is not currently using the full capacity of its Blacksburg, Virginia, plant. Glass production for 50,000 heliostats per year would consume about twice the potential output of the Blacksburg plant, and Corning is willing, and has the enclosed plant space, to double this facility's capacity. Expanding the furnace capability of an existing facility would cost much less than a new facility.

Horizontal vs. Vertical Integration (Buying vs. Making Components)--ARCO elects to make most of its heliostat parts in a rather large, but inexpensive, CMF. Approximately 26 direct labor manhours are required to build one ARCO heliostat. ARCO's manufacturing operations include rolling and welding the steel pedestal and mirroring the float glass used for mirror modules. The high degree of vertical integration proposed by ARCO increases internal profit but requires increased capital expense for equipment. To build 50,000 heliostats per year, ARCO employs 787 direct laborers at its CMF at a fairly low wage rate. If ARCO had to pay higher wages to its laborers, or if its building costs more than anticipated, the manufacturing strategy might change considerably to include fewer laborers, more purchased parts, and less equipment, tooling, and building space for manufacturing.

On the other extreme is MDAC which buys almost all of its parts, such as gears and bearings, and assembles them into heliostats at its CMF. MDAC uses only about 12 direct labor manhours to build one heliostat. At MDAC's CMF, the approximately 320 direct laborers are paid more than the prevailing wage because a higher skill level is required of them. (For example, skilled laborers are needed to operate the automated mirror module and drive fabrication equipment at the CMF). MDAC's low degree of vertical integration decreases internal profits on each heliostat part, but it reduces the number of direct labor hours required to assemble a heliostat. Thus, the greater capital expense of automated lines is offset by the smaller number of laborers required for heliostat assembly. Likewise, higher wage rates are offset by lower incidences of human error because of automated processes. MDAC ships bulky, nearly complete heliostats to the sites and does no site assembly indoors. Although shipping is costly, MDAC concludes that the increased costs are offset by more labor at plant wages than at the higher site wages.

BEC and MMC fall between ARCO and MDAC. MMC makes more heliostat parts such as glass mirroring and support structures than BEC, which buys these types of items. Both MMC and BEC use the output of colocated captive facilities. MMC proposes to locate a casting foundry and a fusion glass plant adjacent to its CMF. BEC proposes to situate a cellular glass plant adjacent to its CMF for materials for its mirror modules.

Automation vs. Manual Labor--The use of partially automated facilities to manufacture at least some heliostat parts may be cost effective. While 50,000 units per year is not normally considered "mass production," certain parts such as mirror modules are required in substantially greater quantities. Mirror modules, of which 12 or 14 are needed per heliostat, need to be produced at a rate of 600,000 to 700,000 per year, which does approach more typical mass production rates. The use of labor-intensive, assembly-line type operations may be warranted for those parts produced in smaller quantities per year. But automation of certain manufacturing processes may be more prudent for those parts required in multiple units per heliostat. Automation results in less human error and faster production rates. It also enables several tasks to be performed on one piece of equipment. In a labor-intensive operation, several pieces of equipment may be needed to perform the same overall tasks. For that reason, equipment costs may even be less in an automated facility than a labor-intensive one. Furthermore, since parts are produced at faster rates in automated facilities, fewer shifts of workers may be required to produce the required 50,000 heliostats per year.

Subcontracted vs. In-House Labor--ARCO and BEC subcontract controls and field wiring and the foundation/pedestal. ARCO also assembles its own controls. MMC subcontracts not only the controls and field wiring and the foundation/pedestal installation but also the assembly of the control circuits. MDAC performs all tasks using in-house labor.

One advantage of subcontracts is that additional workers need not be either temporarily or permanently employed by the heliostat manufacturer. While a subcontractor may or may not be supplied with additional work after a task is completed, more work would have to be created for on-roll employees. However, one disadvantage of subcontracted labor is that any resultant profit (created by more rapid completion of a contract than anticipated, for instance) does not benefit the heliostat manufacturer. On the other hand, the heliostat manufacturer does not risk the subcontractor's potential losses (delays caused by inclement weather, etc.).

On-Site Labor vs. Central Plant Labor--Excluding the controls and field wiring and foundation/pedestal, the number of direct labor hours spent per heliostat on site varies from 3 hours for MDAC to 21 hours for ARCO--or from 24 percent (MDAC) to 48 percent (ARCO) of total direct labor hours per heliostat. BEC and MMC fall between ARCO and MDAC, spending 14 and 10 hours, respectively, on site per heliostat.

The advantage of using more factory labor than on-site labor is lower total direct labor costs. On-site labor rates typically are more than factory labor rates. And since field inefficiencies are typically lower than factory inefficiencies, a factory worker generally performs more work at less cost and in less time than a site worker. However, at least one disadvantage of completing more work at the CMF exists: transporting bulky, nearly finished units is costly. MDAC's high transportation costs attest to this drawback.

Manufacturing Costs Analysis

The purchase price of a manufactured heliostat can be broken down into costs for direct materials, direct labor, and burden. The direct materials category includes all purchased and raw materials that comprise the final assembled heliostat. Cost for direct labor is the product of the number of hours of actual manufacture/assembly of heliostat parts and the fully loaded direct labor rate. The burden category includes profit plus all other expenses not accounted for under direct materials or direct labor, such as consumables, indirect labor, general and administrative (G & A), capital replacement, taxes, and insurance.

The discussion and sets of tables which follow compare costs per square meter for direct materials. Direct materials are emphasized in this section because, of all three categories, this one had the greatest impact on cost. Details on other cost components can be found in each contractor's report.

Direct Materials--Although the contractors have different designs for the reflective assembly, drive mechanism, and support structure, many of the materials used for these major parts are similar (glass, silver, steel, adhesives, castings, fasteners, etc.). However, the materials as they are received at the factory vary from raw goods to finished parts. Since each contractor wants to minimize costs, any part which is purchased probably costs less than the raw materials, labor, and burden required to produce its equivalent part in the factory.

Contractors' sources of supply vary as widely as pricing scenarios; consequently, different prices are charged for similar materials, with each price being equally valid. This study will not determine if one estimate is more valid than another, but instead it will present comparative data for the reader to consider.

Direct materials costs are a large fraction of the total installed price of a heliostat. For comparative purposes, the CMF direct materials costs are divided according to the three major heliostat parts. These parts categories are subdivided, where possible, into other relevant and comparable areas. Some data are not available from the contractors' reports, so side-by-side comparisons are not always possible.

Cost breakdowns for factory direct materials are shown in Table 18 (summary), Table 19 (reflective assembly), Table 20 (drive mechanism), and Table 21 (support structure). A discussion of each table points out both similarities and differences.

Reflective Assemblies--Direct materials costs for the individual reflective assemblies are broken down in Table 19. Each reflective assembly includes mirrored glass, a structure to support the mirrored glass, and edge seals around the mirror to prevent water penetration.

Costs of the mirrored glass are comparable for three of the four contractors. BEC, MMC, and MDAC use mirrored Corning Glass Works 7809 fusion glass at a cost of about $\$8/m^2$. ARCO uses mirrored low-iron float glass at a cost of about $\$5.50/m^2$. Fusion glass costs more since it is not produced in such great quantities as float glass and its processing is somewhat more complicated. However, raw materials for fusion and low-iron float glasses might cost more than those for fusion glass, since low-iron silica is required for its production.

It is interesting to note that the direct materials costs for MMC's mirrored glass, which is manufactured at a colocated captive fusion glass facility, are nearly the same as those for BEC and MDAC, which buy the mirrored glass from Corning's Blacksburg, Virginia, plant and ship it cross-country. The use of a colocated facility for mirrored glass thus results in

TABLE 18

CMF DIRECT MATERIALS COSTS
(Contractors' Estimates, $\$/m^2$)

Heliostat Major Parts	ARCO	BEC	MMC	MDAC
Reflective Assembly	18.19	31.31	24.24	20.67
Drive Mechanism	24.97	24.90	22.80	17.83
Support Structure	8.54	11.98	6.84	10.66
Total CMF Direct Materials Costs, $\$/m^2$	51.70	68.19	53.88	49.16

TABLE 19

CMF REFLECTIVE ASSEMBLY DIRECT MATERIALS COSTS
(Contractors' Estimates, $\$/m^2$)

Reflective Assembly Parts	ARCO	BEC	MMC	MDAC
Mirror	5.33	8.79	7.71	8.12
Glass	(4.69)	(4.73)	(5.54)	*
Silver/Cu/Paint	(0.64)	(4.06)	(2.17)	*
Stiffening	11.83	19.84	15.25	9.69
Sealing	0.87	2.68	1.28	2.90
CMF Reflective Assembly Direct Materials Costs, $\$/m^2$	18.03	31.31	24.24	20.71

*Included in total.

TABLE 20

CMF DRIVE MECHANISM DIRECT MATERIALS COSTS
(Contractors' Estimates, $\$m^2$)

Drive Mechanism Parts	ARCO	BEC	MMC	MDAC
Castings	10.02 ($0.48/lb avg)	*	3.61 ($0.31/lb)	*
Steel Parts	1.81 ($0.45/lb avg)	*	3.84 ($0.57/lb avg)	*
Azimuth Drive	**	13.45	**	4.20
Elevation Drive	**	4.35	**	8.47
Motors	5.68	3.54	4.39	2.14
Other Electrical, Sensors	0.49	1.26	7.48	2.52
Other Miscellaneous	6.97	2.30	3.48	0.50
CMF Drive Mechanism Direct Materials Costs, $\$/m^2$	24.97	24.90	22.80	17.83

*Breakdown by drive elements.
**Breakdown by materials in drive elements.

TABLE 21

CMF SUPPORT STRUCTURE DIRECT MATERIALS COSTS
(Contractors' Estimates, $\$/m^2$)

Support Structure Parts	ARCO	BEC	MMC	MDAC
Torque Tube/ Main Beam	4.78 ($0.30/lb)	4.87 ($0.32/lb)	3.35 (~$0.23/lb avg)	1.85 ($0.32/lb)
Framework	3.76 ($0.30/lb)	6.20* (~$0.33/lb avg)	3.32 (~$0.20/lb avg)	8.44 (~$0.36/lb avg)
CMF Support Structure Direct Materials Costs, $\$/m^2$	8.54	11.07	6.67	10.29

*$\$1.59/m^2$ shipping cost from supplier direct to site not included here.

savings of only about 7 percent. The advantage of a colocated captive fusion plant may be not so much in direct monetary savings as in less breakage in transit and simplified handling procedures.

Mirror support materials vary in cost among the four contractors from around $\$10/m^2$ (MDAC) to almost $\$19/m^2$ (BEC). The MDAC cost is fairly low because float glass, shims, and metal stringers back the mirrored fusion glass. Float glass is relatively inexpensive and readily available in the large sections required. The simply shaped metal stringers and shims are bonded with adhesive to the float glass backing.

In the case of BEC, mirror support materials consist of a cellular glass core and a second piece of fusion glass backing the core. The core is composed of relatively expensive cellular glass pieces that are made in a batch process and adhesively bonded on the sides to form the core for each reflective panel. The core is adhesively bonded on both its top and bottom to fusion glass.

Costs for the MMC and ARCO mirror support materials are intermediate between those for BEC and MDAC. MMC uses an aluminum honeycomb core while ARCO uses steel channel sections as a core. In both instances, a readily producible core material is faced both top and bottom by sheet steel. The top steel face sheet backs the mirrored glass.

Costs for edge-sealing materials for the reflective assemblies are small: from less than $\$1/m^2$ for ARCO to over $\$3/m^2$ for MDAC. Each design requires an edge seal between the mirrored glass and the edge of the mirror support. ARCO and MMC also seal a center strip between two of the mirror facets for each reflective panel. BEC applies a sealant around the edge and across the entire thickness of its cellular glass core.

Drive Mechanisms--Costs ($\$/m^2$) for direct materials used in the Second Generation drive mechanisms are shown in Table 20. Where information was provided by the contractors, the costs were allocated to castings or to steel parts. Otherwise, the costs were simply allocated to either the azimuth or the elevation drive. Total direct materials costs for the drive mechanisms are quite similar, in the range of \$23 to $\$25/m^2$, for ARCO, BEC, and MMC. Total direct materials costs for the MDAC drive are about $\$18/m^2$.

The MMC unfinished castings cost \$0.31/lb, while the ARCO castings cost an average of \$0.48/lb. MMC claims that a colocated captive foundry can make and sell castings to the CMF at almost half the cost of castings obtained from outside suppliers. The MMC estimate accounts for raw materials, profit, return on investment, equipment cost, capital investment, and other expenses associated with such a foundry.

Support Structure--Costs for direct materials used in the support structure are shown in Table 21. Costs (\$/lb) of the torque tube or main beam are quite similar for ARCO, BEC, and MDAC at about \$0.30/lb. Direct materials used in the MMC torque tube cost an average of about \$0.23/lb. Both ARCO and MMC buy coiled metal stock and form their own torque tubes. BEC buys a preformed torque tube, and MDAC buys a premade main beam.

A similar comparison can be made for the direct materials costs of the heliostat frameworks (cross beams, trusses). ARCO, BEC, and MDAC cost the framework direct materials at about $0.30/lb. Again, MMC's cost estimate was lower at about $0.20/lb. Both ARCO and MMC manufacture their entire truss support structures, while BEC and MDAC purchase preformed metal framework and perform some assembly operations.

It would seem that preformed parts should cost somewhat more than coil stock, but this assumption is not entirely substantiated by the contractor estimates. ARCO's estimates for those materials processed into support structure components are a few pennies per pound lower than BEC's or MDAC's estimates for preformed components. MMC estimates significantly lower costs than any of the other contractors for its support structure materials.

Direct Labor and Burden Costs--CMF costs for direct labor and burden are allocated among the contractors in the following tables:

Table 22. CMF DIRECT LABOR
Table 23. CMF CAPITAL REPLACEMENT ALLOWANCE
Table 24. CMF GROSS PROFIT
Table 25. CMF PROPERTY TAXES AND INSURANCE
Table 26. CMF CONSUMABLES
Table 27. CMF INDIRECT LABOR
Table 28. CMF GENERAL AND ADMINISTRATIVE AND ONETIME COSTS

A summary of the CMF required revenue for the reflective assembly, drive mechanism, and support structure is shown in Table 29. All of the costs are from the contractors' reports, but Sandia divided the total costs into the above categories to allow some comparison.

TABLE 22

CMF DIRECT LABOR COSTS
(Contractors' Estimates, $\$/m^2$)

Heliostat Major Parts	ARCO	BEC	MMC	MDAC
Reflective Assembly	0.44	1.52	0.51	0.64
Drive Mechanism	2.20	2.75	1.00	2.06
Support Structure	0.31	0.65	0.31	0.70
CMF Direct Labor Costs, $\$/m^2$	2.95	4.92	1.82	3.40
Base Wage	5.39*	7.50	5.90	8.06
Premiums				
Overtime	0	**	0.41	0.36
Shift Differential	0.16*	**	0.58	0.30
COLA	0	**	1.03	0.92
Fringe	1.34*	3.00**	2.33	9.24
Loaded Direct Labor Rate, $/hour	6.89	10.50	10.25	18.88

*Includes factor of 1.2 to account for inefficiency.
**Includes premiums.

TABLE 23

CMF CAPITAL REPLACEMENT ALLOWANCE COSTS
(Contractors' Estimates, $\$/m^2$)

Heliostat Major Parts	ARCO	BEC*	MMC	MDAC
Reflective Assembly	0.48	~0.92	0.46	0.41
Facilities	(0.13)	(**)	(0.23)	(0.13)
Equipment/Tooling	(0.35)	(**)	(0.23)	(0.28)
Drive Mechanism	2.19	~2.60	0.84	0.94
Facilities	(0.14)	(**)	(**)	(0.10)
Equipment/Tooling	(2.05)	(**)	(**)	(0.84)
Support Structure	0.31	~0.33	0.14	0.58
Facilities	(0.06)	(**)	(**)	(0.08)
Equipment/Tooling	(0.25)	(**)	(**)	(0.50)
CMF Capital Replacement Costs, $\$/m^2$	2.98	3.85	1.44	1.93

*Allocation was made by SNLL since BEC did not provide data.
**Included in total.

TABLE 24

CMF GROSS PROFIT COSTS
(Contractors' Estimates, $\$/m^2$)

Heliostat Major Parts	ARCO	BEC	MMC	MDAC
Reflective Assembly	1.87	2.99	1.54	1.53
Drive Mechanism	7.04	3.17	2.23	1.96
Support Structure	1.11	1.06	0.44	1.30
Total Gross Profit Costs (ROI + taxes), $\$/m^2$	10.02	7.22	4.21	4.79
Return On Investment (ROI) After Taxes	20%,*** or > 15%****	*	17.5%	**

*See text; $2.73 of $7.22 is described as profit on material, labor, etc., rather than ROI.
**15% internal rate of return at end of 10th year; estimate shown by SNLL.
***Value in ARCO report.
****Private communication 8/81.

TABLE 25

CMF PROPERTY TAXES AND INSURANCE COSTS
(Contractors' Estimates, $\$/m^2$)

ARCO	BEC	MMC	MDAC
0.46	1.45 (includes 0.34 insurance)	0.17	0.48

TABLE 26

CMF CONSUMABLES COSTS
(Contractors' Estimates, \$/m^2)

Components of Consumables	ARCO	BEC	MMC	MDAC
Utilities	1.42	0.37	0.68	0.65
Scrap	*	***	0.22	1.54
Perishable Tooling	*	***	1.26	0.34
Supplies	*	0.11	0.09	0.75
Sundry	1.03**	***	***	0.29
Total CMF Consumables Costs, \$/m^2	2.45	0.48	2.20	3.57

*Included in material costs.
**Assumed by SNLL to be part of "Sundry."
***No specific entry.

TABLE 27

CMF INDIRECT LABOR COSTS
(Contractors' Estimates, $\$/m^2$)

Components of Indirect Labor	ARCO	BEC*	MMC	MDAC
Fixed, Overhead, Salaried	1.12	**	0.30	0.90
Variable, Indirect, Hourly	0.58	**	1.42	0.18
Total CMF Indirect Labor Costs, $\$/m^2$	1.70	0.21	1.72	1.08

*Design change administration = 0.08, power utilities and facility maintenance = 0.13.
**Included in total.

TABLE 28

CMF GENERAL AND ADMINISTRATIVE (G & A) & ONETIME COSTS
(Contractors' Estimates, $\$/m^2$)

Cost Components	ARCO	BEC	MMC	MDAC
G & A	7.58	2.65	3.27	2.90
		Onetime Costs (Contractor's Estimate, $\$/m^2$)		
Onetime Costs	**	1.06*	**	**

*Includes (considered by most contractors to be part of building cost rate):

Plant design, construction fees = 0.17
Plant turnover, acceptance = 0.01
Process design = 0.27
Plant start-up = 0.60

**Not specifically called out.

TABLE 29

CMF REQUIRED REVENUE*
(Contractors' Estimates, $/m^2)

Components of Required Revenue	ARCO	BEC	MMC	MDAC
Direct Materials	51.70	68.19	53.88	49.16
Direct Labor	3.00	4.92	1.82	3.41
Consumables				
Utilities	1.42	0.37	0.63	0.65
Other	1.03	0.11	1.56	2.92
Indirects	1.70	0.21	1.72	1.08
G & A	7.58	2.65	3.27	2.90
Capital Replacement	2.98	3.85	1.44	1.92
Property Tax + Insurance	0.46	1.45	0.17	0.43
Onetime Costs	**	1.06	**	**
Return-On-Investment and Income Tax	10.02	7.21	4.20	4.79
Total CMF Required Revenue, $/m^2	79.89	90.02	68.69	67.26

*Reflective assembly, drive mechanism, support structure (does not include controls and field wiring or foundation/pedestal).
**Not specifically called out.

TRANSPORTATION

Central Manufacturing Facility To Site Transportation

General program guidelines for transporting heliostat parts from the CMF to the sites were based on the premise that all of the sites would be uniformly distributed in a 400-mile radius within eight southwestern states and that 50,000 heliostats per year, or about 200 heliostats per day, would be shipped to multiple sites. Any DOE specification could be challenged if the contractor could design a more cost-effective approach. In this section the transportation costs are only for the shipment of the reflective assembly, drive mechanism and support structure from the CMF to the sites.

Transportation Guidelines - Trucking

Trucking limitations occur as a function of the state in which the CMF is located, those states where the sites are located, and those additional states that must be crossed to reach the sites. The contractors selected two states for possible CMF locations: Arizona and New Mexico. Sites would be located in the other six states. The most restrictive limits for trucks traveling in the eight southwestern states are as follows, taken from a Truck Trailer Manufacturer's Association publication:

- maximum width of 96 in.
- maximum total height of 13.5 ft above ground
- maximum length of 60 ft for single semitrailer plus tractor
- maximum length of 65 ft for semi- and full trailer plus tractor
- maximum gross combination of 80,000 lb for weight of tractor, trailer(s), and load
- maximum single-axle load of 20,000 lb
- maximum tandem-axle load of 34,000 lb

A two-axle cab-over-engine tractor (used by ARCO and MDAC, for instance) typically might weigh 13,000 lb dry and 14,500 lb with fuel and driver. A three-axle conventional style tractor (proposed by BEC) typically might weigh 15,000 lb dry and 16,500 lb with fuel and driver. Standard trailers come in two size ranges, from 24 ft to 27 ft, and from 40 ft to 45 ft. Other sizes can be special ordered. Standard flatbed trailers typically weigh from 4,500 lb for a 24 ft single-axle semi up to 10,000 lb for a 45 ft tandem-axle semi. A "doubles" combination, weighing about 11,000 lb and consisting of a 24 ft semi-trailer coupled with a 24 ft full trailer, was used by several contractors. A 45 ft single-axle lowboy trailer (preferred by MDAC) might weigh 10,000 lb or more.

Such transportation schemes would accommodate the following payloads:

	Max Gross wt,lb	-	Loaded Tractor wt,lb	-	Trailer wt,lb	=	Potential Payload wt,lb
• ARCO	80,000		14,500		11,000**		54,500
• BEC	73,000 (If Z beams were trucked thru PA, IN, IL, MO)		16,500		11,000		45,500
	80,000		16,500		10,000*		53,500
	80,000		16,500		11,000**		52,500
• MMC	80,000		16,500		11,000**		52,500
	80,000		16,500		10,000		53,500
• MDAC	80,000		14,500		10,000* lowboy		55,500
	80,000		14,500		10,000* tandem		55,500

*Assumed 45 ft single.
**Assumed 25 ft doubles.

Gross combination weights above 80,000 lb are allowed with more tires per axle and overweight permits; however, most of the proposed shipments of heliostat parts or subassemblies are volume limited rather than weight limited. MDAC may need to obtain oversize permits to ship four reflective assemblies per truck from its CMF in Tucson to the 50 MW_e plant sites. Some question remains concerning the continual use and availability of permits, based on the following stipulations set forth in a 1978 Arizona Department of Transportation publication on Arizona Rules and Regulations R17-4-51 for overdimensional and overweight loads:

"A permit shall not be issued for a material or commodity haul which can be reduced or loaded within the size and weight limits."
"Overdimensional and Overweight Permits for multiple types or fixed loads (are) not to exceed 30 calendar days."
"A permit shall be issued only for 'daylight hours' sunrise to sunset."

These and other permit restrictions may increase the transportation costs of the MDAC reflector units.

Heliostat Truck Loading

The philosophy of each contractor concerning the assembly of certain parts in the CMF, and the transportation of other parts to the sites for subsequent assembly, dictates the truck loading efficiency, whether the loading is volume limited or weight limited, and the eventual transportation cost. Both ARCO and MMC, which ship separate parts with high shipping densities, tend to have low transportation costs. Although MMC uses rail as the baseline transportation mode for its heliostats, MMC also provides scenarios for transportation by truck/trailer. According to MMC trucking scenario figures, 0.244 trucks are required per heliostat. ARCO, on the other hand, requires an average of 0.157 trucks per heliostat.

BEC ships its heliostat parts in essentially the same manner as ARCO and MMC except the drive is shipped with a center torque tube; the packing density of the BEC drive is therefore much lower than that for ARCO or MMC drives. The end result is that BEC requires 0.365 trucks to ship a heliostat. Some support structure Z beams for the BEC heliostat are shipped by rail to the sites directly from New York; if they were trucked according to BEC's contingency plan, the packing density would be even less. Even greater differences are realized on a reflective-area basis since the BEC reflective area is the smallest of all the heliostats.

MDAC approached the transportation scenario in a completely different manner. MDAC assembles two reflective halves at the CMF; a pedestal, drive mechanism, and main beam assembly are also put together at the CMF. The rather bulky MDAC assemblies (without foundation) require 0.556 trucks per heliostat. MDAC proposes to use special 10 ft wide trucks to ship the reflective assembly halves to the sites. If standard 8 ft wide trucks were used, the shipping density would be further reduced to 0.723 trucks per heliostat.

Transportation Guidelines - Railroad

MMC proposes shipping all of its heliostats from the CMF to the sites by rail. BEC proposes shipping support structure Z beams from an outside supplier's location in New York to the sites by rail as well. One argument given for using rail transportation is that a 50 MW_e power plant will require a rail siding for the delivery of heavy and large items. This facility could logically be used for heliostat delivery also.

MMC has determined that applicable rates for rail shipment in and out of Albuquerque would be $2.68/100 lb of freight for a one-way distance of roughly 300 miles. These rates are nearly equivalent to a truck rate of $650 per truckload for a round-trip distance of 533 miles.

Although the payload capacity of a railcar exceeds that of a truck/trailer, rail rates are based on type of cargo and weight. Packing density, therefore, does not strongly affect MMC's rail transportation costs. Actual rates charged per pound would be determined by the individual railroad for distance, weight, type of freight, density of freight, etc. Approximate flatcar limitations would be 162 in. in height, 50 ft in length, 9 ft 3 in. in width, and 140,000 lb in weight. As with truck transport, shipment by rail of all parts except drives would be volume limited. Cost savings might be achieved by shipping bulky components by rail, since railway costs are a strong function of weight. Truck shipping costs are the same per truckload whether a full payload (approximately 52,000 lb) or a less-than-full payload is transported.

Transportation Costs

Contractors figured transportation costs on the basis of their proposed scenarios. They also could have multiplied the truck loading capacity by a constant cost per truckload per round trip or per square meter, thereby determining these costs per heliostat. This amount would represent the manufacturer's cost to subcontract a dedicated truck to deliver the heliostat parts. Cost of reusable crates would normally be additive.

The transportation costs stated by each contractor are as follows:

- ARCO - $96.00 per heliostat. ARCO proposes to use a private fleet of 80 tractors ($54,000 each) and 240 trailers with custom racks ($10,000 each). The assumed tractor-trailer is an 18-wheeler with tandem axles and four wheels per axle.

  The $96.00 per heliostat figure results from:

  533 miles round trip x $1.15/mile x
  0.157 truckloads per heliostat

  The $1.15/mile cost breaks down in the following manner:

Depreciation	$ 0.14/mile
Fuel (5 mpg @ $1.00/gal)	0.20/mile
Tires (18 @ $330 for 60,000 miles)	0.10/mile
Maintenance	0.16/mile
Insurance, taxes, etc.	0.19/mile
Driver ($11.00/hr + 0.30 fringe)	0.36/mile
	$1.15/mile

  This total can be compared to a recent American Transportation figure, which indicated an average truck transportation cost of $0.915/mile.

  If the $96.00 per heliostat price is distributed over the major heliostat parts, the following results:

Reflective assembly facets	$46.00
Drive mechanism	17.00
Support structure	33.00
Total	$96.00

- BEC - $185.56 per heliostat. BEC proposes to employ a commercial trucking firm and to use rail shipment for support structure beams. Cost distribution among heliostat parts is as follows:

Reflective assembly facets	$76.50
Crates ($5,700,000) = $10.96 per heliostat	10.96
Drive mechanism	20.90
Support structure	77.20
Beams by rail ($70.00)	
Torque tubes ($4.70)	
Beam struts, bars, angles ($2.50)	
Total	$185.56

The average distance from the CMF to the site is 300 miles. The beams are transported an average of 2,200 miles from the vendor to the field site.

The transportation costs for BEC's drive mechanism appear very low. BEC proposes to use the same truck packing fraction for the drive mechanism as for the reflective assembly facets. Its estimated costs for drive mechanism transportation, however, are only about 27 percent of those for the reflective assembly facets. A truckload of either drive mechanisms or reflective assembly facets should have the same transportation cost regardless of weight, unless the load is overweight.

- MMC - $191.14 per heliostat. MMC proposes to use rail transportation from the CMF to the sites. The average transportation distance is 283 miles one-way, and the average cost of rail shipment used is $2.68/100 lb. MMC computed total rail shipment costs from a loaded to-site cost plus an empty return cost. Crate cost, prorated to cover each heliostat, was also stated separately.

Breakdown by the heliostat major parts is as follows:

Heliostat Major Parts	To Site	Return	Crate	Total
Reflective assembly facets	$ 75.61	$ 10.18	$ 12.15	$97.94
Large	(71.78)	(10.18)	(11.55)	
Small	(3.03)	(0.00)	(0.60)	
Drive mechanism	31.27	3.04	1.00	35.31
Support structure	50.62	3.22	4.05	57.89
Elevation beam	(26.80)	(1.43)	(1.25)	
Bar joist	(23.82)	(1.79)	(2.80)	
			Total	$191.14

- MDAC - $221.12 per heliostat. The pedestal portion of the drive pedestal/main beam, estimated to cost $11.24, is not included in the $221.12. MDAC assumes an average round trip shipping distance of 288 miles, which might be valid. Proper selection of a CMF site could substantially reduce the average round trip distance resulting from Sandia's specification that field sites must be uniformly distributed within a 400-mile radius of the CMF. MDAC also states that the transportation costs would be $425.23 per heliostat (or an increase of about $4/m^2) if an average one-way shipping distance of 283 miles were used in cost computations.

MDAC uses a privately owned fleet of special trucks to ship major assemblies from the CMF to the site. Some of the trucks would be 10 ft wide, thereby increasing the packing density of reflective asemblies. Ten-foot-wide trucks can transport the reflective assemblies required for 2 heliostats (a total of 4 panels), whereas a standard 96 in. wide truck can carry the reflective assemblies for only 1.5 heliostats (i.e., 3 panels). A fee of $13.00 per truck is levied on 10 ft wide vehicles. If a 100 in. wide truck were used, it might be possible to fit reflective assemblies for 2 heliostats with minimal amounts of cushioning.

Costs estimated by MDAC for a 288-mile round trip can be broken down as as follows:

Heliostat Major Parts	Pallets	Direct Labor	Overhead + G&A	= Total
Reflective assembly (includes permit fee of $6.50)	$11.13	$53.46	$134.05	$198.64
Drive mechanism/ Main beam (w/o pedestal)	2.37	5.94	14.17	$ 22.48

The direct labor rate used in MDAC calculations was $9.90/hr, the overhead rate was $22.12/hr, and the G & A fraction was 15 percent of the direct labor rate. The assumed round trip of 288 miles requires 10.8 man-hours of direct labor per truckload.

Discussion of Comparative Transportation Scenarios and Cost Estimates

One way to compare the contractors' transportation costs is to assume that all shipments are by standard truck and have the same round-trip distance. Once the truck loading is known, then a truckload cost (\$/truck) can be allocated to each heliostat. Table 30 presents the data in this fashion for comparison purposes only; the data were not originally submitted this way. A cost of \$650 per truckload has been used for the reflective assembly, drive mechanism, and support structure parts.

TABLE 30

SNLL NOMINAL ROUND-TRIP* TRANSPORTATION COMPARISON

Comparable Factors	ARCO	BEC	MMC	MDAC
Loading, Trucks/ Heliostat	0.165	0.365	0.246	0.556
Cost, \$/Heliostat	107.25	237.25	159.90	361.40
Cost, $\$/m^2$	2.03	5.39	2.79	6.35

*From CMF to site and return.

According to Sandia's figures, ARCO's transportation costs are the lowest at about $\$2.03/m^2$ (ARCO's own estimate was $\$1.82/m^2$). Most of the parts can be transported using double 25 ft trailers to increase the volume-limited load density. ARCO proposes to ship its drives in a single layer. With the packing manner proposed by ARCO, drive mechanism shipments are volume limited (actually trailer-length limited); only 32 drive mechanisms per truckload would actually fit, compared to the 36 ARCO suggests. A load of 36 drives packed in a single layer would be 54 ft long, which exceeds either a single 45 ft trailer length or two 25 ft trailers. However, double stacking would allow 44 drive mechanisms per truckload to be shipped. The potential cost savings is $\$0.10/m^2$.

A similar situation exists with ARCO's torque tube shipping scenario. Four 16-tube stacks (37.2 ft in total length) can be loaded on a single 40 ft trailer or split between two 25 ft trailers; however, the five stacks proposed by ARCO exceed the lengths of either transport configuration.

ARCO uses custom racks and tiedowns on its dedicated trucks, thereby eliminating the costs associated with shipping crates, i.e., of packing, unpacking, crate return, and disposal of expendable packing material. Miscellaneous hardware can be packaged and transported on most of the trucks since some excess trailer space is available for smaller packages and the weight limit has not been reached.

Sandia projects that BEC transportation from the CMF to the sites costs about $\$5.39/m^2$ (BEC estimated about $\$4.22/m^2$), or more than double the ARCO costs. While some of the difference between the ARCO and BEC costs results from the smaller BEC reflective area, packing density accounts for most of the disparity. The difference between Sandia's calculation and BEC's estimate can be attributed to BEC charging by weight, not volume, for shipping drive mechanisms; instead, a volume-limited trailerload shipped on a dedicated truck should cost the same per truckload, regardless of the weight shipped.

BEC proposes to ship all of the major parts in two 25 ft trailers per truckload. The allowable weight that could be shipped on the two trailers is about 52,000 lb. BEC plans to ship only about 25,000 lb of reflective assembly facets per truckload and to use only 62 in. of the available 96 in. width. The 62 in. accommodate enough facets for one heliostat, but the entire 96 in. width, if filled, would hold enough facets for 1-1/2 heliostats. The result would be a shipping cost savings of over $\$0.50/m^2$.

Compared to the other drive mechanisms, BEC drive mechanisms are very lightweight--about 680 lb each. A 250 lb shipping pallet brings the total unit weight to 930 lb. BEC ships only eight units, or 7440 lb, on a truck. Since the truck/trailers can accommodate at least 50,000 lb, the cost per unit shipped is very high. Double stacking the units would reduce the cost by roughly a factor of two, resulting in a cost savings of about $\$0.90/m^2$.

Z beams for the BEC support structure are shipped 2200 miles from New York rather than 283 miles one-way. BEC's baseline plan is to ship beams by rail; however, a contingency plan for truck shipment is also provided. If only one-way costs were charged for cross-country (New York to site) shipment, the cost per truckload would be roughly 3.9 times the cost of a truckload from the CMF to the site. The BEC beam shipment estimate fully uses the length and width dimensions of the two 25 ft trailers. However, the proposed 60 in. load height is far short of the load height limit of about 114 in.; the payload weight limit of about 45,500 lb (allowable gross weight through PA, IN, IL, and MO is 73,000) is approached by a 37,500 lb load of Z beams and pallets. Adding one more stack to each trailer would make the height about 72 in. and the weight about 45,000 lb. This savings would amount to about $\$0.20/m^2$.

Torque tubes (two required per heliostat) are also volume limited in the BEC estimate. BEC ships 120 torque tubes, weighing 14,400 lb, on two 25 ft trailers. The 18 in. diameter tubes are closely packed in a wedge-like fashion. The 15-tube stacks reach a height of about 84 in., well under the maximum load height. A more efficient arrangement might be stacks of tubes 5 across by 6 high on racks, resulting in 30 tubes per stack. Cost savings from the resultant doubled packing density per trailer could be about $\$0.10/m^2$.

The potential cost savings resulting from increased packing densities could amount to $\$1.70/m^2$ or more. The comparable transportation cost for BEC would then be $\$5.40/m^2$ minus $\$1.70/m^2$, or $\$3.70/m^2$. This figure is somewhat less than the original BEC estimate. More refined estimates might result in even further reductions.

As calculated by Sandia, the MMC transportation costs of about $2.79/m^2$ are only somewhat higher than the ARCO costs. MMC investigated both trucking and rail shipment and concluded that rail shipment was less expensive, at $3.45/m^2$. However, the rail shipment rate used by MMC of $2.68/100 lb does not appear to be cost competitive when compared to a truck shipment rate of roughly $1.30/100 lb (corresponding to $650 per truckload with a payload weight of about 50,000 lb per truckload). The rationale behind MMC's choice of rail shipment is therefore not understood.

MMC shipping loads are volume limited for the large and small reflective assembly facets, torque tubes, and bar joists. The reflective assembly could be shipped three crates per 40 ft trailer. Alternately, they could be shipped on two 25 ft trailers with two large facet crates per trailer for a savings of 25 percent; six small facet crates could fit on each 25 ft trailer for additional savings of at least 20 percent. These cost savings could amount to about $0.40/m^2$.

MMC drive mechanisms are shipped on a 40 ft trailer and are weight limited. MMC proposes to ship 32 drive mechanisms per truckload with a payload weight of about 37,300 lb. The payload on a single 40 ft truck with tandem axles could be as high as 53,500 lb assuming 16,500 lb for the tractor, another 10,000 lb for the trailer, and a gross combination weight of 80,000 lb. This higher limit could allow two packages--2 drive mechanisms wide by 2 drive mechanisms high by 4 drive mechanisms long--plus an additional 12 drive mechanisms in a third package (i.e., less two pairs of drives) for a total of 44 drive mechanisms weighing 53,500 lb. The packing would still be weight limited. Potential cost savings would be $0.10/m^2$, making an overall potential cost savings of about $0.50/m^2$ for MMC shipments by truck.

MDAC transportation costs between the CMF and the sites are higher than those for the other contractors; however, since major assemblies are shipped, no site assembly activities are required. As figured in Sandia's comparative format, the MDAC transportation costs are about $6.35/m^2$ (MDAC estimated about $7.54/m^2$ without pallets based on an average site distance of 566 miles round trip), using standard trucks, $650 per truckload, and an average site distance of 533 miles round trip.

The $6.35/m^2$ cost is based on the use of a standard 8 ft wide truck with a 100 in. load limit, allowing shipment of four reflective assembly halves per truckload. The cost of permits for a 10 ft wide truck are only $13.00 per truckload or $6.50 per heliostat, but the limited hours of travel in Arizona where the CMF is located (Monday through Friday from sunrise to sunset, in good weather, etc.) may hamper prompt deliveries if problems arise. MDAC believes that extra-wide trucks might not be required, since in at least six states four 24 in. wide assemblies could be shipped on 100 in. wide trucks, allowing 4 in. of packing material.

Even when packed at four per truckload, the reflective assemblies are volume limited. Trailers must be a lowboy design; since the assembly is 132 in. high without the shipping crate, no more than 30 in. can be allowed between the load and the ground if the maximum clearance height of 13.5 ft will be met. The reflective assembly is only about 341 in. long; it would easily fit on a trailer shorter than 40 ft.

The MDAC pedestal, drive mechanism, and main beam assembly load is also volume limited. The MDAC estimate packs three crates, each 168 in. long, on a 45 ft trailer. This packing arrangement easily meets interstate trucking requirements.

MDAC proposes that denser market areas having a round-trip shipping distance of 283 miles, rather than the calculated 533 miles, exist within a 400-mile radius of the CMF. MDAC assumes that population centers are closer than 267 miles to the CMF (an average of 533 miles round trip). A judicious choice for the CMF location (MDAC assumes Tucson, AZ) may indeed result in shorter average shipping distances. The resultant reduced shipping costs could easily overcome increased labor rates for areas such as Phoenix or Tucson, as compared to those for Albuquerque. The number of man-hours required to fabricate a heliostat (roughly 10) multiplied by the labor rate difference between Albuquerque and a city like Phoenix (roughly 15 to 20 percent) does not amount to even half the shipping costs.

For instance, suppose the nominal cost of shipping a heliostat a round-trip distance of 533 miles is about $150. If the distance were cut in half, the cost would be halved as well, resulting in $75 per heliostat for transportation. If the labor rates were $10/hr in Albuquerque (a CMF located 533 miles round trip from the average site) but were $12/hr in Phoenix (a CMF located half as far from the average site), it would cost $20 more to produce a heliostat in Phoenix [($12/hr - $10/hr) x (10 direct labor hours per heliostat)]. Although it would cost $20 more to produce a heliostat at the close-to-site CMF, it would cost $75 less to transport the heliostat to the average site. A net savings of $55 per heliostat results.

SITE ACTIVITIES

Site Assembly, Site Transportation, Installation, and Checkout

In this section, the site-related costs are only for the reflective assembly, drive mechanism, and support structure.

All of the contractors chose different scenarios to deploy the heliostats produced at the CMF. If the 50 MW_e (peak) plants were filled at a rate of 50,000 heliostats per year, the heliostats would be deployed as follows:

No. of Heliostats Required per 50 MW_e Field		No. of Possible Fields Completed Per Year*
ARCO	5974	8.37
BEC	6914	7.23
MMC	5147	9.71
MDAC	5412	9.24

The number of heliostats left over after whole fields are completed could be considered as spare and pipeline amounts.

Both ARCO and MDAC chose to install four fields at one time at a rate of roughly 50 heliostats per day, or a total factory output of about 200 heliostats per day. Four fields would be completed in six months or less, and four more fields would be completed in another six months. The MDAC design provides enough heliostats to start a third set of four fields during the calendar year. These rates require that all operations, on an average, be conducted in parallel so that all of the 50,000 heliostats are used and full-field installation is completed in about six months.

BEC and MMC chose to install more than four fields at one time (at installation rates of 27 and 20 heliostats per day, respectively) which means that more than one year is required to complete any field. BEC reports that ten or eleven sites are in progress at any given time. However, BEC's scheduling charts for field assembly and installation, coupled with the production rate at the CMF, provide a nominal installation of seven, not ten, sites. MMC chooses to install nine fields at any nominal time. Both BEC and MMC allow a lead time to install some foundations before starting site assembly and installation. MMC allows additional time to prepare a site assembly building before starting foundation installation. Although BEC does not require site preparation time since the site assembly building is provided by the site owner, it allows time after heliostat installation to complete testing, alignment, system checks, etc.

*SNLL figured the number of heliostats per field using DELSOL I calculations and assuming the heliostats exactly met the specifications and the DOE-estimated cost goals, economic parameters, etc., appropriate at the time of the calculation (summer 1980).

ARCO and MDAC require four sets of equipment for assembly and installation. BEC and MMC would require more than four sets and would have to amortize the equipment over a longer period of time than ARCO and MDAC.

Another economic difference would be that ARCO and MDAC would recover their invested money, including final payment, much more quickly than BEC and MMC. Progress payments would probably be made in any case, but the final payment would not be received until successful system operation of the field was demonstrated.

All of the contractors except MDAC assemble heliostat parts into major subassemblies at the site, transport them to the foundation/pedestal locations, install the subassemblies, and perform checkouts before turning the field over to the site owner.

The site cost categories discussed in this section are:

- Direct Material
- Direct Labor - Assembly
- Direct Labor - Transportation, Installation, and Checkout
- Burden

The costs are summarized in Table 31. The costs of the foundation/pedestal and controls and field wiring, which are also fabricated and installed at the site, are discussed in a subsequent chapter.

Direct Materials

Some purchased materials such as bolts and rivets are used on site in the assembly of the heliostats. ARCO uses studs, washers, and nuts ($9.00 per heliostat) to mount the mirror modules; a cable set, washers, and nuts ($10.96 per heliostat) to mount the drive assembly; bolts and washers ($0.48 per heliostat) to mount the controls; and rivets ($1.08 per heliostat) to attach the support structure elements.

BEC uses hardware to assemble the reflective assemblies ($5.00 per heliostat), drive ($1.35 per heliostat), and support structure ($7.77 per heliostat). BEC also charges $3.00 per heliostat for an initial reflective surface cleaning. This is treated as a pass-through expense with no added burdens.

MMC uses rivets ($1.95 per heliostat) and studs ($3.30 per heliostat) to assemble the heliostats at the site.

MDAC does not assemble heliostats at the site and does not show any specific charges associated with installation.

TABLE 31

SITE-RELATED COST SUMMARY*
(Contractors' Estimates, $\$/m^2$)

Components of Cost	ARCO	BEC	MMC	MDAC
Direct Materials	0.41	0.39	0.09	0.00
Direct Labor				
Assembly	6.25	2.77	1.53	0.00
Transportation, Installation, & Checkout	2.46	1.25	1.31	1.07
Burden	5.85	4.31	4.22	2.91
Total Site-Related Costs, $\$/m^2$	14.97	8.72	7.15	3.98

*Does not include controls and field wiring or foundation/pedestal.

Direct Labor - Assembly

ARCO, BEC, and MMC incur direct labor charges for on-site assembly. (MDAC does not use site assembly activity in its scenario.) BEC and MMC assemble four heliostats in parallel on fixtures, with teams of three and two men, respectively, at each fixture. MMC also employs one man to operate an overhead crane and to service all four teams. BEC uses three shifts to assemble 27 heliostats per day, while MMC uses two shifts to assemble 20 heliostats per day.

Using a single-line series assembly scheme, ARCO assembles 48 heliostats per day in three shifts. Three separate stations require a total of 33 workers per shift. ARCO spends 1.35 hours of assembly time to complete a heliostat; BEC and MMC use 3.4 and 3.2 hours, respectively.

The number of direct labor man-hours for heliostat assembly is highest at 16.5 man-hours for ARCO, intermediate at 10.37 man-hours for BEC, and lowest at 7.2 man-hours for MMC. One factor affecting the cost of direct labor is the efficiency assumed for site assembly. Both ARCO and BEC assume different efficiency factors for each of the three shifts worked. The factors used for ARCO and BEC, respectively, are 0.75 and 0.83 (first shift), 0.67 and 0.79 (second shift) and 0.58 and 0.63 (third shift). MMC uses a constant 0.84 for each of its two shifts. The MMC estimate appears to be optimistic.

ARCO and MMC plan to assemble major parts at the site. Both contractors assemble the support structure and drive units. The mirror modules are then attached, and finally the facets are canted.

ARCO includes laborers for unloading and handling torque tubes and trusses, for riveting, and for welding at work station 1. At station 2, some workers handle the drive assembly, and others mate the half-frame assemblies to the drive assembly. Thirteen workers are involved in these activities.

MMC performs slightly different operations at a single location. Workers install the drive unit on a tooling pedestal, uncrate and install the elevation beam and stow lock parts, and operate the drive to adjust the stow lock. Bar joists are then uncrated, placed, and aligned, and holes are transfer-punched and riveted. A total of 2.25 men are involved at the station with the fractional man operating the overhead crane; thus the number of laborers working on one heliostat is much less than it is for ARCO. Since four such assemblies are ongoing at one time, a total of nine men are involved in MMC's scenario at this point.

In the next stage, both ARCO and MMC unload, handle, and install the mirror modules. ARCO uses twelve additional men while MMC uses the same nine men.

The final step is the mirror canting. Again, MMC uses the same nine assemblers, but ARCO use 8 more workers. Four pairs of workers each cant one-quarter of the facets.

In summary, MMC uses 0.9 man per heliostat, while ARCO uses 1.8 men per heliostat, for direct labor at the site assembly facility. MMC produces 20 heliostats per day in its scenario, and ARCO produces 48 heliostats per day.

BEC performs most of the same assembly operations as ARCO and MMC, but does not mate the two reflector halves to the drive unit in the assembly building. BEC uses twelve men to assemble the heliostat components in a manner similar to MMC's operation, with a direct labor usage of 1.3 men per heliostat. Twenty-seven heliostats per day are assembled.

The contractors estimates of the site assembly direct labor costs are:

	Man-Hours (#/Heliostat)	Labor Rate ($/hr)	Total Direct Labor Cost ($/Heliostat)
ARCO	16.5	20.00	330.00
BEC	10.67	11.44	122.03
MMC	7.2	12.23	88.06
MDAC		- No Assembly Required -	

Costs noted for BEC and MMC are slightly higher than those shown by the contractors to account for integral numbers of workers. Contractors' estimates were $117.60 for BEC and $85.61 for MMC.

For comparison, an attempt was made to separate those activities from the MDAC CMF charges that are similar to the site assembly tasks of the other contractors. An estimate of 1.21 man-hours of handling, assembly, and inspection labor results. MDAC operations are more automated and the efficiency factor is higher at the CMF than at the site, but these factors still may not compensate for the large difference in assembly labor hours.

Direct Labor - Transportation, Installation, and Checkout

All of the contractors incurred direct labor charges for transporting heliostat components from the site assembly building or staging area to the individual heliostat foundation locations and for installing heliostat components on the foundation/pedestal. Charges include final checkout, electrical connections, and testing.

Both ARCO and MMC transport a single assembly to the foundation/pedestal for installation. BEC and MDAC install a drive and support assembly and two reflective assembly halves on the foundation/pedestal.

ARCO performs one step not used by the other contractors. Heliostats are assembled on carts, then routed to a temporary storage or marshalling yard. Eventually, they are rehandled onto trailers for transport to the foundation/pedestal. This extra rehandling occurs on three shifts and uses a total of four workers. Marshalling should be possible with a total of three men, one per shift; another solution might be to eliminate marshalling altogether by combining the carts and trailers or by eliminating the carts. The marshalling activity as described by ARCO consumes as much as 0.68 man-hours of direct labor per heliostat.

Other than the marshalling activity, ARCO spends one shift per day on loading the heliostats, transporting them to the foundation/pedestal, and installing and checking out the controls and system. ARCO allows 20 minutes to load the heliostats from the carts to the trailers; 30 minutes for transport, with 8 minutes for actual round-trip travel time; 30 minutes to unload and install the heliostats; and 50 minutes for controls installation, checkout, and testing. Since all of these activities occur during the first shift, ARCO rates the efficiency at 0.75.

MMC performs essentially the same tasks as ARCO but uses two shifts. MMC assumes the high efficiency of 0.84 for both shifts. Heliostats are assembled and installed during each work shift. The heliostat is removed from the assembly building, transported to the foundation/pedestal, and installed in 48 minutes. One transport vehicle delivers all of the heliostats; only twenty heliostats are installed during the 16-hour work day. The transport scenario reduces the amount of handling to a minimum, with one driver required and only one assembler at the foundation/pedestal.

MMC spends an additional 48 minutes to install the electronics, mate cables, connect the ground wire, and perform a power check. MMC also performs a functional check and test within that 48-minute period. Some checks such as encoder bias adjustment and heliostat levelling settings are done with the Beam Characterization System during daylight hours on individual heliostats, while other checks are performed at night on twenty heliostats at one time.

Controls installation and checkout times are almost identical for ARCO and MMC, i.e., 48 and 50 minutes per heliostat. Transport and installation time is longer for ARCO than for MMC (80 minutes vs. 48 minutes), but much of this difference is in material handling. ARCO also has an additional marshalling time of 27 to 35 minutes per heliostat depending on the shift efficiency.

BEC spends an average of 57 minutes per heliostat in transporting the heliostat parts to the foundation/pedestal. Each tractor-trailer load carries enough reflective assembly halves for one heliostat and enough drive units for four heliostats. Installation takes another 36 minutes per heliostat. BEC did not cost or account for controls hardware or labor. An estimated 50 minutes per heliostat should be included for controls installation and checkout, based on estimates made by ARCO and MMC. Although BEC's installation time is similar to that consumed by ARCO and MMC, BEC installs three major assemblies while ARCO and MMC install only one assembly. BEC predicts a field labor efficiency of 0.81.

MDAC does not show any time for transport of heliostat parts to the foundation/pedestal location in the field. Tractor-trailers travel directly from the CMF to the site, but it is not clear how the tractor loads get to individual foundation/pedestal locations, unless one assumes the trailers will always be parked near empty foundations. Some time should be allocated to move trailers, unload trailers, etc.

The installation of the MDAC pedestal/drive/main beam takes 18 minutes, while the two reflective assemblies take an additional 27 minutes per heliostat. Although the sum of these times, 45 minutes, is close to the times required for ARCO and MMC, MDAC is installing three major assemblies compared to ARCO's and MMC's single assembly. MDAC assumes a field labor efficiency of 0.67. MDAC also allows 32 to 36 minutes for controls installation and checkout. These times are somewhat less than the ARCO and MMC estimate.

The total number of direct laborers for each contractor is as follows:

	No. of Workers	Installed Heliostats Per Day	Workers Per Heliostat
ARCO	39	48	0.81
BEC	10+9*	27	0.70
MMC	12	20	0.60
MDAC	33	52	0.60

*Additional men added for controls installation and checkout.

Total first-year man-hours of direct labor and their cost as estimated by each contractor for site transportation, installation, checkout, and system test (not including controls and field wiring or foundation/pedestal) are as follows:

	Total First-Year Man-Hours (#/Heliostat)	Field Labor Rate ($/hr)	Total Direct Labor Costs ($/Heliostat)
ARCO	6.5	20.00	130.00
BEC	3.9	14.11	55.03
MMC	4.8	15.68	75.26
MDAC	4.0	15.12	60.48

Burden

Site burden costs include charges for assembly buildings; equipment and tooling that are used for assembly, transportation, and installation at one site and then moved to the next (amortized); equipment and tooling that are left at the site after use and retained by the site owner for field maintenance (capitalized); rental equipment; capital equipment for heliostat maintenance; initial spare parts; utilities and consumables; relocation expenses; and indirect labor costs.

Site burden costs can be divided into the following categories (these costs include all charges except those for direct materials and direct labor):

- Assembly building -- Could be partially or completely paid for by site owner.

- Assembly and installation equipment -- Amortized if removed to next site; capitalized if left at site; rental expense.

- Site transportation equipment -- Could be part of assembly or installation equipment.

- Maintenance equipment -- Heliostat washing equipment or other capital item that lasts a significant part of the plant lifetime; could be used for installation and then left at site for maintenance use.

- Initial Spares -- Normally about two months of spare parts initially provided to prevent shortages; restocking of spare parts would be charged to O & M

- Utilities/consumables -- Electricity, gas, and water for the assembly building as well as fuel for various vehicles.

- Relocation expenses -- Equipment relocation expenses, start-up, and teardown; can be itemized separately or included in amortization costs.

- Indirect labor -- Field engineer, craft supervisors, etc.

Various site facility costs can be separately itemized or lumped into an indirect charge based on direct labor. Most of the contractors use a combination of itemized and indirect charges. The only way to compare charges is to examine the costs of similar items, the total items that should be considered, and the total indirect costs. Since the contractors use both itemized and indirect charges, the indirect rates could be considerably different yet be equally valid.

Some site facility costs can also be hidden in subcontracts for the field wiring, foundation/pedestal, and Heliostat Array Controller. These subcontracts include charges such as direct materials, direct labor, all indirects, and profit. Comparison of the costs of different heliostats is difficult when one contractor states indirects costs separately while another provides a single amount for each subcontract. A reconciliation of the site facility costs for each category follows.

Site Assembly Building--ARCO uses a 7500 ft^2 site assembly building that is paid for from an account of $65 per heliostat; this account also pays for capitalized equipment. A rough cost estimate for a $10/$ft^2$ building is $75,000 or $12.55 per heliostat. For a building this size, the site owner could be expected to pay for the entire structure as part of his maintenance facility; however, ARCO includes this cost as part of the heliostat expense.

BEC requires a 6000 ft^2 site assembly building. Since BEC assumes that the site owner pays for the entire building, the heliostat account is not charged with any site facility cost.

MMC requires a much larger site facility building of 28,500 ft^2 and assumes that the site owner will pay for half the area (14,250 ft^2). The heliostat account is charged for the other half. A $1 million building ($35.09/ft^2) results in charges of $97.14 to the account. MMC charges part of the facility cost to the account because the building size exceeds the site owner's needs for maintenance and storage.

Large differences exist in required site assembly building areas. Although ARCO, BEC, and MMC all perform similar assembly and canting activities, ARCO and BEC assemble heliostats using three shifts per day at higher daily assembly rates than MMC and employ more people in smaller buildings; MMC uses only two shifts per day in a much larger building. SNLL does not understand these differences.

As a point of reference, the Barstow Pilot Plant site assembly building used by MMC was a 25,600 ft^2 hangar; the average assembly rate on one shift was roughly the same as that proposed by MMC on two shifts assembling its Second Generation Heliostat. At Barstow, mirror modules and support structures that were awaiting assembly occupied a considerable amount of space. This backlog could probably be eliminated and required floorspace reduced if adequate mirror canting schemes are planned. On the basis of this observation, the site facility building area assumed by MMC appears to be excessive. In addition, the building cost rate of about $35/$ft^2$ is probably high. It is quite conceivable that the site owner would pay for the entire building (if it were small enough), in which case no cost would be charged to the heliostat account. If the site owner pays all building costs, then both ARCO and MMC are conservative in their estimates.

MDAC uses a 4000 ft^2 site building for personnel, general storage, and maintenance, but it does no assembly work on site. MDAC does not charge the heliostat account with any site building expense. The site owner finances the entire maintenance and storage building.

Costs charged by the contractors for site assembly buildings in $/$m^2$ are shown in Table 32.

<u>Capitalized Site Equipment (Assembly, Site Transport, and Installation)</u>--ARCO uses and then leaves at the site such equipment as a crane, a truck, a tractor, a forklift, pedestal stands, carts, etc., that would be paid for by the balance of the $65 per heliostat that is not charged to the site assembly building. If the SNLL-assumed charge of $12.55 per heliostat for the site assembly building is used, a remainder of $52.45 per heliostat, or $313,336, would be available for capitalized site equipment. ARCO did not detail the equipment left at the site.

BEC uses and then leaves the site owner with such equipment as one Drott crane ($55,000), one lineman's truck ($50,000), two tow tractors ($15,000 total), and four trailers ($26,000 total). Some of this equipment is used for assembly and installation and, subsequently, for maintenance. BEC charges the heliostat account with $21.12 per heliostat, or $146,000 worth of capital equipment.

TABLE 32

SITE BURDEN COST SUMMARY
(Contractors' Estimates, $\$/m^2$)

Components of Cost	ARCO	BEC	MMC	MDAC
Assembly Building	0.24	0.00	1.69	0.00
Capitalized Equipment	0.99	0.48	0.78	0.63
Amortized Equipment	*	0.03	0.69	**
Rental Equipment	0.21	0.14	0.00	0.00
Maintenance Equipment	1.74	0.74	0.25	0.63
Initial Spares	0.06	0.11	0.11	0.16
Consumables	*	0.01	0.14	**
Relocation Expense	*	0.12	Inc.	**
Indirect labor	1.45*	2.68	0.56	0.35
Other	1.16*	-	-	1.14**
Total Site Burden Cost, $\$/m^2$	5.85	4.31	4.22	2.91

*Part of overhead charge of $\$2.61/m^2$ (30% of direct labor).
**Part of overhead charge of $\$1.14/m^2$ (70% of direct labor); Social Security, FUI, SUI, Workman's Compensation, etc. ($2.93/hr for 6.1 man-hours per heliostat = $\$0.31/m^2$).

MMC uses and then leaves at the site such equipment as special tools ($20,000), a transport vehicle ($150,000), and work platform vehicles ($60,000). In addition, pedestals are left in the maintenance building and must be included in the special tools costs. Charges for an investment of $230,000 amount to $44.69 per heliostat.

The MDAC on-site capital investment costs include a 10-ton mobile crane ($94,500), a 4,000 lb capacity fork lift ($21,400), a 2.5-ton hydraset ($4,870), a 3/4-ton pickup truck ($24,000), an electronic mini-level ($6,700), a portable control unit ($4,870), a service link lift to stabilize the heliostat reflector during removal and replacement of the elevation jack

($8,900), and other tools, slings, etc. ($29,000), for a total of about $195,200. The charges per heliostat would be $36.07.

Costs charged by the contractors for capitalized equipment on site (in $\$/m^2$) can be found in Table 32.

Amortized Site Equipment (Assembly, Site Transport, and Installation)--ARCO uses some site equipment for six months and then moves the equipment to the next site. The types of equipment in this category include a forklift, at least 30 carts, and pedestal stands. No specific charge was found for the amortization of these items. Return on investment would be 20 percent after taxes.

BEC uses equipment at the site for about one year and then moves it to the next site. This equipment includes reflective assembly tooling ($42,800), 36 trailers ($31,100), and office equipment ($2,500). Although a 5 to 10-ton crane is also required for the assembly building, no cost was allotted for it. The depreciation expense was stated as $1.47 per heliostat.

MMC uses some site equipment and amortizes it over 1-1/2 years. Equipment includes a 15-ton bridge crane ($225,000), four assembly fixtures ($260,000 total), storage pedestals ($20,000), and miscellaneous tooling ($22,500). Four counterweight lifts, which may be part of the assembly fixtures, are also needed. The cost associated with the amortized equipment and tooling is based on a 15-year life for equipment and a 5-year life for tooling. Costs amount to $14.35 per heliostat for depreciation and $25.19 per heliostat for gross income to pay an average 17.5 percent return to investors after taxes.

MDAC uses equipment at each site for about half a year before moving it to the next site. MDAC does not elaborate on the equipment; based on its installation scenario, however, MDAC should need four hydraulic loading systems for pedestal installation, one set of pedestal, drive, and main beam installation equipment, two reflective assembly installation vehicles, three cable plows, four augers, four forklifts, four cranes, and some tractors. MDAC includes all of these charges in the site overhead charge.

Costs charged by the contractors for amortized site equipment and tooling in $\$/m^2$ are contained in Table 32.

Site Equipment Rental--ARCO rents some equipment for assembly, site transportation, and installation operations, including four cranes, two trucks, and one tractor. A charge of $10 per heliostat is assessed. In addition, a rental fee of $1 per heliostat is charged for controls installation and checkout.

BEC rents equipment for site transportation and installation, including five tractors, one Drott crane, and one lineman's truck. The charge for these rentals is $6.25 per heliostat.

MMC and MDAC do not rent any site equipment.

Costs charged by the contractors for site rental of equipment in $\$/m^2$ are shown in Table 32.

Site Maintenance Equipment--ARCO estimates that $550,000 would have to be invested for a heliostat washing system, including the washing rig ($250,000), control system ($100,000), guidance wire ($150,000), and deionizer and storage tanks ($50,000). The capitalized cost per heliostat would be $92.07. This washing system is considerably more elaborate than any proposed by the other contractors.

BEC estimates that three washing trucks at $75,000 each will be required for site maintenance equipment. The capitalized cost per heliostat is $32.54.

MMC projects the need for a single washing truck at $75,000. The capitalized charge per heliostat would be $14.57.

MDAC's plan requires two washing trucks used in tandem, one for washing and the other for rinsing with deionized water. The capitalized charge per heliostat is $35.93, or an initial investment of $194,500 per site.

The site maintenance equipment cost charged by the contractors in $\$/m^2$ (normally included in O & M) appears in Table 32.

Site Initial Spares--ARCO does not specify any initial spares, but based on ARCO's predicted failure rates and assuming a two-month supply of replacement materials, the cost is about $3.28 per heliostat.

BEC costs some initial spare parts, including five reflective facets, twenty-five motors, one drive repair kit, and one set of support system and maintenance support equipment spares. Total initial spares cost is $4.68 per heliostat.

MMC includes an initial spare parts inventory of 6 reflective assemblies, 1 drive, 26 motors, 16 encoders, 46 heliostat controllers, and 13 heliostat field controllers. The cost amounts to $6.08 per heliostat.

MDAC estimates an initial spares cost of $8.80 per heliostat. The spares supply required is based on both annual failure rates and pipeline quantities.

The cost charged by the contractors for initial spares in $\$/m^2$ is listed in Table 32.

Site Utilities and Consumables--ARCO does not break out a specific account for utilities or consumables; however, the amounts spent are included in indirect costs, which are 30 percent of the direct labor charges.

BEC records a specific charge for site utilities of $2800/yr. Charges are broken down to include telephones ($600/yr), power and lights ($1200/yr), and miscellaneous allowance ($1000/yr). These charges total to $0.40 per heliostat.

MMC charges $20,000 for utilities at the site assembly building and $15,000 for consumables, particularly for vehicle operation at the site. A charge of $5000 is also made for perishable tooling. The charges amount to $7.77 per heliostat.

MDAC includes the utilities and consumables costs in the indirect charges and does not break them out separately.

Table 32 shows the costs charged by the contractors for site utilities and consumables in $\$/m^2$.

Site Facility Relocation Expenses--BEC is the only contractor to break out the site facility process design and development costs, preactivation and start-up costs, and teardown and relocation costs. These charges total \$5.22 per heliostat, or $\$0.12/m^2$. The other contractors might have included these costs in other charges or inadvertently overlooked them.

Indirect Labor--ARCO uses eighteen support people (nondirect labor) per day for site assembly, four per day for installation, and one per day for controls checkout. An average of 48 heliostats are installed during the three daily shifts. At fully loaded site labor wages of \$20/hr, the three tasks incur indirect labor charges of \$60.19 per heliostat for assembly, \$13.20 per heliostat for installation, and \$3.17 per heliostat for controls installation and checkout. Indirect labor charges are only part of the expenses included in the 30 percent overhead charge levied by ARCO on direct labor.

BEC includes two categories that can be construed as indirect labor: architectural and engineering (A&E) services (\$701,360 or \$101.44 per heliostat, based on 12 percent of site construction costs minus land costs), and site construction management (based on two percent of the on-site costs of \$112,898 or \$16.33 per heliostat).

MMC uses six indirect laborers per day for the site assembly and installation of its heliostats. For the 20 heliostats produced per day, 2.4 indirect man-hours are spent per heliostat. The pay rate for this indirect labor is not clear, since the site assembly facility rate is \$12.23/hr and the field installation rate is \$15.68/hr. Most of the indirect labor is probably associated with the site assembly facility.

If one assumes that four people support the site assembly facility and two people support the heliostat field installation, a cost of \$32.11 per heliostat results.

MDAC has no assembly facility but does use a number of man-hours per heliostat to support installation (management, supervision, records, field coordination, personnel, quality control, and field engineering). At a loaded site labor rate of \$15.12/hr, the cost per heliostat is \$19.66. The number of indirect labor personnel is eight per day.

Costs charged by the contractors for site indirect labor in $\$/m^2$ are included in Table 32.

Heliostat Controls and Field Wiring

A heliostat requires not only power for its electrical needs (motors, computers, etc.), but also a communication link with the control room so that it can be directed to operate. The Second Generation Heliostat contract deemphasized the contractors' efforts in heliostat controls, both in terms of design and cost estimates. The contractors therefore invested varying amounts of time on this area. As a result, the information presented in this section should be viewed as preliminary and possibly incomplete.

The heliostat power system includes cabling from the power plant to a field transformer, power distribution with cabling and circuit breakers to the individual heliostat locations, and power distribution at or within the heliostat. Costs of the power system are composed of direct material, direct labor, indirects, and profit. The data distribution or communication system includes such parts as a heliostat array controller (HAC), a heliostat field controller (HFC), a heliostat controller (HC), and in some cases a data distribution center (DDC).

These power and communication parts are linked by appropriate cabling and connections. In addition, parts such as a beam characterization system (BCS) may be supplied to help calibrate the entire system. Other system-related items--software and program manuals, for instance--may be included, but are not always itemized separately.

This section summarizes the cost data presented by the contractors for controls and field wiring. Some of the contractors combined costs or offered little detail, but the overall data permit some understanding of estimated costs. A summary of the controls and field wiring costs per heliostat is found in Table 33.

Power System Costs

ARCO grouped power system costs and the data distribution system costs as a subcontract. The total estimate was $200 per heliostat. No details are provided, but ARCO believes the cost is sufficient to cover all required expenses. BEC made no estimates.

Both MMC and MDAC estimated higher costs for the power system alone than ARCO estimated for its entire field wiring system. MMC estimates the subcontracted cost of installed power cabling at $235 per heliostat. This total cost includes primary feeders, transformers, distribution panels, and secondary feeders. For MMC, the power required at each HC is 120 V, single-phase AC.

TABLE 33

CONTROLS AND FIELD WIRING COST SUMMARY
(Contractors' Estimates, \$/heliostat and \$/m^2)

Controls and Field Wiring Parts	ARCO	BEC	MMC	MDAC
Power Systems	200.00	0	235.00	281.43
Data Distribution	*	0	63.26	61.97
HAC	167.39	0	77.71	23.78
HFC	**	0	8.39	2.77
HC	328.27	0	448.84	203.04
BCS	25.11	0	38.86	9.32
Transport	0	0	0	0.50
Total Controls and Field Wiring Cost, \$/heliostat	719.77	0	871.06	582.81
Total Controls and Field Wiring Cost, \$/m^2	13.63	0	15.18	10.24

*Included with Power Systems.
**Included with HC.

The MDAC power supply system consists of the following:

Buried Feeder Cable to Transformer #4 AWG, 3 Conductor, 5kV	$ 9.40/heliostat
Transformer	19.17
Distribution Panel, 480 V, 3 phase w/100 Amp Circuit Breaker	1.99
Installation Labor for Transformer & Panel	
Direct Labor, 0.031 man-hours	0.47
Overhead	0.33
Branch Circuit Breaker, 480 V, 40 Amp	5.09
Buried Branch Circuit Cable	59.06
#8 AWG, 3 Conductor, 600 V	
Power Cable Installation (SNLL assumed 1/2 of Power/Data Total)	
Direct Labor, 0.535 man-hours	8.09
Overhead	5.66
Power Cable Connect, Check (SNLL assumed 1/2 of Power/Data Total)	
Direct Labor, 0.353 man-hours	5.35
Overhead	3.74
Circuit Breaker, 15 Amp	36.48
Junction Box, Mounting Panel, Terminal Strip,	121.14
Terminators, Cable Fittings	
Power Cable, 165 in. #20 AWG, 3 Conducter, 600 V	1.82
Control Cable, 312 in. #24 AWG, 600 V	3.64
Total MDAC Power Supply System Costs, $/heliostat	$281.43

Communication System Costs

ARCO included data distribution costs in its estimate of $200 per heliostat. BEC made no estimate.

MMC data distribution system cabling consists of 619,000 ft of fiber-optic cable per 50 MW_e plant, amounting to an average of 120.26 ft of cable per heliostat and costing $36.65 per heliostat. Also included in the data distribution system are two fiber-optic connectors per heliostat and four per HFC. Since each HFC services 32 heliostats, the average number of connectors per heliostat is 2-1/8 at a cost of $14.87 per heliostat. The subcontracted site direct labor cost is $11.74 per heliostat. Thus the data distribution system cost for cabling, connections, and labor is $63.26 per heliostat.

Besides the HAC, BCS, field control system (DDC and HFC), and HC, MDAC's data distribution system consists of the following:

Cable, 108 in.	$ 3.29/heliostat
Terminators, 4 each	32.88
Connectors, 4 each	25.80
Data Cable Installation (SNLL assumed 1/2 of Power/Data Total)	
Direct Labor, 0.535 man-hours	8.09
Overhead	5.66
Data Cable Connect, Check (SNLL assumed 1/2 of Power/Data Total)	
Direct Labor, 0.353 man-hours	5.35
Overhead	3.74
Total MDAC Data Distribution System Costs, $/heliostat	$84.81

The MDAC description does not indicate if costs are included for the fiber-optic cables between the HC and HFC, the HFC and DDC, and the DDC and HAC.

ARCO estimates spending $1,000,000 for a site-installed HAC, at a per-heliostat cost of $167.39. This estimate is high compared to those estimates made by MMC and MDAC. The MMC dual-redundant minicomputer HAC cost estimate is $400,000 per site; the MDAC dual microcomputer HAC cost estimate is roughly $129,000 per site. BEC did not make an estimate. Details of the costs of MMC's and MDAC's HACs are presented below.

HAC COST ($/site)

HAC Parts	MMC	MDAC
Computers	Mod Comp Classic (2) $118,000	DEC LSI II (2) $19,480
	Shadow Memory $27,000	Data Acquisition $4450
	512 kbyte (2) $50,400	Console Racks (2) $1203
	Interfaces, Switches, Cables $59,868	
Storage	10 Mbyte Disc w/Controller $23,850	Floppy Disc $9080
	10 Mbyte Disc $13,950	
	Magnetic Tape Unit $10,170	
Printer	High Speed Line Printer $7830	150cps Printer (4) $4930
	150cps Printer $3726	
Terminal	ISC-8001G Color CRT $4500	ISC-80001G $5893
	TI-820 KSR (2) $4500	
Display	Graphics Terminal (2) $46,800	
WWV Clock	$1800	$1864
Software	$26,860	$1022
HAC Hardware, Software Design, Installation, Check-Out Labor*		$80,768
Total Installed HAC, $/site	$400,000	$128,690
Total, $/heliostat	$ 77.71	$ 23.78

*Includes direct labor, overhead, and G & A.

MMC's HAC account does not separately list the labor for hardware and software design or for installation and checkout activities. The HAC is similar to the unit installed at the Barstow Pilot Plant and uses available software. The account includes a graphics display unit similar to one which is proving useful at the pilot plant.

While MMC uses magnetic tape storage, MDAC uses a floppy disc memory. The floppy disc may have to be replaced periodically as a result of normal use; it may also be somewhat too slow for a large field.

When the cost of the various direct materials or labor involved in a control system is distributed over 5000 heliostats, the per-heliostat cost is not greatly increased; however, for fields containing fewer heliostats, HAC costs significantly affect total heliostat cost.

The field control system normally consists of a heliostat field controller (HFC), but MDAC also has a data distribution center (DDC). The HFC controls up to 32 HCs while the DDC, which is between the HFC and the HAC, can contain as many as 8 HFCs.

ARCO does not incorporate a separate HFC in its control system. SNLL estimates the cost of the ARCO HC/HFC at $328.27 per heliostat. The factory burden portion for the HC/HFC could not be separated from the total burden costs; however, the $328.27 per heliostat is based on the costs provided by ARCO.

BEC does use an HFC in its design. However, it made no estimate for HCs or HFCs.

The MMC heliostat design incorporates an HFC that costs $8.39 per heliostat.

The MDAC HFC costs $1.53 per heliostat and consists of an optical transceiver, relay, photo transistor, LED, and ceramic capacitor. The DDC materials cost $1.14 per heliostat and includes pairs of optical transceivers, microcomputers, modular power supplies, and miscellaneous parts. Direct labor costs $0.01 per heliostat and overhead costs $0.09 per heliostat, for a combined HFC/DDC cost of $2.77 per heliostat.

The MMC estimated cost for an HC is $412.15 per heliostat for materials and $36.69 per heliostat for subcontracted labor for a total of $448.84 per heliostat. No factory burden is allocated to the HC or HFC by MMC. No charge was found for a transformer described in the design.

The MDAC HC is estimated to cost about $203.04 per heliostat, $176.04 for direct materials and $27.00 for labor and overhead. The tabulation in Table 34 of the HC and HFC parts for MMC and MDAC illustrates some of the cost similarities and differences.

ARCO estimates that a BCS would cost about $150,000 per field installed, or $25.11 per heliostat. MMC estimates a BCS at $200,000 per field installed or $38.86 per heliostat. MDAC estimates $7.47 per heliostat for materials, $0.24 per heliostat for direct labor, and a total of $1.61 per heliostat for indirects. MDAC's total of $9.32 per heliostat equals about $50,440 per field. BEC did not include an estimate for a BCS.

TABLE 34

MMC AND MDAC CONTROLLER PARTS COSTS
(Contractors' Estimates, $/heliostat)

HC and HFC Parts	HC MMC	HC MDAC	HFC MMC	HFC MDAC
Package	4.00	0.62	0.19	0.00
Power supply	70.00	51.11	--	0.37
Rectifiers	45.00	--	--	--
Fiber-optic Transmitter/Receiver	70.00	41.66	4.38	1.64
Connectors	--	4.04	--	--
Labor, inc. overhead	36.69	27.00	0.99	0.10
Computer	--	50.67	--	0.36
Integrated Circuits	101.60	--	2.39	--
Relays	100.00	--	--	0.11
Diodes, resistors, capacitors	16.07	2.02	0.31	0.06
Crystal, socket relay	5.48	--	0.14	--
PCB, interfaces, etc.	--	25.92	--	0.13
Total Controller Parts Costs, $/heliostat	448.84	203.04	8.39	2.77

MDAC charges $0.50 per heliostat to transport the transformers and cabling to the site. This cost includes the pallet charge, direct labor, overhead, and G & A. No charges are provided by the other contractors for transporting controls and field wiring to the sites.

Contractors reported and combined such activities as controls installation, controls checkout, and systems tests under site installation labor; alternately, they could have assigned these costs entirely or partially to the controls and field wiring account.

MMC revised its estimate of the mass-produced HC/HFC and cabling costs in September 1981 to be $0.87/m^2$ less than estimated in its final report. Revised controls and field wiring costs thus are $821.12 per heliostat or $14.31/m^2$. The lower cost reflects the savings resulting from mass production of the HC, HFC, and cabling.

Discussion

Since the contractors placed little emphasis on controls and field wiring, their cost estimates should be considered preliminary. More effort should be spent in this area on design and costing to arrive at credible estimates. Even so, the overall cost differences do not appear to be very significant; a range of $10 to $15/m^2$ amounts to a difference of about 5 percent of the total installed heliostat price.

The estimates made by MMC and MDAC for power system costs are similar, except that MMC's estimate does not include any circuit breakers. If an allocation for circuit breakers were made by MMC similar to that made by MDAC, both power system estimates would be about $280 per heliostat. The ARCO estimate has no backup detail and appears somewhat optimistic.

The data distribution cost estimates provided by MMC and MDAC are somewhat unclear. The total MMC cost estimates for the fiber-optic cable, connections (2-1/8 per heliostat), and labor are less than MDAC's cost estimate, which apparently omitted fiber-optic cable. There are more MDAC connections and terminations (8 per heliostat), resulting in higher costs. If nominal cable costs are added to the MDAC estimate, the total cost is about $120 per heliostat; in contrast, the MMC total cost is only about $63 per heliostat. Use of a DDC by MDAC may account for these cost differences.

ARCO data distribution costs are included in its $200 per heliostat cost. Since the power system alone would probably cost more than $200 per heliostat, the inclusion of data distribution costs in this estimate seems quite optimistic. ARCO and BEC propose to use conventional copper cables for data distribution. Currently, copper wiring is at least as expensive as fiber optics; its use could further add to the costs because of the ancillary equipment required, e.g., lightning protection.

HAC costs per field appear to be extremely conservative for the ARCO estimate ($1 million), slightly conservative for the MMC estimate ($0.4 million), but somewhat optimistic for the MDAC estimate ($0.13 million). A compromise estimate might range from $0.2 million to

$0.3 million per field. The desires of the individual site owner may well dictate the sophistication of HAC equipment and the eventual cost to the system.

The cost of an HFC is small; when divided among the 32 heliostats it services, it costs less than $10 per heliostat. MDAC costs were a fraction of the MMC costs, since eight HFC's share common redundant parts in MDAC's DDC. The two field control systems do have different capabilities, at least in computer memory capacity. The MMC HFC contains 4096 bytes of ROM and 1152 bytes of RAM, while the MDAC DDC/HFC contains 2000 bytes of EPROM and 16,000 bytes of RAM. The dual redundant MDAC computers are shared by up to eight HFCs in each DDC.

HC costs, which are significant, vary considerably among the three contractor estimates. Differences of as much as $250 per heliostat occur. Some of the difference is due to pricing philosophies. When MMC priced its HC, volume discounts were not considered and essentially the same HC was used in these heliostats as the Barstow Pilot Plant heliostats. MDAC's HC computer costs much less than MMC's HC computer. Capabilities may, however, vary enough to justify cost differences. For example, memory capabilities for the MMC computer are 4096 bytes of ROM and 256 bytes of RAM compared to those of the MDAC computer--1000 bytes of EPROM and 64 bytes of RAM.

When a large field is considered, BCS costs are small per heliostat. They could become more significant if field size is reduced. Not enough detail is provided by any contractor to present specific summary comments about BCS costs.

FOUNDATION/PEDESTAL

Just as each of the contractors designed different foundation/pedestal parts, each plans to build or install them differently. Some of the choices in fabrication location (CMF or site), basic materials (concrete or steel), shipping, and installation method (pile driving, vibratory hammer, augering and grout, or poured-in-place) affect foundation/pedestal installed costs.

For all these reasons, comparison of foundation/pedestal costs is difficult. In addition, three of the contractors used subcontracts to install their foundations. Normally a subcontractor supplies only a single total price which includes all direct materials, direct labor, all indirect costs, and profit. However, because of a separate study by Kaiser Engineers and some partial breakdowns by the subcontractors, some comparisons can be made.

In general, all of the foundation/pedestal designs more than meet the load-deflection requirements and could be redesigned to reduce both materials and the resultant installed costs. A new code, PADLL (Pier Analysis and Design for Lateral Loads),* developed by GAI Consultants, Inc., should assist designers to optimize future foundation designs.

Direct Materials Cost

The first cost area is the cost of direct materials. ARCO fabricates a thin-walled (0.125 in.) steel cylinder in its CMF, with a resultant total factory price of $341.98. This price, which contains raw materials and labor costs, essentially represents total direct materials cost and is comparable to the costs of those foundation materials which are installed on site by other contractors. BEC purchases a prestressed concrete pile which costs $618, including delivery to the site. The transportation cost from the pile manufacturer to the site was not stated separately, but could be estimated at $130 per pile (based on five 7200 lb piles per truck and $650 per round-trip truckload). Direct material cost could thus approximate $488.

The MMC direct materials cost consists of a factory-made interface adapter (total price $50.84) and the concrete, rebar cage, and electrical conduit that are installed at the site. Total cost of the last three items is roughly $253 for 3.55 cu yd of concrete, 320 lb of rebar, and 7 lb of electrical conduit. MMC direct materials cost totals $303.84. The MDAC direct materials cost consists of a 436 lb steel pedestal made in the CMF (total price $195.80) and the cost of site-installed materials, including a rebar cage attached to a tapered pipe and concrete. The 296 lb rebar cage and 86 lb tapered pipe cost about $213 including fabrication, and the concrete costs about $123. Total MDAC direct materials cost is $531.80.

*"Laterally Loaded Drilled Pier Research," Electric Power Research Institute, January 1982, EPRI EL-2197.

A summary of the foundation/pedestal direct materials costs are shown:

ARCO	$342
BEC	$488
MMC	$304
MDAC	$532

Some of the cost differences can be accounted for by various rates, but none of the rates seems inappropriate for the particular materials, amount of labor etc., required. The actual rates charged at Barstow are shown for comparison.

	ARCO	MMC	MDAC	Barstow
"Steel", $/lb	0.30	0.23	0.32-0.42	--
Rebar, $/lb	--	0.22	0.30	0.22
Concrete, $/cu yd	--	45.00	53.20	55.00

Transportation Cost

Another cost category to consider is the cost of shipping any material from the CMF or subcontractor's facility to the site. The SNLL-estimated cost of transporting ARCO's foundation/pedestal is based on 26 pedestals per truckload and $650 per round-trip truckload, while ARCO's estimate is based on $1.15 per mile. The SNLL-estimated cost amounts to roughly $25 per foundation/pedestal compared to ARCO's estimate of $23. The BEC transportation cost was estimated previously by SNLL at about $130 per foundation. MMC ships only a pedestal interface adapter tube at 224 per truckload, which SNLL estimated to cost $3.15 per adapter; MMC's estimate of $6.70 consists of $4.79 to-site costs, $1.43 return costs, and $1.48 crate costs. MDAC ships the pedestal tube from the CMF to the site at an SNLL-estimated cost of about $20.80. The rebar cage, assembled and welded to the tapered pipe by a subcontractor located about 100 miles from the site, costs about $23.20 to ship according to SNLL (MDAC estimates only $4.31). The MDAC scenario does not identify how the tapered pipe gets from the CMF to the subcontractor's location, but the added cost should be small. The MDAC estimate for shipping the rebar and cone is $4.31, which includes $1.27 for direct labor and $3.04 for overhead and G & A. The pedestal is shipped along with the drive mechanism and main beam.

A summary of the foundation/pedestal transportation costs per heliostat as normalized by SNLL are:

ARCO	$25
BEC	$130
MMC	$3
MDAC	$44

The higher transportation costs are a result of shipping both heavy and bulky items. A tradeoff exists between transportation costs and site labor charges.

Site Labor Cost

In addition to direct materials and transportation-to-site costs, site labor costs must be included in the total foundation/pedestal costs. Site labor cost is most easily defined in this report as direct labor cost. Support personnel, temporary facilities, consumables, rentals, etc., are often included in a single indirect charge that will be discussed in the next section.

ARCO uses a seven-man crew to install 40 foundation/pedestals per day, amounting to 1.4 man-hours per heliostat. In its documented scenario, ARCO uses an additional seven-man crew to incorporate levelling shims for 48 foundation/pedestals per day, or 1.3 man-hours per heliostat. At the ARCO site labor rate of $20/hr, these direct labor hours would total $54 per heliostat. At 40 heliostats per day, only 12 minutes (including any inefficiency) are allowed for installing a foundation/pedestal. Even though a vibratory hammer can operate very quickly (roughly 2 minutes per pile), factors such as setup time and equipment movement time could make this pace difficult to achieve on an average basis. ARCO notes that two or three crews could increase the 40/day installation rate. The actual costed installation includes augering the hole, installing the foundation/pedestal pipe, and filling the annulus with grout. These activities could well consume more time than the available 9 minutes. Up to 1.5 cu yd of Pole Set* grout (with an assumed 6-in. annulus) could add an estimated $100 to the cost of the direct materials. ARCO also notes that the foundation/pedestal alignment could be performed using software rather than the shims; 1.3 man-hours per heliostat would then be eliminated.

BEC did not provide a breakdown of labor hours since a subcontract was used. An estimate by Kaiser Engineers shows 3.1 man-hours for driving the pile. With a site direct labor rate of $15/hr, this activity would cost $46.50 per pile. BEC also notes that an alternate installation procedure of drilling, installing, and pole setting may be used. This alternate method might require the same number of man-hours as the baseline pile-driving procedure.

MMC subcontracts several site labor activities, including drilling the hole, fabricating the rebar cage and electrical conduit, installing the rebar cage, forming the above-ground pedestal, installing the pedestal interface adapter, and pouring all of the foundation/pedestal concrete. With the data from Black and Veatch and Kaiser Engineers, an estimate of the direct labor man-hours was made for some of these operations, including augering a 1.3 cu yd hole using a two-man crew (~1.6 man-hours); assembling the rebar cage and the electrical conduit and installing the assembly in the hole with a five-man crew (~3.6 man-hours); placing the foundation with a two-man crew (~1.7 man-hours); and forming and placing the pedestal and interface adapter with an eight-man crew (~6.5 man-hours). The total of 13.4 man-hours at a direct labor rate of $15.68/hr amounts to $210 per heliostat. MMC proposes to install foundations using one crew per shift, two shifts per day, for a total of 20 heliostats per day. Use of a second

*Trademark of Forward Enterprises of Texas.

shift of workers necessitates nighttime installation for at least part of the year. Field lighting which could be moved from site to site might be used, and its cost could be amortized over the course of 11 years.

MDAC also has a number of site labor operations, including drilling a 1.8 cu yd hole with a six-man crew (~ 3.0 man-hours); fabricating the rebar cage and tapered pipe at a subcontractor site (but at site labor rates) with a seven-man crew (~ 3.5 man-hours); forming and bracing the foundation with a four-man crew (~ 2.0 man-hours); pouring the foundation with a five-man crew (~ 2.5 man-hours); and supporting the various operations with equipment and vehicles using a five-man crew (~ 2.5 man-hours). All of the MDAC operations are done in 30 minutes; four crews are required to meet the predicted foundation installation rate of 64 heliostats per day on one shift. MDAC also identified 1 man-hour of direct labor, with a two-man crew, to perform the surveying operations for the foundation location. (None of the other contractors included any charges for surveying the foundation location as part of the installed heliostat costs. BEC did, however, include charges of 0.25 man-hours to confirm the foundation/pedestal position after installation.) The total direct labor charge was based on 14.5 man-hours at $15.12/hr or $219.

A summary of the direct labor costs and direct labor hours for foundation/pedestal installation per heliostat follows, including nominal surveying charges; as a point of reference, the Barstow Pilot Plant data for foundations are also included. (The maximum time allowed by the contractor for any single installation activity is also shown.)

	Cost, $	Man-Hours	Time (Minutes)
ARCO	69	3.7	12
BEC	61	4.1	18
MMC	225	14.4	48
MDAC	219	14.5	30
Barstow Pilot Plant (foundation only)	200	10.7	

Some of the cost differences may be the result of SNLL's effort to compare information; that is, one contractor's single subcontracted costs are subdivided for comparison with another contractor's itemized costs. One observed difference is that the two factory-made foundations, i.e., those of ARCO and BEC, require much less site labor for installation than the poured-in-place foundations of MMC and MDAC. The latter foundations, however, use about the same amount of site labor. Kaiser Engineers estimate fewer labor hours for MDAC than MDAC predicted for its foundation installation (10.4 man-hours vs. 14.5 man-hours). MDAC appears conservative in its estimate. An overestimate of 4 man-hours could contribute about $\$2/m^2$ to the installed heliostat price. One other difference between MMC and MDAC is the rate of installation. MDAC allows 30 minutes for any single operation while MMC allows 45 to 50 minutes. (MMC uses smaller crews working longer hours on a total of two shifts, while MDAC uses multiple larger crews on only one shift.) Compared to the maximum time allowances for MMC and MDAC, those for

ARCO and BEC are much shorter (12 and 18 minutes, respectively, for any single operation) and may be optimistic.

Indirect Costs

Besides direct materials and direct labor costs, all other site costs can be considered indirect charges. Indirect costs, whether contractor or subcontractor costs, include consumable supplies, equipment rental, supervision, field engineering, temporary facilities, amortization, capitalization, and gross profit. The easiest way to assess these costs is as a proportion of direct labor costs. If this method is used, the following ratios apply:

	Ratio of Indirect to Direct Labor for Foundation/Pedestal, %	Approximate Indirect Cost, $
ARCO	240	166
BEC	420	257
MMC	60	134
MDAC	72	157
Barstow Pilot Plant (foundation only)	69	139

These ratios vary considerably; further information is required to explain the differences. For point of reference, the Barstow foundation contract had indirect costs amounting to 69 percent of the direct labor costs. Barstow indirect costs did not include the pedestal but did include foundation indirect charges of equipment rentals, overhead, temporary construction, supervision, and profit. Since both the ARCO and BEC foundation installations were subcontracted, neither contractor specified the direct labor hours required. If the direct labor hours per foundation installation are indeed as low as those estimated by Kaiser Engineers, one might conclude that ARCO's and BEC's subcontracted indirect costs are high. These indirect costs, and the resultant total heliostat costs, could be reduced if ARCO and BEC performed their own foundation installations.

Foundation/Pedestal Cost Summary

Costs for the foundation/pedestal are noted in Table 35 as a function of reflective area. All of the foundation/pedestals exceed the load deflection specifications and thus are overdesigned. The designs could reduce costs, especially in direct materials, by using shorter or smaller diameter foundations. The BEC foundation/pedestal is very expensive and could be reduced in cost by changing design. The high costs of the MDAC direct materials reflect not only the use of the steel pedestal, steel tapered cone, and rebar cage (total of 818 lb of steel) but also the high cost rate ($/lb) for the steel. The MMC cost rates for steel are quite low; however, the rebar cage that MMC costed was similar to that actually installed at Barstow at a much lower consumption rate. The MMC rate for delivered concrete may be optimistic even for April 1980 dollars, but it may be

TABLE 35

FOUNDATION/PEDESTAL COST SUMMARY
(Contractors' Estimates, $\$/m^2$)

Component of Cost	ARCO	BEC	MMC	MDAC	Barstow (foundation only)
Direct Material $\$/m^2$	6.50	11.10	5.30	9.40	8.60
Transportation $\$/m^2$	0.50	3.00	**	0.80	**
Direct Labor $\$/m^2$	1.30	1.40	3.90	3.90	5.00
Indirect Costs $\$/m^2$	3.10	5.80	2.30	2.80	3.50
Total Foundation/ Pedestal Costs, $\$/m^2$	11.40	21.30	11.50*	16.90	17.10

*Reduced by MMC (9/30/81 Review) to $\$10.46/m^2$.
**Not specifically called out.

possible. If so, the MDAC direct materials cost for concrete may be conservative. At the September 1981 review, MMC estimated that $\$1.04/m^2$ or \$59.70 per heliostat could be saved on the foundation/pedestal over the cost estimate made by Black and Veatch. This would revise the estimate for the installed foundation/pedestal to $\$10.46/m^2$.

O & M

Operations and Maintenance Cost Estimate

As estimated in this study, the operations and maintenance (O & M) costs include only the periodic costs that occur over the 30-year life of a 50 MW_e plant. The initial investment cost of maintenance equipment and the cost of the initial inventory of spare parts are included in the capital costs of the heliostat. These costs were not uniformly presented in the contractors' reports. Another cost not identified by all of the contractors is the additional cost of first-year O & M expenses over those of the periodic subsequent years. These costs could be part of either the initial investment or the levelized annual O & M cost.

Periodic costs are divided into several categories. One category includes costs for heliostat replacement parts and the labor to implement these changes. A second category includes costs for both the materials and labor involved in miscellaneous repair. A third category includes costs for replacing maintenance equipment that does not last 30 years. Other categories include costs related to reflective surface washing materials and the associated labor, to heliostat field operations, and to the power consumed by the heliostat field when the field is not producing usable power. In this study, the heliostat account is not charged for the parasitic power consumed by operating heliostats. However, power consumption could have been charged to this account.

Heliostat Part Replacement

The heliostat part replacement account incurs costs from both the replacement materials and the labor to replace these materials.

Materials--Estimates of replacement part costs, which are based on failure rates for the various heliostat parts, are shown for each contractor:

ARCO	- Reflective assembly	\$ 2.40/heliostat
	- Drive mechanism	
	Gears, bearings, seals	1.00
	Motors	0.80
	Limit switches	0.08
	Cables, connectors	0.20
	- Controls	1.26
	Total	\$ 5.74/heliostat
BEC	Total	\$14.17/heliostat
MMC	- All except HAC	\$12.50/heliostat
	- HAC (service contract)	4.86
	Total	\$17.36/heliostat

MDAC - Reflective assembly	$ 0.47/heliostat
- Drive mechanism	
Azimuth	0.11
Elevation	0.18
Motors	1.01
Position/limit indicators	0.71
Power supply/distribution	0.11
- Controls	0.84
Total	$ 3.44/heliostat

Labor--Estimates of the cost of labor to replace heliostat parts is dependent on the time and labor rate used.

ARCO - Reflective assembly	$ 0.24/heliostat
- Drive mechanism	
Gears, bearing seals	0.03
Motors	0.02
Limit switches	0.08
Cables, connectors	0.10
- Controls	3.15
Total	$ 3.62/heliostat

In addition, ARCO has a 100 percent overhead charge, which is equal to the direct labor charge of $3.62 per heliostat for a total charge of $7.24 per heliostat.

BEC	Total	$17.90/heliostat
MMC	Total @ $15.08/hour	$21.57/heliostat

The MMC labor excludes mirror washing and includes two men on the day shift and two part-time men on the night shift.

MDAC - Reflective assembly	$ 1.29/heliostat
- Drive mechanism	
Azimuth	10.16
Elevation	2.59
Motors	4.23
Position/limit indicators	0.37
Power supply/distribution	0.55
- Controls	0.96
- Pedestal	0.55
Total @ $18.00/hour	$20.70/heliostat

Miscellaneous Repair Maintenance

The miscellaneous repair maintenance account includes repainting part surfaces, changing oil, lubricating, and repairing parts.

ARCO - Materials costs associated with cleaning and repainting mirror module substrates, drive units, control unit housings, and pedestals and support structures and with changing drive unit oil are estimated at $9.14 per heliostat. Labor and overhead costs associated with these activities are estimated at $9.20 per heliostat for a total charge of $18.34 per heliostat.

BEC - All of the BEC cost estimates are included in other accounts.

MMC - All of the MMC cost estimates are included in other accounts.

MDAC - Several items are included in the miscellaneous repair maintenance account, such as bench repair of defective azimuth and elevation drive parts and repairing defective power transformers at an off-site facility. Charges for these activities are $1.62 per heliostat. Another group of expenses, totaling $6.39 per heliostat, includes parts and shipping costs for replacing or repairing such items as mirror modules, reflective assembly supports, azimuth or elevation drives, drive motors (including encoders and motor controllers), power and data cables (both heliostat and field portions), power transformers, power distribution panels, data distribution interfaces, heliostat controllers, pedestal tube cap covers, and junction boxes. Also included are expenses for crane, forklift, and pickup fuel; lubrication for the azimuth and elevation drives; maintenance supplies; and HAC service contract.

Labor costs associated with the above repairs total $2.77 per heliostat, for a total expense of $10.78 per heliostat.

Maintenance Equipment Replacement

Maintenance equipment replacement costs are based on the initial cost of the equipment lifetime, the maintenance inflation rate, and the discount rate during the lifetime of the plant.

The present value of equipment replacement costs distributed over the plant lifetime and based on a periodic cost (first-year cost estimate) can be estimated by the following equation:*

$$PV = PC \sum_{i=1,j}^{n} \left(\frac{1 + g}{1 + k} \right)^{i}$$

where

PV = present value
PC = periodic cost
n = plant lifetime, i.e., 30 years

*See Reference 8.

j = period of repeated replacement, i.e., 5 years for tooling and 10 years for equipment
g = escalation rate for maintenance cost, assumed at 0.08
k = discount rate for cost of money, assumed at 0.11

If the above variables are used, the ratio of PV to PC is 0.76 and 0.578 for the two 10-year replacement periods typical for equipment. The ratios are 0.872, 0.760, 0.663, 0.578, and 0.504 for the five 5-year replacement periods typical for tooling over the 30-year plant life.

The levelized annual cost (LAC) to provide for periodic equipment or tooling replacement can be estimated by:

$$LAC_{O\&m} = PV_{O\&m}(CRF)$$

where $LAC_{O\&m}$ = levelized annual cost of O & M

CRF = capital recovery factor based on discount rate (k) and plant lifetime (n)

$$= \frac{k}{1 - \frac{1}{(1+k)^n}}$$

The ratio of $LAC_{O\&m}$ to PV is shown for various discount rates, k, over 30 years.

10% = 0.106	16% = 0.162
11% = 0.115	17% = 0.172
12% = 0.124	18% = 0.181
13% = 0.133	19% = 0.191
14% = 0.143	20% = 0.201
15% = 0.152	

If the factors for the 10-year equipment replacement were combined, the levelized annual cost of the present value would be:

$$LAC_{O\&m} = PV\ (0.760 + 0.578)(0.115)$$
$$= PV\ (0.154)$$

ARCO states that its $550,000 washing system has a 30-year life and therefore is not replaced. Other initial equipment having a useful life under 30 years was originally capitalized at $52.45 per heliostat. Since the anticipated lifetimes were not given, the annualized cost of replacement can only be estimated. An estimate of the levelized annual cost of the present value--assuming a 10-year lifetime, 8 percent inflation, and an 11 percent discount rate--is $8.08 per heliostat.

BEC uses three mirror-cleaning trucks but does not specify the life of the equipment. Each truck initially costs $75,000. BEC shows other maintenance equipment originally being capitalized at $21.12 per heliostat. The levelized annual cost of the present value over 30 years, on the basis of the same assumptions as those for ARCO, is estimated at $8.26 per heliostat.

MMC projects a need for one $75,000 mirror washing truck having a 10-year lifetime (costing $14.57 per heliostat) and capitalized equipment having an initial expense of $230,000 (costing $44.69 per heliostat). Lifetimes of ten years for equipment and five years for tooling were specified. The levelized annual cost of the present value for replacing these maintenance items is $9.13 per heliostat based on the same assumptions used by ARCO. MDAC uses two wash trucks in tandem and initially charges $35.93 per heliostat. MDAC also capitalizes other equipment and tools with an initial cost of $36.07 per heliostat. An estimate of the levelized annual cost of the present value of equipment replacement is $11.09 per heliostat based on the assumptions used by ARCO.

Mirror Washing

All of the contractors make some assumptions on mirror washing scenarios but were not tasked with providing any detailed design. These general assumptions are the basis of the estimate.

Mirror Washing Materials--Mirror washing materials were estimated by the contractors.

ARCO - Mirror washing materials used by ARCO include supplies ($2.01 per heliostat), water ($0.67 per heliostat), deionizing chemicals ($1.67 per heliostat), maintenance ($4.18 per heliostat), and electricity ($1.00 per heliostat). Charges are based on the assumption that six washes per year are required.

BEC - The only materials budget that could be associated with washing materials is the repair materials budget, which amounts to $0.72 per heliostat. BEC proposes to wash heliostats eight times a year for the most cost-effective approach. BEC recovers about 75 percent of the wash water.

MMC - Washing materials are costed at $2.80 per heliostat for deionized water and wash truck operation.

MDAC - Scheduled maintenance materials are costed at $11.96 per heliostat. This amount includes the costs of washing solution, deionized wash and rinse water, and diesel fuel for the washing trucks.

Mirror Washing Labor--Mirror washing labor estimates are shown for each contractor.

ARCO - Mirror washing labor charges include direct labor ($7.50/hour), benefits ($1.88/hour), and a G & A allowance ($1.67 per heliostat) for a total cost of $3.30 per heliostat. The loaded labor rate plus G & A is $18.94/hour. The time allowed for the actual washing of each heliostat is 17 seconds; a total of 1.6 minutes is allowed for washing activities, including travel, breaks, etc. On the average, one operator works one shift half-time.

BEC - Scheduled maintenance labor costs $62.47 per heliostat. Of that total, $52.50 is for mirror washing. The remainder is for vehicle maintenance, instrument calibration, weed control, etc. Three cleaning crews operate on the day shift and two on the night shift. Each three-man crew uses a cleaning truck. The heliostats are oriented so that one truck can clean two heliostats at a time. Overall time for cleaning a heliostat is about 10 minutes including travel, breaks, etc.

MMC - Every month, a two-man maintenance crew washes a complete field of mirrors in about 80 nighttime hours. An overall time of 0.93 minute is allowed per heliostat, including travel, breaks, etc. The $15.08/hr labor rate used by MMC yields a labor cost of $2.80 per heliostat.

MDAC - Scheduled labor to wash MDAC mirrors costs $11.21 per heliostat at a labor rate of $18.05/hr. Mirrors are washed twelve times a year, using both a wash truck and a rinse truck. Each heliostat is washed or rinsed for about 28 seconds. The average time allotted for travel, breaks, etc., is about 1.68 minutes per heliostat; although not specified by MDAC, the time predictions require a two-man crew to operate the two trucks on a single shift.

Heliostat Field Operations

Heliostat Field Operations Labor--Contractors estimated annual field operations labor costs.

ARCO - ARCO assumes no operations labor costs. If three 40-hour man-weeks are assigned to this cost account at ARCO's loaded labor rate plus a G & A of $18.94/hr, the cost is $19.78 per heliostat.

BEC - Operations labor, requiring an average of two full-time operators, is estimated as $11.39 per heliostat. BEC plans to use a variable operating schedule--seven days a week from June to September and five days a week for the rest of the year. Average daily operating time is about 12 hours; thus the labor hours need to be supplemented by the part-time effort of other workers if only two men will be employed on regular eight-hour shifts. BEC does note that supervisory or monitoring duties may be the normal responsibility of the collector field operators.

MMC - An equivalent of three 40-hr man-weeks is estimated for collector field operation requirements. At an average wage rate of $14.08/hr, the annual operations labor cost is $17.07 per heliostat.

MDAC - No budget for operations labor is included by MDAC. If three 40-hr man-weeks are assigned to this cost account at the MDAC labor rate of $18.05/hr, the cost is $20.81 per heliostat. However, MDAC states that "the design of plant control is such that the operator attention necessary to monitor the collector field is within the capacity of station personnel normally assigned to a utility operation regardless of plant type"; therefore, no cost is assigned to this account for the contractor estimate.

Heliostat Field Power Consumption--Only BEC provides an estimate of the power consumed by the heliostat field during nonoperational hours. Another contractor lists the total power consumption expected during the year. Data are also available on the power requirements of the motors and the heliostat controllers on each of the Second Generation Heliostats at the CRTF. SNLL uses these data to estimate heliostat power consumption.

ARCO - Power consumption measured at the CRTF was 2.35 kWhr per heliostat during a ten-hour day. Based on 365 eleven-hour days of operation per year, the operational power consumption cost is $47.18 per heliostat at $0.05/kWhr. Nonoperational power consumption is assumed to be half the operational power consumption, or $23.60 per heliostat. ARCO plans to replace its Second Generation Heliostat motors with ones of lower power consumption in subsequent design iterations.

BEC - The operations budget includes an estimated annual cost of nonoperational power at $3.26 per heliostat. This is based on $0.04/kWhr. The amount of estimated power consumed per heliostat can be itemized as follows:

MOTORS -- 0.39 kW x 15 min = 0.10 kWhr/day (morning start-up)

HC -- 0.010 kW x 1.5 hr = 0.015 kWhr/day (morning start-up)
0.010 kW x 11.5 hr = 0.115 kWhr/day (nighttime)

HFC -- 7.0E-4 kW x 1.5 hr = 0.001 kWhr/day (morning start-up)
7.0E-4 kW x 11.5 hr = 0.008 kWhr/day (nighttime)

HAC -- 2.5E-5 kW x 1.5 hr = 3.7E-5 kWhr/day (morning start-up)
2.5E-5 kW x 11.5 hr = 2.8E-4 kWhr/day (nighttime)

WIND MONITORS -- 5.8E-5 kW x 13 hr = 7.5E-4 kWhr/day (nonoperational)

Total nonoperational power consumed per heliostat totals 0.15 kWhr/day, or 54.8 kWhr for 365 days. Cost of this power at $0.05/kWhr is $2.74 per heliostat.

Data from the CRTF indicates an average power consumption by the HC and motors of 0.29 kWhr over a ten-hour day. Average operating time for the motors can be estimated from the CRTF data and the BEC projections.

HC	-- 0.01 kW x 10 hr	= 0.10 kWhr
Motors	-- 0.39 kW x 1 hr x 0.05*	= 0.19 kWhr
		0.29 kWhr

The operational power consumption cost can be estimated as follows:

Motors	-- 0.39 kW x 11 hr x 0.05	= 0.215
HC	-- 0.010 kW x 11 hr	= 0.110
HFC	-- 7.0E-4 kW x 11 hr	= 0.008
HAC	-- 2.5E-4 kW x 11 hr	= 0.003
Wind	-- 2.5E-5 kW x 11 hr	= 0.0003
		= 0.336 kWhr/day/heliostat

At a cost of $0.05/kWhr, the operational power consumption per heliostat per year is $6.14.

*Fraction of ten hours actually operating.

MMC - Power consumption measured at the CRTF for a ten-hour day was 0.257 kWhr. Based on 365 eleven-hour days of operation per year and $0.05/kWhr, the operational power consumption cost is about $5.16 per heliostat. Nonoperational power consumption cost is estimated at about half the operational power consumption cost, or $2.50 per heliostat.

MDAC - Power consumption measured at the CRTF for a ten-hour day was 0.63 kWhr. Operational power consumption cost, based on 365 eleven-hour days of operation and $0.05/kWhr, totals about $12.05 per heliostat. Half of this estimated cost, $6.42 per heliostat, roughly represents the nonoperational power consumption annual cost.

A summary of the various O & M charges that were estimated by each contractor follows in Table 36.

TABLE 36

OPERATIONS AND MAINTENANCE COSTS
(Contractors' Estimates, $/m^2)

Components of Cost	ARCO	BEC	MMC	MDAC
Replacement Components				
Materials	0.11	0.32	0.30	0.06
Labor	0.14	0.41	0.38	0.36
Repair	0.17	inc.	inc.	0.19
Equipment Replacement*	0.15	0.19	0.16	0.19
Mirror Washing				
Materials	0.18	0.02	0.05	0.21
Labor	0.06	1.42	0.05	0.20
Field Operation	0.37*	0.26	0.30	0.00
Field Power*	0.45	0.06	0.04	0.11
Total O & M Costs, $/m^2	1.63	2.68	1.28	1.32

*SNLL-estimated values. See text for explanation.

Discussion

The cost analysis for the Second Generation Heliostat development study charges the initial equipment and spare parts inventory to the heliostat capital costs. Recurring costs are charged to O & M whether they come from daily activities or from replacing equipment so that the utility can operate for 30 years. Replacement costs are annualized over 30 years to represent the present value required for continued use of the equipment. While O & M costs increase at the annual inflation rate, the solar fuel costs remain constant at zero.

All of the O & M costs are strictly estimates since heliostat fields for a 50 MW_e energy generation plant have not existed or been operated, and comparable equipment has not been operated in similar configurations or environments. The Barstow Pilot Plant will in time provide some data, but even its field size and heliostat design are different from those in the Second Generation Heliostat development study scenario.

The contractors make estimates in some areas, but most do not include all the costs that SNLL expects to be in the O & M account. On the other hand, some costs are included that are not part of the O & M account. Most of the individual costs are small, but when the recurring costs are escalated at inflation rates over the 30-year life, the levelized costs become larger. For example, if the parameters used for equipment replacement were applied to the annual O & M "replacement" cost over a 30-year plant life, then the levelized annual cost would be about 2.32 times the initial year cost. Different economic assumptions can give the O & M cost portion more or less leverage than illustrated by this example.

Most of the O & M cost estimates come directly from the contractors' data or are extracted from their data. In a few areas, estimates are provided by SNLL. Equipment replacement costs, which the contractors did not include, are considered part of the recurring costs over the 30-year plant life. Field power consumption costs, which some contractors estimated, are estimated by SNLL to fit a common scenario. Operations labor cost is also estimated by SNLL where not provided.

Total recurring O & M costs vary among the contractors. One major cost difference is the estimate provided by BEC for mirror washing labor. This task could be completed more quickly if more automation were incorporated in BEC's scenario. Perhaps, however, ARCO, MMC, and MDAC are too optimistic in their projection that mirror washing can be completed in about one-tenth the time estimated by BEC.

Another difference among the contractors' designs is the amount of field power consumed during nonoperating hours. ARCO's system currently requires considerably more power than the other systems. Maturation of ARCO's design should reduce this value, making it more competitive.

Other O & M cost differences exist. In addition, the level of detail presented and the experience available to the contractors make an evaluation of a complete estimate difficult. Cost estimates for O & M will be improved only after actual field installation and operation are conducted.

COST REDUCTION

Potential Cost Reductions By Contractors

Each Second Generation Heliostat contractor identified areas for reducing the cost of its design. The cost-reducing modifications were not implemented into the heliostats built for this study or costed into the production planning of 50,000 heliostats per year. Before the proposed changes can be implemented, further technology development, or at least some demonstration of feasibility at specification standards, is required.

The effect of learning over a ten-year production span could provide additional reductions (10 to 15 percent) in the installed heliostat cost over the savings made by the design and process changes described by each contractor. Only two of the contractors (ARCO and MDAC) addressed the effect of learning. The effect of learning may or may not be real, but if appropriate for heliostats, their cost may be reduced by as much as \$15 to \$20/m^2 by the end of the ten-year production schedule.

Atlantic Richfield Company (ARCO)

ARCO identifies areas for potential cost reduction in its reflective assembly, support structure, drive unit, foundation/pedestal, and controls. ARCO suggests three ways to save costs on the reflective assembly: eliminate paint on the back surface of the mirrors, use thinner glass, and use only one piece of glass instead of two for each reflective panel.

In the support structure account, ARCO projects eliminating cross braces and lower braces, thereby reducing factory and field assembly costs. A potential for cost reduction also exists in the drive unit through the use of lighter weight castings, alternate motors to replace the D.C. stepper motors, and longer life crankcase oil.

Other potential ways of reducing costs include using control systems which consume less parasitic power; using a longer life paint for the support structure, drive housing, controls housing, and foundation; producing a lower cost foundation/pile, thereby lowering field installation cost; shifting field labor to the factory; and improving field labor planning.

If all the above changes are implemented, ARCO estimates that the price of installed heliostats would be reduced by 21 percent.

Boeing Engineering and Construction (BEC)

BEC identifies several areas of potential cost reduction. For the reflective assembly, BEC proposes switching to a commercially available cellular glass core from the more costly Foamsil. Furthermore, BEC believes that its initial estimate of \$0.50/ft^2 for silvering was high and that mirroring should cost only about \$0.35/ft^2.

In other cost accounts, BEC predicts that a smaller diameter pedestal would be better than the original, unexpectedly stiff pedestal. If a more slender pedestal were incorporated, the gimbal could have a smaller diameter, also lowering costs. BEC predicts that the drive specification could be relaxed without jeopardizing performance; drive cost would decrease not only as a result of that relaxation but also from the development of competitive drive suppliers.

BEC estimates that the cost savings realized by implementing the above measures could total about 10 percent of the price of an installed heliostat.

Martin Marietta Corporation (MMC)

MMC identifies several areas for potential cost reduction. Costs can be reduced by taking advantage of the depreciation effects on equipment allowed by the new tax laws. Innovative manufacturing processes could also reduce costs, particularly of the drive and mirror module assemblies. MMC claims that a cost savings could result from eliminating the coat of paint between the mirror back and the polyisobutylene layer on the facesheet and by eliminating the associated equipment, personnel, and in-process storage and cure area. MMC predicts that an investment of only $10 million (instead of the $40 million originally predicted) would be sufficient to induce Corning to build a fusion glass plant in Albuquerque, resulting in further cost savings.

In the cost account for the foundation/pedestal, MMC believes that actual construction bids would be lower than stated, based on a Black and Veatch estimate. Further cost savings could result from different scenarios for foundation installation and rebar cage fabrication. Significant cost savings can be achieved in the controls area as well, through an optimized field wiring scenario and as a result of reduced fiber-optic costs by 1984.

A cost savings of about 7 percent could be realized if all the above changes were implemented into MMC's scenario.

McDonnell Douglas Astronautics Company (MDAC)

MDAC identifies potential cost reductions for all its heliostat cost accounts except controls, both in processing and in materials reduction or simplification, while still complying with specifications. In the reflective assembly accounts, MDAC predicts that the addition of two additional mirror modules per heliostat would reduce costs by increasing reflective area. MDAC is currently testing a "shimless" bond of the hat section to the mirror using a rapid cure adhesive; this revision could cut costs for materials, equipment, manpower, and floorspace. Similar cost reductions could result from employing an adhesive lamination process, instead of autoclaving the mirrors to a glass backing sheet. A reduction in the material used in edge seals, or even their potential elimination, could have a corresponding cost savings. MDAC predicts that use of a hat section stringer such as fiberglass, which has the same thermal expansion as mirrors, would permit the use of thinner back laminate float glass and result in further cost savings.

In the support structure cost account, MDAC predicts potential cost reductions for both the main box beam and the elevation support structure. MDAC proposes that cost-reducing tradeoffs can be made between welding complexity and part weights. The elevation support structures might be made at less cost by casting rather than welding.

In the drive mechanism cost account, MDAC predicts several cost-saving methods. These include standardizing fasteners and seals, combining functions of parts, and increasing part size to minimize use of high-cost materials. MDAC also proposes replacing some metal parts with molded plastic parts.

In the foundation account, two alternate areas exist for cost reduction. One approach reduces the volume of concrete in the current foundation design by implanting a hollow tube inside the drilled hole and pouring the concrete between the tube and the hole. The other approach adopts an alternate foundation design--a hole is drilled and a preformed concrete or metal tube is grouted in place with foamed-in-place urethane.

MDAC estimates that implementation of all these changes could mean about 16 percent cost savings for its heliostat.

HELCAT

Heliostat Cost Comparisons Using a Heliostat Cost Analysis Tool (HELCAT)

The HELCAT code (Reference 6) was developed to provide a consistent structure for cost analysis. HELCAT calculates a representative installed-heliostat price based on the contractors' direct input data (i.e., direct materials and consumables, direct labor hours, and capital investment requirements for land, facility areas, and equipment and tooling) and various economic, financial, and accounting assumptions. Corrections have been made where identified, and in some cases judgments have also been made to translate the contractors' data into the HELCAT format. Default HELCAT parameters were used when contractor data were not available.

An endless number of HELCAT calculations and comparisons could be made, but this study concentrates on a best-effort representation of the contractors' estimates. Direct materials costs, direct labor hours, land areas, building sizes, equipment and tooling costs, consumable costs, and other applicable information were taken from the contractors' reports. Financial parameters were also used to simulate the contractors' business method as described in their reports. The remaining parameters were adjusted to reflect the dollar values shown in the reports (e.g., the G & A fraction in HELCAT was adjusted to provide the dollar value provided in the cost breakdown). In general, the total HELCAT-calculated installed price is within 1 to 2 percent of the contractor-calculated installed heliostat price.

HELCAT Input Parameters

In order to resolve the differences between the contractors' prices and the HELCAT calculated prices to within 1 or 2 percent, some SNLL default values had to be revised. (These default values were suggested by studying other businesses of a similar nature.) Some adjustments were necessitated because the HELCAT model does not represent each contractor's particular method of conducting business. However, some price differences resulted from underestimation or overestimation of costs. Table 37 shows the HELCAT parameters which were used to fit the contractors' estimates. These values may or may not be representative of a users' normal business practices.

Some wide variations are apparent in Table 37. The cost rate of improved land is low for ARCO and high for BEC. The factory cost rate is low for ARCO and high for MDAC. ARCO, MMC, and MDAC probably assume blanket insurance policies while BEC does not. The property tax alone, however, probably costs more than the property tax and insurance totals estimated by ARCO, MMC, and MDAC. Even so, these differences have small impact on the final heliostat price. Since land is not depreciated, the price of the land affects only the working capital. Buildings are depreciated over long periods of time (at least ten years), and the property tax and insurance amounts are small.

The contractors' factory labor rate estimates vary somewhat, as do the number of labor hours per heliostat. If the labor hours required to accomplish specific operations are actually those stated by the contractor,

TABLE 37

HELCAT PARAMETERS USED TO FIT CONTRACTORS' COSTS

Parameter	ARCO	BEC	MMC	MDAC	HELCAT DEFAULT
Improved Land Cost ($/acre)	12,000	32,000	20,000	20,000	20,000
Factory Cost ($/ft^2)	29.12	50.00	75.00	138.00	50.00
Property Tax/Insurance (%)	1.8	4.8	1.3	2.1	4.0
Factory Labor Rate ($/hr)	6.90	10.50	10.25	18.88	9.45
Site Labor Rate ($/hr)	20.00	11.44	15.68	15.12	15.00
Scrap Allowance (%)					
Purchased Material	0.0	1.0*	0.7	3.0	1.0
Raw Material	0.0	3.0*	1.0	3.0	3.0
Indirect Fractions (%)					
Capital Cost--Maintenance	2.0	2.0	2.8	2.0	2.0
Capital Cost--Other	0.0	0.6	0.0	0.5	0.6
Direct Materials Cost	0.4	0.4	0.6	0.3	0.35
Direct Labor Cost					
Factory	16.7	27.0*	35.0	22.0	27.0
Site	30.0	30.0*	30.0	70.0	30.0
G & A, Fraction of Sales (%)	10.0	2.9	5.3	4.4	9.0
Transport Rate ($/Truckload)	613.40	395.00	719.20	725.00	650.00
Facility Life (yr)	20	45	33	40	30
Tax Life (yr)	10*	20*	10	20*	25
Equipment Life (yr)	10	10	15	10	10
Tax Life (yr)	5*	10*	5	10*	8
Tooling Life (yr)	5	5	5	5	5
Tax Life (yr)	3*	5*	3	5*	3
Depreciation Method	SL	SOYD	SOYD	SL	
Equity Fraction	0.8	0.8	0.8	1.0	0.8
Return (%)	25.0	9.5	20	15.0*	16.6
Bond Fraction	0.2	0.2	0.2	0.0	0.2
Return (%)	18.0	5.0	15.0	N/A	10.2
Start-up Fraction	0.0	0.30	0.0	0.0	0.1
Inflation (%)	10.0*	10.0*	10.0*	9.4	6.0

Note: Contractors' parameters were used where stated in report. Parameters were fitted to contractor cost data where possible.

*Default value or assumed by SNLL.

SL - Straight line.
SOYD - Sum of years digits.

then the ARCO factory rate is low and the MDAC factory rate is high. However, if in actual practice the rates are different, the contractor might choose a different operations scenario. Site labor rates do not vary as much as factory rates, but ARCO appears somewhat high and BEC somewhat low. This difference is compounded for ARCO since it employs a significant amount of site direct labor.

Scrap rates can also be significant factors (\$1 to \$2/m^2) since the rate applies to the large direct materials charges. Direct materials costs must be examined to assess whether a reasonable scrap rate is contained within those values. For example, ARCO does not include a scrap rate, so the scrap value is assumed to be included in the material cost.

Some of the indirect fractions vary somewhat among the contractors. Fractions based on the capital costs are not very significant, since they are amortized over 50,000 heliostats per year. Some fraction greater than zero should be used by each contractor; ARCO and MMC, however, did not include an allowance for indirect charges attributed to "other than the maintenance account based on capital cost." These charges can be related to janitors, yardmen, and security.

Indirect costs based on direct labors costs vary among the contractors. The rate used by ARCO in the factory appears low at only 16.7 percent, while the others either use somewhat higher rates or, in the case of BEC, the default value. The lower ARCO rate can represent a differential of about \$0.50 to \$1.00/m^2 in installed heliostat price. The MDAC site indirect rate appears very high at 70 percent of direct labor, but only a few direct labor hours are charged for the reflective assembly, drive mechanism, and support structure. Since MDAC has few other specific site charges, this category could compensate for the lack of MDAC's charges elsewhere. (See the site discussion, Table 32.)

The G & A rate estimates vary from about 2.9 percent to 10 percent. Differences amount to as much as \$5/m^2 on the installed heliostat price. The basis for these costs has no precedent, since no one has manufactured and sold many heliostats. Except for the estimate used by ARCO, all of the rates appear low.

Transportation cost rates seem reasonable for all contractors except BEC. A more appropriate rate could add about \$2.50/m^2 to the BEC installed heliostat price.

Different depreciation schedules and lifetimes have some effect on the replacement costs charged to the heliostats account but affect income taxes more significantly. Accelerated depreciation can reduce the installed heliostat price by \$1 to \$2/m^2.

The contractors describe the return to investors in different ways. The rates in Table 37 are SNLL's interpretation of their scenarios. ARCO has the highest return; MMC follows. BEC has some return, and profit at the factory level would result in a higher comparable return than that shown. MDAC's return is described as 15 percent at the end of ten years. The dollar amount of return is not shown in the MDAC report, so an average return of 15 percent is used.

A start-up fraction in the HELCAT analysis accounts for the excessive one-time costs incurred during the first months or year of manufacturing. Depreciation charges by BEC require a 30 percent start-up fraction to simulate its charges. This effectively increases all capital costs of buildings, equipment, and tooling by 30 percent. Other contractors do not have sufficient funds in the capital replacement account to cover any start-up costs. Based on the SNLL default value, BEC overestimates while ARCO, MMC, and MDAC underestimate. This difference amounts to about $\$1/m^2$ on the installed heliostat price.

HELCAT Analysis Results

The HELCAT analysis was performed for each of the four designs using the contractors' data where possible. Costs were then tabulated in a format similar to that shown in the comparative format sections. Costs are listed by cost breakdown structure, by location, and by components of required revenue in Tables 38, 39, and 40, respectively.

Costs by cost breakdown structure show that the contractors of the two larger heliostats, MMC and MDAC, have the lowest costs for the reflective assembly, drive mechanism, and support structure parts. Most of the small difference in costs can be explained by differences in shipping scenarios, inverted or noninverted drives, and standardized or specialized structural steel parts. ARCO spends a large amount of money on its drive mechanism but a small amount on the reflective assembly. The BEC heliostat generally has a high cost per unit area because of its low reflective surface area. SNLL assumes BEC's controls and field wiring costs. The BEC foundation/pedestal cost appears excessive by at least $\$10/m^2$ because of the design choice. MDAC foundation/pedestal costs can be reduced by as much as $\$5/m^2$ by revising the design.

ARCO has very cost-effective transportation costs, even when they are increased to account for the slightly low transport rate that is assumed. The BEC to-site transportation costs are low compared to MMC's because BEC assumes transportation rates about at half the MMC rates. The BEC to-site transportaton costs at the MMC transport rate are $\$5.46/m^2$, while the ARCO to-site transportation costs are $\$2.23/m^2$ on a comparable basis.

ARCO has high site costs, partially because of the higher-than-average site labor rates used, but also because of the large number of labor hours incurred. MDAC site costs are small even if the estimated indirect fraction on site direct labor, which is high, is considered. Site labor hours are expended only on installation, and the resultant site burden costs are thus less for MDAC than for the other contractors.

Costs by location show that the major portion of the installed heliostat price is incurred at the CMF. The main difference between the similar reflective assembly, drive mechanism, and support structure costs of MMC and MDAC are their to-site transportation and on-site costs.

Costs by components of required revenue for the reflective assembly, drive mechanism, and support structure show some wide variations in individual accounts. Some of the accounts include overestimates and some include

TABLE 38

COSTS BY COST BREAKDOWN STRUCTURE FROM HELCAT ANALYSIS
(Contractors' Estimates, $/m^2)

Heliostat Major Parts	ARCO	BEC	MMC	MDAC
Reflective Assembly - Factory* & Transportation	22.23	36.66	29.00	32.56
Drive Mechanism - Factory* & Transportation	34.46	33.60	27.54	23.97
Support Structure - Factory* & Transportation	10.93	13.57	8.99	13.38
Other** Reflective Assembly, Drive Mechanism, & Support Structure - Factory	11.53	9.41	7.91	6.24
Reflective Assembly, Drive Mechanism, & Support Structure - Site	14.57	10.69	6.85	3.85
Subtotal Reflective Assembly, Drive Mechanism, & Support Structure Price, $/m^2	93.72	103.93	80.29	80.00
Controls and Field Wiring	13.51	17.62[1]	14.33	12.47
Foundation/Pedestal	11.45	23.74	10.53	14.75
Installed Heliostat Price, $/m^2	118.68	145.29	105.15	107.22

*Includes direct materials, direct labor, replacement allowance, and gross profit.
**Includes indirect costs, consumables, property tax and insurance, G & A, other.
[1]Assumed by SNLL.

TABLE 39

COSTS BY LOCATION FROM HELCAT ANALYSIS
(Contractors' Estimates, $\$/m^2$)

Location of Incurred Cost	ARCO	BEC	MMC	MDAC
Central Manufacturing Facility*	77.26	90.24	70.05	68.70
To-Site Transportation*	1.90	3.00	3.38	7.43
Site*	14.57	10.69	6.85	3.85
Subtotal Reflective Assembly, Drive Mechanism, & Support Structure Price, $\$/m^2$	93.73	103.93	80.28	79.98
Controls & Field Wiring	13.51	17.62[1]	14.33	12.47
Foundation/Pedestal	11.45	23.74	10.53	14.75
Installed Heliostat Price, $\$/m^2$	118.69	145.29	105.15	107.20

*Includes reflective assembly, drive mechanism, and support structure.
[1]Assumed by SNLL.

TABLE 40

COSTS BY COMPONENTS OF REQUIRED REVENUE FROM HELCAT ANALYSIS
(Contractors' Estimates, $\$/m^2$)

Required Revenue Components	ARCO	BEC	MMC	MDAC
Direct Materials	51.49	69.27	54.03	51.87
Direct Labor	11.73	8.25	4.41	4.84
Consumables	1.26	0.38	2.02	1.34
Indirects	4.99	3.77	2.40	2.60
G & A	6.57	2.36	3.21	2.64
Capital Replacement	1.96	3.05	0.71	1.44
Profit (Gross)	9.26	4.31	6.05	5.74
Property Tax & Insurance	0.42	1.41	0.16	0.41
Other	4.15	8.13	3.90	1.67
To-Site Transportation	1.90	3.00	3.38	7.43
Subtotal Reflective Assembly, Drive Mechanism, & Support Structure Price, $\$/m^2$	93.73	103.93	80.27	79.98
Controls and Field Wiring	13.51	17.62*	14.33	12.47
Foundation/Pedestal	11.45	23.74	10.53	14.75
Installed Heliostat Price, $\$/m^2$	118.69	145.29	105.15	107.20

*Assumed by SNLL.

underestimates. The numbers can be studied from the viewpoint of the manufacturing analysis as well as the cost analysis. For example, the direct materials account comparisons should consider make/buy ratios, scrap allowances, and raw material rates. MDAC buys most parts but includes a 3 percent scrap rate for all materials and has at least average direct material rates. This approach appears conservative compared to MMC, who makes most of its parts, has about a 1 percent scrap rate, and has generally low direct material rates. Although further analysis is required to answer all of the questions, most of the deviations are expected to produce small changes in the total installed heliostat cost unless more drastic modifications are made, that is, the design is changed, learning occurs, etc.

BEC does not account for all of the consumables, while BEC, MMC, and MDAC underestimate G & A costs. MMC's estimate for capital replacement is low, while ARCO pays a high rate of return to its investors. BEC splits its profit partly into a direct input ($\sim \$2.75/m^2$) and partly into a calculated return ($\$4.31/m^2$), for a total of about $\$7.06/m^2$. ARCO, MMC, and MDAC underestimate property tax and insurance while BEC is somewhat conservative. Other expenses are start-up cost for the factory, investment tax credits, allowance for land and factory financing during the assumed three-year construction period, and subcontracts at the site. MDAC may be low, or ARCO, MMC, and MDAC may all be low with their start-up costs.

One other cost hidden in the BEC cost breakdown is the contingency added to various categories. This accounts for over $\$5/m^2$ of the total installed heliostat price. A specific contingency is not included by the other contractors.

More details of the input and output of the HELCAT analysis can be found in Appendix B. The details can be examined and compared to the contractors' final reports or discussed with the contractors.

APPENDIX A

APPENDIX A--SNLL CENTRAL MANUFACTURING FACILITY (CMF) SITE SELECTION ANALYSIS

In considering which locations may be suitable for a CMF, SNLL evaluated a variety of factors, among them potential market areas, i.e., areas with high insolation and sufficient population to warrant the use of 50 MW_e solar power plants. MDAC challenged the SNLL site specification by stating that potential field sites would likely be distributed nonuniformly within a 400-mile radius of the CMF, with the average site located a round-trip distance of only 288 miles from the CMF. SNLL agrees that heliostat fields would probably be located near centers of population, rather than uniformly distributed as the study's ground rules indicated.

A CMF operating for a start-up year plus ten additional years would supply 520,000 heliostats. Depending on heliostat design and insolation level, between 75 and 101 50-MW_e field sites could be built from this supply. The location and distribution of these field sites are important in the selection of the CMF site. While it can be argued that power can always be transmitted from a generating station to the places of end use, the initial 50 MW_e solar plants would probably serve communities near the CMF that have sufficient energy demands to consume the 50 MW_e output. After 50 MW_e plants were constructed near the demand centers, plants would likely be built near less populous communities which are in the area or, perhaps, near cities farther than 400 miles from the CMF.

Potential Field Sites for 50 MW_e Power Plants

The number of potential field sites that are within a 400-mile radius of the CMF and that could consume the output of a 50 MW_e plant is limited. Since a 50 MW_e plant produces enough power for a community of about 30,000 people, the 1980 census figures for the eight-state potential market area were examined to find cities of at least 20,000 people (References 9 and 10). The population in these cities would probably increase before a solar plant started producing power (e.g., 1985) and would consume much of the plant's output. Since Albuquerque, Phoenix, and Tucson were the three locations proposed by the contractors for the CMFs, the cities within 400 miles of these and having 20,000 or more people locations were examined. A summary of the results is in Table A1.

Phoenix is the CMF location from which the most plant sites--409--could be served. Phoenix alone could consume the output of 23 power plants. Most of the power demand, though, would come from the greater Los Angeles area. A CMF located in Tucson could serve as many as 146 field

TABLE A1

NUMBER OF POTENTIAL FIELD SITE LOCATIONS WITH POPULATIONS > 20,000
AND WITHIN 400 MILES OF CMF

CMF Location (Number of Potential Sites)	AZ	CA	CO	NV	NM	OK	TX	UT	Total Potential Sites Within 400 Miles
Albuquerque (10)	49	0	54	0	19	1	38	0	163
Phoenix (23)	50	322	0	8	15	0	14	0	409
Tucson (11)	50	58	0	8	16	0	14	0	146
Number of Cities of 20,000 or More People Within 400 Miles of CMF	11	102*	18**	3*	9	1**	10**	0	

*Phoenix CMF
**Albuquerque CMF

sites within 400 miles. Though Tucson alone could consume the output of eleven 50 MW_e plants, location of the CMF in Tucson eliminates Los Angeles and most of its suburbs from the 400-mile radius of the CMF.

It can be argued that the solar plant sites would not be built in Los Angeles and its suburbs in any case. Land costs are at a premium in the Los Angeles area, space is probably not available, and insolation is lower on the coast (both naturally and also from smog). Power plants would therefore be located inland, and power would be transmitted to the coast by new or existing transmission lines. If 50 MW_e fields were located east of Los Angeles to serve the greater Los Angeles area, then Tucson could conceivably serve more sites than stated in Table A1.

An Albuquerque CMF could serve 162 potential field sites within 400 miles. Albuquerque alone could consume the output of 10 sites. Twenty-four of the potential fields would be in west Texas in areas of lower insolation than sites west of Albuquerque. Those areas of lower insolation would require more heliostats per field to generate 50 MW_e and therefore may not provide power as cost-effectively as sites with higher insolation.

Insolation

An examiniation of average iso-contours for direct normal insolation in the United States shows that, of the eight-state potential market area, the average annual insolation is highest in Arizona, followed closely by New Mexico (References 11 and 12). Southeastern California, southeastern Nevada, and southern Utah also have large areas of high average insolation. Arizona is centrally located among the states of highest insolation and may be a logical location for a CMF.

For a CMF located near higher insolation field sites (e.g., Phoenix compared to Albuquerque), the decreased transportation costs resulting from locating the CMF nearer to potential field sites could more than offset higher labor rates. This subject is discussed more quantitatively in "Central Manufacturing Facility to Site Transportation."

Land Use

The coast of California from Los Angeles southward is highly developed. Besides having lower insolation than inland areas, coastal land is too costly for heliostat field location. However, the portion of southern California within 400 miles of Phoenix contains approximately 20,000 square miles of inland desert shrubland, mostly ungrazed and with high insolation, which would be suitable for solar plants. Neighboring lands in California and Arizona are desert shrubland, both grazed and ungrazed. Arizona also contains large regions of grasslands and semiarid grazing lands which could provide suitable solar sites. New Mexico's land area contains large portions of grassland and semiarid grazing land. Southwest Texas land area consists primarily of grazed desert shrubland and grasslands. Oklahoma, the remainder of Texas, and the eastern third of Colorado consist of cropland and grassland, which are suitable for solar sites, but more costly to purchase. Utah and the western two-thirds of Colorado contain large areas of woodlands, which would be unsuitable land for solar sites.

Terrain

Colorado is fairly mountainous over about two-thirds of the state, making it the most mountainous of the eight potential market states. New Mexico and Utah are less mountainous. Arizona and southern California contain yet fewer mountainous areas. Nevada, Texas, and Oklahoma are the flattest states of the potential market area. The ideal arrangement for transporting heliostats would be from one flat area to another with flat transit in between. In addition to affecting heliostat transportation, the terrain also affects prospective field site locations. A heliostat field for a 50 MW_e plant and the associated facilities (e.g., receiver, turbine, administrative areas, etc.) occupies almost a square mile. Such sites would be difficult to find in mountainous areas. Regions in southern California, Arizona, Nevada, and New Mexico appear to have the most suitable areas of expansive flat terrain for field sites.

SNLL Selection

SNLL concludes that Phoenix may be the best location for a CMF on the basis of its proximity to high insolation market areas, land use, and terrain. Tucson might also be a reasonable choice for a CMF location, but Tucson is located 120 miles further southeast and is closer to Mexico than Phoenix. Within a 400-mile radius, a Tucson plant location would cover approximately 250,000 square miles of potential U.S. market area whereas a Phoenix location would cover about 300,000 square miles of U.S. market area.

The Phoenix area also has potential for using the 520,000 heliostats produced by the CMF. A 50 MW_e solar central receiver plant produces enough power for a community of about 30,000 people. Residential and commercial energy use accounts for about 40 percent of a typical utility's output, while industrial energy use accounts for about 60 percent of the output. Typical personal energy consumption is roughly 200 to 300 watts per person per day (Reference 10).

Electrical energy produced by a solar power plant can be transmitted reasonable distances to outlying areas, but transmission adds to the overall cost of energy. Field sites would initially be located where they are most cost-effective; transportation costs from the CMF (i.e., distance from the CMF) would be minimized, and attempts would be made to keep transmission lines as short as possible. Installing the initial field sites in the state in which the CMF is located would produce minimum transportation costs. Use of existing transmission lines may be possible and would minimize power transmission costs.

The Phoenix area could consume the output of about twenty-three 50 MW_e plants. Arizona contains 11 cities each with at least 20,000 people, which could consume the output of fifty 50 MW_e plants. Thus Arizona could consume over half of the heliostat output of the CMF. In New Mexico, which has about nine cities of 20,000 people or more, the output of about nineteen 50 MW_e plants could be used. New Mexico, then, could consume only 20 to 30 percent of the heliostats produced by a CMF. There are 10 cities in western Texas with more than 20,000 people and within 400 miles of Albuquerque; the total population of those areas is sufficient to consume the output of thirty-eight 50 MW_e plants. In southern California there are 102 cities of over 20,000 people within 400 miles of Phoenix, with a potential for consuming the output of 322 solar plants. Neither southern California nor Nevada would be serviced by a CMF located in and shipping within a 400-mile radius of Albuquerque. Las Vegas, Nevada, is within 400 miles of both Phoenix and Tucson and with its suburbs could consume the output of about eight 50 MW_e plants. At this time, there are no cities of 20,000 or more in Utah within a 400-mile radius of Albuquerque, Phoenix, or Tucson.

APPENDIX B

APPENDIX B--HELCAT PRINTOUTS BASED ON CONTRACTORS' INPUTS

H E L C A T

A HELIOSTAT COST ANALYSIS TOOL

VERSION 1.0

EDITION DATE AUGUST 13, 1981

REVISION SEPTEMBER 22, 1981

ARCO SECOND GENERATION HELIOSTAT

DESIGN (CONTRACTORS' INPUTS)

H E L C A T OPTIONS AND MODEL PARAMETERS

MODEL OPTIONS
STRAIGHT LINE DEPRECIATION
WITH NO LEARNING CURVE COST REDUCTION

PARAMETER MATRIX

		FACTORY	SITE	TRANSPORTATION
1	DURATION OF COST PROJECTION - YEARS	10.000	10.000	10.000
2	BASE RATE DIRECT LABOR COST - $/HOUR	6.900	20.000	15.000
3	BASE RATE PROD FACILITY COST - $/SQFT	29.120	0.000	0.000
4	LAND COST FOR PROD FACILITY - $/ACRE	12000.000	0.000	0.000
5	INFLATION RATE	.100	.100	.060
6	RETURN TO BOND HOLDERS	.180	.102	.102
7	RETURN TO EQUITY HOLDERS	.250	.166	.166
8	COMBINED INCOME TAX RATE	.500	.500	.500
9	INVESTMENT TAX CREDIT	.100	.100	.100
10	EQUITY FRACTION	.800	.800	.800
11	PROPERTY TAX AND INSURANCE FRACTION	.018	.040	.040
12	PURCHASED MATERIAL SCRAP FRACTION	0.000	.010	.010
13	MAINTENANCE FRACTION	.020	.040	.040
14	GENERAL AND ADMINISTRATIVE FRACTION	.107	0.000	0.000
15	WORKING CAPITAL FRACTION	.170	0.000	0.000
16	RAW MATERIAL SCRAP FRACTION	0.000	.030	.030
17	TOOLING LIFETIME (ACCOUNTING) - YEARS	5.000	5.000	5.000
18	EQUIPMENT LIFETIME (ACCOUNTING) - YEARS	10.000	10.000	10.000
19	FACILITY LIFETIME (ACCOUNTING) - YEARS	20.000	30.000	30.000
20	FACILITY CONSTRUCTION PERIOD - YEARS	3.000	0.000	0.000
21	FACILITY PLANT ENGINEERING FRACTION	0.000	0.000	0.000
22	FACILITY STARTUP QUANTITY	20000.000	0.000	0.000
23	COST REDUCTION COEFFICIENT - START UP	.920	0.000	0.000
24	TOOLING LIFETIME (TAX) - YEARS	3.000	3.000	3.000
25	EQUIPMENT LIFETIME (TAX) - YEARS	5.000	8.000	8.000
26	FACILITY LIFETIME (TAX) - YEARS	10.000	25.000	25.000
27	BASE RATE TRANS COST - $/LB	.035	.035	.035
28	INDIRECT FRACTION - LABOR	.167	.300	.300
29	INDIRECT FRACTION - MATERIAL	.024	0.000	0.000
30	INDIRECT FRACTION - TOOL+G,EQUIP+T,FAC+Y	0.000	0.000	0.000

SPECIAL COST MATRICES

CATEGORY NUMBER	FACILITY $/SQ FT	LABOR $/HR	TRANSPORT (UNITS VARY)
1	40.	9.00	613.400 $/TRKLOAD
2	60.	12.00	130.000 $/TRKLOAD
3	80.	18.00	0.000
4	100.	21.00	0.000
5	120.	25.00	0.000
6	140.	30.00	0.000
7	0.	0.00	0.000
8	0.	0.00	0.000
9	0.	0.00	0.000

ARCO 2ND GENERATION HELIOSTAT

4410 FACTORY COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	V=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ENTRY	ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST	
ENTRY TYPE=P 4410	FLOAT GLASS,.094 SOURCE- ARCO 4 FT X 6 FT FACETS,UNTRIMMED	576	SQFT	.43	247.68	/ HELIOSTAT
ENTRY TYPE=P 4410	SILVER,COPPER,PAINT SOURCE-ARCO,1.44OZ AG AT 15/OZ,1.2GAL PAINT AT 10.00/GAL,.48 OZ CU =ZERO	576	SQFT	.06	33.60	/ HELIOSTAT
ENTRY TYPE=L 4410	MIRRORING OF FLOAT GLASS SOURCE-ARCO AT 4.49/HR=6.48	.1440E+01	HRS / HELIOSTAT			
ENTRY TYPE=M 4410	MIRROR BACKING GALVANEALED STEEL SOURCE-ARCO P/N 0116, .028 , 522 LB , .27/LB				141.00	/ HELIOSTAT
ENTRY TYPE=L 4410	MIRROR BACKING FABRICATION SOURCE-ARCO AT 4.49/HR=.10	.2000E-01	HRS / HELIOSTAT			
ENTRY TYPE=P 4410	SILICONE SOURCE-ARCO, 9.50/LB, 10.5 LB				99.72	/ HELIOSTAT
ENTRY TYPE=L 4410	SPREADING SILICONE ON GLASS SOURCE-ARCO, AT 4.49/HR=.30	.7000E-01	HRS / HELIOSTAT			
ENTRY TYPE=M 4410	SUBSTRATE WEB,0.022 INCH SOURCE-ARCO 302. LB,0.35/LB,PREPAINTED				105.84	/ HELIOSTAT
ENTRY TYPE=M 4410	SUBSTRATE STIFFENER,0.078 INCH SOURCE-ARCO 17.LB,0.33/LB,PREPAINTED				5.52	/ HELIOSTAT
ENTRY TYPE=M 4410	SUBSTRATE BACKSHEET PREPAINTED SOURCE-ARCO, 522. LB,0.35/LB				182.76	/ HELIOSTAT
ENTRY TYPE=M 4410	SUBSTRATE RECTANGULAR TUBE SOURCE-ARCO, 180. LB,0.33/LB,PREPAINTED				59.40	/ HELIOSTAT
ENTRY TYPE=M 4410	END CHANNEL SOURCE-ARCO,PREPAINTED				10.08	/ HELIOSTAT
ENTRY TYPE=P 4410	SUBSTRATE ASSEMBLY SOURCE-ARCO,RIVETS,FLOATING NUTS,ADHESIVE				19.68	/ HELIOSTAT

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ENTRY TYPE=L   4410      SUBSTRATE ASSEMBLY LABOR                 .7500E+00  HRS / HELIOSTAT
     SOURCE-ARCO,3.36 AT 4.49/HR

ENTRY TYPE=M   4410      EDGE MOLDING,0.022 INCH                                              8.64  / HELIOSTAT
     SOURCE-ARCO,25. LB, 0.35/LB
     END,SIDE,CORNER+ CENTER TRIM

ENTRY TYPE=L   4410      EDGE MOLDING FABRICATION                 .2900E+00  HRS / HELIOSTAT
     SOURCE-ARCO,1.32 AT 4.49/HR

ENTRY TYPE=P   4410      EDGE MOLDING FOAM,ADHESIVE,SEALANT                                  37.44  / HELIOSTAT
     SOURCE-ARCO-

ENTRY TYPE=P   4410      MIRROR MODULE ASSEMBLY                                               9.00  / HELIOSTAT
     SOURCE-ARCO,STUD(36),FLAT WASHER + JAME NUT(36),
     SPHERICAL NUT-WASHER(72)

ENTRY TYPE=L   4410      MIRROR MODULE ASSEMBLY LABOR             .9400E+00  HRS / HELIOSTAT
     SOURCE-ARCO,4.22 AT 4.49/HR

ENTRY TYPE=A   4410      REFLECTIVE ASSEMBLY LAND                 .2130E+02  ACRE
     SOURCE-BLDG AREA FRAC--.355 X 60

ENTRY TYPE=B   4410      REFLECTIVE ASSEMBLY FACILITIES           .2414E+06  SQFT
     SOURCE-BLDG AREA FRAC--.355 X 680K    .24140E6SQFT

ENTRY TYPE=E   4410      REFLECTIVE ASSEMBLY EQUIPMENT                                  9161000.
     SOURCE-

ENTRY TYPE=T   4410      REFLECTIVE ASSEMBLY TOOLING                                          0.
     SOURCE

ENTRY TYPE=S   4410       SUPPLIES  UTILITIES                                                27.00  / HELIOSTAT
     SOURCE-BLDG AREA FRAC--0.36 X 75.00

ENTRY TYPE=Q   4410      REFLECTIVE ASSEMBLY QUANTITY/YEAR        .5000E+05


   TOTAL PURCHASED MATERIALS=    447.12 $/HELIOSTAT
   TOTAL RAW MATERIALS=    513.24 $/HELIOSTAT
   TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR=    3.5100    HRS/HELIOSTAT
   TOTAL CONSUMABLES=     27.00    $/HELIOSTAT
   LAND REQUIRED=   21.3000    ACRES
   PRODUCTION FACILITY (BASE RATE COST CATEGORY) SIZE=   241400.    SQ FT
   TOTAL EQUIPMENT COST=  9161000.    $
   TOTAL TOOLING COST=        0.    $
   QUANTITY=    50000.    / YEAR

   TOTAL DIRECT LABOR COST=     24.22 $/HELIOSTAT
   TOTAL PRODUCTION FACILITY COST    7029568.  $
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ARCO 2ND GENERATION HELIOSTAT

4420 FACTORY COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	V=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=M 4420 AZIMUTH HOUSING SOURCE-ARCO,297. LB, 0.43/LB				128.84 / HELIOSTAT
ENTRY TYPE=L 4420 AZIMUTH HOUSING FABRICATION SOURCE-ARCO,2.01 AT 4.49/HR	.4500E+00	HRS / HELIOSTAT		
ENTRY TYPE=M 4420 AZIMUTH GEAR SOURCE-ARCO,176. LB, 0.50/LB				87.42 / HELIOSTAT
ENTRY TYPE=L 4420 AZIMUTH GEAR FABRICATION SOURCE-ARCO,3.67 AT 4.49/HR	.8200E+00	HRS / HELIOSTAT		
ENTRY TYPE=M 4420 ELEVATION HOUSING SOURCE-ARCO,229. LB,0.49/LB				111.07 / HELIOSTAT
ENTRY TYPE=L 4420 ELEVATION HOUSING FABRICATION SOURCE-ARCO,2.03 AT 4.49/HR	.4500E+00	HRS / HELIOSTAT		
ENTRY TYPE=M 4420 ELEVATION GEAR SOURCE-ARCO,217. LB,0.53/LB				114.80 / HELIOSTAT
ENTRY TYPE=L 4420 ELEVATION GEAR FABRICATION SOURCE-ARCO,3.89 AT 4.49/HR	.8700E+00	HRS / HELIOSTAT		
ENTRY TYPE=M 4420 GEAR COVER SOURCE-ARCO,48. LB, 0.50/LB				24.00 / HELIOSTAT
ENTRY TYPE=L 4420 GEAR COVER FABRICATION SOURCE-ARCO,1.14 AT 4.49/HR	.2500E+00	HRS / HELIOSTAT		
ENTRY TYPE=M 4420 BEARING RING SOURCE-ARCO,45. LB,0.50/LB				22.50 / HELIOSTAT
ENTRY TYPE=L 4420 BEARING RING FABRICATION SOURCE-ARCO,1.68 AT 4.49/HR	.3700E+00	HRS / HELIOSTAT		
ENTRY TYPE=M 4420 PLANET CASTINGS SOURCE-ARCO,88. LB,0.46/LB				40.32 / HELIOSTAT
ENTRY TYPE=L 4420 PLANET CASTINGS FABRICATION SOURCE-ARCO,12.66 AT 4.49/HR	.2820E+01	HRS / HELIOSTAT		
ENTRY TYPE=M 4420 WORM GEARS-BAR STEEL SOURCE-ARCO,165.6 LB,0.46/LB				75.35 / HELIOSTAT

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ENTRY TYPE=M   4420      GEARS-BAR STEEL                                                        20.42  / HELIOSTAT
     SOURCE-ARCO,48.6LB,0.42/LB

ENTRY TYPE=L   4420      WORM GEAR FABRICATION                   .2310E+01  HRS / HELICSTAT
     SOURCE-ARCO,10.3E AT 4.49/HR

ENTRY TYPE=L   4420      GEARS FABRICATION                       .3950E+01  HRS / HELICSTAT
     SOURCE-ARCO,17.72 AT 4.49/HR

ENTRY TYPE=M   4420      DRIVE ASSEMBLY,PAINT                                                    1.50  / HELIOSTAT
     SOURCE-ARCO,

ENTRY TYPE=L   4420      DRIVE ASSEMBLY,PAINT LABOR              .3600E+01  HRS / HELICSTAT
     SOURCE-ARCO,16.14 AT 4.49/HR

ENTRY TYPE=P   4420      STEPPER MOTORS                                  2  EACH         150.00    300.00  / HELIOSTAT
     SOURCE-ARCO

ENTRY TYPE=P   4420       OIL                                            5  GAL            0.00     45.50  / HELIOSTAT
     SOURCE-ARCO

ENTRY TYPE=M   4420      MOTOR-DRIVE ASSEMBLY                                                   80.00  / HELIOSTAT
     SOURCE-ARCO

ENTRY TYPE=L   4420      MOTOR-DRIVE ASSEMBLY LABOR              .5000E+00  HRS / HELICSTAT
     SOURCE-ARCO,2.25 AT 4.49/HR

ENTRY TYPE=M   4420      OTHER PARTS                                                             5.64  / HELIOSTAT
     SOURCE-ARCO

ENTRY TYPE=P   4420      OTHER PURCHASED PARTS                                                 250.07  / HELIOSTAT
     SOURCE-ARCO

ENTRY TYPE=L   4420      OTHER PARTS FABRICATION                 .7200E+00  HRS / HELICSTAT
     SOURCE-ARCO,3.27 AT 4.49/HR

ENTRY TYPE=A   4420      DRIVE ASSEMBLY LAND                     .2420E+02  ACRE
     SOURCE-BLDG AREA FRAC--.403 X 60

ENTRY TYPE=B   4420      DRIVE ASSEMBLY FACILITIES               .2740E+06  SQFT
     SOURCE-BLDG AREA FRAC--.403 X 680K

ENTRY TYPE=E   4420      DRIVE ASSEMBLY EQUIPMENT                                           54262000.
     SOURCE-

ENTRY TYPE=T   4420      DRIVE ASSEMBLY TOOLING                                                    0.
     SOURCE-

ENTRY TYPE=S   4420       SUPPLIES  UTILITIES                                                   30.00  / HELIOSTAT
     SOURCE-BLDG AREA FRAC--0.40 X 75.00

ENTRY TYPE=Q   4420      DRIVE ASSEMBLY QUANTITY/YEAR            .5000E+05  /YR
     SOURCE-
   TOTAL PURCHASED MATERIALS=    595.57 $/HELIOSTAT
   TOTAL RAW MATERIALS=    711.86 $/HELIOSTAT
   TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR=   17.1100    HRS/HELIOSTAT
   TOTAL CONSUMABLES=     30.00    $/HELIOSTAT
   LAND REQUIRED=   24.2000    ACRES
   PRODUCTION FACILITY (BASE RATE COST CATEGORY) SIZE=   274040.    SQ FT
   TOTAL EQUIPMENT COST= 54262000.    $
   TOTAL TOOLING COST=        0.    $
   QUANTITY=    50000.    / YEAR

   TOTAL DIRECT LABOR COST=    118.06 $/HELIOSTAT
   TOTAL PRODUCTION FACILITY COST    7980045.  $
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ARCO 2ND GENERATION HELIOSTAT

4430 FACTORY COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS
S=SUPPLIES AND CONSUMABLES
B=BUILDING OR FACILITY SIZE
X=TRANSPORTATION REQUIREMENTS
P=PURCHASED MATERIALS
T=TOOLING
A=LAND FOR PRODUCTION FACILITY
Y=SITE-RETAINED CAPITAL
L=DIRECT LABOR HOURS
E=EQUIPMENT
Q=QUANTITY
Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

	ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST	
ENTRY TYPE=P 4430	HC/HFC MICROPROCESSOR SOURCE-ARCO				30.00	/ HELIOSTAT
ENTRY TYPE=P 4430	HC/HFC TRANSLATORS SOURCE-ARCO				150.00	/ HELIOSTAT
ENTRY TYPE=P 4430	HC/HFC POWER SUPPLY SOURCE-ARCO				42.00	/ HELIOSTAT
ENTRY TYPE=M 4430	HC/HFC RACK ASSEMBLY SOURCE-ARCO,30 LB,0.30/LB				9.00	/ HELIOSTAT
ENTRY TYPE=L 4430	HC/HFC RACK ASSY FABRICATION SOURCE-ARCO,2.99 AT 4.49/HR	.6700E+00	HRS / HELIOSTAT			
ENTRY TYPE=P 4430	HC/HFC ASSY.-PAINT SOURCE-ARCO				2.48	/ HELIOSTAT
ENTRY TYPE=L 4430	HC/HFC ASSY.-PAINT LABOR SOURCE-ARCO,7.48 AT 4.49/HR	.1660E+01	HRS / HELIOSTAT			
ENTRY TYPE=A 4430	CONTROLS LAND SOURCE-BLDG AREA FRAC--.052 X 60	.3100E+01	ACRE			
ENTRY TYPE=B 4430	CONTROLS FACILITIES SOURCE-BLDG AREA FRAC--.052 X 680K	.3536E+05	SQFT			
ENTRY TYPE=E 4430	CONTROLS EQUIPMENT				680000.	
ENTRY TYPE=S 4430	SUPPLIES-UTILITIES				3.75	/ HELIOSTAT
ENTRY TYPE=Q 4430	CONTROLS QUANTITY/YEAR	.5000E+05	/YR			

TOTAL PURCHASED MATERIALS= 224.48 $/HELIOSTAT
TOTAL RAW MATERIALS= 9.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 2.3300 HRS/HELIOSTAT
TOTAL CONSUMABLES= 3.75 $/HELIOSTAT
LAND REQUIRED= 3.1000 ACRES
PRODUCTION FACILITY (BASE RATE COST CATEGORY) SIZE= 35360. SQ FT
TOTAL EQUIPMENT COST= 680000. $
TOTAL TOOLING COST= 0. $
QUANTITY= 50000. / YEAR

TOTAL DIRECT LABOR COST= 16.08 $/HELIOSTAT
TOTAL PRODUCTION FACILITY COST 1029683. $

ARCO 2ND GENERATION HELIOSTAT

4440 FACTORY COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASEC MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST	
ENTRY TYPE=M 4440 FOUNDATION/PEDESTAL PIPE,.125 WALL SOURCE-ARCO,22 FT LENGTH,2 FT DIA THIS DESIGN WAS NOT TESTED,685 LB,0.30/LB BECHTEL DESIGN .25 WALL TESTED				205.50	/ HELIOSTAT
ENTRY TYPE=L 4440 FOUND/PED PIPE FABRICATION SOURCE-ARCO,1.80 AT 4.49/HR	.4000E+00	HRS / HELIOSTAT			
ENTRY TYPE=M 4440 FOUND/PED FLANGES SOURCE-ARCO, 91. LB,0.40/LB				36.40	/ HELIOSTAT
ENTRY TYPE=L 4440 FOUND/PED FLANGES FABRICATION SOURCE-ARCO, 0.36 AT 4.49/HR	.6000E-01	HRS / HELIOSTAT			
ENTRY TYPE=L 4440 FOUND/PED ASSEMBLY LABOR SOURCE-ARCO, 1.26 AT 4.49/HR	.2700E+00	HRS / HELIOSTAT			
ENTRY TYPE=P 4440 FOUND/PED PRIME-PAINT SOURCE-ARCO, 0.6 GAL				18.00	/ HELIOSTAT
ENTRY TYPE=L 4440 FOUND/PED PRIME-PAINT LABOR SOURCE-ARCO, 1.20 AT 4.49/HR	.2700E+00	HRS / HELIOSTAT			
ENTRY TYPE=A 4440 FOUND/PED LAND SOURCE-BLDG AREA FRAC--.058 X 60	.3500E+01	ACRE			
ENTRY TYPE=B 4440 FOUNDATION/PEDESTAL FACILITIES SOURCE-BLDG AREA FRAC--.058 X 680K	.3944E+05	SQFT			
ENTRY TYPE=E 4440 FOUND/PED EQUIPMENT				1464000.	
ENTRY TYPE=T 4440 FOUND/PED TOOLING				0.	
ENTRY TYPE=S 4440 SUPPLIES UTILITIES SOURCE-BLDG AREA FRAC--0.06 X 75.00				4.50	/ HELIOSTAT
ENTRY TYPE=Q 4440 FOUND/PED QUANTITY/YEAR	.5000E+05				

TOTAL PURCHASED MATERIALS= 18.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 241.90 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 1.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 4.50 $/HELIOSTAT
LAND REQUIRED= 3.5000 ACRES
PRODUCTION FACILITY (BASE RATE COST CATEGORY) SIZE= 39440. SQ FT
TOTAL EQUIPMENT COST= 1464000. $
TOTAL TOOLING COST= 0. $
QUANTITY= 50000. / YEAR

TOTAL DIRECT LABOR COST= 6.90 $/HELIOSTAT
TOTAL PRODUCTION FACILITY COST 1148493. $

ARCO 2ND GENERATION HELIOSTAT

4450 FACTORY COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	V=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=M 4450 SUPPORT STRUCTURE TORQUE TUBE SOURCE-ARCO,620. LB,0.30/LB				186.12 / HELIOSTAT
ENTRY TYPE=L 4450 TORQUE TUBE FABRICATION SOURCE-ARCO,2.40 AT 4.49/HR	.5400E+00	HRS / HELIOSTAT		
ENTRY TYPE=M 4450 SUPPORT BRACKET SOURCE-ARCO, 68. LB, 0.30/LB				20.40 / HELIOSTAT
ENTRY TYPE=L 4450 SUPPORT BRACKET FABRICATION SOURCE-ARCO,0.16 AT 4.49/HR	.3000E-01	HRS / HELIOSTAT		
ENTRY TYPE=M 4450 FLANGE SOURCE-ARCO, 84. LB , 0.30/LB				33.60 / HELIOSTAT
ENTRY TYPE=L 4450 FLANGE FABRICATION SOURCE-ARCO,0.16 AT 4.49/HR	.3000E-01	HRS / HELIOSTAT		
ENTRY TYPE=P 4450 TORQUE TUBE ASSY-PAINT SOURCE-ARCO				12.00 / HELIOSTAT
ENTRY TYPE=L 4450 TORQUE TUBE ASSY-PAINT LABOR SOURCE-ARCO,2.40 AT 4.49/HR	.5400E+00	HRS / HELIOSTAT		
ENTRY TYPE=M 4450 TOP CHORD SOURCE-ARCO,178. LB,0.30/LB				53.40 / HELIOSTAT
ENTRY TYPE=L 4450 TOP CHORD FABRICATION SOURCE-ARCO, 0.32 AT 4.49/HR	.7000E-01	HRS / HELIOSTAT		
ENTRY TYPE=M 4450 BOTTOM CHORD SOURCE-ARCO, 148.4 LB, 0.30/LB				44.52 / HELIOSTAT
ENTRY TYPE=L 4450 BOTTOM CHORD FABRICATION SOURCE-ARCO,0.32 AT 4.49/HR	.7000E-01	HRS / HELIOSTAT		
ENTRY TYPE=M 4450 WEB SOURCE-ARCO,128. LB,0.30/LB				38.40 / HELIOSTAT
ENTRY TYPE=L 4450 WEB FABRICATION SOURCE-ARCO, 1.48 AT 4.49/HR	.3300E+00	HRS / HELIOSTAT		
ENTRY TYPE=P 4450 ASSEMBLY-PAINT SOURCE-ARCO				18.00 / HELIOSTAT

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ENTRY TYPE=L   4450      ASSEMBLY-PAINT LABOR                     .5400E+00  HRS / HELIOSTAT
     SOURCE-ARCO

ENTRY TYPE=M   4450      TRUSS CROSS BRACE                                                         26.88  / HELIOSTAT
     SOURCE-ARCO,89.6 LB,0.30/LB

ENTRY TYPE=L   4450      TRUSS CROSS BRACE FABRICATION            .6000E-01  HRS / HELIOSTAT
     SOURCE-ARCO, 0.30 AT 4.49/HR

ENTRY TYPE=P   4450      TRUSS CROSS BRACE PAINT                                                    2.40  / HELIOSTAT
     SOURCE-ARCO

ENTRY TYPE=L   4450      TRUSS CROSS BRACE PAINT LABOR            .1300E+00  HRS / HELIOSTAT
     SOURCE-ARCO,0.58 AT 4.49/HR

ENTRY TYPE=M   4450      TRUSS LOWER BRACE                                                         12.84  / HELIOSTAT
     SOURCE-ARCO,42.8 LB,0.30/LB

ENTRY TYPE=L   4450      TRUSS LOWER BRACE FABRICATION            .3000E-01  HRS / HELIOSTAT
     SOURCE-ARCO,0.14 AT 4.49/HR

ENTRY TYPE=P   4450      TRUSS LOWER BRACE PAINT                                                    1.20  / HELIOSTAT
     SOURCE-ARCO,

ENTRY TYPE=L   4450      TRUSS LOWER BRACE PAINT LABOR            .7000E-01  HRS / HELIOSTAT
     SOURCE-ARCO,0.30 AT 4.49/HR

ENTRY TYPE=P   4450      RIVETS                                                                     1.08  / HELIOSTAT
     SOURCE-ARCO

ENTRY TYPE=A   4450      SUPPORT STRUCTURE LAND                   .7900E+01  ACRE
     SOURCE-BLDG AREA FRAC--0.132X 60

ENTRY TYPE=B   4450      SUPPORT STRUCTURE FACILITIES             .8976E+05  SQFT
     SOURCE-BLDG AREA FRAC--0.132X 680K

ENTRY TYPE=E   4450      SUPPORT STRUCTURE EQUIPMENT                                             6640000.
     SOURCE-ARCO

ENTRY TYPE=T   4450      SUPPORT STRUCTURE TOOLING                                                307600.
     SOURCE-ARCO

ENTRY TYPE=S   4450       SUPPLIES  UTILITIES                                                       9.75  / HELIOSTAT
     SOURCE-BLDG AREA FRAC--0.13 X 75.00

ENTRY TYPE=Q   4450      SUPPORT STRUCTURE QUANTITY/YEAR          .5000E+05


     TOTAL PURCHASED MATERIALS=     34.68 $/HELIOSTAT
     TOTAL RAW MATERIALS=    416.16 $/HELIOSTAT
     TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR=    2.4400    HRS/HELIOSTAT
     TOTAL CONSUMABLES=      9.75    $/HELIOSTAT
     LAND REQUIRED=    7.9000     ACRES
     PRODUCTION FACILITY (BASE RATE COST CATEGORY) SIZE=    89760.    SQ FT
     TOTAL EQUIPMENT COST=  6640000.    $
     TOTAL TOOLING COST=    307600.    $
     QUANTITY=    50000.    / YEAR

     TOTAL DIRECT LABOR COST=     16.84 $/HELIOSTAT
     TOTAL PRODUCTION FACILITY COST    2613811.  $
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ARCO 2ND GENERATION HELIOSTAT

4410 TRANSPORTATION COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST	
ENTRY TYPE=S 4410 MIRROR MODULE CUSTOM RACKS SOURCE-IN TRANSPORT COST				0.00	/ HELIOSTAT
ENTRY TYPE=X 4410 MIRROR MODULES TRANSPORT TO SITE SPECIAL TRANSPORTATION COST CATEGORY 1 SOURCE-ARCO,46.01 TOTAL	.7500E-01	TRUCKLOADS			
ENTRY TYPE=Q 4410	.5974E+04	/STE			

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 5974. / SITE
SPECIAL TRANSPORTATION COST CATEGORY 1 = .075 TRUCKLOADS
INPUT (NOT COMPUTED) TRANSPORTATION COST 46.01 $

ARCO 2ND GENERATION HELIOSTAT

4420 TRANSPORTATION COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=S 4420 DRIVE ASSEMBLY CUSTOM PACK SOURCE-IN TRANSPORT COST				0.00 / HELIOSTAT
ENTRY TYPE=X 4420 DRIVE ASSEMBLY TRANSPORT TO SITE SPECIAL TRANSPORTATION COST CATEGORY 1 SOURCE-ARCO,17.00 TOTAL	.3450E-01	TRUCKLOADS		
ENTRY TYPE=Q 4420	.5974E+04	/STE		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 5974. / SITE
SPECIAL TRANSPORTATION COST CATEGORY 1 = .035 TRUCKLOADS
INPUT (NOT COMPUTED) TRANSPORTATION COST 21.16 $

ARCO 2ND GENERATION HELIOSTAT

4430 TRANSPORTATION COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

	ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=Q	4430	.5974E+04	/STE		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 5974. / SITE

ARCO 2ND GENERATION HELIOSTAT

4440 TRANSPORTATION COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=S 4440 FOUND/PED CUSTOM RACK SOURCE-IN TRANSPORT COST				0.00 / HELIOSTAT
ENTRY TYPE=X 4440 FOUND/PED TRANSPORT TO SITE SPECIAL TRANSPORTATION COST CATEGORY 1 SOURCE-ARCO,23.00 TOTAL	.3850E-01	TRUCKLOADS		
ENTRY TYPE=Q 4440	.5974E+04	/STE		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 5974. / SITE
SPECIAL TRANSPORTATION COST CATEGORY 1 = .039 TRUCKLOADS
INPUT (NOT COMPUTED) TRANSPORTATION COST 23.62 $

ARCO 2ND GENERATION HELIOSTAT

4450 TRANSPORTATION COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

	ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=S 4450	SUPPORT STRUCTURE CUSTOM RACK SOURCE-IN TRANSPORT COST				0.00 / HELIOSTAT
ENTRY TYPE=X 4450	SUPPORT STRUCTURE XPORT TO SITE SPECIAL TRANSPORTATION COST CATEGORY 1 SOURCE-ARCO,33.00 TOTAL	.5380E-01	TRUCKLOADS		
ENTRY TYPE=Q 4450		.5974E+04	/STE		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 5974. / SITE
SPECIAL TRANSPORTATION COST CATEGORY 1 = .054 TRUCKLOADS
INPUT (NOT COMPUTED) TRANSPORTATION COST 33.00 $

ARCO 2ND GENERATION HELIOSTAT

4430 SITE COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=Z 4430 HELIOSTAT ARRAY CONTROLLER(HAC) SOURCE-ARCO USED 1E6 FOR FIELD				167.39 / HELIOSTAT
ENTRY TYPE=Z 4430 SIGNAL DIST/POWER CABLE INC INSTL SOURCE-ARCO, 115 VOLTS + 6 WIRE DATA BUS				200.00 / HELIOSTAT
ENTRY TYPE=Z 4430 BEAM CHARACTERIZATION SYSTEM(BCS) SOURCE- NONE IDENTIFIED BY ARCO,HAL USED 150000/FIELD				25.11 / HELIOSTAT
ENTRY TYPE=Q 4430 CONTROLS QUANTITY/	.5974E+04	/STE		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 5974. / SITE
TOTAL SUBCONTRACTS AND FLOW-THROUGH EXPENSES= 392.50 $/HELIOSTAT

ARCO 2ND GENERATION HELIOSTAT

4440 SITE COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=Z 4440 FOUNDATION LOCATION SURVEY SOURCE-NONE IDENTIFIED BY ARCO,HAL USED .25 HR-EST 15.00				15.00 / HELIOSTAT
ENTRY TYPE=Z 4440 AUGER HOLE,INSTALL PIPE,GROUT SOURCE-BECHTEL,NOT TESTED, 1.5 YD GROUT ASSUMED				220.00 / HELIOSTAT
ENTRY TYPE=Q 4440 FOUND/PED QUANTITY/SITE	.5974E+04			

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 5974. / SITE
TOTAL SUBCONTRACTS AND FLOW-THROUGH EXPENSES= 235.00 $/HELIOSTAT

ARCO 2ND GENERATION HELIOSTAT

4460 SITE COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=L 4460 HELIOSTAT ASSEMBLY LABOR SOURCE-HAL(ARCO X .85),ARCO USES 390.00 AT 20.00/HR WHICH INCLUDES INDIRECT LABOR	.1650E+02	HRS / HELIOSTAT		
ENTRY TYPE=Y 4460 HELIOSTAT ASSEMBLY FACILITY/EQUIP SOURCE-ARCO,				388310.
ENTRY TYPE=L 4460 HELIOSTAT INSTALLATION SOURCE-HAL(ARCO X .86),ARCO USES 104.00 AT 20.00/HR WHICH INCLUDES INDIRECT LABOR	.4500E+01	HRS / HELIOSTAT		
ENTRY TYPE=Z 4460 HELIOSTAT INSTALL EQUIPMENT SOURCE-ARCO,RENTAL				10.00 / HELIOSTAT
ENTRY TYPE=L 4460 CONTROLS CHECKOUT AND TEST SOURCE-HAL(ARCO X .92),ARCO USES 44.00 AT 20.00/HR WHICH INCLUDES INDIRECT LABOR	.2000E+01	HRS / HELIOSTAT		
ENTRY TYPE=Z 4460 CONTROLS CHECKOUT AND TEST SOURCE-ARCO,EQUIPMENT RENTAL				1.00 / HELIOSTAT
ENTRY TYPE=E 4460 AMORTIZED EQUIPMENT SOURCE-NONE IDENTIFIED,INCLUDES FORKLIFT,30+ CARTS, PEDESTAL STANDS,ETC., ASSUMED PART OF 30 PERCENT OVERHEAD.	.5000E+00	YRS		0.
ENTRY TYPE=S 4460 SUPPLIES,UTILITIES,CONSUMABLES SOURCE-NONE IDENTIFIED,ASSUMED PART OF 30 PERCENT OVERHEAD.				0.00 / HELIOSTAT
ENTRY TYPE=Y 4460 INITIAL SPARE PARTS SOURCE-NOT DETAILED BY ARCO,HAL BASED ON ARCO FAILURE RATES.				19600.
ENTRY TYPE=Y 4460 MAINTENANCE EQUIPMENT SOURCE-ARCO,INCLUDES WASH RIG(250K),GUIDANCE WIRE(150K), CONTROL SYSTEM(100K),DEIONIZER/STORAGE TANKS(50K), 30 YEAR LIFE AT 15 PERCENT RETURN				550000.
ENTRY TYPE=Q 4460 HELIOSTATS PER 50 MWE SITE	.5974E+04	/STE		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 23.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 5974. / SITE
TOTAL SUBCONTRACTS AND FLOW-THROUGH EXPENSES= 11.00 $/HELIOSTAT
TOTAL SITE-RETAINED CAPITAL= 957910.00 $

TOTAL DIRECT LABOR COST= 460.00 $/HELIOSTAT

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

ARCO 2ND GENERATION HELIOSTAT

4410 - REFLECTIVE ASSEMBLY

FACTORY COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			1322.43
DIRECT MATERIALS		960.36	
PURCHASED MATERIALS	447.12		
RAW MATERIALS	513.24		
SCRAP	0.00		
DIRECT LABOR		24.22	
CONSUMABLES		27.00	
INDIRECT COSTS		33.09	
MAINTENANCE, PLANT ENGINEERING	6.48		
OTHER INDIRECTS	26.61		
CAPITAL REPLACEMENT ALLOWANCE		16.05	
PROPERTY TAX AND INSURANCE		5.61	
GENERAL & ADMINISTRATIVE		115.30	
INTEREST EXPENSE		11.21	
INCOME TAXES		53.79	
RETURN TO EQUITY HOLDERS		62.28	
OTHER EXPENSES		13.53	
ANNUALIZED ONE-TIME COSTS	13.53		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

ARCO 2ND GENERATION HELIOSTAT

4420 - DRIVES

FACTORY COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			2121.14
DIRECT MATERIALS		1307.43	
PURCHASED MATERIALS	595.57		
RAW MATERIALS	711.86		
SCRAP	0.00		
DIRECT LABOR		118.06	
CONSUMABLES		30.00	
INDIRECT COSTS		75.34	
MAINTENANCE, PLANT ENGINEERING	24.90		
OTHER INDIRECTS	50.44		
CAPITAL REPLACEMENT ALLOWANCE		76.36	
PROPERTY TAX AND INSURANCE		13.73	
GENERAL & ADMINISTRATIVE		176.38	
INTEREST EXPENSE		27.46	
INCOME TAXES		116.36	
RETURN TO EQUITY HOLDERS		152.55	
OTHER EXPENSES		27.47	
ANNUALIZED ONE-TIME COSTS	27.47		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

ARCO 2ND GENERATION HELIOSTAT

4430 - CONTROLS

FACTORY COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			320.76
DIRECT MATERIALS		233.48	
PURCHASED MATERIALS	224.48		
RAW MATERIALS	9.00		
SCRAP	0.00		
DIRECT LABOR		16.08	
CONSUMABLES		3.75	
INDIRECT COSTS		8.86	
MAINTENANCE, PLANT ENGINEERING	.68		
OTHER INDIRECTS	8.17		
CAPITAL REPLACEMENT ALLOWANCE		1.47	
PROPERTY TAX AND INSURANCE		1.06	
GENERAL & ADMINISTRATIVE		28.55	
INTEREST EXPENSE		2.12	
INCOME TAXES		10.93	
RETURN TO EQUITY HOLDERS		11.78	
OTHER EXPENSES		2.69	
ANNUALIZED ONE-TIME COSTS	2.69		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

ARCO 2ND GENERATION HELIOSTAT

4440 - FOUNDATION/PEDESTAL

FACTORY COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			345.85
DIRECT MATERIALS		259.90	
PURCHASED MATERIALS	18.00		
RAW MATERIALS	241.90		
SCRAP	0.00		
DIRECT LABOR		6.90	
CONSUMABLES		4.50	
INDIRECT COSTS		8.30	
MAINTENANCE, PLANT ENGINEERING	1.04		
OTHER INDIRECTS	7.26		
CAPITAL REPLACEMENT ALLOWANCE		2.58	
PROPERTY TAX AND INSURANCE		1.24	
GENERAL & ADMINISTRATIVE		30.59	
INTEREST EXPENSE		2.49	
INCOME TAXES		12.46	
RETURN TO EQUITY HOLDERS		13.83	
OTHER EXPENSES		3.05	
ANNUALIZED ONE-TIME COSTS	3.05		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

ARCO 2ND GENERATION HELIOSTAT

4450 - SUPPORT STRUCTURE

FACTORY COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			635.79
DIRECT MATERIALS		450.84	
PURCHASED MATERIALS	34.68		
RAW MATERIALS	416.16		
SCRAP	0.00		
DIRECT LABOR		16.84	
CONSUMABLES		9.75	
INDIRECT COSTS		17.23	
MAINTENANCE, PLANT ENGINEERING	3.82		
OTHER INDIRECTS	13.41		
CAPITAL REPLACEMENT ALLOWANCE		11.20	
PROPERTY TAX AND INSURANCE		2.92	
GENERAL & ADMINISTRATIVE		55.06	
INTEREST EXPENSE		5.83	
INCOME TAXES		27.10	
RETURN TO EQUITY HOLDERS		32.39	
OTHER EXPENSES		6.62	
ANNUALIZED ONE-TIME COSTS	6.62		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

ARCO 2ND GENERATION HELIOSTAT

4410 - REFLECTIVE ASSEMBLY

TRANSPORTATION COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			46.01
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		0.00	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		46.01	
TRANSPORTATION CHARGES	46.01		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

ARCO 2ND GENERATION HELIOSTAT

4420 - DRIVES

TRANSPORTATION COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			21.16
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		0.00	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		21.16	
TRANSPORTATION CHARGES	21.16		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

ARCO 2ND GENERATION HELIOSTAT

4430 - CONTROLS

TRANSPORTATION COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			0.00
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		0.00	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		0.00	

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

ARCO 2ND GENERATION HELIOSTAT

4440 - FOUNDATION/PEDESTAL

TRANSPORTATION COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			23.62
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		0.00	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		23.62	
TRANSPORTATION CHARGES	23.62		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

ARCO 2ND GENERATION HELIOSTAT

4450 - SUPPORT STRUCTURE

TRANSPORTATION COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			33.00
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		0.00	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		33.00	
TRANSPORTATION CHARGES	33.00		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

ARCO 2ND GENERATION HELIOSTAT

4430 - CONTROLS

SITE COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			392.50
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		0.00	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL ^ ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		392.50	
SUBCONTRACTS ^ FLOW-THROUGH	392.50		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

ARCO 2ND GENERATION HELIOSTAT

4440 - FOUNDATION/PEDESTAL

SITE COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			235.00
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		0.00	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		235.00	
SUBCONTRACTS & FLOW-THROUGH	235.00		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

ARCO 2ND GENERATION HELIOSTAT

4460 - ASSEMBLY/INSTALLATION

SITE COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			769.35
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		460.00	
CONSUMABLES		0.00	
INDIRECT COSTS		138.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	138.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		171.35	
SUBCONTRACTS & FLOW-THROUGH	11.00		
SITE-RETAINED CAPITAL	160.35		

COST SUMMARY BY PROFIT CENTER

TOTAL REQUIRED REVENUE

ARCO 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	1322.43	2121.14	320.76	345.85	635.79	0.00	4745.97
TRANSPORTATION	46.01	21.16	0.00	23.62	33.00		123.79
SITE			392.50	235.00		769.35	1396.85
TOTALS BY COMPONENT	1368.44	2142.30	713.26	604.47	668.79	769.35	

TOTAL FOR TOTAL REQUIRED REVENUE 6266.61

COST SUMMARY BY PROFIT CENTER

DIRECT MATERIALS

ARCO 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	960.36	1307.43	233.48	259.90	450.84	0.00	3212.01
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		0.00	0.00
TOTALS BY COMPONENT	960.36	1307.43	233.48	259.90	450.84	0.00	

TOTAL FOR DIRECT MATERIALS 3212.01

COST SUMMARY BY PROFIT CENTER

DIRECT LABOR

ARCO 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	24.22	118.06	16.08	6.90	16.84	0.00	182.10
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		460.00	460.00
TOTALS BY COMPONENT	24.22	118.06	16.08	6.90	16.84	460.00	

TOTAL FOR DIRECT LABOR 642.10

COST SUMMARY BY PROFIT CENTER

CONSUMABLES

ARCO 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	27.00	30.00	3.75	4.50	9.75	0.00	75.00
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		0.00	0.00
TOTALS BY COMPONENT	27.00	30.00	3.75	4.50	9.75	0.00	

TOTAL FOR CONSUMABLES 75.00

COST SUMMARY BY PROFIT CENTER

INDIRECT COSTS

ARCO 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	33.09	75.34	8.86	8.30	17.23	0.00	142.82
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		138.00	138.00
TOTALS BY COMPONENT	33.09	75.34	8.86	8.30	17.23	138.00	

TOTAL FOR INDIRECT COSTS 280.82

COST SUMMARY BY PROFIT CENTER

CAPITAL REPLACEMENT ALLOWANCE

ARCO 2ND GENERATION HELICSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	16.05	76.36	1.47	2.58	11.20	0.00	107.66
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		0.00	0.00
TOTALS BY COMPONENT	16.05	76.36	1.47	2.58	11.20	0.00	

TOTAL FOR CAPITAL REPLACEMENT ALLOWANCE 107.66

COST SUMMARY BY PROFIT CENTER

PROPERTY TAX AND INSURANCE

ARCO 2ND GENERATION HELICSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	5.61	13.73	1.06	1.24	2.92	0.00	24.56
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		0.00	0.00
TOTALS BY COMPONENT	5.61	13.73	1.06	1.24	2.92	0.00	

TOTAL FOR PROPERTY TAX AND INSURANCE 24.56

COST SUMMARY BY PROFIT CENTER

GENERAL & ADMINISTRATIVE

ARCO 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	115.30	176.38	28.55	30.59	55.06	0.00	405.88
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		0.00	0.00
TOTALS BY COMPONENT	115.30	176.38	28.55	30.59	55.06	0.00	

TOTAL FOR GENERAL & ADMINISTRATIVE 405.88

COST SUMMARY BY PROFIT CENTER

INTEREST EXPENSE

ARCO 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	11.21	27.46	2.12	2.49	5.83	0.00	49.11
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		0.00	0.00
TOTALS BY COMPONENT	11.21	27.46	2.12	2.49	5.83	0.00	

TOTAL FOR INTEREST EXPENSE 49.11

COST SUMMARY BY PROFIT CENTER

INCOME TAXES

ARCO 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	53.79	116.36	10.93	12.46	27.10	0.00	220.64
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		0.00	0.00
TOTALS BY COMPONENT	53.79	116.36	10.93	12.46	27.10	0.00	

TOTAL FOR INCOME TAXES 220.64

COST SUMMARY BY PROFIT CENTER

RETURN TO EQUITY HOLDERS

ARCO 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	62.28	152.55	11.78	13.83	32.39	0.00	272.83
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		0.00	0.00
TOTALS BY COMPONENT	62.28	152.55	11.78	13.83	32.39	0.00	

TOTAL FOR RETURN TO EQUITY HOLDERS 272.83

COST SUMMARY BY PROFIT CENTER

OTHER EXPENSES

ARCO 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	13.53	27.47	2.69	3.05	6.62	0.00	53.36
TRANSPORTATION	46.01	21.16	0.00	23.62	33.00		123.79
SITE			392.50	235.00		171.35	798.85
TOTALS BY COMPONENT	59.54	48.63	395.19	261.67	39.62	171.35	

TOTAL FOR OTHER EXPENSES 976.00

H E L C A T

A HELIOSTAT COST ANALYSIS TOOL

VERSION 1.0

EDITION DATE AUGUST 13, 1981

REVISION SEPTEMBER 22, 1981

BEC SECOND GENERATION HELIOSTAT

DESIGN (CONTRACTORS' INPUTS)

4420 FACTORY COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ENTRY	ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=P 4420 SOURCE-BEC	AZIMUTH DRIVE				171.09 / HELIOSTAT
ENTRY TYPE=M 4420 SOURCE-BEC	AZIMUTH DRIVE				395.81 / HELIOSTAT
ENTRY TYPE=L 4420 SOURCE-BEC,36.54 AT 7.50/HR	AZIMUTH DRIVE FABRICATION	.4870E+01	HRS / HELIOSTAT		
ENTRY TYPE=P 4420 SOURCE-BEC	AZIMUTH DRIVE MOTOR,1/6 HP				66.65 / HELIOSTAT
ENTRY TYPE=P 4420 SOURCE-BEC	ELEVATION DRIVE				112.30 / HELIOSTAT
ENTRY TYPE=M 4420 SOURCE-BEC	ELEVATION DRIVE				70.70 / HELIOSTAT
ENTRY TYPE=L 4420 SOURCE-BEC,19.01 AT 7.50/HR	ELEVATION DRIVE FABRICATION	.2530E+01	HRS / HELIOSTAT		
ENTRY TYPE=P 4420 SOURCE-BEC	ELEVATION DRIVE MOTOR,1/3 HP				82.62 / HELIOSTAT
ENTRY TYPE=P 4420 SOURCE-BEC	AZ AND EL DRIVE ASSEMBLY				50.56 / HELIOSTAT
ENTRY TYPE=M 4420 SOURCE-BEC	AZ AND EL DRIVE ASSEMBLY				30.94 / HELIOSTAT
ENTRY TYPE=L 4420 SOURCE-BEC,13.73 AT 7.50/HR	AZ AND EL DRIVE ASSY LABOR	.1830E+01	HRS / HELIOSTAT		
ENTRY TYPE=P 4420 SOURCE-BEC	DRIVE CORROSION PROTECT/HANDLING				17.97 / HELIOSTAT
ENTRY TYPE=L 4420 SOURCE-BEC,11.31 AT 7.50/HR	DRIVE CORROSION/HANDLING LABOR	.1510E+01	HRS / HELIOSTAT		
ENTRY TYPE=P 4420 SOURCE-BEC,INC OIL(20LB),WIRE	DRIVE UNIT ASSY,CHECKOUT				51.16 / HELIOSTAT
ENTRY TYPE=L 4420 SOURCE-BEC,2.38 AT 7.50/HR	DRIVE UNIT ASSY,CHECKOUT LABOR	.3200E+00	HRS / HELIOSTAT		

```
ENTRY TYPE=P   4420     CONTINGENCY AT 0.01=                                                      6.13  / HELIOSTAT
ENTRY TYPE=M   4420     CONTINGENCY AT 0.01=                                                      4.97  / HELIOSTAT
ENTRY TYPE=L   4420     CONTINGENCY AT 0.01=                   .1100E+00  HRS / HELICSTAT
ENTRY TYPE=P   4420     PROFIT AT 0.032                                                          19.62  / HELIOSTAT
ENTRY TYPE=M   4420     PROFIT AT 0.032                                                          15.92  / HELIOSTAT
ENTRY TYPE=L   4420     PROFIT AT 0.032=                       .3500E+00  HRS / HELICSTAT
ENTRY TYPE=A   4420     DRIVE ASSEMBLY LAND                    .2750E+02  ACRE
     SOURCE-BLDG AREA FRAC--.367 X 75
ENTRY TYPE=B   4420     DRIVE ASSEMBLY FACILITIES              .2343E+06  SQFT
     SOURCE-BLDG AREA FRAC--.367 X 638.4K
ENTRY TYPE=E   4420     DRIVE ASSEMBLY EQUIPMENT                                            27248000.
     SOURCE-BEC
ENTRY TYPE=E   4420     PRODUCTION SUPPORT EQUIPMENT                                        12341000.
     SOURCE-BEC TABLE B-1
ENTRY TYPE=T   4420     DRIVE ASSEMBLY TOOLING                                               6257900.
     SOURCE-BEC TABLE B-1
ENTRY TYPE=T   4420     PECULIAR TOOLING                                                      554150.
     SOURCE-BEC TABLES F-3 AND F-7,ITEMS 4-8,13-16
ENTRY TYPE=S   4420     SUPPLIES,UTILITIES AND REPAIRS                                            6.50  / HELIOSTAT
     SOURCE-BEC TABLE F-5,DRIVE FRAC X G/F FRAC X AVG/HEL
     0.703 X 0.57 X 16.23=6.50
ENTRY TYPE=Z   4420     PROCESS DESIGN,FACTORY STARTUP,                                          15.38  / HELIOSTAT
     SOURCE-BEC TABLE 3-3,DESIGN CHANGE ADMINISTRATION
     BLDG AREA FRAC .367 X 41.92=15.38
ENTRY TYPE=Q   4420     DRIVE ASSEMBLY QUANTITY/YEAR           .5000E+05

   TOTAL PURCHASED MATERIALS=    578.10 $/HELIOSTAT
   TOTAL RAW MATERIALS=    518.34 $/HELIOSTAT
   TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR=   11.5200    HRS/HELIOSTAT
   TOTAL CONSUMABLES=      6.50    $/HELIOSTAT
   LAND REQUIRED=   27.5000    ACRES
   PRODUCTION FACILITY (BASE RATE COST CATEGORY) SIZE=   234300.    SQ FT
   TOTAL EQUIPMENT COST= 39589000.    $
   TOTAL TOOLING COST=  6812050.    $
   QUANTITY=    50000.    / YEAR
   TOTAL SUBCONTRACTS AND FLOW-THROUGH EXPENSES=     15.38    $/HELIOSTAT

   TOTAL DIRECT LABOR COST=    120.96 $/HELIOSTAT
   TOTAL PRODUCTION FACILITY COST   11715000.  $
```

BEC 2ND GENERATION HELIOSTAT

4430 FACTORY COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	V=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

	ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST	
ENTRY TYPE=P 4430 SOURCE-NONE	HC				0.00	/ HELIOSTAT
ENTRY TYPE=P 4430 SOURCE-NONE	HFC				0.00	/ HELIOSTAT
ENTRY TYPE=A 4430 SOURCE-NONE	CONTROLS LAND	0.	ACRE			
ENTRY TYPE=B 4430 SOURCE-NONE	CONTROLS FACILITIES	0.	SQFT			
ENTRY TYPE=E 4430 SOURCE-NONE	CONTROLS EQUIPMENT				0.	
ENTRY TYPE=S 4430 SOURCE-BEC NONE	SUPPLIES				0.00	/ HELIOSTAT
ENTRY TYPE=Q 4430	CONTROLS QUANTITY/YEAR	.5000E+05	/YR			

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
LAND REQUIRED= 0.0000 ACRES
PRODUCTION FACILITY (BASE RATE COST CATEGORY) SIZE= 0. SQ FT
TOTAL EQUIPMENT COST= 0. $
TOTAL TOOLING COST= 0. $
QUANTITY= 50000. / YEAR

BEC 2ND GENERATION HELIOSTAT

4440 FACTORY COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS
S=SUPPLIES AND CONSUMABLES
B=BUILDING OR FACILITY SIZE
X=TRANSPORTATION REQUIREMENTS

P=PURCHASED MATERIALS
T=TOOLING
A=LAND FOR PRODUCTION FACILITY
Y=SITE-RETAINED CAPITAL

L=DIRECT LABOR HOURS
E=EQUIPMENT
Q=QUANTITY
Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

		ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=Q	4440	FOUNDATION/PEDESTAL QUANTITY/YEAR	.5000E+05	/YR		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
LAND REQUIRED= 0.0000 ACRES
PRODUCTION FACILITY (BASE RATE COST CATEGORY) SIZE= 0. SQ FT
TOTAL EQUIPMENT COST= 0. $
TOTAL TOOLING COST= 0. $
QUANTITY= 50000. / YEAR

BEC 2ND GENERATION HELIOSTAT

4450 FACTORY COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ENTRY	ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST	
ENTRY TYPE=M 4450	CENTER TORQUE TUBE,100 LB, SOURCE-BEC, 0.32/LB	100	LBS	.32	32.00	/ HELIOSTAT
ENTRY TYPE=L 4450	CENTER TORQUE TUBE FABRICATION SOURCE-BEC,0.50 AT 7.50/HR	.7000E-01	HRS / HELIOSTAT			
ENTRY TYPE=M 4450	OUTBOARD FLANGES(2) SOURCE-BEC				21.74	/ HELIOSTAT
ENTRY TYPE=L 4450	OUTBOARD FLANGE FABRICATION SOURCE-BEC,1.15 AT 7.50/HR	.1500E+00	HRS / HELIOSTAT			
ENTRY TYPE=M 4450	ELEVATION ARM ADAPTER RINGS(2) SOURCE-BEC,NODULAR IRON				21.74	/ HELIOSTAT
ENTRY TYPE=L 4450	EL ARM ADPT RINGS FABRICATION SOURCE-BEC,1.15 AT 7.50/HR	.1500E+00	HRS / HELIOSTAT			
ENTRY TYPE=M 4450	ELEVATION ARM ASSY(10 GA STEEL) SOURCE-BEC,0.1382 INCH				39.44	/ HELIOSTAT
ENTRY TYPE=L 4450	EL ARM ASSY FABRICATION SOURCE-BEC,3.47 AT 7.50/HR	.4700E+00	HRS / HELIOSTAT			
ENTRY TYPE=L 4450	CENTER TORQUE TUBE ASSEMBLY LABOR SOURCE-BEC-5.63 AT 7.50/HR, 185 LB	.7500E+00	HRS / HELIOSTAT			
ENTRY TYPE=M 4450	CONTINGENCY ELEVATION ASSY AT .01=				1.15	/ HELIOSTAT
ENTRY TYPE=L 4450	CONTINGENCY ELEVATION ASSY AT .01= SOURCE-BEC	.2000E-01	HRS / HELIOSTAT			
ENTRY TYPE=P 4450	Z-FRAMES,4 EACH,14 GA(.0785) SOURCE-BEC,SHIPPED DIRECT TO SITE	740	LBS	.34	253.60	/ HELIOSTAT
ENTRY TYPE=Z 4450	Z-FRAME TRANSPORTATION SOURCE-BEC FROM BETHLEHEM STEEL,LACKAWANNA,NY				70.00	/ HELIOSTAT
ENTRY TYPE=M 4450	STRUTS AND BARS,STRUTS 36 LB, SOURCE-BEC,BARS LB, 8 EACH, STRUT,2.X.125X63.9	50	LBS	.23	11.48	/ HELIOSTAT
ENTRY TYPE=L 4450	STRUTS/BARS FABRICATION SOURCE-BEC,2.58 AT 7.50/HR	.3400E+00	HRS / HELIOSTAT			

ENTRY TYPE=M 4450 ANGLES,24 EACH,2.X.125X19 STEEL 32 LBS .24 7.64 / HELIOSTAT
SOURCE-BEC, Z-FRAME STIFFENERS

ENTRY TYPE=L 4450 ANGLE FABRICATION .1000E+00 HRS / HELIOSTAT
SOURCE-BEC,0.76 AT 7.50/HR

ENTRY TYPE=M 4450 TORQUE TUBES,OUTBOARD(2) 176 LBS .32 55.88 / HELIOSTAT
SOURCE-BEC,16. OD X .105 WALL X60 IN

ENTRY TYPE=L 4450 TORQUE TUBE OUTBD FABRICATION .1100E+00 HRS / HELIOSTAT
SOURCE-BEC,0.86 AT 7.50/HR

ENTRY TYPE=M 4450 OUTBOARD FLANGES(2) 21.74 / HELIOSTAT
SOURCE-BEC

ENTRY TYPE=L 4450 OUTBOARD FLANGE FABRICATION .2100E+00 HRS / HELIOSTAT
SOURCE-BEC,1.58 AT 7.50/HR

ENTRY TYPE=M 4450 INBOARD FLANGES(2) 21.74 / HELIOSTAT
SOURCE-BEC

ENTRY TYPE=L 4450 INBOARD FLANGE FABRICATION .1500E+00 HRS / HELIOSTAT
SOURCE-BEC,1.15 AT 7.50/HR

ENTRY TYPE=L 4450 TORQUE TUBE OUTBD ASSEMBLY LABOR .1000E+00 HRS / HELIOSTAT
SOURCE-BEC,0.75 AT 7.50/HR (2 EACH)
SOURCE-BEC,0.032 X 683.38= 21.87

ENTRY TYPE=P 4450 CONTINGENCY FRAME ASSY AT .03= 7.61 / HELIOSTAT

ENTRY TYPE=M 4450 CONTINGENCY FRAME ASSY AT .03= 2.90 / HELIOSTAT

ENTRY TYPE=Z 4450 CONTINGENCY FRAME ASSY AT .03= 2.10 / HELIOSTAT

ENTRY TYPE=L 4450 CONTINGENCY FRAME ASSY AT .03= .3000E-01 HRS / HELIOSTAT

ENTRY TYPE=P 4450 PROFIT SUPPORT STRUCTURE AT .032= 8.12 / HELIOSTAT

ENTRY TYPE=M 4450 PROFIT SUPPORT STRUCTURE AT .032= 8.72 / HELIOSTAT

ENTRY TYPE=L 4450 PROFIT SUPPORT STRUCTURE AT .032= .8000E-01 HRS / HELIOSTAT

ENTRY TYPE=Z 4450 PROFIT SUPPORT STRUCTURE AT .032= 2.24 / HELIOSTAT
SOURCE-BEC,0.03 X 523.90=15.72

ENTRY TYPE=A 4450 SUPPORT STRUCTURE LAND .1160E+02 ACRE
SOURCE-BLDG AREA FRAC--.155 X 75

ENTRY TYPE=B 4450 SUPPORT STRUCTURE FACILITIES .9895E+05 SQFT
SOURCE-BLDG AREA FRAC--.155 X 638.4K
INCLUDES A/C,FURNISHINGS,FEES,TURNOVER,IMPROVEMENTS,SUBSTATION
SEE TABLE 3-1

ENTRY TYPE=E 4450 SUPPORT STRUCTURE EQUIPMENT 2501700.
SOURCE-BEC TABLE 8-1

ENTRY TYPE=E 4450 PRODUCTION SUPPORT EQUIPMENT 2006400.
SOURCE-BEC TABLE 8-1

ENTRY TYPE=T 4450 SUPPORT STRUCTURE TOOLING 931000.
SOURCE-BEC TABLE 8-1

ENTRY TYPE=S 4450 SUPPLIES,UTILITIES AND REPAIRS 2.75 / HELIOSTAT
SOURCE-BEC TABLE F-5,SUPPORT STRUCTURE FRAC X G/F FRAC
X AVG/HEL = 0.297 X 0.57 X 16.23

```
ENTRY TYPE=Z   4450      PROCESS DESIGN,FACTORY STARTUP,                                                 6.50  / HELIOSTAT
     SOURCE-BEC TABLE 3-3,DESIGN CHANGE ADMINISTRATION
     BLDG AREA FRAC .155 X 41.92=6.50

ENTRY TYPE=Q   4450      SUPPORT STRUCTURE QUANTITY/YEAR          .5000E+05  /YR


   TOTAL PURCHASED MATERIALS=    269.33 $/HELIOSTAT
   TOTAL RAW MATERIALS=    246.17 $/HELIOSTAT
   TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR=    2.7380    HRS/HELIOSTAT
   TOTAL CONSUMABLES=      2.75    $/HELICSTAT
   LAND REQUIRED=   11.6000    ACRES
   PRODUCTION FACILITY (BASE RATE COST CATEGORY) SIZE=    98950.    SQ FT
   TOTAL EQUIPMENT COST=  4508100.    $
   TOTAL TOOLING COST=   931000.    $
   QUANTITY=    50000.    / YEAR
   TOTAL SUBCONTRACTS AND FLOW-THROUGH EXPENSES=     80.84    $/HELIOSTAT

   TOTAL DIRECT LABOR COST=     28.67 $/HELIOSTAT
   TOTAL PRODUCTION FACILITY COST    4947500.  $
```

BEC 2ND GENERATION HELIOSTAT

4410 TRANSPORTATION COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

	ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=E 4410	MIRROR MODULE CRATE SOURCE-BEC TABLE F-4	.1380E+00	YRS		5700000.
ENTRY TYPE=X 4410	TRANSPORT-TO-SITE MIRROR MODULES SPECIAL TRANSPORTATION COST CATEGORY 1 SOURCE-BEC, 76.50/HELIOSTAT	.1250E+00	TRUCKLOADS		
ENTRY TYPE=Q 4410	REFLECTIVE ASSEMBLY QUANTITY	.6914E+04	/STE		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 786600. $ TIMES YEARS USED / SITE
QUANTITY= 6914. / SITE
SPECIAL TRANSPORTATION COST CATEGORY 1 = .125 TRUCKLOADS
INPUT (NOT COMPUTED) TRANSPORTATION COST 49.38 $

BEC 2ND GENERATION HELIOSTAT

4420 TRANSPORTATION COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=S 4420 DRIVE ASSEMBLY CRATE SOURCE-NONE IDENTIFIED				0.00 / HELIOSTAT
ENTRY TYPE=X 4420 TRANSPORT-TO-SITE DRIVE ASSY SPECIAL TRANSPORTATION COST CATEGORY 1 SOURCE-BEC,20.90	.1250E+00	TRUCKLOADS		
ENTRY TYPE=Q 4420 DRIVE ASSEMBLY QUANTITY	.6914E+04	/STE		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 6914. / SITE
SPECIAL TRANSPORTATION COST CATEGORY 1 = .125 TRUCKLOADS
INPUT (NOT COMPUTED) TRANSPORTATION COST 49.38 $

BEC 2ND GENERATION HELIOSTAT

4430 TRANSPORTATION COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

	ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=Q 4430	CONTROLS QUANTITY	.6914E+04	/STE		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 6914. / SITE

BEC 2ND GENERATION HELIOSTAT

4440 TRANSPORTATION COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

	ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=Q 4440	FOUNDATION/PEDESTAL QUANTITY	.6914E+04	/STE		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 6914. / SITE

BEC 2ND GENERATION HELIOSTAT

4450 TRANSPORTATION COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=S 4450 STRUTS,BARS,ANGLES CRATE SOURCE-NONE IDENTIFIED				0.00 / HELIOSTAT
ENTRY TYPE=X 4450 TRANSPORT-TO-SITE,STRUTS,BARS,AGLS SPECIAL TRANSPORTATION COST CATEGORY 1 SOURCE-BEC,2.5C	.1700E-01	TRUCKLOADS		
ENTRY TYPE=S 4450 TORQUE TUBE CRATES SOURCE-NONE IDENTIFIED				0.00 / HELIOSTAT
ENTRY TYPE=X 4450 TRANSPORT-TO-SITE TORQUE-TUBES SPECIAL TRANSPORTATION COST CATEGORY 1 SOURCE-BEC,4.70 INC ABOVE	0.	TRUCKLOADS		
ENTRY TYPE=Q 4450 SUPPORT STRUCTURE QUANTITY	.6914E+04	/STE		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 6914. / SITE
SPECIAL TRANSPORTATION COST CATEGORY 1 = .017 TRUCKLOADS
INPUT (NOT COMPUTED) TRANSPORTATION COST 6.72 $

BEC 2ND GENERATION HELIOSTAT

4430 SITE COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=Z 4430 HC SOURCE-NONE IDENTIFIED, 200.00 SUPPLIED BY HAL				200.00 / HELIOSTAT
ENTRY TYPE=Z 4430 HFC SOURCE-NONE IDENTIFIED, 5.00 SUPPLIED BY HAL				5.00 / HELIOSTAT
ENTRY TYPE=Z 4430 HAC SOURCE-NONE IDENTIFIED, 250000/FIELD SUPPLIED BY HAL				36.16 / HELIOSTAT
ENTRY TYPE=Z 4430 SIGNAL DISTRIBUTION INSTALLED SOURCE-NONE IDENTIFIED, 350.00 SUPPLIED BY HAL				350.00 / HELIOSTAT
ENTRY TYPE=Z 4430 POWER CABLING INSTALLED SOURCE-NONE IDENTIFIED,INC IN 350.00 ABOVE				0.00 / HELIOSTAT
ENTRY TYPE=Z 4430 BEAM CHARACTERIZATION SYSTEM(BCS) SOURCE-NONE IDENTIFIED, 150000/FIELD SUPPLIED BY HAL				21.70 / HELIOSTAT
ENTRY TYPE=Z 4430 CONTINGENCY ON HAL SUPPLIED CONTRL SOURCE-HAL AT 0.10 X 612.86				61.29 / HELIOSTAT
ENTRY TYPE=Z 4430 PROFIT ON HAL SUPPLIED CONTROLS SOURCE-HAL AT .032 X 612.86				19.61 / HELIOSTAT
ENTRY TYPE=Z 4430 SITE SPECIFIC SOFTWARE SOURCE-BEC				7.23 / HELIOSTAT
ENTRY TYPE=Z 4430 TAPE/PROGRAMS/MANUALS REPRO ONLY SOURCE-BEC				1.23 / HELIOSTAT
ENTRY TYPE=L 4430 POWER,LIGHTNING,SIGNAL CABLE CONN SOURCE-BEC,2.41 AT 16.05/HR	.1500E+00	HRS / HELIOSTAT		
ENTRY TYPE=L 4430 FINAL PEDESTAL SURVEY,LONG,LAT SOURCE-BEC,2.00 AT 8.00/HR	.2500E+00	HRS / HELIOSTAT		
ENTRY TYPE=L 4430 ZERO REFERENCE LABOR SOURCE-BEC,10.00 AT 8.00/HR	.1250E+01	HRS / HELIOSTAT		
ENTRY TYPE=L 4430 VERIFY GIMBAL OPERATION SOURCE-BEC,1.33 AT 16.05/HR	.8300E-01	HRS / HELIOSTAT		
ENTRY TYPE=Z 4430 INITIAL CALIBRATION SOURCE-BEC				36.16 / HELIOSTAT

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ENTRY TYPE=P   4430      CONTINGENCY                                                         5.60  / HELIOSTAT
     SOURCE-BEC 0.10 X 55.99=5.60

ENTRY TYPE=P   4430      CONTINGENCY ON SOFTWARE                                             1.45  / HELIOSTAT
     SOURCE-BEC,0.20 X 7.23=1.45

ENTRY TYPE=P   4430      PROFIT                                                              4.08  / HELIOSTAT
     SOURCE-BEC,0.06 X 55.99 + 0.10 X 7.23=4.08

ENTRY TYPE=E   4430      CONTROLS EQUIPMENT                        0.                        0.
     SOURCE- NONE IDENTIFIED

ENTRY TYPE=Q   4430      CONTROLS QUANTITY/SITE                     .6914E+04  /STE


   TOTAL PURCHASED MATERIALS=     11.13 $/HELIOSTAT
   TOTAL RAW MATERIALS=      0.00 $/HELIOSTAT
   TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR=    1.7330    HRS/HELIOSTAT
   TOTAL CONSUMABLES=      0.00    $/HELIOSTAT
   WEIGHTED EQUIPMENT COST=        0.    $ TIMES YEARS USED / SITE
   QUANTITY=     6914.    / SITE
   TOTAL SUBCONTRACTS AND FLOW-THROUGH EXPENSES=    738.38    $/HELIOSTAT

   TOTAL DIRECT LABOR COST=     19.83 $/HELIOSTAT
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BEC 2ND GENERATION HELIOSTAT

4440 SITE COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST	
ENTRY TYPE=P 4440 SOIL SAMPLES FOR FOUNDATION DESIGN SOURCE-BEC CHARGED 21.70				0.00	/ HELIOSTAT
ENTRY TYPE=L 4440 SURVEY FOR FOUNDATION LOCATION SOURCE-BEC,2.00 AT 7.50/HR	.2500E+00	HRS / HELIOSTAT			
ENTRY TYPE=Z 4440 FOUNDATION/PEDESTAL SOURCE-BEC,INCLUDES TRANSPORT-TO-SITE HYDRO CONDUIT CORP QUOTE 11/14/80				618.00	/ HELIOSTAT
ENTRY TYPE=Z 4440 FOUNDATION/PEDESTAL INSTALLATION SOURCE-BEC,PILE DRIVING				315.00	/ HELIOSTAT
ENTRY TYPE=P 4440 CONTINGENCY,FOUND/PED,LIGHTNING SOURCE-BEC,0.05 X 658.69=32.93				32.93	/ HELIOSTAT
ENTRY TYPE=P 4440 CONTINGENCY ,INSTALLATION SOURCE-BEC,0.10 X 315.00=31.50				31.50	/ HELIOSTAT
ENTRY TYPE=P 4440 CONTINGENCY,SOIL SAMPLES SOURCE-BEC,0.20 X 21.70=4.34				0.00	/ HELIOSTAT
ENTRY TYPE=P 4440 PROFIT SOURCE-BEC,.032 X 658.69 + .06 X 317.00 + 0.10 X 21.70=42.27				42.27	/ HELIOSTAT
ENTRY TYPE=Q 4440 FOUNDATION/PEDESTAL QUANTITY/SITE	.6914E+04	/STE			

TOTAL PURCHASED MATERIALS= 106.70 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= .2500 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 6914. / SITE
TOTAL SUBCONTRACTS AND FLOW-THROUGH EXPENSES= 933.00 $/HELIOSTAT

TOTAL DIRECT LABOR COST= 2.86 $/HELIOSTAT

BEC 2ND GENERATION HELIOSTAT

4460 SITE COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

	ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=L 4460	REFLECTIVE ASSY,ASSEMBLY,CANT SOURCE-BEC,48.21 AT 8.00/HR	.6030E+01	HRS / HELICSTAT		
ENTRY TYPE=L 4460	REFLECTIVE ASSY TRANSPORT AT SITE SOURCE-BEC,2.67 AT 8.00/HR	.3300E+00	HRS / HELICSTAT		
ENTRY TYPE=L 4460	REFLECTIVE ASSY INSTALLATION SOURCE-BEC,12.40 AT 8.00/HR	.1550E+01	HRS / HELICSTAT		
ENTRY TYPE=L 4460	DRIVE ASSEMBLY TRANSPORT AT SITE SOURCE-BEC,1.32 AT 8.00/HR	.1700E+00	HRS / HELICSTAT		
ENTRY TYPE=P 4460	DRIVE ASSY INSTALLATION HDWR SOURCE-BEC				1.35 / HELIOSTAT
ENTRY TYPE=L 4460	DRIVE ASSY INSTALLATION LABOR SOURCE-BEC,2.08 AT 8.00/HR	.2600E+00	HRS / HELICSTAT		
ENTRY TYPE=P 4460	SUPPORT STRUCTURE ASSEMBLY HDWR SOURCE-BEC				7.77 / HELIOSTAT
ENTRY TYPE=L 4460	SUPPORT STRUCTURE ASSEMBLY LABOR SOURCE-BEC,34.00 AT 8.00/HR	.4250E+01	HRS / HELICSTAT		
ENTRY TYPE=Z 4460	INITIAL CLEANING SOURCE-BEC, $20742/6914				3.00 / HELIOSTAT
ENTRY TYPE=Z 4460	ASSY/INSTALL/MAIN.EQUIP RENTAL SOURCE-BEC TABLE F-7				6.25 / HELIOSTAT
ENTRY TYPE=Z 4460	CONSTRUCTION MANAGEMENT SOURCE-BEC,.02 X AT-SITE COST				16.33 / HELIOSTAT
ENTRY TYPE=Z 4460	A AND E SERVICES SOURCE-BEC,0.12 X ON-SITE COSTS(LESS LAND)				101.44 / HELIOSTAT
ENTRY TYPE=Y 4460	INSTALLATION EQUIPMENT SOURCE-BEC TABLE F-7 DROTT CRANE(55K) LINEMAN TRUCK(50K),2 TOW TRACTORS(15K), 4 TRAILERS(26K)				146000.
ENTRY TYPE=Y 4460	MAINTENANCE EQUIP FOR WASH MACHINE SOURCE-BEC TABLE 3-3				7500.

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ENTRY TYPE=S   4460      UTILITIES 2800.00/YR                                                      .40  / HELIOSTAT
     SOURCE-BEC TABLE 3-2

ENTRY TYPE=E   4460      OFFICE EQUIPMENT AT SITE                  .1000E+01                     2500.
     SOURCE-BEC TABLE 3-2

ENTRY TYPE=T   4460      ASSY/INSTALL TOOLING                      .1000E+01                    73900.
     SOURCE-BEC TABLES F-6,F-7,3-2

ENTRY TYPE=Y   4460      CONTINGENCY AT 0.10                                                    43288.

ENTRY TYPE=P   4460      CONTINGENCY AT 0.10                                                      3.47  / HELIOSTAT

ENTRY TYPE=L   4460      CONTINGENCY AT 0.10                       .1260E+01  HRS / HELIOSTAT

ENTRY TYPE=L   4460      PROFIT AT 0.032                           .4000E+00  HRS / HELIOSTAT

ENTRY TYPE=Y   4460      PROFIT AT 0.032                                                        13852.

ENTRY TYPE=Z   4460      PROFIT AT 0.06                                                           7.25  / HELIOSTAT

ENTRY TYPE=Z   4460      PROFIT AT 0.10                                                           2.89  / HELIOSTAT

ENTRY TYPE=Y   4460      INITIAL SPARE PARTS                                                    32360.
     SOURCE-BEC,5 FACETS,25 MOTORS,1 DRIVE REPAIR KIT,
     MAINTENACE SUPPORT EQUIPMENT, SUPPORT SYSTEM

ENTRY TYPE=Y   4460      MAINTENANCE EQUIPMENT                                                 225000.
     SOURCE-BEC, 3 WASH TRUCKS

ENTRY TYPE=Y   4460      REFLECTIVE ASSY MAINT EQUIP                                             4000.
     SOURCE-BEC

ENTRY TYPE=Y   4460      DRIVE ASSY MAINT EQUIP.                                                10000.
     SOURCE-BEC

ENTRY TYPE=Y   4460      FIELD CALIBRATION/ALIGN MAINT EQ.                                       8000.
     SOURCE-BEC

ENTRY TYPE=Z   4460      SITE DESIGN/ENGINEERING                                                 28.93  / HELIOSTAT
     SOURCE-BEC TABLE 3-3(200K/SITE)

ENTRY TYPE=Z   4460      RELOCATION EXPENSES                                                      5.22  / HELIOSTAT
     SOURCE-BEC,SITE FACILITY PROCESS DESIGN/DEVELOPMENT,
     PREACTIVATION/STARTUP, TEARDOWN AND RELOCATE.

ENTRY TYPE=Q   4460      HELIOSTATS/50 MWE SITE                    .6914E+04  /STE


   TOTAL PURCHASED MATERIALS=     12.59 $/HELIOSTAT
   TOTAL RAW MATERIALS=      0.00 $/HELIOSTAT
   TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR=   14.2500    HRS/HELIOSTAT
   TOTAL CONSUMABLES=       .40    $/HELIOSTAT
   WEIGHTED EQUIPMENT COST=     2500.    $ TIMES YEARS USED / SITE
   QUANTITY=      6914.    / SITE
   TOTAL SUBCONTRACTS AND FLOW-THROUGH EXPENSES=    171.31    $/HELIOSTAT
   TOTAL SITE-RETAINED CAPITAL= 490000.00    $

   TOTAL DIRECT LABOR COST=    163.02 $/HELIOSTAT
```

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

BEC 2ND GENERATION HELIOSTAT

4410 - REFLECTIVE ASSEMBLY

FACTORY COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			1665.55
DIRECT MATERIALS		1391.93	
PURCHASED MATERIALS	1348.26		
RAW MATERIALS	29.31		
SCRAP	14.36		
DIRECT LABOR		50.51	
CONSUMABLES		6.98	
INDIRECT COSTS		34.72	
MAINTENANCE, PLANT ENGINEERING	12.47		
OTHER INDIRECTS	22.25		
CAPITAL REPLACEMENT ALLOWANCE		28.23	
PROPERTY TAX AND INSURANCE		21.62	
GENERAL & ADMINISTRATIVE		44.62	
INTEREST EXPENSE		4.50	
INCOME TAXES		27.86	
RETURN TO EQUITY HOLDERS		34.23	
OTHER EXPENSES		20.37	
ANNUALIZED ONE-TIME COSTS	.37		
SUBCONTRACTS & FLOW-THROUGH	20.00		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

BEC 2ND GENERATION HELIOSTAT

4420 - DRIVES

FACTORY COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			1590.98
DIRECT MATERIALS		1117.77	
PURCHASED MATERIALS	578.10		
RAW MATERIALS	518.34		
SCRAP	21.33		
DIRECT LABOR		120.96	
CONSUMABLES		6.58	
INDIRECT COSTS		66.79	
MAINTENANCE, PLANT ENGINEERING	23.25		
OTHER INDIRECTS	43.55		
CAPITAL REPLACEMENT ALLOWANCE		92.70	
PROPERTY TAX AND INSURANCE		32.61	
GENERAL & ADMINISTRATIVE		41.88	
INTEREST EXPENSE		6.79	
INCOME TAXES		39.06	
RETURN TO EQUITY HOLDERS		51.63	
OTHER EXPENSES		14.28	
SUBCONTRACTS & FLOW-THROUGH	15.38		

H E L C A T OPTIONS AND MODEL PARAMETERS

MODEL OPTIONS

SUM OF THE YEARS' DIGITS DEPRECIATION
WITH NO LEARNING CURVE COST REDUCTION

PARAMETER MATRIX

		FACTORY	SITE	TRANSPORTATION
1	DURATION OF COST PROJECTION - YEARS	10.000	10.000	10.000
2	BASE RATE DIRECT LABOR COST - $/HOUR	10.500	11.440	15.000
3	BASE RATE PROD FACILITY COST - $/SQFT	50.000	0.000	0.000
4	LAND COST FOR PROD FACILITY - $/ACRE	32000.000	0.000	0.000
5	INFLATION RATE	.100	.100	.060
6	RETURN TO BOND HOLDERS	.050	.102	.102
7	RETURN TO EQUITY HOLDERS	.095	.166	.166
8	COMBINED INCOME TAX RATE	.500	.500	.500
9	INVESTMENT TAX CREDIT	.100	.100	.100
10	EQUITY FRACTION	.800	.800	.800
11	PROPERTY TAX AND INSURANCE FRACTION	.048	.040	.040
12	PURCHASED MATERIAL SCRAP FRACTION	.010	.010	.010
13	MAINTENANCE FRACTION	.020	.040	.040
14	GENERAL AND ADMINISTRATIVE FRACTION	.029	0.000	0.000
15	WORKING CAPITAL FRACTION	.170	0.000	0.000
16	RAW MATERIAL SCRAP FRACTION	.030	.030	.030
17	TOOLING LIFETIME (ACCOUNTING) - YEARS	5.000	5.000	5.000
18	EQUIPMENT LIFETIME (ACCOUNTING) - YEARS	10.000	10.000	10.000
19	FACILITY LIFETIME (ACCOUNTING) - YEARS	45.000	30.000	30.000
20	FACILITY CONSTRUCTION PERIOD - YEARS	3.000	0.000	0.000
21	FACILITY PLANT ENGINEERING FRACTION	.300	0.000	0.000
22	FACILITY STARTUP QUANTITY	20000.000	0.000	0.000
23	COST REDUCTION COEFFICIENT - START UP	.920	0.000	0.000
24	TOOLING LIFETIME (TAX) - YEARS	5.000	3.000	3.000
25	EQUIPMENT LIFETIME (TAX) - YEARS	10.000	8.000	8.000
26	FACILITY LIFETIME (TAX) - YEARS	20.000	25.000	25.000
27	BASE RATE TRANS COST - $/LB	.035	.035	.035
28	INDIRECT FRACTION - LABOR	.270	.300	.300
29	INDIRECT FRACTION - MATERIAL	.004	0.000	0.000
30	INDIRECT FRACTION - TOOL+G.EQUIP+T.FAC+Y	.006	0.000	0.000

SPECIAL COST MATRICES

CATEGORY NUMBER	FACILITY $/SQ FT	LABOR $/HR	TRANSPORT (UNITS VARY)
1	40.	9.00	395.000 $/TRKLOAD
2	60.	12.00	130.000 $/TRKLOAD
3	80.	18.00	0.000
4	100.	21.00	0.000
5	120.	25.00	0.000
6	140.	30.00	0.000
7	0.	0.00	0.000
8	0.	0.00	0.000
9	0.	0.00	0.000

BEC 2ND GENERATION HELIOSTAT

4410 FACTORY COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ENTRY	ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST	
ENTRY TYPE=P 4410	7809 FUSION GLASS MIRROR,0.058 SOURCE-PITT-CORNING,.95 YLD,GLASS 0.362/SQFT, AG/CU/PRIMER 0.350/SQFT,XPORT TO FACTORY 0.044/SQFT	480	SQFT	.76	362.88	/ HELIOSTAT
ENTRY TYPE=P 4410	FOAMSIL-75 2 INCH SOURCE-PITT-CORNING,.95 YLD,.47/BDFT				461.18	/ HELIOSTAT
ENTRY TYPE=P 4410	7809 FUSION GLASS BACK SHEET,0.058 SOURCE-PITT-CORNING,.95 YLD,GLASS .362/SQFT, XPORT TO FACTORY 0.044/SQFT,CORNING GLASS WORKS,BLACKSBURG,VA	480	SQFT	.41	195.06	/ HELIOSTAT
ENTRY TYPE=P 4410	ADHESIVES FOR FUSION TO FOAM GLASS SOURCE-PITT-CORNING,.95 YLD,INC XPORT	34	LBS	1.16	39.56	/ HELIOSTAT
ENTRY TYPE=P 4410	ADHESIVE FOR FOAM GLASS JOINTS SOURCE-PITT-CORNING,.95 YLD,	22	LBS	.70	16.03	/ HELIOSTAT
ENTRY TYPE=P 4410	BACKSHEET PAINT,.003 INCH SOURCE-PITT-CORNING,.95 YLD,				33.38	/ HELIOSTAT
ENTRY TYPE=P 4410	EDGE STRIPS,24 GAUGE, SOURCE-PITT-CORNING,.95 YLD,				70.86	/ HELIOSTAT
ENTRY TYPE=P 4410	EDGE STRIP ADHESIVE SOURCE-PITT-CORNING,.95 YLD	5	GAL	5.26	29.56	/ HELIOSTAT
ENTRY TYPE=P 4410	SEALANT,HOT MELT BUTYL SOURCE-PITT-CORNING,.95 YLD,INC XPORT				10.17	/ HELIOSTAT
ENTRY TYPE=L 4410	MIRROR MODULE FAB AND ASSEMBLY SOURCE-PITT-CORNING/BEC CORRECTIONS	.3440E+01	HRS / HELIOSTAT			
ENTRY TYPE=P 4410	MIRROR FACET ATTACH PLATES SOURCE-BEC,96 PLASTIC PADS				15.36	/ HELIOSTAT
ENTRY TYPE=M 4410	MIRROR FACET ATTACH PLATES, SOURCE-BEC,8 EACH=14.7 LB(HAL)	25	LBS	.25	6.48	/ HELIOSTAT
ENTRY TYPE=L 4410	FACET ATTACH PLTS FABRICATION SOURCE-BEC, 3.72 AT 7.50/HR	.5000E+00	HRS / HELIOSTAT			
ENTRY TYPE=M 4410	BRACKETS, 40 EACH=77.6 LB(HAL) SOURCE-BEC. 66.4 LB CALCULATED BY BEC	66	LBS	.32	21.12	/ HELIOSTAT

```
ENTRY TYPE=L   4410      BRACKET FABRICATION                        .2400E+00  HRS / HELIOSTAT
     SOURCE-BEC, 1.78 AT 7.50/HR

ENTRY TYPE=P   4410      ATTACHMENT HARDWARE,NUT,BALL,(96)                                              12.72  / HELIOSTAT
     SOURCE-BEC, SET SCREW,WASHERS(192)

ENTRY TYPE=P   4410      BRACKET-FRAME HARDWARE                                                          5.00  / HELIOSTAT
     SOURCE-BEC

ENTRY TYPE=P   4410      GALVANIZING MATERIAL                                                           12.00  / HELIOSTAT
     SOURCE-BEC, INC REWORK OF PARTS

ENTRY TYPE=L   4410      GALVANIZING LABOR                          .3500E+00  HRS / HELIOSTAT
     SOURCE-BEC, 2.62 AT 7.50/HR

ENTRY TYPE=P   4410      CONTINGENCY AT 0.03=                                                           40.89  / HELIOSTAT

ENTRY TYPE=M   4410      CONTINGENCY AT 0.03=                                                             .83  / HELIOSTAT

ENTRY TYPE=L   4410      CONTINGENCY AT 0.03=                       .1400E+00  HRS / HELIOSTAT

ENTRY TYPE=P   4410      PROFIT AT 0.032=                                                               43.61  / HELIOSTAT

ENTRY TYPE=M   4410      PROFIT AT 0.032=                                                                 .88  / HELIOSTAT

ENTRY TYPE=L   4410      PROFIT AT 0.032=                           .1400E+00  HRS / HELIOSTAT

ENTRY TYPE=A   4410      REFLECTIVE ASSEMBLY LAND                   .3580E+02  ACRE
     SOURCE-BLDG AREA FRAC--.477 X 75

ENTRY TYPE=B   4410      REFLECTIVE ASSEMBLY FACILITIES             .3045E+06  SQFT
     SOURCE-BLDG AREA FRAC--.477 X 638.4K
     INCLUDES A/C,FURNISHINGS,FEES,TURNOVER,IMPROVEMENTS,SUBSTATION
     SEE TABLE 3-1

ENTRY TYPE=E   4410      REFLECTIVE ASSEMBLY EQUIPMENT                                              15231000.
     SOURCE-BEC TABLE F-4

ENTRY TYPE=E   4410      GLASS SHIPPING CRATES                                                        450000.
     SOURCE-BEC TABLE F-4

ENTRY TYPE=T   4410      REFLECTIVE ASSEMBLY TOOLING                                                  268000.
     SOURCE-BEC TABLE F-7,ITEMS 1 AND 2

ENTRY TYPE=S   4410      SUPPLIES,UTILITIES AND REPAIRS                                                  6.98  / HELIOSTAT
     SOURCE-BEC TABLE F-5,REFL. ASSY FRAC X AVG/HEL
     0.43 X 16.23=6.98

ENTRY TYPE=Z   4410      PROCESS DESIGN,FACTORY STARTUP,                                                20.00  / HELIOSTAT
     SOURCE-BEC TABLE 3-3,DESIGN CHANGE ADMINISTRATION
     BLDG AREA FRAC .477 X 41.92

ENTRY TYPE=Q   4410      REFLECTIVE ASSY QUANTITY/YEAR              .5000E+05

TOTAL PURCHASED MATERIALS=   1348.26 $/HELIOSTAT
TOTAL RAW MATERIALS=     29.31 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR=    4.8100    HRS/HELIOSTAT
TOTAL CONSUMABLES=      6.98     $/HELIOSTAT
LAND REQUIRED=   35.8000     ACRES
PRODUCTION FACILITY (BASE RATE COST CATEGORY) SIZE=   304500.    SQ FT
TOTAL EQUIPMENT COST= 15681000.    $
TOTAL TOOLING COST=   268000.    $
QUANTITY=    50000.    / YEAR
TOTAL SUBCONTRACTS AND FLOW-THROUGH EXPENSES=     20.00    $/HELIOSTAT

TOTAL DIRECT LABOR COST=     50.51 $/HELIOSTAT
TOTAL PRODUCTION FACILITY COST   15225000.  $
BEC 2ND GENERATION HELIOSTAT
```

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

BEC 2ND GENERATION HELIOSTAT

4430 - CONTROLS

SITE COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			775.39
DIRECT MATERIALS		11.24	
PURCHASED MATERIALS	11.13		
RAW MATERIALS	0.00		
SCRAP	.11		
DIRECT LABOR		19.83	
CONSUMABLES		0.00	
INDIRECT COSTS		5.95	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	5.95		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		738.38	
SUBCONTRACTS & FLOW-THROUGH	738.38		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

BEC 2ND GENERATION HELIOSTAT

4440 - FOUNDATION/PEDESTAL

SITE COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			1044.49
DIRECT MATERIALS		107.77	
PURCHASED MATERIALS	106.70		
RAW MATERIALS	0.00		
SCRAP	1.07		
DIRECT LABOR		2.86	
CONSUMABLES		0.00	
INDIRECT COSTS		.86	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	.86		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		933.00	
SUBCONTRACTS & FLOW-THROUGH	933.00		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

BEC 2ND GENERATION HELIOSTAT

4460 - ASSEMBLY/INSTALLATION

SITE COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			470.27
DIRECT MATERIALS		12.72	
PURCHASED MATERIALS	12.59		
RAW MATERIALS	0.00		
SCRAP	.13		
DIRECT LABOR		163.02	
CONSUMABLES		.40	
INDIRECT COSTS		49.35	
MAINTENANCE, PLANT ENGINEERING	.44		
OTHER INDIRECTS	48.91		
CAPITAL REPLACEMENT ALLOWANCE		1.66	
PROPERTY TAX AND INSURANCE		.15	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		.08	
INCOME TAXES		.21	
RETURN TO EQUITY HOLDERS		.51	
OTHER EXPENSES		242.18	
SUBCONTRACTS & FLOW-THROUGH	171.31		
SITE-RETAINED CAPITAL	70.87		

COST SUMMARY BY PROFIT CENTER

TOTAL REQUIRED REVENUE

BEC 2ND GENERATION HELICSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	1665.55	1590.98	0.00	0.00	714.16	0.00	3970.69
TRANSPORTATION	75.89	49.38	0.00	0.00	6.72		131.99
SITE			775.39	1044.49		470.27	2290.15
TOTALS BY COMPONENT	1741.44	1640.36	775.39	1044.49	720.88	470.27	

TOTAL FOR TOTAL REQUIRED REVENUE 6392.83

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

BEC 2ND GENERATION HELIOSTAT

4430 - CONTROLS

FACTORY COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			0.00
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		0.00	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		0.00	

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

BEC 2ND GENERATION HELIOSTAT

4440 - FOUNDATION/PEDESTAL

FACTORY COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			0.00
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		0.00	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		0.00	

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

BEC 2ND GENERATION HELIOSTAT

4450 - SUPPORT STRUCTURE

FACTORY COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			714.16
DIRECT MATERIALS		525.58	
PURCHASED MATERIALS	269.33		
RAW MATERIALS	246.17		
SCRAP	10.08		
DIRECT LABOR		26.67	
CONSUMABLES		2.75	
INDIRECT COSTS		14.98	
MAINTENANCE, PLANT ENGINEERING	4.15		
OTHER INDIRECTS	10.83		
CAPITAL REPLACEMENT ALLOWANCE		11.53	
PROPERTY TAX AND INSURANCE		7.85	
GENERAL & ADMINISTRATIVE		17.28	
INTEREST EXPENSE		1.63	
INCOME TAXES		10.53	
RETURN TO EQUITY HOLDERS		12.42	
OTHER EXPENSES		81.02	
ANNUALIZED ONE-TIME COSTS	.18		
SUBCONTRACTS & FLOW-THROUGH	80.84		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

BEC 2ND GENERATION HELIOSTAT

4410 - REFLECTIVE ASSEMBLY

TRANSPORTATION COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			75.89
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		0.00	
INDIRECT COSTS		4.55	
MAINTENANCE, PLANT ENGINEERING	4.55		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		8.67	
PROPERTY TAX AND INSURANCE		1.93	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		.99	
INCOME TAXES		3.96	
RETURN TO EQUITY HOLDERS		6.42	
OTHER EXPENSES		49.38	
TRANSPORTATION CHARGES	49.38		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

BEC 2ND GENERATION HELIOSTAT

4420 - DRIVES

TRANSPORTATION COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			49.38
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		0.00	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		49.38	
TRANSPORTATION CHARGES	49.38		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

BEC 2ND GENERATION HELIOSTAT

4430 - CONTROLS

TRANSPORTATION COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			0.00
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		0.00	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		0.00	

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

BEC 2ND GENERATION HELIOSTAT

4440 - FOUNDATION/PEDESTAL

TRANSPORTATION COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			0.00
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		0.00	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		0.00	

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

BEC 2ND GENERATION HELIOSTAT

4450 - SUPPORT STRUCTURE

TRANSPORTATION COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			6.72
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		0.00	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		6.72	
TRANSPORTATION CHARGES	6.72		

COST SUMMARY BY PROFIT CENTER

DIRECT MATERIALS

BEC 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	1391.93	1117.77	0.00	0.00	525.58	0.00	3035.28
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			11.24	107.77		12.72	131.73
TOTALS BY COMPONENT	1391.93	1117.77	11.24	107.77	525.58	12.72	

TOTAL FOR DIRECT MATERIALS 3167.01

COST SUMMARY BY PROFIT CENTER

DIRECT LABOR

BEC 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	50.51	120.96	0.00	0.00	28.67	0.00	200.14
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			19.83	2.86		163.02	185.71
TOTALS BY COMPONENT	50.51	120.96	19.83	2.86	28.67	163.02	

TOTAL FOR DIRECT LABOR 385.85

COST SUMMARY BY PROFIT CENTER

CONSUMABLES

BEC 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	6.98	6.50	0.00	0.00	2.75	0.00	16.23
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		.40	.40
TOTALS BY COMPONENT	6.98	6.50	0.00	0.00	2.75	.40	

TOTAL FOR CONSUMABLES 16.63

COST SUMMARY BY PROFIT CENTER

INDIRECT COSTS

BEC 2NC GENERATION HELICSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	34.72	66.79	0.00	0.00	14.98	0.00	116.49
TRANSPORTATION	4.55	0.00	0.00	0.00	0.00		4.55
SITE			5.95	.86		49.35	56.16
TOTALS BY COMPONENT	39.27	66.79	5.95	.86	14.98	49.35	

TOTAL FOR INDIRECT COSTS 177.20

COST SUMMARY BY PROFIT CENTER

CAPITAL REPLACEMENT ALLOWANCE

BEC 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	28.23	92.70	0.00	0.00	11.53	0.00	132.46
TRANSPORTATION	8.67	0.00	0.00	0.00	0.00		8.67
SITE			0.00	0.00		1.66	1.66
TOTALS BY COMPONENT	36.90	92.70	0.00	0.00	11.53	1.66	

TOTAL FOR CAPITAL REPLACEMENT ALLOWANCE 142.79

COST SUMMARY BY PROFIT CENTER

PROPERTY TAX AND INSURANCE

BEC 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	21.62	32.61	0.00	0.00	7.85	0.00	62.08
TRANSPORTATION	1.93	0.00	0.00	0.00	0.00		1.93
SITE			0.00	0.00		.15	.15
TOTALS BY COMPONENT	23.55	32.61	0.00	0.00	7.85	.15	

TOTAL FOR PROPERTY TAX AND INSURANCE 64.16

COST SUMMARY BY PROFIT CENTER

GENERAL & ADMINISTRATIVE

BEC 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	44.62	41.88	0.00	0.00	17.20	0.00	103.70
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		0.00	0.00
TOTALS BY COMPONENT	44.62	41.88	0.00	0.00	17.20	0.00	

TOTAL FOR GENERAL & ADMINISTRATIVE 103.70

COST SUMMARY BY PROFIT CENTER

INTEREST EXPENSE

BEC 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	4.50	6.79	0.00	0.00	1.63	0.00	12.92
TRANSPORTATION	.99	0.00	0.00	0.00	0.00		.99
SITE			0.00	0.00		.08	.08
TOTALS BY COMPONENT	5.49	6.79	0.00	0.00	1.63	.08	

TOTAL FOR INTEREST EXPENSE 13.99

COST SUMMARY BY PROFIT CENTER

INCOME TAXES

BEC 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	27.66	39.06	0.00	0.00	10.53	0.00	77.45
TRANSPORTATION	3.96	0.00	0.00	0.00	0.00		3.96
SITE			0.00	0.00		.21	.21
TOTALS BY COMPONENT	31.62	39.06	0.00	0.00	10.53	.21	

TOTAL FOR INCOME TAXES 81.62

COST SUMMARY BY PROFIT CENTER

RETURN TO EQUITY HOLDERS

BEC 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	34.23	51.63	0.00	0.00	12.42	0.00	98.28
TRANSPORTATION	6.42	0.00	0.00	0.00	0.00		6.42
SITE			0.00	0.00		.51	.51
TOTALS BY COMPONENT	40.65	51.63	0.00	0.00	12.42	.51	

TOTAL FOR RETURN TO EQUITY HOLDERS 105.21

COST SUMMARY BY PROFIT CENTER

OTHER EXPENSES

BEC 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	20.37	14.28	0.00	0.00	81.02	0.00	115.67
TRANSPORTATION	49.38	49.38	0.00	0.00	6.72		105.48
SITE			738.38	933.00		242.18	1913.56
TOTALS BY COMPONENT	69.75	63.66	738.38	933.00	87.74	242.18	

TOTAL FOR OTHER EXPENSES 2134.71

H E L C A T

A HELIOSTAT COST ANALYSIS TOOL

VERSION 1.0

EDITICN CATE AUGUST 13, 1981

REVISION SEPTEMBER 22, 1981

MMC SECOND GENERATION HELIOSTAT DESIGN (CONTRACTORS' INPUTS)

H E L C A T OPTIONS AND MODEL PARAMETERS

MODEL OPTIONS
SUM OF THE YEARS+ DIGITS DEPRECIATION
WITH NO LEARNING CURVE COST REDUCTION

PARAMETER MATRIX

		FACTORY	SITE	TRANSPORTATION
1	DURATION OF COST PROJECTION - YEARS	10.000	10.000	10.000
2	BASE RATE DIRECT LABOR COST - $/HOUR	10.250	15.680	15.000
3	BASE RATE PROD FACILITY COST - $/SQFT	75.000	0.000	0.000
4	LAND COST FOR PROD FACILITY - $/ACRE	20000.000	0.000	0.000
5	INFLATION RATE	.100	.100	.060
6	RETURN TO BOND HOLDERS	.150	.150	.102
7	RETURN TO EQUITY HOLDERS	.200	.200	.166
8	COMBINED INCOME TAX RATE	.500	.500	.500
9	INVESTMENT TAX CREDIT	.100	.100	.100
10	EQUITY FRACTION	.800	.800	.800
11	PROPERTY TAX AND INSURANCE FRACTION	.006	.040	.040
12	PURCHASED MATERIAL SCRAP FRACTION	.007	.010	.010
13	MAINTENANCE FRACTION	.028	0.000	.040
14	GENERAL AND ADMINISTRATIVE FRACTION	.053	0.000	0.000
15	WORKING CAPITAL FRACTION	.170	0.000	0.000
16	RAW MATERIAL SCRAP FRACTION	.010	.030	.030
17	TOOLING LIFETIME (ACCOUNTING) - YEARS	5.000	5.000	5.000
18	EQUIPMENT LIFETIME (ACCOUNTING) - YEARS	15.000	15.000	10.000
19	FACILITY LIFETIME (ACCOUNTING) - YEARS	33.000	30.000	30.000
20	FACILITY CONSTRUCTION PERIOD - YEARS	3.000	0.000	0.000
21	FACILITY PLANT ENGINEERING FRACTION	0.000	0.000	0.000
22	FACILITY STARTUP QUANTITY	20000.000	0.000	0.000
23	COST REDUCTION COEFFICIENT - START UP	.920	0.000	0.000
24	TOOLING LIFETIME (TAX) - YEARS	3.000	3.000	3.000
25	EQUIPMENT LIFETIME (TAX) - YEARS	5.000	8.000	8.000
26	FACILITY LIFETIME (TAX) - YEARS	10.000	25.000	25.000
27	BASE RATE TRANS COST - $/LB	.035	.035	.035
28	INDIRECT FRACTION - LABOR	.350	.300	.300
29	INDIRECT FRACTION - MATERIAL	.006	0.000	0.000
30	INDIRECT FRACTION - TOOL+G,EQUIP+T,FAC+Y	0.000	0.000	0.000

SPECIAL COST MATRICES

CATEGORY NUMBER	FACILITY $/SQ FT	LABOR $/HR	TRANSPORT (UNITS VARY)
1	40.	10.25	719.200 $/TRKLOAD
2	60.	12.00	130.000 $/TRKLOAD
3	80.	18.00	0.000
4	100.	21.00	0.000
5	120.	25.00	0.000
6	140.	30.00	0.000
7	0.	0.00	0.000
8	0.	0.00	0.000
9	0.	0.00	0.000

MMC 2ND GENERATION HELIOSTAT

4410 FACTORY COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS
S=SUPPLIES AND CONSUMABLES
B=BUILDING OR FACILITY SIZE
X=TRANSPORTATION REQUIREMENTS
P=PURCHASED MATERIALS
T=TOOLING
A=LAND FOR PRODUCTION FACILITY
Y=SITE-RETAINED CAPITAL
L=DIRECT LABOR HOURS
E=EQUIPMENT
Q=QUANTITY
Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST	
ENTRY TYPE=P 4410 FUSION GLASS,.060, SOURCE-CORNING, 5X6 FT. LITES	622	SQFT	.45	280.16	/ HELIOSTAT
ENTRY TYPE=Z 4410 FUSION GLASS PLANT ALLIED TOOLING ALLIED TOOLING COST FOR GLASS PLANT				38.00	/ HELIOSTAT
ENTRY TYPE=P 4410 SILVER,COPPER,PAINT, SOURCE-MISC. ESTIMATE (.07/FT*2 POSSIBLE),AG-70MG/SQFT,CU-20MG/SQFT, PPG UC44409 GRAY PAINT- 7 TO 9 MG/SQFT	622	SQFT	.20	124.52	/ HELIOSTAT
ENTRY TYPE=P 4410 POLYISOBUTYLENE(PIB) SOURCE-3M EC5354	8	GAL	11.18	89.44	/ HELIOSTAT
ENTRY TYPE=L 4410 MIRROR FABRICATION SOURCE-MMC AT 12.23/HR=4.89	.4000E+00	HRS / HELIOSTAT			
ENTRY TYPE=P 4410 PAPER HONEYCOMB-20IP PHENOLIC PERFORATED(0.060),30 V/O	617	SQFT	.27	169.15	/ HELIOSTAT
ENTRY TYPE=P 4410 ADDED COST OF AL HC SOURCE-MMC AT 9/30/81 REVIEW				249.12	/ HELIOSTAT
ENTRY TYPE=P 4410 BORDEN MJ-6 EPOXY ADHESIVE SOURCE BASED ON BOSTIK	7	GAL	8.84	69.80	/ HELIOSTAT
ENTRY TYPE=L 4410 CORE FABRICATION SOURCE-MMC AT 12.23/HR=2.94	.2400E+00	HRS / HELIOSTAT			
ENTRY TYPE=M 4410 FACE AND BACK SHEETS,.024 STEEL SOURCE-ARMCO 1215 LB AT 0.267/LB, SAE 1010 STEEL	1256	SQFT	.26	323.90	/ HELIOSTAT
ENTRY TYPE=L 4410 FACE AND BACK SHEET FABRICATION SOURCE-MMC AT 12.23/HR=0.98,SAE1010 STEEL	.8000E-01	HRS / HELIOSTAT			
ENTRY TYPE=L 4410 BONDED ASSEMBLY SOURCE-MMC AT 12.23/HR=8.81	.7200E+00	HRS / HELIOSTAT			
ENTRY TYPE=M 4410 EDGE STRIP .024 X 2.3125 X 369FT SOURCE-ARMCO 1010 COIL STOCK	68	LBS	.25	17.19	/ HELIOSTAT
ENTRY TYPE=P 4410 PIB SOURCE-3M EC5354				2.63	/ HELIOSTAT

ENTRY TYPE=L 4410 EDGE STRIP FABRICATICN .2200E+00 HRS / HELIOSTAT
SOURCE-MMC AT 12.23/HR=2.69

ENTRY TYPE=M 4410 CENTER STRIP .024 X 1.625 X 52.2FT 6 LBS .25 1.71 / HELIOSTAT
SOURCE-ARMCO 1010 COIL STOCK

ENTRY TYPE=L 4410 CENTER STRIP FABRICATION .6000E-01 HRS / HELICSTAT
SOURCE-MMC AT 12.23/HR=0.73

ENTRY TYPE=P 4410 SUPPCRT DOUBLERS 33 EACH CAST IRON 51 LBS .31 15.96 / HELIOSTAT
SOURCE-MMC ESTIMATE-CAPTIVE FOUNDRY,1.56 LB EACH

ENTRY TYPE=L 4410 SUPPCRT DOUBLER FLATTEN,DRILL,TAP .8000E-01 HRS / HELICSTAT
SOURCE-MMC AT 12.23/HR= 0.98

ENTRY TYPE=P 4410 RTV SEALANT 4.46 / HELIOSTAT
SOURCE-DOW CORNING 795 RTV SILICONE

ENTRY TYPE=P 4410 SELF TAPPING HEX-HEAD SCREWS 33 EACH .03 .82 / HELIOSTAT
SOURCE- A AND E BOLT NO.6 X 7/16 FOR CENTER STRIPS

ENTRY TYPE=P 4410 STAPLES-NOT IN PROD. DESIGN 369 EACH .01 4.43 / HELIOSTAT
SOURCE- A AND E BOLT

ENTRY TYPE=P 4410 SUPPCRT ANGLE .024X.75X363.3FT 22 LBS .25 5.50 / HELIOSTAT
SOURCE-HAL 22 LB

ENTRY TYPE=P 4410 ACRYLIC ADHESIVE,VERSILOK 204 5 LB 3.90 20.75 / HELIOSTAT
SOURCE-MMC TEL CON
SOURCE-HAL FOR DOUBLERS AND EDGE STRIPS,CENTER STRIPS,SUPPORT ANGLES

ENTRY TYPE=P 4410 POP RIVETS 400 EACH 1/8 AL 400 EACH .01 0.00 / HELIOSTAT
SOURCE-HAL ROM= .01 EACH

ENTRY TYPE=P 4410 PRIME AND FINISH PAINT COAT 1 GAL 20.00 0.00 / HELIOSTAT
SOURCE-HAL ROM=
PRIMER-KANSAS PAINT 63Y18.0005-.001 STRONTIUM CHROMATE
FINISH-KANSAS PAINT 84 SERIES,COLOR NO.25630 FED STD 595A .001-.0015
ACRYLIC HYPERTHANE,ONE COAT

ENTRY TYPE=L 4410 MIRROR MODULE ASSEMBLY .1040E+01 HRS / HELICSTAT
SOURCE-MMC AT 12.23/HR= 12.72

ENTRY TYPE=A 4410 REFLECTIVE ASSEMBLY LAND .4040E+02 ACRE
SOURCE-MMC 95 ACRES X PROD. SPACE RATIO(SSW)
MMC USES 20000./ACRE IMPROVED LAND

ENTRY TYPE=B 4410 REFLECTIVE ASSEMBLY FACILITIES .2153E+06 SQFT
SOURCE S. WHITE

ENTRY TYPE=E 4410 REFLECTIVE ASSEMBLY EQUIPMENT 6928000.
SOURCE-MMC

ENTRY TYPE=T 4410 REFLECTIVE ASSEMBLY TOOLING 565000.
SOURCE-MMC

ENTRY TYPE=S 4410 SUPPLIES(NON-DURABLE TOOLING) .20 / HELIOSTAT
SOURCE-MMC

ENTRY TYPE=S 4410 SUPPLIES,UTILITIES 15.39 / HELIOSTAT
SOURCE-MMC BLDG AREA FRAC X 36.20=15.39

ENTRY TYPE=Q 4410 REFLECTIVE ASSEMBLY QUANTITY/YEAR .5000E+05

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TOTAL PURCHASED MATERIALS=   1036.74 $/HELIOSTAT
TOTAL RAW MATERIALS=    342.80 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR=    2.8400    HRS/HELIOSTAT
TOTAL CONSUMABLES=     15.59    $/HELIOSTAT
LAND REQUIRED=   40.4000    ACRES
PRODUCTION FACILITY (BASE RATE COST CATEGORY) SIZE=   215339.    SQ FT
TOTAL EQUIPMENT COST=  6928000.    $
TOTAL TOOLING COST=   565000.    $
QUANTITY=    50000.    / YEAR
TOTAL SUBCONTRACTS AND FLOW-THROUGH EXPENSES=     38.00    $/HELIOSTAT

TOTAL DIRECT LABOR COST=     29.11 $/HELIOSTAT
TOTAL PRODUCTION FACILITY COST  16150425.  $
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MMC 2ND GENERATION HELIOSTAT

4420 FACTORY COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST	
ENTRY TYPE=P 4420 AZIMUTH/ELEVATION DRIVE PARTS SOURCE-TELEPHONE QUOTES AND CATALOGS BEARINGS,GREASE,SCREWS,WASHERS,NUTS,SEALS,PINS,GASKETS,PAINT				196.32	/ HELIOSTAT
ENTRY TYPE=M 4420 CAST IRON PARTS SOURCE-ESTIMATE CAPTIVE FOUNDRY,0.31/LB AZ SHAFT,EL COVER,OPEN CAP,CLOSED CAP,MOTOR BRACKET,GEAR HOUSING,ENCODER SHAFT MOUNT,AZ COVER, SLIDE TABLE				207.17	/ HELIOSTAT
ENTRY TYPE=M 4420 FORGED GEARS,0.80/LB AZ/EL SOURCE-TELEPHONE QUOTES,130 LB, 8620 STEEL	2	EACH	52.00	104.00	/ HELIOSTAT
ENTRY TYPE=M 4420 INTERMEDIATE GEAR CASTING SOURCE-MMC,14.0 LB,0.80/LB,MN BRONZE, SAE CA863	2	EACH	7.20	14.40	/ HELIOSTAT
ENTRY TYPE=M 4420 BAR STK, .42/LB AVG .40-.53 RGE SOURCE-TELEPHONE QUOTES, 243 LBS EL SHAFT,WORM GEAR,INT. PINION,STOW SLIDE				101.89	/ HELIOSTAT
ENTRY TYPE=P 4420 AZ AND EL MOTORS,DC WITH 120-1 RED SOURCE-BODINE TEL. QUOTE				252.00	/ HELIOSTAT
ENTRY TYPE=P 4420 AZ ENCODER SOURCE-TEL QUOTE,BALDWIN ELECTRONICS,SERVOMETER,A+E BOLT				157.20	/ HELIOSTAT
ENTRY TYPE=M 4420 AZ ENCODER COUPLING FROM STEEL STK SOURCE-JORGENSEN TEL QUOTE				1.75	/ HELIOSTAT
ENTRY TYPE=P 4420 EL ENCODER SOURCE-TEL QUOTE,BALDWIN ELECTRONICS,SERVOMETER,A AND E BOLT				157.08	/ HELIOSTAT
ENTRY TYPE=M 4420 EL ENCODER COUPLING FROM STEEL SOURCE-GORGENSEN TEL QUOTE				1.50	/ HELIOSTAT
ENTRY TYPE=P 4420 ELECTRICAL POWER HARNESS SOURCE-TEL QUOTE,CATALOG,CANNON,BURNDY CORP,RAYCHEM,AMP,T AND B,CONS-ELECT INCLUDES 22.84 CONTRACTED LABOR				44.34	/ HELIOSTAT
ENTRY TYPE=P 4420 EL/AZ LOCK LIMIT SWITCH SOURCE-TEL QUOTE,CATALOG,CANNON,CONS-ELECT,MICROSWITCH,T AND B INCLUDES 18.00 CONTRACTED LABOR				32.70	/ HELIOSTAT

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ENTRY TYPE=P   4420      EL/AZ LIMIT SWITCH                                                        34.90  / HELIOSTAT
     SOURCE-TEL QUOTE,CATALOG,CANNON,CONS-ELECT,MICROSWITCH,T AND B
     INCLUDES 18.00 CONTRACTED LABOR

ENTRY TYPE=P   4420      PAINT,.125 GAL                                                             3.75  / HELIOSTAT
     SOURCE- PREVIOUS ESTIMATE

ENTRY TYPE=L   4420      CAST IRON FABRICATION                   .1785E+01  HRS / HELIOSTAT
     SOURCE-MMC AT 12.23/HR=21.83

ENTRY TYPE=L   4420      FORGED GEAR FABRICATION                 .5860E+00  HRS / HELIOSTAT
     SOURCE-MMC AT 12.23/HR=7.16

ENTRY TYPE=L   4420      BAR STOCK FABRICATION                   .8800E+00  HRS / HELIOSTAT
     SOURCE-MMC AT 12.23/HR=10.75

ENTRY TYPE=L   4420      AZ AND EL ENCODER FABRICATION           .4400E+00  HRS / HELIOSTAT
     SOURCE-MMC AT 12.23/HR=5.40

ENTRY TYPE=L   4420      ASSEMBLY AND PAINT OF DRIVE             .1920E+01  HRS / HELIOSTAT
     SOURCE-MMC AT 12.23/HR=23.48

ENTRY TYPE=A   4420      DRIVE ASSEMBLY LAND                     .4340E+02  ACRE
     SOURCE-MMC 95 ACRES X PROD. SPACE RATIO(SSH)
     MMC USES 20000./ACRE IMPROVED LAND

ENTRY TYPE=B   4420      DRIVE ASSEMBLY FACILITIES               .2317E+06  SQFT

ENTRY TYPE=E   4420      DRIVE ASSEMBLY EQUIPMENT                                               19625000.
     SOURCE-MMC

ENTRY TYPE=T   4420      DRIVE ASSEMBLY TOOLING                                                    62500.
     SOURCE-MMC

ENTRY TYPE=S   4420      DRIVE ASSEMBLY SUPPLIES                                                   70.60  / HELIOSTAT
     SOURCE-MMC,NON-DURABLE TOOLING

ENTRY TYPE=S   4420      SUPPLIES,UTILITIES                                                        16.54  / HELIOSTAT
     SOURCE-MMC BLDG AREA FRAC X 36.20=16.54

ENTRY TYPE=Q   4420      DRIVE ASSEMBLY QUANTITY/YEAR            .5000E+05  1YR


   TOTAL PURCHASED MATERIALS=     878.29 $/HELIOSTAT
   TOTAL RAW MATERIALS=     430.71 $/HELIOSTAT
   TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR=     5.6108     HRS/HELIOSTAT
   TOTAL CONSUMABLES=     87.14    $/HELIOSTAT
   LAND REQUIRED=   43.4000    ACRES
   PRODUCTION FACILITY (BASE RATE COST CATEGORY) SIZE=   231694.     SQ FT
   TOTAL EQUIPMENT COST= 19625000.     $
   TOTAL TOOLING COST=     62500.     $
   QUANTITY=     50000.     / YEAR

   TOTAL DIRECT LABOR COST=     57.51 $/HELIOSTAT
   TOTAL PRODUCTION FACILITY COST    17377050.  $
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MMC 2ND GENERATION HELIOSTAT

4430 FACTORY COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

		ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=E SOURCE-	4430	CONTROL SYSTEM EQUIPMENT				108920.
ENTRY TYPE=T	4430	CONTROL SYSTEM TOOLING				10833.
ENTRY TYPE=Q	4430	QUANTITY	.5000E+05	/YR		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
LAND REQUIRED= 0.0000 ACRES
PRODUCTION FACILITY (BASE RATE COST CATEGORY) SIZE= 0. SQ FT
TOTAL EQUIPMENT COST= 108920. $
TOTAL TOOLING COST= 10833. $
QUANTITY= 50000. / YEAR

MMC 2ND GENERATION HELIOSTAT

4440 FACTORY COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST	
ENTRY TYPE=M 4440 INTERFACE TUBE 18.0 OD X 32.5 L SOURCE-ARMCO,0.25 WALL,132 LB,+ 3.4 LB SCRAP,0.23/LB				31.69	/ HELIOSTAT
ENTRY TYPE=P 4440 1-INCH 8 UNC STUDS THREADED SOURCE-JORGENSEN STEEL,A AND BOLT SOURCE-STUDS 0.50 EA,NUTS 1.25(8), LOCK WASHERS 0.54(8) 7/8-9 NC	8	EACH	.72	5.79	/ HELIOSTAT
ENTRY TYPE=P 4440 CONCRETE ANCHORS .5 X 1.5 SOURCE- A AND BOLT	6	EACH	.15	.88	/ HELIOSTAT
ENTRY TYPE=M 4440 ACCESS COVER 14 X 18 X .036 SOURCH-JORGENSEN STEEL,2.56 LB, .35/LB	1	EACH	.89	.89	/ HELIOSTAT
ENTRY TYPE=L 4440 INTERFACE TUBE/COVER FABRICATION SOURCE-MMC AT 12.23/HR=2.08	.1700E+00	HRS / HELICSTAT			
ENTRY TYPE=P 4440 1/4-20 X 3/4 BOLT SOURCE-A AND BOLT,FOR ACCESS COVER	4	EACH	0.00	.05	/ HELIOSTAT
ENTRY TYPE=A 4440 FOUNDATION/PEDESTAL LAND	0.	ACRE			
ENTRY TYPE=B 4440 FOUNDATION/PEDESTAL BUILDINGS	0.	SQFT			
ENTRY TYPE=E 4440 FOUNDATION/PEDESTAL EQUIPMENT SOURCE:KO-INCLUDES TOOLING				561920.	
ENTRY TYPE=T 4440 FOUNDATION/PEDESTAL TOOLING INCLUDED WITH EQUIPMENT				10833.	
ENTRY TYPE=S 4440 FOUNDATION/PEDESTAL SUPPLIES				0.00	/ HELIOSTAT
ENTRY TYPE=Q 4440 FOUNDATION/PEDESTAL QUANTITY/YEAR	.5000E+05	/YR			

TOTAL PURCHASED MATERIALS= 6.72 $/HELIOSTAT
TOTAL RAW MATERIALS= 32.58 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= .1700 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
LAND REQUIRED= 0.0000 ACRES
PRODUCTION FACILITY (BASE RATE COST CATEGORY) SIZE= 0. SQ FT
TOTAL EQUIPMENT COST= 561920. $
TOTAL TOOLING COST= 10833. $
QUANTITY= 50000. / YEAR

TOTAL DIRECT LABOR COST= 1.74 $/HELIOSTAT

MMC 2ND GENERATION HELIOSTAT

4450 FACTORY COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS
S=SUPPLIES AND CONSUMABLES
B=BUILDING OR FACILITY SIZE
X=TRANSPORTATION REQUIREMENTS

P=PURCHASED MATERIALS
T=TOOLING
A=LAND FOR PRODUCTION FACILITY
Y=SITE-RETAINED CAPITAL

L=DIRECT LABOR HOURS
E=EQUIPMENT
Q=QUANTITY
Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=M 4450 EL BEAM-COIL STOCK 36X.1875,649 LB SOURCE-JORGENSEN STEEL .20/LB				129.80 / HELIOSTAT
ENTRY TYPE=L 4450 EL BEAM FABRICATION SOURCE-MMC AT 12.23/HR=0.98	.8000E-01	HRS / HELIOSTAT		
ENTRY TYPE=M 4450 CONTROL ARM CASTINGS 114 LB SOURCE-MMC EST CAPTIVE FOUNDRY .31/LB				35.34 / HELIOSTAT
ENTRY TYPE=L 4450 CONTROL ARM FABRICATION SOURCE-MMC AT 12.23/HR=1.96	.1600E+00	HRS / HELIOSTAT		
ENTRY TYPE=M 4450 CONTROL ARM CAP-STEEL BAR 18 LB SOURCE-JORGENSEN STEEL,.43/LB				9.54 / HELIOSTAT
ENTRY TYPE=L 4450 CONTROL ARM CAP FABRICATION SOURCE-MMC AT 12.23/HR=0.98	.8000E-01	HRS / HELIOSTAT		
ENTRY TYPE=M 4450 INBOARD/OUTBOARD BRACKETS 33.4 LB SOURCE-JORGENSEN STEEL,.36/LB 4X0.25 1010 STEEL BAR STOCK				11.55 / HELIOSTAT
ENTRY TYPE=L 4450 INBOARD/OUTBOARD BKT FABRICATION SOURCE-MMC AT 12.23/HR=0.49	.4000E-01	HRS / HELIOSTAT		
ENTRY TYPE=M 4450 STOW DISK,3.5 DIA 1018 STEEL BAR SOURCE-JORGENSEN STEEL,0.40/LB,3.2LB				1.29 / HELIOSTAT
ENTRY TYPE=L 4450 STOW DISK FABRICATION SOURCE-MMC AT 12.23/HR=1.30	.1064E+00	HRS / HELIOSTAT		
ENTRY TYPE=P 4450 STOW TUBE,2 DIA 1018 STEEL ROD SOURCE-JORGENSEN STEEL,.40/LB, 12 LB				4.80 / HELIOSTAT
ENTRY TYPE=L 4450 ELEVATION BEAM ASSEMBLY SOURCE-MMC AT 12.23/HR=3.91	.3200E+00	HRS / HELIOSTAT		
ENTRY TYPE=M 4450 BAR JOIST CHORD,2 SHORT,2 LONG SOURCE-ARMCO,4.875X.1875 COIL STOCK SHORT=258.3LB,LONG=303.8LB, .20/LB				109.61 / HELIOSTAT
ENTRY TYPE=M 4450 BAR JOIST WEB,2 SHORT,2 LONG SOURCE-ARMCO,11/16 ROD BAR SHORT=79.4LB,LONG=99.0LB, .20/LB				35.67 / HELIOSTAT

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ENTRY TYPE=M   4450      BAR JOIST CHANNEL,2 SHORT,2 LONG                                          14.71  / HELIOSTAT
     SOURCE-ARMCO,MC3X7.1 ASTM A36
     SHORT=29.4LB,LONG=29.4LB, .25/LB

ENTRY TYPE=P   4450      BAR JOIST PAINT,.2GAL SHORT,.3LONG                                        15.00  / HELIOSTAT
     SOURCE-PREVIOUS PURCHASE,30.00/GAL

ENTRY TYPE=L   4450      BAR JOIST FABRICATION                 .8640E+00  HRS / HELIOSTAT
     SOURCE-MMC AT 12.23/HR=10.56

ENTRY TYPE=M   4450      CROSS BAR,2 EACH FOR SMALL MIRROR                                         13.73  / HELIOSTAT
     SOURCE-ARMCO,4.875X.1875 COIL STOCK
     70.4 LB, .20/LB

ENTRY TYPE=L   4450      CROSS BAR FABRICATION                 .5600E-01  HRS / HELIOSTAT
     SOURCE-MMC AT 12.23/HR=0.68

ENTRY TYPE=M   4450      MIRROR MOUNT BRACKETS,33 EACH                                              1.75  / HELIOSTAT
     SOURCE-UNKNOWN

ENTRY TYPE=L   4450      MIRROR MOUNT BRACKET FABRICATION      .2000E-01  HRS / HELIOSTAT
     SOURCE-MMC AT 12.23/HR=0.24

ENTRY TYPE=A   4450      STRUCTURAL SUPPORT LAND               .1120E+02  ACRE
     SOURCE-MMC 95 ACRES X PROD. SPACE RATIO(SSW)
     MMC USES 20000./ACRE IMPROVED LAND

ENTRY TYPE=B   4450      STRUCTURAL SUPPORT FACILITIES         .5997E+05  SQFT
     SOURCE-MMC

ENTRY TYPE=E   4450      STRUCTURAL SUPPORT EQUIPMENT                                          2375600.
     SOURCE-MMC

ENTRY TYPE=T   4450      STRUCTURAL SUPPORT TOOLING                                             100833.

ENTRY TYPE=S   4450      SUPPLIES,UTILITIES                                                          4.27  / HELIOSTAT
     SOURCE-MMC BLDG AREA FRAC X 36.20=4.27

ENTRY TYPE=S   4450      STRUCTURAL SUPPORT SUPPLIES                                                 1.40  / HELIOSTAT

ENTRY TYPE=Q   4450      STRUCTURAL SUPPORT QUANTITY/YEAR      .5000E+05  /YR


   TOTAL PURCHASED MATERIALS=     19.80 $/HELIOSTAT
   TOTAL RAW MATERIALS=    362.99 $/HELIOSTAT
   TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR=    1.7264    HRS/HELIOSTAT
   TOTAL CONSUMABLES=      5.67    $/HELIOSTAT
   LAND REQUIRED=   11.2000    ACRES
   PRODUCTION FACILITY (BASE RATE COST CATEGORY) SIZE=    59968.    SQ FT
   TOTAL EQUIPMENT COST=  2375600.    $
   TOTAL TOOLING COST=   100833.    $
   QUANTITY=    50000.    / YEAR

   TOTAL DIRECT LABOR COST=     17.70 $/HELIOSTAT
   TOTAL PRODUCTION FACILITY COST    4497600.  $
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MMC 2ND GENERATION HELIOSTAT

4460 FACTORY COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
LAND REQUIRED= 0.0000 ACRES
PRODUCTION FACILITY (BASE RATE COST CATEGORY) SIZE= 0. SQ FT
TOTAL EQUIPMENT COST= 0. $
TOTAL TOOLING COST= 0. $
QUANTITY= 0. / YEAR

DEFAULT QUANTITY USED IN PROFIT CENTER CALCULATION
DEFAULT QUANTITIES = 50000.(FACTORY), 5400.(TRANSPORT/SITE)

MMC 2ND GENERATICN HELIOSTAT

4410 TRANSPORTATION COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABCR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING CR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	V=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ENTRY		ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=S	4410	LARGE MIRROR MODULE CRATE SOURCE-MMC				11.55 / HELIOSTAT
ENTRY TYPE=S	4410	SMALL MIRROR MODULE CRATE SOURCE-MMC				.60 / HELIOSTAT
ENTRY TYPE=X	4410	TRANSPORT TO SITE-LARGE MIRRORS SPECIAL TRANSPORTATION COST CATEGORY 1 SOURCE-MMC $71.78 TO SITE + $10.10 RETURN	.1190E+00	TRUCKLOADS		
ENTRY TYPE=X	4410	TRANSPORT TO SITE-SMALL MIRRORS SPECIAL TRANSPORTATION COST CATEGORY 1 SOURCE-MMC $3.83 TO SITE + $0.00 RETURN	.4000E-02	TRUCKLOADS		
ENTRY TYPE=Q	4410	QUANTITY	.5147E+04	/SITE		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 12.15 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 5147. / SITE
SPECIAL TRANSPORTATION COST CATEGORY 1 = .123 TRUCKLOADS
INPUT (NOT COMPUTED) TRANSPORTATION COST 88.46 $

MMC 2ND GENERATION HELIOSTAT

4420 TRANSPORTATION COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS
S=SUPPLIES AND CONSUMABLES
B=BUILDING OR FACILITY SIZE
X=TRANSPORTATION REQUIREMENTS
P=PURCHASED MATERIALS
T=TOOLING
A=LAND FOR PRODUCTION FACILITY
\=SITE-RETAINED CAPITAL
L=DIRECT LABOR HOURS
E=EQUIPMENT
Q=QUANTITY
Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

	ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=S 4420	DRIVE ASSEMBLY CRATE SOURCE-MMC				1.00 / HELIOSTAT
ENTRY TYPE=X 4420	TRANSPORT TO SITE-DRIVE SPECIAL TRANSPORTATION COST CATEGORY 1 SOURCE-MMC $31.27 TO SITE + $3.04 RETURN	.3130E-01	TRUCKLOADS		
ENTRY TYPE=Q 4420	QUANTITY	.5147E+04	/STE		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 1.00 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 5147. / SITE
SPECIAL TRANSPORTATION COST CATEGORY 1 = .031 TRUCKLOADS
INPUT (NOT COMPUTED) TRANSPORTATION COST 22.51 $

MMC 2ND GENERATION HELIOSTAT

4430 TRANSPORTATION COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 0. / SITE

DEFAULT QUANTITY USED IN PROFIT CENTER CALCULATION
DEFAULT QUANTITIES = 50000.(FACTORY), 5400.(TRANSPORT/SITE)

MMC 2ND GENERATION HELIOSTAT

4440 TRANSPORTATION COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

	ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=S 4440	PEDESTAL INTERFACE TUBE CRATE SOURCE-MMC				.48 / HELIOSTAT
ENTRY TYPE=X 4440	TRANSPORT TO SITE-INTERFACE TUBE SPECIAL TRANSPORTATION COST CATEGORY 1 SOURCE-MMC $4.79 TO SITE + 1.43 RETURN	.4500E-02	TRUCKLOADS		
ENTRY TYPE=Q 4440	QUANTITY	.5147E+04	/STE		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= .48 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 5147. / SITE
SPECIAL TRANSPORTATION COST CATEGORY 1 = .005 TRUCKLOADS
INPUT (NOT COMPUTED) TRANSPORTATION COST 3.24 $

MMC 2ND GENERATION HELIOSTAT

4450 TRANSPORTATION COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM		QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=S 4450 SOURCE-MMC	ELEVATION BEAM CRATE				1.25 / HELIOSTAT
ENTRY TYPE=S 4450 SOURCE-MMC	BAR JOIST CRATE				2.80 / HELIOSTAT
ENTRY TYPE=X 4450 SPECIAL TRANSPORTATION COST CATEGORY 1 SOURCE-MMC $26.80 TO SITE + $1.43 RETURN	TRANSPORT TO SITE-ELEVATION BEAM	.4170E-01	TRUCKLOADS		
ENTRY TYPE=X 4450 SPECIAL TRANSPORTATION COST CATEGORY 1 SOURCE-MMC $23.82 TO SITE + $1.79 RETURN	TRANSPORT TO SITE-BAR JOIST	.5000E-01	TRUCKLOADS		
ENTRY TYPE=Q 4450	QUANTITY	.5147E+04	/STE		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 4.05 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 5147. / SITE
SPECIAL TRANSPORTATION COST CATEGORY 1 = .092 TRUCKLOADS
INPUT (NOT COMPUTED) TRANSPORTATION COST 65.95 $

MMC 2ND GENERATION HELIOSTAT

4430 SITE COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

	ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST	
ENTRY TYPE=Z 4430	HC SOURCE-MMC BASED ON BARSTOW INC 36.69 CONTR. LABOR ICS-101.60,POWER SUPP-70.00,RELAYS-101.04,FIBER OPTICS XMIT,REC-70.00, RECT-45.00,PKG-4.60,RES,CAP,CRYSTAL,DIODE-20.51				448.84	/ HELIOSTAT
ENTRY TYPE=Z 4430	HFC INCLUDES 0.99 CONTR. LABOR SOURCE-MMC BASED ON BARSTOW 1 PER 32 HCS ICS-2.39,FIBER OPTICS XMIT,REC-4.37,PKG-0.19,RES,CAP,CRYSTAL,DIODE-0.44				8.38	/ HELIOSTAT
ENTRY TYPE=Z 4430	REDUCTION IN COST FROM MASS PROD. SOURCE-MMC AT 9/30/81 REVIEW				-49.94	/ HELIOSTAT
ENTRY TYPE=Z 4430	HAC SOURCE-MMC BASED ON BARSTOW SOFTWARE,INSTALL				77.71	/ HELIOSTAT
ENTRY TYPE=Z 4430	SIGNAL DISTRIBUTION INC 11.74 INSTALLATION SUBCONTRACTED LABOR,FIBEROPTIC CABLE 120.26 FEET/HELIOSTAT SOURCE-MMC ESTIMATE				63.26	/ HELIOSTAT
ENTRY TYPE=Z 4430	POWER CABLING INSTALLED SOURCE-MMC				235.00	/ HELIOSTAT
ENTRY TYPE=Z 4430	BEAM CHARACTERIZATION SYSTEM(BCS) SOURCE-MMC				38.86	/ HELIOSTAT
ENTRY TYPE=E 4430		0.			0.	
ENTRY TYPE=Q 4430		.5147E+04	/STE			

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELICSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 5147. / SITE
TOTAL SUBCONTRACTS AND FLOW-THROUGH EXPENSES= 822.11 $/HELIOSTAT

MMC 2ND GENERATION HELIOSTAT

4440 SITE COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=Z 4440 FOUNDATION/PEDESTAL CONCRETE SOURCE-BLACK AND VEATCH,4000 PSI YLD 10 PERCENT EXCESS			160.00	/ HELIOSTAT
ENTRY TYPE=Z 4440 FOUNDATION/PEDESTAL REBAR CAGE SOURCE-BLACK AND VEATCH,FABRICATED 320 LB,ABOUT 3 MAN-HRS+TOOLING REBAR MATERIAL AT 0.22/LB=$70.40			150.00	/ HELIOSTAT
ENTRY TYPE=Z 4440 FOUNDATION/PEDESTAL ELECT CONDUIT SOURCE-BLACK AND VEATCH, 7 LB			3.00	/ HELIOSTAT
ENTRY TYPE=Z 4440 PEDESTAL FORMS SOURCE-BLACK AND VEATCH,LABOR INC W/ PED INST			15.00	/ HELIOSTAT
ENTRY TYPE=Z 4440 INTERFACE TUBE FORMS SOURCE-BLACK AND VEATCH			5.00	/ HELIOSTAT
ENTRY TYPE=Z 4440 FOUNDATION INSTALLATION SUBCONTR. SOURCE-BLACK AND VEATCH,DRILL HOLE .25 HRS, PLACE REBAR .25 HRS,PLACE CONCRETE .5 HRS, INC EQUIP,TOOLING			90.00	/ HELIOSTAT
ENTRY TYPE=Z 4440 PEDESTAL INSTALLATION SUBCONTR. SOURCE-BLACK AND VEATCH, SET FORM,ALIGN REBAR,			120.00	/ HELIOSTAT
ENTRY TYPE=Z 4440 INTERFACE TUBE INSTALLATION SUBC. INSTALL INTERFACE TUBE 1.0HR INC EQUIP/TOOLING			15.00	/ HELIOSTAT
ENTRY TYPE=Z 4440 ELECTRICAL CONDUIT INSTALL SOURCE-BLACK AND VEATCH			12.00	/ HELIOSTAT
ENTRY TYPE=Z 4440 FOUNDATION LOCATION SURVEY SOURCE-MAL .25 HRS, EST. ONLY			15.00	/ HELIOSTAT
ENTRY TYPE=Z 4440 CRANE W/OPERATOR SOURCE-BLACK AND VEATCH			15.00	/ HELIOSTAT
ENTRY TYPE=Z 4440 CONCRETE PUMP W/OPERATOR SOURCE-BLACK AND VEATCH			11.00	/ HELIOSTAT
ENTRY TYPE=Z 4440 REDUCTION OF SUBS ESTIMATE SOURCE-MMC AT 9/30/81 REVIEW			-59.70	/ HELIOSTAT
ENTRY TYPE=Q 4440 FOUNDATION/PEDESTAL QUANTITY/YEAR	.5147E+04			

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 5147. / SITE
TOTAL SUBCONTRACTS AND FLOW-THROUGH EXPENSES= 551.30 $/HELIOSTAT

MMC 2ND GENERATION HELIOSTAT

4460 SITE COSTS
KEY TO ENTRY TYPES

M=RAW MATERIALS
S=SUPPLIES AND CONSUMABLES
B=BUILDING OR FACILITY SIZE
X=TRANSPORTATION REQUIREMENTS
P=PURCHASED MATERIALS
T=TOOLING
A=LAND FOR PRODUCTION FACILITY
Y=SITE-RETAINED CAPITAL
L=DIRECT LABOR HOURS
E=EQUIPMENT
Q=QUANTITY
Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

		ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=P	4460	RIVETS FOR SUPPORT STRUCT. ASSY	39	EACH	.05	1.95 / HELIOSTAT
SOURCE-MMC						
ENTRY TYPE=P	4460	MIRROR MOUNT STUDS	33	EACH	.10	3.30 / HELIOSTAT
SOURCE-MMC						
ENTRY TYPE=L	4460	HELIOSTAT ASSEMBLY,9 MEN X 2 SHFTS	.7200E+01	HRS / HELIOSTAT		
SPECIAL LABOR COST CATEGORY NUMBER 1 SOURCE-HAL CORRECTED FROM 7.0 TO 7.2 HRS MMC WAS $85.61 AT 12.23/HR MOVE COMPONENTS FROM STORAGE TO ASSY AREA,ASSEMBLE SUPPORT STRUCTURE, MIRROR MODULES,DRIVE AND CHECKOUT						
ENTRY TYPE=L	4460	HELIOSTAT INSTALL ON PEDESTAL	.2400E+01	HRS / HELIOSTAT		
SOURCE-HAL CORRECTED FROM 2.03 TO 2.4 HRS MMC WAS $31.83 AT 15.68/HR, 3 MEN X 2 SHIFTS MOVE HELIOSTAT FROM ASSEMBLY AREA TO PEDESTAL,INSTALL HELIOSTAT						
ENTRY TYPE=L	4460	INSTALL AND CHECKOUT ELECTRONICS	.2400E+01	HRS / HELIOSTAT		
SOURCE-HAL CORRECTED FROM 2.03 TO 2.4 HRS MMC WAS $31.83 AT 15.68/HR,3 MEN X 2 SHIFTS TEST HELIOSTAT USING HAC AND BCS						
ENTRY TYPE=E	4460	BRIDGE CRANE,ASSY FIXTURES,PED	.1500E+01	YRS	505000.	
SOURCE-MMC						
ENTRY TYPE=T	4460	MISC. TOOLING	.1500E+01	YRS	22500.	
SOURCE-MMC						
ENTRY TYPE=Y	4460	BUILDING(500K),XPORT VEHICLE(150K)			730000.	
SOURCE-MMC,WORK PLATFORM VEHICLES(60K),SPECIAL TOOLS(20K) ASSY/MAIN BUILDING=28,500 SQFT AT 1000K,OWNER PAYS HALF						
ENTRY TYPE=Y	4460	INITIAL SPARES			31300.	
SOURCE-MMC,6 FACETS,1 DRIVE,26 MOTORS,16 ENCODERS, 46 HC,13 HFC						
ENTRY TYPE=Y	4460	MAINTENANCE EQUIPMENT			75000.	
SOURCE-MMC,WASH TRUCKS						
ENTRY TYPE=S	4460	SUPPLIES,UTILITIES,CONSUMABLES				7.77 / HELIOSTAT
SOURCE-MMC						
ENTRY TYPE=Q	4460	HELIOSTATS PER 50MWE SITE	.5147E+04	/STE		

TOTAL PURCHASED MATERIALS= 5.25 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 4.8000 HRS/HELIOSTAT
SPECIAL DIRECT LABOR COST CATEGORY 1 = 7.2000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 7.77 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 757500. $ TIMES YEARS USED / SITE
QUANTITY= 5147. / SITE
TOTAL SITE-RETAINED CAPITAL= 836300.00 $

TOTAL DIRECT LABOR COST= 149.06 $/HELIOSTAT

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MMC 2ND GENERATION HELIOSTAT

4410 - REFLECTIVE ASSEMBLY

FACTORY COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			1741.01
DIRECT MATERIALS		1390.23	
PURCHASED MATERIALS	1036.74		
RAW MATERIALS	342.80		
SCRAP	10.69		
DIRECT LABOR		29.11	
CONSUMABLES		15.59	
INDIRECT COSTS		31.77	
MAINTENANCE, PLANT ENGINEERING	13.24		
OTHER INDIRECTS	18.53		
CAPITAL REPLACEMENT ALLOWANCE		11.31	
PROPERTY TAX AND INSURANCE		2.73	
GENERAL & ADMINISTRATIVE		79.16	
INTEREST EXPENSE		12.78	
INCOME TAXES		52.20	
RETURN TO EQUITY HOLDERS		68.16	
OTHER EXPENSES		47.99	
ANNUALIZED ONE-TIME COSTS	9.99		
SUBCONTRACTS & FLOW-THROUGH	38.00		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MMC 2ND GENERATION HELIOSTAT

4420 - DRIVES

FACTORY COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			1789.39
DIRECT MATERIALS		1319.46	
PURCHASED MATERIALS	878.29		
RAW MATERIALS	430.71		
SCRAP	10.46		
DIRECT LABOR		57.51	
CONSUMABLES		87.14	
INDIRECT COSTS		48.80	
MAINTENANCE, PLANT ENGINEERING	20.76		
OTHER INDIRECTS	28.05		
CAPITAL REPLACEMENT ALLOWANCE		19.78	
PROPERTY TAX AND INSURANCE		3.43	
GENERAL & ADMINISTRATIVE		82.26	
INTEREST EXPENSE		16.05	
INCOME TAXES		58.62	
RETURN TO EQUITY HOLDERS		85.63	
OTHER EXPENSES		10.71	
ANNUALIZED ONE-TIME COSTS	10.71		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MMC 2ND GENERATION HELIOSTAT

4430 - CONTROLS

FACTORY COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			.42
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		0.00	
INDIRECT COSTS		.07	
MAINTENANCE, PLANT ENGINEERING	.07		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		.12	
PROPERTY TAX AND INSURANCE		.01	
GENERAL & ADMINISTRATIVE		.01	
INTEREST EXPENSE		.03	
INCOME TAXES		.05	
RETURN TO EQUITY HOLDERS		.15	
OTHER EXPENSES		0.00	

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MMC 2ND GENERATION HELIOSTAT

4440 - FOUNDATION/PEDESTAL

FACTORY COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			49.20
DIRECT MATERIALS		39.67	
PURCHASED MATERIALS	6.72		
RAW MATERIALS	32.58		
SCRAP	.37		
DIRECT LABOR		1.74	
CONSUMABLES		0.00	
INDIRECT COSTS		1.17	
MAINTENANCE, PLANT ENGINEERING	.32		
OTHER INDIRECTS	.85		
CAPITAL REPLACEMENT ALLOWANCE		.46	
PROPERTY TAX AND INSURANCE		.07	
GENERAL & ADMINISTRATIVE		2.30	
INTEREST EXPENSE		.35	
INCOME TAXES		1.37	
RETURN TO EQUITY HOLDERS		1.85	
OTHER EXPENSES		.21	
ANNUALIZED ONE-TIME COSTS	.21		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MMC 2ND GENERATION HELIOSTAT

4450 - SUPPORT STRUCTURE

FACTORY COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			490.71
DIRECT MATERIALS		386.56	
PURCHASED MATERIALS	19.80		
RAW MATERIALS	362.99		
SCRAP	3.77		
DIRECT LABOR		17.70	
CONSUMABLES		5.67	
INDIRECT COSTS		12.42	
MAINTENANCE, PLANT ENGINEERING	3.91		
OTHER INDIRECTS	8.51		
CAPITAL REPLACEMENT ALLOWANCE		3.32	
PROPERTY TAX AND INSURANCE		.79	
GENERAL & ADMINISTRATIVE		22.80	
INTEREST EXPENSE		3.72	
INCOME TAXES		15.05	
RETURN TO EQUITY HOLDERS		19.83	
OTHER EXPENSES		2.85	
ANNUALIZED ONE-TIME COSTS	2.85		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MMC 2ND GENERATION HELIOSTAT

4460 - ASSEMBLY/INSTALLATION

FACTORY COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			0.00
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		0.00	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		0.00	

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MMC 2ND GENERATION HELIOSTAT

4410 - REFLECTIVE ASSEMBLY

TRANSPORTATION COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			100.61
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		12.15	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		88.46	
TRANSPORTATION CHARGES	88.46		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MMC 2ND GENERATION HELIOSTAT

4420 - DRIVES

TRANSPORTATION COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			23.51
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		1.00	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		22.51	
TRANSPORTATION CHARGES	22.51		

HELIOSTAT CCST MOCEL

DETAILED EREAKDOWN

MMC 2ND GENERATION HELIOSTAT

4430 - CONTROLS

TRANSPORTATION COSTS

PROCUCTION YEAR 1

TOTAL REQUIRED REVENUE			0.00
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		0.00	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		0.00	

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MMC 2ND GENERATION HELIOSTAT

4440 - FOUNDATION/PEDESTAL

TRANSPORTATION COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			3.72
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		.48	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		3.24	
TRANSPORTATION CHARGES	3.24		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MMC 2ND GENERATION HELIOSTAT

4450 - SUPPORT STRUCTURE

TRANSPORTATION COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			70.00
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		4.05	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		65.95	
TRANSPORTATION CHARGES	65.95		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MMC 2ND GENERATION HELIOSTAT

4430 - CONTROLS

SITE COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			822.11
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		0.00	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		822.11	
SUBCONTRACTS & FLOW-THROUGH	822.11		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MMC 2ND GENERATION HELIOSTAT

4440 - FOUNDATION/PEDESTAL

SITE COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			551.30
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		0.00	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		551.30	
SUBCONTRACTS & FLOW-THROUGH	551.30		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MMC 2ND GENERATION HELIOSTAT

4460 - ASSEMBLY/INSTALLATION

SITE COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			393.42
DIRECT MATERIALS		5.30	
PURCHASED MATERIALS	5.25		
RAW MATERIALS	0.00		
SCRAP	.05		
DIRECT LABOR		149.06	
CONSUMABLES		7.77	
INDIRECT COSTS		44.72	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	44.72		
CAPITAL REPLACEMENT ALLOWANCE		6.55	
PROPERTY TAX AND INSURANCE		2.26	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		1.69	
INCOME TAXES		4.56	
RETURN TO EQUITY HOLDERS		9.02	
OTHER EXPENSES		162.48	
SITE-RETAINED CAPITAL	162.48		

CCST SUMMARY BY PROFIT CENTER

TOTAL REQUIRED REVENUE

MMC 2NC GENERATION HELICSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	1741.01	1789.39	.42	49.20	490.71	0.00	4070.73
TRANSPORTATION	100.61	23.51	0.00	3.72	70.00		197.84
SITE			822.11	551.30		393.42	1766.83
TOTALS BY COMPONENT	1841.62	1812.90	822.53	604.22	560.71	393.42	

TOTAL FCR TOTAL REQUIREC REVENUE 6035.40

COST SUMMARY BY PROFIT CENTER

DIRECT MATERIALS

MMC 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	1390.23	1319.46	0.00	39.67	386.56	0.00	3135.92
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		5.30	5.30
TOTALS BY COMPONENT	1390.23	1319.46	0.00	39.67	386.56	5.30	

TOTAL FOR DIRECT MATERIALS 3141.22

COST SUMMARY BY PROFIT CENTER

DIRECT LABOR

MMC 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	29.11	57.51	0.00	1.74	17.70	0.00	106.06
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		149.06	149.06
TOTALS BY COMPONENT	29.11	57.51	0.00	1.74	17.70	149.06	

TOTAL FOR DIRECT LABOR 255.12

COST SUMMARY BY PROFIT CENTER

CONSUMABLES

MMC 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	15.59	87.14	0.00	0.00	5.67	0.00	108.40
TRANSPORTATION	12.15	1.00	0.00	.48	4.05		17.68
SITE			0.00	0.00		7.77	7.77
TOTALS BY COMPONENT	27.74	88.14	0.00	.48	9.72	7.77	

TOTAL FOR CONSUMABLES 133.85

COST SUMMARY BY PROFIT CENTER

INDIRECT COSTS

MMC 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	31.77	48.80	.07	1.17	12.42	0.00	94.23
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		44.72	44.72
TOTALS BY COMPONENT	31.77	48.80	.07	1.17	12.42	44.72	

TOTAL FOR INDIRECT COSTS 138.95

COST SUMMARY BY PROFIT CENTER

CAPITAL REPLACEMENT ALLOWANCE

MMC 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	11.31	19.78	.12	.46	3.32	0.00	34.99
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		6.55	6.55
TOTALS BY COMPONENT	11.31	19.78	.12	.46	3.32	6.55	

TOTAL FOR CAPITAL REPLACEMENT ALLOWANCE 41.54

COST SUMMARY BY PROFIT CENTER

PROPERTY TAX AND INSURANCE

MMC 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	2.73	3.43	.01	.07	.79	0.00	7.03
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		2.26	2.26
TOTALS BY COMPONENT	2.73	3.43	.01	.07	.79	2.26	

TOTAL FOR PROPERTY TAX AND INSURANCE 9.29

COST SUMMARY BY PROFIT CENTER

GENERAL & ADMINISTRATIVE

MMC 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	79.16	82.26	.01	2.30	22.80	0.00	186.53
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		0.00	0.00
TOTALS BY COMPONENT	79.16	82.26	.01	2.30	22.80	0.00	

TOTAL FOR GENERAL & ADMINISTRATIVE 186.53

COST SUMMARY BY PROFIT CENTER

INTEREST EXPENSE

MMC 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	12.78	16.05	.03	.35	3.72	0.00	32.93
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		1.69	1.69
TOTALS BY COMPONENT	12.78	16.05	.03	.35	3.72	1.69	

TOTAL FOR INTEREST EXPENSE 34.62

COST SUMMARY BY PROFIT CENTER

INCOME TAXES

MMC 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	52.20	58.62	.05	1.37	15.05	0.00	127.29
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		4.56	4.56
TOTALS BY COMPONENT	52.20	58.62	.05	1.37	15.05	4.56	

TOTAL FOR INCOME TAXES 131.85

COST SUMMARY BY PROFIT CENTER

RETURN TO EQUITY HOLDERS

MMC 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	68.16	85.63	.15	1.85	19.83	0.00	175.62
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		9.02	9.02
TOTALS BY COMPONENT	68.16	85.63	.15	1.85	19.83	9.02	

TOTAL FOR RETURN TO EQUITY HOLDERS 184.64

COST SUMMARY BY PROFIT CENTER

OTHER EXPENSES

MMC 2ND GENERATION HELIOSTAT

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	47.99	10.71	0.00	.21	2.85	0.00	61.76
TRANSPORTATION	88.46	22.51	0.00	3.24	65.95		180.16
SITE			822.11	551.30		162.48	1535.89
TOTALS BY COMPONENT	136.45	33.22	822.11	554.75	68.80	162.48	

TOTAL FOR OTHER EXPENSES 1777.81

H E L C A T

A HELIOSTAT COST ANALYSIS TOOL

VERSION 1.0

EDITION DATE AUGUST 13, 1981

REVISION SEPTEMBER 22, 1981

MDAC SECOND GENERATION HELIOSTAT DESIGN (CONTRACTORS' INPUTS)

H E L C A T OPTIONS AND MODEL PARAMETERS

MODEL OPTIONS
STRAIGHT LINE DEPRECIATION
WITH NO LEARNING CURVE COST REDUCTION

PARAMETER MATRIX

		FACTORY	SITE	TRANSPORTATION
1	DURATION OF COST PROJECTION - YEARS	10.000	10.000	10.000
2	BASE RATE DIRECT LABOR COST - $/HOUR	18.880	15.120	15.000
3	BASE RATE PROD FACILITY COST - $/SQFT	136.000	0.000	0.000
4	LAND COST FOR PROD FACILITY - $/ACRE	20000.000	0.000	0.000
5	INFLATION RATE	.094	.094	.060
6	RETURN TO BOND HOLDERS	.102	.102	.102
7	RETURN TO EQUITY HOLDERS	.150	.166	.166
8	COMBINED INCOME TAX RATE	.500	.500	.500
9	INVESTMENT TAX CREDIT	.100	.100	.100
10	EQUITY FRACTION	1.000	.800	.800
11	PROPERTY TAX AND INSURANCE FRACTION	.021	.040	.040
12	PURCHASED MATERIAL SCRAP FRACTION	.030	.010	.010
13	MAINTENANCE FRACTION	.020	.040	.040
14	GENERAL AND ADMINISTRATIVE FRACTION	.044	0.000	0.000
15	WORKING CAPITAL FRACTION	.170	0.000	0.000
16	RAW MATERIAL SCRAP FRACTION	.030	.030	.030
17	TOOLING LIFETIME (ACCOUNTING) - YEARS	5.000	5.000	5.000
18	EQUIPMENT LIFETIME (ACCOUNTING) - YEARS	10.000	10.000	10.000
19	FACILITY LIFETIME (ACCOUNTING) - YEARS	40.000	30.000	30.000
20	FACILITY CONSTRUCTION PERIOD - YEARS	3.000	0.000	0.000
21	FACILITY PLANT ENGINEERING FRACTION	0.000	0.000	0.000
22	FACILITY STARTUP QUANTITY	20000.000	0.000	0.000
23	COST REDUCTION COEFFICIENT - START UP	.920	0.000	0.000
24	TOOLING LIFETIME (TAX) - YEARS	5.000	3.000	3.000
25	EQUIPMENT LIFETIME (TAX) - YEARS	10.000	8.000	8.000
26	FACILITY LIFETIME (TAX) - YEARS	20.000	25.000	25.000
27	BASE RATE TRANS COST - $/LB	.035	.035	.035
28	INDIRECT FRACTION - LABOR	.220	.700	.300
29	INDIRECT FRACTION - MATERIAL	.003	0.000	0.000
30	INDIRECT FRACTION - TOOL+G,EQUIP+T,FAC+Y	.005	0.000	0.000

SPECIAL COST MATRICES

CATEGORY NUMBER	FACILITY $/SQ FT	LABOR $/HR	TRANSPORT (UNITS VARY)
1	40.	9.00	725.000 $/TRKLOAD
2	60.	12.00	120.000 $/TRKLOAD
3	80.	16.00	0.000
4	100.	21.00	0.000
5	120.	25.00	0.000
6	140.	30.00	0.000
7	0.	0.00	0.000
8	0.	0.00	0.000
9	0.	0.00	0.000

MDAC - SECOND GENERATION

4410 FACTORY COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ENTRY		ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST	
ENTRY TYPE=P	4410	MIRROR,.059 FUSION/ID22428-3 SOURCE:GM (BINSWANGER MIRROR, CORNING GLASS), $.75/SQ FT INCLUDING AG, CU, PAINT AND TRANSPORTATION	14		33.00	462.00	/ HELIOSTAT
ENTRY TYPE=P	4410	BACK LITE,.190 FLOAT/ID22428-5 SOURCE:GM (PPG), $.34/SQ FT	14		15.40	215.60	/ HELIOSTAT
ENTRY TYPE=P	4410	ADHESIVE,SHEET,PVB SOURCE:GM, $.24/SQ FT , AUTOCLAVE CURE	14		10.56	147.87	/ HELIOSTAT
ENTRY TYPE=P	4410	STIFFENER,HAT SECT/ID22462-3 SOURCE-HAL,$.35/LB, .064 GALV STEEL MDAC HAD .22/LB OR $86.62 LESS/HEL. SOURCE:GM, $.22/LB, .064 GALV STEEL	28		8.33	233.20	/ HELIOSTAT
ENTRY TYPE=P	4410	SHIM /ID22462-7 SOURCE:GM	28		1.48	41.44	/ HELIOSTAT
ENTRY TYPE=P	4410	EDGE MEMBER /ID22462-11,-13 SOURCE:GM	28		.94	26.18	/ HELIOSTAT
ENTRY TYPE=P	4410	CLINCH FASTENER /S-0518-1-Z SOURCE:GM	56		.02	1.12	/ HELIOSTAT
ENTRY TYPE=P	4410	BONDS,SEALS,PRIMERS SOURCE:MDAC-HFN/0.9				98.31	/ HELIOSTAT
ENTRY TYPE=P	4410	REFL PANEL ASSY HARDWARE SOURCE:MDAC-HFN/0.9				39.46	/ HELIOSTAT
ENTRY TYPE=L	4410	ASSEMBLE MODULES SOURCE:MDAC-HFN/0.82	.8780E+00	HRS / HELIOSTAT			
ENTRY TYPE=L	4410	ASSEMBLE REFL PANEL SOURCE:MDAC-HFN/0.82	.8050E+00	HRS / HELIOSTAT			
ENTRY TYPE=L	4410	MATERIAL HANDLING SOURCE:MDAC-HFN/0.82	.1100E+00	HRS / HELIOSTAT			
ENTRY TYPE=L	4410	INSPECTION SOURCE:MDAC-HFN/0.82	.1460E+00	HRS / HELIOSTAT			
ENTRY TYPE=A	4410	LAND SOURCE-MDAC-SSW BLDG AREA FRAC-.395 X 40	.1580E+02	ACRE			

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ENTRY TYPE=B   4410      BUILDINGS                                    .1027E+06  SQFT
     SOURCE-MDAC-SSW BLDG AREA FRAC-.395 X 260K

ENTRY TYPE=E   4410      EQUIPMENT                                                              7246000.
     SOURCE:GM

ENTRY TYPE=T   4410      TOOLING                                                                 372000.
     SOURCE:GM

ENTRY TYPE=T   4410      OPERATIONS FIXTURES                                                    1173200.
     SOURCE-MDAC-SSW BLDG AREA FRAC .395 X 2.97E6

ENTRY TYPE=S   4410      CONSUMABLES,SUPPLIES                                                      25.51  / HELIOSTAT
     SOURCE:GM; SUPPLIES, UTILITIES AND SUNDRY ALLOCATED TO PROFIT CENTERS
     USING FACTORY FLOOR SPACE FRACTIONS.

ENTRY TYPE=Q   4410      QUANTITY                                     .5000E+05  /YR


   TOTAL PURCHASED MATERIALS=   1265.18 $/HELIOSTAT
   TOTAL RAW MATERIALS=       0.00 $/HELIOSTAT
   TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR=    1.9390    HRS/HELIOSTAT
   TOTAL CONSUMABLES=      25.51    $/HELIOSTAT
   LAND REQUIRED=   15.8000    ACRES
   PRODUCTION FACILITY (BASE RATE COST CATEGORY) SIZE=   102700.    SQ FT
   TOTAL EQUIPMENT COST=  7246000.    $
   TOTAL TOOLING COST=  1545200.    $
   QUANTITY=    50000.    / YEAR

   TOTAL DIRECT LABOR COST=     36.61 $/HELIOSTAT
  TOTAL PRODUCTION FACILITY COST   14172600.  $
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MDAC - SECOND GENERATION

4420 FACTORY COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST	
ENTRY TYPE=P 4420 AZ MOTOR SOURCE:GM (EMERSON ELECTRIC), 1/4 HP, 208 V, 60 CYCLE, 3 PHASE	1		60.93	60.93	/ HELIOSTAT
ENTRY TYPE=M 4420 HARMONIC DRIVE PARTS SOURCE:MDAC-HFN/0.96				87.91	/ HELIOSTAT
ENTRY TYPE=P 4420 HARMONIC DRIVE PARTS SOURCE:MDAC (USM) - HFN/0.9				44.24	/ HELIOSTAT
ENTRY TYPE=L 4420 FAB HARMONIC DRIVE PARTS SOURCE:MDAC-HFN/0.82	.9760E+00	HRS / HELIOSTAT			
ENTRY TYPE=P 4420 BEARING KIT,LUBE PAN,TUBE ASSY SOURCE:MDAC-HFN/0.9				28.47	/ HELIOSTAT
ENTRY TYPE=P 4420 AZ DRIVE ASSY PARTS SOURCE:MDAC-HFN/0.9				106.72	/ HELIOSTAT
ENTRY TYPE=L 4420 HARMONIC DRIVE ASSY SOURCE:MDAC-HFN/0.82	.1090E+01	HRS / HELIOSTAT			
ENTRY TYPE=P 4420 AZ WIRE,SENSOR PARTS SOURCE:MDAC-HFN/0.9				43.11	/ HELIOSTAT
ENTRY TYPE=L 4420 AZ WIRING SOURCE:MDAC-HFN/0.82	.3050E+00	HRS / HELIOSTAT			
ENTRY TYPE=P 4420 ELEV MOTOR SOURCE:GM, 1/3 HP				60.93	/ HELIOSTAT
ENTRY TYPE=M 4420 SUPPORT ASSY,ELEV DRIVE SOURCE: MDAC-HFN/0.96				163.70	/ HELIOSTAT
ENTRY TYPE=P 4420 SUPPORT ASSY,ELEV DRIVE SOURCE:MDAC-HFN/0.9				17.84	/ HELIOSTAT
ENTRY TYPE=L 4420 FAB ELEV DRIVE SUPPORT SOURCE:MDAC-HFN/0.82	.3420E+00	HRS / HELIOSTAT			
ENTRY TYPE=P 4420 ELEV JACK ASSY SOURCE:MDAC (DUFF-NORTON) - HFN/0.9				300.38	/ HELIOSTAT
ENTRY TYPE=L 4420 AZ-ELEV ASSEMBLY SOURCE:MDAC-HFN/0.82	.2070E+01	HRS / HELIOSTAT			

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ENTRY TYPE=M   4420      POS-LIM INDICATOR                                                              3.75  / HELIOSTAT
     SOURCE:MDAC-HFN/0.96

ENTRY TYPE=P   4420      POS-LIM INDICATOR                                                             56.16  / HELIOSTAT
     SOURCE:MDAC-HFN/0.9

ENTRY TYPE=L   4420      POS-LIM INDICATOR ASSY                       .5240E+00  HRS / HELIOSTAT
     SOURCE:MDAC-HFN/0.82

ENTRY TYPE=P   4420      DRIVE/PED ELECTRONICS                                                         40.51  / HELIOSTAT
     SOURCE:MDAC-HFN/0.9

ENTRY TYPE=L   4420      DRIVE/PED ELECTRONICS ASSY                   .9150E+00  HRS / HELIOSTAT
     SOURCE:MDAC-HFN/0.82

ENTRY TYPE=A   4420      LAND                                         .1210E+02  ACRE
     SOURCE-MDAC-SSW BLDG AREA FRAC-.303 X 40

ENTRY TYPE=B   4420      BUILDINGS                                    .7878E+05  SQFT
     SOURCE-MDAC-SSW BLDG AREA FRAC-.303 X 260K

ENTRY TYPE=E   4420      EQUIPMENT                                                                 17600000.
     SOURCE:GM

ENTRY TYPE=E   4420      STAMPING TOOLS/DIES(BOSSERT)                                                508800.
     SOURCE-MDAC

ENTRY TYPE=T   4420      TOOLING                                                                    4010000.
     SOURCE:GM

ENTRY TYPE=T   4420       OPERATIONS FIXTURES                                                        899900.
     SOURCE-MDAC-SSW BLDG AREA FRAC .303 X 2.97E6

ENTRY TYPE=S   4420      CONSUMABLES, SUPPLIES                                                        34.65  / HELIOSTAT
     SOURCE:GM; SUPPLIES, UTILITIES AND SUNDRY ALLOCATED TO PROFIT CENTERS
     USING FACTORY FLOOR SPACE FRACTIONS.

ENTRY TYPE=Q   4420      QUANTITY                                     .5000E+05  /YR


   TOTAL PURCHASED MATERIALS=    759.29 $/HELIOSTAT
   TOTAL RAW MATERIALS=     255.36 $/HELIOSTAT
   TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR=    6.2220    HRS/HELIOSTAT
   TOTAL CONSUMABLES=     34.65    $/HELIOSTAT
   LAND REQUIRED=   12.1000    ACRES
   PRODUCTION FACILITY (BASE RATE COST CATEGORY) SIZE=    78780.    SQ FT
   TOTAL EQUIPMENT COST= 18108800.    $
   TOTAL TOOLING COST=  4909900.    $
   QUANTITY=    50000.    / YEAR

   TOTAL DIRECT LABOR COST=    117.47 $/HELIOSTAT
   TOTAL PRODUCTION FACILITY COST   10871640.  $
```

MDAC - SECOND GENERATION

4430 FACTORY COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

	ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST	
ENTRY TYPE=P 4430	BCS SOURCE-MDAC/.92				6.80	/ HELIOSTAT
ENTRY TYPE=P 4430	FIELD CONTROLLER SOURCE:MDAC-HFN/0.9				2.67	/ HELIOSTAT
ENTRY TYPE=P 4430	HELIOSTAT CONTROLLER SOURCE:MDAC-HFN/0.9				176.83	/ HELIOSTAT
ENTRY TYPE=P 4430	FIELD PWR / DATA DIST SOURCE:MDAC-HFN/0.9				319.76	/ HELIOSTAT
ENTRY TYPE=L 4430	ASSEMBLE CALIB EQP SOURCE:MDAC-HFN/0.82	.2400E-01	HRS / HELIOSTAT			
ENTRY TYPE=L 4430	ASSEMBLE HEL CONTROLLER SOURCE:MDAC-HFN/0.82	.3660E+00	HRS / HELIOSTAT			
ENTRY TYPE=L 4430	ASSEMBLE FIELD PWR/DATA DIST SOURCE:MDAC-HFN/0.82	.9270E+00	HRS / HELIOSTAT			
ENTRY TYPE=A 4430	LAND SOURCE-MDAC-SSW BLDG AREA FRAC-.015 X 40	.6000E+00	ACRE			
ENTRY TYPE=B 4430	BUILDINGS SOURCE-MDAC-SSW BLDG AREA FRAC-.015 X 260K	.3900E+04	SQFT			
ENTRY TYPE=E 4430	EQUIPMENT SOURCE:MDAC; THE 12 PERCENT BURDEN INCREASE ASSUMED BY MDAC RESULTING FROM CONTROLLER MANUFACTURE/ASSEMBLY CORRESPONDS TO A 12 PERCENT INCREASE IN FACTORY EQUIPMENT COST OF $4.3 MILLION.				4300000.	
ENTRY TYPE=T 4430	TOOLING SOURCE:MDAC; THE 12 PERCENT BURDEN INCREASE ASSUMED BY MDAC RESULTING FROM CONTRILLER MANUFACTURE/ASSEMBLY CORRESPONDS TO A 12 PERCENT INCREASE IN FACTORY TOOLING COST OR $0.86 MILLION.				860000.	
ENTRY TYPE=T 4430	OPERATIONS FIXTURES SOURCE-MDAC-SSW BLDG AREA FRAC .015 X 2.97E6				44600.	
ENTRY TYPE=S 4430	CONSUMABLES,SUPPLIES SOURCE:MDAC; THE 12 PERCENT BURDEN INCREASE ASSUMED BY MDAC RESULTING FROM CONTROLLER MANUFACTURE/ASSEMBLY CORRESPONDS TO A 12 PERCENT INCREASE IN FACTORY CONSUMABLES OR $9.48 PER HELIOSTAT.				9.48	/ HELIOSTAT

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ENTRY TYPE=Q   4430      QUANTITY                                     .5000E+05  /YR

   TOTAL PURCHASED MATERIALS=    505.26 $/HELIOSTAT
   TOTAL RAW MATERIALS=      0.00 $/HELIOSTAT
   TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR=    1.3170    HRS/HELIOSTAT
   TOTAL CONSUMABLES=      9.48    $/HELIOSTAT
   LAND REQUIRED=     .6000    ACRES
   PRODUCTION FACILITY (BASE RATE COST CATEGORY) SIZE=     3900.    SQ FT
   TOTAL EQUIPMENT COST=  4300000.    $
   TOTAL TOOLING COST=   904600.    $
   QUANTITY=    50000.    / YEAR

   TOTAL DIRECT LABOR COST=     24.86 $/HELIOSTAT
   TOTAL PRODUCTION FACILITY COST     538200.  $
```

MDAC - SECOND GENERATION

4440 FACTORY COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST	
ENTRY TYPE=P 4440 TUBE /1D22461-3 SOURCE-GM (PACIFIC UNION METAL),436.3 LBS, $0.32/LB, 139 IN LONG COST/LB INCLUDES 4 ITEMS BELOW	1		62.15	62.15	/ HELIOSTAT
ENTRY TYPE=P 4440 PLATE /1D22461-5 SOURCE:GM	1		48.28	48.28	/ HELIOSTAT
ENTRY TYPE=P 4440 CONE /1D22461-9 SOURCE:GM	1		21.58	21.58	/ HELIOSTAT
ENTRY TYPE=P 4440 RING /1D22461-11 SOURCE:GM	1		7.30	7.30	/ HELIOSTAT
ENTRY TYPE=P 4440 NUT /1.00-8 SOURCE:GM	4		.24	1.16	/ HELIOSTAT
ENTRY TYPE=L 4440 FAB (WELD,MACHINE) SOURCE:MDAC-HFN/0.82	.1950E+00	HRS / HELIOSTAT			
ENTRY TYPE=L 4440 PAINT SOURCE:MDAC-HFN/0.82	.7300E-01	HRS / HELIOSTAT			
ENTRY TYPE=L 4440 MATL HANDLING,INSPECTION SOURCE:MDAC-HFN/0.82	.2680E+00	HRS / HELIOSTAT			
ENTRY TYPE=A 4440 LAND SOURCE:MDAC-SSW	.1600E+01	ACRE			
ENTRY TYPE=B 4440 BUILDINGS SOURCE:MDAC-SSW	.6300E+04	SQFT			
ENTRY TYPE=E 4440 EQUIPMENT SOURCE:GM				1460000.	
ENTRY TYPE=T 4440 TOOLING SOURCE:GM				283000.	
ENTRY TYPE=T 4440 OPERATIONS FIXTURES SOURCE-MDAC-SSW BLDG AREA FRAC .040 X 2.97E6				118800.	
ENTRY TYPE=S 4440 CONSUMABLES, SUPPLIES SOURCE:GM; SUPPLIES, UTILITIES AND SUNDRY ALLOCATED TO PROFIT CENTERS USING FACTORY FLOOR SPACE FRACTIONS.				2.93	/ HELIOSTAT
ENTRY TYPE=Q 4440 QUANTITY	.5000E+05	/YR			

```
TOTAL PURCHASED MATERIALS=    140.47 $/HELIOSTAT
TOTAL RAW MATERIALS=      0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR=     .5360    HRS/HELIOSTAT
TOTAL CONSUMABLES=      2.93    $/HELIOSTAT
LAND REQUIRED=    1.6000    ACRES
PRODUCTION FACILITY (BASE RATE COST CATEGORY) SIZE=     6300.    SQ FT
TOTAL EQUIPMENT COST=  1460000.    $
TOTAL TOOLING COST=   401800.    $
QUANTITY=    50000.    / YEAR

TOTAL DIRECT LABOR COST=     10.12 $/HELIOSTAT
TOTAL PRODUCTION FACILITY COST     869400.  $
```

MDAC - SECOND GENERATION

4450 FACTORY COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS
S=SUPPLIES AND CONSUMABLES
B=BUILDING OR FACILITY SIZE
X=TRANSPORTATION REQUIREMENTS

P=PURCHASED MATERIALS
T=TOOLING
A=LAND FOR PRODUCTION FACILITY
Y=SITE-RETAINED CAPITAL

L=DIRECT LABOR HOURS
E=EQUIPMENT
Q=QUANTITY
Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST	
ENTRY TYPE=P 4450 MAIN BEAM /ID22464-1 SOURCE:GM (324.2 LB AT .325/LB)	1		0.00	105.40	/ HELIOSTAT
ENTRY TYPE=P 4450 INBOARD CROSS BEAM /ID22465-1 SOURCE:GM (385.2 LB TOTAL AT .345/LB)	2		66.49	132.98	/ HELIOSTAT
ENTRY TYPE=P 4450 OUTBOARD CROSS BEAM /ID22467-1 SOURCE:GM (315.6 LB TOTAL AT .375/LB)	2		59.25	118.50	/ HELIOSTAT
ENTRY TYPE=P 4450 DIAGONAL BEAMS /ID22466-1,-2 SOURCE:GM (406.8 LB TOTAL AT .383/LB)	4		38.92	155.68	/ HELIOSTAT
ENTRY TYPE=P 4450 ANGLE BRACES/ID22470 SOURCE:GM (125.4 LB TOTAL AT .142/LB)	16		1.11	17.76	/ HELIOSTAT
ENTRY TYPE=P 4450 DOUBLER,PLATE,BAR,DBLR ANGLES SOURCE:MDAC-HFN/8.9 (91.4 LB TOTAL AT .605/LB)				55.28	/ HELIOSTAT
ENTRY TYPE=L 4450 MAIN BEAM FAB SOURCE:MDAC-HFN/8.82	.1740E+01	HRS / HELIOSTAT			
ENTRY TYPE=L 4450 STRUCTURE FAB SOURCE:MDAC-HFN/8.82	.3780E+00	HRS / HELIOSTAT			
ENTRY TYPE=A 4450 LAND SOURCE-MDAC-SSW BLDG AREA FRAC-.248 X 40	.9900E+01	ACRE			
ENTRY TYPE=B 4450 BUILDINGS SOURCE-MDAC-SSW BLDG AREA FRAC-.248 X 260K	.6448E+05	SQFT			
ENTRY TYPE=E 4450 EQUIPMENT SOURCE:GM				9161000.	
ENTRY TYPE=E 4450 ROLLING MILL TOOLS/SCOTCHBRITE EQ				132000.	
ENTRY TYPE=T 4450 TOOLING SOURCE:GM				2503000.	
ENTRY TYPE=T 4450 OPERATIONS FIXTURES SOURCE-MDAC-SSW BLDG AREA FRAC .284 X 2.97E6				736600.	
ENTRY TYPE=S 4450 CONSUMABLES, SUPPLIES SOURCE:GM; SUPPLIES, UTILITIES AND SUNDRY ALLOCATED TO PROFIT CENTERS USING FACTORY FLOOR SPACE FRACTIONS.				15.93	/ HELIOSTAT

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ENTRY TYPE=Q   4450      QUANTITY                                        .5000E+05  /YR

   TOTAL PURCHASED MATERIALS=     585.60 $/HELIOSTAT
   TOTAL RAW MATERIALS=       0.00 $/HELIOSTAT
   TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR=    2.1180    HRS/HELIOSTAT
   TOTAL CONSUMABLES=     15.93    $/HELIOSTAT
   LAND REQUIRED=    9.9000    ACRES
   PRODUCTION FACILITY (BASE RATE COST CATEGORY) SIZE=    64480.    SQ FT
   TOTAL EQUIPMENT COST=  9293000.    $
   TOTAL TOOLING COST=  3239600.    $
   QUANTITY=    50000.    / YEAR

   TOTAL DIRECT LABOR COST=     39.99 $/HELIOSTAT
   TOTAL PRODUCTION FACILITY COST    8898240.  $
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MDAC - SECOND GENERATION

4460 FACTORY COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS
S=SUPPLIES AND CONSUMABLES
B=BUILDING OR FACILITY SIZE
X=TRANSPORTATION REQUIREMENTS

P=PURCHASED MATERIALS
T=TOOLING
A=LAND FOR PRODUCTION FACILITY
Y=SITE-RETAINED CAPITAL

L=DIRECT LABOR HOURS
E=EQUIPMENT
Q=QUANTITY
Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
LAND REQUIRED= 0.0000 ACRES
PRODUCTION FACILITY (BASE RATE COST CATEGORY) SIZE= 0. SQ FT
TOTAL EQUIPMENT COST= 0. $
TOTAL TOOLING COST= 0. $
QUANTITY= 0. / YEAR

DEFAULT QUANTITY USED IN PROFIT CENTER CALCULATION
DEFAULT QUANTITIES = 50000.(FACTORY), 5400.(TRANSPORT/SITE)

MDAC - SECOND GENERATION

4410 TRANSPORTATION COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS
S=SUPPLIES AND CONSUMABLES
B=BUILDING OR FACILITY SIZE
X=TRANSPORTATION REQUIREMENTS
P=PURCHASED MATERIALS
T=TOOLING
A=LAND FOR PRODUCTION FACILITY
Y=SITE-RETAINED CAPITAL
L=DIRECT LABOR HOURS
E=EQUIPMENT
Q=QUANTITY
Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

	ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=S 4410	PALLET FOR PANEL TRANSPORT				11.13 / HELIOSTAT
SOURCE-MDAC					
ENTRY TYPE=X 4410	REFLECTIVE PANEL TRANSPORT	.5000E+00	TRUCKLOADS		
SPECIAL TRANSPORTATION COST CATEGORY 1					
SOURCE:MDAC					
ENTRY TYPE=Z 4410	ROAD PERMIT FOR WIDE LOADS				6.50 / HELIOSTAT
SOURCE:MDAC					

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 11.13 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 0. / SITE
SPECIAL TRANSPORTATION COST CATEGORY 1 = .500 TRUCKLOADS
TOTAL SUBCONTRACTS AND FLOW-THROUGH EXPENSES= 6.50 $/HELIOSTAT
INPUT (NOT COMPUTED) TRANSPORTATION COST 362.50 $

DEFAULT QUANTITY USED IN PROFIT CENTER CALCULATION
DEFAULT QUANTITIES = 50000.(FACTORY), 5400.(TRANSPORT/SITE)

MDAC - SECOND GENERATION

4420 TRANSPORTATION COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=S 4420 PALLET FOR DRIVE TRANSPORT SOURCE-MDAC,.42 OF 3.56 BASED ON WEIGHT				1.50 / HELIOSTAT
ENTRY TYPE=X 4420 DRIVE TRANSPORT SPECIAL TRANSPORTATION COST CATEGORY 1 SOURCE:MDAC; PED/DRIVE/MAIN BEAM TRUCKLOAD ALLOCATED BY WEIGHT	.3500E-01	TRUCKLOADS		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 1.50 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 0. / SITE
SPECIAL TRANSPORTATION COST CATEGORY 1 = .035 TRUCKLOADS
INPUT (NOT COMPUTED) TRANSPORTATION COST 25.28 $

DEFAULT QUANTITY USED IN PROFIT CENTER CALCULATION
DEFAULT QUANTITIES = 50000.(FACTORY), 5400.(TRANSPORT/SITE)

MDAC - SECOND GENERATION

4430 TRANSPORTATION COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS
S=SUPPLIES AND CONSUMABLES
B=BUILDING OR FACILITY SIZE
X=TRANSPORTATION REQUIREMENTS

P=PURCHASED MATERIALS
T=TOOLING
A=LAND FOR PRODUCTION FACILITY
Y=SITE-RETAINED CAPITAL

L=DIRECT LABOR HOURS
E=EQUIPMENT
Q=QUANTITY
Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

	ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=S 4430	PALLET FOR TRANSFORMER,CABLE XPORT SOURCE-MDAC				.05 / HELIOSTAT
ENTRY TYPE=X 4430	TRANSFORMER,CABLE TRANSPORT SPECIAL TRANSPORTATION COST CATEGORY 1 SOURCE-MDAC,EQUIVALENT TRUCKLOADS SEE REPORT FOR ACTUAL LOADING	.1240E-02	TRUCKLOADS		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= .05 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 0. / SITE
SPECIAL TRANSPORTATION COST CATEGORY 1 = .001 TRUCKLOADS
INPUT (NOT COMPUTED) TRANSPORTATION COST .90 $

DEFAULT QUANTITY USED IN PROFIT CENTER CALCULATION
DEFAULT QUANTITIES = 50000.(FACTORY), 5400.(TRANSPORT/SITE)

MDAC - SECOND GENERATION

4440 TRANSPORTATION COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=S 4440 PALLET FOR PEDESTAL TRANSPORT SOURCE-MDAC,.33 OF 3.56 BASED ON WEIGHT				1.17 / HELIOSTAT
ENTRY TYPE=X 4440 PEDESTAL TRANSPORT SPECIAL TRANSPORTATION COST CATEGORY 1 SOURCE:MDAC, PED/DRIVE/MAIN BEAM TRUCKLOAD ALLOCATED BY WEIGHT	.2750E-01	TRUCKLOADS		
ENTRY TYPE=X 4440 REBAR CAGE TRANSPORT SPECIAL TRANSPORTATION COST CATEGORY 2 SOURCE:MDAC, CAGE ASSEMBLED CLOSER TO SITE THAN FACTORY	.3570E-01	TRUCKLOADS		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= 1.17 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 0. / SITE
SPECIAL TRANSPORTATION COST CATEGORY 1 = .028 TRUCKLOADS
SPECIAL TRANSPORTATION COST CATEGORY 2 = .036 TRUCKLOADS
INPUT (NOT COMPUTED) TRANSPORTATION COST 24.22 $

DEFAULT QUANTITY USED IN PROFIT CENTER CALCULATION
DEFAULT QUANTITIES = 50000.(FACTORY), 5400.(TRANSPORT/SITE)

MDAC - SECOND GENERATION

4450 TRANSPORTATION COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=S 4450 PALLET FOR BEAM TRANSPORT SOURCE-MDAC,.25 OF 3.56 BASED ON WEIGHT				.89 / HELIOSTAT
ENTRY TYPE=X 4450 MAIN BEAM TRANSPORT SPECIAL TRANSPORTATION COST CATEGORY 1 SOURCE:MDAC, PED/DRIVE/MAIN BEAM TRUCKLOAD ALLOCATED BY WEIGHT	.2083E-01	TRUCKLOADS		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 0.0000 HRS/HELIOSTAT
TOTAL CONSUMABLES= .89 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 0. / SITE
SPECIAL TRANSPORTATION COST CATEGORY 1 = .021 TRUCKLOADS
INPUT (NOT COMPUTED) TRANSPORTATION COST 15.10 $

DEFAULT QUANTITY USED IN PROFIT CENTER CALCULATION
DEFAULT QUANTITIES = 50000.(FACTORY), 5400.(TRANSPORT/SITE)

MDAC - SECOND GENERATION

4430 SITE COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ENTRY	ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=M 4430	HAC MATERIALS SOURCE-MDAC/.92				8.66 / HELIOSTAT
ENTRY TYPE=L 4430	HAC ASSEMBLY SOURCE-MDAC/.92 BASED ON 15.12/HR AVERAGE	.3400E+00	HRS / HELIOSTAT		
ENTRY TYPE=L 4430	CABLE INSTALLATION SOURCE:MDAC-HFN/0.92	.1065E+01	HRS / HELIOSTAT		
ENTRY TYPE=L 4430	POWER TRANSFORMER INSTALLATION SOURCE:MDAC-HFN/0.92	.3300E-01	HRS / HELIOSTAT		
ENTRY TYPE=L 4430	CABLE CHECKOUT,CLOSEOUT SOURCE:MDAC-HFN/0.92	.7070E+00	HRS / HELIOSTAT		
ENTRY TYPE=Q 4430	QUANTITY	.5412E+04	/STE		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 8.66 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 2.1450 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 5412. / SITE

TOTAL DIRECT LABOR COST= 32.43 $/HELIOSTAT

MDAC - SECOND GENERATION

4440 SITE COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=P 4440 REBAR CAGE SOURCE:MDAC/0.90, 296 LB, $.30/LB				87.67 / HELIOSTAT
ENTRY TYPE=P 4440 TAPERED PIPE SOURCE:MDAC/0.90, 86 LB, $.42/LB				35.70 / HELIOSTAT
ENTRY TYPE=P 4440 CONCRETE SOURCE:MDAC/0.90, 2.32 CU YD, $53.20/CU YD				123.42 / HELIOSTAT
ENTRY TYPE=L 4440 SURVEY SOURCE:MDAC/0.92 NOTE:BASED ON OTHER DATA THIS TIME COULD BE REDUCED TO APPROX. 0.25 HR	.1000E+01	HRS / HELIOSTAT		
ENTRY TYPE=L 4440 DRILLING SOURCE:MDAC/0.92 , 2 FT DIA BY 15 FT DEEP, 1.75 CU YD NOTE:BASED ON OTHER DATA THIS TIME COULD BE REDUCED TO APPROX. 0.25 HR	.2990E+01	HRS / HELIOSTAT		
ENTRY TYPE=P 4440 FORMS,BRACING SOURCE:MDAC/0.90				5.23 / HELIOSTAT
ENTRY TYPE=L 4440 PREFAB REBAR,TAPERED PIPE SOURCE:MDAC/0.92	.3490E+01	HRS / HELIOSTAT		
ENTRY TYPE=L 4440 SET CAGES,FORMS SOURCE:MDAC/0.92	.1990E+01	HRS / HELIOSTAT		
ENTRY TYPE=L 4440 POUR AND FINISH SOURCE:MDAC/0.92	.2490E+01	HRS / HELIOSTAT		
ENTRY TYPE=L 4440 EQUIPMENT OPERATION SOURCE:MDAC/0.92	.2490E+01	HRS / HELIOSTAT		
ENTRY TYPE=Q 4440 QUANTITY	.5412E+04	/SITE		

TOTAL PURCHASED MATERIALS= 252.02 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 14.4500 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 5412. / SITE

TOTAL DIRECT LABOR COST= 218.48 $/HELIOSTAT

MDAC - SECOND GENERATION

4460 SITE COSTS

KEY TO ENTRY TYPES

M=RAW MATERIALS	P=PURCHASED MATERIALS	L=DIRECT LABOR HOURS
S=SUPPLIES AND CONSUMABLES	T=TOOLING	E=EQUIPMENT
B=BUILDING OR FACILITY SIZE	A=LAND FOR PRODUCTION FACILITY	Q=QUANTITY
X=TRANSPORTATION REQUIREMENTS	Y=SITE-RETAINED CAPITAL	Z=SUBCONTRACTS AND FLOW-THROUGH EXPENSES

ENTRY	ITEM	QUANTITY	UNITS	UNIT COST	TOTAL COST
ENTRY TYPE=L 4460	FIELD SUPPORT LABOR SOURCE:MDAC-HFN/0.90	.1300E+01	HRS / HELIOSTAT		
ENTRY TYPE=L 4460	HELIOSTAT INSTALLATION SOURCE:MDAC-HFN/0.90	.3310E+01	HRS / HELIOSTAT		
ENTRY TYPE=L 4460	ALIGN HELIOSTATS SOURCE:HFN/0.90	.7780E+00	HRS / HELIOSTAT		
ENTRY TYPE=Y 4460	INITIAL SPARES SOURCE-MDAC INCLUDES PIPELINE QUANTITIES				47625.
ENTRY TYPE=Y 4460	MAINTENANCE EQUIPMENT SOURCE-MDAC, TWO WASH TRUCKS				194500.
ENTRY TYPE=Y 4460	CAPITALIZED EQUIPMENT SOURCE-MDAC,INCLUDES CRANE(94.5K),FORKLIFT(21.4K), HYDRASET(4.87K),PICKUP(24K),OTHER(49.47K)				195200.
ENTRY TYPE=E 4460	AMORTIZED EQUIPMENT SOURCE-NOT DEFINED,ASSUMED PART OF 70 PERCENT OVERHEAD, TO INCLUDE FOUR HYDRAULIC LOAD SYSTEMS,PEDESTAL INSTALL EQUIPMENT,TWO REFLECTIVE ASSEMBLY INSTALL VEHICLES, THREE CABLE PLOWS,FOUR AUGERS,FOUR FORKLIFTS,FOUR CRANES, TRACTORS,ETC.	0.			0.
ENTRY TYPE=S 4460	SUPPLIES,UTILITIES,CONSUMABLES SOURCE-NOT DEFINED,ASSUMED PART OF 70 PERCENT OVERHEAD				0.00 / HELIOSTAT
ENTRY TYPE=Z 4460	RELOCATION EXPENSES SOURCE-NOT DEFINED,ASSUMED PART OF 70 PERCENT OVERHEAD				0.00 / HELIOSTAT
ENTRY TYPE=Q 4460	QUANTITY	.5412E+04	/STE		

TOTAL PURCHASED MATERIALS= 0.00 $/HELIOSTAT
TOTAL RAW MATERIALS= 0.00 $/HELIOSTAT
TOTAL (BASE RATE COST CATEGORY) DIRECT LABOR= 5.3880 HRS/HELIOSTAT
TOTAL CONSUMABLES= 0.00 $/HELIOSTAT
WEIGHTED EQUIPMENT COST= 0. $ TIMES YEARS USED / SITE
QUANTITY= 5412. / SITE
TOTAL SITE-RETAINED CAPITAL= 437325.00 $

TOTAL DIRECT LABOR COST= 81.47 $/HELIOSTAT

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MDAC - SECOND GENERATION

4410 - REFLECTIVE ASSEMBLY

FACTORY COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			1597.93
DIRECT MATERIALS		1303.14	
PURCHASED MATERIALS	1265.18		
RAW MATERIALS	0.00		
SCRAP	37.96		
DIRECT LABOR		36.61	
CONSUMABLES		25.51	
INDIRECT COSTS		23.45	
MAINTENANCE, PLANT ENGINEERING	9.19		
OTHER INDIRECTS	14.26		
CAPITAL REPLACEMENT ALLOWANCE		17.06	
PROPERTY TAX AND INSURANCE		8.26	
GENERAL & ADMINISTRATIVE		62.22	
INTEREST EXPENSE		0.00	
INCOME TAXES		56.52	
RETURN TO EQUITY HOLDERS		58.99	
OTHER EXPENSES		6.18	
ANNUALIZED ONE-TIME COSTS	6.18		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MDAC - SECOND GENERATION

4420 - DRIVES

FACTORY COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			1488.96
DIRECT MATERIALS		1045.09	
PURCHASED MATERIALS	759.29		
RAW MATERIALS	255.36		
SCRAP	30.44		
DIRECT LABOR		117.47	
CONSUMABLES		34.65	
INDIRECT COSTS		45.92	
MAINTENANCE, PLANT ENGINEERING	13.56		
OTHER INDIRECTS	32.37		
CAPITAL REPLACEMENT ALLOWANCE		41.07	
PROPERTY TAX AND INSURANCE		9.46	
GENERAL & ADMINISTRATIVE		56.92	
INTEREST EXPENSE		0.00	
INCOME TAXES		65.67	
RETURN TO EQUITY HOLDERS		67.56	
OTHER EXPENSES		5.14	
ANNUALIZED ONE-TIME COSTS	5.14		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MDAC - SECOND GENERATION

4430 - CONTROLS

FACTORY COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			644.55
DIRECT MATERIALS		520.42	
PURCHASED MATERIALS	505.26		
RAW MATERIALS	0.00		
SCRAP	15.16		
DIRECT LABOR		24.86	
CONSUMABLES		9.48	
INDIRECT COSTS		9.90	
MAINTENANCE, PLANT ENGINEERING	2.30		
OTHER INDIRECTS	7.61		
CAPITAL REPLACEMENT ALLOWANCE		8.54	
PROPERTY TAX AND INSURANCE		2.89	
GENERAL & ADMINISTRATIVE		25.35	
INTEREST EXPENSE		0.00	
INCOME TAXES		20.53	
RETURN TO EQUITY HOLDERS		20.63	
OTHER EXPENSES		1.95	
ANNUALIZED ONE-TIME COSTS	1.95		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MDAC - SECOND GENERATION

4440 - FOUNDATION/PEDESTAL

FACTORY COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			187.92
DIRECT MATERIALS		144.68	
PURCHASED MATERIALS	140.47		
RAW MATERIALS	0.00		
SCRAP	4.21		
DIRECT LABOR		10.12	
CONSUMABLES		2.93	
INDIRECT COSTS		4.03	
MAINTENANCE, PLANT ENGINEERING	1.09		
OTHER INDIRECTS	2.93		
CAPITAL REPLACEMENT ALLOWANCE		3.33	
PROPERTY TAX AND INSURANCE		.98	
GENERAL & ADMINISTRATIVE		7.31	
INTEREST EXPENSE		0.00	
INCOME TAXES		6.88	
RETURN TO EQUITY HOLDERS		7.03	
OTHER EXPENSES		.63	
ANNUALIZED ONE-TIME COSTS	.63		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MDAC - SECOND GENERATION

4450 - SUPPORT STRUCTURE

FACTORY COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			822.33
DIRECT MATERIALS		603.17	
PURCHASED MATERIALS	585.60		
RAW MATERIALS	0.00		
SCRAP	17.57		
DIRECT LABOR		39.99	
CONSUMABLES		15.93	
INDIRECT COSTS		21.32	
MAINTENANCE, PLANT ENGINEERING	8.57		
OTHER INDIRECTS	12.75		
CAPITAL REPLACEMENT ALLOWANCE		23.97	
PROPERTY TAX AND INSURANCE		5.57	
GENERAL & ADMINISTRATIVE		31.24	
INTEREST EXPENSE		0.00	
INCOME TAXES		38.24	
RETURN TO EQUITY HOLDERS		39.79	
OTHER EXPENSES		3.13	
ANNUALIZED ONE-TIME COSTS	3.13		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MDAC - SECOND GENERATION

4460 - ASSEMBLY/INSTALLATION

FACTORY COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			0.00
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		0.00	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		0.00	

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MDAC - SECOND GENERATION

4410 - REFLECTIVE ASSEMBLY

TRANSPORTATION COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			380.13
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		11.13	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		369.00	
SUBCONTRACTS & FLOW-THROUGH	6.50		
TRANSPORTATION CHARGES	362.50		

HELIOSTAT COST MOCEL

DETAILED BREAKDOWN

MDAC - SECOND GENERATION

4420 - DRIVES

TRANSPORTATION COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			26.88
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		1.50	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		25.38	
TRANSPORTATION CHARGES	25.38		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MDAC - SECOND GENERATION

4430 - CONTROLS

TRANSPORTATION COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			.95
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		.05	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		.90	
TRANSPORTATION CHARGES	.90		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MDAC - SECOND GENERATION

4440 - FOUNDATION/PEDESTAL

TRANSPORTATION COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			25.39
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		1.17	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		24.22	
TRANSPORTATION CHARGES	24.22		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MDAC - SECOND GENERATION

4450 - SUPPORT STRUCTURE

TRANSPORTATION COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			15.99
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		0.00	
CONSUMABLES		.89	
INDIRECT COSTS		0.00	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	0.00		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		15.10	
TRANSPORTATION CHARGES	15.10		

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MDAC - SECOND GENERATION

4430 - CONTROLS

SITE COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			64.05
DIRECT MATERIALS		8.92	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	8.66		
SCRAP	.26		
DIRECT LABOR		32.43	
CONSUMABLES		0.00	
INDIRECT COSTS		22.70	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	22.70		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		0.00	

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MDAC - SECOND GENERATION

4440 - FOUNDATION/PEDESTAL

SITE COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			625.96
DIRECT MATERIALS		254.54	
PURCHASED MATERIALS	252.02		
RAW MATERIALS	0.00		
SCRAP	2.52		
DIRECT LABOR		218.48	
CONSUMABLES		0.00	
INDIRECT COSTS		152.94	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	152.94		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		0.00	

HELIOSTAT COST MODEL

DETAILED BREAKDOWN

MDAC - SECOND GENERATION

4460 - ASSEMBLY/INSTALLATION

SITE COSTS

PRODUCTION YEAR 1

TOTAL REQUIRED REVENUE			219.30
DIRECT MATERIALS		0.00	
PURCHASED MATERIALS	0.00		
RAW MATERIALS	0.00		
SCRAP	0.00		
DIRECT LABOR		81.47	
CONSUMABLES		0.00	
INDIRECT COSTS		57.03	
MAINTENANCE, PLANT ENGINEERING	0.00		
OTHER INDIRECTS	57.03		
CAPITAL REPLACEMENT ALLOWANCE		0.00	
PROPERTY TAX AND INSURANCE		0.00	
GENERAL & ADMINISTRATIVE		0.00	
INTEREST EXPENSE		0.00	
INCOME TAXES		0.00	
RETURN TO EQUITY HOLDERS		0.00	
OTHER EXPENSES		80.81	
SITE-RETAINED CAPITAL	80.81		

COST SUMMARY BY PROFIT CENTER

TOTAL REQUIRED REVENUE

MDAC - SECOND GENERATION

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	1597.93	1488.96	644.55	187.92	822.33	0.00	4741.69
TRANSPORTATION	380.13	26.88	.95	25.39	15.99		449.34
SITE			64.05	625.96		219.30	909.31
TOTALS BY COMPONENT	1978.06	1515.84	7(9.55	839.27	838.32	219.30	

TOTAL FOR TOTAL REQUIRED REVENUE 6100.34

COST SUMMARY BY PROFIT CENTER

DIRECT MATERIALS

MDAC - SECOND GENERATION

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	1303.14	1045.09	520.42	144.68	603.17	0.00	3616.50
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			8.92	254.54		0.00	263.46
TOTALS BY COMPONENT	1303.14	1045.09	529.34	399.22	603.17	0.00	

TOTAL FOR DIRECT MATERIALS 3879.96

COST SUMMARY BY PROFIT CENTER

DIRECT LABOR

MDAC - SECOND GENERATION

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	36.61	117.47	24.86	10.12	39.99	0.00	229.05
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			32.43	218.48		81.47	332.38
TOTALS BY COMPONENT	36.61	117.47	57.29	228.60	39.99	81.47	

TOTAL FOR DIRECT LABOR 561.43

COST SUMMARY BY PROFIT CENTER

CONSUMABLES

MCAC - SECOND GENERATION

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	25.51	34.65	9.48	2.93	15.93	0.00	88.50
TRANSPORTATION	11.13	1.50	.05	1.17	.89		14.74
SITE			0.00	0.00		0.00	0.00
TOTALS BY COMPONENT	36.64	36.15	9.53	4.10	16.82	0.00	

TOTAL FOR CONSUMABLES 103.24

COST SUMMARY BY PROFIT CENTER

INDIRECT COSTS

MDAC - SECOND GENERATION

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	23.45	45.92	9.90	4.03	21.32	0.00	104.62
TRANSPORTATION	0.00	0.01	0.00	0.00	0.00		0.00
SITE			22.70	152.94		57.03	232.67
TOTALS BY COMPONENT	23.45	45.92	32.60	156.97	21.32	57.03	

TOTAL FOR INDIRECT COSTS 337.29

COST SUMMARY BY PROFIT CENTER

CAPITAL REPLACEMENT ALLOWANCE

MDAC - SECOND GENERATION

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	17.06	41.07	8.54	3.33	23.97	0.00	93.97
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		0.00	0.00
TOTALS BY COMPONENT	17.06	41.07	8.54	3.33	23.97	0.00	

TOTAL FOR CAPITAL REPLACEMENT ALLOWANCE 93.97

COST SUMMARY BY PROFIT CENTER

PROPERTY TAX AND INSURANCE

MDAC - SECOND GENERATION

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	8.26	9.46	2.89	.98	5.57	0.00	27.16
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		0.00	0.00
TOTALS BY COMPONENT	8.26	9.46	2.89	.98	5.57	0.00	

TOTAL FOR PROPERTY TAX AND INSURANCE 27.16

COST SUMMARY BY PROFIT CENTER

GENERAL ^ ADMINISTRATIVE

MDAC - SECOND GENERATION

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	62.22	56.92	25.35	7.31	31.24	0.00	183.04
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		0.00	0.00
TOTALS BY COMPONENT	62.22	56.92	25.35	7.31	31.24	0.00	

TOTAL FOR GENERAL ^ ADMINISTRATIVE 183.04

COST SUMMARY BY PROFIT CENTER

INTEREST EXPENSE

MDAC - SECOND GENERATION

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		0.00	0.00
TOTALS BY COMPONENT	0.00	0.00	0.00	0.00	0.00	0.00	

TOTAL FOR INTEREST EXPENSE 0.00

COST SUMMARY BY PROFIT CENTER

INCOME TAXES

MDAC - SECOND GENERATION

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	56.52	65.67	20.53	6.88	38.24	0.00	187.84
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		0.00	0.00
TOTALS BY COMPONENT	56.52	65.67	20.53	6.88	38.24	0.00	

TOTAL FOR INCOME TAXES 187.84

COST SUMMARY BY PROFIT CENTER

RETURN TO EQUITY HOLDERS

MDAC - SECOND GENERATION

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	58.99	67.56	20.63	7.03	39.79	0.00	194.00
TRANSPORTATION	0.00	0.00	0.00	0.00	0.00		0.00
SITE			0.00	0.00		0.00	0.00
TOTALS BY COMPONENT	58.99	67.56	20.63	7.03	39.79	0.00	

TOTAL FOR RETURN TO EQUITY HOLDERS 194.00

COST SUMMARY BY PROFIT CENTER

OTHER EXPENSES

MCAC - SECOND GENERATION

PRODUCTION YEAR 1

	4410	4420	4430	4440	4450	4460	TOTALS BY LOCATION
FACTORY	6.18	5.14	1.95	.63	3.13	0.00	17.03
TRANSPORTATION	369.00	25.38	.90	24.22	15.10		434.60
SITE			0.00	0.00		80.81	80.81
TOTALS BY COMPONENT	375.18	30.52	2.85	24.85	18.23	80.81	

TOTAL FOR OTHER EXPENSES 532.44

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