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Photovoltaic System Costing Methodology Development

Final Report

Theodore Barry & Associates
1520 Wilshire Boulevard
Los Angeles, CA 90017

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ABSTRACT

This report presents the results of a study for Sandia National Laboratories to expand the use of standardized costing methodologies in the National Photovoltaics Program. The costing standards, which include SAMIS for manufacturing costs and M&D for marketing and distribution costs, have been applied to concentrator collectors and power conditioning units. The M&D model was also computerized. Finally, a uniform construction cost accounting structure was developed for use in photovoltaic test and application projects. The appendices contain example cases which demonstrate the use of the models.

Prepared for Sandia National Laboratories under Contract #46-5760.

FOREWORD

This report was prepared for the Photovoltaic Systems Definition Project of Sandia National Laboratories under contract number 46-5760. The project is part of the National Photovoltaics Program sponsored by the U.S. Department of Energy (DOE). The report documents a study to expand costing methodologies in the National Photovoltaics Program. The methodologies include SAMIS for manufacturing costs and M&D for marketing and distribution costs.

The work at Theodore Barry & Associates was performed by many individuals under the supervision of James B. Ayers. Several people worked on the project including Robert Bullemer, Douglas Fischer, Valerie Frank, Alex Guttman, Baldwin Klep, Ted Osborn, Dianne Ronnigen and Jeanne Steinhauer. Many other people provided valuable assistance. The formulation of the SAMIS and M&D models was initiated for the Jet Propulsion Laboratory (JPL) under the direction of Robert Chamberlain with the help of Chet Borden, Robert Aster and Paul Firnett.

Dr. Gary Jones of Sandia served as technical monitor for the project. Patricia Allen reviewed and made numerous contributions to the reports. She was also responsible for implementing the computer programs at Sandia. Several others at Sandia assisted in the enhancement and documentation of the costing methodologies including Don Schueler, Eldon Boes, and B.D. Shafer.

TB&A extends our sincere appreciation for the courtesy and cooperation from the many individuals from both JPL and Sandia who participated in the development and implementation program.

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I EXECUTIVE SUMMARY

A. Introduction

Theodore Barry & Associates (TB&A) was contracted by Sandia National Laboratories to perform a Solar Energy Costing Standards Project. The primary objectives of this study were to:

- Expand the SAMIS manufacturing cost estimating model capabilities to include concentrator technologies and selected balance of system (BOS) components.

- Develop a uniform construction cost accounting structure consistent with PV program requirements and objectives for test and application projects.

- Automate the Marketing and Distribution (M&D) model to estimate the costs of selling and delivering solar energy products to the factory customer.

The results of this have been documented in five reports:

- Photovoltaic Subsystem Production Cost Model (SAMIS) -An overview of the SAMIS model with instructions on input requirements and output reports. (SAND 81-7049)

- Photovoltaic Subsystem Marketing and Distribution Model: Programming Manual - A complete listing of all computer documentation necessary to run the program, including a description of the operating environment, program specifications, subprograms, input options, and output reports. (SAND 81-7048)

- Photovoltaic Subsystem Marketing and Distribution Model - A description of the M&D model, input options, and output reports, geared towards management. (SAND 81-7047)

- Cost Accounting and Reporting System Manual for Photovoltaic Project Management - A uniform construction cost accounting structure for photovoltaic test and application projects including instructions and forms. (SAND 81-7046)

- Photovoltaic System Costing Methodology Development - An overview of the entire project, detailing the project background, study objectives, and technical approach, as well as, SAMIS, M&D, and Costing System results. (SAND 81-7050)

B. SAMIS Model

The purpose of the Standard Assembly-line Manufacturing Industry Simulation (SAMIS) model is to provide a standarized procedure for estimating the cost of manufacturing solar energy products. Manufacturing costs include direct, indirect, and overhead expenses, as well as capital costs for facilities and tooling. To capture all of these costs, the manufacturing processes must be analyzed in the context of an integrated assembly operation in a factory environment.

The model was extended to analyze manufacturing costs for selected BOS components. Detailed manufacturing information was gathered on five designs:

- 200 Kilowatt (KW) Power Conditioning Unit (PCU)
- 10 Kilowatt (KW) Power Conditioning Unit (PCU)
- Photovoltaic Receiver
- Parabolic Trough Collector
- Linear Fresnel Collector.

Reports generated from these analyses may be found in Appendices A through E. The key results are summarized below:

- The 200 KW Power Conditioning Unit (PCU) is a more economic unit to produce than the 10 KW PCU. At an annual production rate of 9000 KW (45 - 200 KW PCU's), the manufacturing price is $370/KW, compared to $654/KW for annual production of 5,000 KW (500 - 10 KW PCU's).

- Significant economies of scale can be realized at higher output rates. For the 10 KW PCU, the price per KW declined from $654 to $563 as annual output was increased from 5000 to 100,000 KW -- a reduction of 13.9%. Similarly, for the 200 KW PCU, the price dropped from $370 to $329, as annual output increased from 9000 to 200,000 KW -- a savings of 11.1%. This savings was obtained without changing the manufacturing process. The number of machines was merely increased to generate a larger volume.

- Photovoltaic receiver manufacturing is an extremely material intensive business. Material costs are estimated at 81% of sales. Most of this is the cost of the silicon solar cell. At 5,000,000 cm^2 annual production rate, the estimated sales price $2.04/$cm^2$.

- The sales price per m^2 of collector was $205 for the parabolic trough at 37,000 m^2 per year and $355 for the fresnel lens at an output rate of 55,575 m^2 per year.

- In order to evaluate potential cost savings from factory integration, the photovoltaic receiver and concentrator collector manufacturing processes were combined. For the fresnel lens system, the sales price was reduced 2% from $855/m^2$ to $835/m^2$. Similarly, for the parabolic trough, a 9% reduction to $694/m^2$ was realized.

The system is documented in "Photovoltaic Subsystem Production Cost Model (SAMIS) SAND 81-7049.

C. M&D Model

While the SAMIS model computes manufacturing costs F.O.B plant, it does not include the costs of marketing and distributing the product to the factory customer. The M&D model is a simplification intended to recognize these additional off-site costs.

Originally developed for flat-plate photovoltaic solar arrays, the model has been extended to evaluate concentrator solar collectors and power conditioning units. TB&A has also computerized the model. The program is written in Standard ANSI FORTRAN IV and has been run on IBM 3300, CDC 6600, and VAX 11 machines.

Example cases were performed for three different solar products: flat-plate photovoltaic collector, linear fresnel lens concentrator, and a 200 KW power conditioning unit. The results presented in Appendices F, G, and H, are summarized below for all customers across all regions.

	Flat-Plate PV Collector (1980 $/Watt)		Linear Fresnel Concentrator (1980 $/Watt)		Power Conditioning (1980 $/Watt)	
Manufacturing Cost	.717	83%	.700	76%	.155	74%
Marketing Expense	.070	8%	.074	9%	.029	14%
Distribution Expense	.034	4%	.096	10%	.015	7%
Income Taxes	.021	3%	.026	3%	.006	3%
Net Profit	.020	2%	.025	2%	.006	2%
Delivered Price	.862	100%	.921	100%	.210	100%
Markup	20%		32%		36%	

For this analysis, the factory was assumed to be located in the Rocky Mountain region. DOE National Photovoltaics Program goals were used for manufacturing costs. The customer demand distribution was assumed to be 40% residential, 20% commercial, and 40% utility.

The results varied significantly by region and type of customer. For example, the concentrator collector average price over all customers and regions was $.92/watt. The highest was $1.15/watt for residential customers in the Great Lakes region. The lowest was $.76/watt for central power stations in the Rocky Mountain region. Similarly, the markup on manufacturing cost ranged from 20% in the Rocky Mountain region to 60% in the Great Lakes.

The system is documented in "Photovoltaic Subsystem Marketing and Distribution Model (SAND 81-7047)" and the "Programming Manual (SAND 81-7048)" explains the computer program.

D. Construction Costing System

A construction costing system has been developed for photovoltaic test and application experiments. The objectives of the reporting system are to:

- provide uniform cost reporting across the varied project technologies at both the level required to monitor costs during procurement and installation, and at planned project cost reconciliation milestones.
- give visibility to all significant cost items.
- permit comparison of components and total PV systems to be made on a credible basis.
- establish a foundation on which to base a continually expanding PV system cost data bank.
- establish a contractual basis for cost reporting on future PV projects.
- provide a reporting system that is understandable and perceived as informative and responsive by the many parties using it.

The cost account structure is based on conventional practices of the Construction Specifications Institute and tailored to satisfy the special requirements of photovoltaic power systems. These special requirements were determined by a detailed review of design documents for the nine PRDA projects currently being sponsored by the Department of Energy. TB&A also conducted personal interviews with representatives from each project.

The construction costing system is intended to accommodate both large and small projects and to capture all costs, not just those capital costs allocated for the construction of a given photovoltaic system. The structure attempts to recognize and capture all monies spent during or for the development, construction, or operation of any PV project.

Following are the major accounts in three general categories:

1.0 PROJECT DEVELOPMENT
1.1 Management Services
1.2 Engineering Design Services
1.3 A/E Design Services
1.4 Testing Programs
1.5 Applications & Approvals
1.6 Construction Management
1.7 Personnel & Public Relations
1.8 Fees & Expenses
1.9 Contingencies & Adjustments

2.0 PROJECT CONSTRUCTION
2.1 Land Acquisition
2.2 Site Preparation & Improvement
2.3 Non-Building Foundations
2.4 Systems Installation
2.5 Buildings/Enclosures
2.6 Spare Parts/Equipment Inventories
2.7 Equipment for Startup/Checkout

3.0 PROJECT OPERATIONS
3.1 Continuing Land Costs
3.2 Personnel
3.3 Utilities
3.4 Insurance
3.5 Administrative Supplies
3.6 Systems Maintenance
3.7 Parts Replacement to Inventory
3.8 Building & Grounds Maintenance
3.9 Equipment

Several major benefits will accrue from the implementation of the construction costing systems. These include:

- remove ambiguity from cost reporting.
- remove need for general catch-all reporting categories.
- allow performance/cost comparisons to be made.
- focus attention on project components for which excessive monies are presently being spent.
- form the nucleus for a set of control documents to be developed for the photovoltaic development program.

The system is documented in a "Cost Accounting and Reporting System Manual for Photovoltaic Project Management (SAND 81-7046)".

II INTRODUCTION

A. Project Background

This report documents a study conducted by Theodore Barry & Associates (TB&A) to develop solar energy costing standards for Sandia National Laboratories under Contract Number 49-5760, in support of the National Photovoltaics Program.

Sponsored by the United States Department of Energy (DOE), this program has as its primary objective the development of low-cost, reliable, photovoltaic (PV) systems that produce electricity from solar energy. Management of the program is divided between two lead centers: the Jet Propulsion Laboratory (JPL), for technology development and applications; and the Solar Energy Research Institute (SERI) for advanced research and development.

Sandia National Laboratories, located in Albuquerque, New Mexico, is participating in the technology development and applications portion of the program. Specific responsibilities of Sandia encompass PV systems and subsystems, and concentrator collector technology development. JPL's Low-Cost Solar Array (LSA) Project -- also part of the technology development effort -- is directed toward flat-plate collectors.

The management process within the program's two lead centers apportions substantial dollars of research funding annually to subcontractors who conduct the research and development necessary to meet the established cost goals. Since the related technologies are all in the early stages of development, the costs of manufacturing, marketing, distribution, installation, and operation must be forecasted for high-volume production and mature market conditions.

The research and development program is being paralleled by prototype system tests. These tests will prove system feasibility in four application areas -- stand alone, residential, commercial load center (shopping center, factory), and central power station. Sandia is currently funding nine photovoltaic prototype projects using flat-plate and concentrator systems.

National Photovoltaics Program goals are expressed in cost per peak watt for collectors and their systems to be reached by certain years. Balance-Of-System (BOS) cost objectives are set to make the total system competitive with alternative energy sources. The commercial readiness calendar objective for systems and collectors is 1986 for residential and load center applications. At that time, demonstrated systems are to be available at prices of $1.60 to $2.60 per peak watt for residential and industrial applications.

Of this $0.70 represents the collector cost in 1980 dollars. The remainder of $.90 to $1.90 is for BOS. There are a variety of contributors to BOS costs. Some are common to all markets while some are unique. Other costs apply to all types of collector systems --flat-plate, concentrator, and thermal/photovoltaic. Some apply to only one or two of these collector systems. Included in BOS cost categories are the following items:

- Inverters.
- Power conditioning units (PCU's).
- Tracking systems.
- Storage.
- Site preparation.
- Engineering.
- Marketing and distribution.
- Switch gear.
- Warranty liabilities.

There will also be costs in operating and maintaining the systems. Since initial costs are often determined by operating and maintenance considerations, these categories will impact commercial readiness. Therefore, DOE utilizes the concept of life cycle costing in comparing systems. The method combines initial and continuing costs over the lifetime of the system. The life cycle concept is particularly valid in comparing solar to conventional systems, since conventional systems require fuel and solar systems do not. Life cycle costs have been used to set the program objectives based on alternative energy prices and insolation (amount of sunshine) in various regions of the country.

Several standard costing methodologies have been developed for evaluation of the competing technologies currently under development by the National Photovoltaics Program subcontractors. To provide consistency and comparability among subcontractor's cost estimates, the SAMIS computer model was developed to estimate manufacturing costs for flat-plate photovoltaic collectors. The subcontractor specifies direct process requirements; SAMIS applies standard overhead and financial parameters to determine the revenues required to recover production costs.

SAMIS is a general model and can be used for any type of manufacturing process. However, very extensive modifications to the standard data would be required to do so. Applications can be expanded by augmenting the Cost Account Catalog and Indirect Requirements Matrix in the model to simulate the structures of other types of operations.

In addition to the SAMIS, the Marketing and Distribution (M&D) Model estimates costs of selling and transporting collectors from the manufacturer's loading dock to the installation site. It was developed for flat-plate collectors in residential, load center, and central station applications.

Both the SAMIS and M&D models can be modified to meet some of the costing requirements. However, some future effort is needed to provide full costing coverage of all systems. Particularly important will be the installation, operating and maintenance costs where coverage by current computer models is almost totally lacking.

B. Study Objectives and Scope

Theodore Barry & Associates performed this study to expand the use of standarized costing methodologies for the National Photovoltaics Program. Specific objectives of this engagement were to:

- Characterize the manufacturing costs in a plant using selected Balance of System (BOS) components.
- Identify financial parameters appropriate for these industries for use with SAMIS.
- Expand the SAMIS Cost Accounting Catalog to include off-the-shelf items for use in BOS component assembly and site construction.
- Modify the Marketing and Distribution (M&D) Model to accomodate concentrator and hybrid systems.
- Automate the M&D model.
- Develop simplified procedures consistent with current construction industry practices, for reporting actual site construction costs for all sizes and types of systems.

This study was divided into three parts which were worked on simultaneously. The first was the program for expanding Sandia's standard costing methodology, building on the SAMIS and M&D models. This provided a consistent framework for estimating and collecting BOS costs and for collecting enough data to estimate probable BOS costs for selected systems.

The second part, on construction costing, addressed how to "cost out" each essential component of a solar installation. A cost accounting structure and a performance measurement system were developed and demonstrated with examples, explanations, and drawings. Standard regional cost indicies were also compiled to adjust for different construction site locations.

The last portion of the study involved the computerization of the M&D model, making the analysis and report generation easier.

C. Technical Approach

The activities associated with this contract have been broken down into five tasks; three specified in the original contract, and two amendments. These include: program development, BOS model development, construction costing procedures, automation of the M&D model, and preparation of an abbreviated construction cost guide.

Task 1 - Program Development: The purpose of this task was to set a strategy for model development and construction costing procedures. A work plan was developed based on a survey of user needs and current programs which were further developed in the study.

- Survey of User Needs - TB&A interviewed a cross section of users for the modified models and construction cost account structure, including Sandia, JPL, and DOE staff as well as representatives from the demonstration projects. The purpose was to define the analytical needs of the users as well as the facility with which manufacturers and contractors are able to collect costs.

- Review of Current Procedures and Plans - From interviews, proposals, project plans and documents, the current methods for cost estimating and collecting were gathered. This summarizes the status of cost accounting for the demonstration projects and the depth of costing information available for BOS components.

- Development of Approaches - Employing methodology utilized by the National PV Program, TB&A recommended the use of current models for BOS costing the types of construction costing methodology appropriate for the PV application experiments. Also taken into consideration were ease and consistency of data collection. At this point, the BOS components to be covered by SAMIS were selected.

- Work Plan Report - TB&A produced a report stating methods to be used in the costing effort. The approaches were then approved by Sandia.

Task 2 - BOS Model Development: The objective of Task 2 was to expand National PV Program Costing methodologies to selected BOS components. The SAMIS and M&D models were expanded to enable analysts to examine all off-site component costs for total systems. The work of this task specifically extended the application of the SAMIS model to PV concentrator collectors and power conditioning units.

- Cost Account Catalog (CAC) Expansion - The CAC was expanded to include "off-the-shelf" components that comprise the experimental project systems. This includes all items for which a price can now be determined from vendors and for which there is no R&D effort aimed at reduced cost or technology development. The CAC was also expanded with known components of new equipment under development. These components were identified in discussions with appropriate technology development managers.

- Alternative Indirect Requirements Matrices - The SAMIS model has an indirect requirement structure that relates direct to indirect costs. The matrix in the version of the model at the start of this project was representative of electronic and semiconductor companies. TB&A has provided other matrices typical of industries in which BOS components are manufactured, including industries such as electrical and metal fabrication. The new matrices cover industry categories for all BOS components that are involved in research and development efforts. Where possible, a single matrix was used for more than one component. The matrices were entered into the computer and tested using test case data.

- M&D Model Modification - The M&D model development by TB&A was designed for flat-plate collector systems. Modifications were made allowing the model to be utilized for both hybrid and concentrator systems. Specifically, changes were made to the transportation cost function to reflect the difference in shipping characteristics and tariff schedules. M&D costs for representative configurations of system components were then computed.

- Computer Analysis - TB&A used the SAMIS program to compute BOS component costs for manufacturing processes provided by technology development managers. This tested the Cost Account Catalog and Indirect Requirements Matrices and provided a component cost estimate based on current technology development. The M&D model was also exercised manually to provide costs of moving concentrator systems to the construction site.

- Model Development Report - The results of this task were consolidated into a report showing the rationale for indir-ect requirements, updates to the Cost Account Catalog, and the results of the computer analyses and M&D model output.

Task 3 - Construction Costing Procedures: This task was designed to develop a cost account structure for categorizing costs associated with photovoltaic application experiments.

- Review of Application Experiments - TB&A reviewed nine PV application experiment designs to determine unique requirements for PV solar energy installations from an accounting point of view. Construction cost categories common to all projects were established. Also, unique or special categories were identified for separate cost collection.

- Development of Cost Account Structure - From knowledge of the plans for the experimental projects plus user needs, TB&A constructed a structure for reporting costs. The recommended structure is based on the cost account structure model supplied by Sandia, the appropriate features of the Construction Specification Institute accounting system, and the evaluation objectives of the National Photovoltaics Program.

- Preparation of Cost Guide - The cost account structure was documented in a Cost Guide describing the account categories and why they were established.

- Preparation of Reporting Manual - This working manual is provided for field forces and contains procedures and forms for reporting to various cost categories. These were based on current systems familiar to contractors, but augmented to meet defined needs. The manual was written to be easily understood by engineers and other non-accountants.

Task 4 - M&D Model Automation: TB&A designed a computer program to automate the marketing, distribution and financial submodels. A programming manual describing the design was written to cover all algorithms.

- Programming - The program design was coded in standard FORTRAN language, and is compatible with IBM, DEC and CDC hardware. The source code was provided on magnetic tape.

- Validation - Several test cases were run to compare the computer program output with manual calculations. These included a concentrator collector and a power conditioning unit (PCU). A programming manual was written describing the model and how to use it.

Task 5 - Abbreviated Cost Guide and Reporting Manual: Prospective system users found the unabridged version of the cost guide and reporting manual to be too detailed with more analysis options than were considered to be either necessary or practical for the majority of projects. Therefore, TB&A has prepared an abbreviated cost guide and reporting manual that is easy to use. This report is titled "Cost Accounting and Reporting System Manual for Photovoltaic Project Management (SAND 81-7046)."

D. End Products

The end products of this engagement consist of five reports and a computer program. The five reports are:

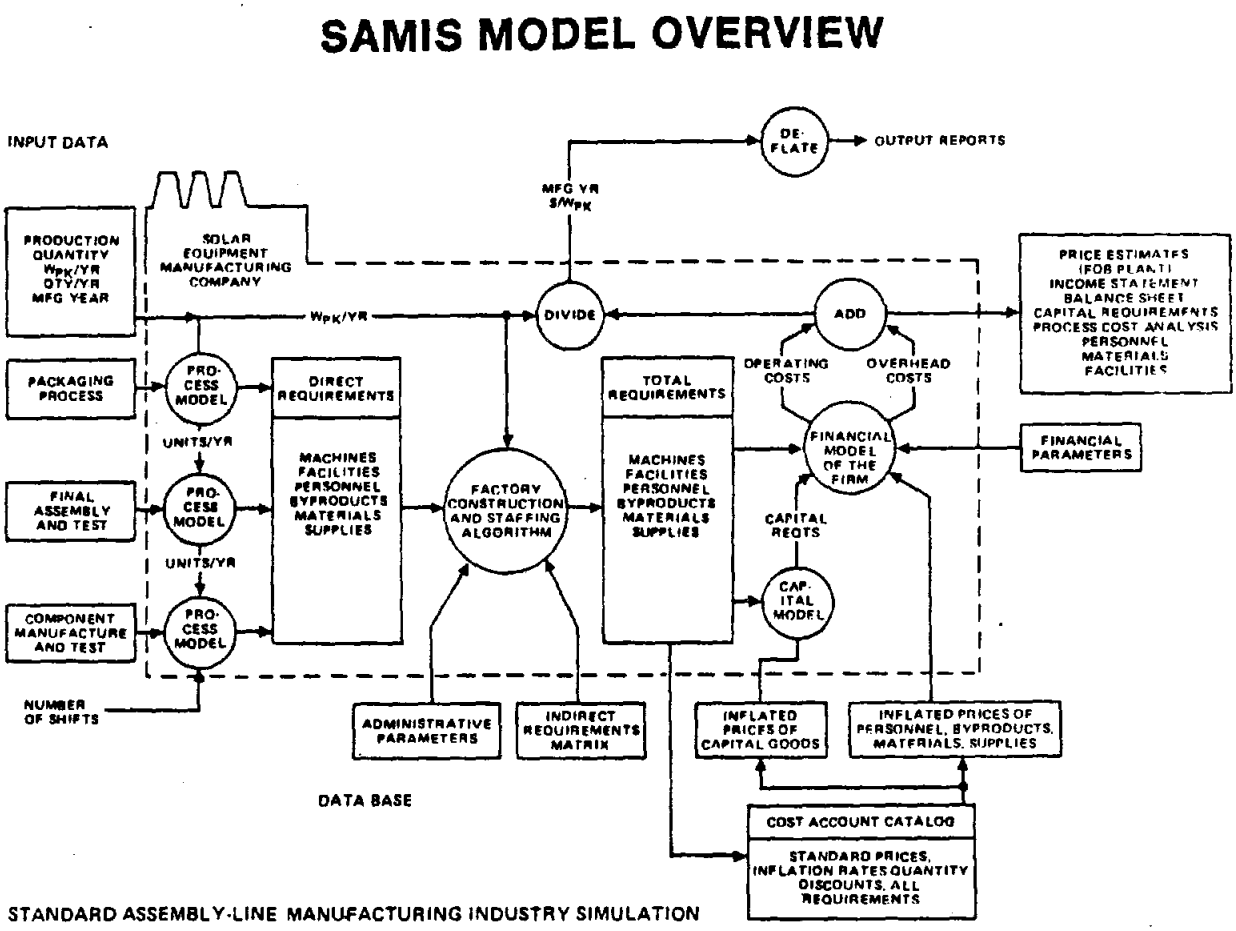
- Cost Accounting and Reporting System Manual for Photovoltaic Project Management (SAND 81-7046).
- Photovoltaic Subsystem Marketing and Distribution Model (SAND 81-7047).
- Photovoltaic Subsystem Marketing and Distribution Model: Programming Manual (SAND 81-7048).
- Photovoltaic Subsystem Production Cost Model (SAMIS) (SAND 81-7049).
- Photovoltaic System Costing Methodology Development (SAND 81-7050).

The computer program was written in standard ANSI FORTRAN IV language and submitted on magnetic tape to Sandia National Laboratories.

III PRODUCTION COST MODEL (SAMIS)

A. Overview

The Standard Assembly-line Manufacturing Industry Simulation (SAMIS) has been formulated as a computer simulation model for manufacturing costs. Given a proper description of the manufacturing technology as input, this model computes the manufacturing price of solar energy equipment for a broad range of production levels.



B. Model Description

Called SAMIS (Standard Assembly-line Manufacturing Industry Simulation), the purpose of the model is to provide a standarized procedure for estimating the cost of producing solar energy equipment with alternative process sequences. Since the model includes a user-specified rate of return on equity and a user-specified interest rate on corporate debt, and treats these elements as costs, the resultant cost estimate is a standardized normative price.

Although the model has been applied initially to assess and compare the commercial viability of new solar energy manufacturing process technologies, the model structure is general enough to support the design and analysis of any manufacturing industry, given the proper input data. However, collection of the input data is a non-trival task requiring considerable time and effort.

The SAMIS model procedure for estimating the normative price consists of four submodels:

- Manufacturing process submodel translates input data describing the manufacturing process in terms of machine characteristics, direct process requirements, process yields, and array performance factors into direct capacity requirements.

- Factory construction and staffing algorithm calculates the indirect costs needed to operate the manufacturing plant.

- Capital requirements submodel computes asset values of land, facilities, equipment, and working capital from the firm's direct and indirect requirements.

- Financial submodel accounts for several general administrative expenses and periodic overhead costs such as taxes, interest, depreciation, insurance, G&A expenses, and net income to the owners.

SAMIS generates a variety of output that permits detailed analyses of the manufacturing process operations, as well as financial information such as income statements, balance sheets, and key financial ratios of interest to the business community. The impact of a variety of government actions can also be assessed with the model. Rather than relying on speculation, an agency could obtain a quantitative measure of the impact of such actions as changes in the tax rates, investment tax credits, subsidies for capital investment, low-interest guaranteed loans, and changes in the inflation rate.

A potential investor could use the model for a variety of sensitivity analyses, such as the effect of changes in the following parameters: industry structure; return on equity; asset depreciation assumptions for useful life, salvage value, and method; plant locations with different labor rates, land costs, state taxes, and property taxes; any cost element such as facilities, equipment, labor, materials, utilities, overhead, or taxes.

To check the reasonableness and practicality of the model, JPL contracted TB&A to conduct a comprehensive validation. This was accomplished by comparing the computer simulation results with conventional hand-calculated estimates developed jointly by our facilities engineers and management consultants. The engineers designed three manufacturing plants for alternate levels of production: .50, 15, and 500 MW's per year by 1980, 1982 and 1986 respectively. The plant designs were based on an ion implantation manufacturing technology starting with silicon wafers as the raw material and ending with photovoltaic collectors as the finished product.

The results of the validation proved to be quite interesting. In general, the bottom-line results of the SAMIS model correlated quite closely with the conventional engineering estimates. They were also compared and have correlated closely to detailed hand-prepared estimates developed by technology research contractors. The validation was equally revealing in the one case where the model results did not correlate with a contractor's estimate. A detailed analysis revealed that SAMIS was right in generating much more realistic results.

On the strength of such positive validation results, the SAMIS model has been released for general industrial use, with programs available on a nationwide computer timesharing system.

C. Example Cases

To demonstrate the use of the model example, case analyses were performed for five photovoltaic products:

- 200 kilowatt (KW) Power Conditioning Unit (PCU)
- 10 kilowatt (KW) Power Conditioning Unit (PCU)
- Photovoltaic Receiver
- Parabolic Trough Collector
- Linear Fresnel Collector

The results, summarized below, are presented in more detail in Appendices A through E.

The 200 KW power conditioning unit is more economical to mass-produce than the 10 KW PCU. As shown in Exhibit III-A, at an actual production rate of 9000 KW (45 units), the price per KW is $370 per KW for the 200 KW PCU. The 10 KW PCU price is $654 per KW at a production rate of 5000 KW (500 units). In both cases, significant economies of scale can be realized at higher output rates.

It is assumed that by increasing the production volume, the unit price per kilowatt should come down. Exhibit III-B summarizes the results of such volume runs for the 10 KW and 200 KW PCU manufacturing processes. Significant economies of scale were achieved as the production volume increased.

For the 10 KW PCU, the price per KW declined from $654 to $563 as output went from 5000 to 100,000 KW/year, a total reduction of 13.9%. Similarly, for the 200 KW PCU the price per kilowatt declined from $370 to $329, as annual output was varied from 9,000 KW to 200,000 KW, a savings of 11.1%.

The distribution of costs remained unchanged, but the productivity per employee (sales/person, KW/person) improved significantly. These results assume no changes in the production methods.

SAMIS merely interpolates out the small volume set-up to larger scale production levels adding more of the same machines as necessary. In reality, an increase in production levels similar to the ones assumed above would evidence changes in the processes, sequence flow, tooling, and equipment.

Photovoltaic receiver manufacturing is an extremely material intensive business. Material costs are 81% of sales, most of which is the cost of the cell (Exhibit III-C. The solar cell is the single most costly item per kilowatt in the solar manufacturing process.

At a 5,000,000 cm^2 annual production rate for photovoltaic receivers, the estimated sales price is $2.04/$cm^2$ based on todays technology and cell costs.

The next two manufacturing operations for concentrator collectors where the photovoltaic receiver is an input product, also turn out to be very high on material costs (Exhibit III-D).

The sales price per m^2 of collector array aperture is $205 for the parabolic trough at a production level of 36,800 m^2 annually. Similarly, for the fresnel lens the price per m^2 is $355 at an output rate of 55,575 m^2/year. The lower price for the parabolic trough is attainable through a more efficient utilization of both personnel and facility resources.

In order to realize potential cost savings, the photovoltaic receiver company and the collector company have been integrated into a single manufacturing company. Two cases involving different types of collectors were analyzed:

- parabolic trough collector and photovoltaic receiver
- linear fresnel collector and photovoltaic receiver.

These two hypothetical companies were simulated by combining the previous results from the independent receiver and collector companies. In both instances, the photovoltaic cell has been treated as a commodity input to the receiver fabrication, at its current market price.

A comparison of results for the parabolic trough and fresnel lens may be found in Exhibit III-E. Although the fresnel lens is more expensive to manufacture ($141/m^2 more), it is also more efficient, yielding 110 Wp/m^2 versus 90 Wp/m^2 for the parabolic trough.

Exhibit III-A

EXAMPLE CASES: PCU

	200KW PCU	10KW PCU
PRODUCTION VOLUME	9,000KW	5,000KW
QUANTITY (Units)	45	500
PRICE (1980 $/KW)	$ 370/KW	$ 654/KW
DIRECT COSTS (% of Sales)		
• Labor	12%	17%
• Material	29%	22%
• Utilities	0%	2%
Total	41%	41%
INDIRECT COSTS (% of Sales)		
• G&A	15%	20%
• Income Tax	18%	16%
• Profit	18%	16%
• Other	8%	7%
Total	59%	59%
PERSONNEL		
• Number	43	58
• KW/person per year	209KW	86KW
• Sales $/person per year	$77,488	$56,362
FACILITIES		
• Square Feet	18,988 ft^2	21,399 ft^2
• KW/ft^2	.47KW/ft^2	.23KW/ft^2
• Sales $\$/ft^2$	$ 175/ft^2	$ 153/ft^2

(The manufacturing process may be similar to existing companies, but the input data have been significantly changed thus making resulting manufacturing costs quite different)

Exhibit III-B

ECONOMIES OF SCALE: PCU

	10KW PCU	10KW PCU	10KW PCU	200KW PCU	200KW PCU	200KW PCU
PRODUCTION VOLUME (KW/yr)	5,000	10,000	100,000	9,000	20,000	200,000
QUANTITY (Units)	500	1,000	10,000	45	100	1,000
PRICE (1980 $/KW)	$654	$637	$563	$370	$365	$329
DIRECT COSTS (% of Sales)						
• Labor	17%	17%	16%	12%	12%	12%
• Material	22%	22%	25%	29%	29%	33%
• Utilities	2%	3%	3%	0%	0%	0%
Total	41%	42%	44%	41%	41%	45%
INDIRECT COSTS (% of Sales)						
• G&A	20%	19%	18%	15%	15%	14%
• Income Tax	16%	16%	16%	18%	18%	18%
• Profit	16%	15%	15%	18%	18%	17%
• Other	7%	8%	7%	8%	8%	6%
Total	59%	58%	56%	59%	59%	55%
PERSONNEL						
• Number	58		910	43		777
• KW/person per year	86		110	209		257
• Sales $/person/year	56,362		61,830	77,488		84,832
FACILITIES						
• Square Feet	21,399ft^2		269,429ft^2	18,988ft^2		295,694ft^2
• KW/ft^2	.23KW/ft^2		.37KW/ft^2	.47KW/ft^2		.67KW/^{2}
• Sales $/ft^2	$ 153/ft^2		$ 209/ft^2	$ 175/ft^2		$ 233/ft^2

(The manufacturing process may be similar to existing companies, but the input data have been significantly changed thus making resulting manufacturing costs quite different.)

Exhibit III-C

EXAMPLE CASES: PV RECEIVER
(4 Foot/313 cm^2)

		($000)	(% Sales)
SALES		$10,141	100%
COST OF GOODS SOLD			
Labor	$ 236		2%
Materials	8,190		81%
Utilities	6		0%
		8,432	83%
G&A			
Salaries	$ 170		
Utilities	31		
Supplies & Misc.	410		
		611	6%
DEPRECIATION		83	1%
INTEREST ON DEBT		23	0%
PROPERTY TAX		19	0%
INSURANCE		85	1%
INCOME BEFORE TAX		$ 888	9%
INCOME TAX		448	4.5%
NET INCOME		$ 440	4.5%

PRICE: 16,000 units/year @ $634/unit
4,978,860 CM**2/year @ $2.04/CM**2

FINANCIAL ASSUMPTIONS:

Cost of Capital	=	15.4%
Return on Equity	=	17.2%
Debt Interest Rate	=	12.5%
Debt/Equity Ratio	=	20.0%
Income Tax Rate	=	49.2%

(The manufacturing process may be similar to existing companies, but the input data have been significantly changed thus making resulting manufacturing costs quite different.)

Exhibit III-D

EXAMPLE CASES: COLLECTOR

	PARABOLIC TROUGH	FRESNEL LENS
PRODUCTION VOLUME (m^2/Yr)	37,000m^2	55,575m^2
QUANTITY (Arrays)	825	2,500
PRICE (1980 \$/m^2)	\$ 204/m^2	\$ 355/m^2
DIRECT COSTS (% of Sales)		
• Labor	4%	4%
• Material	71%	72%
• Utilities	0%	0%
Total	75%	76%
INDIRECT COSTS (% of Sales)		
• G&A	8%	8%
• Income Tax	7%	7%
• Profit	7%	7%
• Other	3%	2%
Total	25%	24%
PERSONNEL		
• Number	32	88
• m^2/person per year	1,156m^2	632m^2
• Sales \$/person per year	\$235,312	\$224,193
FACILITIES		
• Square Feet	28,728 ft^2	72,912 ft^2
• m^2/ft^2	1.29m^2/ft^2	.76m^2/ft^2
• Sales \$/ft^2	\$ 262/ft^2	\$ 271/ft^2

(The manufacturing process may be similar to existing companies, but the input data have been significantly changed thus making resulting manufacturing costs quite different)

Exhibit III-E

FACTORY INTEGRATION: CONCENTRATOR

	P.V. RECEIVER AND PARABOLIC TROUGH	P.V. RECEIVER AND FRESNEL LENS
PRODUCTION VOLUME	3.3 MW 36,788m^2	6.1 MW 55,575m^2
ARRAY EFFICIENCY	9% 90 Wp/m^2	11% 110 Wp/m^2
MANUFACTURING PRICE RECEIVER COLLECTOR TOTAL	 $556/$m^2$ 138/m^2 $694/$m^2$ $7.71/Wp	 $500/$m^2$ 335/m^2 $835/$m^2$ $7.59/Wp
COST OF GOODS SOLD NET PROFIT AFTER TAX RETURN ON INVESTMENT	81% 5% 21%	80% 5% 21%
PERSONNEL PRODUCTIVITY CAPITAL COST	478m^2/Person $162/$m^2$	356 m^2/Person $201/$m^2$

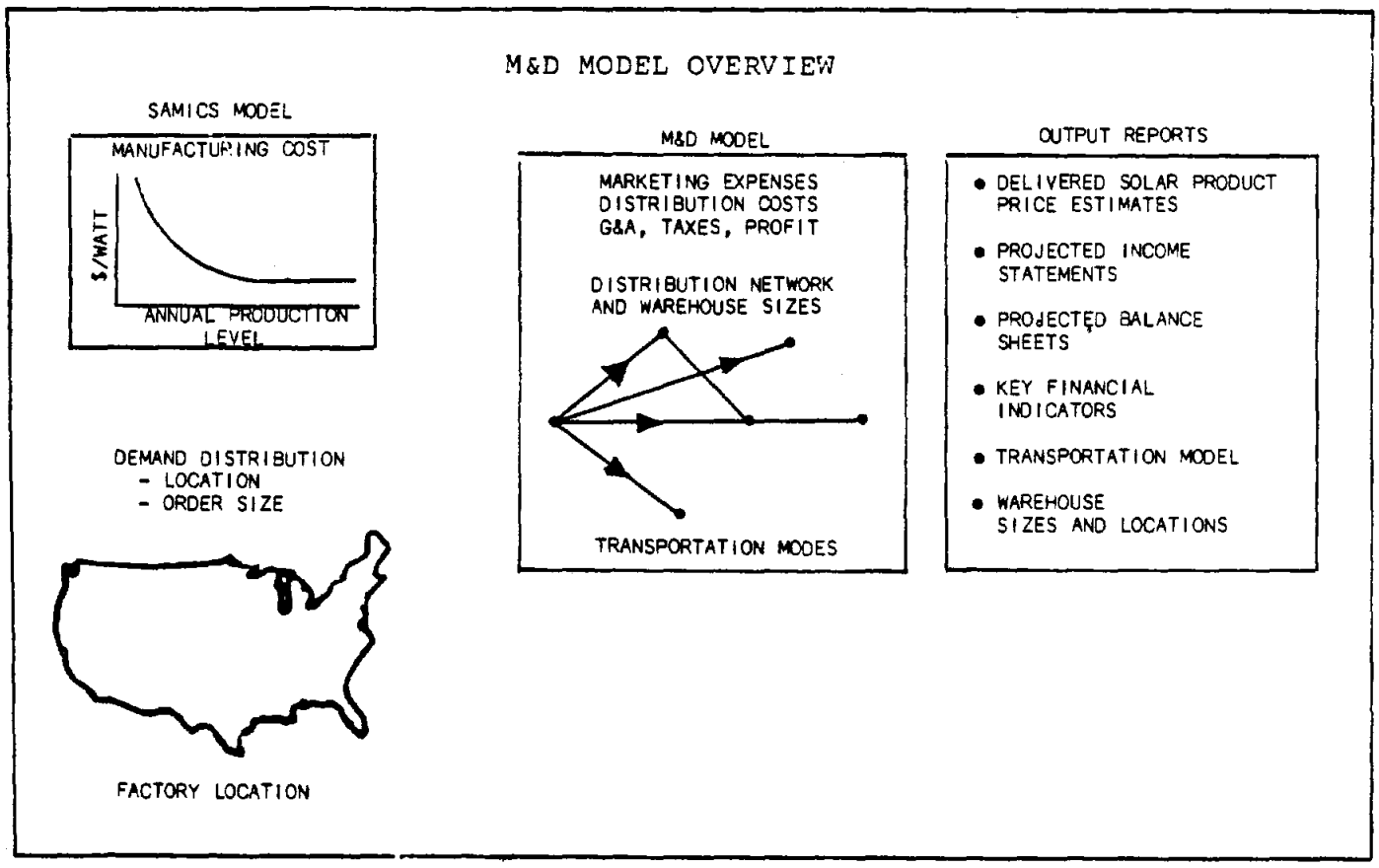
IV MARKETING AND DISTRIBUTION COST MODEL (M&D)

A. Overview

The purpose of the M&D model is to estimate the costs of selling, warehousing, and transporting solar energy products from the factory to the factory customer. The user can analyze the implications of alternative distribution channels and transportation modes. The impact of economies of scale can be evaluated with high volume production in national, regional or local factories. The impacts of a diversion of demand from conventional energy sources to solar can be measured in terms of the delivered product price estimate ($/watt).

On the supply side, separate models of marketing, distribution, and finance are combined in a modular representation of the geographic sales territory. Demand for the solar products is not forecast; rather it is treated parametrically via the total megawatt capacity and the average order quantity by customer type. Although this approach ignores the interaction of supply and demand, it does provide information about the economies and productivity of operating alternative distribution systems at various production levels.

The following picture displays an overview of the M&D model. The major inputs are the manufacturing cost of the solar products and the demand distribution by customer type and geographic region.



B. Model Description

Three submodels compute marketing expenses, distribution costs, G&A, taxes, and profit. Output reports present delivered solar product price estimates, projected income statements, key financial indicators, transportation modes, warehouse sizes and locations.

The marketing submodel computes the cost of selling solar products. These costs include:

- Sales personnel salaries
  - salesman
  - direct support
  - indirect staff
- Office facilities cost
- Sales expenses
  - travel and entertainment
  - communication
  - office supplies
- Advertising expenses.

It is assumed that these costs vary for different types of customers, and the model computes the costs by type of customer. Customers are described by their average order quantity. The model allows for up to three classes of customers. For example, small residential, intermediate commercial, and large utilities. In a test case for Sandia, the average residential customer purchases photovoltaic solar systems in orders of 5 kilowatts, commercial 500 kilowatts and utilities 5 megawatts.

The model user inputs total sales by customer, by region, and the average size per unit. From these, the model calculates marketing costs. The model, restricted to the supply side, does not attempt to measure the impact on demand in a region from lower prices in that region. However, the user can measure the impact on costs of increased or reduced volume through iterations using different input data.

The distribution submodel computes the cost of transporting, warehousing, and delivering the solar products from the factory to the factory customers. The country is divided into seven distribution regions. For each region, there are two distribution alternatives for each type of customer:

- Direct shipments from the factory to the customer

- Transshipments from the factory through a regional warehouse to the customer.

The model computes the alternative which minimizes the total annual distribution cost. In a given region, some types of customers may be supplied directly from the factory and others from a regional warehouse. There will not necessarily be a warehouse in every region, unless it is calculated to be economical to have one. If there is a warehouse, the model computes the optimal warehouse size which balances the number of shipments required with the cost of operating the warehouse, thereby minimizing the cost of the delivered solar products.

The financial submodel of the firm consists of the equations used to compute sales revenues, taxes, and profits based on the marketing and distribution expenses. The model parameters are expressed in standard financial statement terms to facilitate preparation of projected income statements for each region.

The inputs include demand distribution by region, the annual distribution expense by region, the annual marketing expense by region, the manufacturing cost of goods sold, and the manufacturing year.

Several financial parameters are used, including the minimum required rate of return on equity, financial leverage ratio, effective income tax rate, and the risk coverage period.

The model specifies the working capital required for inventories and a cash reserve to cover fixed expenses. Profits are computed to earn the minimum required return on equity. Product prices are derived from the required revenue condition that annual revenues equal annual costs.

The output consists of projected income statements, delivered product price estimates, and three key financial indicators. The key financial indicators are the cost of capital, mark-up, and the profit margin.

The income statements are generated by region for a steady-state manufacturing year. The prices are computed by dividing the annual sales revenue by the demand in each region for each product type. The price estimates include all manufacturing, marketing, and distribution expenses as well as a reasonable profit.

The model forecasts are adjusted for both inflation and regional differences in marketing and distribution costs.

C. Example Cases

To demonstrate the use of the model, example case analyses were performed for three photovoltaic products:

- 200 Kilowatt Power Conditioning Unit
- Concentrator Collector
- Flat-plate Collector

The results, summarized below, are presented in more detail in Appendices F, G, and H.

The same demand distribution was assumed for all three cases: 40% residential, 20% commercial, and 40% utility. The highest demand was set for residential users in the Rocky Mountain region, with the lowest demand for utility users in the North Central, Great Lakes, and South Eastern regions. It was assumed that the factory was located in the Rocky Mountain region.

Salaries and benefits represent the major portion of marketing expenses, comprising 80 - 90% of the cost, while 92 - 97% of the distribution costs are attributable to transportation. The shipping mode for the Rocky Mountain region is direct, while rail is the most cost effective mode for the other regions.

With a 21% rate of return on equity, a gross profit of 18.5% was estimated for a flat-plate PV system (Exhibit IV-A). Based on an average manufacturing price of $.713 per watt (1980$), the minimum delivered price estimate was $.76/watt for utilities in the Rocky Mountain region, and the maximum was $1.01/watt for residential customers in the Great Lakes region (Exhibit IV-B). The average delivered price estimate was $.88/watt, and of this cost, 9.2% was attributable to marketing, and 3.4% to distribution.

In addition, test cases were run for a concentrator collector and for a PCU, both specifying a 17.2% return on equity. The minimum delivered price estimates were also for utilities in the Rocky Mountain region, at $.76/watt for the collector and $.12 for the PCU. Again, the maximums were for residential customers in the North Eastern region; $1.15 for the collector and $.333 for the PCU. Average delivered price estimates were $.92 and $.21, respectively.

Marketing and distribution accounted for a larger percentage of the delivered cost for the concentrator and PCU than for the flat-plate system - 18.5% of the collector cost and 20.6% of the PCU cost versus 12.1% of the flat-plate price. Of course the percentages indicate the relative differences and not the absolute. For example, concentrators are less dense than flat-plate systems and are therefore more difficult to ship. The price of PCU's is lower than collector prices per unit of volume. Consequently, the percentage of price required for marketing and distribution is higher on a relative basis.

Average markup was also higher - 31.5% on the collector and 35.6% on the PCU, while markup on the flat-plate was only 20.3%.

Exhibit IV-A

EXAMPLE CASES: M&D CONSOLIDATED PRICE ESTIMATES
(1980 $/Watt)

	Flat-Plate		Concentrator		PCU	
SALES:						
Residential Products	$.933		$.994		$.391	
Commercial Products	.872		.911		.190	
Central Power Stations	.786		.852		.130	
TOTAL SALES	$.862	100%	$.921	100%	$.210	100%
COST OF GOODS SOLD:						
Residential Products	$.717		$.700		$.211	
Commercial Products	.717		.700		.141	
Central Power Stations	.717		.700		.106	
TOTAL COST	$.717	83.1%	$.700	76.0%	$.155	73.7%
GROSS PROFIT	$.145	16.9%	$.221	24.0%	$.055	26.3%
EXPENSES:						
Distribution	$.034	3.9%	$.096	10.4%	$.015	6.9%
Marketing	.070	8.1%	.074	8.7%	.029	13.6%
TOTAL EXPENSES	$.104	12.1%	$.170	18.5%	$.043	20.6%
NET PROFIT BEFORE TAX	$.041	4.9%	$.051	5.5%	$.012	5.7%
INCOME TAX	.021	2.5%	.026	2.8%	.006	2.9%
NET PROFIT AFTER TAX	$.020	2.4%	$.025	2.7%	$.006	2.8%

Exhibit IV-B

EXAMPLE CASES: M&D REGIONAL PRICE ESTIMATES
(1980 $/Watt)

FLAT-PLATE COLLECTOR

MARKET REGION	CUSTOMER TYPE			ALL CUSTOMERS	AVERAGE MARKUP
	RESIDENTIAL	COMMERCIAL	UTILITY		
West Coast	$.922	$.864	$.768	$.849	18.4%
Rocky Mountain	.919	.848	.753	.845	17.9%
North Central	.949	.889	--	.929	29.7%
Great Lakes	.983	.917	--	.961	34.1%
North Eastern	.978	.921	.834	.881	22.9%
South Eastern	.951	.897	--	.933	30.2%
South Central	.925	.872	.789	.854	19.1%
All Regions	$.933	$.872	$.786	$.862	20.3%

CONCENTRATOR COLLECTOR

MARKET REGION	CUSTOMER TYPE			ALL CUSTOMERS	AVERAGE MARKUP
	RESIDENTIAL	COMMERCIAL	UTILITY		
West Coast	$ .950	$ .871	$.802	$ .875	25.0%
Rocky Mountain	.916	.829	.761	.842	20.3%
North Central	1.082	1.004	--	1.056	50.9%
Great Lakes	1.146	1.062	--	1.118	59.7%
North Eastern	1.150	1.049	.986	1.035	47.8%
South Eastern	1.118	1.044	--	1.093	56.2%
South Central	.996	.921	.861	.921	31.6%
All Regions	$ .994	$ .911	$.852	$ .921	31.5%

POWER CONDITIONING UNIT

MARKET REGION	CUSTOMER TYPE			ALL CUSTOMERS	AVERAGE MARKUP
	RESIDENTIAL	COMMERCIAL	UTILITY		
West Coast	$.297	$.188	$.125	$.206	33.0%
Rocky Mountain	.288	.183	.120	.205	29.5%
North Central	.313	.194	--	.273	45.3%
Great Lakes	.329	.203	--	.287	52.7%
North Eastern	.333	.203	.142	.198	44.6%
South Eastern	.317	.195	--	.276	47.1%
South Central	.294	.189	.134	.202	34.4%
All Regions	$.301	$.190	$.130	$.210	35.6%

V CONSTRUCTION COSTING SYSTEM

A. Overview

A construction costing system has been developed for photovoltaic test and application experiments. These simplified procudures are consistent with construction industry practices for uniform reporting of all project costs. The final product described in this section evolved in a four stage process.

In the first stage, TB&A reviewed nine PV application experiment designs to determine unique requirements for PV solar energy installations from an accounting point of view. Construction cost categories common to all projects were established. Also, unique or special categories were identified for separate cost collection.

The second stage developed a cost account structure. From knowledge of the plans for the experimental projects plus user needs, TB&A constructed a structure for reporting costs. The recommended structure is based on three additional building blocks: the cost account structure model supplied by Sandia, the appropriate features of the Construction specification Institute accounting system, and the evaluation objectives of the National Photovoltaics program.

The third stage documented the construction costing system in two reports: a Cost Guide and a Reporting Manual. The cost guide described the account categories and why they were established the reporting manual for field forces contains procedures and forms for reporting to various cost categories. These were based on current systems familar to contractors, but augmented to meet defined needs. The manual was written to be easily understood by engineers and other non-accountants.

During stage four prospective system users found the initial version of the cost guide and reporting manual un weildy. The documentation was deemed to be too detailed with more analysis options than were considered to be either necessary or practical for the majority of projects. Therefore, TB&A has prepared an abbreviated cost guide and reporting manual that is easy to use. This report is titled "Cost Accounting and Reporting System Manual for Photovoltaic Project Management (SAND 81-7046)"

In this revised truncated form, the objectives of the photovoltaic construction costing system are:

- To provide uniform cost reporting across the varied project technologies at both the level required to monitor costs during procurement and installation, and at planned project cost reconciliation milestones.
- To give visibility to all significant cost items.
- To permit comparison of components and total PV systems to be made on a credible basis.
- To establish a foundation on which to base a continually expanding PV system cost data bank.
- To establish a contractual basis for cost reporting on future PV projects.
- To provide a reporting system that is understandable and perceived as informative and responsive by the many parties using it.

Prior to developing the construction costing system, a preliminary list of the reporting parameters that the system must accommodate were assembled. The resulting system is to replace the existing "internal use" systems for the following functions:

- Internal accounting,
- Estimate recording,
- Cost visibility,
- Preparation to comply with Sandia and DOE reporting requirements and
- Project control.

The specific cost reporting system requirements are as follows:

- Must accommodate input of different PV technologies.
- Must give visibility to PV component costs.
- Must give visibility to material, equipment, and installation costs.
- Must be a useful progress monitoring tool during both development and installation.
- Must be finite, but simple.
- Must include cost/performance factors that can be compared from one system report to another.

Each cost entry, whether reported incrementally during the installation process or reported at a single milestone, is defined as to scope, limits, and interface with adjoining systems or construction. This permits input to be made on a consistent basis from one project to another. This, however, does not provide entries that necessarily permit credible comparisons to be made directly. Each PV system component will have arrived at its final placement through a variety of procurement methods. For one to make a judgment, therefore, of the comparative costs of a component in varying technologies, these procurement differences need be factored out. Entries are to be coded by one or more cost adjustment factors, as applicable. The cost adjustment factors that have been included in the system are:

- Union vs. non-union site labor
- Shop fabricated vs. field constructed
- Geographic location of site
- Variation in freight rates
- Lump sum low bid vs. negotiated price
- Contract incentives
- Schedule constraints
- Expertise of procuror
- Proprietary vs. competitive purchase
- Timing of contractual commitments.

The major anticipated benefits of the construction costing system are as follows:

- Will remove ambiguity from cost reporting
- Will remove need for general catch-all reporting categories
- Will allow performance/cost comparisons to be made
- Will focus attention on project components for which excessive monies are presently being spent
- Will form the nucleus for set of control documents to be developed for the photovoltaic development program.

B. Cost Accounting Structure

The cost accounting structure is intended to accommodate the reporting of all project costs, not just those capital costs allocated for the construction of a given photovoltaic system. The structure attempts to recognize and capture all monies spent for the development, construction, or operation of any PV project. To this end, it has been subdivided into three major activity categories:

I Project Development,

II Project Construction,

III Project Operation.

The project development category encompasses all non-construction activities (management, design, procurement, public relations) from project inception through system commissioning.

Project construction accounts include cost of material, equipment delivered to the site, and labor used at the site for the construction of the PV system. Supervisory time spent by on-site contractor forces is also included in this grouping.

All project costs incurred after system commissioning fall within the third category, project operation.

The accounts selected do not attempt to list every specific activity or every piece of material or equipment represented in a photovoltaic system: but include groups of activities or generic groupings of materials or types of installation work into which all expenditures can be correctly placed for accounting purposes. TB&A has addressed the account structure design to meet several goals, but has emphasized the following dual requirements.

- Each sub-entry should represent information that the project manager and others wish to know, and
- Each sub-entry should represent cost information that the project manager can obtain through normal procurement, contractor, and/or subcontractor relationships.

The entries have been carefully selected so as to be attainable and meaningful.

Each account entry has been assigned an account number into which several codes have been designed. the number codes permit the extraction and subtotaling of entries by PV project phase, activity, system component, or several other options.

The numbering system for the accounts has the following basic structure:

	PHASE	ACTIVITY	COMPONENT	OR TASK	SUBTASK	SUBTASK	DETAIL
Account Number:	3	. 2 .	0	3	2 1	4	

Placement of costs into the three phase categories represents the most general of the cost accounting break down layers. The first digit in the account number, a 1, 2, or 3, clearly defines the cost as an expenditure for system development, an aspect of the construction process or an operating cost.

Each of the three project phase categories, or groupings, is necessarily subdivided into multiple activities, many of which are further subdivided as required by the level to which accounting visibility is considered necessary and meaningful. The multiple activities, for example, as listed under Phase 2, Project Construction, areas follows:

2.1 Land Acquisition
2.2 Site Preparation and Improvement
2.3 Non-Building Foundations
2.4 Systems Installation
2.5 Building/Enclosures
2.6 Spare Parts/Equipment Inventories
2.7 Equipment for Start-Up/Check-Out

The activities are delineated by the digit in the second column. The third and fourth columns are designed for the specific tasks performed or system components developed and/or installed within the operations of a given second column activity. These numbers begin with 01 and run as high as necessary to include the listing within the activity; or are given a specific series of numbers out of sequence per a select code.

Since a variety of tasks relative to specific PV system components are listed under several activity headings, (i.e. design installation, preventative maintenance), the major system components have been assigned dedicated task numbers by which they are consistently referred.

The assigned 3rd and 4th column digits are as follows:

01 Collector/Array System
02 Tracking Drive System
03 Power Conditioning System
04 Electrical System
05 Electrical Storage System
06 Thermal Storage System
07 Instrumentation/Data Collection Systems
08 Security/Safety Systems

Thus, the work task for field installation of collector modules is given the summary account number 2.3.01.

The 5th and 6th column digits have been assigned to "subtasks." These are numbered sequentially beginning with 01, and continue as high as necessary. There are no dedicated numbers in these columns.

An additional digit is added in the 7th column where required to identify "subtask" detail. Following is a complete list of the account names, numbers and definitions.

CONSTRUCTION COSTING SYSTEM

ACCOUNT NUMBER	DESCRIPTION
1.0	Project Development - This summary account number represents the total of all non-construction monies spent through the system commissioning date. As shown by the sub-entries defined below, it represents all management time, design effort, administrative services, the many required interfaces, plus anticipated profits and expenses due the project's prime contractor.
1.1	Management Services - Subtotal of management/administrative activity sub-entries
1.1.11	Program Definition - This entry is to capture all fees and expenses incurred from project inception to development of a firm statement of project scope, goals, and design criteria.
1.1.12	Team Selection & Coordination - Account to carry total of all fees and expenses for the selection and orientation of project participants, and the managerial coordination of the work.
1.1.13	Contract Negotiations - All costs included in negotiating contracts with DOE, Sandia, consultants, engineers, or other contractual parties involved with project development. This account does not include purchase of goods or services relative to system construction.
1.1.14	Budget & Schedule Control - Cost of developing and maintaining project budget and schedule control documents (manual or automated), and the management and support time expended to distribute and manage the controls developed.
1.1.15	Report Preparation - Cost of assembling data and writing and publishing reports required by the various approving agencies throughout the project development phase. Entry to include typing, printing, binding, and other report associated administrative charges.
1.1.16	Reviews & Approvals - Total cost of preparing support materials for reviews, attending meetings, and other direct and indirect expenses related to reviewing development and gaining required approvals.

CONSTRUCTION COSTING SYSTEM

ACCOUNT NUMBER	DESCRIPTION
1.1.17	General Administrative Services - All administrative charges (rentals, equipment, clerical assistance, supplies, telephone, and insurance) directly attributable to the project.
1.2	Engineering Design Services - Subtotal of engineering activity sub-entries.
1.2.01	Collector/Array - All engineering fees and expenses committed to the schematic, preliminary, and final develoment design of the collector/array. Include costs for professional, technical, and clerical personnel and the overhead factors required for their support.
1.2.02	Tracking/Drive System - Comparable design expenditures for the tracking/drive system.
1.2.03	Power Conditioning System - Comparable design expenditures for the power conditioning system.
1.2.04	Electrical System - Comparable design expenditures for the electrical system.
1.2.05	Electrical Storage System - Comparable design expenditures for the electrical storage system.
1.2.06	Thermal Storage System - Comparable design expenditures for the thermal storage system.
1.2.07	Instrumentation/Data Collection - Comparable design expenditures for the instrumentation/data collection.
1.2.08	Safety & Security Systems - Comparable design expenditures for the safety & security systems.
1.2.11	General Engineering Activities - Subtotal of all non-component specific engineering work.
1.2.1101	Systems Integration - Engineering fees and expenses used for conceptual PV system design, and the integration of all separate component design efforts. All monies spent on overall system design and coordinating detailed component design work entered under accounts 1.2 through 1.2.08.

CONSTRUCTION COSTING SYSTEM

ACCOUNT NUMBER	DESCRIPTION
1.2.1102	Construction Document Preparation - All engineering construction document preparation, including drawings and specifications. The engineering design phases of component and system development will include cost of documentation through preliminaries. This account includes all documentation from approval of preliminaries through completion of bid documents.
1.2.1103	Cost Estimating - Cost of all estimating work required by project management for project control, whether performed by staff or external consultants. Does not include estimating costs incurred by outside vendors or contractors, as those costs are entered into their overhead and reflected elsewhere in product price.
1.2.1104	Shop Drawing & Submittal Review - Costs incurred within the respective engineering offices to receive, process, review, and return the shop drawing, brochure, and sample submittals forwarded by the contractors and vendors per the construction specification requirements.
1.2.1105	Construction Supervision - Account to include all engineering personnel fees and expenses charged to supervision and/or surveillance of the construction operations. Costs to include on-site inspection time, meetings, report preparation, and requision and change order review and/or approval.
1.3	Architecture/Engineering Design Services - Summary account for total sub accounts for design work relating to site development, buildings, furnishings and equipment.
1.2.09	Building/Enclosures - Include all professional fees and expenses for schematic and preliminary design work for all buildings, rooms, renovations, and enclosures. Account to cover cost of design for basic building envelope and all structural, mechanical, electrical, and plumbing subsystems.
1.3.10	Site Development - Summary account for total of Civil Engineering and Landscape Design work.

CONSTRUCTION COSTING SYSTEM

ACCOUNT NUMBER	DESCRIPTION
1.3.1001	Civil Engineering - Professional fees and expenses for all sitework, and utilities from a point 5 feet from building walls. Work to include design of grading plans, site utilities, foundations of site structures, paving sections, drainage systems, and fencing.
1.3.1002	Landscape Design - Fees and expenses charged to development through preliminary design drawings, of planting and paving plans, selection of materials, and suggestions, if required for soil sterilization. Note: Generally, the landscape design account will capture the site layout costs, and the civil engineering fees will provide the engineering to support the layout.
1.3.11	Furnishings and Equipment - Account to include all design costs incurred to make selection of all non-technical (non-PV system related) furnishings and equipment for occupied support spaces.
1.3.12	Publicity Document Preparation - Cost of design, assembly, and printing of all publicity documentation prepared for external consumption. Account must not be confused with 1.1.15--Report Preparation, which is to cover preparation of documents for internal meetings, reviews, and approvals.
1.3.13	General A/E Activities - This summary account and the five sub accounts are similar in definition to the 1.2.11--General Engineering series and cover similar jurisdictions. Whereas Engineering covers PV system and component design, A/E covers site development and support building design.
1.3.1301	Systems Integration
1.3.1302	Construction Document Preparation
1.3.1303	Cost Estimating
1.3.1304	Shop Drawing and Submittal Review
1.3.1305	Construction Supervision

CONSTRUCTION COSTING SYSTEM

ACCOUNT NUMBER	DESCRIPTION
1.4	Testing Programs (Pre-construction) - Summary account for totaling the costs of pre-construction test programs conducted during the design phase of the many PV system components.
1.4.01	Collector/Array - Total cost of personnel time, expenses, required equipment, and freight charges, incurred during any testing performed throughout the collector/array design phases.
1.4.02	Tracking/Drive System
1.4.03	Power Conditioning System
1.4.04	Electrical System
1.4.05	Electrical Storage System
1.4.06	Thermal Storage System
1.4.07	Instrumentation/Data Collection
1.4.08	Safety & Security Systems - Equivalent testing expenditures account for each of the other PV system components.
1.4.10	Site Conditions - Summary account for total of specific testing programs performed at the site. If and when site condition tests are performed for which no specific account has been dedicated, a new sequential account (i.e. - 1.4.1004) should be added and its cost summed with the others for the 1.4.10 total.
1.4.1001	Soils Testing - This account includes all work performed by foundation and soils engineers to determine recommendations for building, equipment, foundations, retaining walls, paving sections.

CONSTRUCTION COSTING SYSTEM

ACCOUNT NUMBER	DESCRIPTION
1.4.1002	Percolation Testing - Cost of tests performed to determine the subsurface drainage properties of the site.
1.4.1003	Climatic Criteria Surveys - Cost of any meteorological testing.
1.4.11	PV System Module(s) - This account records all costs related to testing integrated system modules, or assemblies of various components. Any test performed with entire modules, or two or more united components, should be entered in this account.
1.5	Applications & Approvals - Summary account for total cost of external approvals, variances, permits, and licenses required.
1.5.11	Zoning Compliance - Include costs of securing zoning requirements documents, preparing reports, and attending meetings as required to secure approval that project is in compliance with zoning ordinances.
1.5.12	Permits - Cost of all permits required by jurisdictions within which project is constructed.
1.5.13	Variances - Cost of personnel time and expenses incurred in identifying need for variances, preparing and presenting reports, and attending meetings as required to resolve requests for variances.
1.6	Construction Management - Summany account of Construction Management sub accounts.
1.6.11	Procurement Administration - All administrative time (fees) and expenses incurred to manage stepped process of procurement document preparation, bid solicitation and procurement.
1.6.12	Procurement Document Preparation - All work related to preparing specific bid documents for major PV system equipment. This account should not be confused with those for general systems construction documentation, ENG. 1.2.1102, and A/E 1.3.1302, which include drawings and specifications. These specifications will be concerned with installation procedures and operating characteristics. The procurement documents are for equipment bid definition only.

ACCOUNT NUMBER	DESCRIPTION
1.6.13	Solicitation of Bids - This account includes costs incurred to identify and prequalify bidders, issue bid documents, address bid period questions, attend bid related conferences, and terminates for each procurement item upon receipt of bids.
1.6.14	Bid Analysis - As stated, all work related to reviewing bids received to point of selected bid for award.
1.6.15	Procurement of Goods & Services - Preparation of purchase orders, and/or contracts for goods and services, and follow-up communication through time when each item to be procured separately is under contract. Included in the account is the cost of all time and expenses consumed in awarding a contract or contracts to the General Contractor or multiple subcontractors for the site-related work.
1.6.16	Site Construction Administration - Construction administration costs incurred at the site in meetings, to coordinate field purchases and construction efforts with office construction administration activities, equipment purchases, and overall project budget and schedule control.
1.6.17	Expediting Activities - All time and expenses incurred to expedite and control delivery of major equipment items. Activities include plant visits, reports, phone calls, and meetings.
1.6.18	Equipment Manual Assembly - All systems and major equipment items may be specified to be accompanied by unabridged manuals containing full instructions on operation and maintenance. Small equipment items, such as motors and fans, will have standard manuals that come as part of the purchase price. Other system manuals, such as required for PCU's, however, may contain information that is assembled from several sources, including the design engineer. All monies spent to identify manual requirements, assemble information, and produce finished operating manuals are to be captured within this account.

ACCOUNT NUMBER	DESCRIPTION
1.6.19	Spare Parts Inventory Catalog Assembly - Many of the PV system specification sections will require that spare parts be supplied as part of the contract for the basic system or piece of equipment. Someone must necessarily assemble an inventory catalog of all parts; listing their account number, part number, supplier, quantity and stored location. This account is to capture all management costs involved in the design, assembly, and maintenance of the spare parts inventory catalog.
1.7	Personnel & Public Relations Activities - Summary account for all personnel and public relations activities itemized in sub accounts.
1.7.11	Hiring - Include all costs incurred in advertising, recruiting, interviewing, and offer tendering for PV project operating personnel.
1.7.12	Training - All training related to equipping PV project operating personnel with skills to perform intended jobs.
1.7.13	Safety Instruction - Costs for all classes and safety equipment as required for safe operation of the PV facility and as required to comply with governing codes and approval agencies.
1.7.14	Publicity - Costs incurred on external publicity. This account is linked in series with account number 1.3.12. Under this account, record salary, if any, for publicist who generates ideas for brochure materials or articles, and subsequently sees that the material is published.
1.7.15	Community/Utility Interface - All activities involving the project with society. Costs incurred in attending meetings and giving presentations.
1.8	Fees & Expenses - Summary account of separate fees and expenses sub-accounts.
1.8.11	Professional Fees - Account for planned profit, whether stipulated directly by contract or held in reserve for profit.

CONSTRUCTION COSTING SYSTEM

ACCOUNT NUMBER	DESCRIPTION
1.8.12	Reimbursable Expenses -All expenses for which recovery is to be made, but where involved with project related activities other than the specific management and/or design tasks to which expenses are to be assigned. This account mainly captures expenses accompanying general project management activities.
1.9	Contingencies & Adjustments
1.9.11	Design Contingency - Account to carry allotment of money intended to cover cost increases due to design changes required between time of initial cost estimate and bid price.
1.9.12	Material Escalation - Allotment of funds held to cover potential price increases in system dependent and/or sole source materials.
1.9.13	General Construction Period Escalation - Allotment of funds held to cover price escalation potentially caused by delays in construction commencement or an extended construction period.
2.0	Project Construction - This summary account number represents all construction related monies spent through the system commissioning date.
2.1	Land Acquisition - Summary account for costs related to site ownership prior to construction or commissioning of PV system.
2.1.11	Payments on Principal - Expenditures for payments to principal on PV project site through the construction period only. Terminate this account on commissioning date.
2.1.12	Payments of Interest (thru Construction Period Only) Same purpose as account 2.1.11 above except for recording interest payments.
2.1.13	Tax - Payments for required taxes on PV project property through to commissioning date only.

CONSTRUCTION COSTING SYSTEM

ACCOUNT NUMBERS	DESCRIPTION
2.1.14	Pre-Development Security - Account intended to capture monies spent for guards, to secure site, if required, prior to commencement of project construction.
2.1.15	Pre-Development Maintenance - Cost of site maintenance prior to project construction.
2.2	Site Preparation & Improvement - Summary account for all site preparation and improvement sub accounts.
2.2.11	Move-In (Temporary Facilities) - All costs related to establishing base of operations at the job site, including set-up of required office space; temporary sewer, water, power, and telephone; and construction fencing if other than security fencing provided for in account 2.1.14.
2.2.12	Demolition - All work of removing existing buildings, ancillary structures, retaining walls, and/or slabs required to clear site area for new construction. Cost of relocating utilities and clearing vegetation are to be entered in other accounts.
2.2.13	Removal or Relocation of Existing Utilities - Summary account for total cost of work performed in the individual utility sub-accounts.
2.2.1301	Electrical Service - All costs related to removal of existing electrical service hardware (poles, lines, buried cable, and transformers.) if located within site limits and not required to remain active; or costs for relocation to a non-conflicting position if required to remain in service. Costs related to providing utilities specifically for the PV system project are to be entered in accounts 2.2.18 listed below.
2.2.1302	Telephone
2.2.1303	Water
2.2.1304	Gas - Account similar to 2.2.1301 (Electrical Service) to record costs of removing or relocating existing gas utilities.

CONSTRUCTION COSTING SYSTEM

ACCOUNT NUMBER	DESCRIPTION
2.2.1305	Sanitary Sewer
2.2.1306	Storm Sewer - Account similar to 2.2.1301 (Electrical Service) to record costs of removing or relocating existing storm sewer utilities.
2.2.14	Clearing & Grubbing - Removal of all trees, bushes, and other substantive vegetation from the premises in preparation for grading and excavating operations.
2.2.15	Grading & Stabilization - Summary account for grading and soil treatment sub accounts.
2.2.1501	Rough Grading - All costs related to bringing the site area to rough grade elevations as indicated on the site development contract documents.
2.2.1502	Finish Grading - Cost of work to bring grades from rough to finished elevations per site development documents.
2.2.1503	Soil Sterilization - Application of herbicides, oils, plastic sheeting, or other specified option to inhibit growth of vegetation at grade mounted collector/array systems and other locations as selected.
2.2.16	Trenching & Backfill - Summary account for all utility, and system cable and piping trenching and backfill requirements.
2.2.1601	Facility Utilities - Cost of trenching and backfill per system document specifications for PV system related water, telephone, and electrical service requirements.
2.2.1602	Sanitary Sewer - Cost of trenching and backfill related to installation of sanitary sewer system to serve the PV system facility.
2.2.1603	Storm Sewer - Trenching and backfill related to installation of sanitary sewer system to serve the PV system facility.
2.2.1604	Electrical System Cable Runs - Cost of trenching and backfill required for conduit and/or cable runs installed as part of the Electrical Systems.

CONSTRUCTION COSTING SYSTEM

ACCOUNT NUMBER	DESCRIPTION
2.2.1605	Electrical Storage System Cable Runs
2.2.1606	Thermal Energy System Piping
2.2.1607	Instrumentation Interconnecting Wiring
2.2.1608	Safety/Security System Cable Runs - Trenching and backfill accounts, similar to 2.2.1604, for cable or piping runs for Electrical Storage Systems, Thermal Energy Systems, Instrumentation Systems, and Safety/Security Systems.
2.2.17	Utility Installation - Summary account for cost of installation work of all utilities and drainage systems required for service to the PV system facility (exclusive of relocation and trenching).
2.2.1701	Electrical Service
2.2.1702	Telephone
2.2.1703	Water
2.2.1704	Gas
2.2.1705	Sanitary Sewer
2.2.1706	Storm Sewer - Utility accounts, for electrical service, telephone, water, gas, sanitary sewer, and storm sewer installation work. Costs to include all direct costs to the project, but exclude costs incurred by various utility companies for the connection end of each service.
2.2.18	Paving - Summary account for cost of all site paving. Paving work accounts are to include any additional improvements relating directly to paved surfaces; such as curbing, stripping, and wheel stops. Walkways, roadways, and parking areas are all to be entered under this and the following sub accounts.
2.2.1801	Concrete
2.2.1802	Asphalt
2.2.1803	Gravel - Sub account numbers to differentiate the expenditures for concrete, asphalt, or gravel paving surfaces.

CONSTRUCTION COSTING SYSTEM

ACCOUNT NUMBER	DESCRIPTION
2.2.19	Plantings - All costs related to installation of plant materials (trees, shrubs, ground cover, and grass,) including soil preparation, fertilizing, mulching, and watering.
2.2.20	Fencing - Cost of removal and/or relocation of existing site security fencing as required, and installation of new fencing and gates to meet security requirements of the PV system development.
2.3	Non-Building Foundations (including excavation) - Summary account of all work related to construction of foundations for PV system equipment. Foundation costs to include excavation, foundation drains backfill, and embeddments including anchor bolts, plates, and angles.
2.3.01	Collector/Array Systems
2.3.02	Tracking/Drive Systems
2.3.03	Electrical System External Transformers - Foundation work sub accounts for collector/array systems, tracking/drive systems, electrical transformer pads, and thermal tank footings, respectively.
2.3.04	Thermal Storage System External Tanks
2.4	Systems Installation - Summary account for total cost of the systems represented in the sub accounts. All costs are for goods in place, and therefore, are composed of both purchase price and installation cost elements.
2.4.01	Collector/Array System - Summary account for all sub account costs related to delivery and installation of the array. Array system account jurisdiction extends to end of power pigtails or piping stubouts supplied with the system. Electrical cable, and piping from the array to other parts of the PV system are to be recorded in other accounts. The sub accounts are listed in two groupings - 2.4.0101 through 2.4.0106 are accounts assigned to flat panel installations; 2.4.0110 through 2.4.0115 are accounts for concentrator installation components; and 2.4.0116 and 2.4.0117 are common to both.

CONSTRUCTION COSTING SYSTEM

ACCOUNT NUMBER	DESCRIPTION
2.4.0101	Mounting Frames - Cost to supply and install the PV mounting frames, the basic panel structure in flat panel installations.
2.4.0102	Cells - Cost of photovoltaic cells installed within the mounting frames. Include cost of cell to cell wiring within the limits of the mounting frames.
2.4.0103	Module Junction Boxes - Cost of boxes installed.
2.4.0104	Interconnectiong Wiring - Cost of all interconnecting wiring, within jurisdiction of Collector/Array, external to mounting frames and module junction boxes, and exclusive of power pigtails.
2.4.0105	Supporting Structure - All costs associated with the structure designed to support the mounting frames (flat panel installations only). Work under this account to include all painting or other rust inhibiting coating.
2.4.0106	Tilt Adjustment - All costs for hardware - brackets, hinges, and lifting devices, integrated into the sup port structure design to enable mounting frames to be tilted.
2.4.0110	Module Structure - Cost of structural apparatus to be placed on a foundation or secondary tracking structure that serves to hold the specified reflective surface, lens, receiver, cells, and cooling device in their designed location and configuration.
2.4.0111	Reflective Surface - Cost to furnish and install metal, glass, acrylic, or other reflective surfacing material and any required clips, face angles, or hardware used as attachment or finishing trim.
2.4.0112	Lens - Expenditures for furnishing and installing lens and any retaining hardware used in its installation.
2.4.0113	Receiver
2.4.0114	Cells
2.4.0115	Cooling Fins, Sink, Channel - Sub accounts for all costs related to supplying and installing the receivers, cells, and cooling device.

ACCOUNT NUMBER	DESCRIPTION
2.4.0116	Power Pigtails - Wiring in lengths specified to be supplied with completed collector/array modules for connection to electrical system wiring. This account to include cost of short pigtails at each array module only. Interconnecting wiring from pigtail connection to other system components is included in a separate account.
2.4.0117	Plumbing Stubouts - Piping within the collector/array to serve the cooling system or as part of a hybrid thermal energy system will be recorded within the collector/array accounted but only to point of stubout at some set dimension from end of module or run. Piping from stubout to other system components is included in a separate account.
2.4.02	Tracking/Drive Systems - Summary account.
2.4.0201	Array Structure - All components of primary structure on which to mount concentrator module structures (account 2.4.0110) or flat-panel supporting structures (account 2.4.0105) and coordinate the single or double axis tracking.
2.4.0202	Drive Motors, Bearings, & Gear Train - All costs for mechanical/electrical apparatus mounted on array structure to mechanize single or double axis tracking.
2.4.0203	Solar Sensor - Installed costs of controlling sensor or sensors to activate drive mechanisms.
2.4.03	Power Conditioning Systems - Summary account for all power conditioning system sub accounts. Account to capture all costs of PCU equipment, installed, including all standard attributes specified, optional characteristics specified, the terminal wiring connections or pigtails as specified, cabinet and integral filter.
2.4.0301	Power Processor - All costs identified with the actual power processing equipment, including inversion, conversion, and rectification subtotals as applicable. Three sub accounts for the recording of these separate costs are numbered 2.4.03011 - 2.4.03013.

ACCOUNT NUMBER	DESCRIPTION
2.4.03011	Inverter
2.4.03012	DC-DC Converter
2.4.03013	Rectifier
2.4.0302	Input & Output Cable Leads/Connectors - Account for cost of connectors or pigtails of specified length. Wiring from connectors or pigtails to other system components are recorded under accounts 2.4.0402, 2.4.0403, or 2.4.0406 under Electrical Systems.
2.4.0303	Interface Contactors - Summary account for PCU system switching devices. Sub-accounts 2.4.03031 - 2.4.03035 represent several of the contactor interfaces most likely to be included. Others to be included in the specifications should be entered in additional sequentially numbered accounts.
2.4.03031	Input
2.4.03032	Utility
2.4.03033	Load
2.4.03034	Batteries (Energy Storage)
2.4.03035	Paralleling
2.4.0304	Isolation Transformers - All costs related to integration of transformers into the equipment, including required interface wiring within PCU.
2.4.0305	Controls - Summary account for all controlling devices and related integral wiring. The eight sub accounts listed include three standard control systems (2.4.03051 - 2.4.03053), and five optional systems (2.4.03054 - 2.4.03058) that are to be recorded separately depending on availability of separable cost figures. Options specified, but not listed should be entered in additional sequentially numbered accounts.
2.4.03051	Surge Protection
2.4.03052	Override Controls
2.4.03053	Ground Fault

ACCOUNT NUMBER	DESCRIPTION
2.4.03054	Automatic Start & Shutdown
2.4.03055	Peak Power Tracking
2.4.03056	Energy Storage Control
2.4.03057	Load Priority Control and Load Shedding
2.4.03058	Parallel Operation Load Shedding Control
2.4.0306	Instrumentation - Summary account for separable expenditures for PCU instrumentation as specified. As the type instrumentation required for any given installation may vary appreciably, only two sub accounts (Transducer and Other) have been cited.
2.4.03061	Transducer
2.4.03062	Other
2.4.04	Electrical Systems - Summary account to capture all sub account costs related to PV system central transformers and switchgear, system controls and supporting/governing computer software, metering, and wiring/cabling interconnections between all system components, the load, and/or the utility.
2.4.0401	Poles/Towers
2.4.0402	Wiring (Including Conduit)
2.4.0403	Cable Runs (Including Conduit)
2.4.0404	Switchgear
2.4.0405	Transformers
2.4.0406	Interconnects
2.4.0407	Manholes
2.4.0408	System Control/Mode Selection
2.4.0409	Control Software
2.4.0410	Meters

CONSTRUCTION COSTING SYSTEM

ACCOUNT NUMBER	DESCRIPTION
2.4.05	Electrical Storage Systems - Summary account for expenditures for equipment and installation labor specific to on-site storage of electrical energy.
2.4.0501	Battery Banks (Including Racks & Cabling) - Cost of batteries in place, including racks and interconnecting cabling.
2.4.0502	Switching, Wiring, & Controls - All electrical costs related to furnishing and installing the specified controls and switching, and completing interconnecting wiring within the electrical storage system components. Wiring and interconnects from storage to other PV system components to be recorded under appropriate electrical systems sub accounts.
2.4.0503	Safety Related Equipment (Hardware) - All alarms, eyewash stations, and insulating matting, specifically required by code or specification relative to protection of equipment and personnel.
2.4.0504	Instrumentation - All costs to furnish and install storage system related instrumentation.
2.4.06	Thermal Energy Systems - Summary account for all expenditures dedicated to equipment and installation labor related to thermal energy collection, storage, and conversion for use at intended load.
2.4.0601	Piping & Pipe Brackets External to Collectors - Cost of all thermal energy related piping, brackets, and supports from terminus of collector/array piping stubouts.
2.4.0602	Valves
2.4.0603	Meters
2.4.0604	Pumps
2.4.0605	Heat Exchangers
2.4.0606	Storage Tanks
2.4.0607	Support Structures - Cost of all structural members, including columns, beams, and brackets, (excluding foundations) required to support pumps, heat exchanges, and raised, buried, or grade mounted storage tanks.

CONSTRUCTION COSTING SYSTEM

ACCOUNT NUMBER	DESCRIPTION
2.4.07	Instrumentation/Data Collection Systems - Summary account.
2.4.0701	Sensors - All costs related to supplying, locating, and installing specified sensors.
2.4.0702	Interconnecting Wiring - Cost of specialized instrumentation wiring between sensors and readout/recording/computing equipment.
2.4.0703	Recording/Computing Equipment - Cost of all work related to the furnishing, installation, and checkout of all data recording/computing equipment.
2.4.08	Safety/Security Systems - Summary account for all expenditures to install systems required by code or project specifications.
2.4.0801	Lightning Protection (Arrays)
2.4.0802	Facility Grounding
2.4.0803	Inter-Communications System
2.4.0804	Fire Protection Systems - Sub account for separate entry of expenditures for commonly required systems. Additional systems installed in a given PV project should be entered in additional sequentially numbered accounts.
2.4.08041	Alarms
2.4.08042	Local Extinguishers
2.4.08043	Sprinklers
2.4.08044	Chemical Suppression Systems
2.5	Buildings/Enclosures - Summary account of all expenditures made for building or enclosures to house PV system components, materials, and offices, but not to be used for recording any costs of the PV system components.
2.5.03	PCU Enclosure - Summary account of all expenditures made under the several sub accounts to provide enclosure for the PCU and related equipment. The enclosure may be specified as a separate building, or part of an existing building.

CONSTRUCTION COSTING SYSTEM

ACCOUNT NUMBER	DESCRIPTION
2.5.0303	Exterior Closure - All work related to the exterior enclosure including walls and roofing.
2.5.0304	Interior Finishes - Work necessary to subdivide enclosed shell building in specified interior spaces and install all finish materials.
2.5.0305	Electrical Service (Power & Lighting) - All electrical work, including power distribution, lighting, and any secondary systems required to energize the building.
2.5.0306	Mechanical System - All heating, ventilating, and air conditioning related work, including accompanying controls and instrumentation required to maintain a given environment.
2.5.0307	Plumbing Services - All plumbing work within the building and to a point 5 feet outside the perimeter walls.
2.5.04	Electrical Control Center
2.5.0401	Foundation
2.5.0402	Structural Frame
2.5.0403	Exterior Closure
2.5.0404	Interior Finishes
2.5.0405	Electrical Service (Power & Lighting)
2.5.0406	Mechanical System
2.5.0407	Plumbing Services - Separate summary accounts for construction and/or installation of buildings/enclosures for the electrical control center, electrical storage system facility, thermal storage system facility, data collection center, and visitor center, respectively. Each summary account has seven accompanying sub-accounts, 01 through 07.
2.5.05	Electrical Storage System Facility
2.5.0501	Foundation
2.5.0502	Structural Frame
2.5.0503	Exterior Closure

CONSTRUCTION COSTING SYSTEM

ACCOUNT NUMBER	DESCRIPTION
2.5.0301	Foundation - All costs related to providing foundations for the subject building or enclosure. Foundation account to include excavation, backfill, and required embedments.
2.5.0302	Structural Frame - All costs for installing the skeletal structure of the building. In cases where building is a wood-framed structure or a trailer, this account would be omitted and all costs included under exterior closure.
2.5.0504	Interior Finishes
2.5.0505	Electrical Service (Power & Lighting)
2.5.0506	Mechanical System
2.5.0507	Plumbing Services
2.5.06	Thermal Storage System Facility
2.5.0601	Foundation
2.5.0602	Structural Frame
2.5.0603	Exterior Closure
2.5.0604	Interior Finishes
2.5.0605	Electrical Service (Power & Lighting)
2.2.0606	Mechanical System
2.2.0607	Plumbing Services
2.5.07	Data Collection Center
2.5.0701	Foundation
2.5.0702	Structural Frame
2.5.0703	Exterior Closure
2.5.0704	Interior Finishes
2.5.0705	Electrical Service (Power & Lighting)
2.5.0706	Mechanical System

CONSTRUCTION COSTING SYSTEM

ACCOUNT NUMBER	DESCRIPTION
2.2.0707	Plumbing Services
2.5.0801	Foundation
2.5.0802	Structural Frame
2.5.0803	Exterior Closure
2.5.0804	Interior Finishes
2.5.0805	Electrical Service (Power & Lighting)
2.5.0806	Mechanical System
2.5.0807	Plumbing Services
2.6	Spare Parts/Equipment Inventories - Summary account of all spare parts and associated equipment purchased during constuction phase and placed into inventory. Summary is total of eight system component sub accounts into which spare parts are entered as they are ordered and received as part of initial system construction contracts.
2.6.01	Collector/Array System
2.6.02	Tracking/Drive System
2.6.03	Power Conditioning System
2.6.04	Electrical System
2.6.05	Electrical Storage System
2.6.06	Thermal Storage System
2.6.07	Instrumentation/Data Collection System
2.6.08	Safety & Security System
2.7	Equipment for Start-Up/Check-Out - This account represents the sum of all costs of equipment, materials, tools, and minor expendables that are neither integral parts of the PV system, or spare parts of the system, but required by the project for initial start-up. This account closes as of commissioning and the continuing costs of retained equipment and materials passed over the project operations accounts.

CONSTRUCTION COSTING SYSTEM

ACCOUNT NUMBER	DESCRIPTION
2.7.11	Maintenance Vehicles/Material Handling Equipment - Lease or purchase, and operating costs of vehicles, carts, dollies, or other equipment used during system start-up and not attributable to the construction cost of any particular PV system component.
2.7.12	Maintenance Tools & Equipment - All costs for tools and equipment required for general startup/check-out operations but not attributable to construction cost of any particular PV system component.
2.7.13	Expendables - All administrative, building maintenance, and project operation materials expended during start-up interim. All expendables not directly attributable to construction activities but required prior to system commissioning.
3.0	Project Operations (Annualized) - Summary account for system operating costs on yearly basis.
3.1	Continuing Land Costs - Summary account for 3.1.11 - Principle and Interest, and 3.1.12 - Taxes sub-account payments subsequent to PV system commissioning date.
3.1.11	Principle & Interest - Account intended for land cost commitments and expenditures only. Payments on loans, if any, taken for project construction costs must be placed in separate sequential accounts to be opened as required.
3.1.12	Taxes - All tax payments subsequent to project commissioning date. Tax increases due to site improvements to be carried within same account.
3.2	Personnel (Administrative and Operation Staff) - Summary account of all direct personnel expenditures for all full or part-time employees of PV facility.
3.2.11	Salaries
3.2.12	Benefits
3.2.13	Expenses - Separate sub accounts for personnel salaries, benefits, and reimbursable expenses.
3.3.	Utilities - Summary account for expenditures for all water, sewer, telephone, and electrical service serving the PV facility. Add sub accounts as required for gas and other services.

CONSTRUCTION COSTING SYSTEM

ACCOUNT NUMBER	DESCRIPTION
3.3.11	Water
3.3.12	Sewer
3.3.13	Telephone
3.3.14	Electrical Service - Sub accounts for expenditures to each separate utility.
3.4	Insurance - General account for premiums and related costs for all insurance requirements for the PV facility under operation.
3.5	Administrative Supplies - Summary account for two sub accounts of administrative furnishings and equipment, and supply/expense items.
3.5.11	Furnishings - Cost of all furniture, furnishings, typewriters, and copying equipment as required to establish operating administrative offices for PV facility.
3.5.12	Office Supplies/Expenses - Cost of all office use related expendables, and expenditures for reproduction and postage.
3.6	Systems Maintenance - Summary account for all costs of maintaining the PV system in operating order. The sub accounts assume that major replacement parts will be drawn from spare parts inventory (replaced under spearate accounts), and minor parts will be purchased directly as needed. Account to capture costs for labor related to maintenance and the cost of parts purchased. Withdrawals from inventory to be made at no cost to accounts 3.6 and sub accounts 3.6.11 and 3.6.12, but recorded in account 3.7 - Parts Replacement to Inventory.
3.6.11	Preventative Maintenance (Parts from Inventory) - All costs for preventative maintenance program as developed on any or all components of the system. If an extensive P.M. program is established, sub-accounts to 3.6.11 may be set up to separate costs for individual components.
3.6.1101	Valves
3.6.1102	Pumps

ACCOUNT NUMBER	DESCRIPTION
3.6.1103	Switches
3.6.1104	Gauges
3.6.1105	Breakers
3.6.1106	Other
3.7	Parts Replacement to Inventory - Summary account of costs incurred to replace inventory from the several system component sub accounts per an established replacement interval.
3.7.01	Collector/Array Systems
3.7.02	Tracking/Drive Systems
3.7.03	Power Condtioning System
3.7.04	Electrical System
3.7.05	Electrical Storage System
3.7.06	Thermal Storage System
3.7.07	Instrumentation/Data Collection Systems
3.7.08	Safety/Security Systems
3.8	Buildings & Grounds Maintenance - Summary account for all maintenance expenditures for project facilities (building, site, and general cleaning) other than photovoltaic system specific equipment.
3.8.11	Building Enclosure Maintenance - Cost of maintaining the building "envelope", including but not limited to painting, reroofing, and glass replacement.
3.8.12	Building Systems Maintenance - Cost of maintaining the building mechanical, electrical, and plumbing systems.
3.8.13	Building Janitorial (Including Supplies) -Expenditures for janitorial services, required cleaning supplies, and building use expendables (light bulbs, filters, and paper towels.)
3.8.14	Grounds Maintenance - Summary account for all maintenance expenditures for open site area.

ACCOUNT NUMBER	DESCRIPTION
3.8.1401	Growth Containment - Cost of cutting or trimming grass and/or vegetation for both appearance maintenance and array clearance.
3.8.1402	Array Cleaning - Cost of periodic cleaning of array reflective and receiving surfaces.
3.8.1403	General Repair (Fencing, Paving, Litter Removal) - Cost of general site repair and clean-up work as required.
3.9	Equipment (Maintain & Replace) - Summary account for three sub accounts to maintain and replace, or initially purchase the vehicles, tools, and equipment required to service the facility. Record itemized expenditures in accounts 3.9.11 - 3.9.13.
3.9.11	Service Vehicles
3.9.12	Tools/Equipment
3.9.13	Test Equipment

C. Cost Performance Analysis

As photovoltaic systems are in an early development phase, all efforts focus on producing electrical energy more economically, always looking to the goal of matching or exceeding the efficiency of other energy resources.

All performance factors included in this section relate development and progress to cost. As cited earlier, one of the major goals of this cost account structure was to give visibility to the cost of separate components and sub-components, making it possible for project managers to monitor progress as related to cost savings, therefore providing the data necessary to determine where research emphasis should be placed.

The account structure design provides the following to enhance performance evaluation:

- The selected accounts give visibility to all separate components or sub-components of interest.
- The assignations and cross referencing provide for the recall and subtotaling by multiple alternatives and,
- The adjustment factors provide for the purging of exogenously imposed costs so that similar projects and/or sub-systems can be meaningfully compared on an "apples-to-apples" basis.

Due to the divisions represented in the account structure, there are several parameters available with which to judge performance. With the finite breakdown of management and design times and costs, parameters can be selected for evaluating the relative efficiencies experienced during the development phases of the PV systems. The construction cost breakdowns provide component by component detailed cost information which can be related directly to "design" output and "actual" output. The account entries for operations and maintenance provide an opportunity to monitor and record monies allocated and/or spent to maintain each component system at full operating capacity.

Although any single cost or time data point can be placed in relationship to some aspect of system output or point of comparison with similar data from other system accounts, the most likely parameters to be used for performance comparison are as follows:

- Total Project Cost
- Total PV System Cost Exclusive of Non-PV related Costs
- Total PV System DOE Cost
- Total Adjusted PV System Cost (adjusted to normalize exogenous costs imposed by location, timing, and contractual commitments)
- Total Component Cost
- Total Ajusted (normalized) Component Costs
- Total Development Costs
- Total Construction Costs
- Total O & M Costs (annualized)
- Design Output (AC side)
- Design Output (DC side)
- Design Thermal Energy Output
- Actual Output (AC side)
- Actual Output (DC side)
- Actual Thermal Energy Output
- Total Area (Flat Panels)
- Total Area (Concentrator)

The most common performance comparison used by the PV system development community has been the Cost/ (watt peak Wp). With the information available, multiple views of this comparison can readily be established.

- Total Project Cost/Wp
- Total PV System Cost (Exclusive of Non-PV related costs) Wp
- Total PV System DOE Cost/Wp
- Total Adjusted PV System Cost/Wp
- Land Acquisition/Wp

- Cost of Each System Component/Wp
- Total Development Cost/Wp
- Total Construction Cost/Wp
- Operations and Maintenance (Annual-Cost)/Wp

Using the Basic System Data Sheet, comparisons can be made between cost and design output, and then following checkout and commissioning, between cost and actual output. The information on collector area, panel area, total site area, number and rating of PCU's allowed for ready comparisons between costs and physical capacities.

Within the cost breakdowns, subtotals can be extracted and compared easily with other subtotals or individual entries within the given system or other systems that have been similarly recorded. For example:

- Development Costs/Total Project Costs
- Development Costs/Construction Costs
- O & M (annualized costs)/Construction Costs.

Given the numerous cost breakdowns, coding and cross referencing capabilities built into the system, the performance comparisons available to the user are virtually unlimited and easily performed.

APPENDIX A

SAMIS CASE 1: 200 KW PCU

The following example case demonstrates the use of the SAMIS model.

The case involves a hypothetical power conditioning unit manufacturer with a factory in Los Angeles, California. The company currently manufactures power conditioning units of one standard size 10 kilowatts. The company has been very successful with this product and is considering an expansion to add a 200 kilowatt power conditioning unit to its product line.

It is 1980 and the company anticipates rapid growth over the next five years due to the commercialization of photovoltaic solar energy systems. The company's power conditioning unit will be used in these photovoltaic systems to convert electricity from D.C. to A.C. While the 10 KW unit is about the right size for small residential energy systems, the company needs a larger 200 KW unit to supply the market for commercial systems.

To evaluate this strategic decision, the engineering department has just completed a detailed design of a 200 KW uninteruptible power supply with 3 phase, 220 volts and 2 PC cards per phase. The unit is not line commutated. It is 107" high, 120" wide, 33.5" deep and weighs 6000 lbs.

The engineering department has also specified a ten step manufacturing process sequence for the new product.

MANUFACTURING PROCESS SEQUENCE

- fan assembly.
- inverter leg assembly with 6 PC cards wired and mounted on a chassis.
- filter assembly.
- EMI filter assembly.
- module testing.
- receive, test and mount assembled logic cards on drawers.
- install all heavy components and subassemblies in the main cabinet.
- final testing of unit both static and electrical.
- paint the cabinet.
- package units in wooden boxes for shipment.

For each process in the sequence, the engineers have identified requirements for equipment, materials, labor, utilities and facilities.

The president of the company would like to estimate how much capital would be required to build a new plant in Los Angeles capable of producing 45 of these new 200 KW units per year. He would also like to know how much it will cost to manufacture the units in $ per watt and what price to charge in order to earn a net profit after tax of 18%. Finally, he wants an estimate of how long it will take to construct the factory and start production.

The Vice President of Personnel would also like to know how many and what types of people will be needed to staff the new plant. The facilities design group is interested in the nature of the new facilities including the total square footage by type of space. The plant will be sized to produce 45 units per year at 100 percent of capacity with one shift per day, thereby, allowing for expansion by adding operating shifts.

The executive committee decided that the Corporate Planning Department should be responsible for the study. The Vice President of Finance provided the following financial parameters:

FINANCIAL PARAMETERS

- debt interest rate 12.5%/year
- rate of return on equity 17.2%/year
- leverage (total assets/equity) 1.2
- insurance rate 4% of revenues/year
- non-income taxes 2% of revenues/year
- tax depreciation method-double declining balance
- book depreciation method-straight line
- facility tax life 40 years
- accounts receivable turnover 55 days
- accounts payable turnover 55 days
- finished goods inventory turnover 15 days
- raw materials inventory turnover 15 days.

The Corporate Planning Department could perform this analysis with the SAMIS model. To do this, the quantitative information is compiled in the following three formats for input to the computer:

- Format C - Industry Description covers general information about the industry including the name, product, quantity produced, hardware performance and the names of the company along with their estimated market share.

- Format B - Company Description summarizes the company name, product produced, and each manufacturing process.

- Format A - Process Description includes process name, output rate product name, process characteristics, equipment cost factors, direct facilities and personnel requirements, direct byproducts, utilities, commodities, and input product requirements.

SAMIS CASE 1: 200 KW PCU

FORMAT C - INDUSTRY DESCRIPTION

C-1 INDUSTRY REFERENT PCU

C-2 INDUSTRY DESCRIPTION Power Conditioning Unit

C-3 INDUSTRY OBJECTIVE 9,000 KW/year

C-4 ANNUAL VOLUME 45 units/year

DESCRIPTION OF THE FINAL PRODUCT OF THE INDUSTRY

C-5 PRODUCT REFERENT INVERTER

PRODUCT NAME Series Z-200 KW

C-6 PRODUCTION MEASURED units/year

C-7 HARDWARE PERFORMANCE 200 KW/inverter

C-8 PRODUCT DESIGN DESCRIPTION 200 KW uninteruptible power supply, 3 phase, 220 volt, not line commutated

COMPANIES OF THE INDUSTRY

C-9	COMPANY NAME	INVERTERCO	MARKET SHARE	100%
	COMPANY NAME		MARKET SHARE	
	COMPANY NAME		MARKET SHARE	
	COMPANY NAME		MARKET SHARE	
	COMPANY NAME		MARKET SHARE	

SAMIS CASE 1: 200 KW PCU

FORMAT B - COMPANY DESCRIPTION

B-1 COMPANY REFERENT INVERTERCO

B-2 DESCRIPTION Manufacturer of 200 KW power conditioning units

B-3 FINAL PROCESS PACKING FINAL PRODUCT INVERTER

B-4 MANUFACTURING PROCESS SEQUENCE

PROCESS	PAINTING	PRODUCT	PAINTEDUNIT	RATIO	1.0
PROCESS	FINTEST	PRODUCT	TESTEDUNIT	RATIO	1.0
PROCESS	CABASSY	PRODUCT	FINALUNIT	RATIO	1.0
PROCESS	LGCASSY	PRODUCT	LGCDRWR	RATIO	1.0
PROCESS	MODTEST	PRODUCT	TESTEDMODULE	RATIO	1.0
PROCESS	EMIFTASSY	PRODUCT	EMIFTUNIT	RATIO	1.0
PROCESS	FILTASSY	PRODUCT	FILTERUNIT	RATIO	1.0
PROCESS	LEGASSY	PRODUCT	LEGUNIT	RATIO	1.0
PROCESS	FANASSY	PRODUCT	FANUNIT	RATIO	1.0
PROCESS		PRODUCT		RATIO	
PROCESS		PRODUCT		RATIO	
PROCESS		PRODUCT		RATIO	
PROCESS		PRODUCT		RATIO	
PROCESS		PRODUCT		RATIO	
PROCESS		PRODUCT		RATIO	

B-5 PURCHASED PRODUCT none RATIO

SUPPLIER AND PERCENTAGE

SUPPLIER AND PERCENTAGE

FORMAT B - FINANCIAL PARAMETERS*

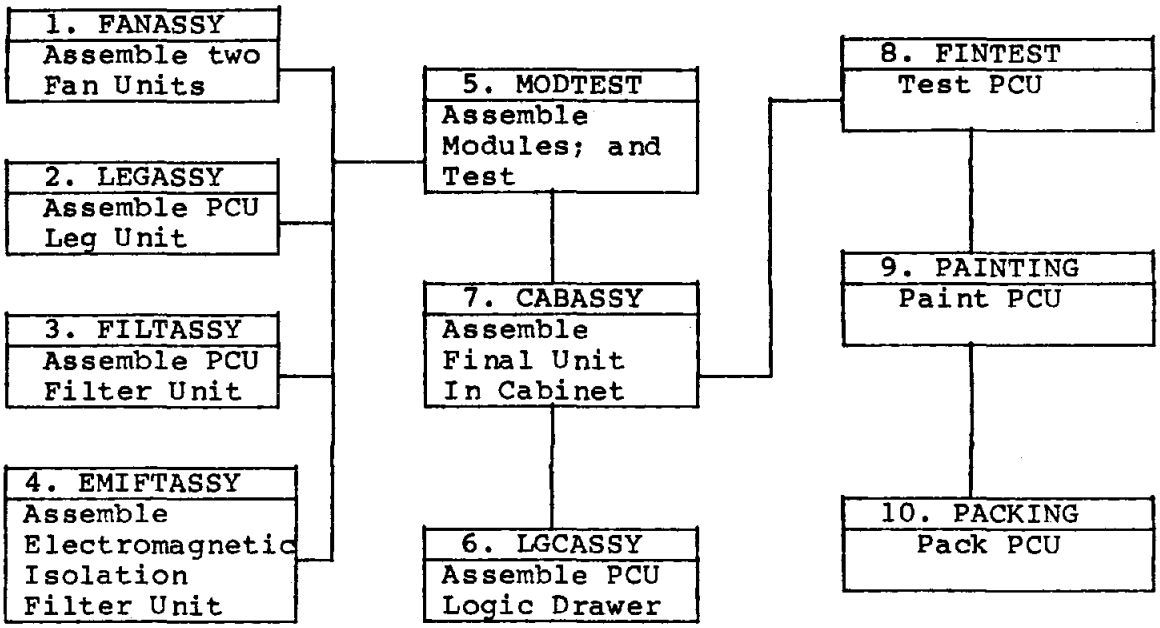
B-1 Percent of Capacity (100%) 100%
B-2 Financial Leverage (1.2 $/$) 1.2
B-3 Debt Interest Rate (9.25%/year) 12.5%/year
B-4 Other Tax Rate (2%/year) 2%/year
B-5 Insurance Rate (4%/year) 4%/year
B-6 Facility Life (40 years) 40 years
B-7 Rate of Return on Equity (21%/year) 17.2%/year
B-8 Miscellaneous Expense (% of Revenues) (3%) 3%
B-9 Miscellaneous Expense (% of Operating Expenses) (4%) 4%
B-10 Miscellaneous Expense (% of Capital Assets) (0%) 0%
B-11 Facilities Tax Depreciation Method (DDB) DDB
B-12 Facilities Book Depreciation Method (SL) SL
B-13 Facilities Inflation Rate Table (1975 8%/year) 1975 8%/year
B-14 Raw Materials Inventory Time (0.04 years) .04 years
B-15 Processing Time Multiplier (1.0 min/min) 1.0
B-16 Finished Goods Inventory Time (.04 years) .04 years
B-17 Accounts Receivable Turnover Time (.10 years) .15 years
B-18 Accounts Payable Turnover Time (.09 years) .15 years
B-19 Startup Direct Commodity Usage Fraction (1.25 units/unit)
B-20 Startup Production Fraction (.635 units/unit) .635
B-21 Cash Balance Operation Time (.06 years) .06 years
B-22 Between Process Inventory Time (0 years) 0 years
B-23 Fiscal Hours Per Shift (8 hour/shift) 8
B-24 Fiscal Minutes Per Fiscal Hour (60) 60
B-25 Fiscal Days Per Fiscal Week (7 days/weeks) 7
B-26 Fiscal Weeks Per Fiscal Year (52.1429 weeks/year) 52
B-27 Closed Weekdays Per Fiscal Year (20 days/year) 20
B-28 Working Hours Per Person Per Shift (8 hours/person/shift) 8
B-29 Working Days Per Working Week (5 days/week) 5
B-30 Paid Holidays Per Fiscal Year (8 days/year) 8
B-31 Paid Vacation Days Per Fiscal Year (13.5 days/year) 18.5
B-32 Working Weeks Per Fiscal Year (52.1429 weeks/year) 52
B-33 Average Paid Absenteeism Days Per Fiscal Year (17.5 days/year) 17.
B-34 Second Shift Wage Factor (1.15) 1.15
B-35 Third Shift Wage Factor (1.20) 1.20
B-36 Fourth Shift Wage Factor (1.20) 1.20
B-37 Number of Shifts Per Day (2 shifts/day) 1
B-38 Facilities Contingency Percentage (15%) 15%
B-39 Equipment Contingency Percentage (15%) 15%

* SAMIS default values are listed in parenthesis

SAMIS CASE 1: 200 KW PCU

The power conditioning unit sequence consists of ten distinct processes summarized below.

OPERATIONS PROCESS CHART



The following paragraphs briefly describe each manufacturing process.

- INSPECTION: The components are delivered from outside suppliers and inspected at this station. Major and more expensive components are individually inspected whereas smaller and more frequently used ones are checked on a sample basis.

- STORAGE: After inspection, the components are stored in a separate area until they can be assembled.

  The components are then manually moved to the next sub assembly station where printed circuit cards and harnesses are assembled. Small components are mounted and wiring networks interconnected for the fan assembly, leg assembly and filter.

- FANASSY: Two fan units are assembled. (Yield = 98%)

- LEGASSY: Six printed circuit cards are assembled and then mounted on a chassis. The chassis is on a cart which is ten rolled around to receive assembly boards. (Yield = 95%)

SAMIS CASE 1: 200 KW PCU

- FILTASSY: All switch filter assembly components are assembled onto a chassis. (Yield = 96%)

- EMIFTASSY: All electromagnetic isolation components are assembled onto a chassis. (Yield = 98%)

- MODTEST: The assembled printed circuit boards mounted on a chassis are then rolled on their carts to an area where they are tested within the sub assembly Station. (Yield = 97%)

- LGCASSY: While the fans, legs, and filter components are being assembled and tested in their station, assembled logic cards are received, tested, and mounting on logic drawers in a separate station. (Yield = 96%)

- CABASSY: All heavy components and subassemblies from two stations are finished in this area and installed in the cabinets. The large transformers and large inductors are mounted first and then the module subassemblies are installed. Finally, the power cablings are made to produce the final product. (Yield = 98%)

- FINTEST: The assembled unit is then rolled on a cart to another station where it undergoes a static test (physical, switches, drawers) and an electrical one. (Yield = 96%)

- PAINTING: The unit is moved to a station where the cabinet is painted. (Yield = 98%)

- PACKAGING: The assembled and painted unit is then packaged into a wooden box which is specifically designed to withstand shipping. This is the final station. (Yield = 96%)

SAMIS CASE 1: 200 KW PCU

Using the SAMIS model, the company estimates that it will have to charge an average price of $74,036 per unit or $.37/watt in order to cover all costs and earn a net profit after tax of 18% of sales. SAMIS generated the following pricing information for the 200 kilowatt power conditioning unit.

PRODUCT PRICING INFORMATION

	$/Unit	$/Watt	Percent
Direct Costs			
Labor	9170	.046	12.4%
Materials	21178	.106	28.6%
Utilities	72	.000	.1%
Subtotal	30420	.152	41.1%
Burden Expenses			
G & A	10934	.055	14.8%
Depreciation	1272	.006	1.7%
Insurance	2764	.014	3.7%
Property Tax	833	.004	1.2%
Subtotal	15803	.079	21.4%
Other Expenses			
Interest	896	.004	1.2%
Income Tax	13556	.068	18.3%
Subtotal	14452	.072	19.5%
Net Profit	13361	.067	18.0%
Product Price	74036	.370	100.0%

Total burden expenses make up about 52% of direct manufacturing costs. This is slightly lower than the company has experienced with its 10 kilowatt product. However, the end price of $.37 per watt is 10 percent lower than the closest competitor's price. Materials represent the largest component making up 28.6% of the price as indicated by the following bill of materials.

SAMIS CASE 1: 200 KW PCU

BILL OF MATERIALS

Part No.	Name	Cost/Unit
E9375	Burden Parts	$5,275
E9232	Assembled P.C. Cards (Logic)	3,076
E5088	Transformer, Power, Large	3,035
E7008	Inductor, 1.4 MH/35A	1,930
E2056	Capacitor, .5 MF/800V	1,846
E7024	Inductor, Very Large	919
E5072	Transformer, Isolation	873
E3040	Diode, Power	714
E8008	Fuse, Semiconductor Type	629
E2040	Capacitor, 90 MF/450V	583
E9312	Enclosure, Metal Cabinet	451
E9344	Crates, Wooden Packing	278
E9200	Bus Bar	264
E8024	Fuse, Slow, Semiconductor Type	248
E9136	P.C. Card, Average Size	172
E9216	Heat Sink, Linear	121
E9296	Plate, Air Flow Indicator	115
E9168	Connector, Circular Multipin Plug	110
E9248	Fan, Shroud with Motor Assembly	102
E3008	Diode, Small	80
E5008	Transformer, Small Encapsulated	77
E6008	Switch, Toggle	38
E9184	Connector, Linear Multipin	38
E3168	Thyristor, 550A/1000V	30
E9360	Paint	26
E9280	Air Filter: 2'x 2' Screen	24
E8040	Fuse, 400/600V	23
E1056	Resistor: 26 Watt/500 Ohm, Power	22
E9120	P.C. Card Assembly: Metal Mounting	17
E6040	Switch, Thermostatic	13
E2024	Capacitor: IMF./50V (Small)	9
E2008	Capacitor: 1200 PF/100V	7
E6056	Switch: Air Flow	7
E6024	Switch: Pushbutton/Tap	6
E1024	Resistor: 2 Watt, Carbon	5
E1072	Resistor: 113 Watt/200 Ohm/5%	5
E9008	Lamp: Small Pilot	4
E1040	Resistor: 5 Watt, Power	3
E3056	Transistor: NPN, Medium Power	2
E1008	Resistor: 1/2 watt, Carbon	1
	TOTAL PARTS COST	$21,178

SAMIS CASE 1: 200 KW PCU

The SAMIS model indicates that approximately $3.1 million will be required for investment in the new plant with a construction lead time of 2 years and another year for production startup.

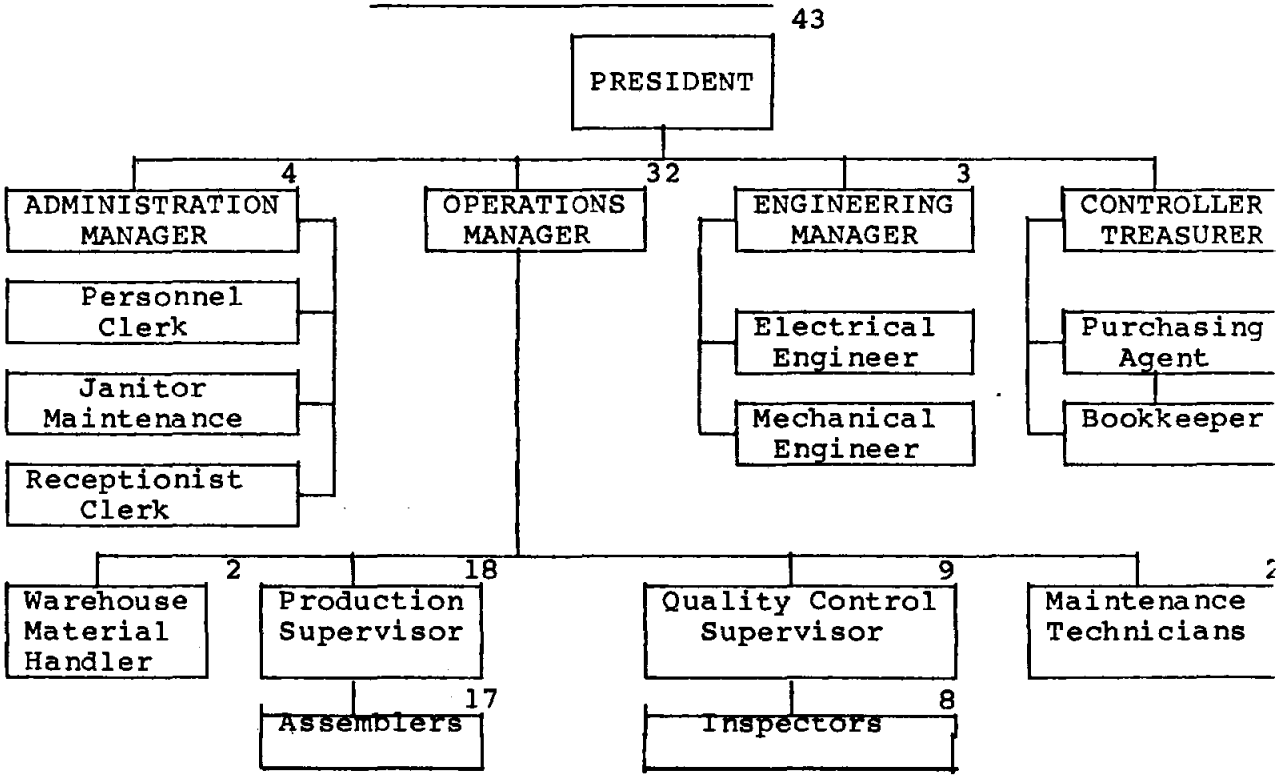
STARTUP CAPITAL REQUIREMENTS	
Facilities	$1,308,470
Land	15,218
Equipment	211,922
Working	1,588,891
TOTAL	$3,124,501

Not many people will be employed in the new facility which is primarily capital intensive:

PERSONNEL		
Direct Manufacturing	29	67%
Indirect Staff	14	33%
TOTAL	43	100%

The following organization chart displays the mix of personnel required by functional area.

PERSONNEL ORGANIZATION



SAMIS CASE 1: 200 KW PCU

With projected revenues of $3,331,637 per year, this is equivalent to $77,480 per employee or stated another way about 1.05 PCU's per employee per year.

SAMIS projects the following facilities space requirements:

FACILITIES SPACE REQUIREMENTS
(Square feet)

Manufacturing Space	14245
Storage Space - In process	82
Office Space - Manufacturing	141
Warehouse	356
Shipping/Receiving Dock	71
Machine Shop	118
Mechanical Equipment Room	47
Electrical Equipment Room	362
Computer Room	18
Rest Rooms	89
Cafeteria and Lunchroom	31
Office Space - Administration	424
Passages and Corridors	3011
TOTAL SPACE	18995

SAMIS provides the following cost information for the manufacturing processes.

MANUFACTURING PROCESS COST SUMMARY

Process Name	Direct Cost/Year	Labor Percent	Material Percent	Other Percent	Percent of Total
1. FANASSY	$ 19,775	1%	2%	0.5%	1.5%
2. LEGASSY	386,509	22%	31%	17.0%	28.0%
3. FILTASSY	206,800	10%	17%	3.0%	15.0%
4. EMIFTASSY	10,312	1%	1%	0.5%	1.0%
5. MODTEST	44,926	7%	2%	4.0%	3.5%
6. LGCASSY	249,336	17%	18%	11.0%	18.0%
7. CABASSY	378,277	27%	28%	19.0%	28.0%
8. FINTEST	56,223	14%	0%	7.0%	4.0%
9. PAINTING	2,562	0.5%	0%	15.0%	0.0%
10. PACKING	14,178	0.5%	1%	23.0%	1.0%
	$1,368,898	100.0%	100%	100.0%	100.0%

Total labor accounts for 30 percent and total material 70 percent of the total annual direct manufacturing cost of goods sold.

SAMIS CASE 1: 200 KW PCU

The following tools and equipment are needed for this manufacturing operation.

TOOLS AND EQUIPMENT

	No. of Units	Total Purchase Price
Scope	3	$30,000
Universal Card Tester	1	25,000
Subassembly Test Fixture	1	20,000
Temperature & Vibration Tester	1	20,000
Car Forklift	2	15,000
Kennedy Tool Boxes	29	10,150
Wire Continuity Tester	1	10,000
Hand Forklift	4	6,000
Metering Panel	1	6,000
Switch Gear	1	4,000
Carts	10	3,000
Storage Rack	3	3,000
Power Supplies	3	3,000
Test Equipment	-	2,000
Load Bank	1	2,000
Voltmeters	4	1,400
Voltohmeter	3	1,350
Solder Pots	4	1,200
Spray Guns	2	1,000
Hydraulic Crimpers	3	750
Cart	2	600
Hydraulic Press	1	500
Ladder	2	500
Wire Crimpers	3	450
TOTAL		$161,900

SAMIS CASE 1: 200 KW PCU

Based on the SAMIS results, the company's financial analyst compiled a proforma income statement using the company's standard chart of accounts.

PROFORMA INCOME STATEMENT		
Revenues		$3,331,637
Cost of Goods Manufactured		
Labor	$412,688	
Materials	952,989	
Utilities	3,221	
		$1,368,898
Contribution Margin		$1,962,739
Overhead		
Depreciation	57,249	
Property Tax	37,507	
Insurance	124,371	
		219,127
Gross Profit		$1,743,612
General & Administrative		
Salaries	307,703	
Utilities	50,349	
Supplies & Miscellaneous	133,963	
		$ 492,015
Operating Income		$1,251,597
Interest Expense		40,327
Profit Before Tax		$1,211,270
Income Tax		610,004
Net Income		$ 601,266

These results for the hypothetical power conditioning unit manufacturer of course would vary substantially with production level. The capital investment required, the number of people, the size of facilities all depend on the production volume. Several of the financial parameters such as the required rate of return on equity and the manufacturing process input also have a significant impact on the results. The SAMIS model is a useful tool to analyze all of these interdependent variables simultaneously.

APPENDIX B

SAMIS CASE 2: 10 KW PCU

The following example case demonstrates the use of the SAMIS model.

The case involves a hypothetical power conditioning unit manufacturer with a factory in Los Angeles, California. The company currently manufactures power conditioning units of one standard size: 10 kilowatts. These units are used in photovoltaic solar energy systems to convert electricity from D.C. to A.C.

It is 1980 and the company anticipates rapid growth over the next five years due to the commercialization of photovoltaic solar energy systems. The 10 KW unit is about the right size for small residential energy systems. To supply the rapidly growing market for systems the company needs a larger manufacturing plant.

To evaluate this strategic decision, the engineering department has just completed a detailed design of an advanced 10 KW uninteruptible power supply with 3 phases and 220 volts.

The mechanical design of this unit is oriented toward high quality production and for use in the basement of a home. The transformer and the inductor are mounted in the bottom for a low center of gravity. An enclosure on 12" legs forms the housing of the unit. The bottom is perforated for inlet air. Louvers are located at both ends for outlet air. Dimensions are 4' W x 2" D x 3' H. Estimated weight is 560 lbs.

The engineering department has also specified a twenty-two step manufacturing process sequence for the new product. For each process in the sequence, the engineers have identified requirements for equipment, materials, labor, utilities and facilities.

The president of the company would like to estimate how much capital would be required to build another plant in Los Angeles to produce 500 of these new 10 KW units per year. He would also like to know how much it will cost to manufacture the units and what price to charge in order to earn a net profit after tax of 16%. Finally, he wants an estimate of how long it will take to construct the factory and startup production.

SAMIS CASE 2: 10 KW PCU

The Vice President of Personnel would also like to know how many and what types of people will be needed to staff the new plant. The facilities design group is interested in the nature of the new facilities including the total square footage by type of space. The plant will be sized to produce 500 units per year at 100 percent of capacity with one shift per day, thereby, allowing for expansion by adding operating shifts.

The executive committee decided that the Corporate Planning Department should be responsible for the study. The Vice President of Finance provided the following financial parameters for the analysis:

FINANCIAL PARAMETERS

- debt interest rate 12.5%/year
- rate of return on equity 17.2%/year
- leverage (total assets/equity) 1.2
- insurance rate 4% of revenues/year
- non-income taxes 2% of revenues/year
- tax depreciation method-double declining balance
- book depreciation method-straight line
- facility tax life 40 years
- accounts receivable turnover 55 days
- accounts payable turnover 55 days
- finished goods inventory turnover 15 days
- raw materials inventory turnover 15 days

The Corporate Planning Department could perform this analysis with the SAMIS model. To do this, the quantitative information is compiled in the following three formats for input to the computer:

- Format C - Industry Description covers general information about the industry including the name, product, quantity produced, hardware performance and the names of the company along with their estimated market share.

- Format B - Company Description summarizes the company name, product produced, and each manufacturing process.

- Format A - Process Description includes process name output rate, product name, process characteristics, equipment cost factors, direct facilities and personnel requirements, direct byproducts, utilities, commodities, and input product requirements.

SAMIS CASE 2: 10 KW PCU

FORMAT C - INDUSTRY DESCRIPTION

C-1 INDUSTRY REFERENT PCU

C-2 INDUSTRY DESCRIPTION Power Conditioning Unit

C-3 INDUSTRY OBJECTIVE 5,000 KW/year

C-4 ANNUAL VOLUME 500 units/year

DESCRIPTION OF THE FINAL PRODUCT OF THE INDUSTRY

C-5 PRODUCT REFERENT PCU

PRODUCT NAME Series R2D2-10 KW

C-6 PRODUCTION MEASURED units/year

C-7 HARDWARE PERFORMANCE 10 KW/PCU

C-8 PRODUCT DESIGN DESCRIPTION 10 KW uninteruptible power supply, 3 phase, 220 volt, not line commutated.

COMPANIES OF THE INDUSTRY

C-9	COMPANY NAME	PCUCO	MARKET SHARE	100%
	COMPANY NAME		MARKET SHARE	
	COMPANY NAME		MARKET SHARE	
	COMPANY NAME		MARKET SHARE	
	COMPANY NAME		MARKET SHARE	

SAMIS CASE 2: 10 KW PCU
FORMAT B - COMPANY DESCRIPTION

B-1 COMPANY REFERENT PCUCO
B-2 DESCRIPTION Manufacturer of 10 KW power conditioning units
B-3 FINAL PROCESS PCUPACK FINAL PRODUCT PCU
B-4 MANUFACTURING PROCESS SEQUENCE

PROCESS	PCUTEST	PRODUCT	PRODUC21	RATIO	1.0
PROCESS	PCTEST	PRODUCT	PRODUC20	RATIO	1.0
PROCESS	PCSOLDER	PRODUCT	PRODUC19	RATIO	1.0
PROCESS	PCASSMBL	PRODUCT	PRODUC18	RATIO	1.0
PROCESS	CASSDK2	PRODUCT	PRODUC17	RATIO	1.0
PROCESS	TSTDK2	PRODUCT	PRODUC16	RATIO	1.0
PROCESS	WREDCK2	PRODUCT	PRODUC15	RATIO	1.0
PROCESS	ASSDCK2	PRODUCT	PRODUC14	RATIO	1.0
PROCESS	TSTHEATS	PRODUCT	PRODUC13	RATIO	1.0
PROCESS	WREHEATS	PRODUCT	PRODUC12	RATIO	1.0
PROCESS	ASSHEATS	PRODUCT	PRODUC11	RATIO	1.0
PROCESS	ASSDKI	PRODUCT	PRODUC10	RATIO	1.0
PROCESS	DKITEST	PRODUCT	PRODUC09	RATIO	1.0
PROCESS	DKIWIRE	PRODUCT	PRODUC08	RATIO	1.0
PROCESS	DKIASSM	PRODUCT	PRODUC07	RATIO	1.0
PROCESS	ASSDKO	PRODUCT	PRODUC06	RATIO	1.0
PROCESS	TSTXFRMR	PRODUCT	PRODUC05	RATIO	1.0
PROCESS	VRNXFRMR	PRODUCT	PRODUC04	RATIO	1.0
PROCESS	ASSXFRM	PRODUCT	PRODUC03	RATIO	1.0
PROCESS	LAMXFMR	PRODUCT	PRODUC02	RATIO	1.0
PROCESS	ASSCOILS	PRODUCT	PRODUC01	RATIO	1.0

B-5 PURCHASED PRODUCT none RATIO

SAMIS CASE 2: 10 KW PCU

FORMAT B - FINANCIAL PARAMETERS*

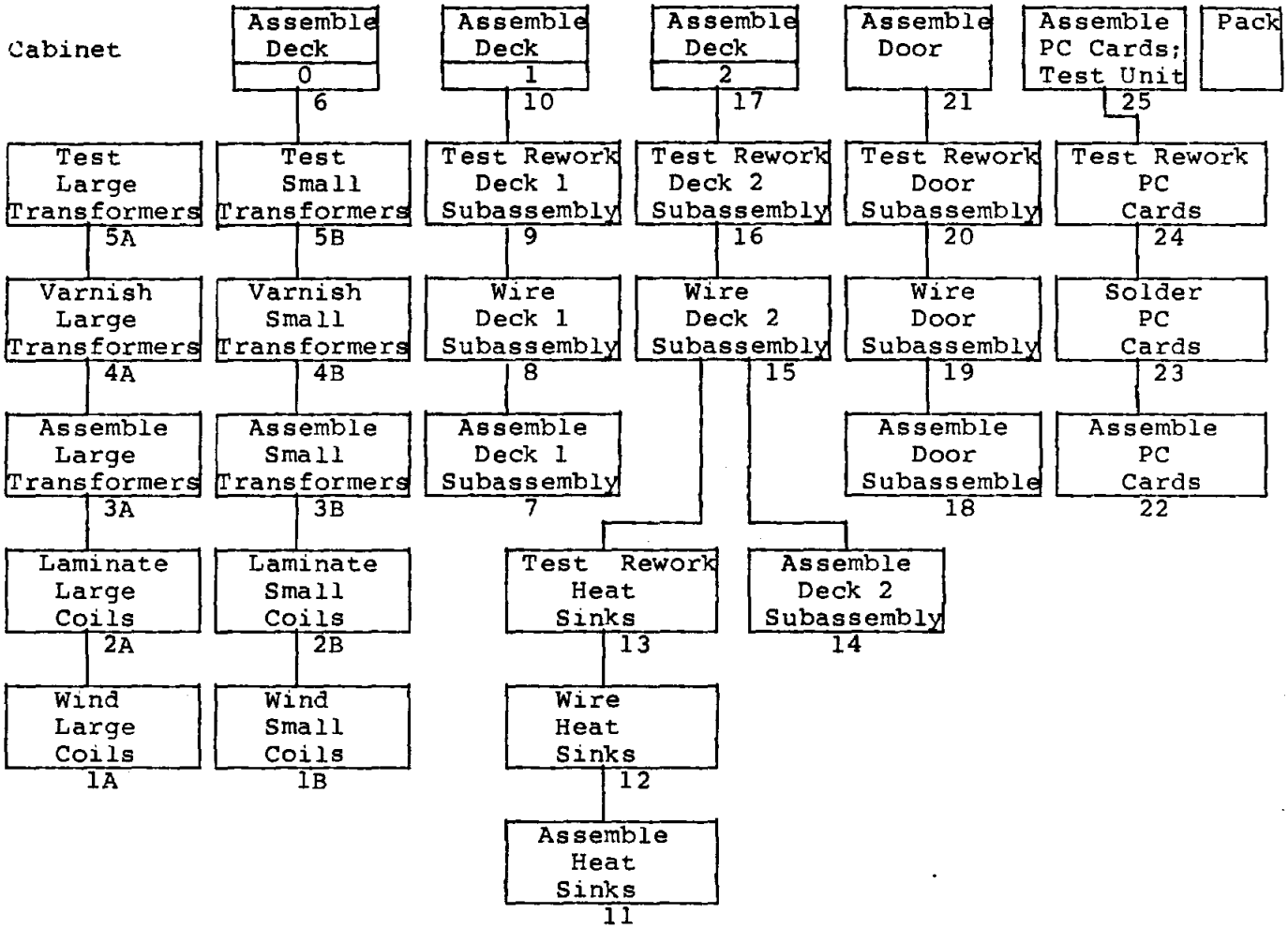
B-1 Percent of Capacity (100%) 100%
B-2 Financial Leverage (1.2 $/$) 1.2
B-3 Debt Interest Rate (9.25%/yr) 12.5%/year
B-4 Other Tax Rate (2%/yr) 2%/year
B-5 Insurance Rate (4%/yr) 4%/year
B-6 Facility Life (40 yrs) 40 year
B-7 Rate of Return on Equity (21%/yr) 17.2%/year
B-8 Miscellaneous Expense (% of Revenues) (3%) 3%
B-9 Miscellaneous Expense (% of Operating Expenses) (4%) 4%
B-10 Miscellaneous Expense (% of Capital Assets) (0%) 0%
B-11 Facilities Tax Depreciation Method (DDB) DDB
B-12 Facilities Book Depreciation Method (SL) SL
B-13 Facilities Inflation Rate Table (1975 8%/yr) 1975 8%/year
B-14 Raw Materials Inventory Time (0.04 yrs) .04 years
B-15 Processing Time Multiplier (1.0 min/min) 1.0
B-16 Finished Goods Inventory Time (.04 yrs) .04 years
B-17 Accounts Receivable Turnover Time (.10 yrs) .15 years
B-18 Accounts Payable Turnover Time (.09 yrs) .15 years
B-19 Startup Direct Commodity Usage Fraction (1.25 units/unit)
B-20 Startup Production Fraction (.635 units/unit) .635
B-21 Cash Balance Operation Time (.06 yr) .06 years
B-22 Between Process Inventory Time (0 yrs) 0 years
B-23 Fiscal Hours Per Shift (8 hr/shift) 8 hours
B-24 Fiscal Minutes Per Fiscal Hour (60 min/hr) 60 minutes
B-25 Fiscal Days Per Fiscal Week (7 days/wk) 7 days
B-26 Fiscal Weeks Per Fiscal Year (52.1429 wks/yr) 52 weeks
B-27 Closed Weekdays Per Fiscal Year (20 days/yr) 20 days
B-28 Working Hours Per Person Per Shift (8 hrs/person/shift) 8 hours
B-29 Working Days Per Working Week (5 days/week) 5 days
B-30 Paid Holidays Per Fiscal Year (8 days/yr) 8 days
B-31 Paid Vacation Days Per Fiscal Year (13.5 days/yr) 13.5 days
B-32 Working Weeks Per Fiscal Year (52.1429 wks/yr) 52 weeks
B-33 Average Paid Absenteesm Days Per Fiscal Year (17.5 days/yr) 17.5
B-34 Second Shift Wage Factor (1.15) 1.15
B-35 Third Shift Wage Factor (1.20) 1.20
B-36 Fourth Shift Wage Factor (1.20) 1.20
B-37 Number of Shifts Per Day (2 shifts/day) 1 shift
B-38 Facilities Contingency Percentage (15%) 15%
B-39 Equipment Contingency Percentage (15%) 15%

*SAMIS default values are listed in parenthesis.

SAMIS CASE 2: 10 KW PCU

The power conditioning unit manufacturing sequence consists of twenty-six elements summarized below.

OPERATIONS PROCESS CHART



The following paragraphs briefly describe each manufacturing process.

SAMIS CASE 2: 10 KW PCU

- ASSCOILS: In the first station the transformer coils are assembled. (Yield 100%)
- LAMXFRMR: The transformers are then laminated. (Yield 100%)
- ASSXFRM: One large and four small transformers are assembled in this station. (Yield 100%)
- VRNXFRMR: The assembled transformers are then varnished. (Yield 99%)
- TSTXFRMR: In this station, the transformers are tested. (Yield 100%)
- ASSDKO: The one larger transformer and the four small ones are assembled in a deck in the PCU cabinet. (Yield 100%)
- DKIASSM: A second deck is assembled in this station. (Yield 100%)
- DKIWIRE: The deck 1 subassembly is wired. (Yield 100%)
- DKITEST: After wiring, the deck is tested. Sometimes rework is necessary but it is very unusual. (Yield 100%)
- ASSDKI: The assembly of deck 1 is placed into the PCU cabinet. (Yield 100%)
- ASSHEATS: The heat sinks are assembled in this station. (Yield 100%)
- WREHEATS: The heat sinks are wired. (Yield 100%)
- TSTHEATS: After wiring, the heat sinks are tested. Sometimes rework is necessary but it is very unusual. (Yield 100%)
- ASSDCK2: In this station, deck 2 subassembly is assembled. (Yield 100%)
- WREDCK2: The deck 2 subassembly is wired. (Yield 100%)
- TSTDK2: After wiring, the deck is tested. (Yield 100%)
- CASSDK2: The assembly of deck 2 is placed into the PCU cabinet. (Yield 100%)

SAMIS CASE 2: 10 KW PCU

- PCASSMBL: In this station, the assembly of the components are placed on the printed circuit cards. (Yield 100%)
- PCSOLDER: The printed circuit cards are soldered together. (Yield 100%)
- PCTEST: After soldering, the printed circuit cards are tested and reworked if necessary. (Yield 100%)
- PCUTEST: The printed circuit cards are then mounted and the power conditioning unit is tested and reworked if necessary (Yield 100%)
- PCUPACK: In this last station, the power conditioning units are crated for storage. (Yield 100%)

SAMIS CASE 2: 10 KW PCU

Using the SAMIS model, the company estimates that it will have to charge an average price of $6,538 per unit or $.65/watt in order to cover all costs and earn a net profit after tax of 16% of sales. SAMIS generated the following pricing information for the 10 kilowatt power conditioning unit.

PRODUCT PRICING INFORMATION

	$/Unit	$/Watt	Percent
Direct Costs			
Labor	1098	.110	16.8%
Materials	1432	.143	21.9%
Utilities	174	.017	2.7%
Subtotal	2704	.270	41.4%
Burden Expenses			
G & A	1274	.128	19.5%
Depreciation	146	.015	2.2%
Insurance	244	.024	3.7%
Property Tax	32	.003	.5%
Subtotal	1696	.170	25.9%
Other Expenses			
Interest	38	.004	.6
Income Tax	1080	.108	16.5
Subtotal	1118	.112	17.1%
Net Profit	1020	.102	15.6%
Product Price	6538	.654	100.0%

Total burden expenses make up about 63% of direct manufacturing costs. This is slightly higher than the company has been experiencing in its existing plant. Materials represent the largest component making up 21.9% of the price as indicated by the following bill of materials.

SAMIS CASE 2: 10 KW PCU

BILL OF MATERIALS

Part No.	Name	Cost/Unit
E9328	Enclosure, Metal Cabinet	$292
E9376	Burden, Parts	170
E2104	Capacitor 45 microf/330	142
E7056	Inductor 7.0 mh	111
E7072	Inductor 1.93 mh	82
E9152	P.C. Card; 12" by 13"	75
E9344	Wooden Crates	68
E3088	Silicon Controlled Rectifier	65
E5580	Wire, Copper Magnet	59
E7040	Inductor, 225 mh	48
E9264	Fan; Assembled	35
E9056	Contactor	34
E3120	Controlled Rectifier	33
E9024	Ferro Control	27
E3104	Silicon Controlled Rectifier	25
E5500	Laminations, Large	24
E6008	Switch, Toggle	16
E5104	Transformer, Aux Power Supply	16
E6024	Switch, Pushbuttom	15
E2072	Capacitor	12
E4024	Integrated Circuit	10
E9057	Inverter Control	10
E5548	Mylar, 10 mil, 115 lb. rolls	8
E2008	Capacitor; 1200 pf/100v	8
E1088	Resistor, Variable	7
E4072	Integrated Circuit	6
E9104	Relay	5
E2088	Capacitor	5
E3166	Controlled Rectifier	5
E4040	Integrated Circuit	4
E9008	Lamp, Small Pilot Type	3
E4056	Integrated Circuit	3
E5516	Laminations, Small	2
E8056	Fuse, Small	1
E3152	Controlled Rectifier	1
E3072	Transistor, MPN	1
E9088	Triac	1
E5564	Varnish, Polyester	1
E9072	Opto-Coupler	1
E4008	Integrated Circuit	1
	TOTAL PARTS COST	$1,437

The SAMIS model indicates that approximately $3.1 million will be required for investment in the new plant with a construction lead time of 2 years and another year for production startup.

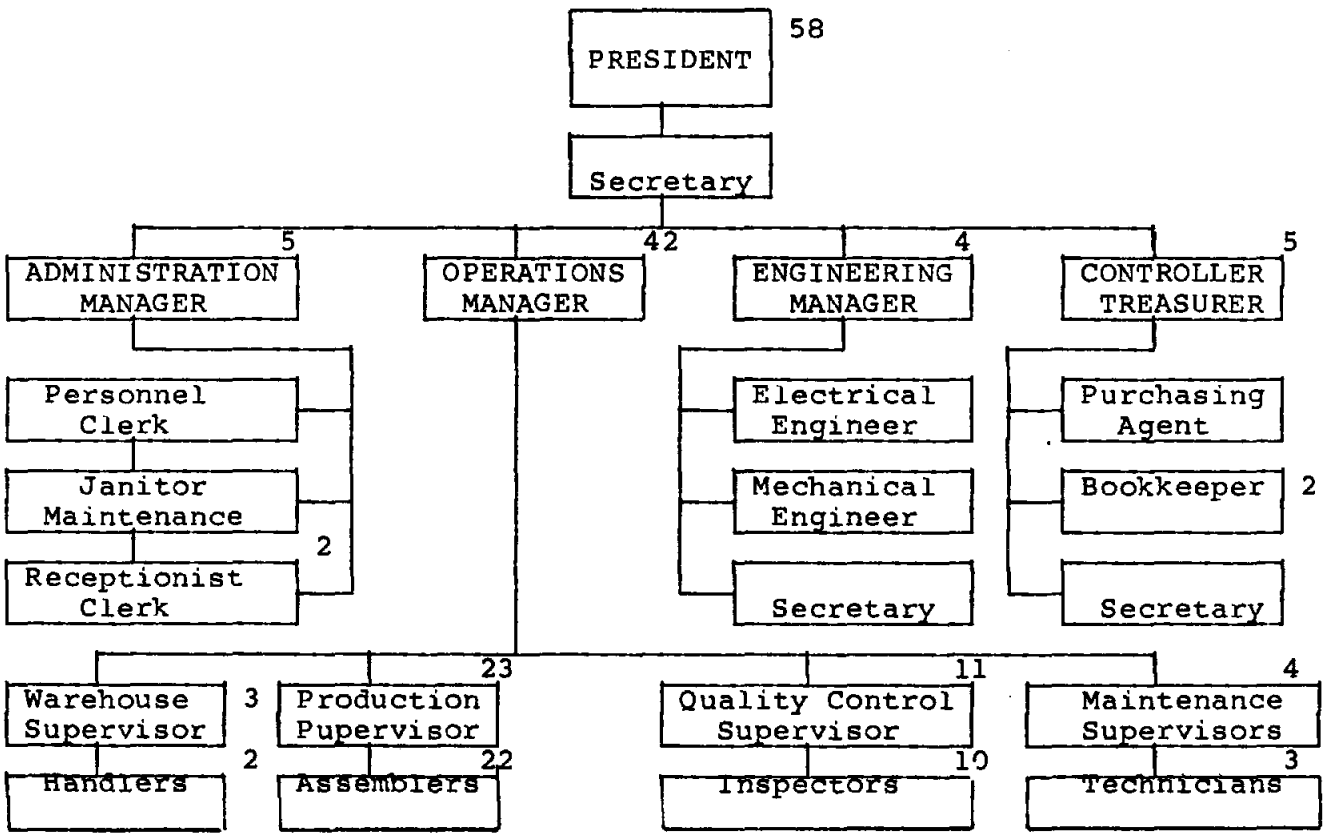
STARTUP CAPITAL REQUIREMENTS	
Facilities	$2,696,000
Land	16,000
Equipment	38,000
Working	308,000
TOTAL	$3,058,000

Not many people will be employed in the new facility which is primarily capital intensive:

PERSONNEL		
Direct Manufacturing	39	67%
Indirect Staff	19	33%
TOTAL	58	100%

The following organization chart displays the mix of personnel required by functional area.

PERSONNEL ORGANIZATION



SAMIS CASE 2: 10 KW PCU

With projected revenues of $3,269,000 per year, this is equivalent to $56,362 per employee or stated another way about .116 PCU's per employee per year.

SAMIS projects the following facilities space requirements:

FACILITIES SPACE REQUIREMENTS
(Square feet)

Manufacturing Space	16041
Storage Space - In process	92
Office Space - Manufacturing	159
Warehouse	401
Shipping/Receiving Dock	80
Machine Shop	133
Mechanical Equipment Room	53
Electrical Equipment Room	408
Computer Room	20
Rest Rooms	100
Cafeteria and Lunchroom	35
Office Space - Administration	477
Passages and Corridors	3391
TOTAL SPACE	21,390

SAMIS CASE 2: 10 KW PCU

SAMIS provides the following cost information for the manufacturing processes.

MANUFACTURING PROCESS COST SUMMARY

	Process Name	Direct Cost/Year	Labor Percent	Material Percent	Other Percent	Percent of Total
1.	ASSDCK2	$ 70,363	5.4%	5.7%	0.0%	5.2%
2.	ASSHEATS	158,229	2.7%	20.0%	0.0%	11.7%
3.	WREHEATS	18,091	2.7%	0.5%	0.0%	1.3%
4	TSTHEATS	2,431	0.4%	0.0%	0.0%	.2%
5.	WREDCK2	89,023	16.2%	0.0%	0.0%	6.6%
6.	TSTDK2	49	0.0%	0.0%	0.0%	.0%
7.	ASSCOILS	48,943	2.2%	5.1%	0.6%	3.6%
8.	LAMXFRMR	22,689	1.8%	1.8%	0.0%	1.7%
9.	ASSXFRMR	17,347	0.8%	1.8%	0.0%	1.3%
10.	VRNXFRMR	3,424	0.4%	0.0%	0.8%	.2%
11.	TSTXFRMR	4,051	0.7%	0.0%	0.0%	.3%
12.	ASSDKO	192,744	2.7%	24.8%	0.0%	14.2%
13.	DKIASSM	135,430	5.4%	14.7%	0.0%	10.0%
14.	DKIWIRE	70,287	10.8%	1.5%	0.0%	5.2%
15.	DKITEST	4,861	0.9%	0.0%	0.0%	.4%
16.	ASSDKI	29,673	5.4%	0.0%	0.0%	2.2%
17.	ASSDK2	85,543	8.1%	5.7%	0.0%	6.3%
18.	PCASSMBL	108,684	2.7%	13.7%	0.0%	8.0%
19.	PCSOLDER	14,057	2.0%	0.4%	0.0%	1.0%
20.	PCTEST	2,431	0.4%	0.0%	0.0%	.2%
21.	PCUTEST	230,991	26.6%	0.0%	98.6%	17.1%
22.	PCUPACK	42,705	1.7%	4.3%	0.0%	3.3%
		$1,352,046	100.0%	100.0%	100.0%	100.0%

Total labor accounts for 41% and total material for 53% of the total annual direct manufacturing cost of goods sold.

SAMIS CASE 2: 10 KW PCU

The following tools and equipment are needed for this manufacturing operation.

TOOLS AND EQUIPMENT

	No. Of Units	Total Purchase Price
Tester	2	$ 10,000
Oven	1	5,000
Miscellaneous Tools	-	4,600
Tester	1	4,000
V Tank	1	3,000
Electronic Tester	1	1,500
Racks	1	1,000
Coil Winder	1	1,000
Drill Press	1	600
Tester	1	300
Test Fixtures	1	200
TOTAL		$ 31,200

SAMIS CASE 2: 10 KW PCU

Based on the SAMIS results, the company's financial analyst compiled a proforma income statement using the company's standard chart of accounts.

PROFORMA INCOME STATEMENT
($000)

Revenues		$3,269
Cost of Goods Manufactured		
Labor	$549	
Materials	716	
Utilities	87	
		$1,352
Contribution Margin		$1,917
Overhead		
Depreciation	$ 73	
Property Tax	16	
Insurance	122	
		211
Gross Profit		$1,706
General & Administrative		
Salaries	$398	
Utilities	52	
Supplies & Miscellaneous	187	
		$ 637
Operating Income		$1,069
Interest Expense		19
Profit Before Tax		$1,050
Income Tax		540
Net Income		$ 510

These results for the hypothetical PCU manufacturer of course would vary substantially with production level. The capital investment required, the number of people, the size of facilities all depend on the production volume. Several of the financial parameters such as the required rate of return on equity and the manufacturing process input also have a significant impact on the results. The SAMIS model is a useful tool to analyze all of these interdependent variables simultaneously.

APPENDIX C

SAMIS CASE 3: PHOTOVOLTAIC RECEIVER

The following example demonstrates the use of the SAMIS model.

The case involves a hypothetical photovoltaic manufacturer with a factory in Los Angeles, California. The company currently manufactures photovoltaic receivers standard 4 foot modules (313 cm^2).

It is 1980 and the company anticipates rapid growth over the next five years due to the commercialization of photovoltaic solar energy systems. The company's receivers will be used with concentrator collectors. The company will need a larger plant to accomodate the potential demand.

To evaluate this strategic decision, the engineering department has just completed a detailed design of a more efficient receiver.

The linear receiver is composed of four, one-foot segments assembled and wired together in an aluminum extrusion. In each one-foot segment, there are twelve rectangular cells, 1.05" by .957" each.

The engineering department has also specified a twelve step manufacturing process for the new product. With one eight hour production shift, the capacity of the line is estimated to be 16,000 of the four foot (313 cm^2) receivers per year.

For each process in the sequence, the engineers have identified requirements for equipment, materials, labor, utilities and facilities.

The president of the company would like to estimate how much capital would be required to build a new plant in Los Angeles to produce 16000 of these new 4 foot (313 cm^2) units per year. He would also like to know how much it will cost to manufacture the units in $ per unit and what price to charge in order to earn a net profit after tax of 4.5%. Finally, he wants an estimate of how long it will take to construct the factory and startup production.

SAMIS CASE 3: PHOTOVOLTAIC RECEIVER

The Vice President of Personnel would also like to know how many and what types of people will be needed to staff the new plant. The facilities design group is interested in the nature of the new facilities including the total square footage by type of space. The plant will be sized to produce 16,000 units per year at 100 percent of capacity with one shift per day, thereby, allowing for expansion by adding operating shifts.

The executive committee decided that the Corporate Planning Department should be responsible for the study. The Vice President of Finance provided the following financial parameters:

FINANCIAL PARAMETERS

- debt interest rate 12.5%/year
- rate of return on equity 17.2%/year
- leverage (total assets/equity) 1.2
- insurance rate 4% of revenues/year
- non-income taxes 2% of revenues/year
- tax depreciation method-double declining balance
- book depreciation method-straight line
- facility tax life 40 years
- accounts receivable turnover 55 days
- accounts payable turnover 55 days
- finished goods inventory turnover 15 days
- raw materials inventory turnover 15 days

The Corporate Planning Department could perform this analysis with the SAMIS model. To do this, the quantitative information is compiled in the following three formats for input to the computer:

- Format C - Industry Description covers general information about the industry including the name, product, quantity produced, hardware performance and the names of the company along with their estimated market share.

- Format B - Company Description summarizes the company name, product produced, and each manufacturing process.

- Format A - Process Description includes process name, output rate, product name, process characteristics, equipment cost factors, direct facilities and personnel requirements, direct byproducts, utilities, commodities, and input product requirements.

SAMIS CASE 3: PHOTOVOLTAIC RECEIVER

FORMAT C - INDUSTRY DESCRIPTION

C-1 INDUSTRY REFERENT PV

C-2 INDUSTRY DESCRIPTION Photovoltaic Solar Energy Industry

C-3 INDUSTRY OBJECTIVE New Photovoltaic Power Capability

C-4 ANNUAL VOLUME 4,978,860 cm^2/year

DESCRIPTION OF THE FINAL PRODUCT OF THE INDUSTRY

C-5 PRODUCT REFERENT PV Receiver

PRODUCT NAME Packaged Photovoltaic Receivers

C-6 PRODUCTION MEASURED units/year

C-7 HARDWARE PERFORMANCE 313 cm^2/unit

C-8 PRODUCT DESIGN DESCRIPTION The linear receiver is composed of four, one foot segments assembled and wired together in an aluminum extrusion.

COMPANIES OF THE INDUSTRY

C-9	COMPANY NAME	PVRECO	MARKET SHARE	100%
	COMPANY NAME		MARKET SHARE	
	COMPANY NAME		MARKET SHARE	
	COMPANY NAME		MARKET SHARE	
	COMPANY NAME		MARKET SHARE	

SAMIS CASE 3: PHOTOVOLTAIC RECEIVER

FORMAT B - COMPANY DESCRIPTION

B-1 COMPANY REFERENT PVRECO

B-2 DESCRIPTION Manufacturer of photovoltaic receiver units for solar energy systems.

B-3 FINAL PROCESS PACKAGE FINAL PRODUCT PVRECEIVER

B-4 MANUFACTURING PROCESS SEQUENCE

PROCESS	FINALTEST	PRODUCT	PRODUC11	RATIO	1.0
PROCESS	FINASSY	PRODUC10		RATIO	1.0
PROCESS	WIRE	PRODUCT	PRODUC09	RATIO	1.0
PROCESS	METALWORK	PRODUCT	PRODUC08	RATIO	1.0
PROCESS	TESTAGAIN	PRODUCT	PRODUC07	RATIO	1.0
PROCESS	AUTOCLAVE	PRODUCT	PRODUC06	RATIO	1.0
PROCESS	PREPAUTCL	PRODUCT	PRODUC05	RATIO	1.0
PROCESS	TESTSEG	PRODUCT	PRODUC04	RATIO	1.0
PROCESS	CLEANING	PRODUCT	PRODUC03	RATIO	
PROCESS	INSTDIODE	PRODUCT	PRODUC02	RATIO	
PROCESS	SOLDRCELL	PRODUCT	PRODUC01	RATIO	
PROCESS		PRODUCT		RATIO	
PROCESS		PRODUCT		RATIO	
PROCESS		PRODUCT		RATIO	

B-5 PURCHASED PRODUCT none RATIO

SUPPLIER AND PERCENTAGE

SUPPLIER AND PERCENTAGE

FORMAT B - FINANCIAL PARAMETERS*

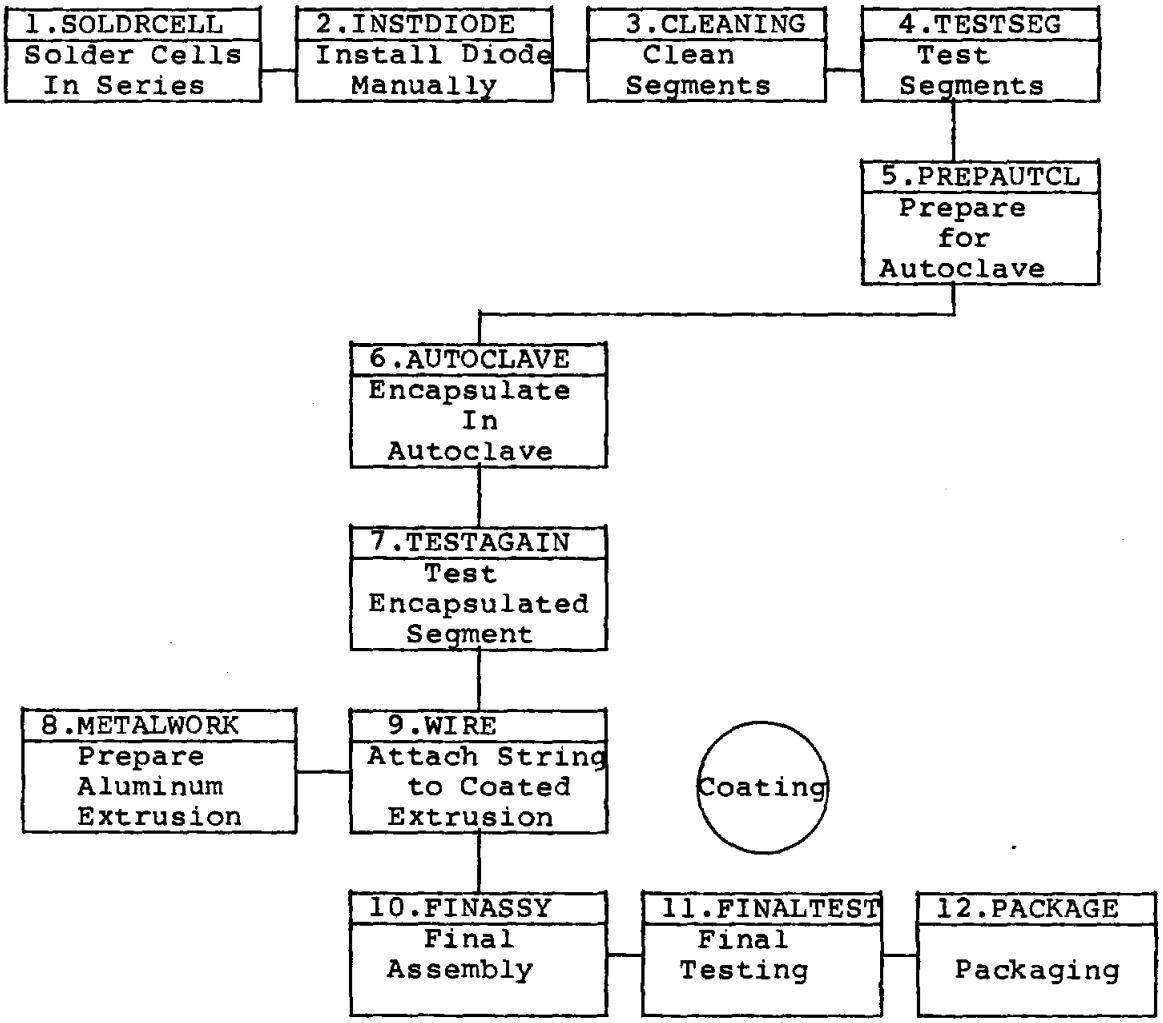
B-1 Percent of Capacity (100%) 100%
B-2 Financial Leverage (1.2 $/$) 1.2
B-3 Debt Interest Rate (9.25%/year) 12.5%/year
B-4 Other Tax Rate (2%/year) 2%/year
B-5 Insurance Rate (4%/year) 4%/year
B-6 Facility Life (40 years) 40 years
B-7 Rate of Return on Equity (21%/year) 17.2%/year
B-8 Miscellaneous Expense (% of Revenues) (3%) 3%
B-9 Miscellaneous Expense (% of Operating Expenses) (4%) 4%
B-10 Miscellaneous Expense (% of Capital Assets) (0%) 0%
B-11 Facilities Tax Depreciation Method (DDB) DDB
B-12 Facilities Book Depreciation Method (SL) SL
B-13 Facilities Inflation Rate Table (1975 8%/year) 1975 8%/year
B-14 Raw Materials Inventory Time (0.04 years) .04 years
B-15 Processing Time Multiplier (1.0 min/min) 1.0
B-16 Finished Goods Inventory Time (.04 years) .04 years
B-17 Accounts Receivable Turnover Time (.10 years) .15 years
B-18 Accounts Payable Turnover Time (.09 years) .15 years
B-19 Startup Direct Commodity Usage Fraction (1.25 units/unit)
B-20 Startup Production Fraction (.635 units/unit) .635
B-21 Cash Balance Operation Time (.06 years) .06 years
B-22 Between Process Inventory Time (0 years) 0 years
B-23 Fiscal Hours Per Shift (8 hour/shift) 8
B-24 Fiscal Minutes Per Fiscal Hour (60 min/hour) 60 minutes
B-25 Fiscal Days Per Fiscal Week (7 days/weeks) 7
B-26 Fiscal Weeks Per Fiscal Year (52.1429 weeks/year) 52
B-27 Closed Weekdays Per Fiscal Year (20 days/year) 20
B-28 Working Hours Per Person Per Shift (8 hours/person/shift) 8
B-29 Working Days Per Working Week (5 days/week) 5
B-30 Paid Holidays Per Fiscal Year (8 days/year) 8
B-31 Paid Vacation Days Per Fiscal Year (13.5 days/year) 18.5
B-32 Working Weeks Per Fiscal Year (52.1429 weeks/year) 52
B-33 Average Paid Absenteeism Days Per Fiscal Year (17.5 days/year) 17.5
B-34 Second Shift Wage Factor (1.15) 1.15
B-35 Third Shift Wage Factor (1.20) 1.20
B-36 Fourth Shift Wage Factor (1.20) 1.20
B-37 Number of Shifts Per Day (2 shifts/day) 1
B-38 Facilities Contingency Percentage (15%) 15%
B-39 Equipment Contingency Percentage (15%) 15%

* SAMIS default values are listed in parenthesis

SAMIS CASE 3: PHOTOVOLTAIC RECEIVER

The photovoltaic receiver manufacturing sequence consists of twelve distinct processes summarized below.

OPERATIONS PROCESS CHART



The following paragraphs briefly describe each manufacturing process.

SAMIS CASE 3: PHOTOVOLTAIC RECEIVER

- SOLDRCELL: Twelve photovoltaic cells are soldered in a series to form a one-foot segment. (Yield 97%)
- INSTDIODE: Two protective diodes are manually installed in each one-foot segment. (Yield 98%)
- CLEANING: All of the segments are then cleaned to remove the residue flux. (Yield 99%)
- TESTSEG: After cleaning, the segments are tested for electrical continuity (i.e. no short or open circuits). (Yield 100%)
- PREPAUTCL: The segments are glued on the glass in preparation for the autoclave phase. (Yield 100%)
- AUTOCLAVE: Two thousand segments are placed in an autoclave for encapsulation. (Yield 100%)
- TESTAGAIN: After the autoclave phase, the segments are tested again for electrical continuity. (Yield 100%)
- METALWORK: The aluminum extrusion is prepared and then cut into four-foot lengths. (Yield 100%)
- WIRE: Strings are attached to the four foot modules (the module extrusion have been coated) with a thermal compound (TC5). (Yield 100%)
- FINASSY: This is the final assembly phase. The four segments are interconnected and the end pieces are attached. (Yield 100%)
- FINALTEST: The assembly is tested in sunlight. (Yield 100%)
- PACKAGE: The final unit is packaged in reusable crates and prepared for shipping. (Yield 100%)

SAMIS CASE 3: PHOTOVOLTAIC RECEIVER

Using the SAMIS model, the company estimates that it will have to charge an average price of $633.82 per unit or $2.025/watt in order to cover all costs and earn a net profit after tax of 4.3% of sales. SAMIS generated the following pricing information for the photovoltaic receiver.

PRODUCT PRICING INFORMATION

	$/Unit	$/cm^2	Percent
Direct Costs			
Labor	14.75	.047	2.3%
Materials	511.87	1.636	80.8%
Utilities	.38	.001	.1%
Subtotal	527.00	1.684	83.2%
Burden Expenses			
G & A	38.19	.122	6.0%
Depreciation	5.19	.016	.8%
Insurance	5.31	.017	.8%
Property Tax	1.19	.004	.3%
Subtotal	49.88	.159	7.9%
Other Expenses			
Interest	1.44	.005	.2%
Income Tax	28.00	.089	4.4%
Subtotal	29.44	.094	4.6%
Net Profit	27.50	.088	4.3%
Product Price	633.82	2.025	100.0%

Total burden expenses make up about 10% of direct manufacturing costs. This is very low due to the high cost of silicon material for photovoltaic products. Materials represent the largest component making up 81% of the price as indicated by the following bill of materials:

SAMIS CASE 3: PHOTOVOLTAIC RECEIVER

BILL OF MATERIALS

Part No.	Name	Cost/Unit
E1500	P.V. Cells; 1.05" by .097"	$447.00
E2500	Coating, Aluminum Oxide	31.00
E3548	End Piece; Metal	9.00
E3564	Extrusion; Aluminum	8.00
E1516	Diode; Mesa Chip	7.00
E3532	Copper Ribbon; Prepared with Solder	2.00
E3580	Glass Cutting; Burden	2.00
E3500	Burden, Miscellaneous Hardware	2.00
E3516	Connection; Active Cooling	1.00
E2516	Compound, Thermal (TC5)	1.00
E3596	Glass Substrate	1.00
E4500	Foam (Packaging)	.50
E2532	Film (Glue)	.37
	TOTAL PARTS COST	$511.87

SAMIS CASE 3: PHOTOVOLTAIC RECEIVER

The SAMIS model indicates that approximately $2.14 million will be required for investment in the new plant with a construction lead time of 2 years and another year for production startup.

STARTUP CAPITAL REQUIREMENTS	
Facilities	$ 806,000
Land	10,000
Equipment	622,000
Working	702,000
TOTAL	$2,140,000

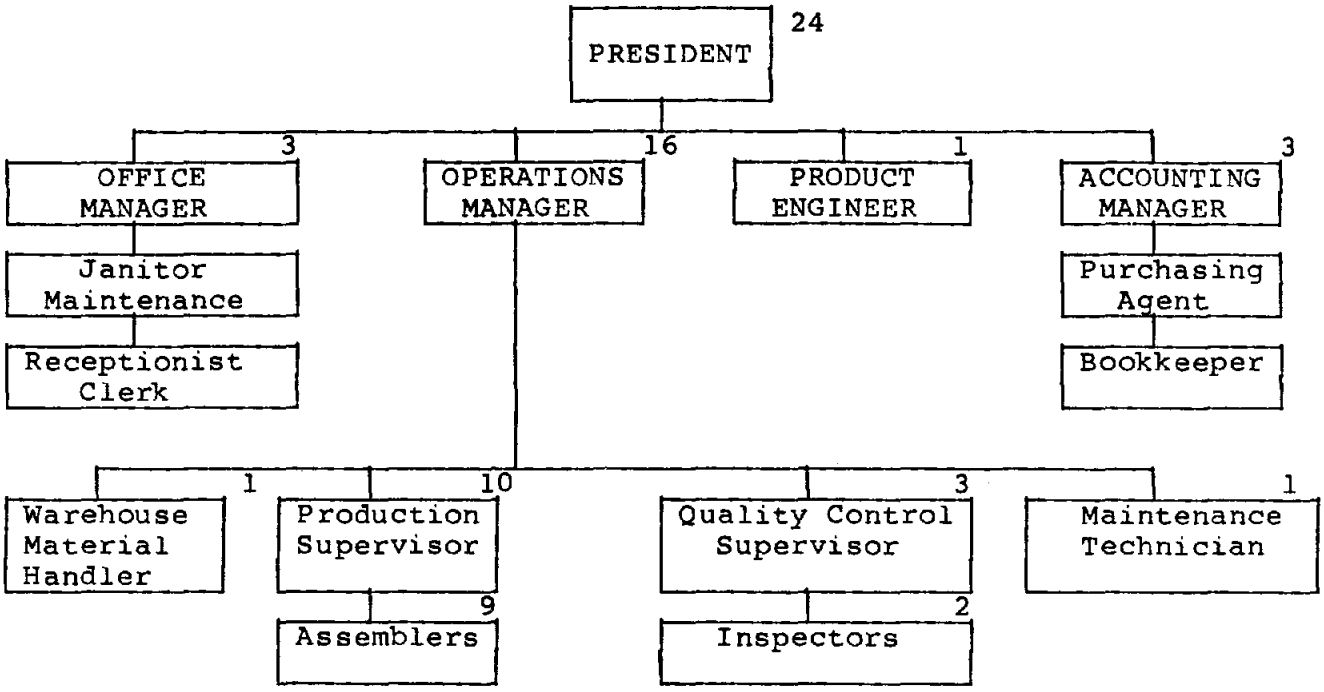
Not many people will be employed in the new facility which is primarily capital intensive:

PERSONNEL		
Direct Manufacturing	16	67%
Indirect Staff	8	33%
TOTAL	24	100%

The following organization chart displays the mix of personnel required by functional area.

SAMIS CASE 3: PHOTOVOLTAIC RECEIVER

PERSONNEL ORGANIZATION



SAMIS CASE 3: PHOTOVOLTAIC RECEIVER

With projected revenues of $10,141,000 per year, this is equivalent to $422,542 per employee or stated another way about 667 receiver units per employee per year.

SAMIS projects the following facilities space requirements:

FACILITIES SPACE REQUIREMENTS
(Square feet)

Manufacturing Space	8543
Storage Space - In process	49
Office Space - Manufacturing	85
Warehouse	213
Shipping/Receiving Dock	43
Machine Shop	71
Mechanical Equipment Room	28
Electrical Equipment Room	217
Computer Room	11
Rest Rooms	53
Cafeteria and Lunchroom	19
Office Space - Administration	254
Passages and Corridors	1806
TOTAL SPACE	11,392

SAMIS CASE 3: PHOTOVOLTAIC RECEIVERS

SAMIS provides the following cost information for the manufacturing processes.

MANUFACTURING PROCESS COST SUMMARY

	Process Name	Direct Cost/Year	Labor Percent	Material Percent	Other Percent	Percent of Total
1.	SOLDRCELL	$7,209,021	5.2%	87.8%	13.5%	85.5%
2.	INSTDIODE	134,557	7.0%	1.4%	4.5%	1.6%
3.	CLEANING	9,051	3.5%	0.0%	13.6%	0.1%
4.	TESTSEG	4,662	1.7%	0.0%	11.2 %	0.1%
5.	PREPAUTCL	66,155	6.9%	0.6%	9.6%	0.8%
6.	AUTOCLAVE	901	0.3%	0.0%	5.2%	0.0%
7.	TESTAGAIN	4,662	1.7%	0.0%	11.2%	0.1%
8.	METALWORK	123,357	0.4%	1.5%	0.6%	1.5%
9.	WIRE	510,808	0.7%	6.2%	0.5%	6.1%
10.	FINASSY	277,393	36.6%	2.3%	2.1%	3.3%
11.	FINALTEST	68,483	28.5%	0.1%	25.4%	0.6%
12.	PACKAGE	22,423	7.5%	0.1%	2.6%	0.3%
		$8,431,473	100.0%	100.0%	100.0%	100.0%

Total labor accounts for 3% and total material for 96% of the total annual direct manufacturing cost of goods sold.

SAMIS CASE 3: PHOTOVOLTAIC RECEIVER

The following tools and equipment needed for this manufacturing operation.

TOOLS AND EQUIPMENT

	No. Of Units	Total Purchase Price
Solderer (automatic)	1	$ 350,000
Autoclave	1	150,000
Tester	4	60,000
Simulator	1	50,000
Solderer	2	6,500
Cleaner (ultrasonic)	1	5,000
Crate	100	4,000
Dispenser	1	3,000
Miscellaneous Tools	-	2,270
I.V. Tracer	1	1,500
Highspeed Saw	1	1,500
TOTAL		$ 633,770

SAMIS CASE 3: PHOTOVOLTAIC RECEIVER

Based on the SAMIS results, the company's financial analyst compiled a proforma income statement using the company's standard chart of accounts.

PROFORMA INCOME STATEMENT
($000)

Revenues		$10,141
Cost of Goods Manufactured		
Labor	$ 236	
Materials	8190	
Utilities	6	
		$8,432
Contribution Margin		$1,709
Overhead		
Depreciation	$ 83	
Property Tax	19	
Insurance	85	
		187
Gross Profit		$1,522
General & Administrative		
Salaries	$170	
Utilities	31	
Supplies & Miscellaneous	410	
		$ 611
Operating Income		$ 911
Interest Expense		23
Profit Before Tax		$ 888
Income Tax		448
Net Income		$ 440

These results for the hypothetical photovoltaic receiver manufacturer of course would vary substantially with production level. The capital investment required, the number of people, the size of facilities all depend on the production volume. Several of the financial parameters such as the required rate of return on equity and the manufacturing process input also have a significant impact on the results. The SAMIS model is a useful tool to analyze all of these interdependent variables simultaneously.

APPENDIX D

SAMIS CASE 4: PARABOLIC TROUGH COLLECTOR

The following example demonstrates the use of the SAMIS model.

The case involves a hypothetical solar energy manufacturer with a factory in Los Angeles, California. The company currently manufactures parabolic trough concentrator collector modules of one standard size: approximately 10 feet long by six feet wide.

It is 1980 and the company anticipates rapid growth over the next five years due to the commercialization of photovoltaic solar energy systems. The company's collector will be used in these photovoltaic systems to concentrate sunlight for conversion to electricity. The company will need a larger plant to supply the rapidly growing market.

To evaluate this strategic decision, the engineering department has just completed a detailed design of a more efficient collector.

The final product is an array comprised of eight modules (each 10 feet long), coupled together and driven by a single drive unit at the center of the line. The aperture width of the reflecting parabolic trough is 6 feet, with rim angle of 90°. The reflecting surface is aluminum lighting sheet. There are nine foundation posts supporting the collector array.

The engineering department has also specified an eight step manufacturing process for the new product. With one eight hour production shift, the capacity of the line is estimated to be 825 arrays per year or stated another way approximately 37,000 square meters of collector aperature area. For each process in the sequence, the engineers have identified requirements for equipment, materials, labor, utilities and facilities.

The president of the company would like to estimate how much capital would be required to build a new plant in Phoenix to produce 825 of these 80 foot array units per year. He would also like to know how much it will cost to manufacture the units in $ per unit and what price to charge in order to earn a net profit after tax of 7%. Finally, he wants an estimate of how long it will take to construct the factory and startup production.

SAMIS CASE 4: PARABOLIC TROUGH COLLECTOR

The Vice President of Personnel would also like to know how many and what types of people will be needed to staff the new plant. The facilities design group is interested in the nature of the new facilities including the total square footage by type of space. The plant will be sized to produce 825 units per year at 100 percent of capacity with one shift per day, thereby, allowing for expansion by adding operating shifts.

The executive committee decided that the Corporate Planning Department should be responsible for the study. The Vice President of Finance provided the following financial parameters:

FINANCIAL PARAMETERS

- debt interest rate 12.5%/year
- rate of return on equity 17.2%/year
- leverage (total assets/equity) 1.2
- insurance rate 4% of revenues/year
- non-income taxes 2% of revenues/year
- tax depreciation method-double declining balance
- book depreciation method-straight line
- facility tax life 40 years
- accounts receivable turnover 55 days
- accounts payable turnover 55 days
- finished goods inventory turnover 15 days
- raw materials inventory turnover 15 days

The Corporate Planning Department could perform this analysis with the SAMIS model. To do this, the quantitative information is compiled in the following three formats for input to the computer:

- Format C - Industry Description covers general information about the industry including the name, product, quantity produced, hardware performance and the names of the company along with their estimated market share.

- Format B - Company Description summarizes the company name, product produced, and each manufacturing process.

- Format A - Process Description includes process name, output rate, product name, process characteristics, equipment cost factors, direct facilities and personnel requirements, direct byproducts, utilities, commodities, and input product requirements.

SAMIS CASE 4: PARABOLIC TROUGH COLLECTOR

FORMAT C - INDUSTRY DESCRIPTION

C-1 INDUSTRY REFERENT PV

C-2 INDUSTRY DESCRIPTION Photovoltaic Solar Energy Industry

C-3 INDUSTRY OBJECTIVE New Photovoltaic Power Capability

C-4 ANNUAL VOLUME 37,000 m^2/year

DESCRIPTION OF THE FINAL PRODUCT OF THE INDUSTRY

C-5 PRODUCT REFERENT PVTROUGH

PRODUCT NAME Packaged Parabolic Trough Collectors

C-6 PRODUCTION MEASURED units/year

C-7 HARDWARE PERFORMANCE 44.85 m^2/unit

C-8 PRODUCT DESIGN DESCRIPTION The parabolic trough collector array is comprised of 8 modules (each 10 feet long) with an aperature width of 6 feet and a rim angle of 90°

COMPANIES OF THE INDUSTRY

C-9	COMPANY NAME	PVCOLLECO	MARKET SHARE	100%
	COMPANY NAME		MARKET SHARE	
	COMPANY NAME		MARKET SHARE	
	COMPANY NAME		MARKET SHARE	
	COMPANY NAME		MARKET SHARE	

SAMIS CASE 4: PARABOLIC TROUGH COLLECTOR

FORMAT B - COMPANY DESCRIPTION

B-1 COMPANY REFERENT PVCOLLECO

B-2 DESCRIPTION Manufacturer of parabolic trough solar energy collectors for photovoltaic systems.

B-3 FINAL PROCESS WHOUSE FINAL PRODUCT

B-4 MANUFACTURING PROCESS SEQUENCE

PROCESS	PACKARRAY	PRODUCT	PRODUK07	RATIO	1.0
PROCESS	SUPPORT	PRODUCT	PRODUK06	RATIO	1.0
PROCESS	LASERINSP	PRODUCT	PRODUK05	RATIO	1.0
PROCESS	ASSEMBLY	PRODUCT	PRODUK04	RATIO	1.0
PROCESS	BOND	PRODUCT	PRODUK03	RATIO	1.0
PROCESS	BACKCOVER	PRODUCT	PRODUK02	RATIO	1.0
PROCESS	GAGE	PRODUCT	PRODUK01	RATIO	1.0
PROCESS		PRODUCT		RATIO	
PROCESS		PRODUCT		RATIO	
PROCESS		PRODUCT		RATIO	

B-5 PURCHASED PRODUCT none RATIO

SUPPLIER AND PERCENTAGE

SUPPLIER AND PERCENTAGE

FORMAT B - FINANCIAL PARAMETERS*

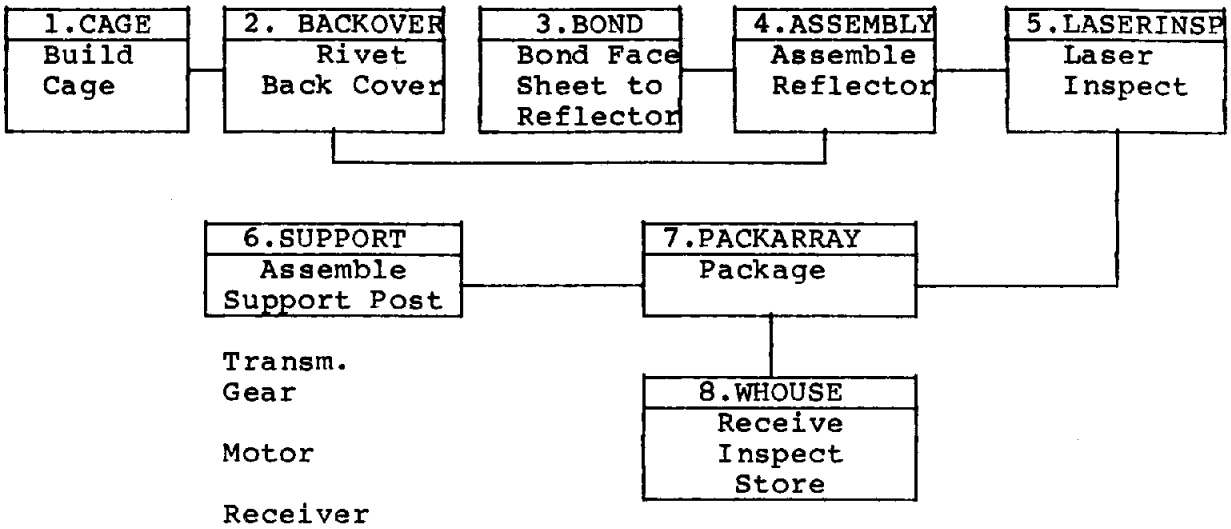
B-1 Percent of Capacity (100%) 100%
B-2 Financial Leverage (1.2 $/$) 1.2
B-3 Debt Interest Rate (9.25%/year) 12.5%/year
B-4 Other Tax Rate (2%/year) 2%/year
B-5 Insurance Rate (4%/year) 4%/year
B-6 Facility Life (40 years) 40 years
B-7 Rate of Return on Equity (21%/year) 17.2%/year
B-8 Miscellaneous Expense (% of Revenues) (3%) 3%
B-9 Miscellaneous Expense (% of Operating Expenses) (4%) 4%
B-10 Miscellaneous Expense (% of Capital Assets) (0%) 0%
B-11 Facilities Tax Depreciation Method (DDB) DDB
B-12 Facilities Book Depreciation Method (SL) SL
B-13 Facilities Inflation Rate Table (1975 8%/year) 1975 8%/year
B-14 Raw Materials Inventory Time (0.04 years) .04 years
B-15 Processing Time Multiplier (1.0 min/min) 1.0
B-16 Finished Goods Inventory Time (.04 years) .04 years
B-17 Accounts Receivable Turnover Time (.10 years) .15 years
B-18 Accounts Payable Turnover Time (.09 years) .15 years
B-19 Startup Direct Commodity Usage Fraction (1.25 units/unit)
B-20 Startup Production Fraction (.635 units/unit) .635
B-21 Cash Balance Operation Time (.06 years) .06 years
B-22 Between Process Inventory Time (0 years) 0 years
B-23 Fiscal Hours Per Shift (8 hour/shift) 8
B-24 Fiscal Minutes Per Fiscal Hour (60) 60
B-25 Fiscal Days Per Fiscal Week (7 days/weeks) 7
B-26 Fiscal Weeks Per Fiscal Year (52.1429 weeks/year) 52
B-27 Closed Weekdays Per Fiscal Year (20 days/year) 20
B-28 Working Hours Per Person Per Shift (8 hours/person/shift) 8
B-29 Working Days Per Working Week (5 days/week) 5
B-30 Paid Holidays Per Fiscal Year (8 days/year) 8
B-31 Paid Vacation Days Per Fiscal Year (13.5 days/year) 18.5
B-32 Working Weeks Per Fiscal Year (52.1429 weeks/year) 52
B-33 Average Paid Absenteeism Days Per Fiscal Year (17.5 days/year) 17.5
B-34 Second Shift Wage Factor (1.15) 1.15
B-35 Third Shift Wage Factor (1.20) 1.20
B-36 Fourth Shift Wage Factor (1.20) 1.20
B-37 Number of Shifts Per Day (2 shifts/day) 1
B-38 Facilities Contingency Percentage (15%) 15%
B-39 Equipment Contingency Percentage (15%) 15%

* SAMIS default values are listed in parenthesis

SAMIS CASE 4: PARABOLIC TROUGH COLLECTOR

The photovoltaic receiver manufacturing sequence consists of twelve distinct processes summarized below:

OPERATIONS PROCESS CHART



The following paragraphs briefly describe each manufacturing process.

- CAGE: Ribs, support shafts, and receiver posts are welded together to produce a cage assembly. (Yield 100%)
- BACKOVER: The back assembly, comprised of 2 pieces of coated steel, is riveted to the cage assembly. (Yield 100%)
- BOND: A face sheet is bonded to the reflector in three different segments. (Yield 100%)
- ASSEMBLY: This face sheet, along with the assembled skeleton and tubing, forms the trough. (Yield 100%)
- LASERINSP: The trough is tested by a laser inspection process. (Yield 100%)
- SUPPORT: With cutting, drilling, and welding, support posts are assembled for the trough. (Yield 100%)

SAMIS CASE 4: PARABOLIC TROUGH COLLECTOR

- PACKARRAY: Eight modules are packed together with nine support posts to form the array. (Yield 100%)
- WHOUSE: The array, consisting of eight modules, is received, inspected and stored in this stage. Also, outside manufactured products are received here, inspected and stored. (Yield 100%)

SAMIS CASE 4: PARABOLIC TROUGH COLLECTOR

Using the SAMIS model, the company estimates that it will have to charge an average price of $74,036 per unit or $203.52/m^2 in order to cover all costs and earn a net profit after tax of 7.0% of sales. SAMIS generated the following pricing information for the parabolic trough collector array.

PRODUCT PRICING INFORMATION

	$/Unit	$/m^2	Percent
Direct Costs			
Labor	327	7.30	3.6%
Materials	6521	145.41	71.5%
Utilities	11	.24	.1%
Subtotal	6859	152.95	75.2%
Burden Expenses			
G & A	749	16.70	8.2%
Depreciation	63	1.41	.7%
Insurance	116	2.59	1.3%
Property Tax	22	.49	.2%
Subtotal	950	21.19	10.4%
Other Expenses			
Interest	24	.54	.2%
Income Tax	654	14.57	7.2%
Subtotal	678	15.11	7.4%
Net Profit	640	14.27	7.0%
Product Price	9127	203.52	100.0%

Total burden expenses make up only about 14% of direct manufacturing costs due to the high cost of solar cells. Materials represent the largest component making up 71.5% of the price as indicated by the following bill of materials:

SAMIS CASE 4: PARABOLIC TROUGH COLLECTOR

BILL OF MATERIALS

Part No.	Name	Cost/Unit
E3742	Receiver Assembly (Mounted PV Cells)	$3,452
E3694	Steel, Coated	794
E3612	Aluminum, Structural (Ribs)	715
E3620	Aluminum, Structural (Support Shaft)	251
E3660	Parts, Machined	239
E3710	Steel, Structural	227
E3726	Transmission Gear (Reduction Box)	197
E3678	Steel Aluminized Sheet (25 mil)	173
E2564	Glue, Bonding Material	143
E2548	Film, Aluminized	122
E3644	Motor, Electrical	80
E3628	Copper Cabling and/or Tubing	73
E4516	Burden, Packaging Material	55
	TOTAL PARTS COST	$6521

SAMIS CASE 4: PARABILIC TROUGH COLLECTOR

The SAMIS model indicates that approximately $2.4 million will be required for investment in the new plant with a construction lead time of 2 years and another year for production startup.

STARTUP CAPITAL REQUIREMENTS	
Facilities	$1,775,400
Land	20,500
Equipment	58,300
Working	577,500
TOTAL	$2,431,700

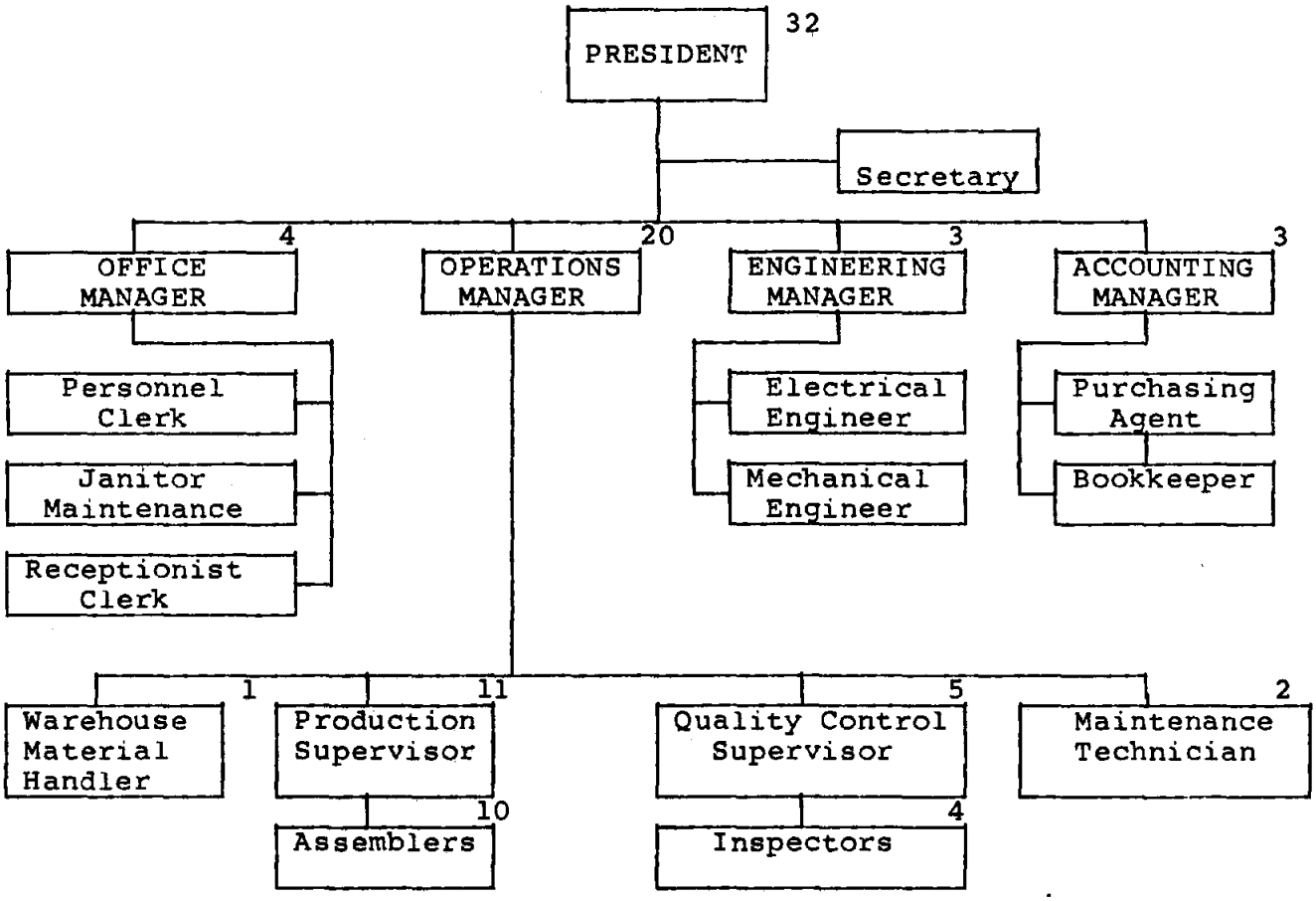
Not many people will be employed in the new facility which is primarily capital intensive:

PERSONNEL		
Direct Manufacturing	20	62%
Indirect Staff	12	38%
TOTAL	32	100%

SAMIS CASE 4: PARABOLIC TROUGH COLLECTOR

The following organization chart displays the mix of personnel required by functional area.

PERSONNEL ORGANIZATION



SAMIS CASE 4: PARABOLIC TROUGH COLLECTOR

With projected revenues of $7,530,000 per year, this is equivalent to $235,312 per employee or stated another way about 25.8 arrays per employee per year.

SAMIS projects the following facilities space requirements:

FACILITIES SPACE REQUIREMENTS
(Square feet)

Manufacturing Space	21544
Storage Space - In process	124
Office Space - Manufacturing	213
Warehouse	538
Shipping/Receiving Dock	107
Machine Shop	178
Mechanical Equipment Room	71
Electrical Equipment Room	547
Computer Room	27
Rest Rooms	135
Cafeteria and Lunchroom	48
Office Space - Administration	642
Passages and Corridors	4554
TOTAL SPACE	28,728

SAMIS provides the following cost information for the manufacturing processes.

MANUFACTURING PROCESS COST SUMMARY

	Process Name	Direct Cost/Year	Labor Percent	Material Percent	Other Percent	Percent of Total
1.	CAGE	$966,797	22.2%	16.8%	24.5%	17.0%
2.	BACKCOVER	635,817	8.2%	11.4%	22.4%	11.2%
3.	BOND	399,367	13.4%	6.7%	2.7%	7.0%
4.	ASSEMBLY	286,704	10.4%	4.8%	14.9%	5.2%
5.	LASERINSP	26,752	9.2%	0.0%	22.3%	0.6%
6.	SUPPORT	151,195	11.3%	2.2%	6.0%	2.8%
7.	PACKARRAY	81,932	13.2%	0.9%	3.6%	1.4%
8.	WHOUSE	3,110,344	12.1%	57.2%	3.6%	54.8%
		$5,658,908	100.0%	100.0%	100.0%	100.0%

Total labor accounts for 4.8% and total material for 95% of the total annual direct manufacturing cost of goods sold.

SAMIS CASE 4: PARABOLIC TROUGH COLLECTOR

The following tools and equipment are needed for this manufacturing operation.

TOOLS AND EQUIPMENT

	No. Of Units	Total Purchase Price
Laser Fixture	2	$ 28,000
Holding Fixture	1	8,000
Spot Welder	2	6,000
Electric Saw	1	3,200
Welding Set-Up	1	3,000
Storage Racks	10	2,500
Laser Unit	2	2,420
Drill Press	1	2,240
Miscellaneous Tools	-	2,030
Pneumatic Wrench	2	900
Pneumatic Rivet Gun	1	300
TOTAL		$ 58,590

SAMIS CASE 4: PARABOLIC TROUGH COLLECTOR

Based on the SAMIS results, the company's financial analyst compiled a proforma income statement using the company's standard chart of accounts.

PROFORMA INCOME STATEMENT
($000)

Revenues		$ 7,530
Cost of Goods Manufactured		
Labor	$ 270	
Materials	5,380	
Utilities	9	
		$5,659
Contribution Margin		$1,871
Overhead		
Depreciation	$ 52	
Property Tax	18	
Insurance	96	
		166
Gross Profit		$1,705
General & Administrative		
Salaries	$237	
Utilities	73	
Supplies & Miscellaneous	308	
		$ 618
Operating Income		$ 1087
Interest Expense		20
Profit Before Tax		$ 1067
Income Tax		539
Net Income		$ 528

These results for the hypothetical parabolic trough manufacturer of course would vary substantially with production level. The capital investment required, the number of people, the size of facilities all depend on the production volume. Several of the financial parameters such as the required rate of return on equity and the manufacturing process input also have a significant impact on the results. The SAMIS model is a useful tool to analyze all of these interdependent variables simultaneously.

APPENDIX E

SAMIS CASE 5: LINEAR FRESNEL COLLECTOR

The following example demonstrates the use of the SAMIS model.

The case involves a hypothetical photovoltaic solar energy manufacturer with a factory in Los Angeles, California. The company currently manufactures linear fresnel lens concentrating collectors

It is 1980 and the company anticipates rapid growth over the next six years due to the commercialization of photovoltaic solar energy systems. The company is considering a new factory to supply the anticipated demand.

To evaluate this strategic decision, the engineering department has just completed the detailed design of a short-focal-length curved acrylic-fresnel lens, which concentrates incident sunlight onto a photovoltaic receiver. A galvanized steel, V-shaped housing serves the dual function of structural support of the lens and receiver as well as environmental enclosure. Dimensionally, the lens aperture is 3 feet wide and 8 feet long. Ten 3' by 8' collector modules are mounted on a common structure, the array assembly. The tilt and roll functions of the collector array are performed by a common system for two axis tracking.

The engineering department has also specified a twenty-one step manufacturing process sequence for the new product. For each process in the sequence, the engineers have identified requirements for equipment, materials, labor, utilities and facilities.

The president of the company would like to estimate how much capital would be required to build a new plant in Phoenix, Arizona to produce 2500 of these 80 foot array units per year. He would also like to know how much it will cost to manufacture the units in $ per unit and what price to charge in order to earn a net profit after tax of 7%. Finally, he wants an estimate of how long it will take to construct the factory and startup production.

SAMIS CASE 5: LINEAR FRESNEL COLLECTOR

The Vice President of Personnel would also like to know how many and what types of people will be needed to staff the new plant. The facilities design group is interested in the nature of the new facilities including the total square footage by type of space. The plant will be sized to produce 2500 units per year at 100 percent of capacity with one shift per day, thereby, allowing for expansion by adding operating shifts.

The executive committee decided that the Corporate Planning Department should be responsible for the study. The Vice President of Finance provided the following financial parameters:

FINANCIAL PARAMETERS

- debt interest rate 12.5%/year
- rate of return on equity 17.2%/year
- leverage (total assets/equity) 1.2
- insurance rate 4% of revenues/year
- non-income taxes 2% of revenues/year
- tax depreciation method-double declining balance
- book depreciation method-straight line
- facility tax life 40 years
- accounts receivable turnover 55 days
- accounts payable turnover 55 days
- finished goods inventory turnover 15 days
- raw materials inventory turnover 15 days

The Corporate Planning Department could perform this analysis with the SAMIS model. To do this, the quantitative information is compiled in the following three formats for input to the computer:

- Format C - Industry Description covers general information about the industry including the name, product, quantity produced, hardware performance and the names of the company along with their estimated market share.

- Format B - Company Description summarizes the company name, product produced, and each manufacturing process.

- Format A - Process Description includes process name, output rate, product name, process characteristics, equipment cost factors, direct facilities and personnel requirements, direct byproducts, utilities, commodities, and input product requirements.

SAMIS CASE 5: LINEAR FRESNEL COLLECTOR

FORMAT C - INDUSTRY DESCRIPTION

C-1 INDUSTRY REFERENT PV

C-2 INDUSTRY DESCRIPTION Photovoltaic Solar Energy Industry

C-3 INDUSTRY OBJECTIVE New Photovoltaic Power Capability

C-4 ANNUAL VOLUME 55,575 square meters/year

DESCRIPTION OF THE FINAL PRODUCT OF THE INDUSTRY

C-5 PRODUCT REFERENT LFRESNEL

PRODUCT NAME Linear Fresnel Lens Collectors

C-6 PRODUCTION MEASURED units/year

C-7 HARDWARE PERFORMANCE 22.23 m^2/unit

C-8 PRODUCT DESIGN DESCRIPTION linear fresnel lens of acrylic material (30 foot x 8 foot modules) with galvanized sheet steel V shaped housing and two axis tracking

COMPANIES OF THE INDUSTRY

C-9	COMPANY NAME	FRESNELCO	MARKET SHARE	100%
	COMPANY NAME		MARKET SHARE	
	COMPANY NAME		MARKET SHARE	
	COMPANY NAME		MARKET SHARE	
	COMPANY NAME		MARKET SHARE	

SAMIS CASE 5: LINEAR FRESNEL COLLECTOR
FORMAT B - COMPANY DESCRIPTION

B-1 COMPANY REFERENT FRESNELCO

B-2 DESCRIPTION Manufacturer of linear fresnel lens photovoltaic concentrator collectors.

B-3 FINAL PROCESS PACKSTORE FINAL PRODUCT PVCOLECT

B-4 MANUFACTURING PROCESS SEQUENCE

PROCESS	CNTRCHNL	PRODUCT	PROC20	RATIO	1.0
PROCESS	SIDECHWL	PRODUCT	PROC19	RATIO	1.0
PROCESS	TILTMORE	PRODUCT	PROC18	RATIO	1.0
PROCESS	TILTDRIVE	PRODUCT	PROC17	RATIO	1.0
PROCESS	RADASSY	PRODUCT	PROC16	RATIO	1.0
PROCESS	ROLLDRIVE	PRODUCT	PROC15	RATIO	1.0
PROCESS	PACKAGING	PRODUCT	PROC14	RATIO	1.0
PROCESS	LENS	PRODUCT	PROC13	RATIO	1.0
PROCESS	ROLLAXIS	PRODUCT	PROC12	RATIO	1.0
PROCESS	RECEIVER	PRODUCT	PROC11	RATIO	1.0
PROCESS	INSULATE	PRODUCT	PROC10	RATIO	1.0
PROCESS	JIGASSY	PRODUCT	PROC09	RATIO	1.0
PROCESS	RIVETPULY	PRODUCT	PROC08	RATIO	1.0
PROCESS	RVPLATE-B	PRODUCT	PROC07	RATIO	1.0
PROCESS	RVPLATE-A	PRODUCT	PROC06	RATIO	1.0
PROCESS	UNLDJIG	PRODUCT	PROC05	RATIO	1.0
PROCESS	DRILLPULY	PRODUCT	PROC04	RATIO	1.0
PROCESS	ENDPLATES	PRODUCT	PROC03	RATIO	1.0
PROCESS	DRILLERS	PRODUCT	PROC02	RATIO	1.0
PROCESS	LOADJIG	PRODUCT	PROC01	RATIO	1.0

B-5 PURCHASED PRODUCT none RATIO

SAMIS CASE 5: LINEAR FRESNEL COLLECTOR

FORMAT B - FINANCIAL PARAMETERS*

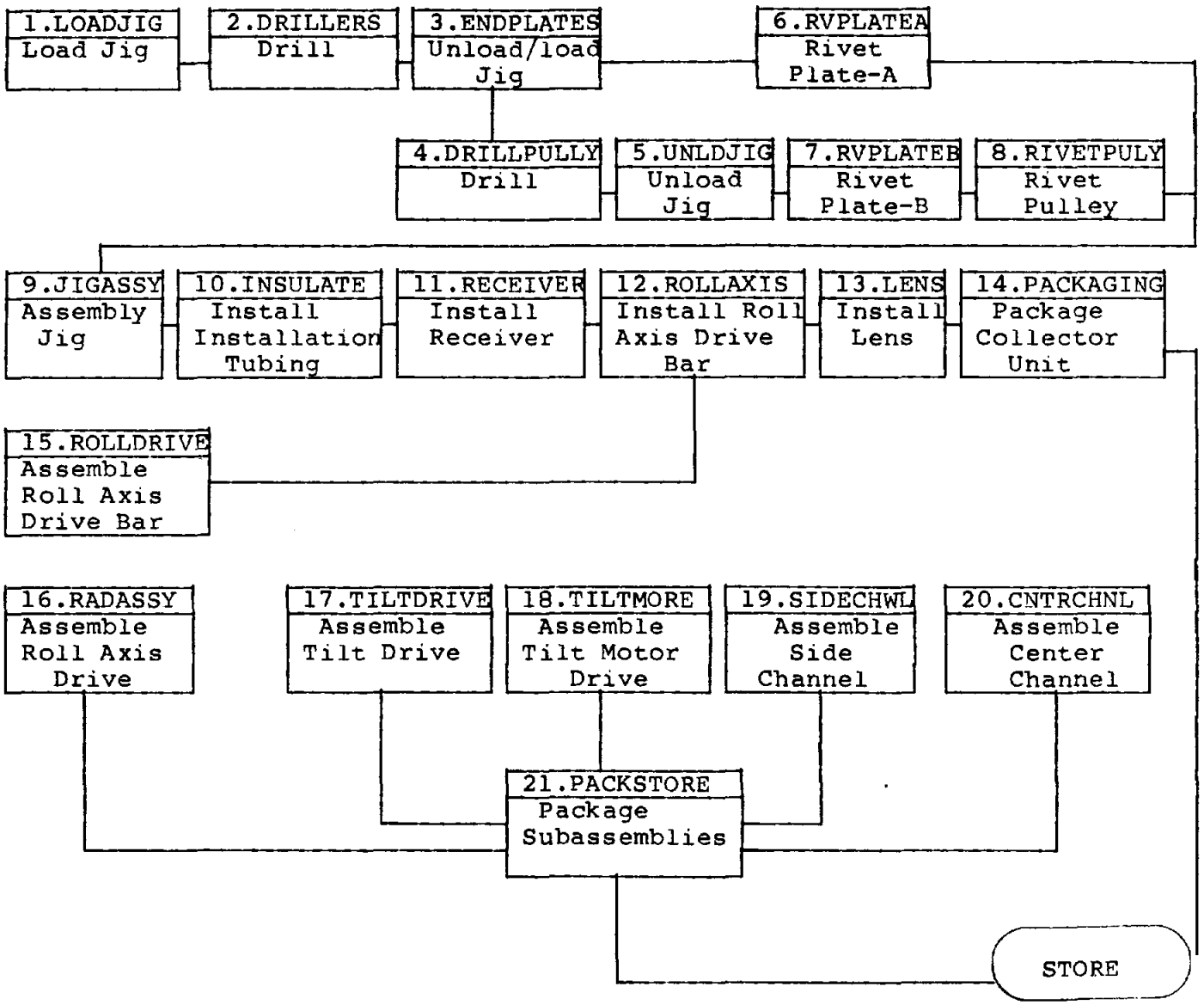
B-1 Percent of Capacity (100%) 100%
B-2 Financial Leverage (1.2 $/$) 1.2
B-3 Debt Interest Rate (9.25%/yr) 12.5%/year
B-4 Other Tax Rate (2%/yr) 2%/year
B-5 Insurance Rate (4%/yr) 4%/year
B-6 Facility Life (40 yrs) 40 year
B-7 Rate of Return on Equity (21%/yr) 17.2%/year
B-8 Miscellaneous Expense (% of Revenues) (3%) 3%
B-9 Miscellaneous Expense (% of Operating Expenses) (4%) 4%
B-10 Miscellaneous Expense (% of Capital Assets) (0%) 0%
B-11 Facilities Tax Depreciation Method (DDB) DDB
B-12 Facilities Book Depreciation Method (SL) SL
B-13 Facilities Inflation Rate Table (1975 8%/yr) 1975 8%/year
B-14 Raw Materials Inventory Time (0.04 yrs) .04 years
B-15 Processing Time Multiplier (1.0 min/min) 1.0
B-16 Finished Goods Inventory Time (.04 yrs) .04 years
B-17 Accounts Receivable Turnover Time (.10 yrs) .15 years
B-18 Accounts Payable Turnover Time (.09 yrs) .15 years
B-19 Startup Direct Commodity Usage Fraction (1.25 units/unit)
B-20 Startup Production Fraction (.635 units/unit) .635
B-21 Cash Balance Operation Time (.06 yr) .06 years
B-22 Between Process Inventory Time (0 yrs) 0 years
B-23 Fiscal Hours Per Shift (8 hr/shift) 8 hours
B-24 Fiscal Minutes Per Fiscal Hour (60 min/hr) 60 minutes
B-25 Fiscal Days Per Fiscal Week (7 days/wk) 7 days
B-26 Fiscal Weeks Per Fiscal Year (52.1429 wks/yr) 52 weeks
B-27 Closed Weekdays Per Fiscal Year (20 days/yr) 20 days
B-28 Working Hours Per Person Per Shift (8 hrs/person/shift) 8 hours
B-29 Working Days Per Working Week (5 days/week) 5 days
B-30 Paid Holidays Per Fiscal Year (8 days/yr) 8 days
B-31 Paid Vacation Days Per Fiscal Year (13.5 days/yr) 13.5 days
B-32 Working Weeks Per Fiscal Year (52.1429 wks/yr) 52 weeks
B-33 Average Paid Absenteesm Days Per Fiscal Year (17.5 days/yr) 17.5
B-34 Second Shift Wage Factor (1.15) 1.15
B-35 Third Shift Wage Factor (1.20) 1.20
B-36 Fourth Shift Wage Factor (1.20) 1.20
B-37 Number of Shifts Per Day (2 shifts/day) 1 shift
B-38 Facilities Contingency Percentage (15%) 15%
B-39 Equipment Contingency Percentage (15%) 15%

*SAMIS default values are listed in parenthesis.

SAMIS CASE 5: LINEAR FRESNEL COLLECTOR

The photovoltaic receiver manufacturing sequence consists of twelve distinct processes summarized below:

OPERATIONS PROCESS CHART



The following paragraphs briefly describe each manufacturing process

SAMIS CASE 5: LINEAR FRESNEL COLLECTOR

- LOADJIG: At this station, the end plates are prepared for drilling. The end plate is loaded on the base and the shaft drill adapter installed. (Yield 100%)

- DRILLERS: The two roll shaft mounting holes are drilled. (Yield 100%)

- ENDPLATES: After drilling, the shaft alignment drill adapter is removed from all end plates and replaced with the pulley alignment drill adapter. (Yield 100%)

- DRILLPULY: Pulley holes are drilled on one half of all end plates. (Yield 100%)

- UNLDJIG: At this station, the jig is unloaded. The jig base is returned to Station 1 and the drill adapter is returned to Station 3. (Yield 100%)

- RVPLATE-A: The roll axis shaft is then riveted to one half of the end plates. The assembled end plates have holes for the roll drive pulley and are routed to the next station. (Yield 100%)

- RVPLATE-B: This station is identical to the previous one. The roll axis shaft is riveted to the remaining half of the end plates. All of the assembled end plates are routed to the assembly line. (Yield 100%)

- RIVETPULY: The drive pulley is riveted to end plate B at this station. (Yield 100%)

- JIGASSY: Mating of the complete solar collector structure is accomplished in four positions. These utilize jig loading crews, drilling crews, riveting crews, and unloading crews which sequentially rotate through the assembly jigs. The unload crew places the assembled structures in a cradle on the conveyor track for the next manufacturing step (Yield 100%)

- INSULATE: Using adhesive bonding and pull stem rivets, the preformed insulation is installed in the receiver area of the collector assembly. Also, the active cooling tubing is installed. (Yield 100%)

- RECEIVER: At this point the photovoltaic receiver assembly, including mounted cells and aluminum extrusion, are installed after which the resulting assembly is moved on to the next station. (Yield 100%)

SAMIS CASE 5: LINEAR FRESNEL COLLECTOR

- ROLLAXIS: The roll axis bar is installed. The cable is pre-attached at one end by a bench assembly operation and stocked for usage at this location. (Yield 100%)

- LENS: The lens is inserted into the slots on the collector and the end band attached. Inspection of the completed assembly is conducted both before and after the lens installation. (Yield 100%)

- PACKAGING: Following assembly and inspection, the solar collector is inserted into a shipping carton and routed to finished goods storage. (Yield 100%)

- ROLLDRIVE: The roll axis drive bar is assembled simultaneously with the collector. It is then ready for installation in Station 12. (Yield 78%)

- RADASSY: The roll axis drive is also assembled in parallel with the solar collector. (Yield 37.5%)

- TILTDRIVE: The tilt drive is assembled in a separate station but parallel to the roll axis drive. (Yield 100%)

- TILTMORE: Assembly of the tilt motor drive takes place simultaneously, with the previous station. (Yield 25%)

- SIDECHWL: The side channel is assembled in conjunction with the four previous stations. (Yield 78%)

- CNTRCHNL: The center channel is assembled. (Yield 75%)

- PACKSTORE: The completed balance of system assemblies from stations 16 throuth 20 are packaged and stored along with the collector assembly. (Yield 48%)

SAMIS CASE 5: LINEAR FRESNEL COLLECTOR

Using the SAMIS model, the company estimates that it will have to charge an average price of $7,891 per unit or $355/m^2 in order to cover all costs and earn a net profit after tax of 6.6% of sales. SAMIS generated the following pricing information for the linear fresnel lens collector.

PRODUCT PRICING INFORMATION

	$/Unit	$/m^2	Percent
Direct Costs			
Labor	313	14.09	4.0%
Materials	5665	254.84	71.8%
Utilities	5	.20	.1%
Subtotal	5983	269.13	75.9%
Burden Expenses			
G & A	653	29.40	8.3%
Depreciation	50	2.25	.6%
Insurance	96	4.32	1.2%
Property Tax	18	.79	.2%
Subtotal	817	36.76	10.3%
Other Expenses			
Interest	19	.88	.2%
Income Tax	549	24.69	7.0%
Subtotal	568	25.57	7.2%
Net Profit	523	23.54	6.6%
Product Price	7891	355.00	100.0%

Total burden expenses make up only about 14% of direct manufacturing costs. This is low due to the high material cost for the photovoltaic cells. Materials represent the largest component making up 71.8% of the price as indicated by the following bill of materials:

SAMIS CASE 5: LINEAR FRESNEL COLLECTOR
BILL OF MATERIALS

Part No.	Name	Cost/Unit
E3742	Receiver Assembly (Mounted PV Cells)	$1,725
E3818	End Plate	653
E3882	Shaft, Roll Axis	476
E3890	Trough, Housing	445
E3758	Assembly Housing	325
E2592	Lens, Fresnel	233
E3754	Assembly, Beam	197
E3774	Bearing, Receiver	155
E3846	Post, Ground Installation	117
E3814	Elbow	116
E3826	Extrusion, Lens	103
E3974	Clamp, Lens	91
E3834	Gear, Tilt Drive	72
E3762	Assembly, Jack	60
E3894	Yoke, Narrow	56
E3746	Angle, 1	53
E3500	Burden, Miscellaneous Hardware	52
E4516	Burden, Packaging Material	50
E3870	Screw	50
E3874	Shaft, 1	48
E3786	Block, Pillow	46
E3790	Cable, Roll Axis Drive	44
E3838	Hat	42
E2580	Burden, Insulation	36
E3778	Bearing, Thrust	35
E3842	Nut	34
E3766	Assembly, Lug	33
E3822	End Plate Band	33
E3898	Yoke, Wide	29
E3770	Bar, Roll Axis Drive	28
E3878	Shaft, 2	28
E3850	Pulley, Roll Axis Drive	26
E3858	Rod	25
E3628	Copper, Cabling and/or Tubing	19
E3782	Block	18
E3862	Rod, 18.6 ft.	17
E3802	Collar, 2	16
E3798	Collar, 1	15
E3644	Motor, Electrical	13
E3810	Cover	11
E3830	Fork	10
E3854	Retainer, Roll Axis Drive	8
E3750	Angle, 2	7
E3660	Parts, Machined	5
E3806	Collar, Threaded	5
E3886	Splice; Roll Axis Drive	3
E3866	Rod, 10 ft.	2
	TOTAL PARTS COST	$5665

SAMIS CASE 5: LINEAR FRESNEL COLLECTOR

The SAMIS model indicates that approximately $6 million will be required for investment in the new plant with a construction lead time of 2 years and another year for production startup.

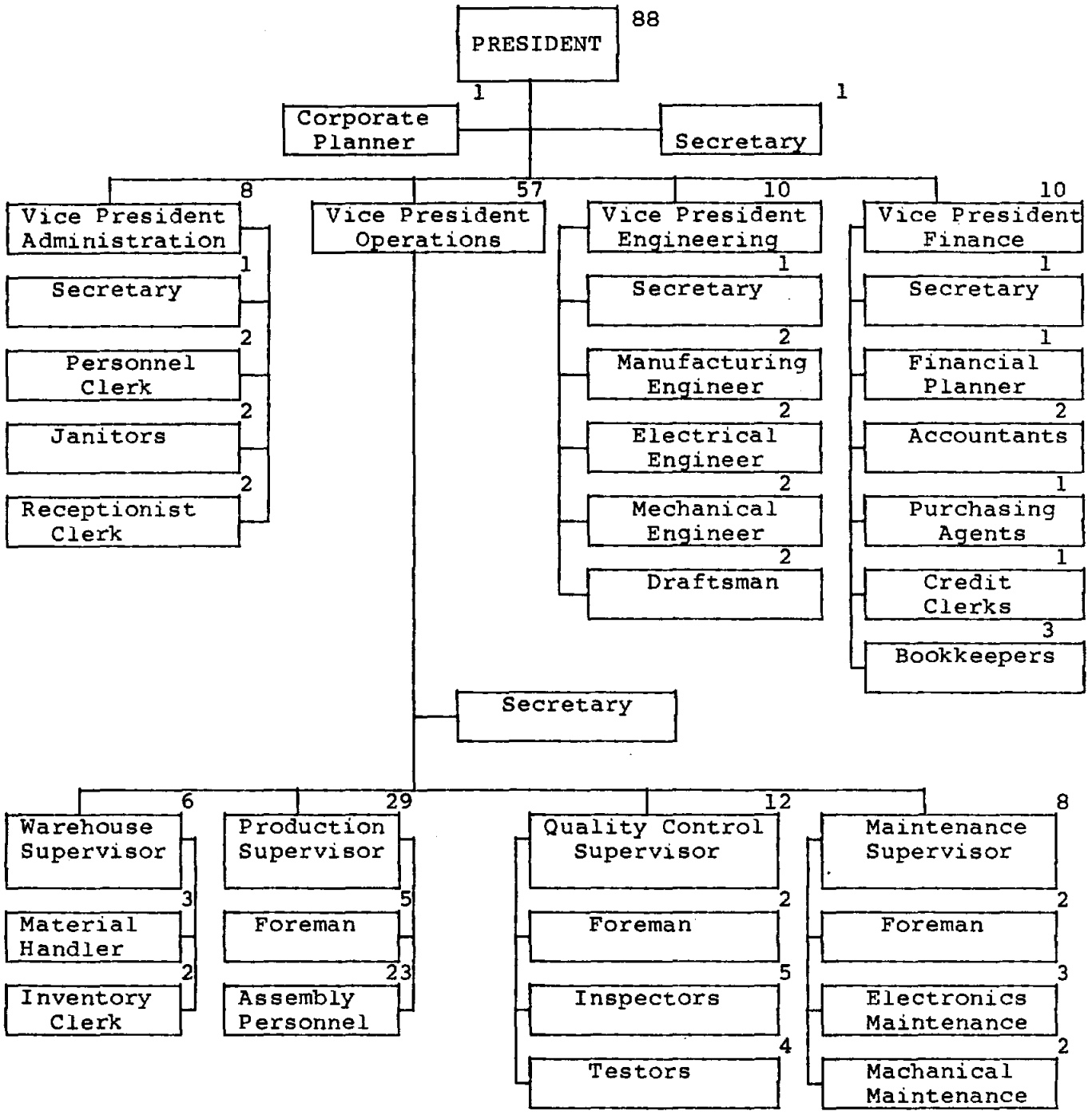
STARTUP CAPITAL REQUIREMENTS	
Facilities	$4,490,300
Land	43,800
Equipment	131,700
Working	1,375,600
TOTAL	$6,041,400

Not many people will be employed in the new facility which is primarily capital intensive:

PERSONNEL		
Direct Manufacturing	57	65%
Indirect Staff	31	35%
TOTAL	88	100%

The following organization chart displays the mix of personnel required by functional area.

SAMIS CASE 5: LINEAR FRESNEL COLLECTOR
PERSONNEL ORGANIZATION



SAMIS CASE 5: LINEAR FRESNEL COLLECTOR

With projected revenues of $19,729,000 per year, this is equivalent to $224,193 per employee or stated another way about 28 collectors per employee per year.

SAMIS projects the following facilities space requirements:

FACILITIES SPACE REQUIREMENTS
(Square feet)

Manufacturing Space	54670
Storage Space - In process	328
Office Space - Manufacturing	541
Warehouse	1366
Shipping/Receiving Dock	272
Machine Shop	453
Mechanical Equipment Room	180
Electrical Equipment Room	1389
Computer Room	69
Rest Rooms	342
Cafeteria and Lunchroom	119
Office Space - Administration	1627
Passages and Corridors	11556
TOTAL SPACE	72,912

SAMIS CASE 5: LINEAR FRESNEL COLLECTOR

SAMIS provides the following cost information for the manufacturing processes.

MANUFACTURING PROCESS COST SUMMARY

	Process Name	Direct Cost/Year	Labor Percent	Material Percent	Other Percent	Percent of Total
1.	LOADJIG	$1,741,825	3.6%	12.3%	4.3%	11.6%
2.	DRILLERS	58,689	3.9%	0.2%	4.6%	0.4%
3.	ENDPLATES	28,999	3.6%	0.0%	5.0%	0.2%
4.	DRILLPULY	43,449	1.9%	0.2%	4.5%	0.3%
5.	UNLDJIG	15,577	1.9%	0.0%	3.6%	0.1%
6.	RVPLATE-A	633,077	3.3%	4.3%	5.8%	4.2%
7.	RVPLATE-B	633,077	3.3%	4.3%	5.8%	4.2%
8.	RIVETPULY	105,648	3.3%	0.6%	5.7%	0.7%
9.	JIGASSY	2,078,140	38.8%	12.6%	19.8%	13.9%
10.	INSULATE	163,491	3.3%	0.1%	5.0%	1.1%
11.	RECEIVER	4,712,635	3.3%	33.3%	4.9%	31.5%
12.	ROLLAXIS	59,737	3.3%	0.2%	5.0%	0.4%
13.	LENS	917,173	3.6%	6.4%	4.8%	6.2%
14.	PACKAGING	88,966	2.3%	0.5%	5.0%	0.6%
15.	ROLLDRIVE	185,609	.8%	1.3%	1.6%	1.2%
16.	RADASSY	54,956	1.2%	0.3%	0.8%	0.4%
17.	TILTDRIVE	426,375	1.3%	2.9%	2.5%	2.8%
18.	TILTMORE	32,399	1.0%	0.2%	0.6%	0.2%
19.	SIDECHNL	363,519	.8%	2.5%	4.0%	2.4%
20.	CNTRCHWL	199,730	.8%	1.4%	4.3%	1.3%
21.	PACKSTORE	2,413,572	14.7%	16.4%	2.4%	16.3%
		$14,956,643	100.0%	100.0%	100.0%	100.0%

Total labor accounts for 5.2% and total material for 94.7% of the total annual direct manufacturing cost of goods sold.

SAMIS CASE 5: LINEAR FRESNEL COLLECTOR

The following tools and equipment are needed for this manufacturing operation.

TOOLS AND EQUIPMENT

	No. Of Units	Total Purchase Price
Forklift	2	$ 34,000
Jig Assembly	4	26,000
Miscellaneous Expenses	-	19,178
Pneumatic Gun	4	14,760
Jig Bases	12	7,254
Press	3	6,960
Conveyor	1	5,520
Wrench	10	5,400
Multi-Spindle Unit	2	4,406
Drill Adapter	12	3,420
Rivet Gun	1	2,435
Screwdrivers	5	1,230
Cradles	6	912
Banding Machine	2	800
Drill Assembly	1	560
Bins	4	480
Clamps	1	330
TOTAL		$ 133,645

SAMIS CASE 5: LINEAR FRESNEL COLLECTOR

Based on the SAMIS results, the company's financial analyst compiled a proforma income statement using the company's standard chart of accounts.

PROFORMA INCOME STATEMENT
($000)

Revenues		$19,729
Cost of Goods Manufactured		
Labor	$ 783	
Materials	14,163	
Utilities	11	
		$14,957
Contribution Margin		$ 4,772
Overhead		
Depreciation	$125	
Property Tax	44	
Insurance	240	
		409
Gross Profit		$ 4,363
General & Administrative		
Salaries	$645	
Utilities	180	
Supplies & Miscellaneous	809	
		$1,634
Operating Income		$2,729
Interest Expense		49
Profit Before Tax		$2,680
Income Tax		1,372
Net Income		$1,308

These results for the hypothetical collector manufacturer of course would vary substantially with production level. The capital investment required, the number of people, the size of facilities all depend on the production volume. Several of the financial parameters such as the required rate of return on equity and the manufacturing process input also have a significant impact on the results. The SAMIS model is a useful tool to analyze all of these interdependent variables simultaneously.

APPENDIX F

M&D CASE 1: POWER CONDITIONING UNIT

The following example case demonstrates the use of the M&D model.

The case involves a hypothetical manufacturer of power conditioning units with a factory in Phoenix, Arizona. The company sells units of three standard sizes: 6 kilowatts for residential customers, 600 kilowatts for commercial customers and 6 megawatts for public utility customers. The company's inverter is used in photovoltaic solar energy systems to convert d.c. to a.c. electricity.

It is 1980 and the company anticipates rapid growth over the next six years due to technological advances and cost reductions of its photovoltaic solar energy systems.

The company plans to expand its production capacity to supply the increased demand. The target capacity is 60 megawatts per year for all types of products by 1986. Demand is expected to be distributed over three major product lines: 40% residential, 20% commercial and 40% public utility.

The engineering department has just completed a detailed manufacturing cost analysis for the new plant. Assuming the SAMIS model, they estimate an average manufacturing cost of $.220 per watt in 1986 dollars including overhead and profit. The cost will vary by type of customer: $.30 (residential), $.20 (commercial) and $.15 (public utility). These systems weigh 46,280 kilograms per megawatt and occupy 140 cubic meters per megawatt.

The marketing department has just performed a long range sales forecast for the next five years. They predicted the following total sales in 1986 by general customer category:

Residential	4000 systems
Commercial	20 systems
Public Utility	4 systems

The president of the company would like to estimate its annual marketing and distribution costs, number of sales people, where to locate its warehouses, how much inventory to store in each warehouse, and what price to charge for each major product in order to cover all expenses and earn a net profit after tax of 4% of sales.

This analysis can be performed quickly and easily with the M&D program. To do this, the quantitative information is compiled in the following format for input to the computer.

M&D CASE 1: POWER CONDITIONING UNIT

GENERAL INFORMATION

- Manufacturing Year 1986
  (the steady-state year for which the distribution costs are computed)

- Report Year 1980
  (the year in which dollars are expressed on the output reports)

- Run Type (check one)

  _____ 1. Distribution only
  _____ 2. Marketing only
  X 3. Marketing, Distribution, & Financial

- Demand by Customer Type and Region (megawatts per year)

MARKET REGION	CUSTOMER TYPE		
	RESIDENTIAL HOUSEHOLD	COMMERCIAL INTERMEDIATE	PUBLIC UTILITY CENTRAL STATION
WEST COAST	6.00	3.00	6.00
ROCKY MOUNTAIN	7.20	3.60	6.00
NORTH CENTRAL	1.20	0.60	0.00
GREAT LAKES	1.20	0.60	0.00
NORTH EASTERN	2.40	1.20	6.00
SOUTH EASTERN	1.20	0.60	0.00
SOUTH CENTRAL	4.80	2.40	6.00

- Manufacturing Price by Customer Type
  (manufacturing year dollars per watt)

  Residential/Household 0.30

  Commercial/Intermediate 0.20

  Public Utility/Central Station 0.15

M&D CASE 1: POWER CONDITIONING UNIT

MARKETING

- Average Order Quantity by Customer Type (megawatts per order)

Residential/Household	0.006
Commercial/Intermediate	0.600
Public Utility/Central Station	6.000

DISTRIBUTION

- Solar Product Volume (cubic meters per megawatt) 140.000

- Solar Product Weight (kilograms per megawatt) 46280.0

- Factory Location Region (check one)

_____	West Coast	_____	North Eastern
x	Rocky Mountain	_____	South Eastern
_____	North Central	_____	South Central
_____	Great Lakes		

- Average Delivery Quantity by Customer Type (megawatts per shipment)

Residential/Household	0.006
Commercial/Intermediate	0.600
Public Utility/Central Station	6.000

- Use of a Warehouse (put a 0 in each region for which the program should determine if a warehouse is wanted; 1 for each region which is forbidden to have a warehouse; and 2 for each region which must have a warehouse)

0	West Coast	0	North Eastern
0	Rocky Mountain	0	South Eastern
0	North Central	0	South Central
0	Great Lakes		

- Solar Product Type: 1. x Power Conditioning Unit
  2. _____ Collector

M&D CASE 1: POWER CONDITIONING UNIT

Following are the input data card images for the power conditioning example case.

CARD 1
6.0 3.0 6.0 7.2 3.6 6.0 1.2 0.6 0.0 1.2 (10f8.2)

CARD 2
0.6 0.0 2.4 1.2 6.0 1.2 0.6 0.0 4.8 2.4 (10F8.2)

CARD 3
6.0 (10F8.2)

CARD 4
0.006 0.600 6.000 (3F6.3)

CARD 5
0.006 0.600 6.000 (3F6.3)

CARD 6
0.241 0.241 0.241 (3F5.3)

CARD 7
1986 1980 46280. 104. 2 (2I6, F8.0, F10.3, I2)

CARD 8
0000000 (7I1)

CARD 9
3 (I4)

CARD 10
1 (I4)

Following are the M&D model output reports for the example case.

M&D CASE 1: POWER CONDITIONING UNIT

MARKET DEMAND DISTRIBUTION *** MSR-1
(MW/YR)

MARKET REGION	CUSTOMER TYPE			TOTAL ANNUAL DEMAND	
	RESIDENTIAL HOUSEHOLD	COMMERCIAL INTERMEDIATE	PUBLIC UTILITY CENTRAL STATION	MW	(%)
WEST COAST	6.00	3.00	6.00	15.00	(25.0)
ROCKY MOUNTAIN	7.20	3.60	6.00	16.80	(28.0)
NORTH CENTRAL	1.20	0.60	0.00	1.80	(3.0)
GREAT LAKES	1.20	0.60	0.00	1.80	(3.0)
NORTH EASTERN	2.40	1.20	6.00	9.60	(16.0)
SOUTH EASTERN	1.20	0.60	0.00	1.80	(3.0)
SOUTH CENTRAL	4.80	2.40	6.00	13.20	(22.0)
TOTAL MW	24.00	12.00	24.00	60.00	
(%)	(40.0)	(20.0)	(40.0)	(100.0)	(100.0)
AVERAGE ORDER QUANTITY (MW)	0.006	0.600	6.000		

** Demand distribution assumed as input to the model

MSR-1 Market Demand Distribution - This is an array of the demand by region and customer type as specified by the user as input data. Total megawatts and percentages are calculated. In addition, the average order quantity by customer type is listed. Again, this is input to the model. As can be seen, the demand distribution in this example case for the hypothetical power conditioning unit manufacturer is 40% residential, 20% commercial, and 40% utility. The total demand is 60 megawatts.

M&D CASE 1: POWER CONDITIONING UNIT

MARKETING EXPENSE SUMMARY
($1,000/YEAR)

MSR-2

	WEST COAST	ROCKY MOUNTAIN	NORTH CENTRAL	GREAT LAKES	NORTH EASTERN	SOUTH EASTERN	SOUTH CENTRAL	ALL REGIONS $1,000	(%)
SALARIES & BENEFITS									
Direct Personnel	$275	$319	$45	$51	$117	$38	$192	$1,037	(60.3)
Support Staff	134	155	21	25	58	18	94	506	(29.4)
SALES EXPENSES -travel/entertain -communications -office supplies	27	31	4	5	12	4	19	101	(5.9)
OFFICE FACILITIES -lease -utilities -maintenance -other expenses	17	18	3	3	8	3	12	64	(3.7)
ADVERTISING	3	4	1	1	1	1	2	12	(0.7)
TOTAL	$ 456	$ 527	$ 74	$ 84	$197	$ 63	$320	$1,720	(100.0)

MSR-2 - Marketing Expense Summary - Salaries and benefits as well as general and administrative expenses are broken down by region. These are calculated from the standard data and the indirect requirements matrix. For the example power conditioning unit manufacturer, total marketing expenses are $1,720,000. Salaries and benefits account for the largest portion of these marketing expenses, comprising 89.7% of the total.

M&D CASE 1: POWER CONDITIONING UNIT

MARKETING PERSONNEL SUMMARY MSR-3

JOB TITLE	ANNUAL COMPENSATION (1980$)*	WEST COAST	ROCKY MOUNTAIN	NORTH CENTRAL	GREAT LAKES	NORTH EASTERN	SOUTH EASTERN	SOUTH CENTRAL	ALL ** REGIONS #	(%)
SALESMEN										
-Residential	$23267	6	8	2	2	3	2	5	24	(49.7)
-Commercial	30920	2	2	1	1	1	1	2	6	(11.7)
-Utility	41124	1	1	0	0	1	0	1	2	(4.0)
DIRECT SUPPORT STAFF										
-Field Engineer	34012	1	1	1	1	1	1	1	3	(4.7)
-Artist	15872	1	1	0	0	1	0	1	1	(0.2)
-Market Research	32465	1	1	1	1	1	1	1	1	(0.9)
-Illustrator	24349	1	1	0	0	1	0	1	1	(0.5)
-Technical Writer	24349	1	1	0	0	1	0	1	1	(0.5)
-Advertising	22546	1	1	0	0	1	0	1	1	(0.2)
SECRETARIES										
-Level I	17586	2	2	1	1	1	1	1	5	(8.8)
-Level II	18758	1	1	1	1	1	1	1	3	(4.7)
-Level III	20471	1	1	1	1	1	1	1	2	(2.3)
MANAGEMENT										
-VP	77042	1	1	1	1	1	1	1	2	(2.3)
-Advertising	49472	0	0	0	0	0	0	0	1	(0.1)
-Market Research	49472	1	1	0	0	1	0	1	1	(0.2)
-Sales	49472	2	2	1	1	1	1	1	5	(8.5)
-Sales Engineer	49472	1	1	1	1	1	1	1	1	(0.6)
TOTAL **		12	14	2	2	5	2	10	48	(100.0)

* Annual Compensation includes wages and 40% benefits, averaged over all regions. These average rates over all regions, are adjusted by labor indices to compute annual sales personnel costs by region.

** Totals may not equal sum of numbers due to rounding.

MSR-3 Marketing Personnel Summary - Personnel are needed to market the three product lines including salesman, direct support staff, secretaries, and management. The annual compensation rates are part of the standard data listed in report year dollars for 1980. The number of personnel needed is generated by the indirect staffing matrix. For the example concentrator manufacturer, a total of 48 marketing personnel are required over all regions. Residential product salesmen form the largest personnel group at 49.7%

M&D CASE 1: POWER CONDITIONING UNIT

SALES OFFICE FACILITIES MSR-4

	WEST COAST	ROCKY MOUNTAIN	NORTH CENTRAL	GREAT LAKES	NORTH EASTERN	SOUTH EASTERN	SOUTH CENTRAL	ALL REGIONS
OFFICE SIZE (square meters)	149	176	27	27	68	27	122	595
TOTAL PEOPLE	12	14	2	2	5	2	10	48
CAPITAL COST (1980 $)	88627	95491	15877	15093	42527	14157	63370	335141
OPERATING COSTS (1980 $/year)								
-Lease	11167	12032	2001	1902	5358	1784	7985	42228
-Utilities	461	338	57	57	208	60	343	1524
-Maintenance	886	955	159	151	425	142	634	3351
-Other	4431	4775	794	755	2126	708	3168	16757
TOTAL ANNUAL OPERATING COSTS (1980 $/YEAR)	16946	18099	3010	2864	8118	2693	12130	63860

MSR-4 Sales Office Facilities - Several types of information are provided in this report broken down by region. The office size needed, total personnel (this agrees with MSR-3), and derived capital costs are given; as well as operating costs, in report year dollars, for lease, utilities, maintenance, and other. In this example case for the power conditioning unit company, the largest office is required in the Rocky Mountain region, which is also the region with the highest demand.

M&D CASE 1: POWER CONDITIONING UNIT

MARKETING PRICE ESTIMATES
($/WATT)

MSR-5

MARKET REGION	CUSTOMER TYPE			TOTAL ANNUAL DEMAND MW (%)
	RESIDENTIAL HOUSEHOLD	COMMERCIAL INTERMEDIATE	PUBLIC UTILITY CENTRAL STATION	
WEST COAST	$0.051	$0.033	$0.009	15.00 (25.0)
ROCKY MOUNTAIN	0.050	0.032	0.009	16.80 (28.0)
NORTH CENTRAL	0.047	0.030	0.000	1.80 (3.0)
GREAT LAKES	0.053	0.034	0.000	1.80 (3.0)
NORTH EASTERN	0.046	0.030	0.008	9.60 (16.0)
SOUTH EASTERN	0.040	0.025	0.000	1.80 (3.0)
SOUTH CENTRAL	0.043	0.028	0.008	13.20 (22.0)
AVERAGE	$0.048	$0.031	$0.009	

MSR-5 Marketing Price Estimates - The estimated price per watt is listed for each type of customer in each region. For the example power conditioning unit company, the highest price is $.053/watt for residential customers in the Great Lakes region. The lowest is $0.008 for public utility customers in the South Central and North Eastern regions.

M&D CASE 1: POWER CONDITIONING UNIT

MARKETING SUBMODEL PARAMETERS

MSR-6

SALES AND ADVERTISING EXPENSE RATES

CUSTOMER/PRODUCT TYPE	AVERAGE ORDER QUANTITY MW	SALES EXPENSE RATE %	ADVERTISING EXPENSE RATE %
Small Household Products	0.006	10.0	0.200
Intermediate Commercial Products	0.600	12.5	0.100
Large Central Power Stations	6.000	15.0	0.010

OFFICE FACILITIES COST PARAMETERS

Office Space Per Person	12.45 Square Meters Per Person
Office Capital Cost	$563.37 Per Square Meter (1980$)
Lease Rate	12.60 Percent of Captial Cost
Utilities Cost Rate	$1.69 Per Square Meter (1980$)
Maintenance Cost Rate	1.00 Percent of Capital Cost
Property Tax Rate	4.00 Percent of Capital Cost

MSR-6 Marketing Submodel Parameters - This report is basically a recapitulation of the important components of the standard data. All dollar amounts are presented in report year dollars. Data listed includes average order quantitites (part of the user specified input), sales expense rates, advertising expense rates, and office facilities cost parameters.

M&D CASE 1: POWER CONDITIONING UNIT

CUSTOMER DEMAND DISTRIBUTION ** (MW/YR) DSR-1

MARKET REGION	CUSTOMER TYPE			TOTAL ANNUAL DEMAND	
	RESIDENTIAL HOUSEHOLD	COMMERCIAL INTERMEDIATE	PUBLIC UTILITY CENTRAL STATION	MW	(%)
WEST COAST	6.00	3.00	6.00	15.00	(25.0)
ROCKY MOUNTAIN	7.20	3.60	6.00	16.80	(28.0)
NORTH CENTRAL	1.20	0.60	0.00	1.80	(3.0)
GREAT LAKES	1.20	0.60	0.00	1.80	(3.0)
NORTH EASTERN	2.40	1.20	6.00	9.60	(16.0)
SOUTH EASTERN	1.20	0.60	0.00	1.80	(3.0)
SOUTH CENTRAL	4.80	2.40	6.00	13.20	(22.0)
TOTAL MW	24.00	12.00	24.00	60.00	
(%)	(40.0%)	(20.0%)	(40.0%)	(100.0%)	(100.0%)
AVERAGE DELIVERY QUANTITY (MW)	0.006	0.600	6.000		
NUMBER OF DELIVERIES PER YEAR	4000.000	20.000	4.000		

** Demand distribution assumed as input to the model

DSR-1 Customer Demand Distribution - The demand distribution array is the same as the one generated in MSR-1. Also included is the average delivery quantity, and from this the number of deliveries per year are calculated. For the power conditioning unit example, the total utility demand is 24 MW, delivered in shipments of 6 MW, requiring 4 deliveries per year.

M&D CASE 1: POWER CONDITIONING UNIT

DISTRIBUTION EXPENSE SUMMARY DSR-2
(1980 $1,000/Year)

	West Coast	Rocky Mount	North Central	Great Lakes	North Eastern	South Eastern	South Central	All Regions $1,000	(%)
Transportation -direct shipments -transshipments -local deliveries	$140	$82	$ 49	$ 61	$ 272	$ 65	$ 164	$ 833	(94.4)
Warehouse Operations -salaries and benefits -utilities -maintenance -other expense	0	0	0	0	0	0	37	37	(4.1)
Warehouse Lease Expense	0	0	0	0	0	0	1	1	(0.1)
Inventory Carrying Charge	0	0	0	0	0	0	12	12	(1.4)
TOTAL	$140	$82	$ 49	$ 61	$ 272	$ 65	$ 213	$ 883	(100.0)

DSR-2 Distribution Expense Summary - A breakdown by region for annual transportation costs, warehouse operations, warehouse leasing expenses, and inventory carrying charges are presented in this report. For the example power conditioning unit, total annual distribution expenses are $883,000. The bulk of the distribution expense is for transportation - 94.4%, with the North Eastern region incurring the largest share of the total expense because it is furthest from the factory which is located in the Rocky Mountain region.

M&D CASE 1: POWER CONDITIONING UNIT

DISTRIBUTION NETWORK CONFIGURATION DSR-3

Regional Warehouse Location	Factory Shipping Mode/ Frequency	Warehouse Size (square meters)	Average Inventory Level (MW)	Delivery Trucks	Warehouse Personnel
West Coast Los Angeles	Direct 0.0 Weeks	0	0.00	0	0
Rocky Mountain Phoenix	Direct 0.0 Weeks	0	0.00	0	0
North Central Omaha	Direct 0.0 Weeks	0	0.00	0	0
Great Lakes Springfield	Direct 0.0 Weeks	0	0.00	0	0
North Eastern Syracuse	Direct 0.0 Weeks	0	0.00	0	0
South Eastern Atlanta	Rail 0.0 Weeks	0	0.00	0	0
South Central Dallas	Rail 2.0 Weeks	15	0.21	1	2
ALL REGIONS		15	0.21	1	2

DSR-3 Distribution Network Configuration - The program determines which factory shipping mode - direct, truck, or rail is most cost effective for each region, as well as the frequency of delivery. In addition, warehouse sizes are calculated according to the average inventory level, and from this the number of delivery trucks and warehouse personnel are determined. For this example power conditioning unit company, only the South Central region proves economical for a warehouse with an annual demand of 13.2 megawatts. Customers in every region can be supplied more economically directly from the factory.

M&D CASE 1: POWER CONDITIONING UNIT

WAREHOUSE FACILITIES DSR-4

	West Coast	Rocky Mountain	North Central	Great Lakes	North Eastern	South Eastern	South Central	All Regions
Warehouse Size (square meters)	0	0	0	0	0	0	15	15
Total People	0	0	0	0	0	0	2	2
Capital Cost (1980 $)	0	0	0	0	0	0	5530	5530
Operating Costs (1980 $/Year)								
-salaries & benefits	0	0	0	0	0	0	36199	36199
-utilities	0	0	0	0	0	0	41	41
-maintenance	0	0	0	0	0	0	55	55
-other	0	0	0	0	0	0	276	276
Lease Expense (1980 $/Year)	0	0	0	0	0	0	753	753
Carrying Charges (1980 $/Year)	0	0	0	0	0	0	11976	11976
Total Annual Facilities Costs (1980 $/Year)	0	0	0	0	0	0	49300	49300

DSR-4 Warehouse Facilities - A breakdown of the total annual facilities costs, in report year dollars. The warehouse sizes and number of personnel are listed for each region, and the capital cost is derived by the program. Operating costs for salaries and benefits, utilities, maintenance, and other are given, as well as lease expenses and carrying charges. For the example power conditioning unit company, the only region with a warehouse is the South Central.

M&D CASE 1: POWER CONDITIONING UNIT

ALTERNATIVE DISTRIBUTION COSTS
FOR WEST COAST REGION
(1980 $)

DSR-5

Customer Type	Distribution Alternative	Annual Cost for Direct Shipments	Annual Cost for Transshipments	Total Annual Distribution Cost
1 Residential	0 Factory Direct	$104436	$ 0	
2 Intermediate	0 Factory Direct	11908	0	$140160
3 Central Station	0 Factory Direct	23816	0	
1 Residential	1 Warehouse	$ 0	$64194	
2 Intermediate	1 Warehouse	0	32097	$160485
3 Central Station	1 Warehouse	0	64194	
1 Residential	0 Factory Direct	$104436	$ 0	
2 Intermediate	1 Warehouse	0	68808	$197060
3 Central Station	0 Factory Direct	23816	0	
1 Residential	0 Factory Direct	$104436	$ 0	
2 Intermediate	0 Factory Direct	11908	0	$194509
3 Central Station	1 Warehouse	0	78165	
1 Residential	1 Warehouse	$ 0	$95739	
2 Intermediate	1 Warehouse	0	47870	$167425
3 Central Station	0 Factory Direct	23816	0	
1 Residential	1 Warehouse	$ 0	$72505	
2 Intermediate	0 Factory Direct	11908	0	$156919
3 Central Station	1 Warehouse	0	72505	
1 Residential	0 Factory Direct	$104436	$ 0	
2 Intermediate	1 Warehouse	0	32356	$201504
3 Central Station	1 Warehouse	0	64712	
1 Residential	1 Warehouse	$ 0	$124706	
2 Intermediate	0 Factory Direct	11908	0	$160430
3 Central Station	0 Factory Direct	23816	0	

DSR-5 Alternative Distribution Costs - A separate report for each region is generated, with the exception of the region where the factory is located; because there can only be direct shipments - there is no warehouse. As can be seen for the example inverter company, annual shipment costs for each customer type are calculated for both factory direct and warehouse distribution to determine the lowest total annual distribution cost. In the case of the West Coast region, direct shipments from the factory are more economical than transshipments through a warehouse.

M&D CASE 1: POWER CONDITIONING UNIT

ECONOMIC WAREHOUSE ORDER QUANTITY FUNCTION
FOR WEST COAST REGION
(1980 $)

DSR-6

Warehouse Order Quantity	0.4154 MW	0.8308 MW	1.2462 MW	1.6615 MW
-Shipping Mode	Rail	Rail	Rail	Rail
-Order Processing Cost	$ 1748	$ 874	$ 583	$ 437
-Cost Per Shipment	103034	103034	103034	103034
Annual Transportation Cost	104782	103908	103617	103471
-Inventory Carrying Cost	11976	23951	35927	47902
-Warehouse Operating Cost	36571	36944	37317	37690
-Warehouse Leasing Cost	753	1506	2259	3012
Annual Warehousing Cost	49300	62401	75503	88604
-Fixed Delivery Cost	31156	31156	31156	31156
-Variable Delivery Cost	5336	5336	5336	5336
Annual Delivery Cost	36492	36492	36492	36492
TOTAL DISTRIBUTION COST FOR TRANSSHIPMENTS	$190574	$202801	$215611	$228567

Major Assumptions

Factory Location:	Rocky Mountain Region
Warehouse Location:	Dallas
Shipping Distance:	1652 Kilometers
Order Processing Cost:	$62.96 per shipment
Minimum Shipping Frequency:	Two Weeks

All Costs are in 1980 $.

DSR-6 Economic Warehouse Order Quantity Function - A separate report for each region is generated, with the exception of the region where the factory is located because there can only be direct shipments - there is no warehouse. As can be seen for the example power conditioning unit company, total annual distribution costs are computed for four different levels of warehouse order quantity: 0.1 MW, 0.2 MW, 0.3 MW, and 0.4 MW. This order quantity, given the annual demand, determines the number of shipments to the warehouse and the inventory level required to avoid stockouts. In this example the most economical order quantity is 0.4154 MW with deliveries every 2 weeks.

M&D CASE 1: POWER CONDITIONING UNIT

DISTRIBUTION PRICE ESTIMATES
(1980 $/Watt)

DSR-7

Market Region	CUSTOMER TYPE			Total Annual Demand	
	Residential Household	Commercial Intermediate	Public Utility Central Station	MW	(%)
West Coast	$0.017406	$0.003969	$0.003969	15.00	(25.0)
Rocky Mountain	0.009783	0.000446	0.000446	16.80	(28.0)
North Central	0.034796	0.012006	0.000000	1.80	(3.0)
Great Lakes	0.042920	0.015761	0.000000	1.80	(3.0)
North Eastern	0.052603	0.020236	0.020236	9.60	(16.0)
South Eastern	0.045945	0.017159	0.000000	1.80	(3.0)
South Central	0.022242	0.009540	0.013969	13.20	(22.0)
AVERAGE	$0.023178	$0.007304	$0.009655		

DSR-7 Distribution Price Estimates - The estimated price per watt is listed for each type of customer in each region. For the example power conditioning company, the highest price is $0.052603 per watt for residential customers in the North Eastern region which is furthest from the factory located in the Rocky Mountain region. The lowest price is $0.000446 per watt for commercial and public utility customers in the Rocky Mountain region.

M&D CASE 1: POWER CONDITIONING UNIT

DISTRIBUTION SUBMODEL PARAMETERS DSR-8

WAREHOUSE STAFFING RELATIONSHIPS

WAREHOUSE SIZE (SQUARE METERS)	TOTAL PERSONNEL REQUIRED
1 < F < 2000	2.00
2000 < F < 5000	0.66 + 0.00067 * F
5000 < F <15000	1.00 + 0.00060 * F
15000 < F	2.50 + 0.00050 * F

TOTAL PERSONNEL PERCENTAGE	PERSONNEL TITLE	ANNUAL COST* (1980$)
10%	Warehouse Supervisor	$27021
50%	Forklift Operator	13857
20%	Inventory Clerk	17019
20%	Material Handler	21163
100%	Weighted Average	$17267

* The annual cost for warehouse personnel includes both wages and benefits and is based on a nationwide survey. The costs should be multiplied by the appropriate labor cost index to reflect regional conditions.

WAREHOUSE FACILITIES COST PARAMETERS

Warehouse Space Utilization Factor	0.25 Cubic Meters of Product Per Square Meter Warehouse
Maintenance Cost Rate	1.00 Percent of Capital Cost
Utility Cost Rate	$1.69 Per Square Meter (1980$)
Insurance Cost Rate	1.00 Percent of Capital Cost
Property Tax Rate	4.00 Percent of Capital Cost
Equipment Lease Rate	25.00 Percent of Capital Cost
Building Lease Rate	12.60 Percent of Capital Cost
Inventory Carrying Charge	37.75 Percent of Unit Value

DSR-8 Distribution Submodel Parameters - There are two sections to this report. The first part shows the warehouse staffing relationships: 1) the total personnel required depending on the warehouse size, and 2) the breakdown of personnel types and their annual salaries. The second section is a listing of some of the more important standard data used by the program, including: warehouse space utilization factor, maintenance cost rate, utility cost rate (in report year dollars), insurance cost rate, property tax rate, equipment lease rate, building lease rate, and inventory carrying charge.

M&D CASE 1: POWER CONDITIONING UNIT

MARKETING AND DISTRIBUTION COMPANY
CONSOLIDATED INCOME STATEMENT ***
FOR THE YEAR ENDING DECEMBER 31, 1986

FSR-1

	(1980 $000)		(% Sales)
SALES:			
- Residential Products	$7215		57.2%
- Intermediate Products	2276		18.0%
- Central Power Stations	3130		24.8%
TOTAL SALES		$12621	100.0%
COST OF GOODS SOLD:			
- Residential Products	$5076		40.2%
- Intermediate Products	1692		13.4%
- Central Power Stations	2538		20.1%
TOTAL COST		$ 9305	73.7%
GROSS PROFIT		$ 3316	26.3%
EXPENSES:			
- Distribution (Schedule A)	$ 876		6.9%
- Marketing (Schedule B)	1720		13.6%
TOTAL EXPENSES		$ 2596	20.6%
NET PROFIT BEFORE TAX		$ 720	5.7%
NET INCOME TAX		367	2.9%
NET PROFIT AFTER TAX		$ 353	2.8%

***Consolidated over all geographic regions
Based on an average manufacturing price of $0.16 per watt in 1980 dollars, a manufacturing facility in the Rocky Mountain region, and a particular assumed demand distribution.

FSR-1 Consolidated Income Statement - A typical income statement showing sales, cost of goods sold, gross profit, expenses, net profit before tax, net income tax, and net profit after tax is consolidated over all marketing regions. For the power conditioning company residential products comprise 57.2% of sales. Marketing and distribution expenses contribute about 20.6% of the total cost of the PCU with 6.9% for distribution and 13.6% for marketing.

M&D CASE 1: POWER CONDITIONING UNIT

MARKETING AND DISTRIBUTION COMPANY — FSR-2
SCHEDULE A: DISTRIBUTION EXPENSES***
FOR THE YEAR ENDING DECEMBER 31, 1986

	(1980 $)		(% TOTAL)
TRANSPORTATION:			
- Direct Shipments	$692003		
- Transshipments	104782		
- Local Deliveries	36492		
TOTAL TRANSPORT		$833277	94.4%
WAREHOUSE OPERATIONS:			
- Salaries & Benefits	$ 36199		
- Utilities	41		
- Maintenance	55		
- Other	276		
TOTAL WAREHOUSE		$ 36571	4.1%
WAREHOUSE LEASE EXPENSE		$ 753	0.1%
INVENTORY CARRYING CHARGES		$ 11976	1.4%
TOTAL DISTRIBUTION EXPENSES		$882577	100.0%

*** Consolidated over all distribution regions
for all types of customers,
based on a single manufacturing facility
located in the Rocky Mountain region
and a particular assumed demand distribution

FSR-2 Schedule A: Distribution Expenses - In this report, transportation costs are broken down by direct shipments, transshipments, and local deliveries and ware house operations are broken down for salaries and benefits, utilities, main tenance, and other. For the example power conditioning company 94.4% of total distribution expenses are transportation. Warehousing costs including lease and carrying charges are only 5.6% of the total.

M&D CASE 1: POWER CONDITIONING UNIT

MARKETING AND DISTRIBUTION COMPANY FSR-3
SCHEDULE B: MARKETING EXPENSES ***
FOR THE YEAR ENDING DECEMBER 31, 1986

	(1980 $)		(% TOTAL)
SALARIES & BENEFITS:			
- Direct Staff	$1037007		
- Support Staff	506343		
TOTAL SALARIES		$1543350	89.7%
SALES EXPENSES:			
- Travel/Entertainment	$50532		
- Communications	30319		
- Office Supplies	20213		
TOTAL EXPENSES		$101064	5.9%
OFFICE FACILITIES:			
- Lease	42228		
- Utilities	1524		
- Maintenance	3351		
- Other Expenses	16757		
TOTAL FACILITIES:		$ 63860	3.7%
ADVERTISING		$ 12097	0.7%
TOTAL MARKETING EXPENSES		$1720372	100.0%

*** Consolidated over all marketing regions
for all types of customers
based on a particular assumed demand distribution

FSR-3 Schedule B: Marketing Expenses - In this report, marketing expenses are broken down by salaries & benefits, sales expenses, office facilities, and advertising. For the example power conditioning company, salaries and benefits comprise 89.7% of the total marketing expenses. Advertising represents only 0.7% of the total for the power conditioning company.

M&D CASE 1: POWER CONDITIONING UNIT

MARKETING AND DISTRIBUTION COMPANY
REGIONAL INCOME STATEMENTS ***
FOR THE YEAR ENDING DECEMBER 31, 1986

FSR-4

(1980 $000)

	West Coast	Rocky Mountain	North Central	Great Lakes	North Eastern	South Eastern	South Central	All Regions
SALES	3095	3452	492	517	1896	498	2672	12621
COST OF GOODS SOLD	2326	2665	338	338	1311	338	1988	9305
EXPENSES:								
-Marketing	456	527	74	84	197	63	320	1720
-Distribution	140	75	49	61	272	65	213	876
INCOME TAXES	88	95	15	17	59	16	77	367
NET PROFIT	84	91	15	16	57	15	74	353

*** Based on an average manufacturing price of $0.16 per watt in 1980 dollars, a manufacturing facility in the Rocky Mountain region, and a particular assumed demand distribution.

FSR-4 Regional Income Statements - This report lists income statements for each regional office. For the example power conditioning company, the Rocky Mountain region is the highest profit center with $91,000 net profit after tax or 2.6% of sales.

M&D CASE 1: POWER CONDITIONING UNIT

MARKETING AND DISTRIBUTION COMPANY
DELIVERED PRICE ESTIMATES ***

FSR-5

	(1980 $/Watt)		(% PRICE)	
COST OF GOODS SOLD:				
- Residential Products	$0.211			
- Intermediate Products	0.141			
- Central Power Stations	0.106			
TOTAL COST		$0.155		73.7%
EXPENSES:				
- Distribution	$0.015		6.9%	
- Marketing	0.029		13.6%	
TOTAL EXPENSES		0.043		20.6%
INCOME TAXES		0.006		2.9%
NET PROFIT AFTER TAX		0.006		2.8%
DELIVERED PRODUCT PRICES:				
- Residential Products	$0.301			
- Intermediate Products	0.190			
- Central Power Stations	0.130			
ALL PRODUCTS		$0.210		100.0%

*** Based on an average manufacturing price of $0.16 per watt in 1980 dollars, a manufacturing facility in the Rocky Mountain region, and a particular assumed demand distribution.

FSR-5 Delivered Price Estimates - This report lists the components of the delivered product price in report year $ per watt and as a percent of the total price. These figures are consolidated over all regions. For the example power conditioning company, the cost of goods sold or manufacturing cost is 73.7% of the average price of $0.210 per watt over all customers. Residential prices are the highest at $0.301 per watt and public utility prices are lowest at $0.130 per watt for the example power conditioning company.

M&D CASE 1: POWER CONDITIONING UNIT

MARKETING AND DISTRIBUTION COMPANY
DELIVERED PRICE ESTIMATES ***
FOR EACH TYPE OF CUSTOMER BY REGION

FSR-6

(1980 $/Watt)

MARKET REGION	Residential Household Products	Intermediate Commercial Products	Central Station Public Utility Products	All Customer Products
WEST COAST	$0.297	$0.188	$0.125	$0.206
ROCKY MOUNTAIN	0.288	0.183	0.120	0.205
NORTH CENTRAL	0.313	0.194	0.000	0.273
GREAT LAKES	0.329	0.203	0.000	0.287
NORTH EASTERN	0.333	0.203	0.142	0.198
SOUTH EASTERN	0.317	0.195	0.000	0.276
SOUTH CENTRAL	0.294	0.189	0.134	0.202
ALL REGIONS	$0.301	$0.190	$0.130	$0.210

Price Ranges:

MINIMUM = $0.120/watt for central station utility in the Rocky Mountain region

MAXIMUM = $0.333/watt for residential household in the North Eastern region

AVERAGE = $0.210/watt over all products and regions

*** Based on an average manufacturing price of $0.16 per watt in 1980 dollars, a manufacturing facility in the Rocky Mountain region, and a particular assumed demand distribution

FSR-6 Delivered Price Estimates - In this report, delivered price estimates in report year dollars per watt are listed by region and customer type. The minimum is $.120/watt for utility customers in the Rocky Mountain region, and the maximum is $.333/watt for residential customers in the North Eastern region.

M&D CASE 1: POWER CONDITIONING UNIT

MARKETING AND DISTRIBUTION COMPANY FSR-7
KEY FINANCIAL INDICATORS

Market Region	MARK-UP BY CUSTOMER TYPE			Mark-up (Revenue - CGS)/CGS	Profit Margin (NPAT/Revenue)
	Residential Household	Commercial Intermediate	Public Utility Central Station		
West Coast	40.5%	33.3%	17.8%	33.0%	2.7%
Rocky Mountain	36.0%	30.0%	13.8%	29.5%	2.6%
North Central	47.8%	37.7%	0.0%	45.3%	3.0%
Great Lakes	55.6%	44.1%	0.0%	52.7%	3.2%
North Eastern	57.3%	44.3%	34.6%	44.6%	3.0%
South Eastern	50.0%	38.2%	0.0%	47.1%	3.1%
South Central	39.1%	33.9%	27.2%	34.4%	2.8%
ALL REGIONS	42.1%	34.5%	23.4%	35.6%	2.8%

Financial Parameters:

Rate of Return on Equity	= 17.20% (input)
After Tax Cost of Capital	= 15.39% (derived)
Financial Leverage	= 1.20 (input)
Corporate Income Tax Rate	= 51.00% (standard data)
Cost of Debt Capital	= 12.90% (standard data)
Deflation Rate	= 6.00% (standard data)
Average Inventory Turnover Time	= 1.50 months (standard data)
Average Expense Coverage Time	= 6.00 months (standard data)
Inventory Carrying Charge Rate	= 37.75% (standard data)

FSR-7 Key Financial Indicators - An array by region and customer type shows mark-up percentages for all products. Profit margin is also listed for each region over all products. A listing of financial parameters is provided at the bottom of the report, specifying whether the information is part of the user input, derived, or part of the standard data base which can also be modified by the user. For the example power conditioning company, the North Eastern region posted the highest mark-up of 57.3% for commercial products and a profit margin of 3.0% over all products. The lowest mark-up is 13.8% for public utility customers in the Rocky Mountain region closest to the factory.

M&D CASE 1: POWER CONDITIONING UNIT

MARKETING AND DISTRIBUTION COMPANY
GENERAL M&D MODEL PARAMETERS

FSR-8

INPUT DATA:

• Product Manufacturing Cost (Mfg Year $/Watt)	$0.241
• Manufacturing Year	1986
• Product Volume (Cubic Meters/MW)	10200.0
• Product Weight (kilograms/MW)	462800.0
• Factory Location Region	Rocky Mountain

STANDARD DATA:

• Base Price Year	1981
• Deflation Rate Solar Products	6.00%
• Inflation Rates	
- Raw Materials	11.00%
- Labor	8.00%
- Chemicals	13.00%
- Commodities	8.00%
- Energy	12.00%
- Land	4.00%
- Facilities	9.00%
- Construction	8.00%
- Equipment	7.00%
- Resources	15.00%
- Transportation	7.00%

FSR-8 General M&D Model Parameters - There are two sections to this financial report: 1) input data including the product manufacturing cost, manufacturing year, volume, weight, and factory location region, and 2) standard data including the base price year, deflation rate, and eleven inflation rates. The numbers listed here are for the example power conditioning unit company.

M&D CASE 1: POWER CONDITIONING UNIT

The example case involves a hypothetical power conditioning unit manufacturer with a factory in Phoenix, Arizona. The company sells PCU's of three standard sizes: 6 kilowatts for residential customers, 600 kilowatts for commercial customers and 6 megawatts for public utility customers. In 1986, sales are predicted to be 50 megawatts distributed as follows:

1986 SALES FORECAST

	Units	Megawatts
Residential	4000	24
Commercial	20	12
Public Utility	4	24
	4024	60

Based on a manufacturing cost analysis, the company estimates an average manufacturing cost including overhead and profit of $.220 per watt in 1986 dollars. This is equivalent to $0.16 per watt in 1980 dollars.

Using the M&D model, the company estimates average marketing expenses of $0.029 per watt and distribution expenses of $0.015 per watt in 1980 dollars. After adding in taxes and profit, the following delivered product prices were obtained:

DELIVERED PRODUCT PRICES

	(1980 $/Watt)
Residential	.301
Commercial	.190
Public Utility	.130
Weighted Average	.210

Based on the demand forecast for 1986, these prices will generate the following sales revenues:

SALES REVENUES

	(1980 $000)	
Residential	$ 7215	57%
Commercial	2276	18%
Public Utility	3130	25%
All products	$12621	100%

Distribution costs will total $882,577 and marketing costs will total $1,720,372 in 1980 dollars. Together these costs represent 20.6% of sales. Net profit after tax is estimated at $353,000.

M&D CASE 1: POWER CONDITIONING UNIT

Markup, defined as revenue less cost of goods manufactured divided by cost of goods manufactured, varies by region and type of customer.

MARK-UP

	(Revenue - CGS/CGS)
Residential	42.1%
Commercial	34.5%
Public Utility	23.4%
All Products	35.6%

The M&D model projects a sales force of about 48 people for this level of sales and productivity. About 65% consist of salesman and the balance are support staff and management

	SALES FORCE SIZE
SALESMAN	
- Residential	24
- Commercial	6
- Public Utility	2
DIRECT SUPPORT STAFF	
- Field Engineer	2
- Commercial Artist	0
- Marketing Research Analyst	1
- Technical Illustrator	1
- Technical Writer	0
- Advertising Salesman	0
SECRETARIES	
- Level I	4
- Level II	2
- Level III	1
MANAGEMENT	
- Vice President	1
- Advertising Manager	0
- Marketing Research Manager	0
- Sales Manager	4
- Sales Engineering Manager	0
TOTAL	48

M&D CASE 1: POWER CONDITIONING UNIT

To minimize shipping costs, the company determined that it would be economical to supply its residential and commercial customers in the South Central Region from a warehouse in Dallas.

Customers in all other regions will be supplied directly from the factory in Phoenix.

These results for the hypothetical power conditioning unit manufacturer of course would vary substantially with production level. The number of sales people, the location of the warehouses and the average inventory mix all depend on the level of sales, geographic distribution and product mix. The M&D model is a useful tool to analyze all of these interdependent variables simultaneously.

APPENDIX G
M&D CASE 2: CONCENTRATOR COLLECTOR

The following example case demonstrates the use of the M&D model.

The case involves a hypothetical manufacturer of photovoltaic concentrator collectors with a factory in Phoenix, Arizona. The company sells systems of three standard sizes: 5 kilowatts for residential customers, 500 kilowatts for commercial customers and 5 megawatts for public utility customers. The company produces concentrating collectors which focuses the sunlight converting it to electricity in just one step.

It is 1980 and the company anticipates rapid growth over the next five years due to technological advances and cost reductions of its photovoltaic solar energy systems. As the cost per watt declines, demand is expected to grow exponentially.

The company plans to expand its production capacity to supply the increased demand. The target capacity is 50 megawatts per year for all types of products by 1986. Demand is expected to be distributed over three major product lines: 40% residential, 20% commercial and 40% public utility.

The engineering department has just completed a detailed manufacturing cost analysis for the new plant. Assuming the SAMIS model, they estimate an average manufacturing cost of $.9929 per watt in 1986 dollars including overhead and profit. These systems weigh 462,800 kilograms per megawatt and occupy 10,200 cubic meters per megawatt.

The marketing department has just performed a long range sales forecast for the next five years. They predicted the following total sales in 1986 by general customer category:

Residential	4000 systems
Commercial	20 systems
Public Utility	4 systems

The president of the company would like to estimate its annual marketing and distribution costs, number of sales people, where to locate its warehouses, how much inventory to store in each warehouse, and what price to charge for each major product in order to cover all expenses and earn a net profit after tax of 3% of sales.

This analysis can be performed quickly and easily with the M&D program. To do this, the quantitative information is compiled in the following format for input to the computer.

M&D CASE 2: CONCENTRATOR COLLECTOR

GENERAL INFORMATION

- Manufacturing Year 1986
  (the steady-state year for which the distribution costs are computed)

- Report Year 1980
  (the year in which dollars are expressed on the output reports)

- Run Type (check one)

  _____ 1. Distribution only
  _____ 2. Marketing only
  X 3. Marketing, Distribution, & Financial

- Demand by Customer Type and Region (megawatts per year)

MARKET REGION	CUSTOMER TYPE		
	RESIDENTIAL HOUSEHOLD	COMMERCIAL INTERMEDIATE	PUBLIC UTILITY CENTRAL STATION
WEST COAST	5.0	2.5	5.0
ROCKY MOUNTAIN	6.0	3.0	5.0
NORTH CENTRAL	1.0	0.5	0.0
GREAT LAKES	1.0	0.5	0.0
NORTH EASTERN	2.0	1.0	5.0
SOUTH EASTERN	1.0	0.5	0.0
SOUTH CENTRAL	4.0	2.0	5.0

- Manufacturing Price by Customer Type
  (manufacturing year dollars per watt)

  Residential/Household .9929
  Commercial/Intermediate .9929
  Public Utility/Central Station .9929

M&D CASE 2: CONCENTRATOR COLLECTOR

MARKETING

- Average Order Quantity by Customer Type (megawatts per order)

Residential/Household	0.005
Commercial/Intermediate	0.500
Public Utility/Central Station	5.000

DISTRIBUTION

- Solar Product Volume (cubic meters per megawatt) 10,200.0

- Solar Product Weight (kilograms per megawatt) 462,800.0

- Factory Location Region (check one)

_____	West Coast	_____	North Eastern
x	Rocky Mountain	_____	South Eastern
_____	North Central	_____	South Central
_____	Great Lakes		

- Average Delivery Quantity by Customer Type (megawatts per shipment)

Residential/Household	0.005
Commercial/Intermediate	0.500
Public Utility/Central Station	5.000

- Use of a Warehouse (put a 0 in each region for which the program should determine if a warehouse is wanted; 1 for each region which is forbidden to have a warehouse; and 2 for each region which must have a warehouse)

0	West Coast	0	North Eastern
0	Rocky Mountain	0	South Eastern
0	North Central	0	South Central
0	Great Lakes		

- Solar Product Type: 1. _____ Power Conditioning Unit
  2. x Collector

M&D CASE 2: CONCENTRATOR COLLECTOR

Following are the input data card images for the photovoltaic concentrator collector example case.

CARD 1
5.0 2.5 5.0 6.0 3.0 5.0 1.0 0.5 0.0 1.0 (10F8.2)

CARD 2
0.5 0.0 2.0 1.0 5.0 1.0 0.5 0.0 4.0 2.0 (10F8.2)

CARD 3
5.0 (10F8.2)

CARD 4
0.005 0.500 5.000 (3F6.3)

CARD 5
0.005 0.500 5.000 (3F6.3)

CARD 6
0.9929 0.9929 0.9929 (3F5.3)

CARD 7
1986 1980 462800. 10200. 2 (2I6, F8.0, F10.3, I2)

CARD 8
0000000 (7I1)

CARD 9
3 (I4)

CARD 10
2 (I4)

Following are the M&D model output reports for the example case.

M&D CASE 2: CONCENTRATOR COLLECTOR

MARKET DEMAND DISTRIBUTION *** MSR-1
(MW/YR)

MARKET REGION	CUSTOMER TYPE			TOTAL ANNUAL DEMAND	
	RESIDENTIAL HOUSEHOLD	COMMERCIAL INTERMEDIATE	PUBLIC UTILITY CENTRAL STATION	MW	(%)
WEST COAST	5.00	2.50	5.00	12.50	(25.0)
ROCKY MOUNTAIN	6.00	3.00	5.00	14.00	(28.0)
NORTH CENTRAL	1.00	0.50	0.00	1.50	(3.0)
GREAT LAKES	1.00	0.50	0.00	1.50	(3.0)
NORTH EASTERN	2.00	1.00	5.00	8.00	(16.0)
SOUTH EASTERN	1.00	0.50	0.00	1.50	(3.0)
SOUTH CENTRAL	4.00	2.00	5.00	11.00	(22.0)
TOTAL MW	20.00	10.00	20.00	50.00	
(%)	(40.0)	(20.0)	(40.0)	(100.0)	(100.0)
AVERAGE ORDER QUANTITY (MW)	0.005	0.500	5.000		

** Demand distribution assumed as input to the model

MSR-1 Market Demand Distribution - This is an array of the demand by region and customer type as specified by the user as input data. Total megawatts and percentages are calculated. In addition, the average order quantity by customer type is listed. Again, this is input to the model. As can be seen, the demand distribution in this example case for the hypothetical concentrator manufacturer is 40% residential, 20% commercial, and 40% utility.

M&D CASE 2: CONCENTRATOR COLLECTOR

MARKETING EXPENSE SUMMARY
(1980 $1,000/YEAR)

MSR-2

	WEST COAST	ROCKY MOUNTAIN	NORTH CENTRAL	GREAT LAKES	NORTH EASTERN	SOUTH EASTERN	SOUTH CENTRAL	ALL REGIONS $1,000	(%)
SALARIES & BENEFITS									
Direct Personnel	$637	$733	$97	$112	$289	$82	$451	$2,401	(55.4)
Support Staff	289	332	44	50	131	37	204	1,087	(25.1)
SALES EXPENSES -travel/entertain -communications -office supplies	94	108	15	17	42	12	66	353	(8.2)
OFFICE FACILITIES -lease -utilities -maintenance -other expenses	32	33	6	6	19	6	23	124	(2.9)
ADVERTISING	91	109	18	18	39	18	74	364	(8.4)
TOTAL	$1,142	$1,315	$180	$202	$519	$155	$819	$4,331	(100.0)

MSR-2 - Marketing Expense Summary - Salaries and benefits as well as general and administrative expenses are broken down by region. These are calculated from standard data and the indirect requirements matrix. For the example concentrator manufacturer, total marketing expenses are $4,331,000. Salaries and benefits account for the largest portion of these marketing expenses, comprising 75.5% of the total.

M&D CASE 2: CONCENTRATOR COLLECTOR

MARKETING PERSONNEL SUMMARY

MSR-3

JOB TITLE	ANNUAL COMPENSATION (1980$)*	WEST COAST	ROCKY MOUNTAIN	NORTH CENTRAL	GREAT LAKES	NORTH EASTERN	SOUTH EASTERN	SOUTH CENTRAL	ALL ** REGIONS #	(%)
SALESMEN										
-Residential	$23267	10	12	2	2	4	2	8	40	(38.1)
-Commercial	30920	3	4	1	1	2	1	3	11	(9.9)
-Utility	41124	1	1	0	0	1	0	1	4	(3.7)
DIRECT SUPPORT STAFF										
-Field Engineer	34012	4	5	1	1	3	1	4	16	(14.5)
-Artist	15872	1	1	1	1	1	1	1	1	(0.7)
-Market Research	32465	1	1	1	1	1	1	1	4	(2.9)
-Illustrator	24349	1	1	1	1	1	1	1	2	(1.5)
-Technical Writer	24349	1	1	1	1	1	1	1	2	(1.5)
-Advertising	22546	1	1	1	1	1	1	1	1	(0.7)
SECRETARIES										
-Level I	17586	2	3	1	1	1	1	2	9	(7.7)
-Level II	18758	2	2	1	1	1	1	2	5	(4.7)
-Level III	20471	1	1	1	1	1	1	1	3	(2.4)
MANAGEMENT										
-VP	77042	1	1	1	1	1	1	1	3	(2.4)
-Advertising	49472	1	1	0	0	1	0	1	1	(0.2)
-Market Research	49472	1	1	1	1	1	1	1	1	(0.5)
-Sales	49472	2	3	1	1	1	1	2	8	(6.8)
-Sales Engineer	49472	1	1	1	1	1	1	1	3	(1.9)
TOTAL **		26	30	4	4	13	4	22	104	(100)

* Annual compensation includes wages and 40% benefits, averaged over all regions. These average rates over all regions, are adjusted by labor indices to compute annual sales personnel costs by region.

** Totals may not equal sum of numbers due to rounding.

MSR-3 Marketing Personnel Summary - Personnel are needed to market the three product lines including salesman, direct support staff, secretaries, and management. The annual compensation rates are part of the standard data listed in report year dollars for 1980. The number of personnel needed is generated by the indirect staffing matrix. For the example concentrator manufacturer, a total of 104 marketing personnel are required over all regions. Residential products salesman form the largest personnel group at 38.1%.

M&D CASE 2: CONCENTRATOR COLLECTOR

SALES OFFICE FACILITIES MSR-4

	WEST COAST	ROCKY MOUNTAIN	NORTH CENTRAL	GREAT LAKES	NORTH EASTERN	SOUTH EASTERN	SOUTH CENTRAL	ALL REGIONS
OFFICE SIZE (square meters)	324	379	56	56	157	56	268	1295
TOTAL PEOPLE	26	30	4	4	13	4	22	104
CAPITAL COST (1980 $)	$164461	173974	32821	31199	98140	29264	121371	651231
OPERATING COSTS (1980 $/year)								
-Lease	20722	21921	4135	3931	12366	3687	15293	82055
-Utilities	1004	731	117	117	479	124	756	3328
-Maintenance	1645	1740	328	312	981	293	1214	6512
-Other	8223	8699	1641	1560	4907	1463	6069	32562
TOTAL ANNUAL OPERATING COSTS (1980 $/YEAR)	31593	33090	6222	5920	18733	5567	23331	124457

MSR-4 Sales Office Facilities - This report lists various statistics related to the regional sales office facilities including office size, total people, capital cost and total annual operating costs in report year dollars. Total personnel agrees with report MSR-3. In this case, the Rocky Mountain Region has the largest staff of 30 people which is approximately 29% of the total of 104. The demand is 14 megawatts which is 28% of the total of 50 megawatts.

M&D CASE 2: CONCENTRATOR COLLECTOR

MARKETING PRICE ESTIMATES
(1980 $/WATT)

MSR-5

MARKET REGION	CUSTOMER TYPE			
	RESIDENTIAL HOUSEHOLD	COMMERCIAL INTERMEDIATE	PUBLIC UTILITY CENTRAL STATION	TOTAL ANNUAL DEMAND MW (%)
WEST COAST	0.126	0.087	0.027	12.50 (25.0)
ROCKY MOUNTAIN	0.124	0.086	0.026	14.00 (28.0)
NORTH CENTRAL	0.118	0.081	0.000	1.50 (3.0)
GREAT LAKES	0.132	0.091	0.000	1.50 (3.0)
NORTH EASTERN	0.116	0.080	0.024	8.00 (16.0)
SOUTH EASTERN	0.102	0.070	0.000	1.50 (3.0)
SOUTH CENTRAL	0.109	0.082	0.025	11.00 (22.0)
AVERAGE	0.136	0.095	0.033	

MSR-5 Marketing Price Estimates - The estimated marketing price per watt for each type of customer in each region is also averaged over all regions. These prices are for marketing only and do not include manufacturing cost, distribution cost, income tax or profit. For the example concentrator company the highest price is $0.132 for residential customers in the Great Lakes region and lowest is 0.023 for utility customers in the South Central region.

M&D CASE 2: CONCENTRATOR COLLECTOR

MARKETING SUBMODEL PARAMETERS MSR-6

SALES AND ADVERTISING EXPENSE RATES

CUSTOMER/PRODUCT TYPE	AVERAGE ORDER QUANTITY MW	SALES EXPENSE RATE %	ADVERTISING EXPENSE RATE %
Small Household Products	0.005	20.0	2.0
Intermediate Commercial Products	0.500	25.0	1.0
Large Central Power Stations	5.000	30.0	0.1

OFFICE FACILITIES COST PARAMETERS

Office Space Per Person	12.45 Square Meters Per Person
Office Capital Cost	$502.81 Per Square Meter (1980$)
Lease Rate	12.60 Percent of Captial Cost
Utilities Cost Rate	$1.69 Per Square Meter (1980$)
Maintenance Cost Rate	1.00 Percent of Capital Cost
Property Tax Rate	4.00 Percent of Capital Cost

MSR-6 Marketing Submodel Parameters - This report is basically a recapitulation of the important components of the standard data. All dollar amounts are presented in report year dollars. Data listed includes average order quantitites (part of the user specified input), sales expense rates, advertising expense rates, and office facilities cost parameters.

M&D CASE 2: CONCENTRATOR COLLECTOR

CUSTOMER DEMAND DISTRIBUTION ** (MW/YR) DSR-1

MARKET REGION	CUSTOMER TYPE			TOTAL ANNUAL DEMAND	
	RESIDENTIAL HOUSEHOLD	COMMERCIAL INTERMEDIATE	PUBLIC UTILITY CENTRAL STATION	MW	(%)
WEST COAST	5.00	2.50	5.00	12.50	(25.0)
ROCKY MOUNTAIN	6.00	3.00	5.00	14.00	(28.0)
NORTH CENTRAL	1.00	0.50	0.00	1.50	(3.0)
GREAT LAKES	1.00	0.50	0.00	1.50	(3.0)
NORTH EASTERN	2.00	1.00	5.00	8.00	(16.0)
SOUTH EASTERN	1.00	0.50	0.00	1.50	(3.0)
SOUTH CENTRAL	4.00	2.00	5.00	11.00	(22.0)
TOTAL MW	20.00	10.00	20.00	50.00	
(%)	(40.0)	(20.0)	(40.0)	(100.0)	(100.0)
AVERAGE DELIVERY QUANTITY (MW)	0.005	0.50	5.00		
NUMBER OF DELIVERIES PER YEAR	4000.00	20.00	4.00		

** Demand distribution assumed as input to the model

FACTORY LOCATION: Rocky Mountain

DSR-1 Customer Demand Distribution - The demand distribution array is the same as the one generated in MSR-1. Also included is the average delivery quantity, and from this the number of deliveries per year are calculated. For the example concentrator company, the total utility demand is 20 MW, delivered in shipments of 5 MW, requiring 4 deliveries per year.

M&D CASE 2: CONCENTRATOR COLLECTOR

DISTRIBUTION EXPENSE SUMMARY (1980 $1,000/YEAR) DSR-2

	WEST COAST	ROCKY MOUNTAIN	NORTH CENTRAL	GREAT LAKES	NORTH EASTERN	SOUTH EASTERN	SOUTH CENTRAL	ALL REGIONS $1,000	(%)
TRANSPORTATION	537	346	215	271	1655	292	1089	4404	(90.9)
- Direct Shipments									
- Transshipments									
- Local Delivery									
WAREHOUSE OPERATIONS	57	0	43	49	45	37	46	276	(5.7)
- Salaries & Benefit									
- Utilities									
- Maintenance									
- Other Expenses									
WAREHOUSE LEASE EXPENSE	28	0	9	8	12	8	20	85	(1.8)
INVENTORY CARRYING CHARGE	25	0	8	8	10	8	20	79	(1.6)
TOTAL	647	346	274	336	1722	344	1175	4844	(100.0)

DSR-2 Distribution Expense Summary - An annual breakdown by region for transportation costs, warehouse operations, warehouse leasing expenses, and inventory carrying charges may be found in this report. For the example concentrator company, the total distribution expense is $4,844,000 per year. The bulk of the distribution expense is for transportation - 90.9%, with the North Eastern region incurring the largest share of the total expense.

M&D CASE 2: CONCENTRATOR COLLECTOR

DISTRIBUTION NETWORK CONFIGURATION DSR-3

REGIONAL WAREHOUSE LOCATION	FACTORY SHIPPING MODE/ FREQUENCY	WAREHOUSE SIZE (SQUARE METERS)	AVERAGE INVENTORY LEVEL (MW)	DELIVERY TRUCKS	WAREHOUSE PERSONNEL
West Coast Los Angeles	Rail 2.0 Weeks	490	0.10	1	2
Rocky Mountain Phoenix	Direct 0.0 Weeks	0	0.00	0	0
North Central Omaha	Rail 2.0 Weeks	147	0.03	1	2
Great Lakes Springfield	Rail 2.0 Weeks	147	0.03	1	2
North Eastern Syracuse	Rail 1.0 Weeks	196	0.04	1	2
South Eastern Atlanta	Rail 2.0 Weeks	147	0.03	1	2
South Central Dallas	Rail 2.0 Weeks	392	0.08	1	2
ALL REGIONS		1520	0.30	6	12

DSR-3 Distribution Network Configuration - The program determines which factory shipping modes - direct, truck, or rail - is most cost effective for each region, as well as the frequency of delivery. In addition, warehouse sizes are calculated according to the average inventory level, and from this the number of delivery trucks and warehouse personnel are determined. Since the concentrator manufacturing factory is in the Rocky Mountain region, a warehouse is not needed - there are only direct shipments. Every other region requires one delivery truck and two warehouse personnel.

M&D CASE 2: CONCENTRATOR COLLECTOR

WAREHOUSE FACILITIES DSR-4

	WEST COAST	ROCKY MOUNTAIN	NORTH CENTRAL	GREAT LAKES	NORTH EASTERN	SOUTH EASTERN	SOUTH CENTRAL	ALL REGIONS
WAREHOUSE SIZE (Square Meters)	490	0	147	147	196	147	392	1520
TOTAL PEOPLE	2	0	2	2	2	2	2	12
CAPITAL COST (1980$)	$207229	$0	$63501	$60362	$89657	$56619	$145881	$623249
OPERATING COSTS (1980 $/Year)								
-Salaries & Benefits	42611	0	39173	44852	38555	33147	36199	234537
-Utilities	1520	0	311	311	599	328	1105	4174
-Maintenance	2072	0	635	604	897	566	1459	6232
-Other	10361	0	3175	3018	4483	2831	7294	31162
LEASE EXPENSE (1980 $/Year)	28288	0	8648	8221	12210	7711	19901	84980
Carrying Charges (1980 $/Year)	25410	0	7623	7623	10164	7623	20328	78770
TOTAL ANNUAL FACILITIES COSTS (1980 $/Year)	$110263	$0	$59565	$64628	$66908	$52206	$86286	$439856

DSR-4 Warehouse Facilities - This report is a breakdown of the total annual facilities costs in report year dollars. The warehouse sizes and number of personnel are listed for each region, and the capital cost is derived by the program. Operating costs for salaries and benefits, utilities, maintenance, and other are given, as well as lease expenses and carrying charges. For the example concentrator company, the highest costs are incurred on the West Coast, and the lowest in the South Eastern region, with the exception of the Rocky Mountain region, where there is no warehouse because this is the factory location.

M&D CASE 2: CONCENTRATOR COLLECTOR

ALTERNATIVE DISTRIBUTION COSTS
FOR WEST COAST REGION
(1980$)

DSR-5

CUSTOMER TYPE	DISTRIBUTION ALTERNATIVE	ANNUAL COST FOR DIRECT SHIPMENTS	ANNUAL COST FOR TRANSSHIPMENTS	TOTAL ANNUAL DISTRIBUTION COST
1 Residential	0 Factory Direct	$566367	$ 0	
2 Intermediate	0 Factory Direct	$ 99233	$ 0	$864066
3 Central Station	0 Factory Direct	$198466	$ 0	
1 Residential	1 Warehouse	$ 0	$311660	
2 Intermediate	1 Warehouse	$ 0	$155830	$779150
3 Central Station	1 Warehouse	$ 0	$311660	
1 Residential	0 Factory Direct	$566367	$ 0	
2 Intermediate	1 Warehouse	$ 0	$178943	$943776
3 Central Station	0 Factory Direct	$198466	$ 0	$
1 Residential	0 Factory Direct	$566367	$ 0	$
2 Intermediate	0 Factory Direct	$ 99233	$ 0	$1009027
3 Central Station	1 Warehouse	$ 0	$343427	$
1 Residential	1 Warehouse	$ 0	$321973	$
2 Intermediate	1 Warehouse	$ 0	$160987	$681426
3 Central Station	0 Factory Direct	$198466	$ 0	$
1 Residential	1 Warehouse	$ 0	$308132	$
2 Intermediate	0 Factory Direct	$ 99233	$ 0	$715497
3 Central Station	1 Warehouse	$ 0	$308132	$
1 Residential	0 Factory Direct	$566367	$ 0	$
2 Intermediate	1 Warehouse	$ 0	$158929	$1043153
3 Central Station	1 Warehouse	$ 0	$317857	$
1 Residential	1 Warehouse	$ 0	$349600	$
2 Intermediate	0 Factory Direct	$ 99233	$ 0	$647300
3 Central Station	0 Factory Direct	$198466	$ 0	$

DSR-5 Alternative Distribution Costs - A separate report is generated for each region with the exception of the region where the factory is located because there can only be direct shipments, there is no warehouse. As can be seen for the example concentrator company, annual shipment costs for each customer type are calculated for both factory direct and warehouse distribution to determine the lowest total annual distribution cost. In the case of the West Coast region, it was found that the use of a warehouse was most cost effective for residential whose total demand is 5 megawatts per year. However, for intermediate and central station customers direct shipments from the factory are more economical with only 6 deliveries per year.

M&D CASE 2: CONCENTRATOR COLLECTOR

ECONOMIC WAREHOUSE ORDER QUANTITY FUNCTION
FOR WEST COAST REGION
(1980$)

DSR-6

WAREHOUSE ORDER QUANTITY	0.1923 MW	0.3846 MW	0.5769 MW	0.7692 MW
- Shipping Mode	Rail	Rail	Rail	Rail
- Order Processing Cost	$1748	$ 874	$ 583	$ 437
- Cost Per Shipment	198466	198466	198466	198466
ANNUAL TRANSPORTATION COST	200214	199340	199049	198903
- Inventory Carrying Cost	25410	50819	76229	101638
- Warehouse Operating Cost	56565	70116	82710	95268
- Warehouse Leasing Cost	28288	55731	80753	105689
ANNUAL WAREHOUSING COST	110263	176666	239692	302596
- Fixed Delivery Cost	31156	31156	31156	31156
- Variable Delivery Cost	7967	7967	7967	7967
ANNUAL DELIVERY COST	39123	39123	39123	39123
TOTAL DISTRIBUTION COST FOR TRANSSHIPMENTS	349600	415129	477864	540622

Major Assumptions

Factory Location: Rocky Mountain
Warehouse Location: Los Angeles
Shipping Distance: 640. Kilometers
Order Processing Cost: $62.96 Per Shipment
Minimum Shipping Frequency: Two Weeks
All Costs are in 1980 $

DSR-6 Economic Warehouse Order Quantity Function - A separate report is generated for each region with the exception of the region where the factory is located; because there can only be direct shipments, there is no warehouse. As can be seen for the example concentrator company, total annual distribution costs are computed for four different levels of warehouse order quantity. This order quantity, given the annual demand determines the number of shipments to the warehouse and the inventory level required to avoid stockouts. In this example for the concentrator company, the most economical order quantity is 0.1923 MW with 26 deliveries per year which is equivalent to one delivery every 2 weeks.

M&D CASE 2: CONCENTRATOR COLLECTOR

DISTRIBUTION PRICE ESTIMATES
(1980$/WATT)

DSR-7

MARKET REGION	CUSTOMER TYPE			TOTAL ANNUAL DEMAND	
	RESIDENTIAL HOUSEHOLD	COMMERCIAL INTERMEDIATE	PUBLIC UTILITY CENTRAL STATION	MW	(%)
WEST COAST	0.069920	0.039693	0.039693	12.50	(25.0)
ROCKY MOUNTAIN	0.042460	0.004462	0.004462	14.00	(28.0)
NORTH CENTRAL	0.193533	0.161619	0.000000	1.50	(3.0)
GREAT LAKES	0.234451	0.202537	0.000000	1.50	(3.0)
NORTH EASTERN	0.253860	0.202361	0.202361	8.00	(16.0)
SOUTH EASTERN	0.240152	0.208238	0.000000	1.50	(3.0)
SOUTH CENTRAL	0.126793	0.095402	0.095402	11.00	(22.0)
AVERAGE	0.114369	0.079198	0.085480		

DSR-7 Distribution Price Estimates - The estimated price per watt is listed for each type of customer in each region. For the example concentrator company, the highest price is $0.253860 per watt for residential customers in the North Eastern region. The lowest price is $0.004462 per watt for commercial and public utility customers in the Rocky Mountain region.

M&D CASE 2: CONCENTRATOR COLLECTOR

DISTRIBUTION SUBMODEL PARAMETERS DSR-8

WAREHOUSE STAFFING RELATIONSHIPS

WAREHOUSE SIZE (SQUARE METERS)	TOTAL PERSONNEL REQUIRED
1 < F < 2000	2.00
2000 < F < 5000	0.66 + 0.00067 * F
5000 < F <15000	1.00 + 0.00060 * F
15000 < F	2.50 + 0.00050 * F

TOTAL PERSONNEL PERCENTAGE	PERSONNEL TITLE	ANNUAL COST* (1980$)
10%	Warehouse Supervisor	$27021
50%	Forklift Operator	13857
20%	Inventory Clerk	17019
20%	Material Handler	21163
100%	Weighted Average	$17267

* The annual cost for warehouse personnel includes both wages and benefits and is based on a nationwide survey. The costs should be multiplied by the appropriate labor cost index to reflect regional conditions.

WAREHOUSE FACILITIES COST PARAMETERS

Warehouse Space Utilization Factor	0.25 Cubic Meters of Product Per Square Meter Warehouse
Maintenance Cost Rate	1.00 Percent of Capital Cost
Utility Cost Rate	$1.69 Per Square Meter (1980$)
Insurance Cost Rate	1.00 Percent of Capital Cost
Property Tax Rate	4.00 Percent of Capital Cost
Equipment Lease Rate	25.00 Percent of Capital Cost
Building Lease Rate	12.60 Percent of Capital Cost
Inventory Carrying Charge	37.75 Percent of Unit Value

DSR-8 Distribution Submodel Parameters - There are two sections to this report. The first part shows the warehouse staffing relationships: 1) the total personnel required depending on the warehouse size, and 2) the breakdown of personnel types and their annual salaries. The second section is a listing of some of the more important standard data used by the program, including: warehouse space utilization factor, maintenance cost rate, utility cost rate (in report year dollars), insurance cost rate, property tax rate, equipment lease rate, building lease rate, and inventory carrying charge.

M&D CASE 2: CONCENTRATOR COLLECTOR

MARKETING AND DISTRIBUTION COMPANY FSR-1
CONSOLIDATED INCOME STATEMENT ***
FOR THE YEAR ENDING DECEMBER 31, 1986

	(1980 $000)		(% SALES)
SALES:			
- Residential Products	$19878		43.2%
- Intermediate Products	9109		19.8%
- Central Power Stations	17047		37.0%
TOTAL SALES		$46034	
COST OF GOODS SOLD:			
- Residential Products	14001		30.4%
- Intermediate Produsts	7000		15.2%
- Central Power Stations	14001		30.4%
TOTAL COST		$35001	76.0%
GROSS PROFIT		$11032	24.0%
EXPENSES:			
- Distribution (Schedule A)	4789		10.4%
- Marketing (Schedule B)	3719		8.1%
TOTAL EXPENSES		$ 8508	18.5%
NET PROFIT BEFORE TAX		$ 2524	5.5%
NET INCOME TAX		$ 1287	2.8%
NET PROFIT AFTER TAX		$ 1237	2.7%

***Consolidated over all geographic regions.
Based on an average manufacturing price of $0.70 per watt, a manufacturing facility in the Rocky Mountain Region, and a particular assumed demand distribution.

FSR-1 Consolidated Income Statement - A typical income statement showing sales, cost of goods sold, gross profit, expenses, net profit before tax, and net profit after tax is generated based on an average manufacturing price of $.70/watt, a factory in the Rocky Mountain region, an assumed demand distribution given as input by the user, and standard data specified in the program. For the concentrator company residential products comprise 43.2 percent of sales. Marketing & distribution expenses contribute about 18.5% to the final price of the collector with 10.4% for marketing and 8.1% for distribution.

M&D CASE 2: CONCENTRATOR COLLECTOR

MARKETING AND DISTRIBUTION COMPANY FSR-2
SCHEDULE A: DISTRIBUTION EXPENSES***
FOR THE YEAR ENDING DECEMBER 31, 1986

	(1980$)		(%TOTAL)
TRANSPORTATION:			
- Direct Shipments	$2525351		
- Transshipments	1669172		
- Local Deliver	209796		
TOTAL TRANSPORT		$4404320	90.9%
WAREHOUSE OPERATIONS:			
- Salaries & Benefits	234537		
- Utilities	4174		
- Maintenance	6232		
- Other	31162		
TOTAL WAREHOUSE		$ 276106	5.7%
WAREHOUSE LEASE EXPENSE		84980	1.8%
INVENTORY CARRYING CHARGES		78770	1.6%
TOTAL DISTRIBUTION EXPENSES		$ 4844176	100.0%

**Consolidated over all distribution regions
For all types of customers,
Based on a single manufacturing facility
Located in the Rocky Mountain Region
and a particular assumed demand distribution

FSR-2 Schedule A: Distribution Expenses - In this report, transportation costs are broken down by direct shipments, transshipments, are local deliveries; and warehouse operations are broken down for salaries and benefits, utilities, maintenance, and other. For the example concentrator company 90.9% of total distribution expenses are transportation. Warehousing costs including lease and carrying charges are only 9.1% of the total.

M&D CASE 2: CONCENTRATOR COLLECTOR

MARKETING AND DISTRIBUTION COMPANY FSR-3
SCHEDULE B: MARKETING EXPENSES ***
FOR THE YEAR ENDING DECEMBER 31, 1986

	(1980 $)		(% TOTAL)
SALARIES & BENEFITS:			
- Direct Staff	$2401255		
- Support Staff	1087481		
TOTAL SALARIES		$3488736	80.6%
SALES EXPENSES:			
- Travel/Entertainment	176710		
- Communications	106026		
- Office Supplies	70684		
TOTAL EXPENSES		$353420	8.2%
OFFICE FACILITIES:			
- Lease	82055		
- Utilities	3328		
- Maintenance	6512		
- Other Expenses	32562		
TOTAL FACILITIES		$124457	2.9%
ADVERTISING		$364014	8.4%
TOTAL MARKETING EXPENSES		$4330626	100.0%

***Consolidated over all marketing regions
for all types of customers.
Based on a particular assumed demand distribution.

FSR-3 Schedule B: Marketing Expenses - In this report, marketing expenses are broken down by salaries & benefits, sales expenses, office facilities, and advertising. For the example concentrator company, salaries and benefits comprise 80.6% of the total marketing expenses. Advertising represents 8.4% of the total for the concentrator company.

M&D CASE 2: CONCENTRATOR COLLECTOR

MARKETING AND DISTRIBUTION COMPANY
REGIONAL INCOME STATEMENTS ***
FOR THE YEAR ENDING DECEMBER 31, 1986
(1980 $000)

FSR-4

	WEST COAST	ROCKY MOUNTAIN	NORTH CENTRAL	GREAT LAKES	NORTH EASTERN	SOUTH EASTERN	SOUTH CENTRAL	ALL REGIONS
SALES	10935	11789	1584	1677	8277	1640	10132	46034
COST OF GOODS SOLD	8750	9800	1050	1050	5600	1050	7700	35001
EXPENSES:								
- Marketing	980	1132	158	177	435	137	700	3719
- Distribution	647	290	274	336	1722	344	1175	4789
INCOME TAXES	285	289	52	58	265	55	283	1287
NET PROFIT	273	278	50	56	255	53	272	1237

*** Based on an average manufacturing price of $0.70 per watt in 1980 dollars, a manufacturing facility in the Rocky Mountain region, and a particular assumed demand distribution.

FSR-4 Regional Income Statements - This report lists income statements for each regional office. For the example concentrator company, the Rocky Mountain region is the highest profit center earning $278,000 net profit after tax. In this case the Great Lakes region has the highest profit margin of 3.3% of sales while the Rocky Mountain region yields the lowest margin of 2.4% after tax.

M&D CASE 2: CONCENTRATOR COLLECTOR

MARKETING AND DISTRIBUTION COMPANY
DELIVERED PRICE ESTIMATES ***

FSR-5

	(1980 $/WATT)		(% PRICE)	
COST OF GOODS SOLD:				
- Residential Products	$0.700			
- Intermediate Products	0.700			
- Central Power Stations	0.700			
TOTAL COST		$0.700		76.0%
EXPENSES				
- Distribution	0.096		10.4%	
- Marketing	0.074		8.1%	
TOTAL EXPENSES		0.170		18.5%
INCOME TAXES		0.026		2.8%
NET PROFIT AFTER TAX		0.025		2.7%
DELIVERED PRODUCT PRICES:				
- Residential Products	0.994			
- Intermediate Products	0.911			
- Central Power Stations	0.852			
ALL PRODUCTS		$0.921		100.0%

*** Based on an average manufacturing price of $0.70 per watt, a manufacturing facility in the Rocky Mountain region, and a particular assumed demand distribution.

FSR-5 Delivered Price Estimates - This report lists the components of the delivered product price in report year $ per watt and as a percent of the total price. These figures are consolidated over all regions. For the example concentrator company, the cost of goods sold or manufacturing cost is 76.0% of the average price of $0.921 per watt over all customers. Residential prices are the highest at $0.994 per watt and public utility prices are lowest at $0.852 per watt for the example concentrator company.

M&D CASE 2: CONCENTRATOR COLLECTOR

MARKETING AND DISTRIBUTION COMPANY FSR-6
DELIVERED PRICE ESTIMATES ***
FOR EACH TYPE OF CUSTOMER BY REGION
(1980 $/WATT)

MARKET REGION	RESIDENTIAL HOUSEHOLD PRODUCTS	INTERMEDIATE COMMERCIAL PRODUCTS	CENTRAL STATION PUBLIC UTILITY PRODUCTS	ALL CUSTOMER PRODUCTS
WEST COAST	$0.950	$0.871	$0.802	$0.875
ROCKY MOUNTAIN	0.916	0.829	0.761	0.842
NORTH CENTRAL	1.082	1.004	0.000	1.056
GREAT LAKES	1.146	1.062	0.000	1.118
NORTH EASTERN	1.150	1.049	0.986	1.035
SOUTH EASTERN	1.118	1.044	0.000	1.093
SOUTH CENTRAL	0.996	0.921	0.861	0.921
ALL REGIONS	$0.994	$0.911	$0.852	$0.921

PRICE RANGES:

MINIMUM = $0.761/Watt for Central Station Utility in the Rocky Mountain Region

MAXIMUM = $1.150/Watt for Residential Household in the North Eastern Region

AVERAGE = $0.921/Watt Over All Products and Regions

*** Based on an average manufacturing price of $0.70 per watt, a manufacturing facility in the Rocky Mountain region, and a particular assumed demand distribution.

FSR-6 Delivered Price Estimates - In this report, delivered price estimates in report year $/watt are listed by region and customer type. The minimum is $.761/watt for utility customers in the Rocky Mountain region, and the maximum is $1.150/watt for residential customers in the North Eastern region.

M&D CASE 2: CONCENTRATOR COLLECTOR

MARKETING AND DISTRIBUTION COMPANY FSR-7
KEY FINANCIAL INDICATORS

MARKET REGION	CUSTOMER TYPE			MARK-UP (REVENUE - CGS)/CGS)	PROFIT MARGIN (NPAT/REVENUE)
	RESIDENTIAL HOUSEHOLD	COMMERCIAL INTERMEDIATE	PUBLIC UTILITY CENTRAL STATION		
WEST COAST	35.7%	24.4%	14.5%	25.0%	2.5%
ROCKY MOUNTAIN	30.9%	18.4%	8.7%	20.3%	2.4%
NORTH CENTRAL	54.6%	43.4%	0.0%	50.9%	3.1%
GREAT LAKES	63.6%	51.7%	0.0%	59.7%	3.3%
NORTH EASTERN	64.3%	49.9%	40.8%	47.8%	3.1%
SOUTH EASTERN	59.7%	49.2%	0.0%	56.2%	3.2%
SOUTH CENTRAL	42.3%	31.5%	23.0%	31.6%	2.7%
ALL REGIONS	42.0%	30.1%	21.8%	31.5%	2.7%

FINANCIAL PARAMETERS:

Rate of Return on Equity	=	17.20% (input)
After Tax Cost of Capital	=	15.39% (derived)
Financial Leverage	=	1.20 (input
Corporate Income Tax Rate	=	51.00% (standard data)
Cost of Debt Capital	=	12.90% (standard data)
Deflation Rate	=	6.00% (standard data)
Average Inventory Turnover Time	=	1.50 months (standard data)
Average Expense Coverage Time	=	6.00 months (standard data)
Inventory Carrying Charge Rate	=	37.75% (standard data)

FSR-7 Key Financial Indicators - An array by region and customer type shows mark-up percentages, for all products. A listing of financial parameters is provided at the bottom of the report, specifying whether the information is part of the user input, derived, or part of the standard data base which can also be modified by the user. For the example concentrator company, the North Eastern region posted the highest markup of 64.3% for residential products and a profit margin of 3.1% over all products. The lowest markup is 8.7% for public utility customers in the Rocky Mountain region closest to the factory.

M&D CASE 2: CONCENTRATOR COLLECTOR

MARKETING AND DISTRIBUTION COMPANY FSR-8
GENERAL M&D MODEL PARAMETERS

INPUT DATA:

• Product Manufacturing Cost (Mfg Year $/Watt)	$0.993
• Manufacturing Year	1986
• Product Volume (Cubic Meters/MW)	10200.0
• Product Weight (kilograms/MW)	462800.0
• Factory Location Region	Rocky Mountain

STANDARD DATA:

• Base Price Year	1981
• Deflation Rate Solar Products	6.00%
• Inflation Rates	
- Raw Materials	11.00%
- Labor	8.00%
- Chemicals	13.00%
- Commodities	8.00%
- Energy	12.00%
- Land	4.00%
- Facilities	9.00%
- Construction	8.00%
- Equipment	7.00%
- Resources	15.00%
- Transportation	7.00%

FSR-8 General M&D Model Parameters - There are two sections to this financial report: 1) input data including the product manufacturing cost, manufacturing year, volume, weight, and factory location region, and 2) standard data including the base price year, deflation rate, and eleven inflation rates. The numbers listed here are for the example concentrator company.

M&D CASE 2: CONCENTRATOR COLLECTOR

The example case involves a hypothetical photovoltaic concentrator manufacturer with a factory in Phoenix, Arizona. The company sells photovoltaic concentrator systems of three standard sizes: 5 kilowatts for residential customers, 500 kilowatts for commercial customers and 5 megawatts for public utility customers. In 1986, sales are predicted to be 50 megawatts distributed as follows:

1986 SALES FORECAST

	Units	Megawatts
Residential	4000	20
Commercial	20	10
Public Utility	4	20
	4024	50

Based on a manufacturing cost analysis, the company estimates an average manufacturing cost including overhead and profit of $0.9929 per watt in 1986 dollars. This is equivalent to $0.70 per watt in 1980 dollars.

Using the M&D model, the company estimates average marketing expenses of $0.074 per watt and distribution expenses of $0.096 per watt in 1980 dollars. After adding in taxes and profit, the following delivered product prices were obtained:

DELIVERED PRODUCT PRICES

	(1980 $/Watt)
Residential	.994
Commercial	.911
Public Utility	.852
Weighted Average	.921

Based on the demand forecast for 1986, these prices will generate the following sales revenues:

SALES REVENUES

	(1980 $000)	
Residential	$19878	43.2%
Commercial	9109	19.8%
Public Utility	17047	37.0%
All products	$46034	100.0%

Distribution costs will total $4,789,000 and marketing costs will total $3,719,000 in 1980 dollars. Together these costs represent 18.5% of sales. Net profit after tax is estimated at $1237 or 2.7% of sales.

M&D CASE 2: CONCENTRATOR COLLECTOR

Markup, defined as revenue less cost of goods manufactured divided by cost of goods manufactured, varies by region and type of customer.

MARK-UP

	(Revenue - CGS/CGS)
Residential	42.0%
Commercial	30.1%
Public Utility	21.8%
All Products	31.5%

The M&D model projects a sales force of about 104 people for this level of sales and productivity. About 52% consist of salesman and the balance are support staff and management

	SALES FORCE SIZE
SALESMAN	
- Residential	40
- Commercial	10
- Public Utility	4
DIRECT SUPPORT STAFF	
- Field Engineer	15
- Commercial Artist	1
- Marketing Research Analyst	3
- Technical Illustrator	1
- Technical Writer	1
- Advertising Salesman	1
SECRETARIES	
- Level I	8
- Level II	5
- Level III	2
MANAGEMENT	
- Vice President	2
- Advertising Manager	1
- Marketing Research Manager	1
- Sales Manager	7
- Sales Engineering Manager	2
TOTAL	104

M&D CASE 2: CONCENTRATOR COLLECTOR

To minimize shipping costs, the company determined that it would be economical to supply its residential and commercial customers from regional warehouses in the following locations:

REGIONAL WAREHOUSE CONFIGURATION

	Inventory (kilowatts)	Delivery Trucks	Warehouse Personnel
West Coast - Los Angeles	100	1	2
North Central - Omaha	30	1	2
Great Lakes - Springfield	30	1	2
North Eastern - Syracuse	40	1	2
South Eastern - Atlanta	30	1	2
South Central - Dallas	80	1	2

Customers in the Rocky Mountain region around the factory will be supplied directly from the factory in Phoenix. The four public utility units sold each year will also be shipped directly.

These results for the hypothetical photovoltaic concentrator manufacturer of course would vary substantially with production level. The number of sales people, the location of the warehouses and the average inventory mix all depend on the level of sales, geographic distribution and product mix. The M&D model is a useful tool to analyze all of these interdependent variables simultaneously.

APPENDIX H

M&D CASE 3: FLAT-PLATE COLLECTOR

The following example case demonstrates the use of the M&D model.

The case involves a hypothetical manufacturer of power flat-plate collector with a factory in Phoenix, Arizona. The company sells units of three standard sizes: 10 kilowatts for residential customers, 500 kilowatts for commercial customers and 50 megawatts for public utility customers.

It is 1981 and the company anticipates rapid growth over the next six years due to technological advances and cost reductions of its photovoltaic solar energy systems. As the cost per watt declines, demand is expected to grow exponentially.

The company plans to expand its production capacity to supply the increased demand. The target capacity is 500 megawatts per year for all types of products by 1986. Demand is expected to be distributed over three major product lines: 40% residential, 20% commercial and 40% public utility.

The engineering department has just completed a detailed manufacturing cost analysis for the new plant. Assuming the SAMIS model, they estimate an average manufacturing cost of $0.959 per watt in 1986 dollars including overhead and profit. These systems weigh 155,925 kilograms per megawatt and occupy 1,415.805 cubic meters per megawatt.

The marketing department has just performed a long range sales forecast for the next six years. They predicted the following total sales in 1986 by general customer category:

Residential	20000 systems
Commercial	200 systems
Public Utility	4 systems

The president of the company would like to estimate its annual marketing and distribution costs, number of sales people, where to locate its warehouses, how much inventory to store in each warehouse, and what price to charge for each major product in order to cover all expenses and earn a net profit after tax of 3% of sales.

This analysis can be performed quickly and easily with the M&D program. To do this, the quantitative information is compiled in the following format for input to the computer.

M&D CASE 3: FLAT-PLATE COLLECTOR

MARKETING

- Average Order Quantity by Customer Type (megawatts per order)

Residential/Household	0.010
Commercial/Intermediate	0.500
Public Utility/Central Station	50.000

DISTRIBUTION

- Solar Product Volume (cubic meters per megawatt) 1,415.805

- Solar Product Weight (kilograms per megawatt) 155,925.

- Factory Location Region (check one)

_____	West Coast	_____	North Eastern
x	Rocky Mountain	_____	South Eastern
_____	North Central	_____	South Central
_____	Great Lakes		

- Average Delivery Quantity by Customer Type (megawatts per shipment)

Residential/Household	0.010
Commercial/Intermediate	0.500
Public Utility/Central Station	5.000

- Use of a Warehouse (put a 0 in each region for which the program should determine if a warehouse is wanted; 1 for each region which is forbidden to have a warehouse; and 2 for each region which must have a warehouse)

0	West Coast	0	North Eastern
0	Rocky Mountain	0	South Eastern
0	North Central	0	South Central
0	Great Lakes		

- Solar Product Type: 1. _____ Power Conditioning Unit
  2. x Collector

M&D CASE 3: FLAT-PLATE COLLECTOR

Following is the input data card image for the photovoltaic flat-plate collector example case.

```
CARD 1
50.0 25.0 50.0 60.0 30.0 50.0 10.0 5.0 0.0 10.0   (10F8.2)

CARD 2
5.0 0.0 20.0 10.0 50.0 10.0 5.0 0.0 40.0 20.0     (10F8.2)

CARD 3
50.0                                              (10F8.2)

CARD 4
0.010  0.500  50.000                              ( 3F6.3)

CARD 5
0.010  0.500  5.000                               ( 3F6.3)

CARD 6
0.959  0.959  0.959                               ( 3F5.3)

CARD 7
1986  1981  155925.  1415.805 2        (2I6, F8.0, F10.3, I2)

CARD 8
0000000                                             (7I1)

CARD 9
3                                                   (I4)

CARD 10
2                                                   (I4)
```

Following are the M&D model output reports for the example case.

M&D CASE 3: FLAT-PLATE COLLECTOR

MARKET DEMAND DISTRIBUTION *** MSR-1
(MW/YR)

MARKET REGION	CUSTOMER TYPE			TOTAL ANNUAL DEMAND	
	RESIDENTIAL HOUSEHOLD	COMMERCIAL INTERMEDIATE	PUBLIC UTILITY CENTRAL STATION	MW	(%)
WEST COAST	50.00	25.00	50.00	125.00	(25.0)
ROCKY MOUNTAIN	60.00	30.00	50.00	140.00	(28.0)
NORTH CENTRAL	10.00	5.00	0.00	15.00	(3.0)
GREAT LAKES	10.00	5.00	0.00	15.00	(3.0)
NORTH EASTERN	20.00	10.00	50.00	80.00	(16.0)
SOUTH EASTERN	10.00	5.00	0.00	15.00	(3.0)
SOUTH CENTRAL	40.00	20.00	50.00	110.00	(22.0)
TOTAL MW	200.00	100.00	200.00	500.00	
(%)	(40.0)	(20.0)	(40.0)	(100.0)	(100.0)
AVERAGE ORDER QUANTITY (MW)	0.010	0.500	50.000		

** Demand distribution assumed as input to the model

MSR-1 Market Demand Distribution - This is an array of the demand by region and customer type as specified by the user as input data. Total megawatts and percentages are calculated. In addition, the average order quantity by customer type is listed. Again, this is input to the model. As can be seen, the demand distribution in this example case for the hypothetical flat-plate collector manufacturer is 40% residential, 20% commercial, and 40% utility.

M&D CASE 3: FLAT-PLATE COLLECTOR

MARKETING EXPENSE SUMMARY
(1981 $1,000/YEAR)

MSR-2

	WEST COAST	ROCKY MOUNTAIN	NORTH CENTRAL	GREAT LAKES	NORTH EASTERN	SOUTH EASTERN	SOUTH CENTRAL	ALL REGIONS $1,000 (%)
SALARIES & BENEFITS								
Direct Personnel	$5974	$6995	$1027	$1176	$2373	$869	$4126	$22,539 (55.6)
Support Staff	2667	3128	463	531	1045	392	1837	10,064 (24.8)
SALES EXPENSES -travel/entertain -communications -office supplies	854	1008	154	176	318	130	583	3,223 (7.9)
OFFICE FACILITIES -lease -utilities -maintenance -other expenses	266	284	52	50	125	47	190	1,014 (2.5)
ADVERTISING	932	1111	179	179	394	179	752	3,726 (9.2)
TOTAL	10,692	12,525	1,876	2,112	4,255	1,617	7,489	40,566 (100.0)

MSR-2 - Marketing Expense Summary - Salaries and benefits as well as general and administrative expenses are broken down by region. These are calculated from standard data and the indirect requirements matrix. For the example flat-plate collector manufacturer, total marketing expenses are $40,566,000. Salaries and benefits account for the largest portion of these marketing expenses, comprising 80.4% of the total.

M&D CASE 3: FLAT-PLATE COLLECTOR

MARKETING PERSONNEL SUMMARY MSR-3

JOB TITLE	ANNUAL COMPENSATION (1981$)*	WEST COAST	ROCKY MOUNTAIN	NORTH CENTRAL	GREAT LAKES	NORTH EASTERN	SOUTH EASTERN	SOUTH CENTRAL	ALL ** REGIONS #	(%)
SALESMEN										
-Residential	$25128	99	118	20	20	40	20	79	393	(41.9)
-Commercial	33394	26	31	6	6	11	6	21	103	(10.9)
-Utility	44413	1	1	0	0	1	0	1	4	(0.4)
DIRECT SUPPORT STAFF										
-Field Engineer	36733	33	39	6	6	17	6	28	132	(14.0)
-Artist	17142	2	2	1	1	1	1	2	7	(0.7)
-Market Research	35063	7	8	2	2	4	2	6	27	(2.8)
-Illustrator	26297	4	4	1	1	2	1	3	14	(1.4)
-Technical Writer	26297	4	4	1	1	2	1	3	14	(1.4)
-Advertising	24350	2	2	1	1	1	1	2	7	(0.7)
SECRETARIES										
-Level I	18993	18	21	4	4	8	4	15	71	(7.5)
-Level II	20259	11	13	3	3	5	3	9	43	(4.6)
-Level III	22109	6	7	1	1	3	1	5	22	(2.3)
MANAGEMENT										
-VP	83205	6	7	1	1	3	1	5	22	(2.3)
-Advertising	53430	1	1	1	1	1	1	1	2	(0.2)
-Market Research	53430	2	2	1	1	1	1	1	5	(0.5)
-Sales	53430	16	19	4	4	7	4	13	62	(6.6)
-Sales Engineer	53430	5	6	1	1	3	1	4	18	(1.9)
TOTAL **		234	279	44	44	101	44	190	937	(100)

* Annual Compensation includes wages and 40% benefits, averaged over all regions. These average rates over all regions, are adjusted by labor indices to compute annual sales personnel costs by region.

** Totals may not equal sum of numbers due to rounding.

MSR-3 Marketing Personnel Summary - Personnel are needed to market the three product lines including salesman, direct support staff, secretaries, and management. The annual compensation rates are part of the standard data listed in report year dollars for 1981. The number of personnel needed is generated by the indirect staffing matrix. For the example flat-plate collector manufacturer, a total of 937 marketing personnel are required over all regions. Residential product salesmen form the largest personnel group at 41.9%.

M&D CASE 3: FLAT-PLATE COLLECTOR

SALES OFFICE FACILITIES

MSR-4

	WEST COAST	ROCKY MOUNTAIN	NORTH CENTRAL	GREAT LAKES	NORTH EASTERN	SOUTH EASTERN	SOUTH CENTRAL	ALL REGIONS
OFFICE SIZE (square meters)	2917	3469	552	552	1260	552	2365	11668
TOTAL PEOPLE	234	279	44	44	101	44	190	937
CAPITAL COST (1981 $)	1378407	1488515	274633	261058	649835	244872	982374	5279695
OPERATING COSTS (1981 $/year)								
-Lease	173679	187553	34604	32893	81879	30854	123779	665242
-Utilities	9584	7081	1238	1238	4076	1306	7062	31584
-Maintenance	13789	14885	2746	2611	6498	2449	9824	52797
-Other	68920	74426	13732	13053	32492	12244	49119	263985
TOTAL ANNUAL OPERATING COSTS (1981 $/YEAR)	265967	283945	52319	49794	124945	46853	189784	1013608

MSR-4 Sales Office Facilities - Several types of information are provided in this report broken down by region. The office size needed, total personnel (this agrees with MSR-3), and derived capital costs are given; as well as operating costs, in report year dollars, for lease, utilities, maintenance, and other. In this example case for the flat-plate collector company, the largest office is required in the Rocky Mountain region, which is also the region with the highest demand.

M&D CASE 3: FLAT-PLATE COLLECTOR

MARKETING PRICE ESTIMATES
(1980 $/WATT)

MSR-5

MARKET REGION	CUSTOMER TYPE			TOTAL ANNUAL DEMAND MW (%)
	RESIDENTIAL HOUSEHOLD	COMMERCIAL INTERMEDIATE	PUBLIC UTILITY CENTRAL STATION	
WEST COAST	0.131	0.091	0.008	125.00 (25.0)
ROCKY MOUNTAIN	0.129	0.090	0.007	140.00 (28.0)
NORTH CENTRAL	0.122	0.085	0.000	15.00 (3.0)
GREAT LAKES	0.137	0.096	0.000	15.00 (3.0)
NORTH EASTERN	0.120	0.083	0.007	80.00 (16.0)
SOUTH EASTERN	0.106	0.073	0.000	15.00 (3.0)
SOUTH CENTRAL	0.114	0.079	0.007	110.00 (22.0)
AVERAGE	0.125	0.086	0.007	

MSR-5 Marketing Price Estimates - The estimated price per watt is listed for each type of customer in each region. For the example flat-plate collector company, the highest price is $0.137/watt for residential customers in the Great Lakes region. The lowest is $0.007/watt for public utility customers in the South Central, North Eastern, and Rocky Mountain regions.

M&D CASE 3: FLAT-PLATE COLLECTOR

MARKETING SUBMODEL PARAMETERS

MSR-6

SALES AND ADVERTISING EXPENSE RATES

CUSTOMER/PRODUCT TYPE	AVERAGE ORDER QUANTITY MW	SALES EXPENSE RATE %	ADVERTISING EXPENSE RATE %
Small Household Products	0.010	20.0	2.0
Intermediate Commercial Products	0.500	25.0	1.0
Large Central Power Stations	50.000	30.0	0.1

OFFICE FACILITIES COST PARAMETERS

Office Space Per Person	12.45 Square Meters Per Person
Office Capital Cost	$452.49 Per Square Meter (1981$)
Lease Rate	12.60 Percent of Captial Cost
Utilities Cost Rate	$1.89 Per Square Meter (1981$)
Maintenance Cost Rate	1.00 Percent of Capital Cost
Property Tax Rate	4.00 Percent of Capital Cost

MSR-6 Marketing Submodel Parameters - This report is basically a recapitulation of the important components of the standard data. All dollar amounts are presented in report year dollars. Data listed includes average order quantitites (part of the user specified input), sales expense rates, advertising expense rates, and office facilities cost parameters.

M&D CASE 3: FLAT-PLATE COLLECTOR

CUSTOMER DEMAND DISTRIBUTION ** DSR-1
(MW/YR)

MARKET REGION	CUSTOMER TYPE			TOTAL ANNUAL DEMAND	
	RESIDENTIAL HOUSEHOLD	COMMERCIAL INTERMEDIATE	PUBLIC UTILITY CENTRAL STATION	MW	(%)
WEST COAST	50.00	25.00	50.00	125.00	(25.0)
ROCKY MOUNTAIN	60.00	30.00	50.00	140.00	(28.0)
NORTH CENTRAL	10.00	5.00	0.00	15.00	(3.0)
GREAT LAKES	10.00	5.00	0.00	15.00	(3.0)
NORTH EASTERN	20.00	10.00	50.00	80.00	(16.0)
SOUTH EASTERN	10.00	5.00	0.00	15.00	(3.0)
SOUTH CENTRAL	40.00	20.00	50.00	110.00	(22.0)
TOTAL MW	200.00	100.00	200.00	500.00	
(%)	(40.0)	(20.0)	(40.0)	(100.0)	(100.0)
AVERAGE DELIVERY QUANTITY (MW)	0.01	0.50	5.00		
NUMBER OF DELIVERIES PER YEAR	2000.00	200	40		

** Demand distribution assumed as input to the model
FACTORY LOCATION: Rocky Mountain

DSR-1 Customer Demand Distribution - The demand distribution array is the same as the one generated in MSR-1. Also included is the average delivery quantity, and from this the number of deliveries per year are calculated. For the example flat-plate collector, the total utility demand is 200 MW, delivered in shipments of 5 MW, requiring 40 deliveries per year.

M&D CASE 3: FLAT-PLATE COLLECTOR

DISTRIBUTION EXPENSE SUMMARY
(1980 $1,000/YEAR)

DSR-2

	WEST COAST	ROCKY MOUNTAIN	NORTH CENTRAL	GREAT LAKES	NORTH EASTERN	SOUTH EASTERN	SOUTH CENTRAL	ALL REGIONS $1,000 (%)
TRANSPORTATION - Direct Shipments - Transshipments - Local Delivery	$1945	$1796	$686	$887	$5865	$962	$3913	$16054 (93.3)
WAREHOUSE OPERATIONS - Salaries & Benefits - Utilities - Maintenance - Other Expenses	66	0	46	51	50	39	53	304 (1.8)
WAREHOUSE LEASE EXPENSE	41	0	8	8	18	8	29	112 (0.7)
INVENTORY CARRYING CHARGE	260	0	52	52	104	52	208	728 (4.2)
TOTAL	2312	1796	792	998	6037	1060	4203	17198 (100.0)

DSR-2 Distribution Expense Summary - An annual breakdown by region for transportation costs, warehouse operations, warehouse leasing expenses, and inventory carrying charges may be found in this report. The bulk of the distribution expense is for transportation 93.3%, with the North Eastern region incurring the largest share of the total expense because it is furthest from the factory located is the Rocky Mountain region.

M&D CASE 3: FLAT-PLATE COLLECTOR

DISTRIBUTION NETWORK CONFIGURATION DSR-3

REGIONAL WAREHOUSE LOCATION	FACTORY SHIPPING MODE/ FREQUENCY	WAREHOUSE SIZE (SQUARE METERS)	AVERAGE INVENTORY LEVEL (MW)	DELIVERY TRUCKS	WAREHOUSE PERSONNEL
West Coast Los Angeles	Rail 2 Weeks	681	0.96	4	2
Rocky Mountain Phoenix	Direct 0.0 Weeks	0	0.00	0	0
North Central Omaha	Rail 2 Weeks	136	0.19	1	2
Great Lakes Springfield	Rail 2 Weeks	136	0.19	1	2
North Eastern Syracuse	Rail 2 Weeks	272	0.38	2	2
South Eastern Atlanta	Rail 2 Weeks	136	0.19	1	2
South Central Dallas	Rail 2 Weeks	545	0.77	4	2
ALL REGIONS		1906	2.69	13	12

DSR-3 Distribution Network Configuration - The program determines which factory shipping mode - direct, truck, or rail - is most cost effective for each region, as well as the frequency of delivery. In addition, warehouse sizes are calculated according to the average inventory level, and from this the number of delivery trucks and warehouse personnel are determined. Since the factory is in the Rocky Mountain region, a warehouse is not needed - there are direct shipments necessitating six delivery trucks. Every other region requires two ware house personnel.

M&D CASE 3: FLAT-PLATE COLLECTOR

WAREHOUSE FACILITIES

DSR-4

	WEST COAST	ROCKY MOUNTAIN	NORTH CENTRAL	GREAT LAKES	NORTH EASTERN	SOUTH EASTERN	SOUTH CENTRAL	ALL REGIONS
WAREHOUSE SIZE (Square Meters)	681	0	136	136	272	136	545	1906
TOTAL PEOPLE	2	0	2	2	2	2	2	12
CAPITAL COST (1981$)	$ 302142	$0	$62287	$59208	$131251	$55537	$212229	$822654
OPERATING COSTS (1981 $/Year)								
-Salaries & Benefits	45168	0	41524	47543	40868	35135	38370	248609
-Utilities	2236	0	305	305	881	322	1626	5676
-Maintenance	3021	0	623	592	1313	555	2122	8227
-Other	15107	0	3114	2960	6563	2777	10611	41123
LEASE EXPENSE (1981 $/Year)	41273	0	8483	8064	17882	7564	28978	112243
CARRYING CHARGES (1980 $/Year)	260120	0	52024	52024	104048	52024	208096	728335
TOTAL ANNUAL FACILITIES COSTS (1980 $/Year)	366926	$0	$106072	$111488	$171554	$98377	289804	$1144222

DSR-4 Warehouse Facilities - This report is a breakdown of the total annual facilities costs in report year dollars. The warehouse sizes and number of personnel are listed for each region, and the capital cost is derived by the program. Operating costs for salaries and benefits, utilities, maintenance, and other are given, as well as lease expenses and carrying charges. For the example flat-plate collector company, the highest costs are incurred on the West Coast, and the lowest in the South Eastern region, with the exception of the Rocky Mountain region, where there is no warehouse because this is the factory location.

M&D CASE 3: FLAT-PLATE COLLECTOR

ALTERNATIVE DISTRIBUTION COSTS DSR-5
FOR WEST COAST REGION
(1981$)

CUSTOMER TYPE	DISTRIBUTION ALTERNATIVE	ANNUAL COST FOR DIRECT SHIPMENTS	ANNUAL COST FOR TRANSSHIPMENTS	TOTAL ANNUAL DISTRIBUTION COST
1 Residential	0 Factory Direct	2445411	0	
2 Intermediate	0 Factory Direct	354393	0	3508590
3 Central Station	0 Factory Direct	708786	0	
1 Residential	1 Warehouse	0	1132120	
2 Intermediate	1 Warehouse	0	566060	2830300
3 Central Station	1 Warehouse	0	1132120	
1 Residential	0 Factory Direct	2445411	0	
2 Intermediate	1 Warehouse	0	599499	3753695
3 Central Station	0 Factory Direct	708786	0	
1 Residential	0 Factory Direct	2445411	0	
2 Intermediate	0 Factory Direct	354393	0	3916842
3 Central Station	1 Warehouse	0	1117039	
1 Residential	1 Warehouse	0	1199853	
2 Intermediate	1 Warehouse	0	599926	2508565
3 Central Station	0 Factory Direct	708786	0	
1 Residential	1 Warehouse	0	1157372	
2 Intermediate	0 Factory Direct	354393	0	2669138
3 Central Station	1 Warehouse	0	1157372	
1 Residential	0 Factory Direct	2445411	0	
2 Intermediate	1 Warehouse	0	544998	4080404
3 Central Station	1 Warehouse	0	1089995	
1 Residential	1 Warehouse	0	1248800	
2 Intermediate	0 Factory Direct	354393	0	2311979
3 Central Station	0 Factory Direct	708786	0	

DSR-5 Alternative Distribution Costs - A separate report is generated for each region with the exception of the region where the factory is located; because there can only be direct shipments, there is no warehouse. As can be seen for the example flat-plate collector company, annual shipment costs for each customer type are calculated for both factory direct and warehouse distribution to determine the lowest total annual distribution cost. In the case of the West Coast region, it was found that the use of a warehouse was most cost effective for residential customers whose total demand is 50 megawatts per year. However, for commercial and public utility customers direct shipments from the factory are more economical with only 240 deliveries per year.

M&D CASE 3: FLAT-PLATE COLLECTOR

ECONOMIC WAREHOUSE ORDER QUANTITY FUNCTION
FOR WEST COAST REGION
(1981$)

DSR-6

WAREHOUSE ORDER QUANTITY	1.9231 MW	3.8462 MW	5.7692 MW	7.6923 MW
- Shipping Mode	Rail	Rail	Rail	Rail
- Order Processing Cost	1853	926	618	463
- Cost Per Shipment	708786	708786	708786	708786
ANNUAL TRANSPORTATION COST	710639	708786	709403	709249
- Inventory Carrying Cost	260120	520239	780359	1040478
- Warehouse Operating Cost	65533	84692	103802	131677
- Warehouse Leasing Cost	41273	79680	116369	151201
ANNUAL WAREHOUSING COST	366926	684611	1000529	1323356
- Fixed Delivery Cost	132099	132099	132099	132099
- Variable Delivery Cost	39136	39136	39136	39136
ANNUAL DELIVERY COST	171235	171235	171235	171235
TOTAL DISTRIBUTION COST FOR TRANSSHIPMENTS	1248800	1565558	1881168	2203841

Major Assumptions

Factory Location:	Rocky Mountain
Warehouse Location:	Los Angeles
Shipping Distance:	640. Kilometers
Order Processing Cost:	$68 Per Shipment
Minimum Shipping Frequency:	Two Weeks

All Costs are in 1981 $

DSR-6 Economic Warehouse Order Quantity Function - A separate report is generated for each region with the exception of the region where the factory is located; because there can only be direct shipments, there is no warehouse. As can be seen for the example flat-plate collector company, total annual distribution costs are computed for four different levels of warehouse order quantity. This order quantity, given the annual demand determines the number of shipments to the warehouse and the inventory level required to avoid stockouts. In this example for the flat-plate collector company, the most economical order quantity is 1.9231 MW with 26 deliveries per year which is equivalent to about 1 delivery every 2 weeks.

M&D CASE 3: FLAT-PLATE COLLECTOR

DISTRIBUTION PRICE ESTIMATES (1981 $/WATT) DSR-7

MARKET REGION	CUSTOMER TYPE			TOTAL ANNUAL DEMAND	
	RESIDENTIAL HOUSEHOLD	COMMERCIAL INTERMEDIATE	PUBLIC UTILITY CENTRAL STATION	MW	(%)
WEST COAST	0.024976	0.014176	0.014176	125.00	(25.0)
ROCKY MOUNTAIN	0.024591	0.001594	0.001594	140.00	(28.0)
NORTH CENTRAL	0.057756	0.042879	0.000	15.00	(3.0)
GREAT LAKES	0.071706	0.056286	0.000	15.00	(3.0)
NORTH EASTERN	0.085025	0.072269	0.072269	80.00	(16.0)
SOUTH EASTERN	0.075388	0.061280	0.000	15.00	(3.0)
SOUTH CENTRAL	0.045448	0.034071	0.034071	110.00	(22.0)
AVERAGE	$0.041456	$0.026085	$0.030527		

DSR-7 Distribution Price Estimates - The estimated price per watt is listed for each type of customer in each region. For the example flat-plate collector company, the highest price is $0.085025 per watt for residential customers in the North Eastern region. The lowest price is less than $0.001594 per watt for public utility customers in the Rocky Mountain region.

M&D CASE 3: FLAT-PLATE COLLECTOR

DISTRIBUTION SUBMODEL PARAMETERS DSR-8

WAREHOUSE STAFFING RELATIONSHIPS

WAREHOUSE SIZE (SQUARE METERS)	TOTAL PERSONNEL REQUIRED
1 < F < 2000	2.00
2000 < F < 5000	0.66 + 0.00067 * F
5000 < F <15000	1.00 + 0.00060 * F
15000 < F	2.50 + 0.00050 * F

TOTAL PERSONNEL PERCENTAGE	PERSONNEL TITLE	ANNUAL COST* (1981$)
10%	Warehouse Supervisor	$29183
50%	Forklift Operator	14965
20%	Inventory Clerk	18380
20%	Material Handler	22856
100%	Weighted Average	$18648

* The annual cost for warehouse personnel includes both wages and benefits and is based on a nationwide survey. The costs should be multiplied by the appropriate labor cost index to reflect regional conditions.

WAREHOUSE FACILITIES COST PARAMETERS

Warehouse Space Utilization Factor	0.25 Cubic Meters of Product Per Square Meter Warehouse
Maintenance Cost Rate	1.00 Percent of Capital Cost
Utility Cost Rate	$1.89 Per Square Meter (1981$)
Insurance Cost Rate	1.00 Percent of Capital Cost
Property Tax Rate	4.00 Percent of Capital Cost
Equipment Lease Rate	25.00 Percent of Capital Cost
Building Lease Rate	12.60 Percent of Capital Cost
Inventory Carrying Charge	37.75 Percent of Unit Value

DSR-8 Distribution Submodel Parameters - There are two sections to this report. The first part shows the warehouse staffing relationships: 1) the total personnel required depending on the warehouse size, and 2) the breakdown of personnel types and their annual salaries. The second section is a listing of some of the more important standard data used by the program, including: warehouse space utilization factor, maintenance cost rate, utility cost rate (in report year dollars), insurance cost rate, property tax rate, equipment lease rate, building lease rate, and inventory carrying charge.

M&D CASE 3: FLAT-PLATE COLLECTOR

MARKETING AND DISTRIBUTION COMPANY — FSR-1
CONSOLIDATED INCOME STATEMENT ***
FOR THE YEAR ENDING DECEMBER 31, 1986

	(1981 $000)		(% SALES)
SALES:			
- Residential Products	$186618		43.3%
- Intermediate Products	87186		20.2%
- Central Power Stations	157204		36.5%
TOTAL SALES		$431009	100.0%
COST OF GOODS SOLD:			
- Residential Products	143324		33.3%
- Intermediate Produsts	71662		16.6%
- Central Power Stations	143324		33.3%
TOTAL COST		$358310	83.1%
GROSS PROFIT		$ 72699	16.9%
EXPENSES:			
- Distribution (Schedule A)	17005		3.9%
- Marketing (Schedule B)	34988		8.1%
TOTAL EXPENSES		$51993	12.1%
NET PROFIT BEFORE TAX		$20706	4.8%
NET INCOME TAX		$10560	2.5%
NET PROFIT AFTER TAX		$10146	2.4%

***Consolidated over all geographic regions.
Based on an average manufacturing price of $0.72 per watt in 1981 dollars, a manufacturing facility in the Rocky Mountain Region, and a particular assumed demand distribution.

FSR-1 Consolidated Income Statement - This typical income statement shows sales, cost of goods sold, gross profit, expenses, net profit before tax, net income tax, and net profit after tax. The results are consolidated over all marketing regions. For the flat-plate collector company, residential products comprise the 43.3% of sales. Marketing and distribution expenses contribute about 12.1% to the final price of the collector with 8.1% for marketing and 3.9% for distribution.

M&D CASE 3: FLAT-PLATE COLLECTOR

MARKETING AND DISTRIBUTION COMPANY FSR-2
SCHEDULE A: DISTRIBUTION EXPENSES***
FOR THE YEAR ENDING DECEMBER 31, 1986

	(1981 $)		(% TOTAL)
TRANSPORTATION:			
- Direct Shipments	$10382133		
- Transshipments	5132579		
- Local Deliveries	538903		
TOTAL TRANSPORT		$16053615	93.3%
WAREHOUSE OPERATIONS:			
- Salaries & Benefits	248609		
- Utilities	5676		
- Maintenance	8227		
- Other	41133		
TOTAL WAREHOUSE		$ 303644	1.8%
WAREHOUSE LEASE EXPENSE		112243	0.7%
INVENTORY CARRYING CHARGES		728335	4.2%
TOTAL DISTRIBUTION EXPENSES		$17197836	100.0%

**Consolidated over all distribution regions
for all types of customers.
Based on a single manufacturing facility
located in the Rocky Mountain region
and a particular assumed demand distribution.

FSR-2 Schedule A: Distribution Expenses - In this report, transportation costs are broken down by direct shipments, transshipments, and local deliveries; and warehouse operations are broken down for salaries and benefits, utilities, maintenance, and other. For the example flat-plate collector company 93.3% of total distribution expenses are transportation. Warehousing costs including lease and carrying charges are only 6.7% of the total.

M&D CASE 3: FLAT-PLATE COLLECTOR

MARKETING AND DISTRIBUTION COMPANY FSR-3
SCHEDULE B: MARKETING EXPENSES ***
FOR THE YEAR ENDING DECEMBER 31, 1986

	(1981 $)		(% TOTAL)
SALARIES & BENEFITS:			
- Direct Staff	$22539322		
- Support Staff	10063575		
TOTAL SALARIES		$32602898	80.4%
SALES EXPENSES:			
- Travel/Entertainment	1611422		
- Communications	966853		
- Office Supplies	644569		
TOTAL EXPENSES		$3222845	7.9%
OFFICE FACILITIES:			
- Lease	665242		
- Utilities	31584		
- Maintenance	52797		
- Other Expenses	263985		
TOTAL FACILITIES		$1013608	2.5%
ADVERTISING		$3726828	9.2%
TOTAL MARKETING EXPENSES		$40565780	100.0%

***Consolidated over all marketing regions
for all types of customers.
Based on a particular assumed demand distribution.

FSR-3 Schedule B: Marketing Expenses - In this report, marketing expenses are broken down by salaries & benefits, sales expenses, office facilities, and advertising. For the example flat-plate collector company, salaries and benefits comprise 80.4% of the total marketing expenses. Advertising represents 9.2% of the total for the flat-plate collector company.

MARKETING AND DISTRIBUTION COMPANY
REGIONAL INCOME STATEMENTS ***
FOR THE YEAR ENDING DECEMBER 31, 1986
(1981 $000)

FSR-4

	WEST COAST	ROCKY MOUNTAIN	NORTH CENTRAL	GREAT LAKES	NORTH EASTERN	SOUTH EASTERN	SOUTH CENTRAL	ALL REGIONS
SALES	106064	118243	13939	14410	70452	13990	93910	431009
COST OF GOODS SOLD	89578	100327	10749	10749	57330	10749	78828	358310
EXPENSES:								
- Marketing	9213	10827	1648	1853	3582	1424	6440	34988
- Distribution	2312	1603	792	998	6037	1060	4203	17005
INCOME TAXES	2530	2798	382	413	1787	386	2264	10560
NET PROFIT	2431	2688	367	397	1717	371	2175	10146

*** Based on an average manufacturing price of $0.72 per watt in 1981 dollars, a manufacturing facility in the Rocky Mountain region, and a particular assumed demand distribution.

FSR-4 Regional Income Statements - This report lists income statements for each regional office. For the example flat-plate collector company, the Rocky Mountain region is the highest profit center earning $2,688,000 net profit after tax. In this case the South Eastern region has the highest profit margin of 3.3% of sales while the Rocky Mountain region yields the lowest margin of 2.8% after tax.

M&D CASE 3: FLAT-PLATE COLLECTOR

MARKETING AND DISTRIBUTION COMPANY
DELIVERED PRICE ESTIMATES ***

FSR-5

	(1981 $/WATT)		(% PRICE)	
COST OF GOODS SOLD:				
- Residential Products	$0.717			
- Intermediate Products	0.717			
- Central Power Stations	0.717			
TOTAL COST		$0.717		83.1%
EXPENSES				
- Distribution	0.034		3.9%	
- Marketing	0.070		8.1%	
TOTAL EXPENSES		0.104		12.1%
INCOME TAXES		0.021		2.5%
NET PROFIT AFTER TAX		0.020		2.4%
DELIVERED PRODUCT PRICES:				
- Residential Products	0.933			
- Intermediate Products	0.872			
- Central Power Stations	0.786			
ALL PRODUCTS		$0.862		100.0%

*** Based on an average manufacturing price of $0.72 per watt in 1981 dollars, a manufacturing facility in the Rocky Mountain region, and a particular assumed demand distribution.

FSR-5 Delivered Price Estimates - This report lists the components of the delivered product price in report year $ per watt and as a percent of the total price. These figures are consolidated over all regions. For the example flat-plate collector company, the cost of goods sold or manufacturing cost is 83.1% of the average price of $0.862 per watt over all customers. Residential prices are the highest at $0.933 per watt and public utility prices are lowest at $0.786 per watt for the example flat-plate collector company.

M&D CASE 3: FLAT-PLATE COLLECTOR

MARKETING AND DISTRIBUTION COMPANY
DELIVERED PRICE ESTIMATES ***
FOR EACH TYPE OF CUSTOMER BY REGION
(1981 $/WATT)

FSR-6

MARKET REGION	RESIDENTIAL HOUSEHOLD PRODUCTS	INTERMEDIATE COMMERCIAL PRODUCTS	CENTRAL STATION PUBLIC UTILITY PRODUCTS	ALL CUSTOMER PRODUCTS
WEST COAST	$0.922	$0.864	$0.768	$0.849
ROCKY MOUNTAIN	0.919	0.848	0.753	0.845
NORTH CENTRAL	0.949	0.889	0.000	0.929
GREAT LAKES	0.983	0.917	0.000	0.961
NORTH EASTERN	0.978	0.921	0.834	0.881
SOUTH EASTERN	0.951	0.897	0.000	0.933
SOUTH CENTRAL	0.925	0.872	0.789	0.854
ALL REGIONS	$0.933	$0.872	$0.786	$0.862

PRICE RANGES:

MINIMUM = $0.753/Watt for Central Station Utility
In the Rocky Mountain Region

MAXIMUM = $0.983/Watt for Residential Household
In the Great Lakes Region

AVERAGE = $0.862/Watt Over All Products and Regions

*** Based on an average manufacturing price of $0.72 per watt in 1981 dollars, a manufacturing facility in the Rocky Mountain region, and a particular assumed demand distribution.

FSR-6 Delivered Price Estimates - In this report, delivered price estimates in report year $/watt are listed by region and customer type. The minimum is $0.753/watt for utility customers in the Rocky Mountain region, and the maximum is $0.983/watt for residential customers in the Great Lakes region.

M&D CASE 3: FLAT-PLATE COLLECTOR

MARKETING AND DISTRIBUTION COMPANY
KEY FINANCIAL INDICATORS

FSR-7

MARKET REGION	MARKUP BY CUSTOMER TYPE				
	RESIDENTIAL HOUSEHOLD	COMMERCIAL INTERMEDIATE	PUBLIC UTILITY CENTRAL STATION	MARK-UP (REVENUE - CGS)/CGS)	PROFIT MARGIN (NPAT/REVENUE)
WEST COAST	28.6%	20.5%	7.1%	18.4%	2.3%
ROCKY MOUNTAIN	28.3%	18.3%	5.1%	17.9%	2.3%
NORTH CENTRAL	32.5%	24.1%	0.0%	29.7%	2.6%
GREAT LAKES	37.1%	28.0%	0.0%	34.1%	2.8%
NORTH EASTERN	36.5%	28.5%	16.3%	22.9%	2.4%
SOUTH EASTERN	32.7%	25.1%	0.0%	30.2%	2.6%
SOUTH CENTRAL	29.1%	21.7%	10.2%	19.1%	2.3%
ALL REGIONS	30.2%	21.7%	9.7%	20.3%	2.4%

FINANCIAL PARAMETERS:

Rate of Return on Equity	=	17.20% (input)
After Tax Cost of Capital	=	15.39% (derived)
Financial Leverage	=	1.20 (input)
Corporate Income Tax Rate	=	51.00% (standard data)
Cost of Debt Capital	=	12.90% (standard data)
Deflation Rate	=	6.00% (standard data)
Average Inventory Turnover Time	=	1.50 months (standard data)
Average Expense Coverage Time	=	6.00 months (standard data)
Inventory Carrying Charge Rate	=	37.75% (standard data)

FSR-7 Key Financial Indicators - An array by region and customer type shows mark-up percentages for all products. A listing of financial parameters is provided at the bottom of the report , specifying whether the information is part of the user input, derived, or part of the standard data base which can also be modified by the user. For the example flat-plate collector company, the Great Lakes region posted the highest markup of 37.1% for residential products and a profit margin of 3.4% over all products. The lowest markup is 5.1% for public utility customers in the Rocky Mountain region closest to the factory.

M&D CASE 3: FLAT-PLATE COLLECTOR

MARKETING AND DISTRIBUTION COMPANY FSR-8
GENERAL M&D MODEL PARAMETERS

INPUT DATA:

• Product Manufacturing Cost (Mfg Year $/Watt)	$.959
• Manufacturing Year	1986
• Product Volume (Cubic Meters/MW)	1415.8
• Product Weight (kilograms/MW)	155925.0
• Factory Location Region	Rocky Mountain

STANDARD DATA:

• Base Price Year	1981
• Deflation Rate Solar Products	6.00%
• Inflation Rates	
- Raw Materials	11.00%
- Labor	8.00%
- Chemicals	13.00%
- Commodities	8.00%
- Energy	12.00%
- Land	4.00%
- Facilities	9.00%
- Construction	8.00%
- Equipment	7.00%
- Resources	15.00%
- Transportation	7.00%

FSR-8 General M&D Model Parameters - There are two sections to this financial report: 1) input data including the product manufacturing cost, manufacturing year, volume, weight, and factory location region, and 2) standard data including the base price year, deflation rate, and eleven inflation rates. The numbers listed here are for the example flat-plate collector company.

M&D CASE 3: FLAT-PLATE COLLECTOR

The example case involves a hypothetical photovoltaic solar energy manufacturer with a factory in Phoenix, Arizona. The company sells flat-plate collector systems of three standard sizes: 10 kilowatts for residential customers, 500 kilowatts for commercial customers and 50 megawatts for public utility customers. In 1986, sales are predicted to be 500 megawatts distributed as follows:

1986 SALES FORECAST

	Units	Megawatts
Residential	20000	200
Commercial	200	100
Public Utility	4	200

Based on a manufacturing cost analysis, the company estimates an average manufacturing cost including overhead and profit of $0.959 per watt in 1986 dollars. This is equivalent to $0.72 per watt in 1981 dollars.

Using the M&D model, the company estimates average marketing expenses of $0.070 per watt and distribution expenses of $0.034 per watt in 1981 dollars. After adding in taxes and profit, the following delivered product prices were obtained:

DELIVERED PRODUCT PRICES

	(1981 $/Watt)
Residential	0.933
Commercial	0.872
Public Utility	0.786
Weighted Average	0.862

Based on the demand forecast for 1986, these prices will generate the following sales revenues:

SALES REVENUES

	(1981 $000)
Residential	$186618
Commercial	87186
Public Utility	157204
All products	$431009

Distribution costs will total $17,005,000 and marketing costs will total $34,988 1981 dollars. Together these costs represent 12.1% of sales. Net profit after tax is estimated at $10,146,000 or 2.4% of sales.

M&D CASE 3: FLAT-PLATE COLLECTOR

Markup, defined as revenue less cost of goods manufactured divided by cost of goods manufactured, varies by region and type of customer.

MARK-UP

	(Revenue - CGS/CGS)
Residential	30.2%
Commercial	21.7%
Public Utility	9.7%
All Products	20.3%

The M&D model projects a sales force of about 938 people for this level of sales and productivity. About 53% consist of salesman and the balance are support staff and management

	SALES FORCE SIZE
SALESMAN	
- Residential	393
- Commercial	102
- Public Utility	4
DIRECT SUPPORT STAFF	
- Field Engineer	131
- Commercial Artist	7
- Marketing Research Analyst	26
- Technical Illustrator	13
- Technical Writer	13
- Advertising Salesman	7
SECRETARIES	
- Level I	70
- Level II	43
- Level III	22
MANAGEMENT	
- Vice President	21
- Advertising Manager	2
- Marketing Research Manager	5
- Sales Manager	62
- Sales Engineering Manager	18
TOTAL	938

M&D CASE 3: FLAT-PLATE COLLECTOR

To minimize shipping costs, the company determined that it would be economical to supply its residential and commercial customers from regional warehouses in the following locations:

REGIONAL WAREHOUSE CONFIGURATION

	Inventory (kilowatts)	Delivery Trucks	Warehouse Personnel
West Coast - Los Angeles	100	1	2
North Central - Omaha	30	1	2
Great Lakes - Springfield	30	1	2
North Eastern - Syracuse	40	1	2
South Eastern - Atlanta	30	1	2
South Central - Dallas	80	1	2

Customers in the Rocky Mountain region around the factory will be supplied directly from the factory in Phoenix. The four public utility units sold each year will also be shipped directly.

These results for the hypothetical photovoltaic flat-plate collector manufacturer of course would vary substantially with production level. The number of sales people, the location of the warehouses and the average inventory mix all depend on the level of sales, geographic distribution and product mix. The M&D model is a useful tool to analyze all of these interdependent variables simultaneously.

APPENDIX I

PV CONSTRUCTION COST REPORTING SYSTEM

The appendix presents the reporting forms for the construction costing system explained in section V. The system consists of sixteen forms:

PV-1	Project Development Expenditure Input Form
PV-2	Project Construction Cost Estimation Input Form
PV-3	Project Construction Expenditures Input Form
PV-4	Basic Photovoltaic System Data
PV-5	Account Code Form
PV-6	Development (Design) Document Status
PV-7	Document Log
PV-8	Procurement Document Status
PV-9	Procurement Log
PV-10	Contract Determination Record
PV-11	Daily Time Sheet - Construction Labor
PV-12	Daily Time Sheet - Non Construction Services
PV-13	Materials Received Form
PV-14	Equipment Rental Form
PV-15	Activity Completion Status Report
PV-16	Account Cost Adjustment Work Form

The following pages contain examples of each form. The field installation segment of a hypothetical PV collector/array system has been used to demonstrate the completion of the forms and to indicate the interrelationship of the control, support, and reporting aspects of the various forms.

PROJECT DEVELOPMENT EXPENDITURE INPUT FORM

PHOTOVOLTAIC SYSTEMS
COST REPORTING FORM PV-1

SANTA CATALINA LIGHTHOUSE PV PROJECT

	ACCOUNT NUMBER	ACCOUNT DESCRIPTION	TIME PERIOD					
			START DATE		COMPLETION DATE		SPAN (DAYS)	
			EST.	ACT.	EST.	ACT.	EST.	ACT.
1	1.1.11	PROGRAM DEFINITION	2/5/80	2/5/80	2/15/80	2/11/80	7	5
2	1.1.15	REPORT PREP.	2/15/80	2/16/80	2/18/80	2/20/80	3	5
3	1.1.16	REVIEWS & APPROVALS	4/15/80	4/20/80	4/27/80	4/30/80	12	10
4	1.2.01	COLLECTOR/ ARRAY (DESIGN)	3/1/80	3/6/80	3/20/80	4/20/80	15	25
5	1.2.1102	CONSTRUCTION DOCUMENT PREP.	3/18/80	3/25/80	4/15/80	4/22/80	20	20
6	1.2.1105	CONSTRUCTION SUPERVISION	7/2/80		7/26/80		17	
7	1.4.01	COLLECTOR/ ARRAY (TESTING)	3/12/80	4/15/80	3/19/80	4/24/80	5	6
8								
9								
10								
11								
12								
13								
14								
15								

	LUMP SUM ALLOWANCE	MANPOWER PROJECTIONS			MANPOWER & ALLOWANCE EXPENDITURES				
		ESTIMATED HOURS	AVERAGE RATE	TOTAL EXTENSION	% HOURS EXPENDED	% WORK COMPLETED	$ EXPENDED	$ REMAINING	% $ REMAINING
1	-	80	50	4000	80	100	3200	800	20
2	2000	-	-	-	-	100	1800	200	10
3	1000	-	-	-	-	100	1500	(500)	(50)
4	-	250	38	9500	140	100	13,300	(3800)	(40)
5	-	150	22	3300	94	100	3102	198	6
6						0			
7	3000	-	-	-	-	100	2200	800	27
8									
9									
10									
11									
12									
13									
14									
15									

PROJECT CONSTRUCTION COST ESTIMATION INPUT FORM

PHOTOVOLTAIC SYSTEMS
COST REPORTING FORM PV-2

ACCOUNT NUMBER	ACCOUNT DESCRIPTION	QUANTITY	UNIT	MATERIAL		EQUIPMENT		LABOR		M+E+L TOTAL PER UNIT	TOTAL COST (UNIT COST x QUANTITY)
				PER UNIT	EXTENSION	PER UNIT	EXTENSION	PER UNIT	EXTENSION		
2.2.1501	ROUGH GRADING	5000	CY	-	-	1.25	$6250	.75	$3750	2.00	$10,000
2.3.01	COLLECTOR/ARRAY (FDN)	20	-	500	$10000	210	$4200	160	$3200	870	$17,400
2.4.01	COLLECTOR/ARRAY (INSTALL)	20	-	(SUMMARY OF		2.4.0110 - 2.4.0117		BELOW)		3640	$72,800
2.4.0110	MODULE STRUCTURE	60	-	400	$24,000	40	2400	50	$3000	490	$29,400
2.4.0111	REFLECTIVE SURFACE	60	-	200	$12,000	-	-	40	$2400	240	$14,400
2.4.0113	RECEIVER	60	-	80	$4,800	-	-	20	$1200	100	$6,000
2.4.0114	CELLS	60	LOTS	350	$21,000	-	-	-	-	350	$21,000
2.4.0116	POWER PIGTAILS	20	-	20	$400	-	-	10	$200	30	$600
2.4.0117	PLUMBING STUBOUTS	20	-	40	$800	-	-	30	$600	70	$1400

PROJECT CONSTRUCTION EXPENDITURES INPUT FORM

PHOTOVOLTAIC SYSTEMS
COST REPORTING FORM PV-3

ACCOUNT NUMBER	ACCOUNT DESCRIPTION	CONSTRUCTION PERIOD						QUANT.	UNIT	MATERIAL				
		START		FINISH		SPAN (DAYS)				TOTAL EXT.	RECEIVED		REMAINING	
		EST.	ACT.	EST.	ACT.	EST.	ACT.				NO.	COST	NO.	COST
2.2.1501	ROUGH GRADING	5/1/80	5/1/80	5/8/80	5/10/80	5	7	5000	CY	-	-	-	-	-
2.3.01	COLLECTOR/ARRAY (FCN.)	5/15/80	5/22/80	6/07/80		17		20	-	10,000	5	2500	15	7500
2.4.01	COLLECTOR/ARRAY (INSTALL)	7/2/80		7/26/80		18		20	-	-				
2.4.0110	MODULE STRUCTURE	7/2/80		7/18/80		12		60	-	24,000				
2.4.0111	REFLECTIVE SURFACE	7/2/80		7/12/80		* (W/ MOD. STRUCT)				12,000				
2.4.0113	RECEIVER	7/2/80		7/18/80		*		60	-	4,800				
2.4.0114	CELLS	7/2/80		7/18/80		*		60	LOTS	21,000				
2.4.0116	POWER PIGTAILS	7/12/80		7/24/80		10		20	-	400				
2.4.0117	PLUMBING STUBOUTS	7/18/80		7/24/80		5		20	-	800				

EQUIPMENT					LABOR			TOTALS		
TOTAL EXT.	RECEIVED		REMAINING		TOTAL COST TO DATE	% COMPLETE	REMAINING COST	TOTAL COST	EXPENDED TO DATE	REMAINING ALLOCATION
	NO.	COST	NO.	COST						
6250	-	5500	-	-	2500	100	-	$9,000	$9,000	$1,000
4200	5	1050	15	3150	800	25	2400	$17,400	$4,350	$13,050
								$72,800		
2400								$29,400		
-								$14,400		
-								$6,000		
-								$21,000		
-								$600		
-								$1,400		

BASIC PHOTOVOLTAIC SYSTEM DATA

PHOTOVOLTAIC SYSTEMS COST REPORTING FORM PV-4

1. PROJECT TITLE SANTA CATALINA LIGHTHOUSE PV. PROJECT.

2. PROJECT LOCATION 2000 MAIN ST, CATALINA ISLAND, CALIFORNIA

3. PRIME CONTRACTOR BURGESS CORP. MGR BOB PETERS

ADDRESS 1 BC STREET, SAN DIEGO CA. TEL (217) 489-[illegible]

4. PROJECT DATES

DESIGN PHASE 2/5/80 - 4/30/80

CONSTRUCTION PHASE 4/28/80 - 11/19/80

COMMISSIONING 1/2/81

5. SITE DESCRIPTION 10% SLOPE TO NORTH - WOODED AREA 2.46 ACRES

6. UTILITY AFFILIATION PACIFIC GAS & ELECTRIC.

7. PV SYSTEM GENERAL DESCRIPTION 35 KW SYSTEM (PARABOLIC CONCENTRATOR) TO SERVE ISOLATED LIGHTHOUSE BEACON. ARRAY GROUND MOUNTED 200' TO NORTH OF LOAD.

ARRAY TYPE PARABOLIC TROUGH.

LOCATION MOUNTED @ GRADE

SURFACE AREA 1500 SQ. FT.

NOMINAL DESIGN OUTPUT - DC SIDE 35 KW. AC SIDE 30 KW.

PCU-NO. 1 CAPACITY 35

STANDARD FEATURES SURGE PROTECTION GROUND FAULT OVERLOAD CONTROLS.

OPTIONAL FEATURES AUTOMATIC START & SHUTDOWN

CONNECTED LOAD LIGHTHOUSE - 25 KW TOTAL CONNECTED LOAD

UTILITY TIE-IN CHARACTERISTICS REVERSE FEED

8. ELECTRICAL ENERGY STORAGE CAPACITY —

9. THERMAL ENERGY STORAGE CAPACITY —

10. COSTS

	ESTIMATED	ACTUAL
TOTAL PV PROJECT	$946,000	( ) LATER
PV SYSTEM RELATED	$612,000	( ) LATER.

ACCOUNT CODE FORM

PHOTOVOLTAIC SYSTEMS
COST REPORTING FORM PV-5

ACCOUNT NUMBER	ACCOUNT DESCRIPTION	CODES 1 NPVR OR NDOE OR N2	2 COST RELATED TO CODE 1	3 EARLY INSTALL (E)	4 PROCUROR EXPERIENCE 1(L), 2(M) OR 3(H)	5 DOC. PRECISION 1, 2 OR 3	6 SHOP (S) OR FIELD (F) FAB.	7 CONST. TRADE	8 FREIGHT ($)	9 TAX ($)
1.1.11	PROGRAM DEFINITION	-	-							
1.1.15	REPORT PREP.	-	-			NOT APPLICABLE				
1.1.16	REVIEWS & APPROVALS	-	-							
1.2.01	COLLECTOR/ARRAY (DESIGN)	-	-							
1.2.1102	CONSTRUCTION DOCUMENT PREP.	-	-							
1.2.1105	CONSTRUCTION SUPERVISION	-	-							
1.4.01	COLLECTOR/ARRAY (TESTING)	-	-	-	-	-	-	-	$1800	-
2.2.1501	ROUGH GRADING	-	-	-	-	-	-	O	-	-
2.3.01	COLLECTOR/ARRAY (FDN)	-	-	-	-	2	F	C	-	-
2.4.01	COLLECTOR/ARRAY (INSTALL)	-	-	-	3	2	S	O	$5200	$750
2.4.0110	MODULE STRUCTURE	-	-	-	3	2	S	-	-	-
2.4.0111	REFLECTIVE SURFACE	-	-	-	3	3	S	-	-	-
2.4.0113	RECEIVER	-	-	-	3	1	S	-	-	-
2.4.0114	CELLS	-	-	-	3	3	S	-	-	-
2.4.0116	POWER METALS	-	-	-	3	3	S	-	-	-
2.4.0117	PLUMBING STUBOUTS	NPVR	$1400	-	1	3	F	P	-	-

LEGEND:

NPVR = NON PV RELATED
NDOE = NON DOE RELATED
N2 = NPVR & NDOE

E = EARLY INSTALLATION
1 = LOW EXP. OR PRECISION
3 = HIGH EXP. OR PRECISION

CONSTRUCTION TRADES

C = CARPENTER
E = ELECTRICIAN
L = LABORER
P = PIPEFITTER
M = METALWORKER
O = OPERATOR (EQUIP)

DEVELOPMENT (DESIGN) DOCUMENT STATUS

PHOTVOLTAIC SYSTEMS
COST REPORTING FORM PV-6

	ACCOUNT NUMBER	ACCOUNT DESCRIPTION	DOCUMENT NUMBER(S)	TIME PERIOD					
				START DATE		COMPLETION DATE		SPAN (DAYS)	
				EST.	ACT.	EST.	ACT.	EST.	ACT.
1	2.3.01	COLLECTOR / ARRAY	FDN-1	2/10/80	2/14	3/1/80	3/12	15	20
2		(FDN.)	3	2/10/80	2/14	3/5/80	3/6	17	15
3			6	2/12/80	2/18	3/5/80	3/12	15	15
4									
5	2.3.0110	MODULE STRUCTURE	SMS-23	2/5/80	2/10	2/20/80	2/20	12	17
6			24	2/5/80	2/5	2/28/80	2/20	17	19
7									
8	2.3.0111	REFLECTIVE SURFACE	RS-1	3/15/80	2/29	3/24/80	4/1	7	30
9									
10	2.3.0112	RECEIVER	SMS-2	2/10/80	2/15	4/1/80		35	
11			3	2/11/80	2/15	3/15/80	4/1	25	31
12			5	3/1/80	2/25	3/22/80	4/1	19	20
13									
14	2.3.0114	CELLS	SMS-1	2/15/80	2/18	4/1/80		30	
15									
16									
17									
18									
19									
20									
21									
22									

	PROGRESS DATES					MILESTONES			
	% COMPLETED					CHECKED	APPROVED	ISSUED	REVISED
	20	40	60	80	100				
1	2/20	2/25	2/28	3/5	3/12/80	3/12	3/12	3/15	
2	–	–	–	–	3/6/80	3/12	3/12	3/12	
3	–	–	–	–	3/12/80	3/12	3/12	3/20	4/12
4									
5	2/15	–	–	–	2/20/80	3/2	3/2	3/5	3/12
6	2/8	–	2/20	–	2/20/80	3/4	3/4	3/5	
7									
8	3/5	3/8	3/20	3/26	4/1/80	4/8	4/15	4/15	
9									
10	2/20	2/27	4/12	5/5					
11	2/20	3/5	3/12	3/26	4/1/80	4/1	4/1	4/2	4/5
12	2/28	3/4	3/16	3/22	4/1/80	4/1	4/1	4/8	4/15
13									
14	2/20	3/1/80	3/15	5/1					
15									
16									
17									
18									
19									
20									
21									
22									

DOCUMENT LOG

PHOTOVOLTAIC SYSTEMS
COST REPORTING FORM PV-7

ACCOUNT NUMBER	ACCOUNT DESCRIPTION	DOCUMENT NUMBER(S)	DOCUMENT TITLE	DATE INITIALLY LOGGED
2.3.01	COLLECTOR/ARRAY	FDN-1	FOUNDATION - PLAN	2/14/80
	(FDN.)	2	" - SECTIONS	2/14/80
		6	" - DETAILS	2/18/80
2.3.0110	MODULE STRUCTURE	SMS-23	STRUCTURAL FRAMING	2/15/80
		24	CONNECTIONS	2/5/80
2.3.0111	REFLECTIVE SURFACE	RS-1	FASTENING DETAILS	2/21/80
2.3.0113	RECEIVER	SMS-2	ISOMETRIC - FULL SCALE	2/15/80
		3	DETAILS	2/15/80
		8	CELL MTG DETAILS	2/22/80
2.3.0114	CELLS	EMS-1	WIRING DIAGRAM	2/18/80

PROCUREMENT DOCUMENT STATUS

PHOTOVOLTAIC SYSTEMS
COST REPORTING FORM PV-8

	ACCOUNT NUMBER	ACCOUNT DESCRIPTION	PROCUREMENT DOCUMENT NUMBER CODE	TIME PERIOD					
				START DATE		COMPLETION DATE		SPAN (DAYS)	
				EST.	ACT.	EST.	ACT.	EST.	ACT.
1	2.4.0110	MODULE STRUCTURE	SCPMS-2	5/15/80	5/18/80	6/15/80		23	
2									
3	2.4.0113	RECEIVER	SCPR - 12	5/5/80	5/7/80	6/1/80	5/27/80	19	16
4									
5	2.4.0114	CELLS	SCPC - 4	5/1/80	5/5/80	5/20/80	5/25/80	15	17
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									

	MILESTONE DATES							
	COMPLETED	CHECKED	APPROVAL	ISSUED	REVISIONS			BIDS TAKEN
					1	2	3	
1								
2								
3	5/27/80	5/27/80	5/30/80	6/1/80	6/8/80	6/10/80		
4								
5	5/25/80	*	*	6/1/80	6/8/80	6/10/80		6/20/80
6								
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* SENT OUT W/O BEING CHECKED OR APPROVED

PROCUREMENT LOG

PHOTOVOLTAIC SYSTEMS
COST REPORTING FORM PV-9

ACCOUNT NUMBER	ACCOUNT DESCRIPTION	PROCUREMENT DOCUMENT NUMBER	PROCUREMENT DOCUMENT TITLE	DATE INITIALLY LOGGED
2.4.0110	MODULE STRUCTURE	SCPMS - 2	MOD. STRUCT SPEC.	5/18/80
2.4.0113	RECEIVER	SCPR - 12	RECEIVER RFP. DOC	5/7/80
2.4.0114	PLLLS	SCPC - 4	RECEIVER RFP. DOC.	5/5/80

CONTRACT DETERMINATION RECORD

PHOTOVOLTAIC SYSTEMS
COST REPORTING FORM PV-10

ACCOUNT NUMBER	ACCOUNT DESCRIPTION	PROCUREMENT DOCUMENT NUMBER	BID RECEIPT DATE		BID REVIEW COMPLETE	SELECTION DATE	CONTRACT DATES	
			ORIGINAL	ACTUAL			AUTH.	SIGNED
2.4.0110	MODULE STRUCTURE	SCPM5-2	7/1/80					
2.4.0113	RECEIVER	SCPR-12	7/1/80					
2.4.0114	CELLS	SCPC-4	6/15/80	6/20/80				

DAILY TIME SHEET - CONSTRUCTION LABOR

PHOTOVOLTAIC SYSTEMS
COST REPORTING FORM PV-11

DATE: 7/15/80

COMPANY NAME: BIGGS ELECTRICAL CO, INC.
(Employer)
12 ELEVENTH ST.
LAGUNA BEACH, CA.

EMPLOYEE NAME	EMPLOYEE NUMBER	CONSTRUCTION TRADE	UNION CLASS	WAGE RATE	HOURS (TOTAL) REG.	1½	2		ACCOUNT DESCRIPTION: RECEIVER	POWER PEDESTALS						
									ACCOUNT NUMBER: 2.3.0113	2.3.0116						
								O.T.								
ELROD JOHNSON	213	ELECT.	2	14.55	8			REG.	4	4						
						2		O.T.	2							
JESSE OGLLEY	72	ELECT.	2	14.55	8			REG.	8							
								O.T.								
JANE HOPKINS	416	ELECT.	3	15.05	8			REG.		8						
								O.T.								
								REG.								
								O.T.								
								REG.								
								O.T.								
								REG.								
								O.T.								
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								O.T.								
								REG.								
								O.T.								
								REG.								
								O.T.								
								REG.								

DAILY TIME SHEET - NON CONSTRUCTION SERVICES

PHOTOVOLTAIC SYSTEMS
COST REPORTING FORM PV-12

DATES RECORDED: 3/16/80 - 3/31/80

COMPANY NAME: JOHNSTONE CIVIL ENG.
1202 STONE AVE., L.A., CA.

EMPLOYEE NAME: JERRY TURNDALE

EMPLOYEE NO.: 7773

ACCOUNT NUMBER	ACCOUNT DESCRIPTION	TIME WORKED (IN HOURS)																TOTAL HOURS	EXTENDED COST ($)
		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		
1.1.15	REPORT PREP.		8	8	4													20	1000
1.1.16	REVIEW & APPROVALS									4	8							12	600
1.2.01	COLLECTOR/ ARRAY (DESIGN)				4	8	8			4		8	8	8			8	56	2800

MATERIALS RECEIVED FORM

PHOTOVOLTAIC SYSTEMS
COST REPORTING FORM PV-13

ACCOUNT NUMBER	ACCOUNT DESCRIPTION	MATERIAL (EQUIP.) RECEIVED	DATE RECEIVED	QUANTITY	UNIT	COST ($)
2.3.01	COLLECTOR/ARRAY	GRAVEL	5/24/80	32.5	CY	$325
	(FOUNDATION)					
		REBAR	5/26/80	2	TONS	$1200
		CONCRETE.	5/27/80	15	CY	$975

EQUIPMENT RENTAL FORM

PHOTOVOLTAIC SYSTEMS
COST REPORTING FORM PV-14

RENTAL DATE(S) 5/1/80 - 6/1/80

EQUIPMENT LEASOR:

NAME BIG JOHN'S EQUIPMENT CO. ADDRESS LAVERNE CA. TELEPHONE (213) 671-4051

EQUIPMENT LEASEE:

NAME BURKESS CORP. (FOR) SANTA CATALINA LIGHTHOUSE PV PROJECT ADDRESS 1 PC CT. SAN DIEGO, CA. TELEPHONE (217) 489-2324

JOB ADDRESS FOR EQUIPMENT USE 2000 MAIN ST., CATALINA ISLAND, CA.

ACCOUNT NUMBER	ACCOUNT DESCRIPTION	DESCRIPTION OF EQUIPMENT	QUANTITY	DATE/ TIME OUT	DATE/ TIME IN	TOTAL TIME	RENTAL RATES				AMOUNT
							HOURS	DAY	WEEK	MONTH	
2.2.1501	ROUGH GRADING	BACKHOE	1	5/1/80	5/10/80	7 DAYS		200			$1400
"	"	DUMP TRUCK (2T)	2	5/1/80	5/10/80	7 DAYS		250			$3500
"	"	PULLPOLLK	1	5/2/80	5/8/80	5 DAYS		270			$1350
2.3.01	COLLECTOR / ARRAY	BACKHOE	1	5/22/80	5/30/80	6 DAYS		200			$1200
	(FDN.)	DUMP TRUCK (2T)	2	5/23/80	5/30/80	5 DAYS		250			$2500
		VIBRATOR	1	5/24/80	5/30/80	4 DAYS		125			$500

SIGNATURE OF LEASEE [signature] TOTAL CHARGE $10,450

ACTIVITY COMPLETION STATUS REPORT

PHOTOVOLTAIC SYSTEMS
COST REPORTING FORM PV-15

AS OF 6/1/80

ACCOUNT NUMBER	ACCOUNT DESCRIPTION	ACTUAL CONSTRUCTION START DATE	ESTIMATE COMPLETE DATE	% COMPLETE AS OF REPORT DATE	ON, AHEAD, OR BEHIND SCHEDULE (O,A, OR B)	PROJECT MANAGER REVIEW SIGNATURE
2.2.1501	ROUGH GRADING	5/1/80	5/10/80 A	100	B	[illegible]
2.3.01	COLLECTOR/ARRAY (FDN)	5/22/80	6/07/80	25	B	[illegible]
2.4.01	COLLECTOR/ARRAY (INSTALL)	7/2/80				

ACCOUNT COST ADJUSTMENT WORK FORM

PHOTOVOLTAIC SYSTEMS
COST REPORTING FORM PV-16

ACCOUNT NUMBER	ACCOUNT DESCRIPTION	ACTUAL PRICE	ADJUSTMENT FACTORS (USE AS APPLICABLE)												ADJUSTED PRICE
			1	2	3	4	5	6	7	8	9	10	11	12	
2.2.1501	ROUGH GRADING	$9,000	–	–	–	–	–	–	–	–	–	–	–	–	$9,000
2.3.01	COLLECTOR/ ARRAY (FDN.)	$17,400	–	–	–		-1740	–		-500	–	–	–	–	
2.4.01	COLLECTOR/ ARRAY (INSTALL)	$72,800	–	–	–		-7280	–	-1000	–	–	–	-5250	-750	

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