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SAMICS
Marketing & Distribution Model
Jet Propulsion Laboratory
Pasadena, California

Theodore Barry & Associates Management Consultants

(NASA-CR-157552) SAMICS MARKETING AND DISTRIBUTION MODEL (Barry (Theodore) and Associates) 109 p HC A06/MP A01 CSCL 10A

UNCLAS G3/44 28646
SAMICS
Marketing & Distribution Model
Jet Propulsion Laboratory
Pasadena, California

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This work was performed for the Jet Propulsion Laboratory, California Institute of Technology, under NASA Contract NAS7-100 for the U.S. Department of Energy, Division of Solar Energy.

The JPL Low-Cost Solar Array (LSA) Project is funded by DOE and forms part of the DOE Photovoltaic Conversion Program to initiate a major effort toward the development of low-cost solar arrays.

The Solar Array Manufacturing Industry Costing Standards (SAMICS) are a part of the LSA Project Analysis and Integration Activity and are intended to provide a standard procedure and data base for estimating, from descriptions of the manufacturing processes, the price at which solar modules would have to be sold to realize a specified after-tax of return on equity.

April 1978
Los Angeles • New York • Atlanta • Chicago
ACKNOWLEDGEMENTS

We extend our sincere appreciation for the courtesy and cooperation we received from the many individuals who participated in this study for the Low-Cost Solar Array project at the Jet Propulsion Laboratory.

Mr. Robert Chamberlain deserves special recognition for his effort to develop the Solar Array Manufacturing Industry Costing Standards and his assistance in the development of this model. Mr. Chester Borden also provided several valuable suggestions for the model formulation and presentation.
# SAMICS
Marketing And Distribution Model

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<td>B. Marketing Model Data</td>
<td>B-1</td>
</tr>
<tr>
<td>C. Distribution Model Data</td>
<td>C-1</td>
</tr>
<tr>
<td>D. Test Case Data</td>
<td>D-1</td>
</tr>
</tbody>
</table>
I. EXECUTIVE SUMMARY

A. Introduction

The Jet Propulsion Laboratory (JPL) is currently managing a research and development project sponsored by the Department of Energy to reduce the cost of photovoltaic solar collectors. JPL has subcontracted the technology development to over 50 universities and manufacturing firms.

An important part of the program is the development of the Solar Array Manufacturing Industry Costing Standards (SAMICS). These standards unify economic and financial assumptions to provide comparable cost estimates for the alternative manufacturing technologies under development by the subcontractors.

Theodore Barry & Associates has been contacted to provide industrial management consulting and facilities engineering support for the development and implementation of SAMICS.

SAMICS has been formulated as a computer simulation model. Given a proper description of the manufacturing technology as input, this model computes the manufacturing price of solar arrays for a broad range of production levels. However, the ending point of the model is the loading dock of the final manufacturer. That is, the SAMICS model does not include the cost of marketing and distributing the product to the final customer and the costs of preparing the site and installing the arrays. This report presents a model for computing these marketing and distribution costs. Other models will be developed to compute the site installation and operations costs.

This marketing and distribution model is a simplification intended to recognize the added costs of marketing and transporting the solar arrays from the factory to the customer. The model covers selling, transportation, and storage costs in transit from the loading dock to the point of use.

This section presents an executive summary of the model equations and the test case results. The test case exercised the equations in the model and provides a clearer understanding of the magnitude of marketing and distribution costs in deciding the economic feasibility of photovoltaic solar collectors.

B. Marketing Model

The marketing model computes the cost of selling solar arrays. These costs include:

- Sales personnel salaries
- Office facilities cost
- Sales expenses
  - Travel and entertainment
  - Communications
  - 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 the test case, the average residential customer purchases solar arrays in orders of 10,000 peak watts, commercial 500,000 peak watts, and utilities 50 megawatts.

The model user inputs total sales by customer by region and the average sales per unit. From these the model calculates 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.

C. Distribution Model

The distribution model computes the cost of transporting, warehousing, and delivering the solar arrays from the factory to the final customers.

The country is divided into seven distribution regions shown in Exhibit I-1. There are two distribution alternatives for each type of customer:

1. Direct shipments from the factory to the customer.
2. 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 delivered solar modules.
D. Test Case

The validity of the model was checked by performing a test case analysis. To do this, a factory capable of producing 500 megawatts/year was assumed to be located in Region II: Rocky Mountain corresponding to Phoenix, Arizona. Exhibit I-2 shows the customer demand distribution:

Test Case Demand Distribution

- 40% residential
- 20% commercial
- 40% utility

For the test case, the manufacturing price for the solar arrays was assumed to be $.50 per peak-watt expressed in 1975 dollars. As shown in Exhibit I-3, the model results in a computed markup of about $6.1 per peak watt for marketing and distribution. The results vary from region to region and by customer type.

Exhibit I-4 shows the variation in solar array price estimates for different customers by region. Since the factory was assumed to be located in the Rocky Mountain Region, the lowest cost ($7.72/peak watt) would be to utility customers in the Rocky Mountain Region, while the highest cost of $9.91/peak watt would be to residential customers in the Great Lakes Region. Overall, utility customers would enjoy the lowest prices ($7.75/peak watt), commercial next ($8.82), and finally residential ($8.96) due to economies of scale in both marketing and distribution.

Exhibits I-5 and I-6 present pro forma Income Statements for SELCO, the hypothetical solar array sales and distribution company. The model forecasts were made for 1986, the test case manufacturing year. The results show gross profit of 38% and a net profit after tax of 14% compared to 40% and 14% for the SAMICS manufacturing cost estimates.

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

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Customer Type 1</th>
<th>Customer Demand Distribution (MW/YR)</th>
<th>Total Annual Demand (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Residential Household</td>
<td>Commercial Intermediate</td>
<td>Public Utility Central Station</td>
</tr>
<tr>
<td>I West Coast</td>
<td>50.0</td>
<td>25.0</td>
<td>50.0</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>60.0</td>
<td>30.0</td>
<td>50.0</td>
</tr>
<tr>
<td>III North Central</td>
<td>10.0</td>
<td>5.0</td>
<td>0.0</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>10.0</td>
<td>5.0</td>
<td>0.0</td>
</tr>
<tr>
<td>V North Eastern</td>
<td>20.0</td>
<td>10.0</td>
<td>50.0</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>10.0</td>
<td>5.0</td>
<td>0.0</td>
</tr>
<tr>
<td>VII South Central</td>
<td>40.0</td>
<td>20.0</td>
<td>50.0</td>
</tr>
<tr>
<td>Total</td>
<td>200.0 (40%)</td>
<td>100.0 (20%)</td>
<td>200.0 (40%)</td>
</tr>
</tbody>
</table>
TEST CASE RESULTS

SELLCO

SOLAR ARRAY SALES AND DISTRIBUTION COMPANY

PRICE ESTIMATES

<table>
<thead>
<tr>
<th>Cost of goods sold</th>
<th>1975 $/Watt</th>
<th>% Of Price</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$.500</td>
<td>61.9%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Expenses:</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution</td>
<td>$.020</td>
<td></td>
</tr>
<tr>
<td>Marketing</td>
<td>$.057</td>
<td></td>
</tr>
</tbody>
</table>

| Total expenses     | $.077       | 9.5%       |
| Income tax         | $.118       | 14.6%      |
| Net profit         | $.113       | 14.0%      |

<table>
<thead>
<tr>
<th>Solar array prices:</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Household products</td>
<td>$.864</td>
<td></td>
</tr>
<tr>
<td>Commercial products</td>
<td>$.820</td>
<td></td>
</tr>
<tr>
<td>Central power stations</td>
<td>$.747</td>
<td></td>
</tr>
</tbody>
</table>

| All products       | $.808       | 100.0%     |
## TEST CASE RESULTS

### SOLAR ARRAY PRICE ESTIMATES

(1975 $/Watt)

<table>
<thead>
<tr>
<th>Customer Type</th>
<th>Market Region</th>
<th>Residential Household</th>
<th>Commercial Intermediate</th>
<th>Public Utility Central Station</th>
<th>All Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I West Coast</td>
<td>$.8595</td>
<td>$.8127</td>
<td>$.7316</td>
<td>$.7990</td>
</tr>
<tr>
<td></td>
<td>II Rocky Mountain</td>
<td>.8408</td>
<td>.8007</td>
<td>.7204</td>
<td>.7892</td>
</tr>
<tr>
<td></td>
<td>III North Central</td>
<td>.8839</td>
<td>.8376</td>
<td>-</td>
<td>.8685</td>
</tr>
<tr>
<td></td>
<td>IV Great Lakes</td>
<td>.9144</td>
<td>.8634</td>
<td>-</td>
<td>.8974</td>
</tr>
<tr>
<td></td>
<td>V North Eastern</td>
<td>.9036</td>
<td>.8599</td>
<td>.7869</td>
<td>.8252</td>
</tr>
<tr>
<td></td>
<td>VI South Eastern</td>
<td>.8857</td>
<td>.8424</td>
<td>-</td>
<td>.8713</td>
</tr>
<tr>
<td></td>
<td>VII South Central</td>
<td>.8596</td>
<td>.8180</td>
<td>.7486</td>
<td>.8016</td>
</tr>
<tr>
<td></td>
<td>All regions</td>
<td>$.8636</td>
<td>$.8201</td>
<td>$.7469</td>
<td>$.8082</td>
</tr>
</tbody>
</table>
# TEST CASE RESULTS

**SELLCO**

**SOLAR ARRAY SALES AND DISTRIBUTION COMPANY**

**INCOME STATEMENT FOR THE YEAR ENDING DECEMBER 31, 1986**

<table>
<thead>
<tr>
<th></th>
<th>1986 $</th>
<th>% Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sales:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household products</td>
<td>$331,251,931</td>
<td>42.7</td>
</tr>
<tr>
<td>Commercial products</td>
<td>157,295,662</td>
<td>20.3</td>
</tr>
<tr>
<td>Central power stations</td>
<td>286,492,674</td>
<td>37.0</td>
</tr>
<tr>
<td><strong>Total sales</strong></td>
<td>$775,040,267</td>
<td>100.0%</td>
</tr>
<tr>
<td><strong>Cost of goods sold:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household products</td>
<td>$191,800,000</td>
<td>24.7</td>
</tr>
<tr>
<td>Commercial products</td>
<td>95,900,000</td>
<td>12.5</td>
</tr>
<tr>
<td>Central power stations</td>
<td>191,800,000</td>
<td>24.7</td>
</tr>
<tr>
<td><strong>Total cost</strong></td>
<td>$479,500,000</td>
<td>61.9%</td>
</tr>
<tr>
<td><strong>Gross profit</strong></td>
<td>$295,540,267</td>
<td>38.1%</td>
</tr>
<tr>
<td><strong>Expenses:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distribution (Schedule A)</td>
<td>$19,661,719</td>
<td>2.6</td>
</tr>
<tr>
<td>Marketing (Schedule B)</td>
<td>54,438,472</td>
<td>7.0</td>
</tr>
<tr>
<td><strong>Total expenses</strong></td>
<td>$74,100,191</td>
<td>9.6</td>
</tr>
<tr>
<td><strong>Net profit before tax</strong></td>
<td>$221,440,076</td>
<td>28.5%</td>
</tr>
<tr>
<td><strong>Net income tax</strong></td>
<td>112,934,438</td>
<td>14.5</td>
</tr>
<tr>
<td><strong>Net profit after tax</strong></td>
<td>$108,505,638</td>
<td>14.0%</td>
</tr>
</tbody>
</table>
TEST CASE RESULTS

Schedule A:

Distribution expenses:
Salaries and benefits $629,095 38%
Transportation $18,650,303 95%

Warehouse facilities:
Lease
Utilities
Other expenses

Total warehouse expenses 118,071 1%

Inventory carrying charges 264,250 1%

Total distribution expenses $19,661,719 100%

Schedule B:

Marketing expenses:
Salaries and benefits $43,771,892 80%
Sales expenses 4,320,405 9%

Office facilities:
Lease $892,162
Utilities 42,339
Maintenance 70,807
Other expenses 354,067

Total office expenses 1,359,375 2%

Advertising 4,986,800 9%

Total marketing expenses $54,438,472 100%
II. MARKETING MODEL

A. General Description

B. Direct Sales Requirements
   1. Average Order Quantity
   2. Salesman Productivity Assumptions
   3. Annual Megawatt Sales Per Salesman
   4. Size Of The Sales Force
   5. Salesman Support Index
   6. Total Direct Sales Personnel Cost

C. Indirect Sales Requirements
   1. Indirect Sales Support Personnel Submodel
   2. Office Facilities Cost Submodel
   3. Sales Expenses Submodel
   4. Advertising Expenses Submodel
   5. Total Indirect Sales Costs

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Page</th>
</tr>
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<tr>
<td>Average Order Quantity</td>
<td>II-3</td>
</tr>
<tr>
<td>Salesman Productivity Assumptions</td>
<td>II-3</td>
</tr>
<tr>
<td>Annual Megawatt Sales Per Salesman</td>
<td>II-5</td>
</tr>
<tr>
<td>Size Of The Sales Force</td>
<td>II-5</td>
</tr>
<tr>
<td>Salesman Support Index</td>
<td>II-5</td>
</tr>
<tr>
<td>Total Direct Sales Personnel Cost</td>
<td>II-7</td>
</tr>
<tr>
<td>Indirect Sales Support Personnel Submodel</td>
<td>II-8</td>
</tr>
<tr>
<td>Office Facilities Cost Submodel</td>
<td>II-8</td>
</tr>
<tr>
<td>Sales Expenses Submodel</td>
<td>II-11</td>
</tr>
<tr>
<td>Advertising Expenses Submodel</td>
<td>II-11</td>
</tr>
<tr>
<td>Total Indirect Sales Costs</td>
<td>II-12</td>
</tr>
</tbody>
</table>
II. MARKETING MODEL

A. General Description

This section presents the solar array marketing model assumptions and equations. Standard values to be used for the model parameters are given in Appendix B. Test case calculations and results are presented in Section V. Following are the key assumptions of the model.

The marketing model is strictly a supply side model. No attempt is made to model the interaction of supply and demand. If demand in all categories is assumed known, this procedure gives the associated marketing costs. Hence, demand is assumed to be completely inelastic or independent of the solar array price. The manufacturing cost of the solar arrays is specified as input by the user.

The country is divided into seven market regions and the total annual demand in each region is specified as input by the user. The total annual demand is assumed to be constant in each region.

Marketing costs are assumed to vary for different types of customers. Customers are described completely by their location and average order size in megawatts. The model allows for a maximum of three types of customers or products. The total demand for each customer type in each region is specified as input by the user along with the average order quantity for each customer type.

Regional sales offices are assumed to be located in every region where the demand is greater than zero. Marketing costs vary with customer location, but are assumed to be independent of the factory location. The distribution model, however, computes the cost of warehousing and delivering the product to the customer. Following is a list of input variables for the marketing model:

The following input data must be specified by the user:

- $AOQ_i$ = Average order quantity for customer type $i$ (in megawatts per order)
  
  for $i = 1, 2, \text{ and } 3$

- $d_{ij}$ = Total annual demand in Region $j$ by customers of type $i$ (in megawatts per year)
  
  for $i = 1, 2, \text{ and } 3$

  and $j = 1, 2, \ldots, \text{ and } 7$

- $p$ = SAMICS Manufacturing Price for Solar Arrays (manufacturing year dollars/watt)

- $t_m$ = Manufacturing Year
The manufacturing year is the steady-state year for which the marketing costs are computed.

Given this input data, the model computes the total annual marketing cost in each region. The total cost consists of the following components:

<table>
<thead>
<tr>
<th>Marketing Expenses</th>
<th>Model Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Salaries and Benefits</strong></td>
<td></td>
</tr>
<tr>
<td>• Direct personnel</td>
<td>DSC \text{j}</td>
</tr>
<tr>
<td>• Indirect personnel</td>
<td>CIS \text{j}</td>
</tr>
<tr>
<td><strong>Sales Expenses</strong></td>
<td>SEC \text{j}</td>
</tr>
<tr>
<td>• Office supplies</td>
<td></td>
</tr>
<tr>
<td>• Travel and entertainment</td>
<td></td>
</tr>
<tr>
<td>• Communications</td>
<td></td>
</tr>
<tr>
<td><strong>Office Facilities Costs</strong></td>
<td>OFC \text{j}</td>
</tr>
<tr>
<td>• Office rental</td>
<td></td>
</tr>
<tr>
<td>• Utilities</td>
<td></td>
</tr>
<tr>
<td>• Maintenance</td>
<td></td>
</tr>
<tr>
<td>• Other expenses (property tax and insurance)</td>
<td></td>
</tr>
<tr>
<td><strong>Advertising Expenses</strong></td>
<td>SAC \text{j}</td>
</tr>
<tr>
<td>• Product A</td>
<td></td>
</tr>
<tr>
<td>• Product B</td>
<td></td>
</tr>
<tr>
<td>• Product C</td>
<td></td>
</tr>
</tbody>
</table>

Exhibit II-1 shows the model personnel organization structure for the region sales and marketing office. Personnel are divided into three categories:

• Salesman
• Direct Support Personnel
• Indirect Support Personnel

The number of salesman required is determined by the total demand and average order size separately for each customer type.

The number of direct support personnel is determined by the number of salesman and average order size for each type of customer recognizing that different classes of customers have different support requirements. These include:

• Field Engineers
• Market Research Analysts
• Technical Writers
• Commercial Artists
• Technical Illustrators
• Advertising Salesman
The number of indirect support personnel are computed from the number of salesman and direct support personnel using an indirect requirements matrix.

The total annual sales cost is the sum of direct and indirect components:

\[ ISC_j = \text{Total Annual Direct Sales Cost in Region } j \]  
\[ ISC_j = \text{Total Annual Indirect Sales Cost in Region } j \]  

The direct sales costs consist of salaries and benefits for the salesman and direct support personnel.

The indirect sales costs consist of:

- Indirect Sales Support Personnel Cost
- Office Facilities Cost
- Sales Expenses
- Advertising Expenses

Following is a description of the parameters and underlying assumptions for the model equations to compute these costs.

B. Direct Sales Requirements

The primary determinant of selling requirements is the average order quantity per customer expressed in megawatts per order. Sales requirements are implicitly assumed to vary for different types of customers. It is assumed that this variation can be modeled through the average order size.

1. Average Order Quantity

\[ AOQ_i = \text{Average order quantity in megawatts for customer type } i. \]

Note: This is specified as input by the user and is not necessarily the same as the physical delivery quantity or the total sales contract which may extend over several years. It is defined as the total sales contract for one year.

2. Salesman Productivity Assumptions

The first step in determining how many salesmen are required for a particular product-market scenario is to identify the number of orders an individual salesman can obtain per year at various levels of AOQ. Clearly, when the order quantity is small, less sales effort will be devoted to each order and each salesman will be expected to obtain more orders then if the order size were larger. At the same time, at larger values of AOQ the overall productivity of each salesman will be greater.
The basic assumptions used for computing salesman productivity are outlined below. The assumptions are predicated on the sales requirements for an established product. Although the photovoltaics industry is far from established today, this is consistent with the SAMICS steady-state assumption.

To simplify the analysis, the interaction between advertising and salesman productivity is not modeled explicitly. That is, productivity is assumed to be independent of advertising. The impact of advertising is extremely difficult to model even for established products and is beyond the scope of this model.

The user could test different relationships by varying the advertising expense rates and the salesman productivity rates for different types of customers. However, the usefulness of such results is dubious.

The specific productivity assumptions are as follows:

At very low levels of ACQ (one kilowatt per order) it is assumed that the order-taking ability of salesmen will be comparable to that of account representatives for industrial products firms, namely that each salesman can make an average of 1750 calls per year and obtain one order for every 3.5 calls. Hence, for an average order quantity of .001 MW, each salesman averages 500 orders per year.

It is further assumed that at the level of 10 MW per order and above, approximately one salesman is required for every order obtained. Through linear interpolation an equation is thus designed to yield the value for any level of ACQ.

<table>
<thead>
<tr>
<th>ACQ Average Order Quantity (MW)</th>
<th>OES Orders Per Salesman (Orders/yr)</th>
<th>MWS Megawatt Sales Per Salesman (MW/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>.000</td>
<td>0.00</td>
<td>.00</td>
</tr>
<tr>
<td>.001</td>
<td>500.00</td>
<td>.50</td>
</tr>
<tr>
<td>.010</td>
<td>51.00</td>
<td>.51</td>
</tr>
<tr>
<td>.100</td>
<td>5.90</td>
<td>.59</td>
</tr>
<tr>
<td>1.000</td>
<td>1.45</td>
<td>1.45</td>
</tr>
<tr>
<td>10.000 and above</td>
<td>1.00</td>
<td>10.00 or more</td>
</tr>
</tbody>
</table>

Note: The intermediate points in this table are interpolations, not breakpoints on a piecewise linear function.

The size of a typical residential unit could range from 1 kilowatt (.001 MW) to 10 kilowatts (0.010 MW) depending upon the application. For example, 1 kilowatt would provide electricity for a water heater while 10 kilowatts would be required to supply all of the household's electrical needs.
Thus, the productivity relationships imply that a salesman could sell 500 solar water heating units in a year or 50 larger household electrical units.

Solar units of 10 MW or more would be purchased by public or private utilities for central power stations. Based on experience with the utility industry, a single salesman can typically make one large sale per year.

3. Annual Megawatt Sales Per Salesman

Assuming a piece-wise linear relationship between annual megawatt sales per salesman and the average order quantity per customer, the following equations correspond to the data presented in the table above.

\[
MWS = \begin{cases} 
500^*ACQ & \text{for } 0 \leq ACQ \\
0.4999 + 0.9501^*ACQ & \text{for } 0.001 \leq ACQ < 10.000 \\
ACQ & \text{for } ACQ \geq 10.000 
\end{cases}
\]

The coefficients are expressed to 4 decimal digits so that substitution will yield the results presented in the table. They do not reflect the degree of accuracy of the linear productivity assumptions.

4. Size Of The Sales Force

The number of salesmen required is computed separately for each type of customer based on the total annual demand and the salesmen productivity ratio. The total annual demand in each region and the average demand per customer are assumed to be known and constant over time for each customer type.

\[
d_{ij} = \text{Total annual demand in Region } j \text{ by customers of type } i \quad \text{(MW/Year)}
\]

\[
SR_{ij} = \text{Total number of salesman required in Region } j \text{ for customers of type } i
\]

\[
SR_{ij} = \frac{d_{ij}}{MWS_i}
\]

5. Salesman Support Index

Direct sales support personnel include:

- Field Engineers
- Market Research Analysts
- Technical Writers
- Commercial Artists
- Technical Illustrators
- Advertising Salesman
The amount of direct support per salesperson is assumed to depend on the type of customer as follows:

<table>
<thead>
<tr>
<th>ACQ</th>
<th>SSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order Quantity (MW)</td>
<td>Salesman Support Index</td>
</tr>
<tr>
<td>0.000</td>
<td>0.00</td>
</tr>
<tr>
<td>.001</td>
<td>0.10</td>
</tr>
<tr>
<td>1.000</td>
<td>0.19</td>
</tr>
<tr>
<td>10.000</td>
<td>1.00</td>
</tr>
<tr>
<td>100.000</td>
<td>5.00</td>
</tr>
</tbody>
</table>

\[ SSI = \text{Salesman support index for customer type } i \]

\[ SSI = \begin{cases} 
100 \times ACQ_i & \text{for } 0 \leq ACQ_i \leq 0.001 \\
0.0999 + 0.9000 \times ACQ_i & \text{for } 0.001 < ACQ_i \leq 1.0 \\
0.5556 + 0.444 \times ACQ_i & \text{for } ACQ_i > 10 
\end{cases} \]

These equations correspond to the data presented in the table above (assuming a piece-wise linear relationship). The coefficients are expressed to 4 decimal digits so that the linear segments intersect at the breakpoints. This does not indicate the degree of accuracy in the estimates.

The number of direct sales support personnel required is computed by multiplying the number of salesmen by the support index by a requirement coefficient for each type of personnel.

\[ DSP_j = \text{Total direct sales support personnel required in Region } j \]

\[ = \sum_{k=1}^{6} \sum_{i=1}^{3} RC_k \times SSI_i \times SR_{ij} \]

where

\[ RC_k = \text{Requirement coefficient for direct support personnel of type } k \]
<table>
<thead>
<tr>
<th>Index</th>
<th>Description</th>
<th>Annual Compensation $</th>
<th>Requirement Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Field Engineer</td>
<td>$26,400</td>
<td>2.0</td>
</tr>
<tr>
<td>2</td>
<td>Commercial Artist</td>
<td>12,320</td>
<td>1.0</td>
</tr>
<tr>
<td>3</td>
<td>Market Research Analyst</td>
<td>25,200</td>
<td>4.0</td>
</tr>
<tr>
<td>4</td>
<td>Technical Illustrator</td>
<td>18,900</td>
<td>2.2</td>
</tr>
<tr>
<td>5</td>
<td>Technical Writer</td>
<td>18,900</td>
<td>2.2</td>
</tr>
<tr>
<td>6</td>
<td>Advertising Salesman</td>
<td>17,500</td>
<td>1.1</td>
</tr>
</tbody>
</table>

*Expressed in 1977 dollars.

The requirement coefficients indicate the number of direct support personnel required per salesman when the salesman support index is one. This corresponds to an average order quantity per customer of 10 MW. It is assumed that the sales support required for customers of this size is equivalent to that for a small public utility.

6. **Total Direct Sales Personnel Cost**

\[
\text{DSC}_j = \text{Total direct sales cost in Region } j \quad \text{(in manufacturing year dollars)}
\]

\[
= \sum_{i=1}^{3} \text{SR}_{ij} \times CS_i \times I_j \times (1 + g_B)^n
\]

\[
+ \sum_{k=1}^{6} \sum_{i=1}^{3} \text{RC}_k \times SSI_i \times I_j \times \text{SR}_{ij} \times AC_k \times (1 + g_B)^n
\]

This can be expressed more simply as:

\[
\text{DSC} = \left[ \sum_{i=1}^{3} \text{SR}_{ij} \times (CS_i + SSI_i \times \sum_{k=1}^{6} \text{RC}_k \times AC_k) \right]^n \times I_j \times (1 + g_B)
\]

where

- $I_j$ = Labor cost index in Region $j$
- $g_B$ = Labor cost inflation rate
- $n$ = (Manufacturing Year) - (Base Price Year)
- $AC_k$ = Annual compensation rate for direct sales personnel type $k$
  (Base Price Year $/\text{Year}$)
- $CS_i$ = Annual compensation rate for salesman type $i$ (Base Price Year $/\text{Year}$)

Standard values to be used for these parameters are presented in Appendix B.
c. Indirect Sales Requirements

1. Indirect Sales Support Personnel Submodel

Indirect sales support personnel are assumed to include the following:

- Regional Vice President Sales and Marketing
- Manager, Advertising
- Manager, Marketing Research
- Manager, Sales
- Manager, Sales Engineering
- Secretary I (lower management)
- Secretary II (middle management)
- Secretary III (upper management)

The number required is determined from the number of salesmen and direct sales staff following the line-staff relationships indicated on the organization chart and the indirect requirements matrix as follows:

\[ ISP_j = \text{Total indirect sales support personnel (a vector) required in Region } j \]

\[ = D + R \cdot D + R \cdot (R \cdot D) + R^3 \cdot D + \ldots \]

where

- \( R \) = Indirect personnel requirements matrix
- \( D \) = Direct personnel requirements vector for Region \( j \)

The indirect requirements matrix coefficients are presented in Appendix B.

The compensation rates for all indirect sales support personnel are also given in Appendix B to be used for computing indirect personnel costs.

\[ C_{IS_j} = \text{Annual indirect sales personnel cost in Region } j \]

\[ = \sum_i (ISP_{ij} \cdot \text{Salary}_i) \cdot l_j \cdot (1 + g_B)^n \]

2. Office Facilities Cost Submodel

Office facility costs include:

- Office rental
- Utilities
- Maintenance
- Other expenses (property tax and insurance)

Office rental consists of the buildings, furniture, fixtures, and equipment. The amount of space required is determined by the number of people. The equations for Sales Office Facility Costs are presented below. Standard values to be used for each of the parameters are given in Appendix B.
\[ OS_j = \frac{Sales\ office\ size\ in\ Region\ j}{(ISP_j + ISP_{ij}) \times SPP} \]

where
\[ SPP = \frac{Amount\ of\ office\ space\ per\ person}{(square\ meters/person)} \]

The total annual office facility costs in Region \( j \) are computed from the following relationship:

\[ OFC_j = \text{Total\ annual\ office\ facility\ costs\ in\ Region\ } j \]
\[ (\text{Manufacturing\ Year\ Dollars}) = ORC_j + OUC_j + OMC_j + OCC_j \]

where
\[ ORC_j = \text{Office\ Rental\ Expense\ in\ Region\ } j \]
\[ OUC_j = \text{Office\ Utilities\ Expense\ in\ Region\ } j \]
\[ OMC_j = \text{Office\ Maintenance\ Expense\ in\ Region\ } j \]
\[ OCC_j = \text{Other\ Office\ Expenses\ in\ Region\ } j \]
\[ (\text{Manufacturing\ Year\ Dollars}) \]

Note that the amount of office space per person has been expressed as a constant for all types of personnel. Actually, different personnel require different amounts of space. However, these differences are not important. For the purposes of this model, an average figure will provide a good enough estimate of the office space because the personnel mix remains homogeneous at all levels of sales.

\* Office Rental Expense Submodel

\[ ORC_j = b_j \times K_0(OF_j)^{2} \times (1 + g_{H})^{n} \]

where
\[ b_j = \text{Facilities\ Cost\ Index\ for\ Region\ } j \]
\[ OS_j = \text{Sales\ Office\ Size\ in\ Region\ } j \]
\[ K_0(OF_j) = \text{Office\ Facilities\ Capital\ Cost\ Function} \]
\[ g_{H} = \text{Facilities\ Inflation\ Rate\ (%/year)} \]
\[ n = (\text{Manufacturing\ Year}) - (\text{Base\ Price\ Year}) \]
- **Office Utilities Expense Submodel**

\[ \text{CUC}_j = u_j \times p \times C_S_j \times (1 + g_E)^n \]

where

- \( u_j \) = Utilities Cost Index for Region \( j \)
- \( p \) = Office Utilities Cost Rate ($/square meter)
- \( C_S_j \) = Sales Office Size in Region \( j \) (square meters)
- \( g_E \) = Utilities Inflation Rate (%/year)
- \( n \) = (Manufacturing Year) - (Base Price Year)

- **Office Maintenance Expense Submodel**

\[ \text{CMC}_j = m \times b_j \times K_0 (C_S_j) \times (1 + g_W)^n \]

where

- \( m \) = Office Maintenance Cost Rate (% of Capital Cost)
- \( b_j \) = Facilities Capital Cost Index for Region \( j \)
- \( K_0 (C_S_j) \) = Office Facilities Capital Cost Function
- \( g_W \) = Facilities Inflation Rate (%/year)
- \( n \) = (Manufacturing Year) - (Base Price Year)

**Note:** Although maintenance costs are more labor intensive than capital costs, it is assumed that the total maintenance requirement depends on the capital cost of the office facilities. Capital costs include materials, construction labor, and architectural and engineering design fees. Furthermore, office maintenance represents a relatively small portion of the total sales office facilities cost. Thus, the office maintenance expense is not adjusted by the labor cost index for differences in regional labor costs or by the labor cost inflation rate.

- **Other Office Expenses Submodel**

\[ \text{OC}_j = p \times b_j \times K_0 (C_S_j) \times (1 + g_W)^n \]

where

- \( p \) = Property Tax Rate (% of Capital Cost)
- \( b_j \) = Insurance Rate (% of Capital Cost)
3. **Sales Expense Submodel**

Sales expenses include:
- Office supplies
- Travel and entertainment
- Communications

These expenses are assumed to vary with the type of customer and are computed as a function of the direct cost of salesmen.

\[
\text{SEG}_i = \text{Annual Sales Expense Cost in Region } j \quad \text{(Manufacturing Year Dollars)}
\]

\[
= \sum_{i=1}^{3} \text{SAE}_i \cdot \text{SR}_{ij} \cdot \text{CS}_i \cdot \text{C}(1+g_B)
\]

where

\[
\text{SAE}_i = \text{Sales Expense Rate associated with the salesmen who sell to Customer Type } i
\]

4. **Advertising Expenses Submodel**

Since this is a supply side model, the intent of the advertising expenses submodel is to prescribe a reasonable estimate of the advertising budget rather than to model the optimal advertising budget. The impact of advertising is extremely difficult to model even for established products and is beyond the scope of this model.

Thus, the size of the advertising budget is computed as a function of the cost of the product for each customer type. This allows the user to specify different advertising rates for different types of customers.

The submodel is expressed symbolically as follows:

\[
\text{SAC}_j = \text{Annual Advertising Cost in Region } j \quad \text{(Manufacturing Year Dollars)}
\]

\[
= \sum_{i=1}^{3} \text{ADE}_i \cdot \text{P} \cdot \text{d}_{ij} \cdot 10^5
\]

where

\[
\text{ADE}_i = \text{Advertising Rate (% of Manufacturing Price) for Customer Type } i
\]

\[
\text{P} = \text{SAMICS Manufacturing Price for Solar Arrays (Manufacturing Year $/watt)}
\]

\[
\text{d}_{ij} = \text{Annual Demand in Region } j \text{ by all customers of type } i \quad \text{(megawatts/year)}
\]

\[
10^5 = \text{Conversion Factor (watts/megawatt)}
\]
Standard values to be used for the advertising rate, \( A_{\text{DEL}} \), are given in Appendix B. The standard rates vary inversely with the cost of the product. That is, the advertising budget rate for small residential customers is higher than for large central power station customers.

The following rules of thumb were used to establish the standard values:

Firms typically allocate between 1% and 2% of sales to advertising. Of course this varies among industries. The percentage was nearly 5% for tobacco companies and .7% for food retailers in 1977.

5. Total Indirect Sales Costs

The total annual indirect sales costs are computed as the sum of indirect sales personnel, office facility, sales expense, and advertising costs in Region \( j \).

\[
\text{ISC}_j = \text{Total Indirect Sales Cost in Region } j \\
\quad \text{(in manufacturing year dollars)}
\]

\[
= \text{CIS}_j + \text{OFC}_j + \text{SEC}_j + \text{SAC}_j
\]

where

\[
\text{CIS}_j = \text{Annual indirect sales personnel cost in Region } j \\
\quad \text{(manufacturing year dollars)}
\]

\[
\text{OFC}_j = \text{Annual Office Facility Costs in Region } j \\
\quad \text{(manufacturing year dollars)}
\]

\[
\text{SEC}_j = \text{Annual Sales Expense Cost in Region } j \\
\quad \text{(manufacturing year dollars)}
\]

\[
\text{SAC}_j = \text{Annual Advertising Cost in Region } j \\
\quad \text{(manufacturing year dollars)}
\]
III. DISTRIBUTION MODEL

A. General Description

B. Direct Factory - Customer Shipments

C. Factory-Warehouse Transshipments

1. Factory-Warehouse Transportation Costs
2. Warehouse Costs
   a. Inventory Carrying Cost
   b. Warehouse Operating Cost
   c. Warehouse Leasing Cost
3. Customer Delivery Costs
III. DISTRIBUTION MODEL

A. General Description

This section presents the solar array distribution model assumptions and equations. Standard values to be used for the model parameters are given in Appendix C. Test case calculations and results are presented in Section V.

The purpose of the distribution model is to compute the cost of distributing solar arrays from the manufacturing plant to the final customer.

To do this, the country is divided into seven geographic areas with one regional warehouse distribution center in each area. Exhibit III-I gives the location of the distribution centers.

The model assumes a single factory whose regional location is specified by the user. Multiple factory locations can be modeled by restricting the distribution demand and making separate runs for each factory.

For a given manufacturing factory the distribution demand is specified as input. The demand is described in total megawatts per year in each Region $j$ by customer type $i$, $(d_{ij})$, and in megawatts per shipment by customer type $i$, $(q_i)$. The model allows for a maximum of three types of customers and seven distribution regions.

For each combination of customer type and distribution region, there are two distribution alternatives:

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

The model computes the least cost distribution alternative for each type of customer in each region based on their assumed demand. Thus, some regions may have warehouses and others may not. Furthermore, some customers in a region may be supplied directly from the factory and others from a local warehouse.

The size of the regional warehouses is optimized by computing the economic warehouse order quantity based on their assumed demand. This balances the number of shipments with the size of the warehouse. Transportation costs are reduced by having larger warehouses requiring fewer shipments. However, warehouse operating and inventory holding costs are higher. The problem is to compute the warehouse order quantities for each customer to minimize the total annual distribution cost.
### REGIONAL WAREHOUSE DISTRIBUTION CENTERS

<table>
<thead>
<tr>
<th>Region</th>
<th>Geographic Area</th>
<th>Distribution Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>West Coast</td>
<td>Los Angeles</td>
</tr>
<tr>
<td>II</td>
<td>Rocky Mountain</td>
<td>Phoenix</td>
</tr>
<tr>
<td>III</td>
<td>North Central</td>
<td>Omaha</td>
</tr>
<tr>
<td>IV</td>
<td>Great Lakes</td>
<td>Springfield</td>
</tr>
<tr>
<td>V</td>
<td>North Eastern</td>
<td>Syracuse</td>
</tr>
<tr>
<td>VI</td>
<td>South Eastern</td>
<td>Atlanta</td>
</tr>
<tr>
<td>VII</td>
<td>South Central</td>
<td>Dallas</td>
</tr>
</tbody>
</table>
Distribution costs consist of the following components:

**Distribution Expenses**

- Salaries and benefits
- Transportation costs
- Warehouse facility costs
  - Building lease
  - Utilities
  - Other expenses
- Inventory carrying charges

Transportation costs vary with weight rather than volume. For a given weight, the model determines the least cost transportation mode.

Exhibit III-2 illustrates the relationship between cost, mode, and shipment weight. Transportation costs are assumed to depend only on distance and weight and are independent of the geographic relationship between the origin and destination.

It is assumed that the manufacturer has a finished goods warehouse at the factory and that the associated costs are part of the manufacturing price.

The warehouse inventory model for the regional distribution centers assumes uniform, deterministic demand over time. Penalty costs for stockouts are assumed to be sufficiently high so that stockouts are not allowed. This implies that the warehouse must be large enough to supply all demand on time. Furthermore, there are no manufacturing price discounts for large order quantities, although the distribution price is lower.

The distribution model requires the following input data from the user:

**Input Data**

- $v =$ Solar array volume  
  (cubic meters/megawatt)
- $w =$ Solar array weight  
  (kilograms/megawatt)
- $t_m =$ Manufacturing year
- $p =$ SAMICS Manufacturing Price for solar arrays  
  (manufacturing year dollars/watt)
- $k =$ Factory Location Region
- $q_i =$ Average delivery quantity for customers of type $i$  
  (megawatts/shipment)

for $i = 1, 2, \text{ and } 3$
FACTORY-CUSTOMER TRANSPORTATION COSTS
From Region k to Region j

Build factory in Region j

Cost
$C_{kj}$

Transportation mode selected

Quantity shipped
$q*w$ (kilograms)

The numerical details of this function depend on the average distance between k and j and the weight of the product shipment.
\[ d_{ij} = \text{Annual demand in Region } j \text{ by all customers of type } i \]  
\[ \text{megawatts/year} \]

for \( i = 1, 2, \text{ and } 3 \)

and \( j = 1, 2, 3, \ldots, 7 \)

\[ Y_{ij} = \text{Average distance from the warehouse to the delivery location} \]
\[ \text{for customer type } i \text{ in Region } j \]  
\[ \text{(kilometers)} \]

From this input, the model computes the total annual distribution cost for each region. This corresponds to the least cost combination of direct shipments and warehouse transshipments and the economic warehouse size.

\[ X_{ij} = \begin{cases} 
0 & \text{if customers of type } i \text{ in Region } j \text{ are supplied directly from} \\
& \text{the factory} \\
1 & \text{if customers of type } i \text{ in Region } j \text{ are supplied from a warehouse} \\
& \text{in Region } j 
\end{cases} \]

\[ F_j = \text{Optimal warehouse size in Region } j \]
\[ \text{(square meters)} \]

\[ Q_j = \text{Optimal warehouse order quantity in Region } j \]
\[ \text{(megawatts/shipment)} \]

\[ \text{Total cost} = IC_{kj}(Q_j) + DC_{kj} \]

where

\[ DC_{kj} = \text{Annual Distribution Cost in Region } j \text{ for customers supplied} \]
\[ \text{directly from the factory in Region } k \]
\[ \text{(manufacturing year dollars)} \]

\[ IC_{kj}(Q_j) = \text{Annual Distribution Cost in Region } j \text{ for customers supplied} \]
\[ \text{from a regional warehouse in Region } j \text{ with transshipments from} \]
\[ \text{the factory in Region } k \]
\[ \text{(manufacturing year dollars)} \]

The optimal warehouse order quantity, \( Q_j \) * is determined by varying the order quantity parametrically (over a broad range), computing the corresponding warehouse size and distribution costs for each quantity, and selecting the quantity which yields the lowest annual distribution cost. This is repeated for all possible combinations of direct and indirect shipments, \( X_{ij} \). The optimal value \( X_{ij} \) * is the combination which yields the lowest total cost. The corresponding warehouse order quantity is the optimal value, \( Q_j \) *.

Following is a description of the parameters and underlying assumptions for the model equations to compute these costs.
B.  **Direct Factory - Customer Shipments**

If there is a warehouse in Region \( j \) (that is, if \( X_{ij} = 1 \)), all deliveries to customers of type \( i \) in Region \( j \) go thru the warehouse. All other customers (that is, if \( X_{ij} = 0 \)) are supplied directly from the factory.

The cost of supplying customers directly from the factory is given by the following relationship:

\[
DC_{kj} = \sum_{i=1}^{3} \frac{d_{ij} \cdot (1-X_{ij}) \cdot C(Z_{ij}, s_{kj}) \cdot (1+g_T)}{q_i^n}
\]

where

- \( DC_{kj} \) = Annual distribution cost in Region \( j \) for customers supplied directly from the factory in Region \( k \) (in Manufacturing Year Dollars/year)
- \( d_{ij} \) = Annual demand in Region \( j \) by all customers of type \( i \) (megawatts/year)
- \( X_{ij} \) = \( \begin{cases} 0 & \text{if customers of type } i \text{ in Region } j \text{ are supplied directly from the factory} \\ 1 & \text{if customers of type } i \text{ in Region } j \text{ are supplied from a warehouse in Region } j \end{cases} \)
- \( g_T \) = Transportation inflation rate
- \( n \) = (Manufacturing Year) - (Base Price Year)
- \( q_i \) = Average delivery quantity for customers of type \( i \) (megawatts/delivery)
- \( w \) = Solar array weight (kg/megawatt)
- \( Z_{ij} \) = Average shipment weight to customers of type \( i \) (kilograms/delivery)
  \[ = q \cdot w \]
- \( s_{kj} \) = Average shipping distance from Region \( k \) to Region \( j \) (kilometers)

\( C(Z_{ij}, s_{kj}) \) = Interregional transportation cost as a function of the shipment weight, \( Z_{ij} \) and distance, \( s_{kj} \). This is a table look-up function presented in Appendix C. The transportation mode is optimized by quantity ordered, but regional geography is not considered.
C. Factory-Warehouse Transshipments

The cost of supplying demand in Region \( j \) from a regional warehouse is composed of three parts:

- **Factory-Warehouse Transportation Cost**

  The cost of transporting the product in bulk from the factory in Region \( k \) to the warehouse in Region \( j \). This is a function of the distance and the economic shipment quantity and includes the cost of processing the order.

- **Warehousing Costs**

  This consists of inventory carrying costs, warehouse operating costs, and warehouse capital costs.

- **Delivery Costs**

  This is the cost of distributing individual units from the warehouse to the customers.

Given the total demand in Region \( j \) by each type of customer, \( d_{ij} \), the first two cost functions must be optimized to determine the economic warehouse order quantity. This balances the number of shipments with the size of the warehouse. It is assumed that the penalty cost associated with stockouts is sufficiently high that stockouts are not allowed. (This would likely be the case, for example, if the customer - not merely the sale - were lost if the product could be delivered on time.)

The annual demands, \( d_{ij} \), the average delivery quantities, \( q_i \), and the solar array weight, \( w \), are input variables whose values are specified by the user.

The interregional shipping distances and the transportation cost function are standard data whose values are listed in Appendix C. The cost function is a piecewise linear function of the quantity shipped and the distance traveled. \( x_{ij} \) is a decision variable whose value is determined to minimize total annual distribution costs. This determines which customers are supplied from the factory and which are supplied from a regional warehouse.

\[
T_{kj} (Q_j) = \text{Annual transportation cost for shipments from the factory in Region } k \text{ to the warehouse in Region } j \text{ as a function of the order quantity } Q_j \text{ (in Manufacturing Year Dollars)}
\]

\[
W_j (Q_j) = \text{Warehouse operating costs for Region } j \text{ (in Manufacturing Year Dollars)}
\]

\[
L_j = \text{Warehousing costs for Region } j \text{ (in Manufacturing Year Dollars)}
\]

\[
T_{kj} (Q_j) = T_{kj} (Q_j) + W_j (Q_j) + L_j
\]

where

\[
T_{kj} (Q_j) = \text{Total annual distribution cost for Region } j \text{ warehouse transshipments from the factory in Region } k \text{ as a function of the warehouse order quantity } Q_j \text{ (in Manufacturing Year Dollars)}
\]
\( W_j (Q_j) \) = Annual warehousing cost in Region \( j \) (in Manufacturing Year Dollars)

\( L_j \) = Annual delivery cost in Region \( j \) (in Manufacturing Year Dollars)

1. **Factory-Warehouse Transportation Cost**

\[
T_{kj}(Q_j) = \sum_{i=1}^{n} \frac{d_{ij} \times x_{ij}}{Q_j} \left[ \text{OP} + C(Q_j \times w, s_{kj}) \right] \left( 1 + g_T \right)^n
\]

where

\( Q_j \) = Factory Warehouse Shipment Quantity in Region \( j \) (megawatts)

\( d_{ij} \) = Annual demand by all customers of type \( i \) in Region \( j \) (megawatts/year)

\( x_{ij} \) = \( \begin{cases} 0 & \text{if customers of type } i \text{ in Region } j \text{ are supplied directly from the factory} \\ 1 & \text{if customers of type } i \text{ in Region } j \text{ are supplied from a warehouse in Region } j \end{cases} \)

\( \text{OP} \) = Order processing cost ($/shipment)

\( w \) = Solar array weight (kilograms/megawatt)

\( s_{kj} \) = Average shipping distance from Region \( k \) to Region \( j \) (kilometers)

\( C(Q_j \times w, s_{kj}) \) = Interregional transportation cost as a function of the shipment weight and distance

\( g_T \) = Transportation Inflation Rate

\( n \) = (Manufacturing Year) - (Base Price Year)

2. **Warehouse Costs**

\( W_j (Q_j) \) = Annual warehousing cost in Region \( j \) as a function of the order quantity \( Q_j \) (in manufacturing year dollars)

\( = CC(Q_j) + OC_j(Q_j) + LC_j(Q_j) \)

\( CC(Q_j) \) = Annual inventory carrying cost as a function of the warehouse order quantity in Region \( j \) (in manufacturing year dollars)

\( OC_j(Q_j) \) = Annual warehouse operating cost in Region \( j \) as a function of the order quantity, \( Q_j \) (in manufacturing year dollars)

\( LC_j(Q_j) \) = Annual warehouse leasing cost in Region \( j \) as a function of the warehouse order quantity \( Q_j \) (in manufacturing year dollars)

III-6
a. **Inventory Carrying Cost**

\[
CC(Q_j) = \left(\frac{Q_j}{2}\right) \times p \times \varepsilon \times 10^6 \text{ ($/year)}
\]

where

\( Q_j \) = Factory-warehouse shipment quantity in Region \( j \)

Note: \( (Q_j/2) \) = Average inventory level assuming zero safety stock and uniform demand over time. Given a deterministic demand, this assumption minimizes the warehouse costs.

\( p \) = SAMICS manufacturing price for Solar Arrays ($/watt)

i.e., the unit value of inventory in manufacturing year dollars

\( \varepsilon \) = Annual inventory carrying charge as a % of unit value

\( 10^6 \) = Conversion factor (watts/megawatt)

b. **Warehouse Operating Cost**

Operating costs include personnel, utilities, maintenance, property tax, and insurance on the building and equipment.

\[
OC_j(Q_j) = PC_j + UC_j + XC_j + SC_j + MC_j
\]

\( PC_j = \text{Personnel Cost} = l * p(F_j) * (1+g_B)^n \)

\( UC_j = \text{Utilities Cost} = \sum_w u_j * F_j * (1+g_{U_E})^n \)

\( XC_j = \text{Property Tax Cost} = \sum_w x_j * K_{P_J} * (1+g_{P_H})^n \)

\( SC_j = \text{Insurance Cost} = \sum_w s_j * K_{E_J} * (1+g_{E_H})^n \)

\( MC_j = \text{Maintenance Cost} = m * e_j * K_{E_J} * (1+g_{E_H})^n \)

where

\( l_j \) = Labor Cost Index for Region \( j \)

\( g_B \) = Labor Inflation Rate (%/year)

\( u_j \) = Utility Cost Index for Region \( j \)

\( g_{U_E} \) = Utilities Inflation Rate (%/year)

\( e_j \) = Equipment Cost Index for Region \( j \)

\( g_J \) = Equipment Inflation Rate (%/year)

\( b_j \) = Building Cost Index for Region \( j \)

\( g_{F_H} \) = Facilities Inflation Rate (%/year)
\( \rho_w \) = Utility Cost Rate ($/square meter/year)

\( \beta_w \) = Property Tax Rate (% of capital cost/year)

\( \lambda_w \) = Insurance Rate (% of capital cost/year)

\( m \) = Maintenance Cost Rate (% of capital cost/year)

\( F_j \) = Warehouse size in Region \( j \) as a function of the warehouse order quantity (square meters)

Note: This is a piece-wise linear function of the order size, \( Q \) and is derived in Appendix C.

\( P(F_j) \) = Personnel Cost Function ($/year) includes both wages and benefits

\( K_e(F_j) \) = Equipment Capital Cost Function

\( K_b(F_j) \) = Building Capital Cost Function

\( n \) = (Manufacturing Year) - (Base Price Year)

Warehouse Size

The size of the regional warehouses is a function of the economic or optimal factory-warehouse order quantity, \( Q^e_j \), the physical volume of the solar array modules, \( j \), and the warehouse space utilization factor, \( \alpha \). This is a piece-wise linear function of \( Q \) and is derived in Appendix C.

\( F_j = \) Warehouse size in Region \( j \) (Square meters)

\( F^*_j = \alpha \times v \times Q^e_j \) (Table look-up function of \( Q^e_j \))

where

\( Q \) = Factory-warehouse shipment quantity in Region \( j \) (megawatts)

\( v \) = Solar array volume (cubic meters/megawatt)

\( \alpha \) = Warehouse space utilization factor

The utilization factor adjusts for the stacking height and the amount of space required for circulation and offices. A standard value for this parameter is derived in Appendix C.

c. Warehouse Leasing Cost

Annual warehouse leasing costs are computed separately for plant and equipment based on the economic lives and the lessor's rate of return.

\( LC_j(Q_j) = \) Annual warehouse leasing cost in Region \( j \) as a function of the warehouse order quantity \( Q_j \)

III-8
\[ LC_j(Q_j) = \gamma_e^{\frac{e_j}{(1+g_j)^n}} + \gamma_b^{\frac{b_j}{(1+g_H)^n}} \]

- \( e_j \) = Equipment Cost Index
- \( b_j \) = Building Cost Index
- \( \gamma_e \) = Annual lease Rate for Equipment
  (fraction of capital cost/year)
- \( g_j \) = Equipment Inflation Rate (%/year)
- \( n \) = (Manufacturing Year) - (Base Price Year)
- \( \gamma_b \) = Annual lease Rate for Building
  (fraction of capital cost/year)
- \( g_H \) = Facilities Inflation Rate (%/year)
- \( F_j \) = Warehouse size in Region \( j \) (square meters) as a function
  of the order quantity \( Q \)
- \( K_e(F_j) \) = Equipment Capital Cost Function
- \( K_b(F_j) \) = Building and Land Capital Cost Function

### 3. Customer Delivery Costs

Based on an analysis of local freight carriage costs in different
regions of the U.S., transportation costs from the warehouse to the
customers can be minimized when the company owns and operates a fleet
of delivery trucks. The costs of owning and operating a delivery truck
are divided into fixed and variable components. Fixed costs
include drivers' wages and benefits, vehicle capital charges, depre-
ciation, and insurance. Variable costs per kilometer consist of
gas, oil, and maintenance. The following are formulas for computing
these costs and the fleet size required.

\[ L_j = \text{Total Annual Local or Intraregional Delivery Costs in Region } j \]
\[ \text{(in manufacturing year dollars)} \]
\[ = [TK \times FC + VC \times KM] (1 + g_T)^n \]

where

- \( TK \) = Vehicle Fleet Size (vehicles)
- \( FC \) = Annual Fixed Cost per vehicle ($/vehicle-year)
- \( VC \) = Variable Operating Cost per vehicle-kilometer ($/kilometers)
- \( KM \) = Total distance traveled (kilometers/year) by all vehicles
- \( g_T \) = Transportation Inflation Rate (%/year)
- \( n \) = (Manufacturing Year) - (Base Price Year)
The fleet size and total distance traveled are given by the following relationships:

**Fleet Size Submodel**

The number of regional delivery trucks required is computed by dividing the total travel distance by the vehicle distance capacity.

\[ TK = \frac{KM}{MC} \] (rounded up to an integer value)

**Travel Distance Submodel**

The total travel distance by all delivery trucks in a given region is computed as follows:

\[ KM = \text{Total Distance Traveled by all vehicles} \]
\[ = (# \text{ Tours}) \times (\text{Distance per tour}) \]
\[ = \left(\frac{\text{# Customers}}{\text{# Customers/Tour}}\right) \times (\text{Distance per tour}) \]

\[ \# \text{ Customers} = \frac{d_{ij} \times x_{ij}}{q_i} \]

\[ \# \text{ Customers/Tour} = \frac{WC}{q_i \times w} \]

Distance/Tour \[ = y_{ij} \times \left(\frac{WC}{q_i \times w}\right) + y_{ij} \]

\[ KM = \sum_{i=1}^{3} \left(\frac{d_{ij} \times x_{ij}}{q_i} \right) \left(\frac{q_i \times w}{WC}\right) \left(1 + \frac{WC}{q_i \times w}\right) y_{ij} \]

\[ KM = \sum_{i=1}^{3} \frac{d_{ij} \times x_{ij} \left(1 + \frac{q_i \times w}{WC}\right)}{q_i} y_{ij} \]

\[ x_{ij} = \begin{cases} 0 & \text{if customers of type } i \text{ in Region } j \text{ are supplied directly from the factory} \\ 1 & \text{if customers of type } i \text{ in Region } j \text{ are supplied from a warehouse in Region } j \end{cases} \]

\[ WC = \text{Vehicle Load Capacity (kilograms/shipment)} \]
\[ w = \text{Solar Array Weight (kilograms/megawatt)} \]
\[ y_{ij} = \text{Average distance from the warehouse to the delivery location for customer type } i \text{ (kilometers) in Region } j \]
The average delivery distance, $y_{ij}$, is specified as input by the user and can be used to model differences in the customer location distribution between regions and/or types of customers. A constant value of 50 kilometers for all regions and customers was used for the test case presented in Section V.

Appendix C contains standard values for the fixed cost, variable operating cost, distance capacity, and load capacity for medium sized trucks.
IV. FINANCIAL MODEL

A. General Description

B. Projected Income Statements
   Revenue
   Cost of Goods Sold
   Gross Profit
   Distribution Expense
   Marketing Expense
   Net Profit Before Tax
   Income Tax
   Net Profit After Tax

C. Solar Array Price Estimates
A. General Description

The financial model of the firm consists of the equations used to compute sales revenues, taxes, and profit based on the marketing and distribution expenses.

The model parameters are expressed in the standard financial statement terms to facilitate the preparation of projected income statements for each region.

The inputs include the demand distribution by region, the manufacturing price, the effective income tax rate, and the net after tax profit margin. With this data and the marketing and distribution costs, projected income statements and solar array price estimates are produced.

The income statements are generated for a steady-state manufacturing year. The solar array prices (expressed in dollars per peak watt) are computed by dividing the annual array sales revenues by the demand. The price estimates include all manufacturing, marketing, and distribution expenses as well as a reasonable profit margin. The profit margin is a model parameter whose standard value is presented in Appendix A.

For comparisons with the JPL project price goals which are stated in 1975 dollars, a price level adjustment is made to deflate the prices to 1975 base year dollars.

Following is a more detailed description of the model parameters and equations.

B. Projected Income Statements

Exhibit IV-1 shows the income statement accounts for SELLCO, the hypothetical solar array sales and distribution company.

The costs and revenues on this statement are expressed in manufacturing year dollars.

The cost of goods sold is computed from the SAMICS manufacturing price and the demand distribution. These are specified as inputs by the model user.

Following are the financial model equations defining each of the income statement variables.
SELLCO
SOLAR ARRAY SALES AND DISTRIBUTION COMPANY
INCOME STATEMENT FOR THE YEAR ENDING _______

Sales:
Household products
Commercial products
Central power stations

Total sales

Cost of goods sold:
Household products
Commercial products
Central power stations

Total cost

Gross profit

Expenses:
Distribution (Schedule A)
Marketing (Schedule B)

Total expenses

Net profit before tax
Net income tax

Net profit after tax

Schedule A

Distribution expenses:
Salaries and benefits
Transportation
Warehouse facilities:
  Lease
  Utilities
  Other expenses

  Total warehouse expenses

Inventory carrying charges

Total distribution expenses

Schedule B

Marketing expenses:
Salaries and benefits
Sales expenses
Office facilities:
  Lease
  Utilities
  Maintenance
  Other expenses

  Total office expenses

Advertising

Total marketing expenses
Revenue

\[ \text{REV}_j = \text{Total Annual Revenue in Region } j \]  
\[ = (1 - \tau') \left( \text{CGS}_j + \text{TDX}_j + \text{TMX}_j \right) \]

where

\[ \text{CGS}_j = \text{Total Annual Cost of Goods Sold in Region } j \]  
\[ = \text{Total Annual Cost of Goods Sold in Region } j \]  
\[ = \text{Total Annual Distribution Expense in Region } j \]  
\[ = \text{Total Annual Marketing Expense in Region } j \]  
\[ \gamma' = \text{Effective Income Tax Rate} \]  
\[ \phi = \text{Net Profit Margin Rate} \]

Cost of Goods Sold

\[ \text{CGS}_j = \text{Total Annual Cost of Goods Sold in Region } j \]  
\[ = \sum_{i=1}^{3} d_{ij} \cdot p \cdot 10^6 \]

where

\[ d_{ij} = \text{Annual Demand in Region } j \text{ by all customers of type } i \]  
\[ p = \text{SAMICS Manufacturing Price for Solar Arrays} \]  
\[ = \text{SAMICS Manufacturing Price for Solar Arrays} \]  
\[ = \text{Total Annual Distribution Expense in Region } j \]  
\[ (\text{manufacturing year dollars}) \]

\[ \gamma' = \text{Effective Income Tax Rate} \]

\[ \phi = \text{Net Profit Margin Rate} \]

Gross Profit

\[ \text{GRO}_j = \text{Total Annual Gross Profit in Region } j \]  
\[ = \text{REV}_j - \text{CGS}_j \]

Distribution Expense

\[ \text{TDX}_j = \text{Total Annual Distribution Expense in Region } j \]  
\[ = \text{IC}_{kj} (Q_i') + D_{kj} \]

IV-2
where

\[ \text{DC}_{kj} = \text{Annual Distribution Cost in Region } j \text{ for customers supplied directly from the factory in Region } k \] (manufacturing year dollars)

\[ \text{IC}_{kj} (Q_j) = \text{Annual Distribution Cost in Region } j \text{ for customers supplied from a regional warehouse in Region } j \text{ with transshipments from the factory in Region } k \] (manufacturing year dollars)

\[ Q_j = \text{Optimal warehouse order quantity in Region } j \] (megawatts/shipment)

**Marketing Expense**

\[ \text{TMX}_j = \text{Total Annual Marketing Expense in Region } j \] (manufacturing year dollars)

\[ \text{TMX}_j = \text{DSC}_j + \text{ISC}_j \]

where

\[ \text{DSC}_j = \text{Total Annual Direct Sales Cost in Region } j \] (manufacturing year dollars)

\[ \text{ISC}_j = \text{Total Annual Indirect Sales Cost in Region } j \] (manufacturing year dollars)

**Net Profit Before Tax**

\[ \text{NPB}_j = \text{Net Profit Before Income Taxes in Region } j \] (manufacturing year dollars)

\[ \text{NPB}_j = \text{GRO}_j - \text{TDX}_j - \text{TMX}_j \]

**Income Tax**

\[ \text{TAX}_j = \text{Total Annual Income Tax Expense in Region } j \] (manufacturing year dollars)

\[ \text{TAX}_j = \gamma \ast \text{NPB}_j \]

where

\[ \gamma = \text{Effective Income Tax Rate} \]

\[ \text{NPB}_j = \text{Net Profit Before Taxes in Region } j \]

IV-3
Net Profit After Tax

\[
\text{NPA} = \text{Net Profit After Income Tax in Region } j \\
\quad \quad \quad \quad \quad \text{(manufacturing year dollars)} \\
\quad = \text{NPB}_j - \text{TAX}_j \\
\quad = \phi \cdot \text{REV}_j
\]

where

\( \phi \) = After Tax Profit Margin \\
\quad = (\text{Fraction of Total Revenues})

C. Solar Array Price Estimates

The solar array prices expressed in dollars per peak watt are computed separately for each customer product. The annual array sales revenues are divided by the demand.

The prices include the manufacturing cost, marketing expense, distribution expense, income tax, and profit.

\[
\text{SAP}_{ij} = \text{Solar Array Price for Customer Type } i \text{ in Region } j \\
\quad \quad \quad \quad \quad \text{(1975 dollars/watt)} \\
\quad = \frac{\text{REV}_{ij}}{d_{ij}} \phi \cdot \text{DEF}_i
\]

where

\( \text{REV}_{ij} \) = Total Annual Sales Revenues for product \( i \) in Region \( j \) \\
\quad = \text{(manufacturing year dollars)} \\
\( d_{ij} \) = Total Annual Demand for product \( i \) in Region \( j \) \\
\( \phi \) = Deflator \\
\quad = (1 + i) \\
\( \text{DEF}_i \) = Steady-State Manufacturing Year \\
\( i \) = Deflation Rate

The standard value for the deflation rate is presented in Appendix A.
V. TEST CASE

A. Test Case Input Data
   1. Supply Side Description
   2. Demand Side Description

B. Marketing Model Results
   1. Sales and Marketing Personnel Requirements
   2. Sales and Marketing Expense Summary
   3. Solar Array Marketing Costs Per Watt

C. Distribution Model Results
   1. Distribution Network Configuration
   2. Distribution Expense Summary
   3. Solar Array Distribution Costs Per Watt

D. Financial Model Results
   1. SELLCO Projected Income Statements
   2. Solar Array Price Estimates
V. TEST CASE

A. Test Case Input Data

1. Supply Side Description

- Production level = 500 MW/year
- Manufacturing year = 1986
- Manufacturing price = $0.50 (1975 dollars) = $0.959/watt (1986 dollars)
- Deflation multiplier = 0.5214
- Solar array weight = 55 lb/array = 24.948 kg/array
- Array dimensions = 14.6 ft$^2$ x 2 in thick = 1.36 m x 5.09 cm
- Packaged in wood crates
- Array volume (packaged) = 8 ft$^3$/array = 0.2265 m$^3$/array
- Array performance = 160 watts/array
- Efficiency = 11.8%

MODEL INPUT PARAMETERS

\[ w = \text{Solar array unit weight} = 155,925 \text{ kg/mW} \]
\[ v = \text{Solar array unit volume} = 1415.805 \text{ m}^3/\text{mW} \]
\[ p = \text{Solar array unit price} = 0.959/\text{watt} \]
\[ \text{1986 dollars} \]

Factory location = Region II: Phoenix
Rocky Mountain Region

\[ t = \text{Manufacturing year} = 1986 \]
2. Demand Side Description

<table>
<thead>
<tr>
<th>i</th>
<th>Customer Type</th>
<th>( \text{Average Order Quantity} ) ( AOQ_i ) (MW)</th>
<th>( \text{Average Delivery Quantity} ) ( q_i ) (MW)</th>
<th>( \text{Total Demand} ) ( D_i ) (MW)</th>
<th>( \text{Number of Orders} ) Per Year</th>
<th>( \text{Number of Deliveries} ) Per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Residential Household</td>
<td>.01</td>
<td>.01</td>
<td>200 (40%)</td>
<td>20,000</td>
<td>20,000</td>
</tr>
<tr>
<td>2</td>
<td>Commercial Intermediate</td>
<td>.50</td>
<td>.50</td>
<td>100 (20%)</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>3</td>
<td>Public Utility Central Station</td>
<td>50.00</td>
<td>5.00</td>
<td>200 (40%)</td>
<td>4</td>
<td>40</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>( d_{ij} )</th>
<th>Customer Demand Distribution (MW/yr)</th>
<th>Total Annual Demand (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Residential Household 1 (( j = 1 ))</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Commercial Intermediate 2 (( j = 2 ))</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Public Utility Central Station 3 (( j = 3 ))</td>
<td></td>
</tr>
<tr>
<td>I West Coast</td>
<td>50.0</td>
<td>125.0</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>60.0</td>
<td>140.0</td>
</tr>
<tr>
<td>III North Central</td>
<td>10.0</td>
<td>15.0</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>10.0</td>
<td>15.0</td>
</tr>
<tr>
<td>V North Eastern</td>
<td>20.0</td>
<td>80.0</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>10.0</td>
<td>15.0</td>
</tr>
<tr>
<td>VII South Central</td>
<td>40.0</td>
<td>110.0</td>
</tr>
<tr>
<td>Total</td>
<td>200.0</td>
<td>500.0</td>
</tr>
</tbody>
</table>
### B. Marketing Model Results

1. **Sales and Marketing Personnel Requirements**

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Salesman</th>
<th>Direct Sales Support Staff</th>
<th>Indirect Sales Support Staff</th>
<th>Total Sales Personnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. West Coast</td>
<td>125</td>
<td>50</td>
<td>60</td>
<td>235</td>
</tr>
<tr>
<td>II. Rocky Mountain</td>
<td>150</td>
<td>58</td>
<td>72</td>
<td>280</td>
</tr>
<tr>
<td>III. North Central</td>
<td>25</td>
<td>18</td>
<td>11</td>
<td>44</td>
</tr>
<tr>
<td>IV. Great Lakes</td>
<td>25</td>
<td>8</td>
<td>11</td>
<td>44</td>
</tr>
<tr>
<td>V. North Eastern</td>
<td>50</td>
<td>25</td>
<td>26</td>
<td>101</td>
</tr>
<tr>
<td>VI. South Eastern</td>
<td>25</td>
<td>8</td>
<td>11</td>
<td>44</td>
</tr>
<tr>
<td>VII. South Central</td>
<td>100</td>
<td>41</td>
<td>49</td>
<td>190</td>
</tr>
<tr>
<td><strong>All Regions</strong></td>
<td>500</td>
<td>198</td>
<td>240</td>
<td>938</td>
</tr>
<tr>
<td></td>
<td>(53%)</td>
<td>(21%)</td>
<td>(26%)</td>
<td>(100%)</td>
</tr>
</tbody>
</table>
2. **Sales and Marketing Expense Summary***

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Salaries and Expenses</th>
<th>Sales Facilities Expenses</th>
<th>Advertising Expenses</th>
<th>Total Marketing Expenses</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. West Coast</td>
<td>$11,600,665</td>
<td>$357,015</td>
<td>$1,246,700</td>
<td>$14,349,414</td>
</tr>
<tr>
<td>II. Rocky Mountain</td>
<td>13,585,452</td>
<td>380,565</td>
<td>1,486,450</td>
<td>16,803,008</td>
</tr>
<tr>
<td>III. North Central</td>
<td>1,996,253</td>
<td>69,525</td>
<td>239,750</td>
<td>2,827,939</td>
</tr>
<tr>
<td>IV. Great Lakes</td>
<td>2,285,647</td>
<td>66,169</td>
<td>239,750</td>
<td>2,827,939</td>
</tr>
<tr>
<td>V. North Eastern</td>
<td>4,603,451</td>
<td>168,483</td>
<td>527,450</td>
<td>5,725,584</td>
</tr>
<tr>
<td>VI. South Eastern</td>
<td>1,689,135</td>
<td>62,261</td>
<td>239,750</td>
<td>2,165,803</td>
</tr>
<tr>
<td>VII. South Central</td>
<td>8,011,289</td>
<td>255,357</td>
<td>1,006,950</td>
<td>10,055,225</td>
</tr>
<tr>
<td><strong>All Regions</strong></td>
<td><strong>$43,771,892</strong></td>
<td><strong>$1,359,375</strong></td>
<td><strong>$4,986,800</strong></td>
<td><strong>$54,438,472</strong></td>
</tr>
</tbody>
</table>

*Expenses are expressed in 1986 (manufacturing year) dollars.*
3. Solar Array Marketing Costs Per Watt

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Customer Type</th>
<th>Residential Household</th>
<th>Commercial Intermediate</th>
<th>Public Utility Central Station</th>
<th>All Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td>I West Coast</td>
<td>1</td>
<td>$.1004</td>
<td>$.0174</td>
<td>$.0136</td>
<td>$.0599</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>1</td>
<td>.0994</td>
<td>.0708</td>
<td>.0135</td>
<td>.0626</td>
</tr>
<tr>
<td>III North Central</td>
<td>1</td>
<td>.0966</td>
<td>.0687</td>
<td>-</td>
<td>.0873</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>1</td>
<td>.1086</td>
<td>.0776</td>
<td>-</td>
<td>.0983</td>
</tr>
<tr>
<td>V North Eastern</td>
<td>1</td>
<td>.0895</td>
<td>.0634</td>
<td>.0112</td>
<td>.0373</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>1</td>
<td>.0834</td>
<td>.0590</td>
<td>-</td>
<td>.0753</td>
</tr>
<tr>
<td>VII South Central</td>
<td>1</td>
<td>.0862</td>
<td>.0611</td>
<td>.0114</td>
<td>.0477</td>
</tr>
<tr>
<td>All Regions</td>
<td></td>
<td>$.0955</td>
<td>$.0579</td>
<td>$.0124</td>
<td>$.0568</td>
</tr>
</tbody>
</table>

*Expressed in 1975 $/watt.*
## Distribution Model Results

### 1. Distribution Network Configuration

<table>
<thead>
<tr>
<th>Region</th>
<th>Factory-Warehouse Shipping Mode</th>
<th>Warehouse Size (Square Meters)</th>
<th>Average Inventory Level (MW)</th>
<th>Delivery Truck Fleet Size</th>
<th>Warehouse Personnel Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>I West Coast</td>
<td>Rail</td>
<td>353.95</td>
<td>.50</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>Direct Shipping</td>
<td>-</td>
<td>-</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>III North Central</td>
<td>Rail</td>
<td>70.79</td>
<td>.10</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>Rail</td>
<td>70.79</td>
<td>.10</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>V North Eastern</td>
<td>Rail</td>
<td>141.58</td>
<td>.20</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>Rail</td>
<td>70.79</td>
<td>.10</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>VII South Central</td>
<td>Rail</td>
<td>283.16</td>
<td>.40</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>All Regions</td>
<td></td>
<td>991.06</td>
<td>1.40</td>
<td>19</td>
<td>12</td>
</tr>
</tbody>
</table>
2. Distribution Expense Summary*

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Residential</th>
<th>Commercial</th>
<th>Public Utility</th>
<th>All Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td>I West Coast</td>
<td>$1,296,406</td>
<td>$432,523</td>
<td>$865,050</td>
<td>$2,593,979</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>127,947</td>
<td>63,974</td>
<td>106,623</td>
<td>298,544</td>
</tr>
<tr>
<td>III North Central</td>
<td>665,811</td>
<td>283,217</td>
<td>0</td>
<td>949,028</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>852,920</td>
<td>375,104</td>
<td>0</td>
<td>1,228,024</td>
</tr>
<tr>
<td>V North Eastern</td>
<td>2,145,472</td>
<td>974,241</td>
<td>4,871,208</td>
<td>7,990,921</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>944,205</td>
<td>409,328</td>
<td>0</td>
<td>1,353,533</td>
</tr>
<tr>
<td>VII South Central</td>
<td>2,127,709</td>
<td>291,423</td>
<td>2,228,558</td>
<td>5,247,690</td>
</tr>
<tr>
<td>All Regions</td>
<td>$8,160,470</td>
<td>$3,429,810</td>
<td>$8,071,439</td>
<td>$1,966,719</td>
</tr>
</tbody>
</table>

*Expenses are expressed in 1986 (manufacturing year) dollars.
3. **Solar Array Distribution Costs Per Watt**

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Residential Household</th>
<th>Commercial Intermediate</th>
<th>Public Utility Central Station</th>
<th>All Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td>I West Coast</td>
<td>$.0135</td>
<td>$.0090</td>
<td>$.0090</td>
<td>$.0108</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>.0011</td>
<td>.0011</td>
<td>.0011</td>
<td>.0011</td>
</tr>
<tr>
<td>III North Central</td>
<td>.0347</td>
<td>.0295</td>
<td>-</td>
<td>.0330</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>.0445</td>
<td>.0391</td>
<td>-</td>
<td>.0427</td>
</tr>
<tr>
<td>V North Eastern</td>
<td>.0559</td>
<td>.0508</td>
<td>.0508</td>
<td>.0521</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>.0492</td>
<td>.0427</td>
<td>-</td>
<td>.0470</td>
</tr>
<tr>
<td>VII South Central</td>
<td>.0277</td>
<td>.0232</td>
<td>.0232</td>
<td>.0249</td>
</tr>
<tr>
<td>All Regions</td>
<td>$.0213</td>
<td>$.0179</td>
<td>$.0210</td>
<td>$.0205</td>
</tr>
</tbody>
</table>

*Expressed in 1986 (manufacturing year) dollars.*
### Bellco Projected Income Statements for the year ending December 31, 1986

<table>
<thead>
<tr>
<th>Region</th>
<th>Total Sales Revenues</th>
<th>Cost Of Goods Sold</th>
<th>Gross Profit</th>
<th>Expenses</th>
<th>Net Profit Before Tax</th>
<th>Income Tax</th>
<th>Net Profit After Tax</th>
</tr>
</thead>
<tbody>
<tr>
<td>I  West Coast</td>
<td>191,545,190</td>
<td>119,875,000</td>
<td>71,670,190</td>
<td>16,942,993</td>
<td>54,727,197</td>
<td>27,910,870</td>
<td>26,816,327</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>211,906,173</td>
<td>134,260,000</td>
<td>77,646,173</td>
<td>17,101,552</td>
<td>60,544,621</td>
<td>30,877,757</td>
<td>29,666,864</td>
</tr>
<tr>
<td>III North Central</td>
<td>24,984,354</td>
<td>14,385,000</td>
<td>10,599,354</td>
<td>3,460,967</td>
<td>7,138,387</td>
<td>3,640,577</td>
<td>3,497,810</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>25,817,292</td>
<td>14,385,000</td>
<td>11,432,292</td>
<td>4,055,923</td>
<td>7,376,369</td>
<td>3,761,948</td>
<td>3,614,421</td>
</tr>
<tr>
<td>V  North Eastern</td>
<td>126,611,107</td>
<td>76,620,000</td>
<td>49,891,107</td>
<td>13,716,505</td>
<td>36,174,602</td>
<td>18,449,047</td>
<td>17,725,555</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>25,066,070</td>
<td>14,385,000</td>
<td>10,681,070</td>
<td>3,519,336</td>
<td>7,161,734</td>
<td>3,652,484</td>
<td>3,509,250</td>
</tr>
<tr>
<td>VII South Central</td>
<td>169,110,081</td>
<td>105,490,000</td>
<td>63,620,081</td>
<td>15,302,915</td>
<td>48,317,166</td>
<td>24,641,755</td>
<td>23,675,411</td>
</tr>
<tr>
<td>Overall Regions</td>
<td>775,040,267</td>
<td>479,500,000</td>
<td>295,540,267</td>
<td>74,100,191</td>
<td>221,440,076</td>
<td>112,934,438</td>
<td>108,505,638</td>
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</tbody>
</table>
## Solar Array Price Estimates (1975 $/Watt)

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Residential Household 1</th>
<th>Commercial Intermediate 2</th>
<th>Public Utility Central Station 3</th>
<th>All Customers 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>I West Coast</td>
<td>$.8595</td>
<td>$.8127</td>
<td>$.7316</td>
<td>$.7990</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>.8408</td>
<td>.8007</td>
<td>.7204</td>
<td>.7892</td>
</tr>
<tr>
<td>III North Central</td>
<td>.8839</td>
<td>.8376</td>
<td>-</td>
<td>.8685</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>.9144</td>
<td>.8634</td>
<td>-</td>
<td>.8974</td>
</tr>
<tr>
<td>V North Eastern</td>
<td>.9036</td>
<td>.8599</td>
<td>.7869</td>
<td>.8252</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>.8857</td>
<td>.8424</td>
<td>-</td>
<td>.8713</td>
</tr>
<tr>
<td>VII South Central</td>
<td>.8596</td>
<td>.8180</td>
<td>.7486</td>
<td>.8016</td>
</tr>
<tr>
<td>All Regions</td>
<td>$.8636</td>
<td>$.8201</td>
<td>$.7469</td>
<td>$.8082</td>
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</tbody>
</table>
APPENDIX A

General Model Data

1. MARKETING AND DISTRIBUTION GEOGRAPHIC REGIONS A-1
2. REGIONAL MARKETING AND DISTRIBUTION CENTERS A-2
3. INFLATION RATES A-3
4. REGIONAL COST INDICES A-4
5. FINANCIAL PARAMETERS A-5
REGIONAL MARKETING AND DISTRIBUTION CENTERS

<table>
<thead>
<tr>
<th>REGION</th>
<th>GEOGRAPHIC AREA</th>
<th>MARKETING AND DISTRIBUTION CENTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>West Coast</td>
<td>Los Angeles</td>
</tr>
<tr>
<td>II</td>
<td>Rocky Mountain</td>
<td>Phoenix</td>
</tr>
<tr>
<td>III</td>
<td>North Central</td>
<td>Omaha</td>
</tr>
<tr>
<td>IV</td>
<td>Great Lakes</td>
<td>Springfield</td>
</tr>
<tr>
<td>V</td>
<td>North Eastern</td>
<td>Syracuse</td>
</tr>
<tr>
<td>VI</td>
<td>South Eastern</td>
<td>Atlanta</td>
</tr>
<tr>
<td>VII</td>
<td>South Central</td>
<td>Dallas</td>
</tr>
</tbody>
</table>
## INFLATION RATES

<table>
<thead>
<tr>
<th>CODE</th>
<th>INFLATION CLASS</th>
<th>MEASURE</th>
<th>ANNUAL RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Raw materials</td>
<td>Crude materials price index</td>
<td>11%</td>
</tr>
<tr>
<td>B</td>
<td>Labor</td>
<td>Manufacturing labor</td>
<td>8%</td>
</tr>
<tr>
<td>C</td>
<td>Chemicals</td>
<td>Industrial chemicals</td>
<td>13%</td>
</tr>
<tr>
<td>D</td>
<td>Commodities</td>
<td>Producer finished goods</td>
<td>8%</td>
</tr>
<tr>
<td>E</td>
<td>Energy &amp; Utilities</td>
<td>Electric power</td>
<td>12%</td>
</tr>
<tr>
<td>G</td>
<td>Land</td>
<td>Springfield Real Estate</td>
<td>4%</td>
</tr>
<tr>
<td>H</td>
<td>Facilities</td>
<td>Factory and commercial buildings</td>
<td>9%</td>
</tr>
<tr>
<td>I</td>
<td>Construction</td>
<td>Construction and contract labor</td>
<td>8%</td>
</tr>
<tr>
<td>J</td>
<td>Equipment</td>
<td>Machinery and equipment</td>
<td>7%</td>
</tr>
<tr>
<td>F</td>
<td>Resources</td>
<td>Natural resources</td>
<td>15%</td>
</tr>
<tr>
<td>T</td>
<td>Transportation</td>
<td>Transportation</td>
<td>7%</td>
</tr>
</tbody>
</table>

**Sources:**
(a) Survey of current business statistics (1967 = 100) published by the U.S. Department of Commerce.

(b) Bureau of Labor Statistics.

(c) Springfield Illinois Chamber of Commerce.
## REGIONAL COST INDICES

<table>
<thead>
<tr>
<th>Region</th>
<th>Labor</th>
<th>Energy and Utilities</th>
<th>Facilities</th>
<th>Construction</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>I West Coast</td>
<td>1.103</td>
<td>1.320</td>
<td>1.062</td>
<td>1.062</td>
<td>1.062</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>1.088</td>
<td>1.320</td>
<td>0.969</td>
<td>0.969</td>
<td>0.969</td>
</tr>
<tr>
<td>III North Central</td>
<td>1.014</td>
<td>0.900</td>
<td>1.052</td>
<td>1.052</td>
<td>1.052</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>1.161</td>
<td>0.900</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>V North Eastern</td>
<td>0.998</td>
<td>1.300</td>
<td>1.114</td>
<td>1.114</td>
<td>1.114</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>0.858</td>
<td>0.950</td>
<td>0.938</td>
<td>0.938</td>
<td>0.938</td>
</tr>
<tr>
<td>VII South Central</td>
<td>0.937</td>
<td>1.200</td>
<td>0.927</td>
<td>0.927</td>
<td>0.927</td>
</tr>
<tr>
<td>National Average</td>
<td>1.000</td>
<td>1.000</td>
<td>1.041</td>
<td>1.041</td>
<td>1.041</td>
</tr>
</tbody>
</table>

FINANCIAL PARAMETERS

\( \tau = \text{Effective income tax rate} = 51\% \)

\( \lambda = \text{Financial leverage} = \frac{\text{Total Capital}}{\text{Total Equity}} = 1.20 \)

\( r = \text{Annual return on equity} = 21\% \)

\( i = \text{Deflation Rate} = 6\% \)

\( \rho = \text{After Tax Profit Margin} = 14\% \)
APPENDIX B
MARKETING MODEL DATA

1. SALES MAN PRODUCTIVITY AND SUPPORT INDICES B-1
2. DIRECT SALES PERSONNEL COMPENSATION RATES B-2
3. INDIRECT SALES SUPPORT STAFF RELATIONSHIPS B-3
4. INDIRECT SALES PERSONNEL COMPENSATION RATES B-4
5. SALES OFFICE FACILITIES COST PARAMETERS B-5
6. SALES AND ADVERTISING EXPENSE PARAMETERS B-6
<table>
<thead>
<tr>
<th>Average Order Quantity (MW) ACQ</th>
<th>Megawatt Sales Per Salesman (MW/yr) MWS</th>
<th>Salesman Support Index SSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>.001</td>
<td>.50</td>
<td>.100</td>
</tr>
<tr>
<td>.010</td>
<td>.51</td>
<td>.101</td>
</tr>
<tr>
<td>.100</td>
<td>.59</td>
<td>.109</td>
</tr>
<tr>
<td>1.000</td>
<td>1.45</td>
<td>.190</td>
</tr>
<tr>
<td>10.000</td>
<td>10.00</td>
<td>1.000</td>
</tr>
<tr>
<td>100.000</td>
<td>95.51</td>
<td>5.000</td>
</tr>
</tbody>
</table>
### DIRECT SALES PERSONNEL COMPENSATION RATES

#### Salesman

<table>
<thead>
<tr>
<th>Index</th>
<th>Description</th>
<th>Annual Compensation*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Salesman, Household Products</td>
<td>$18,060</td>
</tr>
<tr>
<td>2</td>
<td>Salesman, Intermediate Commercial Products</td>
<td>$24,000</td>
</tr>
<tr>
<td>3</td>
<td>Salesman, Central Power Stations</td>
<td>$31,920</td>
</tr>
</tbody>
</table>

#### Direct Sales Support Personnel

<table>
<thead>
<tr>
<th>Index</th>
<th>Description</th>
<th>Requirement Coefficient $RC_k$</th>
<th>Annual Compensation* $AC_k$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Field Engineer</td>
<td>2.0</td>
<td>$26,400</td>
</tr>
<tr>
<td>2</td>
<td>Commercial Artist</td>
<td>0.1</td>
<td>$12,320</td>
</tr>
<tr>
<td>3</td>
<td>Market Research Analyst</td>
<td>0.4</td>
<td>$25,200</td>
</tr>
<tr>
<td>4</td>
<td>Technical Illustrator</td>
<td>0.2</td>
<td>$18,900</td>
</tr>
<tr>
<td>5</td>
<td>Technical Writer</td>
<td>0.2</td>
<td>$18,900</td>
</tr>
<tr>
<td>6</td>
<td>Advertising Salesman</td>
<td>0.1</td>
<td>$17,500</td>
</tr>
</tbody>
</table>

*Compensation rates include all wages and benefits, are expressed in 1977 dollars per year, and based on nationwide averages.
# INDIRECT SALES SUPPORT STAFF RELATIONSHIPS*

<table>
<thead>
<tr>
<th>Indirect Staff</th>
<th>Required By Staff</th>
<th>D1</th>
<th>D2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secretary I (Lower Management)</td>
<td>Salesman, Household Products</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Salesman, Intermediate Commercial</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Salesman, Central Station</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Market Research Analyst</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Salesman, Advertising</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Secretary II (Middle Management)</td>
<td>Manager, Sales Engineering</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Manager, Sales</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Manager, Advertising</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Manager, Market Research</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Secretary III (Upper Management)</td>
<td>Regional Vice President, Sales and Marketing</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Manager, Advertising</td>
<td>Commercial Artist</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Salesman, Advertising</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Manager, Marketing Research</td>
<td>Marketing Research Analyst</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Manager, Sales</td>
<td>Salesman, Household Products</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Salesman, Intermediate Commercial</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Salesman, Central Station</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Manager, Sales Engineering</td>
<td>Field Engineer</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Technical Writer</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Technical Illustrator</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Vice President, Sales and Marketing</td>
<td>Manager, Sales</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Manager, Sales Engineering</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Manager, Advertising</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Manager, Marketing Research</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

*1 is the number of "Indirect Staff" for D1 of the "Required by Staff". For example, one Secretary I (Lower Management) is required for every nine salesmen of household products.
<table>
<thead>
<tr>
<th>Job Title</th>
<th>Annual Compensation (Wages + Benefits) (1977 $/Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vice President, Sales and Marketing</td>
<td>$59,800</td>
</tr>
<tr>
<td>Manager, Sales Engineering</td>
<td>$38,400</td>
</tr>
<tr>
<td>Manager, Sales</td>
<td>$38,400</td>
</tr>
<tr>
<td>Manager, Advertising</td>
<td>$38,400</td>
</tr>
<tr>
<td>Manager, Marketing Research</td>
<td>$38,400</td>
</tr>
<tr>
<td>Market Research Analyst</td>
<td>$25,200</td>
</tr>
<tr>
<td>Technical Illustrator</td>
<td>$18,900</td>
</tr>
<tr>
<td>Commercial Artist</td>
<td>$12,320</td>
</tr>
<tr>
<td>Technical Writer</td>
<td>$18,900</td>
</tr>
<tr>
<td>Field Engineer</td>
<td>$26,400</td>
</tr>
<tr>
<td>Salesman, Advertising</td>
<td>$17,500</td>
</tr>
<tr>
<td>Salesman, Household Products</td>
<td>$18,060</td>
</tr>
<tr>
<td>Salesman, Intermediate Commercial Products</td>
<td>$24,000</td>
</tr>
<tr>
<td>Salesman, Central Power Stations</td>
<td>$31,920</td>
</tr>
<tr>
<td>Secretary I (Lower Management)</td>
<td>$13,650</td>
</tr>
<tr>
<td>Secretary II (Middle Management)</td>
<td>$14,560</td>
</tr>
<tr>
<td>Secretary III (Upper Management)</td>
<td>$15,890</td>
</tr>
</tbody>
</table>
SALES OFFICE FACILITIES COST PARAMETERS

- $p_{OP}$ = Amount of office space per person = 12.45
  (square meters/person)
- $y_o$ = Office Facilities Lease Rate (% of capital cost) = 12.6%
- $\rho_o$ = Office Utilities Cost Rate (1977 $/square meter) = $1.20
- $m$ = Office Maintenance Cost Rate (% of capital cost) = 1.0%
- $\beta$ = Property Tax Rate (% of capital cost) = 4.0%
- $\sqrt{}$ = Insurance Rate (% of capital cost) = 1.0%

SALES OFFICE CAPITAL COST FUNCTION

<table>
<thead>
<tr>
<th>Sales Office Size (Square Meters) $S$</th>
<th>Total Office Capital Cost (1977 $) $K_o(S)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0 &lt; S &lt; 185$</td>
<td>$K_o(S) = 366.49 + 366.49S$</td>
</tr>
<tr>
<td>$185 &lt; S &lt; 278$</td>
<td>$K_o(S) = 28412.90 + 212.90S$</td>
</tr>
<tr>
<td>$278 &lt; S &lt; 372$</td>
<td>$K_o(S) = 5382.98 + 295.74S$</td>
</tr>
<tr>
<td>$372 &lt; S &lt; 557$</td>
<td>$K_o(S) = 21696.22 + 251.89S$</td>
</tr>
<tr>
<td>$557 &lt; S &lt; 1115$</td>
<td>$K_o(S) = 3284.95 + 284.95S$</td>
</tr>
<tr>
<td>$1115 &lt; S$</td>
<td>$K_o(S) = 24781.24 + 265.67S$</td>
</tr>
</tbody>
</table>
### Sales and Advertising Expense Parameters

<table>
<thead>
<tr>
<th>Customer/Product Type i</th>
<th>Average Order Quality Range ( ACQ_i ) (Megawatts/Order)</th>
<th>Sales Expense Rate ( SAE_i )</th>
<th>Advertising Cost Rate ( ADE_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Small Household Products</td>
<td>0.00-0.05</td>
<td>20%</td>
<td>2.0%</td>
</tr>
<tr>
<td>2. Intermediate Commercial Products</td>
<td>0.05-1.00</td>
<td>25%</td>
<td>1.0%</td>
</tr>
<tr>
<td>3. Large Central Power Stations</td>
<td>1.00-500</td>
<td>30%</td>
<td>0.1%</td>
</tr>
</tbody>
</table>
APPENDIX C
DISTRIBUTION MODEL DATA

1. INTERREGIONAL SHIPPING DISTANCES C-1

2. INTERREGIONAL TRANSPORTATION COST FUNCTION C-2

3. INTRAREGIONAL TRANSPORTATION COSTS C-3

4. WAREHOUSE COST PARAMETER STANDARD VALUES C-4
   - Warehouse Space Utilization Factor C-5
   - Building Capital Cost Function C-5
   - Equipment Capital Cost Function C-6
   - Warehouse Personnel Cost C-6
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   - Utility Cost Rate C-8
   - Insurance Rate C-9
   - Property Tax Rate C-9
   - Equipment Lease Rate C-10
   - Building Lease Rate C-10
   - Inventory Carrying Charge Rate C-10
### TABLE C-1

**INTERREGIONAL SHIPPING DISTANCES**  
(Kilometers)

<table>
<thead>
<tr>
<th>Destination Region</th>
<th>I West Coast Los Angeles</th>
<th>II Rocky Mountain Phoenix</th>
<th>III North Central Omaha</th>
<th>IV Great Lakes Springfield</th>
<th>V North Eastern Syracuse</th>
<th>VI South Eastern Atlanta</th>
<th>VII South Central Dallas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Origin Region</td>
<td>640</td>
<td>2788</td>
<td>3057</td>
<td>4344</td>
<td>3540</td>
<td>2293</td>
<td>1652</td>
</tr>
<tr>
<td>I West Coast Los Angeles</td>
<td>2100</td>
<td>2782</td>
<td>3595</td>
<td>3036</td>
<td>1609</td>
<td>1064</td>
<td>965</td>
</tr>
<tr>
<td>II Rocky Mountain Phoenix</td>
<td>644</td>
<td>1770</td>
<td>1287</td>
<td>965</td>
<td>1207</td>
<td>1529</td>
<td>2414</td>
</tr>
<tr>
<td>III North Central Omaha</td>
<td>3057</td>
<td>2782</td>
<td>644</td>
<td>1287</td>
<td>1529</td>
<td>1287</td>
<td>-</td>
</tr>
<tr>
<td>IV Great Lakes Springfield</td>
<td>4344</td>
<td>3595</td>
<td>1770</td>
<td>1287</td>
<td>-</td>
<td>1287</td>
<td>-</td>
</tr>
<tr>
<td>V North Eastern Syracuse</td>
<td>3540</td>
<td>3036</td>
<td>1609</td>
<td>965</td>
<td>1529</td>
<td>-</td>
<td>1287</td>
</tr>
<tr>
<td>VI South Eastern Atlanta</td>
<td>2293</td>
<td>1652</td>
<td>1064</td>
<td>1207</td>
<td>2414</td>
<td>1287</td>
<td>-</td>
</tr>
<tr>
<td>VII South Central Dallas</td>
<td>2100</td>
<td>2782</td>
<td>3595</td>
<td>3036</td>
<td>1609</td>
<td>1064</td>
<td>965</td>
</tr>
</tbody>
</table>
TABLE C-2
INTERREGIONAL TRANSPORTATION COST FUNCTION

<table>
<thead>
<tr>
<th>Weight Class (Kilograms)</th>
<th>Transportation Mode</th>
<th>Freight Charge Rate (1977 $ Per 100 Kilograms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 225</td>
<td>Truck</td>
<td>20.8400 + .01845*S</td>
</tr>
<tr>
<td>225 to 450</td>
<td>Truck</td>
<td>16.3100 + .01986*S</td>
</tr>
<tr>
<td>450 to 900</td>
<td>Truck</td>
<td>13.3400 + .01951*S</td>
</tr>
<tr>
<td>900 to 2250</td>
<td>Truck</td>
<td>11.4800 + .01774*S</td>
</tr>
<tr>
<td>2250 to 4500</td>
<td>Truck</td>
<td>7.0790 + .01845*S</td>
</tr>
<tr>
<td>4500 to 10800</td>
<td>Truck</td>
<td>5.9020 + .01880*S</td>
</tr>
<tr>
<td>10800 to 18000</td>
<td>Truck</td>
<td>5.4320 + .01135*S</td>
</tr>
<tr>
<td>18000 to 36000</td>
<td>Rail</td>
<td>0.7440 + .00918*S</td>
</tr>
<tr>
<td>More than 36000</td>
<td>Rail</td>
<td>0.0192 + .00940*S</td>
</tr>
</tbody>
</table>

Where S = Shipping distance in kilometers

*Rail rates have been adjusted to include delivery to and from the train depot and to reflect differences between rail distance and road distance. Thus, the freight charges represent door-to-door transportation costs.
TABLE C-3

INTRAREGIONAL TRANSPORTATION COSTS*

Following is a list of delivery cost parameters for a medium duty conventional truck. A medium duty truck with a capacity of 80,000 kg was selected for the base case since it is capable of carrying a load of 500 kw of solar collectors. This would correspond approximately to 50 residential customers or to one commercial customer.

- **Vehicle Distance Capacity**
  
  Assuming 250 days per year and 320 kilometers per day
  
  $MC = 75,000$ kilometers/vehicle-year

- **Vehicle Load Capacity**
  
  $WC = 80,000$ kilograms/delivery

- **Annual Fixed Cost Per Vehicle**
  
  Purchase cost, net $12,500
  
  Capital recovery (5 year life, 20% salvage) $2,000
  
  Annual interest ($10.5\%$, $A = 1.2$) 219
  
  Annual return on equity ($21\%$, $A = 1.2$) 2,188
  
  Tax on equity 2,188

  Where $A = \frac{\text{Financial}}{\text{Total Capital}} = \frac{\text{Leverage}}{\text{Equity Capital}}$

  Present value of tax savings $484

  Assuming accelerated depreciation at 18.37%

  Annual amortization of tax saving $156

  Net capital cost $6,439
  Insurance 2,000
  Driver's wages and benefits 15,600

  $FC = \text{Annual Fixed Cost per Vehicle} = 24,039$

- **Variable Operating Cost Per Vehicle Kilometer**
  
  Gas
  Oil and maintenance $0.075$/kilometer
  .020/kilometer

  $VC = \text{Variable Operating Cost} = 0.095$/kilometer per vehicle kilometer

*All costs are expressed in 1977 dollars per year.*
WAREHOUSE COST PARAMETERS STANDARD VALUES

\( \alpha \) = Warehouse space utilization factor = .25

\( K_b \) = Building capital cost function (Table C-4)

\( K_e \) = Equipment capital cost function (Table C-5)

\( P \) = Personnel cost function (Table C-6)

\( m \) = Maintenance cost rate = 1%/year
  (% of capital cost/year)

\( \rho_w \) = Warehouse utilities cost rate = $1.20/square meter/year

\( \delta \) = Property tax rate = 4%/year
  (% of capital cost/year)

\( \upsilon \) = Insurance rate = 1%/year
  (% of capital cost/year)

\( \gamma_e \) = Equipment lease rate = .25/year
  (fraction of capital cost/year)

\( \gamma_b \) = Building lease rate = .126/year
  (fraction of capital cost/year)

\( \sigma \) = Inventory carrying charge rate = 37.75%/year
o Warehouse Space Utilization Factor

The warehouse space utilization factor is used to compute the total amount of warehouse space required, based on the maximum inventory quantity and the physical volume of the solar array units.

The multiplier includes the stacking height and allows for circulation and office areas. The standard value is based on the following assumptions:

- The inventory is stacked on pallets five meters high.
- A single factory shipment occupies 80% of the total warehouse area. This is the maximum inventory level with no space for safety stock. The remaining 20% of the warehouse is occupied by aisles, office areas, and restrooms.

\[ \text{Warehouse space utilization factor} \]
\[ = \left( \frac{100\%}{80\%} \right) \left( \frac{1 \text{ square meter of warehouse floor}}{5 \text{ cubic meters of product}} \right) \]
\[ = 0.25/\text{meter} \]

o Building Capital Cost Function

The capital cost for construction of a warehouse depends on the size and location of the facility. A TB&A engineering cost analysis yielded the following average 1977 warehouse construction costs for Springfield, Illinois.

<table>
<thead>
<tr>
<th>Warehouse Size (Square Meters)</th>
<th>Average Construction Cost* ($/square meter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>245.96</td>
</tr>
<tr>
<td>1000</td>
<td>233.58</td>
</tr>
<tr>
<td>2500</td>
<td>221.21</td>
</tr>
<tr>
<td>25000</td>
<td>181.92</td>
</tr>
</tbody>
</table>

*Expressed in 1977 dollars for Springfield, Illinois in Region IV.

These point estimates were used to develop a piecewise linear function to compute building capital costs. The relationships, tabulated on the following page were adjusted to include land costs. Since land costs vary considerably from one location to another and do not represent a major portion of the total cost, a simplifying assumption was made. The cost of land is taken to be 10% of the total warehouse cost. This value may actually range from 5% to 18% depending on the location.

To account for regional differences in construction costs, the cost relations should be adjusted using the regional construction cost index.
TABLE C-4

BUILDING CAPITAL COST FUNCTION

<table>
<thead>
<tr>
<th>Warehouse Size $F$ (Square Meters)</th>
<th>Total Land And Building Cost $(1977 $)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0 &lt; F \leq 250$</td>
<td>$K_b(F) = 0.00 + 245.96 \times F$</td>
</tr>
<tr>
<td>$250 &lt; F &lt; 1000$</td>
<td>$K_b(F) = 4126.70 + 229.45 \times F$</td>
</tr>
<tr>
<td>$1000 \leq F \leq 2500$</td>
<td>$K_b(F) = 20616.75 + 212.96 \times F$</td>
</tr>
<tr>
<td>$2500 &lt; F$</td>
<td>$K_b(F) = 109140.00 + 177.55 \times F$</td>
</tr>
</tbody>
</table>

- **Equipment Capital Cost Function**

Warehouse equipment consists of forktrucks, conveyors, lifts, carts, pallets, and other materials handling equipment. The cost of items are approximated as a function of the size of the warehouse. The following table gives the approximated capital cost relationships. The function yields economies of scale (that is, decreasing costs per square meter) for larger warehouses. The rationale for this phenomena is that larger warehouses are able to substitute capital for labor making automated equipment more economically.

TABLE C-5

<table>
<thead>
<tr>
<th>Warehouse Size $F$ (Square Meters)</th>
<th>Equipment Capital Cost $(1977 $)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0 &lt; F \leq 1000$</td>
<td>$K_e(F) = 26 \times F$</td>
</tr>
<tr>
<td>$1000 \leq F \leq 2500$</td>
<td>$K_e(F) = 5000 + 21 \times F$</td>
</tr>
<tr>
<td>$2500 &lt; F$</td>
<td>$K_e(F) = 10000 + 19 \times F$</td>
</tr>
</tbody>
</table>

- **Warehouse Personnel Cost**

The number of warehouse personnel required per square meter of space varies with the size of the warehouse. This reflects the assumption that larger warehouses will operate more efficiently and hence require fewer people per square meter. The following tables indicate the type of personnel and the quantity required for different warehouse sizes.
### Personnel Costs

<table>
<thead>
<tr>
<th>Personnel Description</th>
<th>Percent Of Total Personnel</th>
<th>Annual Cost*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warehouse Supervisor</td>
<td>10%</td>
<td>$21,450</td>
</tr>
<tr>
<td>Forklift Operator</td>
<td>50%</td>
<td>$11,000</td>
</tr>
<tr>
<td>Inventory Clerk</td>
<td>20%</td>
<td>$13,510</td>
</tr>
<tr>
<td>Material Handler</td>
<td>20%</td>
<td>$16,800</td>
</tr>
<tr>
<td>Total weighted average</td>
<td>100%</td>
<td>$13,707</td>
</tr>
</tbody>
</table>

*The annual cost for 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 Size

<table>
<thead>
<tr>
<th>Warehouse Size (Square Meters)</th>
<th>Total Personnel</th>
<th>Personnel Per 1000 Square Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>1.00</td>
</tr>
<tr>
<td>2000</td>
<td>2</td>
<td>.80</td>
</tr>
<tr>
<td>5000</td>
<td>4</td>
<td>.70</td>
</tr>
<tr>
<td>10000</td>
<td>7</td>
<td>.67</td>
</tr>
<tr>
<td>15000</td>
<td>10</td>
<td>.60</td>
</tr>
<tr>
<td>25000</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

The annual cost for personnel includes both wages and benefits based on a nationwide survey. The amounts are expressed in 1977 dollars and should be multiplied by the appropriate labor cost index to reflect regional conditions. The following table presents equations (corresponding to the above table) for computing the annual personnel cost as a function of the warehouse size.
TABLE C-6
PERSONNEL COST FUNCTION

<table>
<thead>
<tr>
<th>Warehouse Size</th>
<th>Annual Personnel Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0 &lt; F \leq 2000$</td>
<td>$P(F) = 27,414$</td>
</tr>
<tr>
<td>$2000 &lt; F \leq 5000$</td>
<td>$P(F) = 9,138 + 9.1380*F$</td>
</tr>
<tr>
<td>$5000 &lt; F \leq 15000$</td>
<td>$P(F) = 13,707 + 8.2242*F$</td>
</tr>
<tr>
<td>$15000 &lt; F$</td>
<td>$P(F) = 34,267.50 + 6.8535*F$</td>
</tr>
</tbody>
</table>

$F$ = Warehouse size (square meters)

$P(F)$ = Annual warehouse personnel cost (1977 $/year)

- **Maintenance Cost Rate**
  
  Maintenance costs for a warehouse can be approximated as a percent of the capital cost of the building and equipment.

  $m = $Maintenance Cost Rate ($/year) = 1%/year

- **Utility Cost Rate**
  
  For a warehouse the major utility expense is the electric power cost. Hence, only electricity costs are computed directly. Other utility expenses (telephone, water, sewage disposal, fuel oil, etc.) are assumed to be a multiple of the total electricity cost. Since utility expenses are a small portion of the total warehouse operating cost, this simplifying assumption will not affect the end results significantly. Following are the assumptions for computing the annual utility cost rate per square meter of warehouse space:
Electric Power Cost:

Capacity = \( \frac{0.5 \, \text{watts}}{\text{square foot}} \times \frac{1 \, \text{square foot}}{0.0929 \, \text{square meters}} \)

= 5.38 \, \text{watts/square meter}

Demand = \( 40\% \times \frac{365 \, \text{days}}{\text{year}} \times \frac{24 \, \text{hours}}{\text{day}} \)

= 3504 \, \text{hours/year}

Rate = \$0.0319/\text{kilowatt-hour} \, \text{(in 1977 dollars)}

Cost = \( 5.38 \times \frac{3504}{1000} \times 0.0319 \)

= \$0.60/\text{square meter}

Total Utility Cost:

\( \omega \) = Warehouse Utility Cost Rate

\( \omega = 2 \) (electric power cost)

= $1.20/\text{square meter/year}

The electricity cost rate is from Springfield, Illinois in Region III in 1977. The utility cost index must be used to obtain the cost for other regions, and the utility inflation rate must be used to adjust for other years.

- **Insurance Rate**

The cost of insurance for a warehouse is assumed to be 1\% of the original book value of the warehouse building and equipment.

\( \gamma \) = Insurance Rate (\% of capital cost/year)

= 1\%/year

- **Property Tax Rate**

Property taxes are assumed to be 4\% of the market value of the warehouse building and equipment.

\( \beta \) = Property Tax Rate (\% of capital cost/year)

= 4\%/year

The annual leasing cost for both the warehouse building and equipment is computed to yield the lessor a gross return of 12.5\% on the capital investment. The economic lives are assumed to be five years for equipment and 40 years for buildings.
- **Equipment Lease Rate**

\[ \gamma_e = \frac{(1-s)}{1 - (1+i)^{-n}} \]

where

- \( s = \) Salvage Value Fraction = .10; that is \((1-s) = \) Effective replacement cost (that is, purchase price minus salvage value) fraction of the purchase price
- \( n = \) Economic Life = 5 years
- \( i = \) Lessor's Rate of Return = 12.5%
- \( \gamma_e = .25 \)

- **Building Lease Rate**

\[ \gamma_b = \frac{(1-s)}{1 - (1+i)^{-n}} \]

where

- \( s = 0 \)
- \( n = 40 \) years
- \( i = 12.5\% \)
- \( \gamma_b = .126 \)

- **Inventory Carrying Charge Rate**

Inventory carrying charges represent the cost of capital tied up in inventories. The model computes this cost by multiplying the average inventory value by the carrying charge rate, \( \gamma' \). The standard value of \( \gamma' \) is computed as follows:

\[ \gamma' = \text{Inventory Carrying Charge Rate} \]

\[ \gamma' = \frac{1}{\lambda} \left( \frac{1}{\lambda} \right) + \left( \frac{1}{1-\tau} \right) - \left( \frac{1}{1-\tau} \right) \]

where

- \( i = \) Cost of debt capital = .105
- \( \lambda = \) Leverage ratio = \( \frac{\text{Total capital}}{\text{Total equity}} = 1.2 \)
- \( \tau = \) Rate of return on equity = .21
- \( \gamma' = \) Effective income Tax Rate = .51
- \( \Upsilon = \) Inventory Insurance Rate = .01

The values listed above yield \( \gamma' = 37.75\% \)

- C-10
APPENDIX D

TEST CASE CALCULATIONS

1. MARKETING MODEL CALCULATIONS INDEX
   Page D-2

2. DISTRIBUTION MODEL CALCULATIONS INDEX
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3. FINANCIAL MODEL CALCULATIONS
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## MARKETING MODEL CALCULATIONS

### INDEX

<table>
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<tr>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
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<tr>
<td>Marketing Expense Summary (For All Products by Region)</td>
<td>D-3</td>
</tr>
<tr>
<td>Salaries and Benefits (By Product and Region)</td>
<td>D-4</td>
</tr>
<tr>
<td>Sales Expenses (By Product and Region)</td>
<td>D-5</td>
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<td>Office Facilities Expenses (By Product and Region)</td>
<td>D-6</td>
</tr>
<tr>
<td>Advertising Expenses (By Product and Region)</td>
<td>D-7</td>
</tr>
<tr>
<td>Total Marketing Expenses (By Product and Region)</td>
<td>D-8</td>
</tr>
<tr>
<td>Marketing Expense Summary (For Household Products by Region)</td>
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<td>Marketing Expense Summary (For Intermediate Commercial Products by Region)</td>
<td>D-10</td>
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<td>Marketing Expense Summary (For Central Power Station Products by Region)</td>
<td>D-11</td>
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<td>Sales and Marketing Personnel Cost Summary</td>
<td>D-12</td>
</tr>
<tr>
<td>(By Personnel Category and Region)</td>
<td></td>
</tr>
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<td>Salesman Costs (By Product and Region)</td>
<td>D-13</td>
</tr>
<tr>
<td>Direct Sales Support Personnel Costs</td>
<td>D-14</td>
</tr>
<tr>
<td>Indirect Sales Support Personnel Costs</td>
<td>D-15</td>
</tr>
<tr>
<td>Sales and Marketing Personnel Summary</td>
<td>D-16</td>
</tr>
<tr>
<td>(By Personnel Category and Region)</td>
<td></td>
</tr>
<tr>
<td>Sales Force Size (By Product and Region)</td>
<td>D-17</td>
</tr>
<tr>
<td>Salesman Productivity and Support Indices</td>
<td>D-18</td>
</tr>
<tr>
<td>Direct Sales Support Personnel Requirements</td>
<td>D-19</td>
</tr>
<tr>
<td>(By Personnel Type and Region)</td>
<td></td>
</tr>
<tr>
<td>Indirect Sales Support Personnel Requirements</td>
<td>D-20</td>
</tr>
<tr>
<td>(By Personnel Type and Region)</td>
<td></td>
</tr>
<tr>
<td>Sales and Marketing Office Facilities Expenses</td>
<td>D-21</td>
</tr>
</tbody>
</table>
MARKETING EXPENSE SUMMARY
(For All Products by Region)

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Salaries and Benefits</th>
<th>Salaries Expenses</th>
<th>Office Facilities Expenses</th>
<th>Advertising Expenses</th>
<th>Total Marketing Expenses</th>
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</thead>
<tbody>
<tr>
<td>I West Coast</td>
<td>$11,600,665</td>
<td>$1,144,634</td>
<td>$357,015</td>
<td>$1,246,700</td>
<td>$14,349,014</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>13,585,452</td>
<td>1,350,541</td>
<td>380,565</td>
<td>1,486,450</td>
<td>16,803,008</td>
</tr>
<tr>
<td>III North Central</td>
<td>1,996,253</td>
<td>206,411</td>
<td>69,525</td>
<td>239,750</td>
<td>2,511,939</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>2,285,647</td>
<td>236,333</td>
<td>66,169</td>
<td>239,750</td>
<td>2,827,899</td>
</tr>
<tr>
<td>V North Eastern</td>
<td>4,603,451</td>
<td>426,200</td>
<td>168,483</td>
<td>527,450</td>
<td>5,725,584</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>1,689,135</td>
<td>174,657</td>
<td>62,261</td>
<td>239,750</td>
<td>2,165,803</td>
</tr>
<tr>
<td>VII South Central</td>
<td>8,011,289</td>
<td>781,629</td>
<td>255,357</td>
<td>1,006,950</td>
<td>10,055,225</td>
</tr>
<tr>
<td>All Regions</td>
<td>$43,771,892</td>
<td>$4,320,405</td>
<td>$1,359,375</td>
<td>$4,986,800</td>
<td>$54,438,472</td>
</tr>
</tbody>
</table>

*Costs are expressed in 1986 (manufacturing year) dollars.
### SALARIES AND BENEFITS*
*By Product and Region*

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Residential Household Products</th>
<th>Intermediate Commercial Products</th>
<th>Central Power Stations</th>
<th>Total Salaries and Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>I West Coast</td>
<td>$7,667,142</td>
<td>$2,765,895</td>
<td>$1,167,628</td>
<td>$11,600,665</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>9,127,576</td>
<td>3,293,462</td>
<td>1,164,414</td>
<td>13,585,452</td>
</tr>
<tr>
<td>III North Central</td>
<td>1,466,447</td>
<td>529,806</td>
<td>0</td>
<td>1,996,253</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>1,679,036</td>
<td>606,611</td>
<td>0</td>
<td>2,285,647</td>
</tr>
<tr>
<td>V North Eastern</td>
<td>2,683,643</td>
<td>966,761</td>
<td>953,047</td>
<td>4,063,451</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>1,240,838</td>
<td>448,297</td>
<td>0</td>
<td>1,689,135</td>
</tr>
<tr>
<td>VII South Central</td>
<td>5,169,816</td>
<td>1,864,431</td>
<td>977,042</td>
<td>8,011,289</td>
</tr>
<tr>
<td>All Regions</td>
<td>$29,034,498</td>
<td>$10,475,263</td>
<td>$4,262,131</td>
<td>$43,771,892</td>
</tr>
</tbody>
</table>

*Expressed in 1986 (manufacturing year) dollars and adjusted by the regional labor cost indices.
SALES EXPENSES*  
(By Product and Region)

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Residential Household Products</th>
<th>Intermediate Commercial Products</th>
<th>Central Power Stations</th>
<th>Total Advertising Expense</th>
</tr>
</thead>
<tbody>
<tr>
<td>I  West Coast</td>
<td>$783,094</td>
<td>$339,547</td>
<td>$21,993</td>
<td>$1,144,634</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>926,936</td>
<td>401,912</td>
<td>21,693</td>
<td>1,350,541</td>
</tr>
<tr>
<td>III North Central</td>
<td>143,984</td>
<td>62,427</td>
<td>0</td>
<td>206,411</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>164,857</td>
<td>71,476</td>
<td>0</td>
<td>236,333</td>
</tr>
<tr>
<td>V North Eastern</td>
<td>283,417</td>
<td>122,885</td>
<td>19,893</td>
<td>426,200</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>121,833</td>
<td>52,824</td>
<td>0</td>
<td>174,657</td>
</tr>
<tr>
<td>VII South Central</td>
<td>532,189</td>
<td>230,757</td>
<td>18,683</td>
<td>781,629</td>
</tr>
<tr>
<td>All Regions</td>
<td>$2,956,310</td>
<td>$1,281,828</td>
<td>$82,267</td>
<td>$4,320,405</td>
</tr>
</tbody>
</table>

*Expressed in 1986 (manufacturing year) dollars. Sales expenses include office supplies, travel and entertainment, and communication.
**OFFICE FACILITIES EXPENSES**  
(By Product and Region)

<table>
<thead>
<tr>
<th>Market</th>
<th>Residential Household Products</th>
<th>Intermediate Commercial Products</th>
<th>Central Power Stations</th>
<th>Total Office Facilities Expense</th>
</tr>
</thead>
<tbody>
<tr>
<td>I West Coast</td>
<td>$214,178</td>
<td>$80,364</td>
<td>$62,473</td>
<td>$357,015</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>235,165</td>
<td>88,238</td>
<td>57,162</td>
<td>380,565</td>
</tr>
<tr>
<td>III North Central</td>
<td>50,556</td>
<td>18,969</td>
<td>0</td>
<td>69,525</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>48,116</td>
<td>18,053</td>
<td>0</td>
<td>66,169</td>
</tr>
<tr>
<td>V North Eastern</td>
<td>81,185</td>
<td>30,461</td>
<td>56,837</td>
<td>168,483</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>45,274</td>
<td>16,987</td>
<td>0</td>
<td>62,261</td>
</tr>
<tr>
<td>VII South Central</td>
<td>146,770</td>
<td>55,072</td>
<td>53,515</td>
<td>255,357</td>
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<tr>
<td>All Regions</td>
<td>$821,244</td>
<td>$308,144</td>
<td>$229,987</td>
<td>$1,359,375</td>
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</table>

*Expressed in 1986 (manufacturing year) dollars and adjusted by the regional facilities cost indices.
### Advertising Expenses*
(By Product and Region)

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Residential Products</th>
<th>Intermediate Products</th>
<th>Central Power Stations</th>
<th>Total Advertising Expense</th>
</tr>
</thead>
<tbody>
<tr>
<td>I West Coast</td>
<td>$959,000</td>
<td>$239,750</td>
<td>$47,950</td>
<td>$1,246,700</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>1,150,800</td>
<td>287,700</td>
<td>47,950</td>
<td>1,486,450</td>
</tr>
<tr>
<td>III North Central</td>
<td>191,800</td>
<td>47,950</td>
<td>0</td>
<td>239,750</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>191,800</td>
<td>47,950</td>
<td>0</td>
<td>239,750</td>
</tr>
<tr>
<td>V North Eastern</td>
<td>383,600</td>
<td>95,900</td>
<td>47,950</td>
<td>527,450</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>191,800</td>
<td>47,950</td>
<td>0</td>
<td>239,750</td>
</tr>
<tr>
<td>VII South Central</td>
<td>767,200</td>
<td>191,800</td>
<td>47,950</td>
<td>1,006,950</td>
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<tr>
<td>All Regions</td>
<td>$3,836,000</td>
<td>$959,000</td>
<td>$191,800</td>
<td>$4,986,800</td>
</tr>
</tbody>
</table>

*Expressed in 1986 (manufacturing year) dollars.
## TOTAL MARKETING EXPENSES
(By Product and Region)

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Residential Household Products</th>
<th>Intermediate Commercial Products</th>
<th>Central Power Stations</th>
<th>Total Advertising Expense</th>
</tr>
</thead>
<tbody>
<tr>
<td>I West Coast</td>
<td>$9,263,414</td>
<td>$3,425,556</td>
<td>$1,300,044</td>
<td>$14,349,014</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>11,440,477</td>
<td>4,071,312</td>
<td>1,291,219</td>
<td>16,803,008</td>
</tr>
<tr>
<td>III North Central</td>
<td>1,852,787</td>
<td>659,152</td>
<td>0</td>
<td>2,511,939</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>2,083,809</td>
<td>744,090</td>
<td>0</td>
<td>2,827,899</td>
</tr>
<tr>
<td>V North Eastern</td>
<td>3,431,845</td>
<td>1,216,007</td>
<td>1,077,732</td>
<td>5,725,584</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>1,599,745</td>
<td>566,058</td>
<td>0</td>
<td>2,165,803</td>
</tr>
<tr>
<td>VII South Central</td>
<td>6,615,975</td>
<td>2,342,060</td>
<td>1,097,190</td>
<td>10,055,225</td>
</tr>
<tr>
<td>All Regions</td>
<td>$36,648,052</td>
<td>$13,024,235</td>
<td>$4,766,185</td>
<td>$54,438,472</td>
</tr>
</tbody>
</table>
## MARKETING EXPENSE SUMMARY
(For Household Products by Region)

<table>
<thead>
<tr>
<th>Region</th>
<th>Salaries And Benefits</th>
<th>Sales Expenses</th>
<th>Office Facilities Expense</th>
<th>Advertising Expenses</th>
<th>Total Marketing Expenses</th>
</tr>
</thead>
<tbody>
<tr>
<td>I West Coast</td>
<td>$7,667,142</td>
<td>$783,094</td>
<td>$214,178</td>
<td>$959,000</td>
<td>$9,623,414</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>9,127,576</td>
<td>926,936</td>
<td>235,165</td>
<td>1,150,800</td>
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<td>81,185</td>
<td>383,600</td>
<td>3,431,845</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>1,240,838</td>
<td>121,833</td>
<td>45,274</td>
<td>191,800</td>
<td>1,599,745</td>
</tr>
<tr>
<td>VII South Central</td>
<td>5,169,816</td>
<td>532,189</td>
<td>146,770</td>
<td>767,200</td>
<td>6,615,975</td>
</tr>
<tr>
<td>All Regions</td>
<td>$29,034,498</td>
<td>$2,956,310</td>
<td>$821,244</td>
<td>$3,836,000</td>
<td>$36,648,052</td>
</tr>
</tbody>
</table>

*Expressed in 1986 (manufacturing year) dollars.*
MARKETING EXPENSE SUMMARY*
(For Intermediate Commercial Products by Region)

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Salaries And Benefits</th>
<th>Sales Expenses</th>
<th>Office Facilities Expense</th>
<th>Advertising Expenses</th>
<th>Total Marketing Expenses</th>
</tr>
</thead>
<tbody>
<tr>
<td>I West Coast</td>
<td>$2,765,895</td>
<td>$339,547</td>
<td>$80,364</td>
<td>$239,750</td>
<td>$3,425,556</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>3,293,462</td>
<td>401,912</td>
<td>88,238</td>
<td>287,700</td>
<td>4,071,312</td>
</tr>
<tr>
<td>III North Central</td>
<td>529,806</td>
<td>62,427</td>
<td>18,969</td>
<td>47,950</td>
<td>659,152</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>606,611</td>
<td>71,476</td>
<td>18,053</td>
<td>47,950</td>
<td>744,090</td>
</tr>
<tr>
<td>V North Eastern</td>
<td>966,761</td>
<td>122,885</td>
<td>30,461</td>
<td>95,900</td>
<td>1,216,007</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>448,297</td>
<td>52,824</td>
<td>16,987</td>
<td>47,950</td>
<td>566,058</td>
</tr>
<tr>
<td>VII South Central</td>
<td>1,864,431</td>
<td>230,757</td>
<td>55,072</td>
<td>191,800</td>
<td>2,342,060</td>
</tr>
<tr>
<td>All Regions</td>
<td>$10,475,263</td>
<td>$1,281,828</td>
<td>$308,144</td>
<td>$959,000</td>
<td>$13,024,235</td>
</tr>
</tbody>
</table>

*Expressed in 1986 (manufacturing year) dollars.
MARKETING EXPENSE SUMMARY*
(For Central Power Station Products By Region)

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Salaries And Benefits</th>
<th>Sales Expenses</th>
<th>Office Facilities Expenses</th>
<th>Advertising Expenses</th>
<th>Total Marketing Expenses</th>
</tr>
</thead>
<tbody>
<tr>
<td>I West Coast</td>
<td>$1,167,628</td>
<td>$21,993</td>
<td>$62,473</td>
<td>$47,950</td>
<td>$1,300,044</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>1,164,414</td>
<td>21,693</td>
<td>57,162</td>
<td>47,950</td>
<td>1,291,219</td>
</tr>
<tr>
<td>III North Central</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>V North Eastern</td>
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<td>19,898</td>
<td>56,837</td>
<td>47,950</td>
<td>1,077,732</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>VII South Central</td>
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<td>18,683</td>
<td>53,515</td>
<td>47,950</td>
<td>1,097,190</td>
</tr>
<tr>
<td>All Regions</td>
<td>$4,262,131</td>
<td>$82,267</td>
<td>$229,987</td>
<td>$191,800</td>
<td>$4,766,185</td>
</tr>
</tbody>
</table>

*Expressed in 1986 (manufacturing year) dollars.
### Sales and Marketing Personnel Cost Summary

(By Personnel Category and Region)

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Salesman</th>
<th>Direct Sales Support Staff</th>
<th>Indirect Sales Support Staff</th>
<th>Total Sales Personnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>I West Coast</td>
<td>$5,346,964</td>
<td>$2,674,567</td>
<td>$3,579,134</td>
<td>$11,600,665</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>6,314,644</td>
<td>3,073,567</td>
<td>4,197,241</td>
<td>13,585,452</td>
</tr>
<tr>
<td>III North Central</td>
<td>969,632</td>
<td>405,687</td>
<td>620,934</td>
<td>1,996,253</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>1,110,200</td>
<td>464,500</td>
<td>710,947</td>
<td>2,285,647</td>
</tr>
<tr>
<td>V North Eastern</td>
<td>1,974,954</td>
<td>1,222,062</td>
<td>1,406,435</td>
<td>4,603,451</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>820,458</td>
<td>343,274</td>
<td>525,403</td>
<td>1,689,135</td>
</tr>
<tr>
<td>VII South Central</td>
<td>3,646,254</td>
<td>1,897,294</td>
<td>2,467,741</td>
<td>8,011,289</td>
</tr>
</tbody>
</table>

| All Regions      | $20,183,106 | $10,080,951              | $13,507,835                 | $43,771,892           |

*Costs are expressed in 1986 (manufacturing year) dollars and adjusted by the regional labor cost indices. Compensation includes both salaries and benefits.
SALESMAN COSTS*  
(By Product and Region)

<table>
<thead>
<tr>
<th>Personnel Description (Base Compensation) 1977 Dollars</th>
<th>West Coast I</th>
<th>Rocky Mountain II</th>
<th>North Central III</th>
<th>Great Lakes IV</th>
<th>North Eastern V</th>
<th>South Eastern VI</th>
<th>South Central VII</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salesman, Household Products ($18,060)</td>
<td>$3,915,472</td>
<td>$4,634,686</td>
<td>$719,922</td>
<td>$824,290</td>
<td>$1,417,638</td>
<td>$609,165</td>
<td>$2,660,947</td>
</tr>
<tr>
<td>Salesman, Intermediate Commercial ($24,000)</td>
<td>$1,358,184</td>
<td>$1,607,646</td>
<td>$249,710</td>
<td>$285,910</td>
<td>$491,537</td>
<td>$211,293</td>
<td>$923,032</td>
</tr>
<tr>
<td>Salesman, Central Power Stations ($31,920)</td>
<td>$73,308</td>
<td>$72,312</td>
<td>0</td>
<td>0</td>
<td>$66,329</td>
<td>0</td>
<td>$62,275</td>
</tr>
<tr>
<td>Total Salesman Cost</td>
<td>$5,346,964</td>
<td>$6,314,644</td>
<td>$969,632</td>
<td>$1,110,200</td>
<td>$1,974,954</td>
<td>$820,458</td>
<td>$3,646,254</td>
</tr>
</tbody>
</table>

*Expressed in 1986 (manufacturing year) dollars/year and adjusted by the regional labor cost indices. Base compensation includes both salary and benefits.
## DIRECT SALES SUPPORT PERSONNEL COSTS*

<table>
<thead>
<tr>
<th>Personnel Description (Base Compensation) 1977 Dollars</th>
<th>Market Region</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>West Coast I</td>
</tr>
<tr>
<td>Field Engineer ($26,400)</td>
<td>$1,923,414</td>
</tr>
<tr>
<td>Commercial Artist ($12,320)</td>
<td>44,876</td>
</tr>
<tr>
<td>Market Research Analyst ($25,200)</td>
<td>367,163</td>
</tr>
<tr>
<td>Technical Illustrator ($18,900)</td>
<td>137,685</td>
</tr>
<tr>
<td>Technical Writer ($18,900)</td>
<td>137,685</td>
</tr>
<tr>
<td>Advertising Salesman ($17,500)</td>
<td>63,744</td>
</tr>
<tr>
<td><strong>Total Direct Sales Support Personnel Cost</strong></td>
<td><strong>$2,674,567</strong></td>
</tr>
</tbody>
</table>

*Expressed in 1986 (manufacturing year) dollars/year and adjusted by the regional labor cost indices base compensation includes both salary and benefits.
### INDIRECT SALES SUPPORT PERSONNEL COSTS*

<table>
<thead>
<tr>
<th>Personnel Description</th>
<th>Market Region</th>
<th>West Coast</th>
<th>Rocky Mountain</th>
<th>North Central</th>
<th>Great Lakes</th>
<th>North Eastern</th>
<th>South Eastern</th>
<th>South Central</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
<td>IV</td>
<td>V</td>
<td>VI</td>
<td>VII</td>
</tr>
<tr>
<td>Regional Vice President</td>
<td>($59,800)</td>
<td>$706,204</td>
<td>$827,702</td>
<td>$122,063</td>
<td>$139,758</td>
<td>$278,927</td>
<td>$103,285</td>
<td>$487,353</td>
</tr>
<tr>
<td>Manager, Advertising</td>
<td>($38,400)</td>
<td>38,439</td>
<td>44,682</td>
<td>5,915</td>
<td>6,773</td>
<td>17,773</td>
<td>5,006</td>
<td>27,548</td>
</tr>
<tr>
<td>Manager, Market Research</td>
<td>($38,400)</td>
<td>93,220</td>
<td>107,153</td>
<td>14,167</td>
<td>16,220</td>
<td>42,595</td>
<td>11,986</td>
<td>66,171</td>
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<tr>
<td>Manager, Sales</td>
<td>($38,400)</td>
<td>1,309,224</td>
<td>1,545,313</td>
<td>236,700</td>
<td>271,015</td>
<td>485,772</td>
<td>200,284</td>
<td>893,461</td>
</tr>
<tr>
<td>Manager, Sales Engineering</td>
<td>($38,400)</td>
<td>372,964</td>
<td>428,693</td>
<td>56,666</td>
<td>64,880</td>
<td>170,377</td>
<td>47,948</td>
<td>264,686</td>
</tr>
<tr>
<td>Secretary I (Lower Management)</td>
<td>($13,650)</td>
<td>527,539</td>
<td>620,739</td>
<td>93,547</td>
<td>107,109</td>
<td>201,052</td>
<td>79,155</td>
<td>361,702</td>
</tr>
<tr>
<td>Secretary II (Middle Management)</td>
<td>($14,560)</td>
<td>343,891</td>
<td>403,023</td>
<td>59,438</td>
<td>68,056</td>
<td>135,824</td>
<td>50,295</td>
<td>237,320</td>
</tr>
<tr>
<td>Secretary III (Upper Management)</td>
<td>($15,890)</td>
<td>187,653</td>
<td>219,936</td>
<td>32,434</td>
<td>37,136</td>
<td>74,115</td>
<td>27,444</td>
<td>129,500</td>
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<tr>
<td>Total Indirect Sales Support Personnel Costs</td>
<td></td>
<td>$3,579,134</td>
<td>$4,197,241</td>
<td>$620,934</td>
<td>$710,947</td>
<td>$1,406,435</td>
<td>$525,403</td>
<td>$2,467,741</td>
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</tbody>
</table>

*Expressed in 1986 (manufacturing year) dollars/year and adjusted by the regional labor cost indices. Base compensation includes both salary and benefits.*
SALES AND MARKETING PERSONNEL SUMMARY
(By Personnel Category and Region)

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Salesman</th>
<th>Direct Sales Support Staff</th>
<th>Indirect Sales Support Staff</th>
<th>Total Sales Personnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>I West Coast</td>
<td>125.036</td>
<td>49.563</td>
<td>60.375</td>
<td>234.974</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>149.834</td>
<td>57.744</td>
<td>71.818</td>
<td>279.396</td>
</tr>
<tr>
<td>III North Central</td>
<td>24.799</td>
<td>8.178</td>
<td>11.346</td>
<td>44.413</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>24.799</td>
<td>8.178</td>
<td>11.346</td>
<td>44.413</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>24.799</td>
<td>8.178</td>
<td>11.346</td>
<td>44.413</td>
</tr>
<tr>
<td>VII South Central</td>
<td>100.237</td>
<td>41.389</td>
<td>48.956</td>
<td>190.582</td>
</tr>
<tr>
<td>All Regions</td>
<td>500.142</td>
<td>198.259</td>
<td>241.545</td>
<td>939.946</td>
</tr>
<tr>
<td></td>
<td>(53%)</td>
<td>(21%)</td>
<td>(26%)</td>
<td>(100%)</td>
</tr>
</tbody>
</table>
## SALES FORCE SIZE
*(By Product and Region)*

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Residential Household</th>
<th>Commercial Intermediate</th>
<th>Public Utility Central Station</th>
<th>All Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td>I West Coast</td>
<td>98.328</td>
<td>25.666</td>
<td>1.0415</td>
<td>125.036</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>117.994</td>
<td>30.799</td>
<td>1.0415</td>
<td>149.834</td>
</tr>
<tr>
<td>III North Central</td>
<td>19.666</td>
<td>5.133</td>
<td>0.0000</td>
<td>24.799</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>19.666</td>
<td>5.133</td>
<td>0.0000</td>
<td>24.799</td>
</tr>
<tr>
<td>V North Eastern</td>
<td>39.331</td>
<td>10.266</td>
<td>1.0415</td>
<td>50.638</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>19.666</td>
<td>5.133</td>
<td>0.0000</td>
<td>24.799</td>
</tr>
<tr>
<td>VII South Central</td>
<td>78.662</td>
<td>20.533</td>
<td>1.0415</td>
<td>100.237</td>
</tr>
<tr>
<td>All Regions</td>
<td>393.313</td>
<td>102.663</td>
<td>4.1664</td>
<td>500.142</td>
</tr>
<tr>
<td>Customer Type</td>
<td>Number Of Customers All Regions Per Year</td>
<td>Average Order Quantity ( ACQ_i ) (MW)</td>
<td>Megawatt Sales Per Salesman ( MW_{Si} ) (MW/YR)</td>
<td>Salesman Support Index (SSI_i)</td>
</tr>
<tr>
<td>---------------</td>
<td>-----------------------------------------</td>
<td>----------------------------------------</td>
<td>-----------------------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>1 Residential Household</td>
<td>20,000</td>
<td>.01</td>
<td>50.850</td>
<td>.1008</td>
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<tr>
<td>2 Commercial Intermediate</td>
<td>200</td>
<td>.50</td>
<td>1.948</td>
<td>.1449</td>
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<td>3 Public Utility Central Station</td>
<td>4</td>
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<td>.960</td>
<td>48.0040</td>
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<td>All Regions</td>
<td>20,204</td>
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<td>40.408</td>
<td>.997</td>
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</table>
### Direct Sales Support Personnel Requirements

*(By Personnel Type and Region)*

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Personnel Type</th>
<th>Field Engineer 1</th>
<th>Commercial Artist 2</th>
<th>Market Research Analyst 3</th>
<th>Technical Illustrator 4</th>
<th>Technical Writer 5</th>
<th>Advertising Salesman 6</th>
<th>Total Direct Sales Support Personnel in Region j TSPj</th>
</tr>
</thead>
<tbody>
<tr>
<td>I  West Coast</td>
<td></td>
<td>33.043</td>
<td>1.652</td>
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<td>3.304</td>
<td>3.304</td>
<td>1.652</td>
<td>49.563</td>
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<td>38.495</td>
<td>1.925</td>
<td>7.699</td>
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<td>3.850</td>
<td>1.925</td>
<td>57.744</td>
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<tr>
<td>III North Central</td>
<td></td>
<td>5.452</td>
<td>.273</td>
<td>1.090</td>
<td>.545</td>
<td>.545</td>
<td>.273</td>
<td>8.178</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td></td>
<td>5.452</td>
<td>.273</td>
<td>1.090</td>
<td>.545</td>
<td>.545</td>
<td>.273</td>
<td>8.178</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td></td>
<td>5.452</td>
<td>.273</td>
<td>1.090</td>
<td>.545</td>
<td>.545</td>
<td>.273</td>
<td>8.178</td>
</tr>
<tr>
<td>VII South Central</td>
<td></td>
<td>27.591</td>
<td>1.380</td>
<td>5.518</td>
<td>2.760</td>
<td>2.760</td>
<td>1.380</td>
<td>41.389</td>
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</table>
## INDIRECT SALES SUPPORT PERSONNEL REQUIREMENTS
(By Personnel Type and Region)

<table>
<thead>
<tr>
<th>Personnel Description</th>
<th>Market Region</th>
<th>West Coast</th>
<th>Rocky Mountain</th>
<th>North Central</th>
<th>Great Lakes</th>
<th>North Eastern</th>
<th>South Eastern</th>
<th>South Central</th>
<th>All Regions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
<td>IV</td>
<td>V</td>
<td>VI</td>
<td>VII</td>
<td></td>
</tr>
<tr>
<td>Regional Vice President</td>
<td></td>
<td>5.356</td>
<td>6.364</td>
<td>1.007</td>
<td>1.007</td>
<td>2.338</td>
<td>1.007</td>
<td>4.351</td>
<td>21.430</td>
</tr>
<tr>
<td>Manager, Advertising</td>
<td></td>
<td>.454</td>
<td>.535</td>
<td>.076</td>
<td>.076</td>
<td>.232</td>
<td>.076</td>
<td>.383</td>
<td>1.832</td>
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<tr>
<td>Manager, Market Research</td>
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<td>1.101</td>
<td>1.283</td>
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<td>.182</td>
<td>.556</td>
<td>.182</td>
<td>.920</td>
<td>4.406</td>
</tr>
<tr>
<td>Manager, Sales</td>
<td></td>
<td>15.463</td>
<td>18.503</td>
<td>3.041</td>
<td>3.041</td>
<td>6.341</td>
<td>3.041</td>
<td>12.422</td>
<td>61.852</td>
</tr>
<tr>
<td>Manager, Sales Engineering</td>
<td></td>
<td>4.405</td>
<td>5.133</td>
<td>.728</td>
<td>.728</td>
<td>2.224</td>
<td>.728</td>
<td>3.680</td>
<td>17.626</td>
</tr>
<tr>
<td>Secretary I (Lower Mgmt.)</td>
<td></td>
<td>17.528</td>
<td>20.909</td>
<td>3.381</td>
<td>3.381</td>
<td>7.383</td>
<td>3.381</td>
<td>14.147</td>
<td>70.110</td>
</tr>
<tr>
<td>Secretary II (Middle Mgmt.)</td>
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<td>10.712</td>
<td>12.727</td>
<td>2.014</td>
<td>2.014</td>
<td>4.676</td>
<td>2.014</td>
<td>8.702</td>
<td>42.859</td>
</tr>
<tr>
<td>Secretary III (Upper Mgmt.)</td>
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<td>5.356</td>
<td>6.364</td>
<td>1.007</td>
<td>1.007</td>
<td>2.338</td>
<td>1.007</td>
<td>4.351</td>
<td>21.430</td>
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</tbody>
</table>
## Sales and Marketing Office Facilities Expenses

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I West Coast</td>
<td>1.062</td>
<td>1.320</td>
<td>235</td>
<td>2,926</td>
<td>$1,850,936</td>
<td>$233,118</td>
<td>$12,853</td>
<td>$18,502</td>
<td>$92,542</td>
<td>$357,015</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>0.969</td>
<td>0.820</td>
<td>279</td>
<td>3,475</td>
<td>1,995,073</td>
<td>251,379</td>
<td>9,461</td>
<td>19,951</td>
<td>99,754</td>
<td>380,565</td>
</tr>
<tr>
<td>III North Central</td>
<td>1.052</td>
<td>0.500</td>
<td>44</td>
<td>548</td>
<td>364,963</td>
<td>45,986</td>
<td>1,642</td>
<td>3,649</td>
<td>18,248</td>
<td>69,525</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>1.000</td>
<td>0.500</td>
<td>44</td>
<td>548</td>
<td>346,923</td>
<td>43,712</td>
<td>1,642</td>
<td>3,469</td>
<td>17,346</td>
<td>66,169</td>
</tr>
<tr>
<td>V North Eastern</td>
<td>1.114</td>
<td>1.300</td>
<td>102</td>
<td>1,270</td>
<td>876,287</td>
<td>110,412</td>
<td>5,493</td>
<td>8,764</td>
<td>43,814</td>
<td>168,483</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>0.938</td>
<td>0.950</td>
<td>44</td>
<td>548</td>
<td>325,413</td>
<td>41,003</td>
<td>1,733</td>
<td>3,254</td>
<td>16,271</td>
<td>62,261</td>
</tr>
<tr>
<td>VII South Central</td>
<td>0.927</td>
<td>1.200</td>
<td>191</td>
<td>2,378</td>
<td>1,321,836</td>
<td>166,552</td>
<td>9,495</td>
<td>13,218</td>
<td>66,092</td>
<td>255,357</td>
</tr>
<tr>
<td><strong>All Regions</strong></td>
<td><strong>1.041</strong></td>
<td><strong>1.000</strong></td>
<td><strong>939</strong></td>
<td><strong>11,693</strong></td>
<td><strong>$7,081,333</strong></td>
<td><strong>$892,162</strong></td>
<td><strong>$42,339</strong></td>
<td><strong>$70,807</strong></td>
<td><strong>$354,067</strong></td>
<td><strong>$1,359,375</strong></td>
</tr>
</tbody>
</table>
**INDEX**

<table>
<thead>
<tr>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Annual Distribution Cost Calculations for the West Coast Region</td>
<td>D-23</td>
</tr>
<tr>
<td>Direct - Factory West Coast Customer Shipments Cost Calculations</td>
<td>D-24</td>
</tr>
<tr>
<td>Warehouse Cost Calculation For Region I West Coast</td>
<td>D-25</td>
</tr>
<tr>
<td>Annual Distribution Cost For West coast Warehouse Transshipments</td>
<td>D-26</td>
</tr>
<tr>
<td>Direct - Factory Rocky Mountain Customer Shipments Cost Calculations</td>
<td>D-27</td>
</tr>
<tr>
<td>Total Annual Distribution Cost Calculations for the North Central Region</td>
<td>D-28</td>
</tr>
<tr>
<td>Direct - Factory North Central Customer Shipments Cost Calculations</td>
<td>D-29</td>
</tr>
<tr>
<td>Warehousing Cost Calculation For Region III North Central</td>
<td>D-30</td>
</tr>
<tr>
<td>Annual Distribution Cost For North Central Warehouse Transshipments</td>
<td>D-31</td>
</tr>
<tr>
<td>Total Annual Distribution Cost Calculations for the Great Lakes Region</td>
<td>D-32</td>
</tr>
<tr>
<td>Direct - Factory Great Lakes Customer Shipments Cost Calculations</td>
<td>D-33</td>
</tr>
<tr>
<td>Warehousing Cost Calculation For Region IV Great Lakes</td>
<td>D-34</td>
</tr>
<tr>
<td>Annual Distribution Cost For Great Lakes Warehouse Transshipments</td>
<td>D-35</td>
</tr>
<tr>
<td>Total Annual Distribution Cost Calculations for the North Eastern Region</td>
<td>D-36</td>
</tr>
<tr>
<td>Direct - Factory North Eastern - Customer Shipments Cost Calculations</td>
<td>D-37</td>
</tr>
<tr>
<td>Warehousing Cost Calculation For Region V North Eastern</td>
<td>D-38</td>
</tr>
<tr>
<td>Annual Distribution Cost For North Eastern Warehouse Transshipments</td>
<td>D-39</td>
</tr>
<tr>
<td>Total Annual Distribution Cost Calculations for the South Eastern Region</td>
<td>D-40</td>
</tr>
<tr>
<td>Direct - Factory South Eastern Customer Shipments Cost Calculations</td>
<td>D-41</td>
</tr>
<tr>
<td>Warehousing Cost Calculation For Region VI South Eastern</td>
<td>D-42</td>
</tr>
<tr>
<td>Annual Distribution Cost For South Eastern Warehouse Transshipments</td>
<td>D-43</td>
</tr>
<tr>
<td>Total Annual Distribution Cost Calculations for the South Central Region</td>
<td>D-44</td>
</tr>
<tr>
<td>Direct - Factory South Central Customer Shipments Cost Calculations</td>
<td>D-45</td>
</tr>
<tr>
<td>Warehousing Cost Calculation For Region VII South Central</td>
<td>D-46</td>
</tr>
<tr>
<td>Annual Distribution Cost For South Central Warehouse Transshipments</td>
<td>D-47</td>
</tr>
<tr>
<td></td>
<td>D-22</td>
</tr>
</tbody>
</table>
### TOTAL ANNUAL DISTRIBUTION COST CALCULATIONS

**FROM THE FACTORY IN REGION** $k = \text{II ROCKY MOUNTAIN}

**TO CUSTOMERS IN REGION** $j = \text{I WEST COAST}

<table>
<thead>
<tr>
<th>Customer Type</th>
<th>Shipping Indicator $X_{ij}$</th>
<th>Annual Direct Shipping Cost (1986 $) (D_{X_{ij}})</th>
<th>Annual Distribution Costs For Transshipments (1986 $) (I_{C_{ij}})</th>
<th>Total Annual Distribution Cost Region $j$ (1986 $) (TC_{ij})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>3,272,805.70</strong></td>
<td><strong>0.00</strong></td>
<td><strong>2,856,572.00</strong></td>
</tr>
<tr>
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</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>3,272,805.70</strong></td>
<td><strong>1,627,026.00</strong></td>
<td><strong>4,899,831.70</strong></td>
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<tr>
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<tr>
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<tr>
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<td>0.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>432,523.67</strong></td>
<td><strong>2,333,564.00</strong></td>
<td><strong>2,766,087.67</strong></td>
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</tr>
<tr>
<td>3</td>
<td>0</td>
<td>865,049.73</td>
<td>0.00</td>
<td>865,049.73</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>865,049.73</strong></td>
<td><strong>1,817,623.00</strong></td>
<td><strong>2,682,672.73</strong></td>
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<tr>
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<td>3,272,805.70</td>
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<td><strong>3,272,805.70</strong></td>
</tr>
<tr>
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</tr>
<tr>
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<td>0.00</td>
<td>1,105,809.00</td>
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<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>3,705,329.30</strong></td>
<td><strong>1,105,809.00</strong></td>
<td><strong>4,811,138.30</strong></td>
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<td><strong>3,272,805.70</strong></td>
</tr>
<tr>
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<td>1</td>
<td>0.00</td>
<td>587,513.00</td>
<td>587,513.00</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>865,049.73</td>
<td>0.00</td>
<td>865,049.73</td>
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<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>4,137,855.4</strong></td>
<td><strong>587,513.00</strong></td>
<td><strong>4,725,368.40</strong></td>
</tr>
<tr>
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<td>1</td>
<td>0.00</td>
<td>1,296,406.00</td>
<td>1,296,406.00</td>
</tr>
<tr>
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<td>0</td>
<td>432,523.67</td>
<td>0.00</td>
<td>432,523.67</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>865,049.73</td>
<td>0.00</td>
<td>865,049.73</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>1,297,573.40</strong></td>
<td><strong>1,296,406.00</strong></td>
<td><strong>2,593,979.40</strong></td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>3,272,805.70</td>
<td>0.00</td>
<td><strong>3,272,805.70</strong></td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>432,523.67</td>
<td>0.00</td>
<td>432,523.67</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>865,049.73</td>
<td>0.00</td>
<td>865,049.73</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>4,570,379.10</strong></td>
<td><strong>0.00</strong></td>
<td><strong>4,570,379.10</strong></td>
</tr>
</tbody>
</table>

\(T_{C_{ij}} = D_{C_{ij}} + I_{C_{ij}}\) = Total Distribution Cost in Region $j$ (1986 $)

\(X_{ij} = \begin{cases} 
0 & \text{if customers of type } i \text{ in Region } j \text{ are supplied directly from the factory} \\
1 & \text{if customers of type } i \text{ in Region } j \text{ are supplied from a warehouse in Region } j
\end{cases}\)

D-23
## DIRECT - FACTORY-CUSTOMER SHIPMENTS COST CALCULATIONS

Factory Region \( k = II \) Rocky Mountain  
Market Region \( j = I \) West Coast

### Customer Type Demand in Region \( j \) (MW/yr) \( \text{Customer Type} \)

<table>
<thead>
<tr>
<th>Customer Type</th>
<th>Annual Demand In Region ( j ) (MW/yr) ( d_{ij} )</th>
<th>Average Delivery Quantity (MW/Ship) ( q_i )</th>
<th>Number Shipments Per Year ( \frac{d_{ij}}{q_i} )</th>
<th>Shipment Weight (kg) ( z_i = q_i \cdot w )</th>
<th>Shipping Distance (km) ( s_{kj} )</th>
<th>Shipment Cost ($) ( C(z_i, s_{kj}) )</th>
<th>Annual Cost ($/yr) ( B_{kij} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Household</td>
<td>50.0</td>
<td>0.01</td>
<td>5000</td>
<td>1599.25</td>
<td>640</td>
<td>$356.03 (Truck)</td>
<td>3,272,805.70</td>
</tr>
<tr>
<td>Intermediate Commercial</td>
<td>25.0</td>
<td>0.50</td>
<td>50</td>
<td>77,962.50</td>
<td>640</td>
<td>$4,705.19 (Rail)</td>
<td>432,523.57</td>
</tr>
<tr>
<td>Central Station Utility</td>
<td>50.0</td>
<td>5.00</td>
<td>10</td>
<td>779,625.00</td>
<td>640</td>
<td>$47,051.93 (Rail)</td>
<td>865,049.73</td>
</tr>
</tbody>
</table>

where \( w \) = Solar Array Unit Weight (kg/MW)  
\( = 155,925 \text{ kg/MW} \)

\( B_{kij} \) = Annual distribution cost in Region \( j \) for customers supplied directly from the factory in Region \( k \) (in manufacturing year dollars)

\[ B_{kij} = \sum_{i=1}^{3} d_{ij} * (1-X_{ij}) * C(z_i, s_{kj}) \cdot (1+g_{T}^{1986-1977}) \]

where

\( X_{ij} = \begin{cases} 
0 & \text{if customers of type in Region } j \text{ are supplied directly from the factory} \\
1 & \text{if customers of type } i \text{ in Region } j \text{ are supplied from a warehouse in Region } j 
\end{cases} \)

### Transportation Inflation Rate

\( g_{T} = 7\% \text{/year} \)
WAREHOUSING COST CALCULATION FOR REGION \( j = 1 \) WEST COAST

<table>
<thead>
<tr>
<th>Shipment QTV  ( Q_j ) (MW)</th>
<th>.25</th>
<th>.50</th>
<th>1.00</th>
<th>1.50</th>
<th>2.00</th>
<th>2.50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warehouse size ( F = 353.95 Q_j m^2 )</td>
<td>88.4875</td>
<td>176.975</td>
<td>353.95</td>
<td>530.925</td>
<td>707.90</td>
<td>884.875</td>
</tr>
<tr>
<td>Equipment Cost ( E = (1.07)^9 * Ke (F_j) * e_j )</td>
<td>4,492</td>
<td>8,984</td>
<td>17,968</td>
<td>26,952</td>
<td>35,936</td>
<td>47,919</td>
</tr>
<tr>
<td>Facilities Cost ( B = (1.09)^9 * Kb (F_j) * b_j )</td>
<td>50,201</td>
<td>100,401</td>
<td>196,845</td>
<td>290,508</td>
<td>384,171</td>
<td>477,835</td>
</tr>
<tr>
<td>Warehouse Lease Cost (1986 $/YR) ( LC_j (Q_j) = 0.25E + 0.126B )</td>
<td>7,448</td>
<td>14,897</td>
<td>29,294</td>
<td>43,342</td>
<td>57,389</td>
<td>71,437</td>
</tr>
<tr>
<td>Regional Personnel Cost ( (1.08)^9 * P(F_j) * l_j )</td>
<td>60,445</td>
<td>60,445</td>
<td>60,445</td>
<td>60,445</td>
<td>60,445</td>
<td>60,445</td>
</tr>
<tr>
<td>Utilities Cost ( (1.12)^9 * 1.20* u_j * F_j )</td>
<td>389</td>
<td>777</td>
<td>1,555</td>
<td>2,332</td>
<td>1,310</td>
<td>3,887</td>
</tr>
<tr>
<td>Property Tax, Maintenance and Insurance ( 0.06 * (E + B) )</td>
<td>3,282</td>
<td>6,563</td>
<td>12,889</td>
<td>19,048</td>
<td>25,206</td>
<td>31,365</td>
</tr>
<tr>
<td>Warehouse Operating Cost (1986 $/YR) ( OC_j (Q_j) )</td>
<td>64,116</td>
<td>67,785</td>
<td>74,889</td>
<td>81,825</td>
<td>86,961</td>
<td>95,697</td>
</tr>
<tr>
<td>Inventory Carrying Cost (1986 $/YR) ( CC(Q_j) = 94375*Q_j )</td>
<td>23,594</td>
<td>47,188</td>
<td>94,375</td>
<td>141,562</td>
<td>188,750</td>
<td>235,938</td>
</tr>
<tr>
<td>Warehousing Cost (1986 $/YR) ( W_j (Q_j) = CC(Q_j) + OC_j (Q_j) + LC_j (Q_j) )</td>
<td>95,158</td>
<td>129,870</td>
<td>198,558</td>
<td>266,729</td>
<td>333,100</td>
<td>403,072</td>
</tr>
</tbody>
</table>

**Regional Cost Indices**
- \( e_j = \) Equipment = 1.062
- \( b_j = \) Facilities = 1.062
- \( l_j = \) Labor = 1.103
- \( u_j = \) Utilities = 1.320

**Inflation Rates**
- \( g_j = \) Equipment = 7%
- \( g_H = \) Facilities = 9%
- \( g_B = \) Labor = 8%
- \( g_E = \) Utilities = 12%
- \( g_T = \) Transportation = 7%
### ANNUAL DISTRIBUTION COST FOR WAREHOUSE TRANSFERMENTS

**IN REGION \( j = I \) WEST COAST**

**FACTORY LOCATION REGION \( k = II \) ROCKY MOUNTAIN**

<table>
<thead>
<tr>
<th>Customer Type 1</th>
<th>( x_{ij} )</th>
<th>( d_{ij} )</th>
<th>( x_{ij} \cdot d_{ij} )</th>
<th>( q_j )</th>
<th>( (d_{ij} \cdot q_j) \cdot l \cdot w \cdot y_{ij} )</th>
<th>( y_{ij} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Household</td>
<td>1</td>
<td>50.0</td>
<td>50.0</td>
<td>.01</td>
<td>298,726.56</td>
<td>50.0</td>
</tr>
<tr>
<td>2 Intermediate</td>
<td>0</td>
<td>25.0</td>
<td>0.0</td>
<td>.50</td>
<td>0.0</td>
<td>50.0</td>
</tr>
<tr>
<td>3 Central Station</td>
<td>0</td>
<td>50.0</td>
<td>0.0</td>
<td>.50</td>
<td>0.0</td>
<td>50.0</td>
</tr>
<tr>
<td><strong>∑</strong></td>
<td></td>
<td>125.0</td>
<td>50.0</td>
<td></td>
<td><strong>KM = 298,726.56</strong></td>
<td></td>
</tr>
</tbody>
</table>

- **Warehouse – customer distance** = \( y_{ij} \)
- **Factory-warehouse distance** = \( s_{ij} \) = 640 km
- **Solar Array Unit Weight** = \( w = 155.925 \) kg/MW

\[
\text{Weight} = q_j \cdot w
\]

\[
\text{Deliveries/Year} = \frac{d_{ij} \cdot x_{ij}}{q_j}
\]

\[
\text{Order processing cost 85$50/delivery}
\]

\[
\text{Cost/delivery} = C(q_j \cdot w \cdot s_{ij})
\]

\[
\text{Inflation Factor} = (1 + .07)
\]

\[
\text{Annual Transportation Cost} = T_{kj}(Q_j) \quad (1986 \text{ Dollars})
\]

\[
\text{Inventory Carrying Cost} = CC(Q_j)
\]

\[
\text{Warehouse Operating Cost} = CC(Q_j)
\]

\[
\text{Warehouse Operating Cost} = CC(Q_j)
\]

\[
\text{Annual Warehousing Cost} = W_j(Q_j) \quad (1986 \text{ Dollars})
\]

\[
\text{Fixed Delivery Cost} = FC \cdot KM
\]

\[
\text{Variable Delivery Cost} = VC \cdot KM
\]

\[
\text{Annual Local Delivery Cost} = L_j(1986 \text{ Dollars})
\]

\[
\text{Total Annual Distribution Cost} = (Q_j) + \sum_{j} \left[ T_{kj}(Q_j) + W_j(Q_j) + L_j \right]
\]

\[
T_{kj}(Q_j) = \frac{Q_j}{Y_{ij}}
\]

\[
\text{Cost/delivery} = C(Q_j)
\]

\[
\text{Annual Transportation Cost} = T_{kj}(Q_j)
\]

- \( FC = \$24,039/\text{year} \)
- \( VC = \$0.095/\text{km} \)
- \( VC = \$75,000 \text{ km/vehicle} \)

- \( VC = \$8,000 \text{ kg/delivery} \)

<table>
<thead>
<tr>
<th>Warehouse Order Quantity ( Q_j ) (MW)</th>
<th>.50</th>
<th>1.00</th>
<th>1.50</th>
<th>2.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight ( q_j \cdot w )</td>
<td>77,982.15</td>
<td>155,925</td>
<td>233,881.5</td>
<td>779,622</td>
</tr>
<tr>
<td>Deliveries/Year ( d_{ij} \cdot x_{ij} ) ( q_j )</td>
<td>100</td>
<td>50</td>
<td>33.33</td>
<td>10</td>
</tr>
<tr>
<td>Order processing cost 85$50/delivery</td>
<td>5,000</td>
<td>2,500</td>
<td>1,667</td>
<td>500</td>
</tr>
<tr>
<td>Cost/delivery ( C(q_j \cdot w \cdot s_{ij}) )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inflation Factor ( (1 + .07) )</td>
<td>4,705</td>
<td>9,410</td>
<td>14,116</td>
<td>47,052</td>
</tr>
<tr>
<td>Annual Transportation Cost ( T_{kj}(Q_j) ) ( (1986 \text{ Dollars}) )</td>
<td>874,223</td>
<td>869,646</td>
<td>868,095</td>
<td>865,969</td>
</tr>
<tr>
<td>Inventory Carrying Cost ( CC(Q_j) )</td>
<td>41,168</td>
<td>94,375</td>
<td>141,562</td>
<td></td>
</tr>
<tr>
<td>Warehouse Operating Cost ( OC_j(Q_j) )</td>
<td>67,785</td>
<td>74,889</td>
<td>81,025</td>
<td></td>
</tr>
<tr>
<td>Warehouse Leasing Cost ( L_{kj}(Q_j) )</td>
<td>14,897</td>
<td>29,294</td>
<td>43,342</td>
<td></td>
</tr>
<tr>
<td>Annual Warehousing Cost ( W_j(Q_j) ) ( (1986 \text{ Dollars}) )</td>
<td>129,870</td>
<td>199,558</td>
<td>266,729</td>
<td>721,769</td>
</tr>
<tr>
<td>Fixed Delivery Cost ( FC \cdot KM )</td>
<td></td>
<td>176,028</td>
<td>176,028</td>
<td>176,028</td>
</tr>
<tr>
<td>Variable Delivery Cost ( VC \cdot KM )</td>
<td>52,174</td>
<td>52,174</td>
<td>52,174</td>
<td></td>
</tr>
<tr>
<td>Annual Local Delivery Costs ( L_j ) ( (1986 \text{ Dollars}) )</td>
<td>228,202</td>
<td>228,202</td>
<td>228,202</td>
<td>228,202</td>
</tr>
<tr>
<td>Total Annual Distribution Cost for Region ( j ) Transmissions ( (1986 $) )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[
T_{kj}(Q_j) = \frac{Q_j}{Y_{ij}}
\]
DIRECT - FACTORY-CUSTOMER SHIPMENTS COST CALCULATIONS

Factory Region \( k = \) II Rocky Mountain
Market Region \( j = \) II Rocky Mountain

<table>
<thead>
<tr>
<th>Customer Type</th>
<th>Annual Demand In Region ( j ) (MW/Year) ( d_{ij} )</th>
<th>Average Delivery Quantity (MW/Ship) ( q_i )</th>
<th>Number Shipments Per Year ( d_j / q_i )</th>
<th>Shipment Weight (kg) ( z_i ) = ( q_i * w )</th>
<th>Average Shipping Distance (km) ( y_{ij} )</th>
<th>Average Shipping Cost (1986 $)</th>
<th>Total Annual Cost (1986 $/YR) ( DC_{kij} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Residential Household</td>
<td>60.0</td>
<td>.01</td>
<td>600</td>
<td>1559.25</td>
<td>50.0</td>
<td>213,245</td>
<td>127,947</td>
</tr>
<tr>
<td>2 Intermediate Commercial</td>
<td>30.0</td>
<td>.50</td>
<td>60</td>
<td>77,962.50</td>
<td>50.0</td>
<td>1,056,233</td>
<td>63,974</td>
</tr>
<tr>
<td>3 Central Station Utility</td>
<td>50.0</td>
<td>5.00</td>
<td>10</td>
<td>779,625.00</td>
<td>50.0</td>
<td>10,652,330</td>
<td>106,623</td>
</tr>
<tr>
<td>Totals</td>
<td>140.0</td>
<td>.21</td>
<td>670</td>
<td>32,581.38</td>
<td>50.0</td>
<td>405,588</td>
<td>290,543</td>
</tr>
</tbody>
</table>

\( DC_{kij} \) = Annual distribution cost in Region \( k \) for customers supplied directly from the factory in Region \( k \) (in Manufacturing Year Dollars)

\[
DC_{kij} = \frac{3}{n} \sum_{i=1}^{\frac{3}{i}} \frac{d_{ij} * 1 + q_i * w * y_{ij}}{MC} + VC * (1 + g_T)^n
\]

\( w = 155,925 \text{ kg/MW} \)
\( FC = $24,039/\text{year} \)
\( VC = $.095/\text{km} \)
\( MC = 75,000 \text{ km/vehicle} \)
\( WC = 8,000 \text{ kg/delivery} \)

\( g_T = \text{Transportation inflation rate} = 7\% \)
\( n = 1986-1977 = 9 \)
TOTAL ANNUAL DISTRIBUTION COST CALCULATIONS
FROM THE FACTORY IN REGION \( k = II \) ROCKY MOUNTAIN
TO CUSTOMERS IN REGION \( j = III \) NORTH CENTRAL

<table>
<thead>
<tr>
<th>Customer Type ( i )</th>
<th>Shipping Indicator ( X_{ij} )</th>
<th>Annual Direct Shipping Cost (1986 $) ( DC_{kj} )</th>
<th>Annual Distribution Costs For Transshipments (1986 $) ( IC_{kj} )</th>
<th>Total Annual Distribution Cost Region ( j ) (1986 $) ( TC_{kj} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

| 1               | 0               | 1,397,039.30    | 0.00            | 1,397,039.30    |
| 2               | 1               | 0.00            | 376,536.00      | 376,536.00      |
| 3               | 0               | 0.00            | 0.00            | 0.00            |
| Total           | 1               | 1,397,039.30    | 376,536.00      | 1,773,575.30    |

| 1               | 1               | 0.00            | 0.00            | 0.00            |
| 2               | 0               | 283,216.62      | 0.00            | 283,216.62      |
| 3               | 0               | 0.00            | 0.00            | 0.00            |
| Total           | 1               | 283,216.62      | 0.00            | 949,027.62      |

| 1               | 0               | 1,397,039.30    | 0.00            | 1,397,039.30    |
| 2               | 0               | 283,216.62      | 0.00            | 283,216.62      |
| 3               | 0               | 0.00            | 0.00            | 0.00            |
| Total           | 0               | 1,680,225.90    | 0.00            | 1,680,225.90    |

\[
TC_{kj} = DC_{kj} + IC_{kj} = \text{Total Distribution Cost in Region } j \text{ (1986 $)}
\]

\[
X_{ij} = \begin{cases} 
0 & \text{if customers of type } i \text{ in Region } j \text{ are supplied directly from the factory} \\
1 & \text{if customers of type } i \text{ in Region } j \text{ are supplied from a warehouse in Region } j
\end{cases}
\]
DIRECT - FACTORY-CUSTOMER SHIPMENTS COST CALCULATIONS

Factory Region $k = \text{II Rocky Mountain}$
Market Region $j = \text{III North Central}$

<table>
<thead>
<tr>
<th>Customer Type</th>
<th>Annual Demand In Region $j$ ($M/\text{Yr}$) $d_{ij}$</th>
<th>Average Delivery Quantity (MW/Ship) $q_i$</th>
<th>Number Shipments Per Year $d_{ij}/q_i$</th>
<th>Shipment Weight (kg) $z_i = q_i * w$</th>
<th>Average Shipping Distance (km) $S_{kj}$</th>
<th>Average Shipment Cost ($) $C(z_i, S_{kj})$</th>
<th>Total Annual Cost (1986 $$/\text{YR}) D_{kj}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Residential Household</td>
<td>10</td>
<td>.01</td>
<td>1000</td>
<td>1,559.25</td>
<td>2100</td>
<td>759.88</td>
<td>1,397,039.30</td>
</tr>
<tr>
<td>2 Intermediate Commercial</td>
<td>5</td>
<td>.50</td>
<td>10</td>
<td>77,962.50</td>
<td>2100</td>
<td>15,404.76</td>
<td>283,216.62</td>
</tr>
<tr>
<td>3 Central Station Utility</td>
<td>0.0</td>
<td>.00</td>
<td>0</td>
<td>0</td>
<td>2100</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

$w = \text{Solar Array Unit Weight (kg/MW)}$
$= 155,925 \text{ kg/MW}$

$D_{kj} = \text{Annual distribution cost in Region } j \text{ for customers supplied directly from the factory in Region } k$
(in manufacturing year dollars)

$$D_{kj} = \sum_{i=1}^{3} \frac{d_{ij} \cdot (1-X_{ij}) \cdot C(z_i, S_{kj}) \cdot (1+g_T)^{1986-1977}}{q_i}$$

where

$X_{ij} = \begin{cases} 
0 & \text{if customers of type in Region } j \text{ are supplied directly from the factory} \\
1 & \text{if customers of type } i \text{ in Region } j \text{ are supplied from a warehouse in Region } j 
\end{cases}$

Transportation Inflation Rate

$g_T = 7\%/\text{year}$

D-29
WAREHOUSING COST CALCULATION FOR REGION \( j = \text{III NORTH CENTRAL} \)

<table>
<thead>
<tr>
<th>Shipment QTY ( Q_j ) (MW)</th>
<th>.10</th>
<th>.20*</th>
<th>.30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warehouse size ( F = 353.95 \text{ Q}_j ) (m²)</td>
<td>35,395</td>
<td>70,790</td>
<td>106,185</td>
</tr>
<tr>
<td>Equipment Cost ( E = (1.07)^9 \text{ Ke (F}_j \text{)*e}_j )</td>
<td>1,780</td>
<td>3,560</td>
<td>5,340</td>
</tr>
<tr>
<td>Facilities Cost ( B = (1.09)^9 \text{ Kh (F}_j \text{)*b}_j )</td>
<td>19,891</td>
<td>39,782</td>
<td>59,674</td>
</tr>
<tr>
<td>Warehouse Lease Cost (1986 $/YR) ( LC_j(Q_j) = .25E + .126B )</td>
<td>2,951</td>
<td>5,902</td>
<td>8,854</td>
</tr>
<tr>
<td>Personnel Cost ( (1.08)^9 \text{ P(F}_j \text{)*l}_j )</td>
<td>55,568</td>
<td>55,568</td>
<td>55,568</td>
</tr>
<tr>
<td>Utilities Cost ( (1.12)^9 \text{ u}_j*F_j )</td>
<td>212</td>
<td>212</td>
<td>318</td>
</tr>
<tr>
<td>Property Tax, Maintenance and Insurance ( .06*(E + B) )</td>
<td>1,300</td>
<td>2,600</td>
<td>3,900</td>
</tr>
<tr>
<td>Warehouse Operating Cost (1986 $/YR) ( OC_j(Q_j) )</td>
<td>56,974</td>
<td>58,380</td>
<td>59,786</td>
</tr>
<tr>
<td>Inventory Carrying Cost (1986 $/YR) ( CC(Q_j) = 94375*Q_j )</td>
<td>9,438</td>
<td>18,875</td>
<td>28,312</td>
</tr>
<tr>
<td>Warehousing Cost (1986 $/YR) ( W_j(Q_j) = CC(Q_j) + OC_j(Q_j) + LC_j(Q_j) )</td>
<td>69,363</td>
<td>83,157</td>
<td>96,952</td>
</tr>
</tbody>
</table>

Regional Cost Indices

- \( e_j = \text{Equipment} = 1.052 \)
- \( b_j = \text{Facilities} = 1.052 \)
- \( l = \text{Labor} = 1.014 \)
- \( u_j = \text{Utilities} = .900 \)

Inflation Rates

- \( g_j = \text{Equipment} = 7\% \)
- \( g_H = \text{Facilities} = 9\% \)
- \( g_B = \text{Labor} = 8\% \)
- \( g_E = \text{Utilities} = 12\% \)
- \( g_T = \text{Transportation} = 7\% \)
ANNUAL DISTRIBUTION COST FOR WAREHOUSE TRANSSHIPMENTS
IN REGION \( j = \text{III NORTH CENTRAL} \)
FACTORY LOCATION REGION \( k = \text{II ROCKY MOUNTAIN} \)

<table>
<thead>
<tr>
<th>Customer Type</th>
<th>( x_{ij} )</th>
<th>( d_{ij} )</th>
<th>( x_{ij} \cdot d_{ij} )</th>
<th>( q_{ij} )</th>
<th>( (d_{ij} \cdot x_{ij} / q_{ij}) \cdot 10^3 \cdot 155,925 )</th>
<th>( Y_{ij} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Household</td>
<td>1</td>
<td>50.0</td>
<td>10.0</td>
<td>.01</td>
<td>59,745.31</td>
<td>50.0</td>
</tr>
<tr>
<td>2 Intermediate</td>
<td>0</td>
<td>25.0</td>
<td>0.0</td>
<td>.50</td>
<td>0.00</td>
<td>50.0</td>
</tr>
<tr>
<td>3 Central Station</td>
<td>0</td>
<td>50.0</td>
<td>0.0</td>
<td>5.00</td>
<td>0.00</td>
<td>50.0</td>
</tr>
</tbody>
</table>

\[ \sum \]

\[ \text{Warehouse - customer distance} = Y_{ij} \]
\[ \text{Factory-warehouse distance} = S_{kj} = 2,100 \text{ km} \]
\[ \text{Solar Array Unit Weight} = u = 155.925 \text{ kg/km} \]

Warehouse Order Quantity \( Q \) (MW)

<table>
<thead>
<tr>
<th>( Q ) (MW)</th>
<th>.10</th>
<th>.20</th>
<th>.30</th>
</tr>
</thead>
</table>

\[ \text{Weight} = q_i \cdot w \]
\[ \text{Deliveries/Year} = \sum d_{ij} \cdot x_{ij} / Q \]
\[ \text{Order processing cost} = \$50 / \text{delivery} \]
\[ \text{Cost/delivery} = C(Q_j \cdot w, S_{kj}) \]
\[ \text{Inflation Factor} = (1 \leftarrow 0.07) \]
\[ \text{Annual Transportation Cost} = S_{kj} (Q_j) \]

Inventory Carrying Cost \( CC(Q_j) \)

\[ \text{Warehouse Operating Cost} = \text{OC} (Q_j) \]
\[ \text{Warehouse Leasing Cost} = \text{LC} (Q_j) \]

\[ \text{Annual Warehousing Cost} = W_j (Q_j) \]

\[ \text{Fixed Delivery Cost} = \text{FC} \cdot \text{EM} \]
\[ \text{Variable Delivery Cost} = \text{VC} \cdot KM \]

\[ \text{Annual Local Delivery Costs} = L_j \]

\[ \text{Total Annual Distribution Cost} \]

\[ IC_{kj} (Q_j) = \sum_{kj} (Q_j) + W_j (Q_j) + L_j \]
### Total Annual Distribution Cost Calculations

**From the Factory in Region \( k = \text{II Rocky Mountain} \)**

**To Customers in Region \( j = \text{IV Great Lakes} \)**

<table>
<thead>
<tr>
<th>Customer Type ( i )</th>
<th>Shipping Indicator ( X_{ij} )</th>
<th>Annual Direct Shipping Cost (1986 $) ( DC_{kj} )</th>
<th>Annual Distribution Costs for Transshipments (1986 $) ( IC_{kj} )</th>
<th>Total Annual Distribution Cost Region ( j ) (1986 $) ( TC_{kj} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0.00</td>
<td>1,238,369.00</td>
<td>1,238,369.00</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1,743,872.40</td>
<td>0.00</td>
<td>1,743,872.40</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>0.00</td>
<td>473,909.00</td>
<td>473,909.00</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1,743,872.40</td>
<td>473,909.00</td>
<td>2,217,781.40</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0.00</td>
<td>852,920.00</td>
<td>852,920.00</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>375,103.63</td>
<td>0.00</td>
<td>375,103.63</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>375,103.63</td>
<td>852,920.00</td>
<td>1,228,023.63</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1,743,872.40</td>
<td>0.00</td>
<td>1,743,872.40</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>375,103.63</td>
<td>0.00</td>
<td>375,103.63</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2,118,976.00</td>
<td>0.00</td>
<td>2,118,976.00</td>
</tr>
</tbody>
</table>

\[
TC_{kj} = DC_{kj} + IC_{kj} = \text{Total Distribution Cost in Region } j \text{ (1986 $)}
\]

\[
X_{ij} = \begin{cases} 
0 & \text{if customers of type } i \text{ in Region } j \text{ are supplied directly from the factory} \\
1 & \text{if customers of type } i \text{ in Region } j \text{ are supplied from a warehouse in Region } j 
\end{cases}
\]
### Direct - Factory-Customer Shipment Cost Calculations

Factory Region \( k = \) II Rocky Mountain  
Market Region \( j = \) IV Great Lakes

<table>
<thead>
<tr>
<th>Customer Type</th>
<th>Annual Demand In Region ( j ) (MW/yr) ( d_{ij} )</th>
<th>Average Delivery Quantity (MW/Ship) ( q_i )</th>
<th>Number Shipments Per Year ( d_{ij}/q_i )</th>
<th>Shipment Weight (kg) ( z_i = q_i \times w )</th>
<th>Average Shipping Distance (km) ( S_k )</th>
<th>Average Shipment Cost ($) ( C(z_i, S_k) )</th>
<th>Total Annual Cost (1986 $/yr) ( D_{C_{kj}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Residential Household</td>
<td>10.0</td>
<td>.01</td>
<td>1000</td>
<td>1,559.25</td>
<td>2782</td>
<td>249.53</td>
<td>1,743,872.40</td>
</tr>
<tr>
<td>2 Intermediate Commercial</td>
<td>5.0</td>
<td>.50</td>
<td>10</td>
<td>77,962.50</td>
<td>2782</td>
<td>20,402.79</td>
<td>375,103.63</td>
</tr>
<tr>
<td>3 Central Station Utility</td>
<td>0.0</td>
<td>.00</td>
<td>0</td>
<td>0.00</td>
<td>2782</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

\( w \) = Solar Array Unit Weight (kg/MW)  
\( w = 155,925 \text{ kg/MW} \)

\( D_{C_{kj}} \) = Annual distribution cost in Region \( j \) for customers supplied directly from the factory in Region \( k \)  
(in manufacturing year dollars)

\[
D_{C_{kj}} = \sum_{i=1}^{3} d_{ij} \times (1-X_{ij}) \times (z_i \times S_k) \times (1+g_T)
\]

where  
\( X_{ij} = 0 \) if customers of type \( i \) in Region \( j \) are supplied directly from the factory  
\( X_{ij} = 1 \) if customers of type \( i \) in Region \( j \) are supplied from a warehouse in Region \( j \)

<table>
<thead>
<tr>
<th>Transportation</th>
<th>Inflation Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>( g_T = 7% \text{/year} )</td>
<td></td>
</tr>
</tbody>
</table>
WAREHOUSING COST CALCULATION FOR REGION $j = IV$ GREAT LAKES

<table>
<thead>
<tr>
<th>Shipment Qty $Q_j$ (MW)</th>
<th>.10</th>
<th>.20</th>
<th>.30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warehouse size $E_j = 353.95$ $Q_j$ m³</td>
<td>35.395</td>
<td>70.790</td>
<td>106.185</td>
</tr>
<tr>
<td>Equipment Cost $E = (1.07)^t * K_e (F_j)^{e_j}$</td>
<td>21.692</td>
<td>3,384</td>
<td>5,076</td>
</tr>
<tr>
<td>Facilities Cost $B = (1.09)^t * K_f (F_j)^{b_j}$</td>
<td>18,908</td>
<td>37,816</td>
<td>56,724</td>
</tr>
<tr>
<td>Warehouse Lease Cost (1986 $/$YR) $L_C (Q_j) = .25E + .126B$</td>
<td>2,805</td>
<td>5,611</td>
<td>8,416</td>
</tr>
<tr>
<td>Personel Cost $(1.08)^t * P(F_j)^{p_j}$</td>
<td>63,624</td>
<td>63,624</td>
<td>63,624</td>
</tr>
<tr>
<td>Utilities Cost $(1.12)^t * 1.20^u_j * u_j$</td>
<td>106</td>
<td>212</td>
<td>318</td>
</tr>
<tr>
<td>Property Tax, Maintenance and Insurance $.06^t(E + B)$</td>
<td>1,236</td>
<td>2,472</td>
<td>3,708</td>
</tr>
<tr>
<td>Warehouse Operating Cost (1986 $/$YR) $C_C (Q_j)$</td>
<td>64,966</td>
<td>66,309</td>
<td>67,650</td>
</tr>
<tr>
<td>Inventory Carrying Cost (1986 $/$YR) $C_C (Q_j) = 0.4375^t Q_j$</td>
<td>9,438</td>
<td>18,875</td>
<td>28,312</td>
</tr>
<tr>
<td>Warehousing Cost (1986 $/$YR) $W (Q_j) = C_C (Q_j) + C_C (Q_j) + L_C (Q_j)$</td>
<td>77,209</td>
<td>90,274</td>
<td>104,978</td>
</tr>
</tbody>
</table>

Regional Cost Indices
- $e_j = Equipment = 1.000$
- $b_j = Facilities = 1.000$
- $l_j = Labor = 1.161$
- $u_j = Utilities = .900$

Inflation Rates
- $g_e = Equipment = 7%$
- $g_b = Facilities = 9%$
- $g_l = Labor = 8%$
- $g_u = Utilities = 12%$
- $g_T = Transportation = 7%$
### ANNUAL DISTRIBUTION COST FOR WAREHOUSE TRANSSHIPMENTS

**IN REGION \( j = IV \) GREAT LAKES**

**FACTORY LOCATION REGION \( k = II \) ROCKY MOUNTAIN**

<table>
<thead>
<tr>
<th>Customer Type</th>
<th>( x_{ij} )</th>
<th>( d_{ij} )</th>
<th>( q_i )</th>
<th>( (d_{ij} \times x_{ij})/q_i \times \log_{10} q_i \times w \times x_{ij} )</th>
<th>( Y_{ij} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Household</td>
<td>1</td>
<td>10.0</td>
<td>10.0</td>
<td>59,745.31</td>
<td>50.0</td>
</tr>
<tr>
<td>2 Intermediate</td>
<td>0</td>
<td>5.0</td>
<td>0.0</td>
<td>0.00</td>
<td>50.0</td>
</tr>
<tr>
<td>3 Central Station</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.00</td>
<td>50.0</td>
</tr>
<tr>
<td><strong>( \sum )</strong></td>
<td><strong>15.0</strong></td>
<td><strong>10.0</strong></td>
<td><strong>.51</strong></td>
<td><strong>59,745.31</strong></td>
<td><strong>50.0</strong></td>
</tr>
</tbody>
</table>

Warehouse - customer distance = \( Y_{ij} \)

Factory - warehouse distance = \( s_{kj} = 2,782 \text{ km} \)

Solar Array Unit Weight = \( w = 155,925 \text{ kg/MW} \)

### Warehouse Order Quantity \( Q_j \) (MW)

<table>
<thead>
<tr>
<th>( Q_j ) (MW)</th>
<th>.10</th>
<th>.20</th>
<th>.30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight = ( q_i \times w )</td>
<td>15,592.5</td>
<td>31,182.0</td>
<td>46,777.5</td>
</tr>
<tr>
<td>Deliveries/Year = ( \sum d_{ij} \times x_{ij} /Q )</td>
<td>100</td>
<td>50</td>
<td>33.33</td>
</tr>
<tr>
<td>Order processing cost ( $500 / \text{delivery} )</td>
<td>5,000</td>
<td>2,500</td>
<td>1,567</td>
</tr>
<tr>
<td>Cost/delivery ( C(Q_j; w, s_{kj}) )</td>
<td>5,770</td>
<td>8,196</td>
<td>12,242</td>
</tr>
<tr>
<td>Inflation Factor = ( (1 + .07)^q )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Transportation Cost ( T_{kj} ) (Q_j) ( (1986 \text{ Dollars}) )</td>
<td>1,070,062</td>
<td>756,022</td>
<td>753,258</td>
</tr>
<tr>
<td>Inventory Carrying Cost ( IC(Q_j) )</td>
<td>9,438</td>
<td>16,875</td>
<td>28,312</td>
</tr>
<tr>
<td>Warehouse Operating Cost ( OC_j(Q_j) )</td>
<td>64,966</td>
<td>66,308</td>
<td>67,650</td>
</tr>
<tr>
<td>Warehouse Leasing Cost ( LC_j(Q_j) )</td>
<td>2,805</td>
<td>5,611</td>
<td>8,416</td>
</tr>
<tr>
<td>Annual Warehousing Cost ( W_j ) (Q_j) ( (1986 \text{ Dollars}) )</td>
<td>77,209</td>
<td>90,794</td>
<td>104,376</td>
</tr>
<tr>
<td>Fixed Delivery Cost ( FC = \frac{KW}{WC} )</td>
<td>35,206</td>
<td>35,206</td>
<td>35,206</td>
</tr>
<tr>
<td>Variable Delivery Cost ( VC \times KM )</td>
<td>10,435</td>
<td>10,435</td>
<td>10,435</td>
</tr>
<tr>
<td>Inflation Factor = ( (1.04)^{yr} = 1.83846 )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Local Delivery Costs ( L_j ) ( (1986 \text{ Dollars}) )</td>
<td>45,641</td>
<td>45,641</td>
<td>45,641</td>
</tr>
<tr>
<td>Total Annual Distribution Cost for Region ( j ) Transshipments ( (1986 \text{ $}) ) ( IC_{kj}(Q_j) )</td>
<td>1,151,375</td>
<td>852,920</td>
<td>861,740</td>
</tr>
</tbody>
</table>

\[
IC_{kj}(Q_j) = T_{kj}(Q_j) + W_j(Q_j) + L_j
\]
### TOTAL ANNUAL DISTRIBUTION COST CALCULATIONS
FROM THE FACTORY IN REGION $k = II$ ROCKY MOUNTAIN
TO CUSTOMERS IN REGION $j = V$ NORTH EASTERN

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>8,173,641.00</td>
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<tr>
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<tr>
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<tr>
<td>Total</td>
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<tr>
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<td>974,241.37</td>
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<tr>
<td>3</td>
<td>0</td>
<td>0.00</td>
<td>974,241.37</td>
<td>974,241.37</td>
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<tr>
<td>Total</td>
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<td>4,871,207.70</td>
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<tr>
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<td>4,871,207.70</td>
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<tr>
<td>3</td>
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<td>4,871,207.70</td>
<td>4,871,207.70</td>
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<tr>
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<td>8,022,281.70</td>
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<tr>
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<td>974,241.37</td>
</tr>
<tr>
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<td>5,083,379.00</td>
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<tr>
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<td>0.00</td>
<td>4,314,665.30</td>
</tr>
<tr>
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<td>1</td>
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<td>1,063,053.00</td>
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<tr>
<td>3</td>
<td>0</td>
<td>0.00</td>
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<tr>
<td>Total</td>
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<td>10,248,926.00</td>
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<td>4,871,207.70</td>
<td>4,871,207.70</td>
</tr>
<tr>
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<td>0</td>
<td>0.00</td>
<td>4,871,207.70</td>
<td>4,871,207.70</td>
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<tr>
<td>Total</td>
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<td>7,999,921.07</td>
<td>17,945,370.14</td>
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</tr>
<tr>
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<td>974,241.37</td>
<td>0.00</td>
<td>974,241.37</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0.00</td>
<td>4,871,207.70</td>
<td>4,871,207.70</td>
</tr>
<tr>
<td>Total</td>
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<td>10,160,114.37</td>
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</tr>
</tbody>
</table>

$T_{kj} = DC_{kj} + IC_{kj}$ = Total Distribution Cost in Region $j$ (1986 $$/Year)

$X_{ij}$ = \begin{cases} 
0 & \text{if customers of type } i \text{ in Region } j \text{ are supplied directly from the factory} \\
1 & \text{if customers of type } i \text{ in Region } j \text{ are supplied from a warehouse in Region } j 
\end{cases}$
### DIRECT - FACTORY-CUSTOMER SHIPMENTS COST CALCULATIONS

Factory Region $k = \text{II Rocky Mountain}$  
Market Region $k = \text{V North Eastern}$

<table>
<thead>
<tr>
<th>Customer Type</th>
<th>Annual Demand In Region $j$ (MW/yr) $d_{ij}$</th>
<th>Average Delivery Quantity (MW/Ship) $q_{ij}$</th>
<th>Number Shipments Per Year $d_{ij}/q$</th>
<th>Shipment Weight (kg) $z_{ij}$</th>
<th>Average Shipping Distance (km) $S_{k,j}$</th>
<th>Average Shipment Cost ($) $C(z_{ij}, S_{k,j})$</th>
<th>Total Annual Cost (1986 $$ /yr) $DC_{k,j}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Residential Household</td>
<td>20.0</td>
<td>.01</td>
<td>2000</td>
<td>1,559.25</td>
<td>3595</td>
<td>1,173.42</td>
<td>4,314,665.30</td>
</tr>
<tr>
<td>2 Intermediate Commercial</td>
<td>10.0</td>
<td>.50</td>
<td>20</td>
<td>77,962.50</td>
<td>3595</td>
<td>26,495.55</td>
<td>974,284.37</td>
</tr>
<tr>
<td>3 Central Station Utility</td>
<td>50.0</td>
<td>5.00</td>
<td>10</td>
<td>778,625.00</td>
<td>3595</td>
<td>264,955.55</td>
<td>4,871,207.70</td>
</tr>
</tbody>
</table>

$w = \text{Solar Array Unit Weight (kg/MW)}$  
$= 155,925 \text{ kg/MW}$

$DC_{k,j} = \text{Annual distribution cost in Region } j \text{ for customers supplied directly from the factory in Region } k$  
\( \text{(in manufacturing year dollars)} \)

$$= \sum_{i=1}^{3} q_{ij} * (1 - x_{ij}) * C(z_{ij}, S_{k,j}) * (1 + g_T)$$

where  
\( x_{ij} = \begin{cases} 
0 & \text{if customers of type } i \text{ in Region } j \text{ are supplied directly from the factory} \\
1 & \text{if customers of type } i \text{ in Region } j \text{ are supplied from a warehouse in Region } j 
\end{cases} \)

<table>
<thead>
<tr>
<th>Transportation Inflation Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>$g_T = 7% / \text{year}$</td>
</tr>
</tbody>
</table>
WAREHOUSING COST CALCULATION FOR REGION j = V NORTH EASTERN

<table>
<thead>
<tr>
<th>Shipment QIV Qj (M)</th>
<th>.20</th>
<th>.40</th>
<th>.60</th>
<th>1.00</th>
<th>1.20</th>
<th>1.40</th>
<th>1.60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warehouse size Fj = 353.95 Qi m²</td>
<td>70,790</td>
<td>141,580</td>
<td>212,370</td>
<td>353,950</td>
<td>424,740</td>
<td>495,530</td>
<td>566,320</td>
</tr>
<tr>
<td>Equipment Cost E = (1.07)^j * K (Pj)*ej</td>
<td>3,770</td>
<td>7,539</td>
<td>11,309</td>
<td>16,848</td>
<td>22,617</td>
<td>26,387</td>
<td>30,156</td>
</tr>
<tr>
<td>Facilities Cost B = (1.09) * Kb(Fj)*bj</td>
<td>42,127</td>
<td>84,254</td>
<td>126,381</td>
<td>205,483</td>
<td>245,783</td>
<td>285,083</td>
<td>324,383</td>
</tr>
<tr>
<td>Warehouse Lease Cost (1986 $/YR) LCj(Qj) = 0.25E + 0.126B</td>
<td>6,250</td>
<td>12,501</td>
<td>18,751</td>
<td>30,729</td>
<td>36,623</td>
<td>42,517</td>
<td>48,411</td>
</tr>
<tr>
<td>Personnel Cost (1.08)^j *P(Fj) *lj</td>
<td>54,691</td>
<td>54,691</td>
<td>54,691</td>
<td>54,691</td>
<td>54,691</td>
<td>54,691</td>
<td>54,691</td>
</tr>
<tr>
<td>Utilities Cost (1.12)^j <em>1.20</em>uj*Fj</td>
<td>306</td>
<td>612</td>
<td>861</td>
<td>1,531</td>
<td>1,837</td>
<td>2,144</td>
<td>2,445</td>
</tr>
<tr>
<td>Property Tax, Maintenance and Insurance .05*(E + B)</td>
<td>2,754</td>
<td>5,508</td>
<td>8,251</td>
<td>13,520</td>
<td>16,104</td>
<td>18,688</td>
<td>21,272</td>
</tr>
<tr>
<td>Warehouse Operating Cost (1986 $/YR) OCj(Qj)</td>
<td>57,751</td>
<td>60,811</td>
<td>63,813</td>
<td>69,742</td>
<td>72,632</td>
<td>75,523</td>
<td>78,408</td>
</tr>
<tr>
<td>Inventory Carrying Cost (1986 $/YR) CC(Qj) = 94375*Qj</td>
<td>18,875</td>
<td>37,750</td>
<td>56,625</td>
<td>94,375</td>
<td>113,250</td>
<td>132,125</td>
<td>151,000</td>
</tr>
<tr>
<td>Warehousing Cost (1986 $/YR) Wi(Qj) = OC(Qj) + CC(Qj) + LCj(Qj)</td>
<td>82,876</td>
<td>111,062</td>
<td>139,189</td>
<td>194,846</td>
<td>222,505</td>
<td>250,165</td>
<td>277,819</td>
</tr>
</tbody>
</table>

Regional Cost Indices

- e_j = Equipment = 1.114
- b_j = Facilities = 1.114
- l_j = Labor = .998
- u_j = Utilities = 1.300

Inflation Rates

- g_j = Equipment = 7%
- g_h = Facilities = 9%
- g_l = Labor = 8%
- g_u = Utilities = 12%
- g_v = Transportation = 7%
### Annual Distribution Cost for Warehouse Transshipments

**Region j = V North Eastern**

**Factory Location Region k = II Rocky Mountain**

<table>
<thead>
<tr>
<th>Customer Type</th>
<th>$x_{ij}$</th>
<th>$d_{ij}$</th>
<th>$x_{ij}*d_{ij}$</th>
<th>$q_j$</th>
<th>$(d_{ij}*x_{ij}/q_j)*1000$</th>
<th>$Y_{ij}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Household</td>
<td>1</td>
<td>20.0</td>
<td>20.0</td>
<td>.01</td>
<td>119,450.63</td>
<td>50.0</td>
</tr>
<tr>
<td>2 Intermediate</td>
<td>0</td>
<td>10.0</td>
<td>0.0</td>
<td>.50</td>
<td>0.00</td>
<td>50.0</td>
</tr>
<tr>
<td>3 Central Station</td>
<td>0</td>
<td>50.0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.00</td>
<td>50.0</td>
</tr>
<tr>
<td>4 Warehouse</td>
<td>0</td>
<td>80.0</td>
<td>20.0</td>
<td>.51</td>
<td>KM = 59,745.31</td>
<td></td>
</tr>
</tbody>
</table>

Warehouse - customer distance = $Y_{ij}$

Factory-warehouse distance = $s_{kj} = 3,595 \text{ km}$

Solar Array Unit Weight = $w = 155,925 \text{ kg/MW}$

<table>
<thead>
<tr>
<th>Warehouse Order Quantity $Q_j$ (MW)</th>
<th>.10</th>
<th>.15</th>
<th>.20</th>
<th>.25</th>
<th>.40</th>
<th>1.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight = $q_j*w$</td>
<td>15,592.5</td>
<td>23,386.78</td>
<td>31,185</td>
<td>38,981</td>
<td>62,370</td>
<td>155,925</td>
</tr>
<tr>
<td>Deliveries/Year = $\sum d_{ij} * x_{ij}/Q_j$</td>
<td>200</td>
<td>133.33</td>
<td>100</td>
<td>80</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>Order processing cost @$50/delivery</td>
<td>10,000</td>
<td>6,667</td>
<td>5,000</td>
<td>4,000</td>
<td>2,500</td>
<td>1,000</td>
</tr>
<tr>
<td>Cost/delivery C(Q_j * w, s_{kj})</td>
<td>7,209</td>
<td>7,993</td>
<td>10,544</td>
<td>13,180</td>
<td>21,089</td>
<td>52,722</td>
</tr>
<tr>
<td>Inflation Factor = $(1 + .07)^3$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Transportation Cost $T_{kj}$ (Q_j) (1986 Dollars)</td>
<td>2,669,160</td>
<td>1,947,000</td>
<td>1,947,725</td>
<td>1,945,887</td>
<td>1,943,129</td>
<td>1,940,371</td>
</tr>
<tr>
<td>Inventory Carrying Cost CC(Q_j)</td>
<td>9,438</td>
<td>14,155</td>
<td>19,675</td>
<td>23,594</td>
<td>37,750</td>
<td>94,375</td>
</tr>
<tr>
<td>Warehouse Operating Cost OC(Q_j)</td>
<td>56,221</td>
<td>55,986</td>
<td>57,751</td>
<td>58,516</td>
<td>60,811</td>
<td>69,742</td>
</tr>
<tr>
<td>Warehouse Leasing Cost LC(Q_j)</td>
<td>3,125</td>
<td>4,688</td>
<td>6,258</td>
<td>7,813</td>
<td>12,501</td>
<td>30,729</td>
</tr>
<tr>
<td>Annual Warehousing Cost $W_j$ (Q_j) (1986 Dollars)</td>
<td>68,784</td>
<td>75,830</td>
<td>82,886</td>
<td>89,923</td>
<td>111,052</td>
<td>194,846</td>
</tr>
<tr>
<td>Fixed Delivery Cost FC * RM</td>
<td>70,411</td>
<td>70,411</td>
<td>70,411</td>
<td>70,411</td>
<td>70,411</td>
<td>70,411</td>
</tr>
<tr>
<td>Variable Delivery Cost VC*RM</td>
<td>20,670</td>
<td>20,870</td>
<td>20,870</td>
<td>20,870</td>
<td>20,870</td>
<td>20,870</td>
</tr>
<tr>
<td>Annual Local Delivery Costs L_j (1986 Dollars)</td>
<td>91,281</td>
<td>91,281</td>
<td>91,281</td>
<td>91,281</td>
<td>91,281</td>
<td>91,281</td>
</tr>
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</table>

Total Annual Distribution Cost for Region j Transshipments (1986 $) $IC_{kj}(Q_j)$

$IC_{kj}(Q_j) = T_{kj}(Q_j) + W_j(Q_j) + L_j$
TOTAL ANNUAL DISTRIBUTION COST CALCULATIONS
FROM THE FACTORY IN REGION $k = \text{II Rock}y\ Mountain$
TO CUSTOMERS IN REGION $j = \text{VI South Eastern}$

<table>
<thead>
<tr>
<th>Customer Type $i$</th>
<th>Shipping Indicator $x_{ij}$</th>
<th>Annual Direct Shipping Cost (1986 $$$) $D_{kij}$</th>
<th>Annual Distribution Costs For Transshipments (1986 $$$) $IC_{kij}$</th>
<th>Total Annual Distribution Cost Region $j$ (1986 $$$) $T_{kij}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>0.00</td>
<td>1,369,336.00</td>
<td>1,369,336.00</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>0.00</td>
<td>1,873,050.30</td>
<td>1,873,050.30</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>0.00</td>
<td>1,369,336.00</td>
<td>1,369,336.00</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1,873,050.30</td>
<td>0.00</td>
<td>1,873,050.30</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>0.00</td>
<td>490,236.00</td>
<td>490,236.00</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>0.00</td>
<td>1,873,050.30</td>
<td>1,873,050.30</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1,873,050.30</td>
<td>490,236.00</td>
<td>2,363,286.30</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>944,205.00</td>
<td>944,205.00</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>0.00</td>
<td>409,327.64</td>
<td>409,327.64</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>0.00</td>
<td>944,205.00</td>
<td>1,353,532.64</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>0.00</td>
<td>409,327.64</td>
<td>1,353,532.64</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>1,873,050.30</td>
<td>0.00</td>
<td>1,873,050.30</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>0.00</td>
<td>409,327.64</td>
<td>409,327.64</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>0.00</td>
<td>1,873,050.30</td>
<td>2,282,377.94</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>0.00</td>
<td>409,327.64</td>
<td>2,282,377.94</td>
</tr>
</tbody>
</table>

$T_{kij} = D_{kij} + IC_{kij} = \text{Total Distribution Cost in Region } j \text{ (1986 $\$$)}$

$x_{ij} = \begin{cases} 
0 & \text{if customers of type } i \text{ in Region } j \text{ are supplied directly from the factory} \\
1 & \text{if customers of type } i \text{ in Region } j \text{ are supplied from a warehouse in Region } j 
\end{cases}$
## DIRECT - FACTORY-CUSTOMER SHIPLMENTS COST CALCULATIONS

Factory Region $k = \text{II Rocky Mountain}$  
Market Region $j = \text{VI South Eastern}$

<table>
<thead>
<tr>
<th>Customer Type</th>
<th>Annual Demand in Region $j$ (MW/Year)</th>
<th>Average Delivery Quantity (MW/Ship)</th>
<th>Number Shipments Per Year $d_{ij} / q_i$</th>
<th>Shipment Weight (kg) $z_i = q_i w$</th>
<th>Average Shipping Distance (km) $S_{kj}$</th>
<th>Average Shipment Cost ($) $C(Z_i, S_{kj})$</th>
<th>Total Annual Cost (1986 $$/YR) $DC_{kj}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Residential Household</td>
<td>10.0</td>
<td>0.01</td>
<td>1000</td>
<td>1,559.25</td>
<td>3036</td>
<td>1,173.42</td>
<td>1,873,050.30</td>
</tr>
<tr>
<td>2 Intermediate Commercial</td>
<td>5.0</td>
<td>0.50</td>
<td>10</td>
<td>77,962.50</td>
<td>3036</td>
<td>22,264.22</td>
<td>409,327.64</td>
</tr>
<tr>
<td>3 Central Station Utility</td>
<td>0.0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
<td>3036</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

$w = \text{Solar Array Unit Weight (kg/MW)}$  
$= 155,925 \text{ kg/MW}$

$DC_{kj} = \text{Annual distribution cost in Region } j \text{ for customers supplied directly from the factory in Region } k \text{ (in manufacturing year dollars)}$

$$DC_{kj} = \sum_{i=1}^{3} d_{ij} * (1-X_{ij})^* C(Z_i, S_{kj})^* (1+g_T)$$

where

$X_{ij} = \begin{cases} 
0 & \text{if customers of type } i \text{ in Region } j \text{ are supplied directly from the factory} \\
1 & \text{if customers of type } i \text{ in Region } j \text{ are supplied from a warehouse in Region } j 
\end{cases}$

<table>
<thead>
<tr>
<th>Transportation Inflation Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>$g_T = 7%$/year</td>
</tr>
</tbody>
</table>
WAREHOUSING COST CALCULATION FOR REGION \( j = VI \) SOUTH EASTERN

<table>
<thead>
<tr>
<th>Shipment Qty ( Q_j ) (MW)</th>
<th>( .10 )</th>
<th>( .20 )</th>
<th>( .30 )</th>
<th>( .40 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warehouse size ( F_j ) = 353.95 ( Q_j ) m(^2)</td>
<td>35,395</td>
<td>70,790</td>
<td>106,185</td>
<td>141,580</td>
</tr>
<tr>
<td>Equipment Cost</td>
<td>( E = (1.07)^{10} \times K_e (F_j) \times e_j )</td>
<td>1,587</td>
<td>3,174</td>
<td>4,761</td>
</tr>
<tr>
<td>Facilities Cost</td>
<td>( B = (1.09)^{10} \times K_f (F_j) \times b_j )</td>
<td>17,736</td>
<td>35,471</td>
<td>53,207</td>
</tr>
<tr>
<td>Warehouse Lease Cost (1986 $/YR) ( LC_j (Q_j) = .925E + .126B )</td>
<td>2,631</td>
<td>5,253</td>
<td>7,894</td>
<td>10,509</td>
</tr>
<tr>
<td>Personnel Cost</td>
<td>( (1.08)^{10} \times P(F_j) \times 1_j )</td>
<td>47,019</td>
<td>47,019</td>
<td>47,019</td>
</tr>
<tr>
<td>Utilities Cost</td>
<td>( (1.12)^{10} \times u_j E )</td>
<td>112</td>
<td>224</td>
<td>336</td>
</tr>
<tr>
<td>Property Tax, Maintenance and Insurance</td>
<td>( .06(E+B) )</td>
<td>1,159</td>
<td>2,319</td>
<td>3,478</td>
</tr>
<tr>
<td>Warehouse Operating Cost (1986 $/YR) ( OC_j (Q_j) )</td>
<td>48,290</td>
<td>49,502</td>
<td>50,833</td>
<td>52,095</td>
</tr>
<tr>
<td>Inventory Carrying Cost (1986 $/YR) ( CC(Q_j) = 94375 \times Q_j )</td>
<td>9,438</td>
<td>18,875</td>
<td>28,312</td>
<td>37,750</td>
</tr>
<tr>
<td>Warehousing Cost (1986 $/YR) ( W_j (Q_j) = CC(Q_j) + OC_j (Q_j) + LC_j (Q_j) )</td>
<td>60,359</td>
<td>73,700</td>
<td>87,039</td>
<td>100,355</td>
</tr>
</tbody>
</table>

Regional Cost Indices

\( e_j = \text{Equipment} = .938 \)
\( b_j = \text{Facilities} = .938 \)
\( l_j = \text{Labor} = .858 \)
\( u_j = \text{Utilities} = .950 \)

*Optimal Level

Inflation Rates

\( g_e = \text{Equipment} = 7\% \)
\( g_b = \text{Facilities} = 9\% \)
\( g_l = \text{Labor} = 8\% \)
\( g_u = \text{Utilities} = 12\% \)
\( g_t = \text{Transportation} = 7\% \)
## ANNUAL DISTRIBUTION COST FOR WAREHOUSE TRANSSHIPMENTS IN REGION \( j \) = VI South Eastern FACTORY LOCATION REGION \( k \) = II Rocky Mountain

<table>
<thead>
<tr>
<th>Customer Type ( i )</th>
<th>( x_{ij} )</th>
<th>( d_{ij} )</th>
<th>( x_{ij} \cdot d_{ij} )</th>
<th>( q_{ij} )</th>
<th>( (d_{ij} \cdot x_{ij}) \cdot q_{ij} \cdot \frac{1}{WC} \cdot \frac{WC}{q_{ij}} \cdot Y_{ij} )</th>
<th>( Y_{ij} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Household</td>
<td>1</td>
<td>10.0</td>
<td>10.0</td>
<td>.01</td>
<td>59,745.31</td>
<td>59.7</td>
</tr>
<tr>
<td>2 Intermediate</td>
<td>0</td>
<td>5.0</td>
<td>0.0</td>
<td>.50</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>3 Central Station</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15.0</td>
<td>10.0</td>
<td>5.51</td>
<td></td>
<td>KM = 59,745.31</td>
<td>59.7</td>
</tr>
</tbody>
</table>

Warehouse - customer distance = \( y_{ij} \)

Factory-warehouse distance = \( s_{kj} \) = 3,036 km

Solar Array Unit Weight = \( w \) = 155,925 kg/MW

- WC = $8,800 km/delivery
- Fixed Delivery Cost FC = $24,039/year
- VC = $0.095/km
- NC = 75,000 km/vehicle

<table>
<thead>
<tr>
<th>Warehouse Order Quantity ( Q_j ) (MW)</th>
<th>0.10</th>
<th>0.20</th>
<th>0.30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight = ( q_j \times w )</td>
<td>15,592.5</td>
<td>31,185.0</td>
<td>46,777.5</td>
</tr>
<tr>
<td>Deliveries/Year = ( \sum d_{ij} \cdot x_{ij} / Q_j )</td>
<td>100</td>
<td>50</td>
<td>33.33</td>
</tr>
<tr>
<td>Order processing cost @$50/delivery</td>
<td>5,000</td>
<td>2,500</td>
<td>1,667</td>
</tr>
<tr>
<td>Cost/delivery C(( Q_j ) *w, ( s_{kj} ))</td>
<td>6,220</td>
<td>8,923</td>
<td>13,259</td>
</tr>
<tr>
<td>Inflation Factor = ( (1 + .07) )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Transportation Cost ( T_{kj}(Q_j) ) (1986 Dollars)</td>
<td>1,152,703</td>
<td>824,864</td>
<td>821,619</td>
</tr>
<tr>
<td>Inventory Carrying Cost ( CC(Q_j) )</td>
<td>9,438</td>
<td>18,875</td>
<td>29,212</td>
</tr>
<tr>
<td>Warehouse Operating Cost ( OC_j(Q_j) )</td>
<td>48,290</td>
<td>49,562</td>
<td>50,833</td>
</tr>
<tr>
<td>Warehouse Leasing Cost ( LC_j(Q_j) )</td>
<td>2,631</td>
<td>5,263</td>
<td>7,894</td>
</tr>
<tr>
<td>Annual Warehousing Cost ( W_j(Q_j) ) (1986 Dollars)</td>
<td>60,359</td>
<td>73,700</td>
<td>87,039</td>
</tr>
<tr>
<td>Fixed Delivery Cost FC * KM</td>
<td>35,205</td>
<td>35,205</td>
<td>35,205</td>
</tr>
<tr>
<td>Variable Delivery Cost VC*KM</td>
<td>10,435</td>
<td>10,435</td>
<td>10,435</td>
</tr>
<tr>
<td>Inflation Factor = ( (1 + .07)^n ) = 1.83846</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Local Delivery Costs ( L_j ) (1986 Dollars)</td>
<td>45,641</td>
<td>45,641</td>
<td>45,641</td>
</tr>
<tr>
<td>Total Annual Distribution Cost for Region ( j ) Transshipments (1986 $)</td>
<td>1,258,703</td>
<td>944,205</td>
<td>954,299</td>
</tr>
</tbody>
</table>

\[ IC_{kj}(Q_j) = T_{kj}(Q_j) + W_j(Q_j) + L_j \]
TOTAL ANNUAL DISTRIBUTION COST CALCULATIONS

FROM THE FACTORY IN REGION \( k = \text{II ROCKY MOUNTAIN} \)
TO CUSTOMERS IN REGION \( j = \text{VII SOUTH CENTRAL} \)

<table>
<thead>
<tr>
<th>Customer Type ( i )</th>
<th>Shipping Indicator ( X_{ij} )</th>
<th>Annual Direct Shipping Cost (1986 $) ( DC_{ki} )</th>
<th>Annual Distribution Costs For Transshipments (1986 $) ( IC_{kj} )</th>
<th>Total Annual Distribution Cost Region ( j ) (1986 $) ( TC_{kj} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0.00</td>
<td>5,446,280.00</td>
<td>5,446,280.00</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>0.00</td>
<td>4,676,873.10</td>
<td>4,676,873.10</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>0.00</td>
<td>5,446,280.00</td>
<td>5,446,280.00</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>4,676,873.10</td>
<td>0.00</td>
<td>4,676,873.10</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>4,676,873.10</td>
<td>0.00</td>
<td>4,676,873.10</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>891,423.12</td>
<td>0.00</td>
<td>891,423.12</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>891,423.12</td>
<td>0.00</td>
<td>891,423.12</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>2,228,557.80</td>
<td>0.00</td>
<td>2,228,557.80</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2,228,557.80</td>
<td>0.00</td>
<td>2,228,557.80</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>891,423.12</td>
<td>0.00</td>
<td>891,423.12</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>0.00</td>
<td>2,417,814.00</td>
<td>2,417,814.00</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>5,288,906.67</td>
<td>0.00</td>
<td>5,288,906.67</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>0.00</td>
<td>1,017,065.00</td>
<td>1,017,065.00</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>2,228,557.80</td>
<td>0.00</td>
<td>2,228,557.80</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>9,115,622.00</td>
<td>0.00</td>
<td>9,115,622.00</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0.00</td>
<td>2,127,709.00</td>
<td>2,127,709.00</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>891,423.12</td>
<td>0.00</td>
<td>891,423.12</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>2,228,557.80</td>
<td>0.00</td>
<td>2,228,557.80</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>3,119,588.90</td>
<td>0.00</td>
<td>3,119,588.90</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0.00</td>
<td>2,127,709.00</td>
<td>2,127,709.00</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>891,423.12</td>
<td>0.00</td>
<td>891,423.12</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>2,228,557.80</td>
<td>0.00</td>
<td>2,228,557.80</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>7,796,854.02</td>
<td>0.00</td>
<td>7,796,854.02</td>
</tr>
</tbody>
</table>

\[ TC_{kj} = DC_{kj} + IC_{kj} \]

\( X_{ij} = \begin{cases} 
0 & \text{if customers of type } i \text{ in Region } j \text{ are supplied directly from the factory} \\
1 & \text{if customers of type } i \text{ in Region } j \text{ are supplied from a warehouse in Region } j 
\end{cases} \)
**DIRECT - FACTORY - CUSTOMER SHIPMENTS COST CALCULATIONS**

Factory Region \( k = \) II Rocky Mountain  
Market Region \( j = \) VII South Central

<table>
<thead>
<tr>
<th>Customer Type</th>
<th>Annual Demand In Region ( J ) (MW/yr) ( d_{ij} )</th>
<th>Average Delivery Quantity (MW/ship) ( q_i )</th>
<th>Number Shipments Per Year ( d_{ij}/q_i )</th>
<th>Shipment Weight ( Z_i = q_i w )</th>
<th>Shipping Distance ( S_{kj} )</th>
<th>Shipping Cost ( C(Z_i,S_{kj}) )</th>
<th>Annual Cost ( DC_{ij} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Household</td>
<td>40.0</td>
<td>.01</td>
<td>4000</td>
<td>1559.25</td>
<td>1652</td>
<td>635.96</td>
<td>4,676,873.10</td>
</tr>
<tr>
<td>Intermediate Commercial</td>
<td>20.0</td>
<td>.50</td>
<td>40</td>
<td>77,962.50</td>
<td>1652</td>
<td>12121.61</td>
<td>891,423.12</td>
</tr>
<tr>
<td>Central Station Utility</td>
<td>50.0</td>
<td>5.00</td>
<td>10</td>
<td>779,625.00</td>
<td>1652</td>
<td>121216.10</td>
<td>2,228,557.80</td>
</tr>
</tbody>
</table>

\( w = \) Solar Array Unit Weight (kg/MW)  
\( = 155.325 \text{ kg/MW} \)

\( DC_{ij} = \) Annual distribution cost in region \( j \)  
for customers supplied directly  
from the factory in Region \( k \)  
in manufacturing year \( 1986-1977 \)

\[
DC_{ij} = \sum_{i=1}^{3} \frac{d_{ij} * (1-X_{ij}) * C(Z_i,S_{kj})(1+g_T)^{1986-1977}}{q_i}
\]

Where \( X_{ij} = \begin{cases} 
0 & \text{if customers of type } i \text{ in region } j \\
1 & \text{if customers of type } i \text{ in region } j \\
\end{cases} \)

\( T = 7\% \text{/year} \)

---

D-45
**WAREHOUSING COST CALCULATION FOR REGION j = VII SOUTHWEST CENTRAL**

<table>
<thead>
<tr>
<th>Shipment Qty Qi (m²)</th>
<th>.40</th>
<th>.50</th>
<th>1.00</th>
<th>1.20</th>
<th>1.40</th>
<th>1.60</th>
<th>2.20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warehouse size Fj = 353.95 Qi (m²)</td>
<td>141.58</td>
<td>283.16</td>
<td>353.95</td>
<td>424.74</td>
<td>495.53</td>
<td>637.11</td>
<td>778.69</td>
</tr>
<tr>
<td><strong>Equipment Cost</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E = (1.07)*k_e (Fj)*e</td>
<td>6,273</td>
<td>12,547</td>
<td>15,684</td>
<td>18,820</td>
<td>21,957</td>
<td>28,231</td>
<td>34,504</td>
</tr>
<tr>
<td><strong>Facilities Cost</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F = (1.09)*k_F (Fj)*b</td>
<td>78,111</td>
<td>139,120</td>
<td>171,622</td>
<td>204,525</td>
<td>237,228</td>
<td>302,633</td>
<td>368,039</td>
</tr>
<tr>
<td><strong>Warehouse Lease Cost (1986 $/YR)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LC, Qi (Qi) = .25E + .126F</td>
<td>10,402</td>
<td>20,666</td>
<td>25,572</td>
<td>30,475</td>
<td>35,380</td>
<td>47,189</td>
<td>54,909</td>
</tr>
<tr>
<td><strong>Personnel Cost</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1.08)*P(Fj)*P</td>
<td>51,348</td>
<td>51,348</td>
<td>51,348</td>
<td>51,348</td>
<td>51,348</td>
<td>51,348</td>
<td>51,348</td>
</tr>
<tr>
<td><strong>Utilities Cost</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1.12)<em>.20</em>uj*Fj</td>
<td>4,583</td>
<td>9,100</td>
<td>11,250</td>
<td>13,401</td>
<td>15,551</td>
<td>19,852</td>
<td>24,153</td>
</tr>
<tr>
<td><strong>Property Tax, Maintenance and Insurance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.06*(E + F)</td>
<td>565</td>
<td>1,131</td>
<td>1,413</td>
<td>1,696</td>
<td>1,979</td>
<td>2,544</td>
<td>3,109</td>
</tr>
<tr>
<td><strong>Warehouse Operating Cost (1986 $/YR)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OC, Qi (Qi)</td>
<td>56,496</td>
<td>61,579</td>
<td>64,011</td>
<td>66,445</td>
<td>68,878</td>
<td>73,744</td>
<td>78,610</td>
</tr>
<tr>
<td><strong>Inventory Carrying Cost (1986 $/YR)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC(Qi) = 37,750</td>
<td>75,500</td>
<td>94,375</td>
<td>113,250</td>
<td>132,125</td>
<td>169,875</td>
<td>207,625</td>
<td></td>
</tr>
<tr>
<td><strong>Warehousing Cost (1986 $/YR)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WA, Qi (Qi) = CC(Qi) + OC, Qi (Qi) + LC, Qi (Qi)</td>
<td>104,648</td>
<td>157,745</td>
<td>183,957</td>
<td>210,170</td>
<td>236,383</td>
<td>288,808</td>
<td>341,234</td>
</tr>
</tbody>
</table>

*Optimal Level*

**Regional Cost Indices**

- \( e_j = \text{Equipment} = 0.927 \)
- \( b_j = \text{Facilities} = 0.927 \)
- \( l_j = \text{Labor} = 0.937 \)
- \( u_j = \text{Utilities} = 0.200 \)

**Inflation Rates**

- \( g_j = \text{Equipment} = 7\% \)
- \( g_b = \text{Facilities} = 9\% \)
- \( g_l = \text{Labor} = 8\% \)
- \( g_u = \text{Utilities} = 12\% \)
- \( g_t = \text{Transportation} = 7\% \)

D-46
### ANNUAL DISTRIBUTION COST FOR WAREHOUSE TRANSMISSIONS

**IN REGION j = II ROCKY MOUNTAIN**  
**FACTORY LOCATION REGION k = VII SOUTH CENTRAL**

<table>
<thead>
<tr>
<th>Customer Type</th>
<th>( x_{ij} )</th>
<th>( d_{ij} )</th>
<th>( x_{ij} \times d_{ij} )</th>
<th>( q_i )</th>
<th>( (d_{ij} \times x_{ij})^2 \times \frac{149_i}{2} \times 50 )</th>
<th>( y_{ij} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Household</td>
<td>1</td>
<td>40.0</td>
<td>40.0</td>
<td>.01</td>
<td>238,981.250</td>
<td>50.0</td>
</tr>
<tr>
<td>2 Intermediate</td>
<td>0</td>
<td>20.0</td>
<td>0.0</td>
<td>.50</td>
<td>0.000</td>
<td>50.0</td>
</tr>
<tr>
<td>3 Central Station</td>
<td>0</td>
<td>50.0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.000</td>
<td>50.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>110.0</td>
<td>40.0</td>
<td>5.51</td>
<td>KM = 238,981.250</td>
<td></td>
</tr>
</tbody>
</table>

Warehouse - customer distance = \( y_{ij} \), \( FC = $24,039/\text{year} \)

Factory-warehouse distance \( s_{kj} = 1,652 \text{ km} \), \( VC = $.095/\text{km} \)

Solar Array Unit Weight \( v = 155,925 \text{ kg/MW} \), \( WC = 75,000 \text{ km/vehicle} \)

<table>
<thead>
<tr>
<th>Warehouse Order Quantity ( Q_j ) (MW)</th>
<th>.40</th>
<th>.80</th>
<th>1.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight ( = q_j \times w )</td>
<td>62,370</td>
<td>124,740</td>
<td>135,925</td>
</tr>
<tr>
<td>Deliveries/Year ( = d_{ij} \times x_{ij} /Q_j )</td>
<td>100</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>Order processing cost @$50/delivery</td>
<td>5,000</td>
<td>2,500</td>
<td>2,000</td>
</tr>
<tr>
<td>Cost/delivery ( C(Q_j \times W, s_{kj}) )</td>
<td>9,697</td>
<td>19,395</td>
<td>24,243</td>
</tr>
<tr>
<td>Inflation Factor ( = (1 + .07)^t )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Transportation Cost ( T_{kj}(Q_j) ) (1986 Dollars)</td>
<td>1,791,699</td>
<td>1,787,402</td>
<td>1,785,484</td>
</tr>
<tr>
<td>Inventory Carrying Cost ( CC(Q_j) )</td>
<td>37,750</td>
<td>75,500</td>
<td>94,375</td>
</tr>
<tr>
<td>Warehouse Operating Cost ( OC_j(Q_j) )</td>
<td>56,496</td>
<td>61,579</td>
<td>64,011</td>
</tr>
<tr>
<td>Warehouse Leasing Cost ( LC_j(Q_j) )</td>
<td>10,402</td>
<td>26,006</td>
<td>25,571</td>
</tr>
<tr>
<td>Annual Warehousing Cost ( W_j(Q_j) ) (1986 Dollars)</td>
<td>104,648</td>
<td>157,745</td>
<td>183,557</td>
</tr>
<tr>
<td>Fixed Delivery Cost ( FC \times KM )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable Delivery Cost ( VC \times KM )</td>
<td>41,739</td>
<td>41,739</td>
<td>41,739</td>
</tr>
<tr>
<td>Inflation Factor ( = (1 + .07)^t = 1.833846 )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Local Delivery Costs ( L_j ) (1986 Dollars)</td>
<td>182,562</td>
<td>182,562</td>
<td>182,562</td>
</tr>
<tr>
<td>Total Annual Distribution Cost for Region ( j ) Transmissions (1986 $)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( IC_kj(Q_j) )</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[
IC_kj(Q_j) = T_{kj}(Q_j) + W_j(Q_j) + L_j
\]
FINANCIAL MODEL CALCULATIONS

INDEX

Sales Revenues (By Product and Region) D-49
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Income Taxes (By Product and Region) D-53
Net Profit After Taxes (By Product and Region) D-54
Solar Array Price Estimates (By Product and Region) D-55
## SALES REVENUES*
*(By Product and Region)*

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Customer Type</th>
<th>Residential</th>
<th>Commercial</th>
<th>Public Utility</th>
<th>All Products</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Household</td>
<td>Intermediate</td>
<td>Central Station</td>
<td>Products</td>
</tr>
<tr>
<td>1</td>
<td>West Coast</td>
<td>$82,417,748</td>
<td>$38,966,310</td>
<td>$70,161,132</td>
<td>$191,545,190</td>
</tr>
<tr>
<td>11</td>
<td>Rocky Mountain</td>
<td>95,751,794</td>
<td>46,067,400</td>
<td>69,036,979</td>
<td>211,906,173</td>
</tr>
<tr>
<td>111</td>
<td>North Central</td>
<td>16,952,037</td>
<td>8,032,317</td>
<td>0</td>
<td>24,984,354</td>
</tr>
<tr>
<td>1V</td>
<td>Great Lakes</td>
<td>17,537,420</td>
<td>8,279,872</td>
<td>0</td>
<td>25,817,292</td>
</tr>
<tr>
<td>V</td>
<td>North Eastern</td>
<td>34,660,244</td>
<td>16,492,347</td>
<td>75,458,516</td>
<td>126,611,107</td>
</tr>
<tr>
<td>VI</td>
<td>South Eastern</td>
<td>16,987,530</td>
<td>8,078,540</td>
<td>0</td>
<td>25,066,070</td>
</tr>
<tr>
<td>VII</td>
<td>South Central</td>
<td>65,945,158</td>
<td>31,378,876</td>
<td>71,786,047</td>
<td>169,110,081</td>
</tr>
<tr>
<td>All Regions</td>
<td></td>
<td>$331,251,931</td>
<td>$157,295,662</td>
<td>$286,492,674</td>
<td>$775,040,267</td>
</tr>
<tr>
<td></td>
<td>(42.7%)</td>
<td>(20.3%)</td>
<td>(37.0%)</td>
<td></td>
<td>(100.0%)</td>
</tr>
</tbody>
</table>

*Expressed in 1986 Manufacturing Year $/Year*
COST OF GOODS SOLD*
(By Product and Region)

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Residential Household Products</th>
<th>Intermediate Commercial Products</th>
<th>Central Utility Stations</th>
<th>Total Cost of Good Sold</th>
</tr>
</thead>
<tbody>
<tr>
<td>I West Coast</td>
<td>$47,950,000</td>
<td>$23,975,000</td>
<td>$47,950,000</td>
<td>$119,875,000</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>57,540,000</td>
<td>28,770,000</td>
<td>47,950,000</td>
<td>134,260,000</td>
</tr>
<tr>
<td>III North Central</td>
<td>9,590,000</td>
<td>4,795,000</td>
<td>0</td>
<td>14,385,000</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>9,590,000</td>
<td>4,795,000</td>
<td>0</td>
<td>14,385,000</td>
</tr>
<tr>
<td>V North Eastern</td>
<td>19,180,000</td>
<td>9,590,000</td>
<td>47,950,000</td>
<td>76,720,000</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>9,590,000</td>
<td>4,795,000</td>
<td>0</td>
<td>14,385,000</td>
</tr>
<tr>
<td>VII South Central</td>
<td>38,360,000</td>
<td>19,180,000</td>
<td>47,950,000</td>
<td>105,490,000</td>
</tr>
<tr>
<td>All Regions</td>
<td>$191,800,000</td>
<td>$95,900,000</td>
<td>$191,800,000</td>
<td>$479,500,000</td>
</tr>
</tbody>
</table>

*Expressed in 1986 Manufacturing Year Dollars
Based on a Manufacturing Price of $.959/Peak Watt
MARKETING EXPENSES*  
(By Product and Region)

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Customer Type</th>
<th>Residential Household 1</th>
<th>Commercial Intermediate 2</th>
<th>Public Utility Central Station 3</th>
<th>All Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>West Coast</td>
<td>$9,623,414</td>
<td>$3,425,556</td>
<td>$1,300,044</td>
<td>$14,349,014</td>
</tr>
<tr>
<td>11</td>
<td>Rocky Mountain</td>
<td>11,440,477</td>
<td>4,071,312</td>
<td>1,291,219</td>
<td>16,803,008</td>
</tr>
<tr>
<td>111</td>
<td>North Central</td>
<td>1,852,787</td>
<td>659,152</td>
<td>0</td>
<td>2,511,939</td>
</tr>
<tr>
<td>IV</td>
<td>Great Lakes</td>
<td>2,083,809</td>
<td>744,090</td>
<td>0</td>
<td>2,827,899</td>
</tr>
<tr>
<td>V</td>
<td>North Eastern</td>
<td>3,431,845</td>
<td>1,216,007</td>
<td>1,077,732</td>
<td>5,725,584</td>
</tr>
<tr>
<td>VI</td>
<td>South Eastern</td>
<td>1,599,745</td>
<td>566,058</td>
<td>0</td>
<td>2,165,803</td>
</tr>
<tr>
<td>VII</td>
<td>South Central</td>
<td>6,615,975</td>
<td>2,342,060</td>
<td>1,097,190</td>
<td>10,055,225</td>
</tr>
<tr>
<td></td>
<td>All Regions</td>
<td>$36,648,052</td>
<td>$13,024,235</td>
<td>$4,766,185</td>
<td>$54,438,472</td>
</tr>
</tbody>
</table>

*Expressed in 1986 Manufacturing Year Dollars/Year
## DISTRIBUTION EXPENSES*
*(By Product and Region)*

<table>
<thead>
<tr>
<th>Market Region Type</th>
<th>Customer Type</th>
<th>Residential 1 From Warehouse</th>
<th>Commercial Intermediate 2 Direct</th>
<th>Public Utility Central Station 3 Direct</th>
<th>All Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>I West Coast</td>
<td>Household</td>
<td>$1,296,406</td>
<td>$432,523</td>
<td>$856,050</td>
<td>$2,593,979</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>Residential</td>
<td>127,947</td>
<td>63,974</td>
<td>106,623</td>
<td>298,544</td>
</tr>
<tr>
<td>III North Central</td>
<td>Household</td>
<td>665,811</td>
<td>283,217</td>
<td>0</td>
<td>949,028</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>Commercial</td>
<td>852,920</td>
<td>375,104</td>
<td>0</td>
<td>1,228,024</td>
</tr>
<tr>
<td>V North Eastern</td>
<td>Commercial</td>
<td>2,145,472</td>
<td>974,241</td>
<td>4,871,208</td>
<td>7,990,921</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>Household</td>
<td>944,205</td>
<td>409,328</td>
<td>0</td>
<td>1,353,533</td>
</tr>
<tr>
<td>VII South Central</td>
<td>Commercial</td>
<td>2,127,709</td>
<td>891,423</td>
<td>2,228,558</td>
<td>5,247,690</td>
</tr>
<tr>
<td>All Regions</td>
<td>Residential</td>
<td>$8,160,470</td>
<td>$3,249,810</td>
<td>$8,071,439</td>
<td>$19,661,719</td>
</tr>
</tbody>
</table>

*Expressed in 1986 Manufacturing Year Dollars/Year.
INCOME TAXES*
(By Product and Region)

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Residential Household 1</th>
<th>Commercial Intermediate 2</th>
<th>Public Utility Central Station 3</th>
<th>All Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>I West Coast</td>
<td>$12,009,443</td>
<td>$5,677,947</td>
<td>$10,223,480</td>
<td>$27,910,870</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>14,098,118</td>
<td>6,712,679</td>
<td>10,066,960</td>
<td>30,877,757</td>
</tr>
<tr>
<td>III North Central</td>
<td>2,470,154</td>
<td>1,170,423</td>
<td>0</td>
<td>3,640,577</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>2,555,453</td>
<td>1,206,495</td>
<td>0</td>
<td>3,761,948</td>
</tr>
<tr>
<td>V North Eastern</td>
<td>5,050,493</td>
<td>2,403,171</td>
<td>10,995,383</td>
<td>18,449,047</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>2,475,325</td>
<td>1,177,159</td>
<td>0</td>
<td>3,652,484</td>
</tr>
<tr>
<td>VII South Central</td>
<td>9,609,152</td>
<td>4,572,351</td>
<td>10,460,252</td>
<td>24,641,755</td>
</tr>
<tr>
<td>All Regions</td>
<td>$48,268,138</td>
<td>$22,920,225</td>
<td>$41,746,075</td>
<td>$112,934,438</td>
</tr>
</tbody>
</table>

*Expressed in 1986 (manufacturing year) dollars.
### NET PROFIT AFTER TAXES*  
(By Product and Region)

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Customer Type</th>
<th>Residential</th>
<th>Commercial</th>
<th>Public Utility</th>
<th>All Products</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Household 1</td>
<td>Intermediate 2</td>
<td>Central Station 3</td>
<td></td>
</tr>
<tr>
<td>I West Coast</td>
<td></td>
<td>$11,538,485</td>
<td>$5,455,283</td>
<td>$9,822,559</td>
<td>$26,816,327</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td></td>
<td>13,545,251</td>
<td>6,449,436</td>
<td>9,672,177</td>
<td>29,666,864</td>
</tr>
<tr>
<td>III North Central</td>
<td></td>
<td>2,373,285</td>
<td>1,124,525</td>
<td>0</td>
<td>3,497,810</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td></td>
<td>2,455,239</td>
<td>1,159,182</td>
<td>0</td>
<td>3,614,421</td>
</tr>
<tr>
<td>V North Eastern</td>
<td></td>
<td>4,852,434</td>
<td>2,308,929</td>
<td>10,564,192</td>
<td>17,725,555</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td></td>
<td>2,378,254</td>
<td>1,130,996</td>
<td>0</td>
<td>3,509,250</td>
</tr>
<tr>
<td>VII South Central</td>
<td></td>
<td>9,232,322</td>
<td>4,393,043</td>
<td>10,050,046</td>
<td>23,675,411</td>
</tr>
<tr>
<td>All Regions</td>
<td></td>
<td>$46,275,270</td>
<td>$22,021,394</td>
<td>$40,108,974</td>
<td>$108,505,638</td>
</tr>
</tbody>
</table>

*Expressed in 1986 (manufacturing year) dollars.
### SOLAR ARRAY PRICE ESTIMATES*
(By Product and Region)
(1975 $/Watt)

<table>
<thead>
<tr>
<th>Market Region</th>
<th>Residential Household 1</th>
<th>Residential Intermediate 2</th>
<th>Public Utility Central Station 3</th>
<th>All Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>I West Coast</td>
<td>$.860</td>
<td>$.813</td>
<td>$.732</td>
<td>$.799</td>
</tr>
<tr>
<td>II Rocky Mountain</td>
<td>$.841</td>
<td>$.801</td>
<td>$.720</td>
<td>$.789</td>
</tr>
<tr>
<td>III North Central</td>
<td>$.884</td>
<td>$.838</td>
<td>-</td>
<td>$.868</td>
</tr>
<tr>
<td>IV Great Lakes</td>
<td>$.914</td>
<td>$.863</td>
<td>-</td>
<td>$.897</td>
</tr>
<tr>
<td>V North Eastern</td>
<td>$.904</td>
<td>$.860</td>
<td>$.787</td>
<td>$.825</td>
</tr>
<tr>
<td>VI South Eastern</td>
<td>$.886</td>
<td>$.842</td>
<td>-</td>
<td>$.871</td>
</tr>
<tr>
<td>VII South Central</td>
<td>$.860</td>
<td>$.818</td>
<td>$.749</td>
<td>$.801</td>
</tr>
<tr>
<td>All Regions</td>
<td>$.864</td>
<td>$.820</td>
<td>$.747</td>
<td>$.808</td>
</tr>
</tbody>
</table>

*Expressed in deflated 1975 dollars per watt.