PV LARGE SYSTEMS PROJECT
AEROSPACE CORP.
S.L. Leonard
Utility Oil Conservation
A Near-Term PV Central-Station Market

* PRIMARY MARKET AREAS
  * CALIFORNIA, FLORIDA, HAWAII, PUERTO RICO
  * OIL-DEPENDENT
  * HIGH INSOLATION
  * PRESENT (1978) OIL USE: 500,000 BBLS/DAY (30% OF U.S. UTILITY OIL CONSUMPTION)

* SECONDARY MARKET AREAS
  * LOUISIANA, TEXAS, OKLAHOMA
  * DEPENDENT ON NATURAL GAS, OIL
  * GOOD INSOLATION
  * PRESENT (1978) OIL USE: 85,000 BBLS/DAY
  * PRESENT (1978) NATURAL GAS USE: 1,000,000 BBLS/DAY (OIL EQUIVALENT)

* CONCLUSION
  * IF BASELINE TECHNOLOGY COMMERCIAL READINESS GOALS ARE REACHED, IT WILL BE COST-EFFECTIVE BY THE LATE 1980'S IN THE PRIMARY MARKET AREAS TO CONSTRUCT PHOTOVOLTAIC PLANTS SOLELY TO REDUCE OIL CONSUMPTION, EVEN IF THE REAL (INFLATION-ADJUSTED) PRICE OF OIL DOES NOT INCREASE OVER 1980 VALUES.
Issues

- **QUESTION**: IS THIS APPARENT OPPORTUNITY REAL, OR IS THE ANALYTICAL APPROACH TOO SIMPLIFIED?
  - **RESPONSE**: DETAILED ANALYSES OF VALUE OF PHOTOVOLTAIC GENERATION IN SPECIFIC OIL-DEPENDENT SUNBELT UTILITIES

- **QUESTION**: ARE THESE RESULTS CREDIBLE TO THE INDUSTRIES THAT WOULD BE INVOLVED?
  - **RESPONSE**: EXTENSIVE IN-DEPTH DISCUSSIONS WITH REPRESENTATIVE ORGANIZATIONS IN THE UTILITY, PHOTOVOLTAIC MANUFACTURING, AND CONSTRUCTION INDUSTRIES

- **QUESTION**: HOW CAN TECHNICAL AND ECONOMIC RISKS BE REDUCED TO THE POINT THAT THE PRIVATE SECTOR WILL TAKE ADVANTAGE OF THIS OPPORTUNITY?
  - **RESPONSE**: ANALYSES OF INNOVATIVE FINANCING ARRANGEMENTS THAT COULD LEAD TO HAND-OFF TO THE PRIVATE SECTOR AT CURRENTLY ACHIEVABLE SYSTEM COSTS, ONCE TECHNICAL FEASIBILITY HAS BEEN DEMONSTRATED

SUPPORT OF FEDERAL PARTICIPATION IN INITIAL UTILITY-SCALE PROJECTS THAT DEMONSTRATE TECHNICAL FEASIBILITY OF LARGE PHOTOVOLTAIC SYSTEMS FOR UTILITY APPLICATIONS

Value Analysis Methodology
Value of PV Power Plants in the Southern California Edison System

ASSUMPTIONS

- All costs in 1980 dollars
- General inflation rate
  - 1981 - 1987: ~8.4%/yr
  - 1988 - : 5%/yr
- Real fuel price escalation
  - 1981 - 1984: ~2.7%/yr
  - 1985 - : 2%/yr
- Photovoltaic system life: 30 yr
- Photovoltaic penetration
  - Energy: 5%
  - Capacity: 11%

Expected capital cost range for photovoltaic plants

Full savings

Capacity credit (at $600/kW)
Value of PV Power Plants in the Los Angeles Department of Water and Power System

ASSUMPTIONS

- ALL COSTS IN 1981 DOLLARS
- GENERAL INFLATION RATE
  - 1981 - 85: 9.12% / YEAR
  - 1986 - 90: 8.30% / YEAR
  - 1991 - : 5.95% / YEAR
- REAL FUEL PRICE ESCALATION
  - 1981 - 85: 0.88% / YEAR
  - 1986 - 90: 1.70% / YEAR
  - 1991 - : 2.05% / YEAR
- PHOTOVOLTAIC SYSTEM LIFE: 30 YEARS
- PHOTOVOLTAIC PENETRATION
  - 1981: 2.1% OF ELECTRIC ENERGY FROM THERMAL UNITS
  - 1994: 1.5% OF ELECTRIC ENERGY FROM THERMAL UNITS

EXPECTED CAPITAL COST RANGE FOR PHOTOVOLTAIC PLANTS

![Expected Capital Cost Range](image)

- FUEL SAVINGS
- CAPACITY CREDIT (at $600/kW)
Third-Party Ownership Option

CONCEPT:
INVESTOR GROUP FINANCES CONSTRUCTION OF PHOTOVOLTAIC POWER PLANT, SELLS ELECTRICITY TO UTILITY, TAKES ADVANTAGE OF TAX INCENTIVES NOT AVAILABLE TO UTILITY

ADVANTAGES:
INCLUSION OF TAX BENEFITS MAKES INVESTMENT ATTRACTIVE WHEN COST OF PLANT IS STILL TOO HIGH FOR UTILITY PURCHASE

DIAGRAM:
- ELECTRIC UTILITY SYSTEM
  - REVENUE FROM POWER SALE
- STATE TAX BOARD
  - TAX CREDITS AND DEDUCTIONS
- INVESTOR GROUP
  - EQUITY CAPITAL
  - RESERVE RELEASE
  - INTEREST ON RESERVE
- LOAN SOURCE
  - LOAN
- DEBT SERVICE
- SYSTEMS HOUSE OR AGE FIRM
- IRS
- GENERAL CONTRACTOR, SUB CONTRACTORS, SUPPLIERS
### Investment Evaluation: Third-Party Financing Arrangement

#### ECONOMIC ASSUMPTIONS

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<th>13.00</th>
<th>10.50</th>
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<tr>
<td><strong>SYSTEM COST ($/Wp)</strong></td>
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<tr>
<td><strong>REAL ESCALATION OF ELECTRICITY PRICE</strong></td>
<td>5%/yr</td>
<td>3%/yr</td>
<td>0%/yr</td>
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<tr>
<td><strong>EQUITY CAPITAL (% of system cost)</strong></td>
<td>25</td>
<td>25</td>
<td>50</td>
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<tr>
<td><strong>DEBT CAPITAL (% of system cost)</strong></td>
<td>75</td>
<td>75</td>
<td>50</td>
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<tr>
<td><strong>EQUITY RESERVE (% of system cost)</strong></td>
<td>50</td>
<td>48</td>
<td>21</td>
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<tr>
<td><strong>REQUIRED AFTER-TAX RETURN ON EQUITY</strong></td>
<td>15%/yr</td>
<td>15%/yr</td>
<td>15%/yr</td>
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#### BENEFIT/COST BREAKDOWN (After-Tax Net Present Value as Percentage of Equity)

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<td><strong>CALIFORNIA ENERGY CREDIT (net of Federal Tax)</strong></td>
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<td>17.2</td>
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<td><strong>CALIFORNIA (net of Federal Tax)</strong></td>
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<td>4.4</td>
<td>4.5</td>
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<tr>
<td><strong>NET LOAN COST (less interest shelter)</strong></td>
<td>(46.8)</td>
<td>(48.1)</td>
<td>(32.7)</td>
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<tr>
<td><strong>NET ELECTRIC POWER REVENUE (net of O&amp;M)</strong></td>
<td>15.5</td>
<td>15.6</td>
<td>17.4</td>
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<td><strong>RESERVE RELEASE</strong></td>
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<td>12.7</td>
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<td><strong>RESERVE INTEREST</strong></td>
<td>19.4</td>
<td>18.9</td>
<td>7.6</td>
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<tr>
<td><strong>100.0</strong></td>
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**ECONOMIC ASSUMPTIONS**

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<th>Economic Assumptions</th>
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<td>System Cost ($/Wp)</td>
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<tr>
<td>System Service Life (years)</td>
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<tr>
<td>Real Escalation of Electricity Price</td>
<td>3%/yr</td>
<td>3%/yr</td>
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<tr>
<td>Equity Capital (percent of system cost)</td>
<td>25</td>
<td>60</td>
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<td>30</td>
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<tr>
<td>Debt Capital (percent of system cost)</td>
<td>75</td>
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<td>70</td>
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<tr>
<td>Equity Reserve (percent of system cost)</td>
<td>47.4</td>
<td>9.65</td>
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<td>Rate of Interest on Debt</td>
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<td>12%</td>
<td>16%</td>
<td>12%</td>
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<tr>
<td>Required After-Tax Return on Equity</td>
<td>15%</td>
<td>15%</td>
<td>15%</td>
<td>15%</td>
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<tr>
<td>Federal and State Solar Tax Credits</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
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**Benefit/Cost Breakdown (after-tax net present value as percentage of equity)**

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<tr>
<th>Benefit/Cost Breakdown</th>
<th>Wp 10.50</th>
<th>Wp 6.00</th>
<th>Wp 7.60</th>
<th>Wp 4.50</th>
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<td>Federal Investment Tax Credit</td>
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<td>Federal Energy Credit</td>
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<tr>
<td>California Energy Credit (net of federal tax)</td>
<td>17.2</td>
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<td>0</td>
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<td>Depreciation: Federal</td>
<td>38.9</td>
<td>40.8</td>
<td>37.9</td>
<td>55.5</td>
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<tr>
<td>California (net of federal tax)</td>
<td>4.4</td>
<td>4.6</td>
<td>4.2</td>
<td>6.2</td>
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<tr>
<td>Net Loan Cost (less interest shelter)</td>
<td>(-48.1)</td>
<td>(-31.2)</td>
<td>(-58.7)</td>
<td>(-64.0)</td>
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<td>Net Electric Power Revenue (net of O&amp;M)</td>
<td>15.6</td>
<td>22.7</td>
<td>21.0</td>
<td>51.9</td>
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<td>Reserve Release</td>
<td>22.1</td>
<td>9.2</td>
<td>23.5</td>
<td>24.9</td>
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<tr>
<td>Reserve Interest</td>
<td>18.9</td>
<td>2.2</td>
<td>25.0</td>
<td>7.6</td>
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<tr>
<td>Total</td>
<td>101.0</td>
<td>99.9</td>
<td>100.8</td>
<td>100.3</td>
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Current Large-System Projects

- **SACRAMENTO MUNICIPAL UTILITY DISTRICT PROJECT**
  - PLANNED CAPACITY: 1 MW (AC)
  - SITE: RANCHO SECO NUCLEAR POWER PLANT, 30 MILES SOUTH OF SACRAMENTO, CALIFORNIA
  - FUNDING ALLOCATION: $12 MILLION -- $6.8 MILLION FROM DOE, $2 MILLION FROM STATE OF CALIFORNIA, $3.2 MILLION FROM SMUD
  - PROJECTED IOC DATE: JUNE 1984
  - FIRST STAGE OF PLANNED 100 MW PHOTOVOLTAIC POWER PLANT

- **ARCO SOLAR / SOUTHERN CALIFORNIA EDISON COMPANY PROJECT**
  - PLANNED CAPACITY: 1 MW (DC)
  - SITE: LUGO SUBSTATION NEAR VICTORVILLE, CALIFORNIA
  - ARCO SOLAR TO BE BUILDER, OWNER, AND OPERATOR
  - SOUTHERN CALIFORNIA EDISON TO PURCHASE AND DISTRIBUTE OUTPUT POWER
  - PROJECTED IOC DATE: DECEMBER 1982
  - PRIVATE VENTURE MADE POSSIBLE BY STATE AND FEDERAL TAX INCENTIVES
Conclusions

- Detailed analyses of the value of photovoltaic generation to specific utilities confirm the results of simplified analysis:
  - Photovoltaic plants costing $1.50 - 2.00/Wp would be cost-effective in an oil-dependent southwestern investor-owned utility.
  - The breakeven cost in a similar municipal utility would be even larger: $3.00 - 4.00/Wp.

- The progressive elements of the utility industry are keenly interested in photovoltaic technology but require assistance to proceed with large commercial (i.e., non-R&D) projects:
  - Risks arising from uncertainties in system cost and performance are too large to be justified under allowed rates of return.
  - Utilities are, however, willing to enter into agreements with third-party financed projects.

- Under a properly-structured third-party arrangement, constructing a photovoltaic plant at currently achievable costs can be an attractive investment:
  - Current solar tax credits contribute heavily to effective rate of return on investment.
  - Leveraged financing at reasonable rates significantly increases returns.