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 BBL/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 BBL/DAY
  - PRESENT (1978) NATURAL GAS USE: 1,000,000 BBL/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

- COST OF PRODUCTION PROGRAM
  - UTILITY SYSTEM OPERATION MODEL
  - THERMAL PLANT DETAILS
    - OPERATING RANGE
    - FUEL TYPE
    - HEAT RATE CURVES
    - STARTUP/SHUTDOWN COSTS
  - SYSTEM OPERATING RULES
    - SPINNING RESERVE
    - MUST RUN UNITS
    - HOUR BY HOUR ECONOMIC DISPATCH

- LOSS OF LOAD PROBABILITY PROGRAM
  - UTILITY SYSTEM RELIABILITY MODEL
    - UNIT FORCED OUTAGE RATES AS FUNCTIONS OF OPERATING LEVEL
    - MAINTENANCE SCHEDULE
    - HOUR BY HOUR COMPUTATION OF LOSS OF LOAD PROBABILITY (LOLP)
    - DETERMINATION OF EFFECT OF PHOTOVOLTAIC GENERATION ON LOLP

- FUEL SAVINGS
- VALUE OF PHOTOVOLTAIC GENERATION
  - FUEL SAVINGS
  - CAPACITY VALUE
- PHOTOVOLTAIC LOAD CARRYING CAPABILITY

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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

Baseline technology

Advanced technology

Year of photovoltaic plant installation

Fuel 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
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.
Investment Evaluation: Third-Party Financing Arrangement

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<td>Required After-Tax Return on Equity</td>
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Benefit/Cost Breakdown (After-Tax Net Present Value as Percentage of Equity)

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<td>Net Loan Cost (less interest shelter)</td>
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<td>Total</td>
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Before-Tax Cash Flow

- Net Electric Power Revenue
- Net Cash Flow
- Loan Costs
- Reserve Release

Years: 2, 6, 10, 14, 18, 22, 26, 30

Fraction of Investment Equity: 0.6, 0.5, 0.4, 0.3, 0.2, 0.1, 0, 0.1
Investment Evaluation: Selected Sensitivities

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<th>Economic Assumptions</th>
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<td>System Service Life (years)</td>
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<td>Debt Capital (percent of system cost)</td>
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<td>Required After-Tax Return on Equity</td>
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<td>Federal and State Solar Tax Credits</td>
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Benefit/Cost Breakdown (after-tax net present value as percentage of equity):

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<tr>
<td>Net Loan Cost (less interest shelter)</td>
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<td>(31.2)</td>
<td>(58.7)</td>
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<td>Net Electric Power Revenue (net of O&amp;M)</td>
<td>15.6</td>
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<td>Total</td>
<td>101.0</td>
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PLENARY SESSION: S.L. LEONARD

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.