PROCESS DEVELOPMENT

N86-29387
LIFE-CYCLE COSTS OF HIGH-PERFORMANCE CELLS
JET PROPULSION LABORATORY

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Introduction

• Value of PV system must include all costs and revenues associated with the system over its lifetime

• Methodology used in this study determines:
  (1) The value of improvements to the lifetime power output of a PV system
  (2) How much additional expense could be added during cell and module fabrication to achieve that added performance

• How does the initial cost relate to the final value?

Study Activities

• To compare the NPV of the life-cycle cost of four PV module production technologies
  (1) 1985 MY SOA Cz at 5 MW annual prod.
  (2) 1992 MY SOA Cz at 25 MW annual prod.
  (3) 1992 MY high-eff. Cz at 25 MW annual prod.
  (4) 1992 MY high-eff. web at 25 MW annual prod.

• Look at various module and system configurations:
  • Large and standard module size
  • Series — parallel circuitry
  • Cross strapping
  • Bypass diodes around each cell
  • Series — parallel modules
  • Bypass diodes around each series block, module and parallel module group

• Module replacement
  • Cell failure (opens only; 1 per 10,000 per year), causing module back bias of 0.5 volt
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Methodology

• Use three PA&I-developed simulation models
  • PVARRAY — system array performance
  • SAMICS — simulated module manufacturing industry
  • LCP — simulates the energy output, cost and value of a PV power plant over its useful lifetime

PV Array Design Economic Evaluation Methodology

PVARRAY Terminology
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PVARRAY Module Configurations

**STANDARD MODULE**
12SC, 3SS
OR
3SC, 3SS, 4SB
(W/ CROSS STRAPS)

**LARGE MODULE**
12SC, 12SS
OR
3SC, 12SS, 4SB
(W/ CROSS STRAPS)

**input Parameters**

**LCP**
- Mfg. yr: 1985, 1992
- ABOS ($/m^2$): 115, 60
- PBOS ($/kW$): 600, 150
- O&M ($/m^2/yr$): 1.30, 1.30

Rate Structure ($/kWh$) - 8.5 peak, 7.1 mid-peak, 6.0 off-peak
Insulation - 2300 kWh/yr

**NPV**
- Inflation rate - 5%
- Discount rate - 9%
- Depreciation - 15-yr life
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SAMICS: SOLAR ARRAY MANUFACTURING INDUSTRY COSTING STANDARDS

LCP: LIFETIME COST AND PERFORMANCE MODEL
### Process Development

<table>
<thead>
<tr>
<th></th>
<th>SOA Cz 1985</th>
<th>SOA Cz 1992</th>
<th>High-Efficiency Cz 1992</th>
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</thead>
<tbody>
<tr>
<td>Mod. Size</td>
<td>1.2 x 1.2 m</td>
<td>1.2 x 1.2 m</td>
<td>1.2 x 1.2 m</td>
</tr>
<tr>
<td>Cell Eff.</td>
<td>11.9%</td>
<td>11.9%</td>
<td>18.7%</td>
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<tr>
<td>Mod Eff.</td>
<td>9.5%</td>
<td>9.5%</td>
<td>16.2%</td>
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<td>Wp/Mod.</td>
<td>147</td>
<td>147</td>
<td>233</td>
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<tr>
<td>Annual Prod.</td>
<td>5 MW</td>
<td>25 MW</td>
<td>25 MW</td>
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<tr>
<td>Si Cost, 82$</td>
<td>$34 /kg</td>
<td>$18/kg</td>
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<td>Value Added</td>
<td>$/Wp</td>
<td>$/m²</td>
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<td></td>
<td>3.52</td>
<td>2.40</td>
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</table>

**Sensitivity of Net Benefit to Module Cost Change**

![Graph showing sensitivity of net benefit to module cost change](image_url)
Sensitivity of Net Benefit to Efficiency Change

Summary

- Models PVARRAY, SAMIS and LCP provide a tool for evaluating PV technologies and PV systems
- Two evaluation rankings possible, system performance and NPV
- Can identify system and performance tradeoffs

Preliminary Conclusions

- Parallel redundancy recommended
- For large modules, value of bypass diodes is marginal
- High efficiency and lower module cost are needed for PV to be economically attractive
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Future Work

- High-efficiency web
- Standard-size modules (0.30 x 1.2 m)
- Cross strapping
- Diodes around series blocks and individual cells
- A look at several specific processes and their effects on module cost and efficiency