N85-32398

FLAT-PLATE MODULE EFFICIENCY VS COST TRADEOFFS

JET PROPULSION LABORATORY

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Objective

The study objective is to use the Five-Year Research Plan energy cost methodology and to perform in-depth analyses based on the extensive data that are relevant to PV systems to facilitate the accomplishment of the $0.15/kWh energy cost goal

The basis for the Five-Year Research Plan energy cost methodology is the equation:

$$\overline{EC} = \left[\frac{FCR}{INSOL}\right][INDC][A(\$MSQMD + \$MSQBS) + \$KWBS] + A \cdot G \cdot CRF\left[\frac{\$MSQOM}{INSOL}\right]$$

Parameters Varied in the Study

Parameter	Range	Nominal Value
Module efficiency* (25°C)	3% - 30%	15%
Module cost,* $/m^2	30-500	90
Type**	Fixed, one-axis, two-axis	
Insolation		2000 (F), 2400 (1), 2600 (2)
Energy cost,* ¢/kWh	10-25	15
Fixed charge rate	0.11-0.203	0.153
Indirect costs	1.3-2.1	1.5
O&M Cost, $/m^2	0.11-8.82 (F), 0.19-10.02 (T)	1.1 (F), 1.4 (1&2)
Area-related BOS, $/m^2		50 (F), 58 (1), 90 (2)
BOS efficiency, %	0.755-0.930	0.865
Module degradation rate	0.45% - 0.75%/yr	0.5%/yr
Module replacement rate	0.05-0.00001/yr	0.004/yr
Module cleaning frequency	0-12/yr	None

*Indicates sensitivities shown in this presentation

**F = Fixed, T = Tracking

Other Baseline Parameters

Values for the other baseline parameters were described at the 23rd PIM. However, since that time the baseline values for insolation have changed:

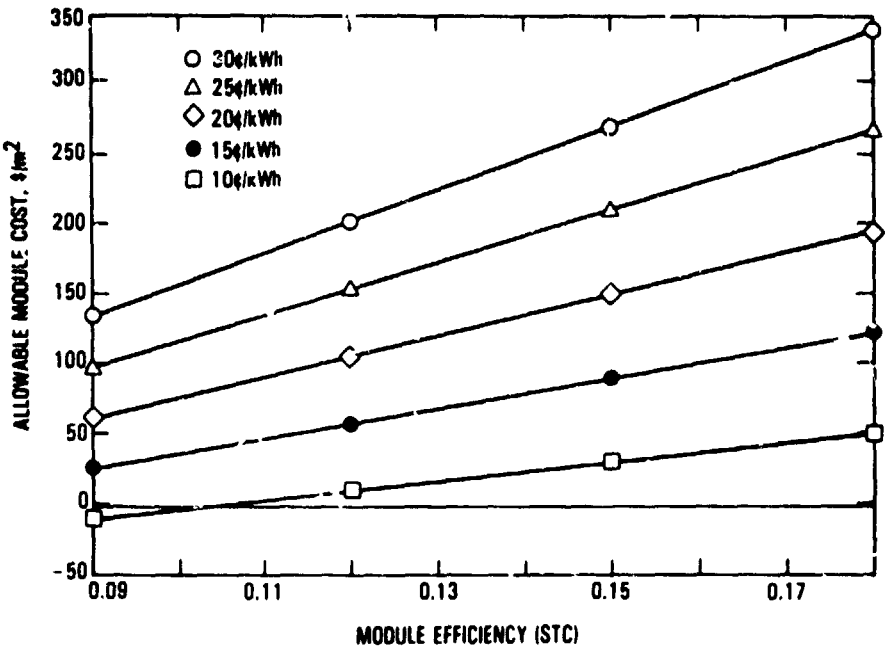
Tracking Option	Insolation Values ($kWh/m^2/yr$)	
	23rd PIM	Current Baseline
Fixed	2250	2000
One-axis	2700	2400
Two-axis	2925	2600

Allowable Module Cost, $\$/m^2$, vs Module Efficiency and Energy Cost

Module Efficiency, % (STC)	Energy Cost, $/kWh				
	0.10	0.15*	0.20	0.25	0.30
9	-11	25	61	97	132
12	10	57	105	153	201
15*	30	90*	150	209	269
18	51	122	194	265	337

*DOE goals and JPL milestones.

Allowable Module Costs for Various Energy Costs



Allowable Module Cost vs Module Efficiency and Insolation, $/m^2

Module Efficiency, % (STC)	Annual Insolation (kWh/m^2/yr)				
	Fixed:	1833[1]	2000[2]	2250[3]	2400[4]
	One-axis:	2200	2400	[illegible]	2890
	Two-axis:	2380	2600	[illegible]	3130
9		[illegible]	25	[illegible]	47
12		45	57	[illegible]	[illegible]
15		75	90	[illegible]	[illegible]
18		104	122	[illegible]	[illegible]

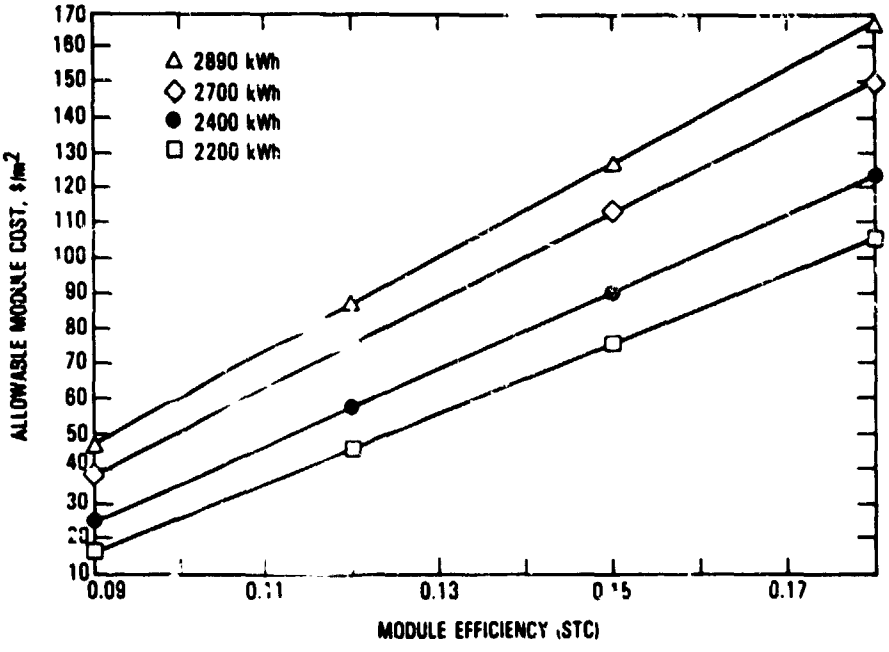
[1]Typical for the Southeast

[2]Typical for the greater Southwest region

[3]Typical for Nevada, Arizona, New Mexico, southern Utah, portions of California and Texas

[4]Phoenix, Albuquerque

Allowable Module Costs for Various Insolation Levels



Energy Cost vs Module Cost and Efficiency, $/kWh

Module Efficiency, % (STC)	Module Cost, $/m²				
	30	60	90	200	500
3	0.44	0.57	0.69	1.15	
6	0.23	0.29	0.35	0.58	
9	0.16	0.20	0.24	0.39	
12	0.12	0.15	0.19	0.30	0.61
15		0.13	0.15*	0.24	0.49
18			0.13	0.20	0.41

*DOE goal and JPL milestone.

Flat-Plate Allocation Guidelines

The Allocation Guidelines are a working tool of FSA Project management. They provide targets for PV R&D that are consistent with the accomplishment of DOE milestones for FSA and the overall energy cost goal of the PV Program

Alignment of the Allocation Guidelines to the DOE energy goal produces module cost guidelines that are parametric with module efficiency. This provides researchers with a tool to make appropriate tradeoffs between cost and efficiency at the subsystem level

Baseline Allocation Guidelines ($0.15/kWh)

	Module Efficiency (STC)			
	0.13	0.14	0.15	0.16
Sheet, $/m^2 sheet*	24	30	36	37
Cells, $/m^2 cell**	20	25	30	40
Encapsulants, $/m^2 module	14	14	14	14
Fabrication, $/m^2 module	12	12	12	12
Total, $/m^2 module	68	79	90	100

*To convert to $/m^2 module, multiply by 0.990 to account for yields and packing efficiency.

**To convert to $/m^2 module, multiply by 0.927 to account for packing efficiency and module yield.

Conclusion

The Allocation Guidelines are designed to be consistent with FSA milestones for module cost ($90/m^2), module efficiency (15%, STC), and the programmatic goal for energy cost ($0.15/kWh)

They are research targets that appear to be achievable, given prior accomplishments and planned activities in the areas of:

- **Low-cost silicon purification**
- **Low-cost sheet material**
- **High-efficiency cell processing**
- **Low-cost, long-life encapsulants**
- **Automated fabrication methods**

Extensive sensitivity analysis work has been performed that shows that these guidelines represent an efficient way to meet the intent of the DOE program

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