



Levelized Cost Of Electricity Sensitivity Assessment

PV Systems Integrator Workshop Clarion Hotel, San Jose

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Levelized Cost of Energy

- **A Convenient Metric for Comparing Energy Costs Across Energy Sources**
 - Captures Installed, Financing, and O&M Costs, and Reduction in Future Energy Output (Degradation)
 - Used by DOE to Evaluate Competitiveness of Solar Relative to Conventional Energy Sources
- **Other Metrics May Be More Important to Customer or Investor Decisions, e.g.**
 - First Cost – a barrier to purchase
 - Return on Investment – 3rd Party-Owned Systems

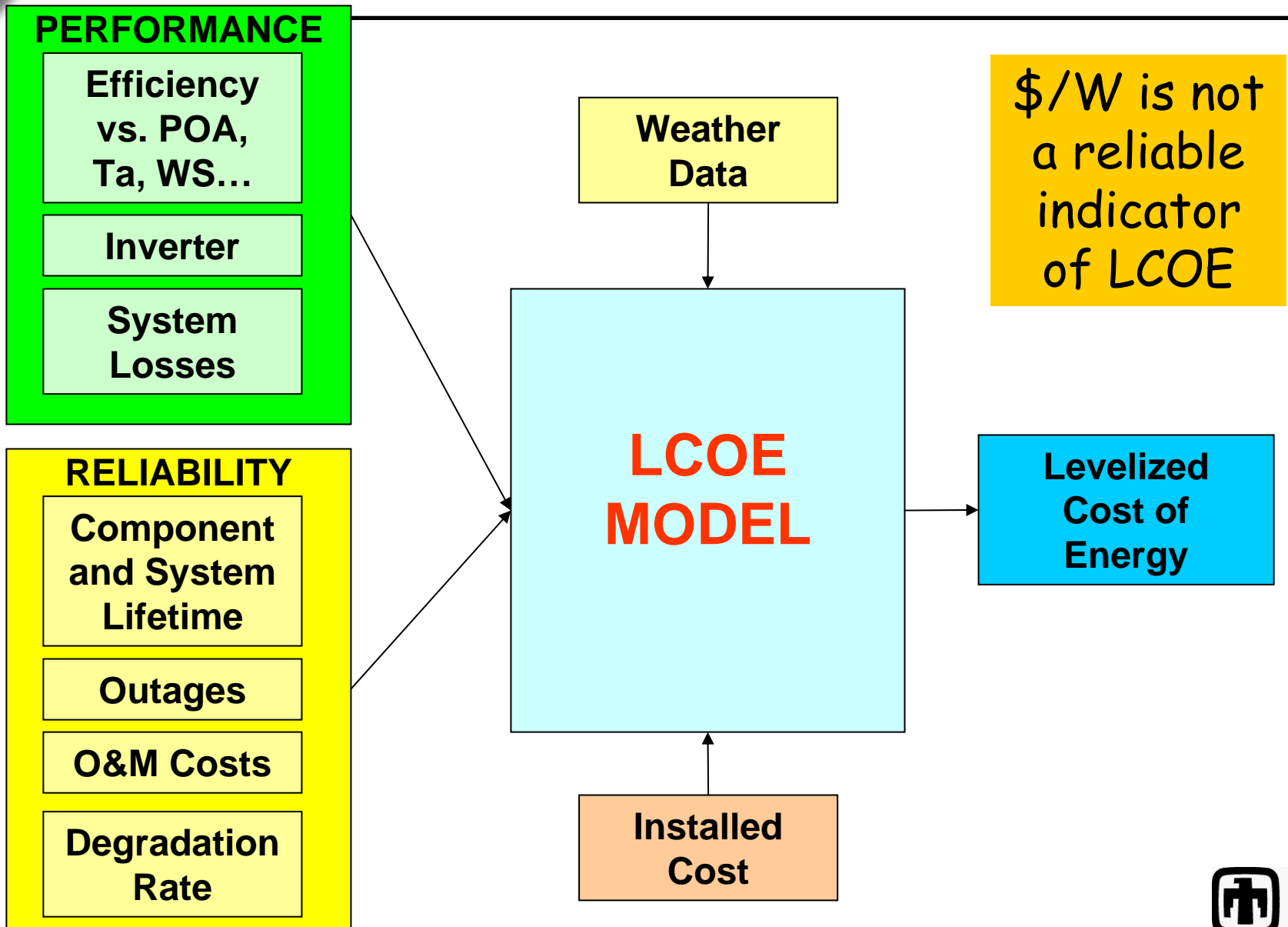


Levelized Cost of Energy

- Numerator includes *all* costs, C_n , by year
 - Includes first cost, financing, incentives, O&M
- Denominator includes energy production, Q_n , by year
 - Includes reduced energy production due to degradation
- d is discount rate
 - Future year costs and energy production have lower value/impact
- LCOE is calculated in real dollars

$$LCOE = \frac{\sum_{n=0}^N \frac{C_n}{(1+d)^n}}{\sum_{n=1}^N \frac{Q_n}{(1+d)^n}}$$

LCOE Model



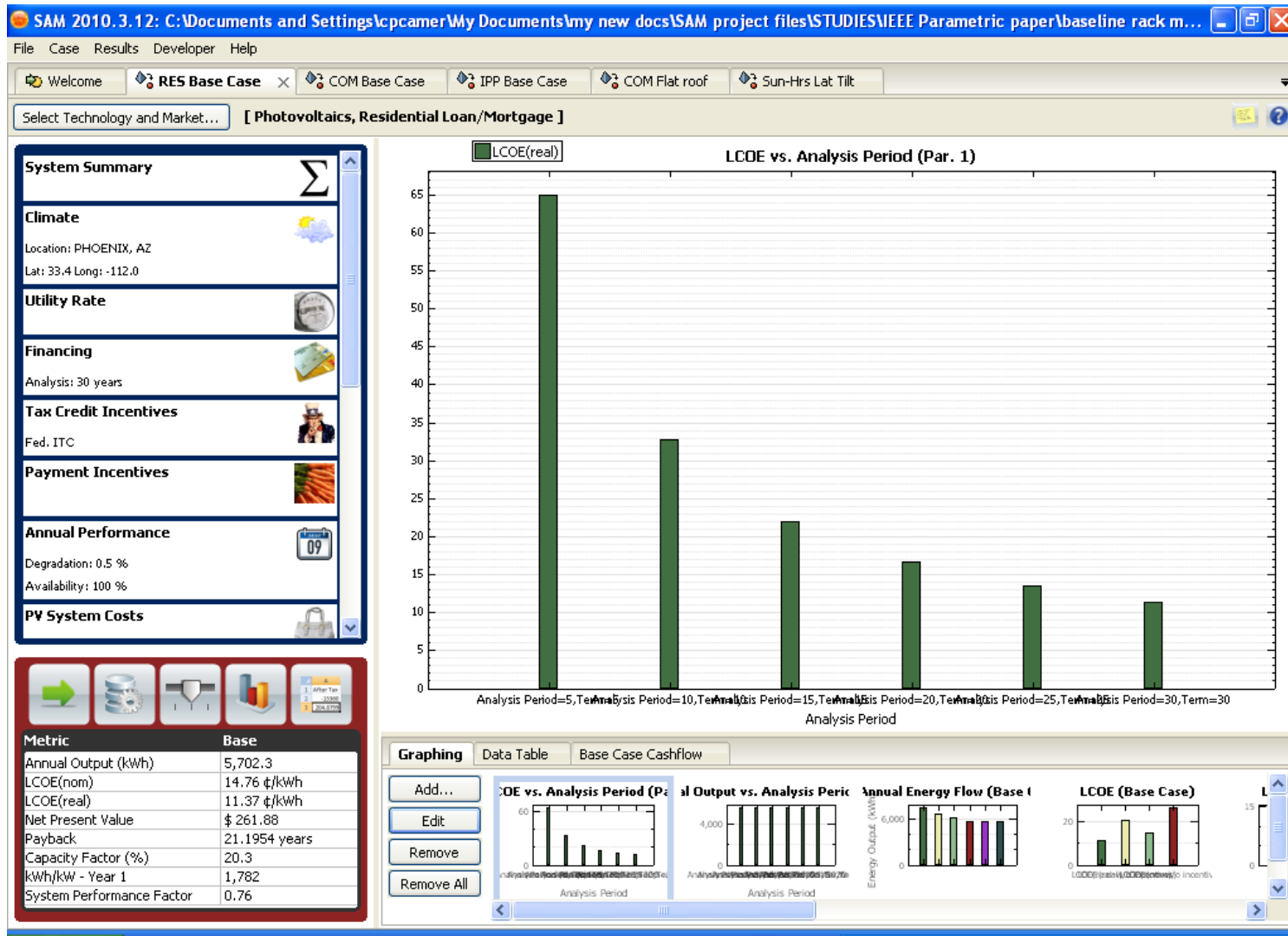
Financial Assumptions

Type of Financing	Residential Mortgage	Commercial Loan
Inflation Rate (%)	2.5	2.5
Analysis Period (yrs)	30	30
Real Discount Rate (%)	5.5	5.5
Loan Term (yrs)	30	15
Loan Rate (%)	6	6
Loan (Debt) Fraction (%)	100	50
Federal Tax (%)	28	35
State Tax (%)	7	7
Property Tax (%)	0	0
Insurance (%)	0	0
Sales Tax (%)	0	0
Federal Depreciation Type	n/a	MACRS-Mid-Q
State Depreciation Type	n/a	
Incentives		
Federal Tax Credit (%)	30%	30%

Reference Systems - Phoenix

Rack Mount	Res	Com
Array Power (Wdc)	3,200	500,000
System Derate Factor	90.0%	90.0%
System Degradation	0.50%	0.50%
Tilt	20.00	33.40
Inverter Efficiency	94.2%	94.8%
Yield kWh/kW- yr 1	1782	1816
System Perf Factor	0.76	0.76
COSTS		
Module \$/Wdc	\$4.84	\$4.35
Inverter \$/Wac	\$0.71	\$0.64
Total Installed Cost \$/Wdc	\$7.96	\$6.59
Inverter Replace/Rebuild (%)	100%	50%
Inverter Life (Yrs)	10	10
Routine O&M (\$/yr)	\$127	\$8,237
Routine O&M (% of 1st cost)	0.50%	0.25%

Analysis Performed with Solar Advisor Model A Decision Support Tool



Free: www.nrel.gov/analysis/sam/

O&M Inputs in SAM

Edit Schedule [Close]

Schedule: Number of values:

	5	6	7	8	9	10	11
		0	0	0	0	2272	0

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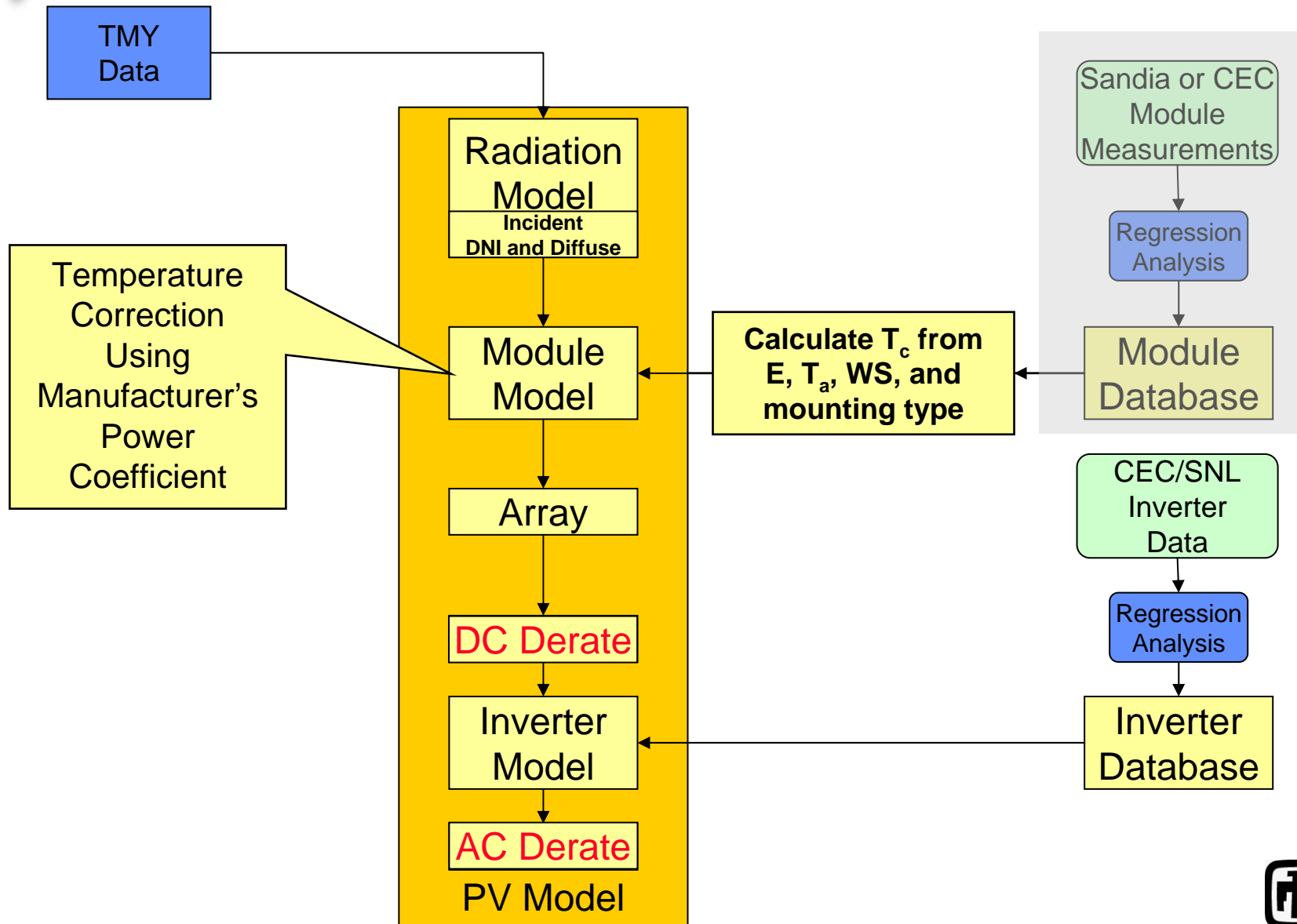
Operation and Maintenance Costs

	First Year Cost	Escalation Rate (above inflation)
Fixed Annual Cost	<input type="text" value="Edit..."/> \$/yr	<input type="text" value="0 %"/>
Fixed Cost by Capacity	<input type="text" value="40.00"/> \$/kW-yr	<input type="text" value="0 %"/>

Annual System Performance

System Degradation	<input type="text" value="0.5 %"/>
Availability	<input type="text" value="99 %"/>

Solar Advisor Model Includes PVWatts, CEC-5 Parameter Model, Sandia PV Array Performance Model



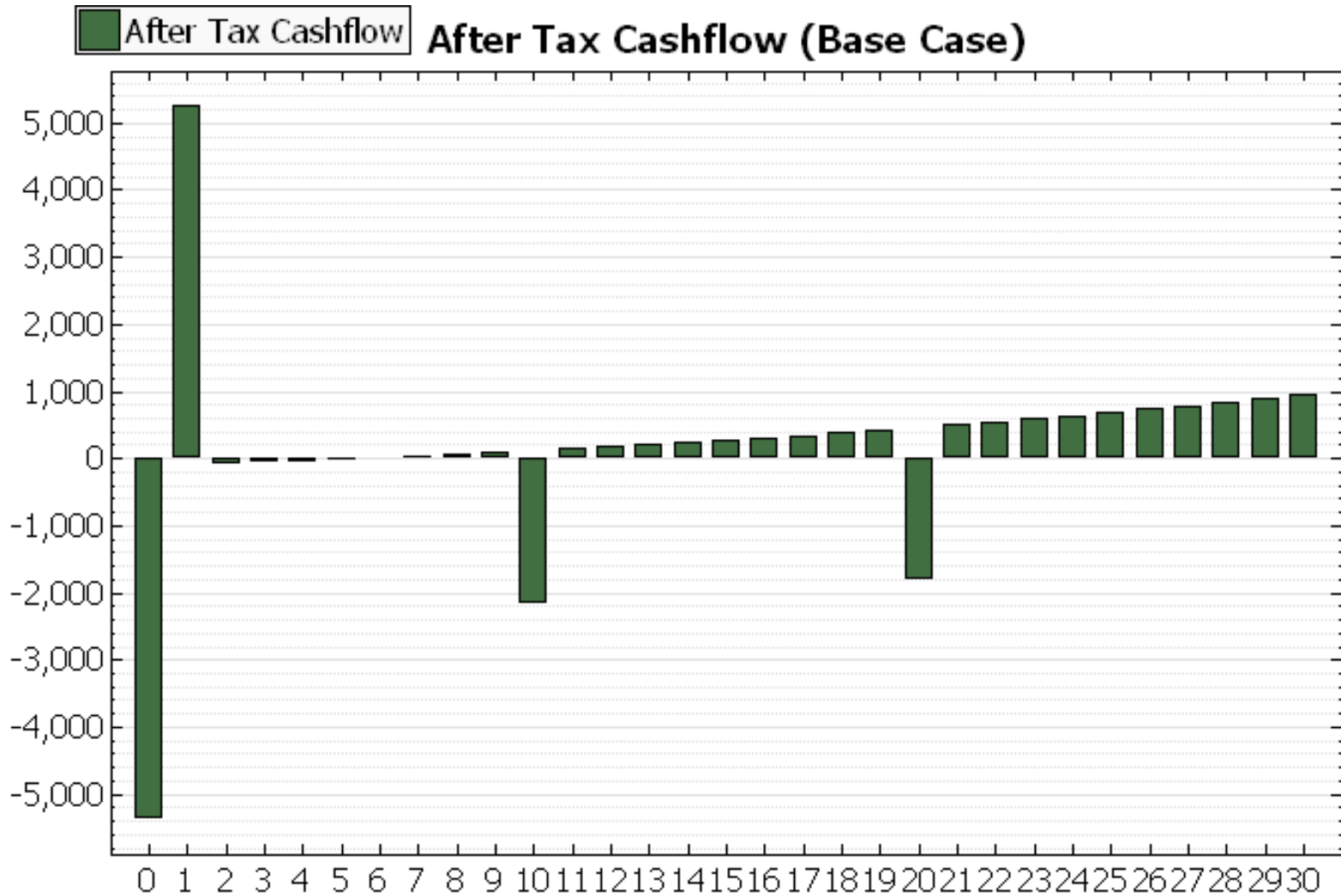
Levelized Cost of Energy for Reference Systems

LCOE (¢/kWh)	Res	Comm
Total	15.6	7.9
First Cost Contribution	11.4	6.9
Total O&M Contribution	4.2	1.1
Routine O&M Contribution	2.3	0.6
Inverter O&M Contribution	1.9	0.5

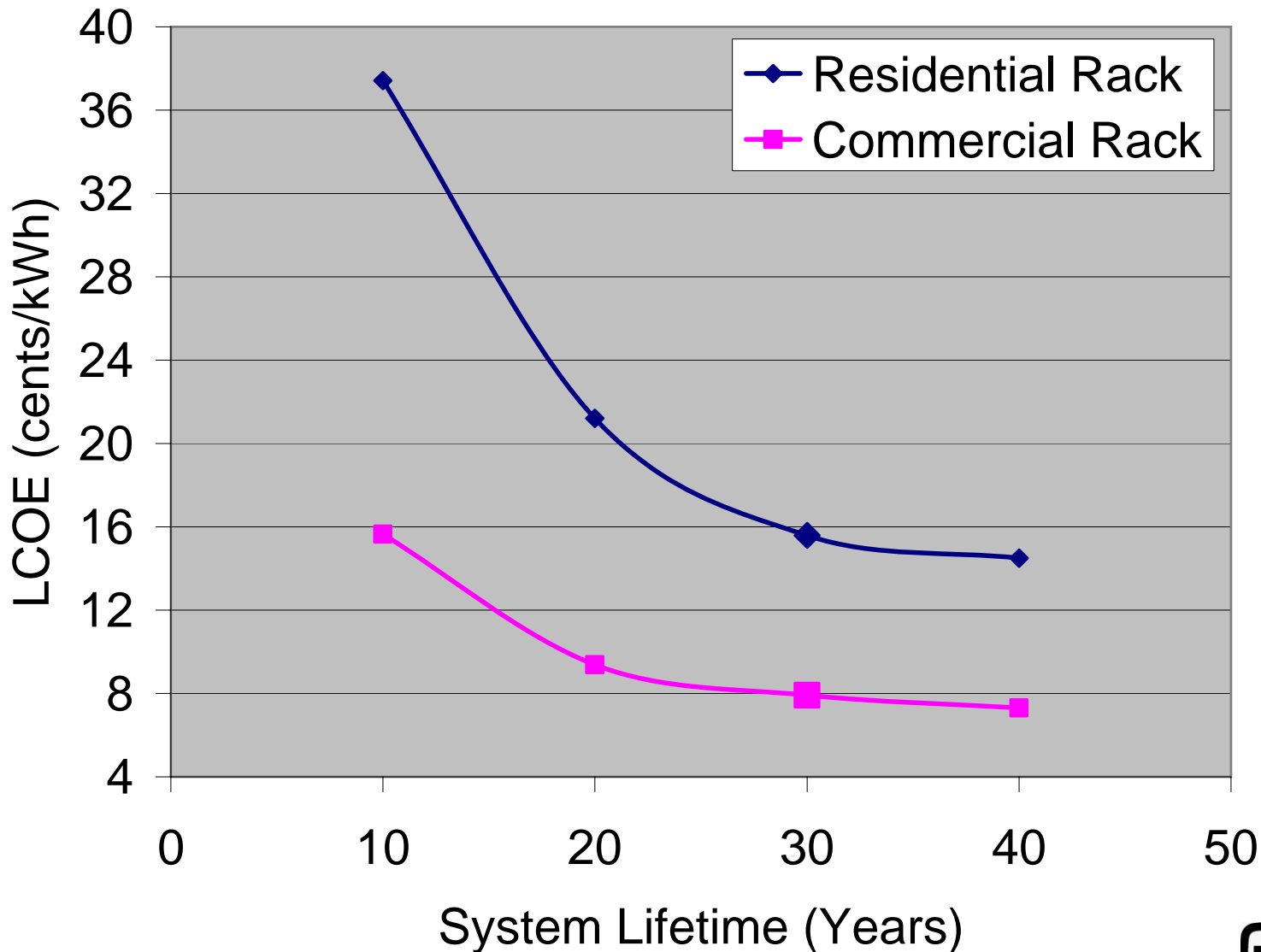
Scales with First-Cost and Energy Yield

Scales with O&M Cost and Energy Yield

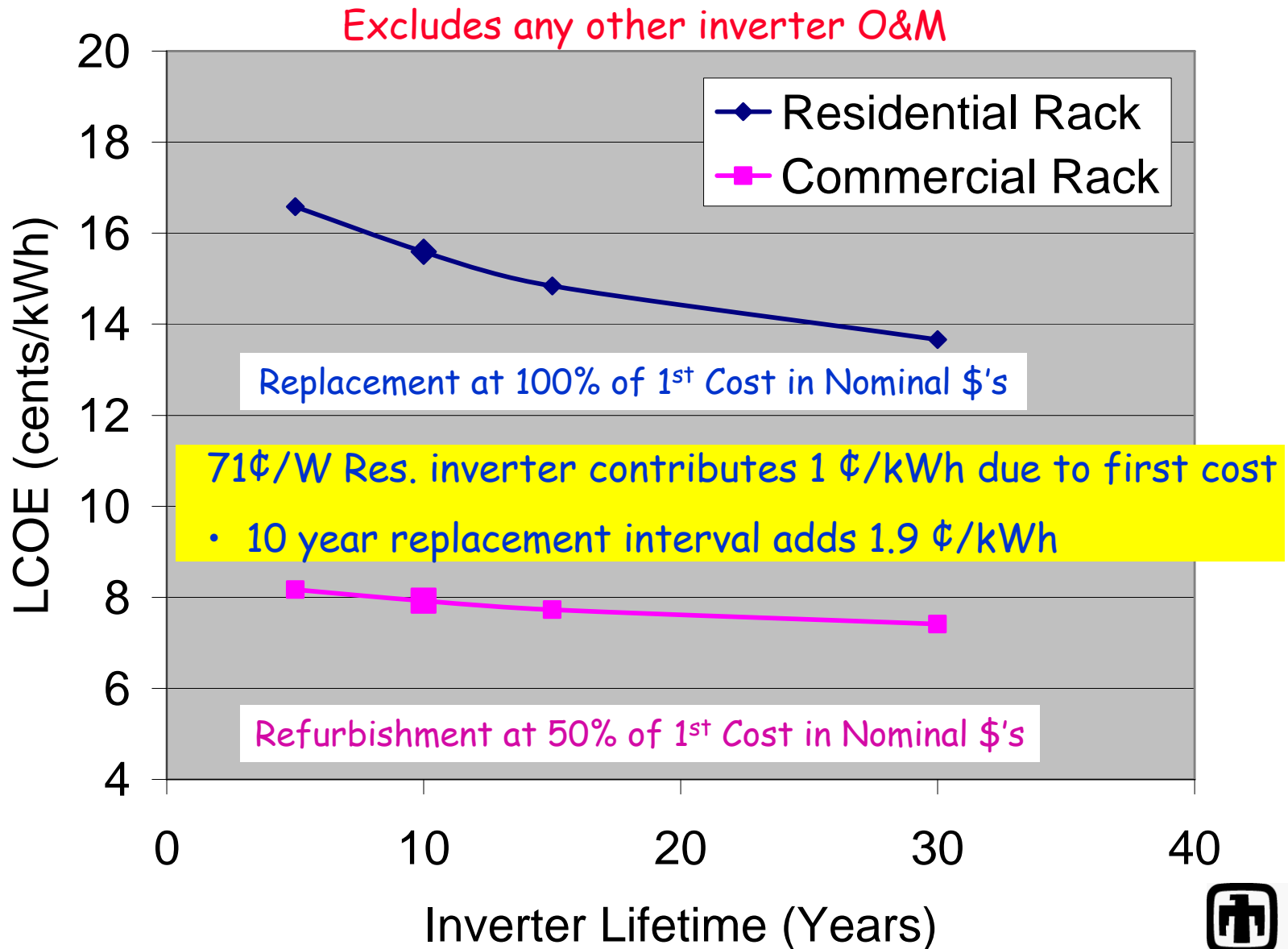
Cash Flow with 12¢/kWh Utility Rate with 2% Escalation (above inflation)



Effect of System Lifetime on LCOE



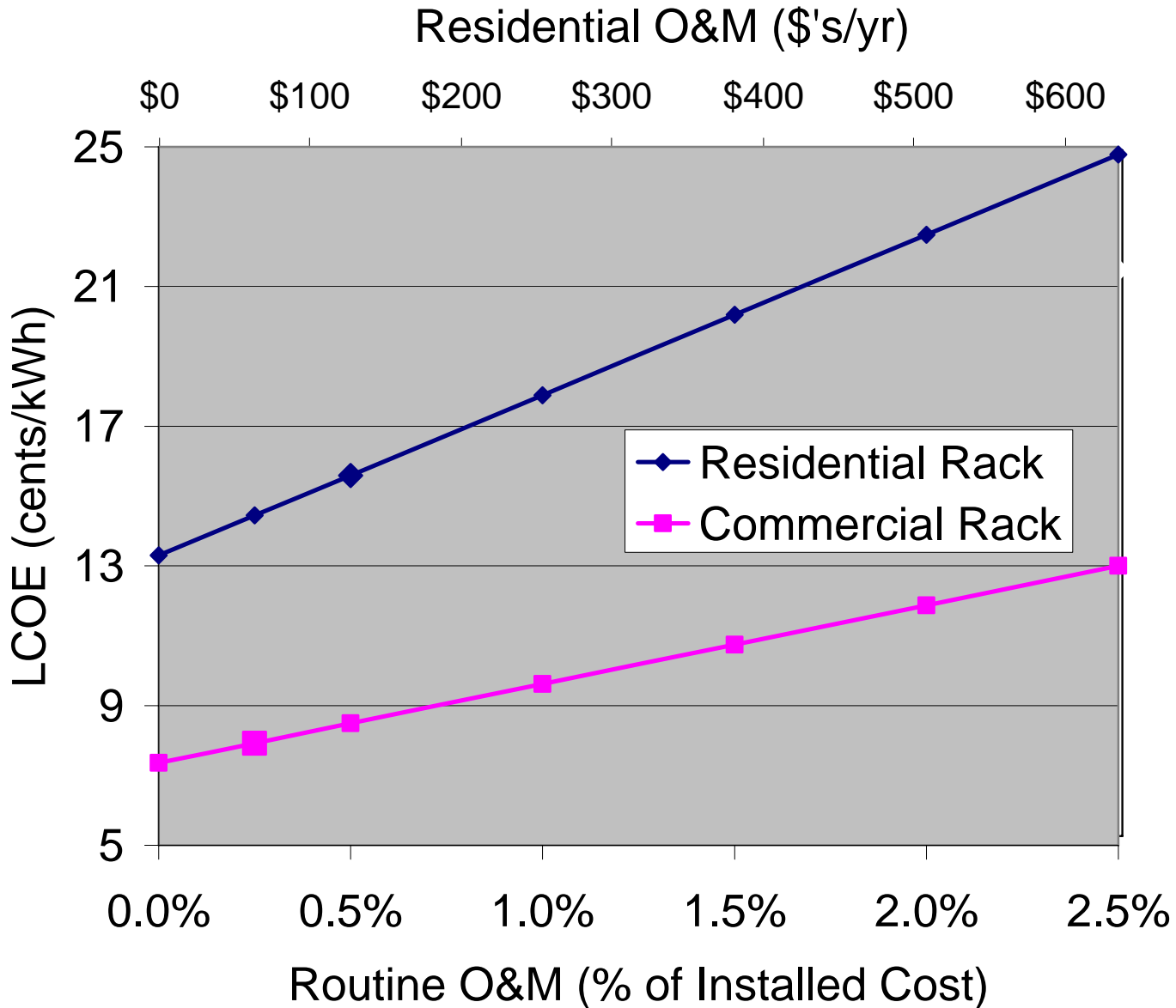
Effect of Inverter Lifetime on LCOE



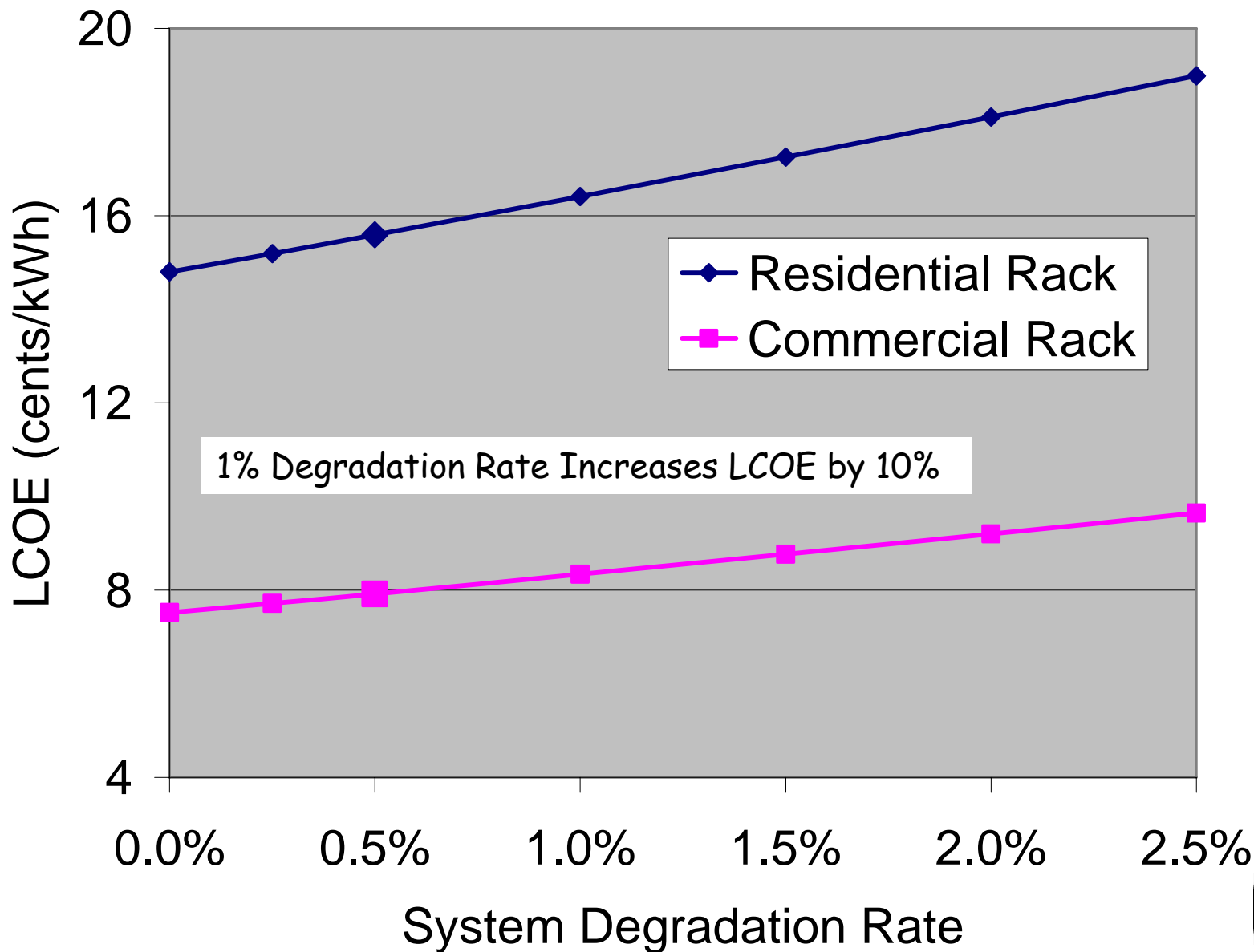


Effect of Routine* O&M on LCOE

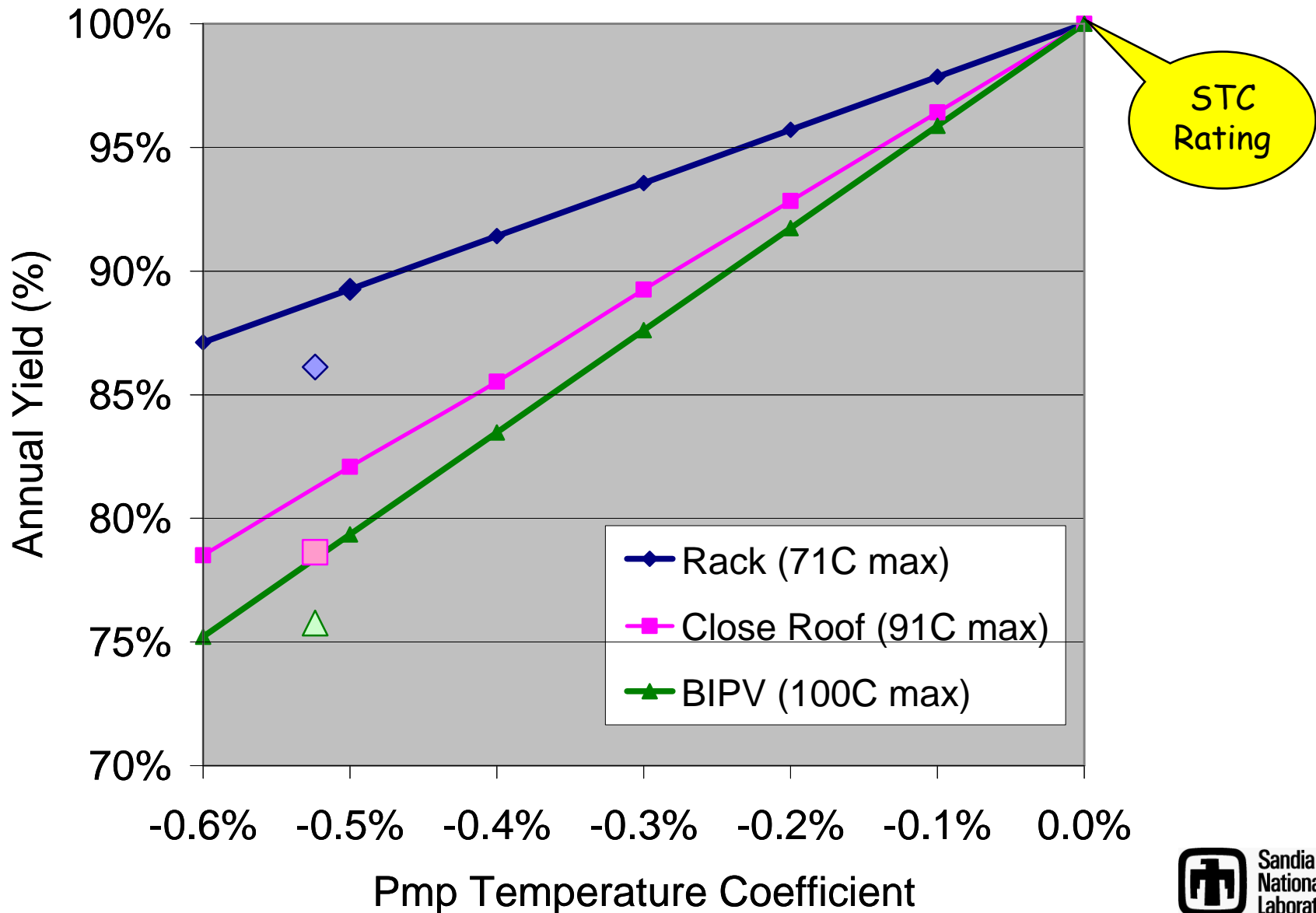
*Other Than Inverter Replacement/Refurbishment



Effect of System Degradation Rate



Mounting Configuration Affects Cell Temperature and Performance





What Values Should We Be Using for Model Inputs Low, High, Most Likely?

Residential (~ 4 kW)

- System
 - Installed Cost (\$/W)
 - O&M (\$/yr)
 - Derate Factor
- Modules (\$/Wp)
- Inverter
 - First Cost (\$/Wp)
 - Lifetime (Yrs)
 - Replacement Cost
 - % of First Cost for Inverter
 - \$'s for Labor...

Commercial (500kW)

- System
 - Installed Cost (\$/W)
 - O&M (\$/yr)
 - Monitoring Cost (\$/yr)
 - Derate Factor
- Modules (\$/Wp)
- Inverter
 - First Cost (\$/Wp)
 - Lifetime (Yrs)
 - Replacement Cost
 - % of First Cost for Inverter
 - \$'s for Labor...

What, If Any, Routine Maintenance Do You Perform? Inspection?
Cleaning? Other?