2009 Integrated Energy Policy Report Staff Workshop

FUTURE ENERGY SUPPLY COSTS: MULTIPLE MOVING TARGETS

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Outline

Presentation purpose: To provide market and technology context for renewable energy cost data
Theme: Increasing need to evaluate vs. compare

- Renewable Energy Options
  - Scale
  - Readiness
  - Diversity
- Cost Data Development
  - Research Context
  - Study Design

Renewable Energy Technology Menu

√ = primary application	Deployment Venues		
√ = secondary application	Utility-Scale Renewables	RE Secure Communities	RE Secure Buildings
Technology/ Resource	Utility-scale power plants and bio-refineries	Smaller energy plants exploiting high-quality local resources	Modular systems for building and industrial power, heat, cooling and lighting
Wind Power Plants	√	√	
Geothermal Power	√	√	
Hi Temp Solar Thermal	√	√	√
Biomass Power	√	√	√
Ocean/Wave	√	√	
Solar PV	√	√	√
DG Wind		√	√
Solar Heat & Cooling		√	√
Direct Geothermal		√	√
Geothermal Heat Pumps		√	√
Biofuels	√	√	√

Commercial vs. Emerging – Technology Perspective

C = Commercial	Deployment Venues		
E = Emerging	Utility-Scale Renewables	RE Secure Communities	RE Secure Buildings
Technology/ Resource	Utility-scale power plants and bio-refineries	Smaller energy plants exploiting high-quality local resources	Modular systems for building and industrial power, heat, cooling and lighting
Wind Power Plants	C	C	
Geothermal Power	C	C	
Hi Temp Solar Thermal	C/E	C/E	E
Biomass Power/CHP	C	C	C
Ocean/Wave	E	E	
Solar PV	E	C/E	C
DG Wind		C/E	C/E
Solar Heat & Cooling		C/E	C/E
Direct Geothermal		C	C
Geothermal Heat Pumps		C	C
Cellulosic Biofuels	E	E	E

Commercial vs. Emerging – California Industry Capability Perspective

C = Capable	Deployment Venues		
D = Developing	Utility-Scale Renewables	RE Secure Communities	RE Secure Buildings
Technology/ Resource	Utility-scale power plants and bio-refineries	Smaller energy plants exploiting high-quality local resources	Modular systems for building and industrial power, heat, cooling and lighting
Wind Power Plants	C	D	
Geothermal Power	C	D	
Hi Temp Solar Thermal	C/D	D	D
Biomass Power/CHP	D	C/D	D
Ocean/Wave	D	D	
Solar PV	D	C	C
DG Wind		D	D
Solar Heat & Cooling		D	D
Direct Geothermal		D	D
Geothermal Heat Pumps		D	D
Cellulosic Biofuels	D	D	D

Dimensions of Diversity

- Resource
  - Quality
  - Location
- Resource Conversion Technology
  - Resource conversion technique
  - Variations on basic technique
  - Conversion efficiency
  - Enabling technologies
- End Product or Service
  - Electricity, fuel, heat, etc.
  - Hybrid systems
- Equipment
  - Manufacturing scale
  - Materials price
  - Global market dynamics
- Plant
  - Scale
  - Functionality
  - Equipment modularity
- Economic
  - Customer requirements
  - Avoided cost
  - Finance model
  - Tax
- Deployment Experience
  - Industry Strength and Maturity
  - Standardization

New ball game – extremely diverse menu of renewable energy solutions that vary in several dimensions, affecting cost, price, risk and economic value.

The challenge of COG data development is dealing with a large flock of moving targets each following its own path.

INPUTS

Plant Characteristics
- Capacity (MW)
- Capacity Factor
- Forced Outage Rate
- Scheduled Outage Rate
- Heat Rate (if applicable)
- Heat Rate & Capacity Degradation

Deflator Series

- Fuel Prices ($/MMBtu)

- Instant Cost ($/kW)
- Installed Cost ($/kW)

Fixed O&M ($/kW-Yr)

Variable O&M ($/MWh)

General Assumptions
(Merchant, Muni & IOU)
- Insurance
- Ad Valorem
- State & Federal Taxes
- O&M Escalation
- Labor Escalation

Financial Assumptions
(Merchant, Muni & IOU)
- % Debt
- Cost of Debt (%)
- Cost of Equity (%)
- Loan/Debt Term (Years)
- Book Life (Years)
- Federal Tax Life (Years)
- State Tax Life (Years)

COST OF GENERATION MODEL

Wholesale Electricity Prices
($/MWh)
- Fixed Cost
- Variable Cost - Marketsym
- Total Cost

OUTPUTS

Levelized Fixed Costs
($/kW-Yr & $/MWh)
- Capital & Financing
- Insurance
- Ad Valorem
- Fixed O&M
- Corporate Taxes

Levelized Variable Costs
($/kW-Yr & $/MWh)
- Fuel
- Variable O&M

Total Levelized Costs
($/kW-Yr & $/MWh)
- Levelized Fixed Costs
- Levelized Variable Costs

Annual Costs
($/MWh)
- Fixed Cost
- Variable Cost
- Total Cost

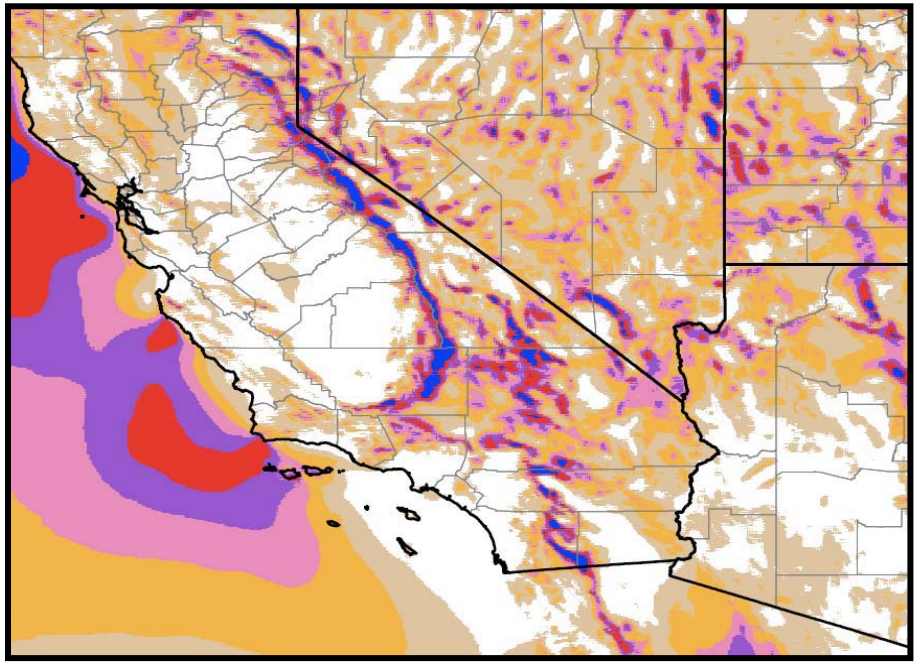
Screening Curves
($/kW-Yr & $/MWh)
- Fixed Cost
- Variable Cost
- Total Cost

Sensitivity Curves
(%)
- Fuel Price
- Capacity Factor
- Installed Cost
- Discount Rate
- Cost of Equity
- Cost of Dept

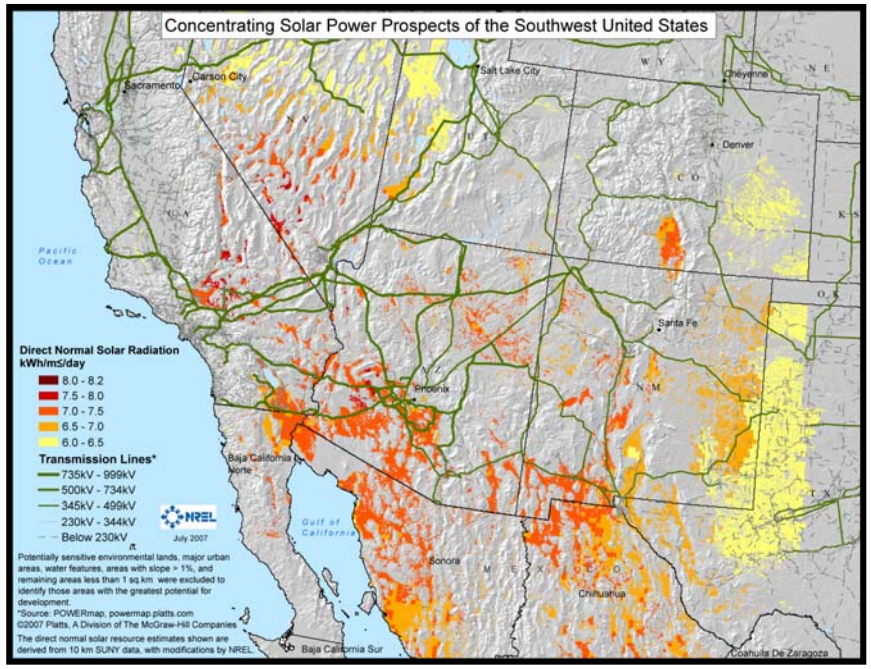
Resource Quality

Average annual resource intensity is an indicator, not an answer. Local resources vary and in some cases may change as the resource is used, e.g. geothermal.

Wind

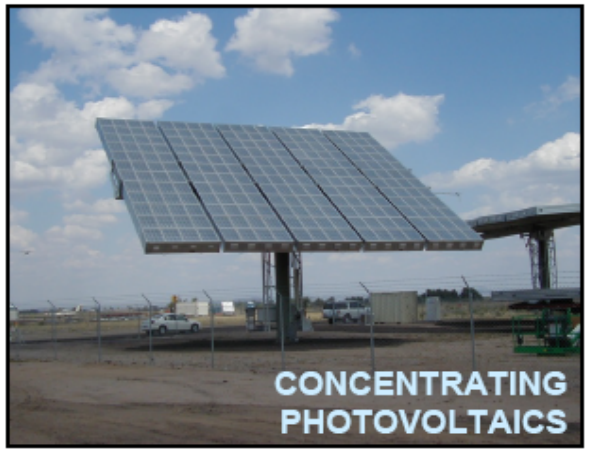


Concentrating Solar



Technology – Variations

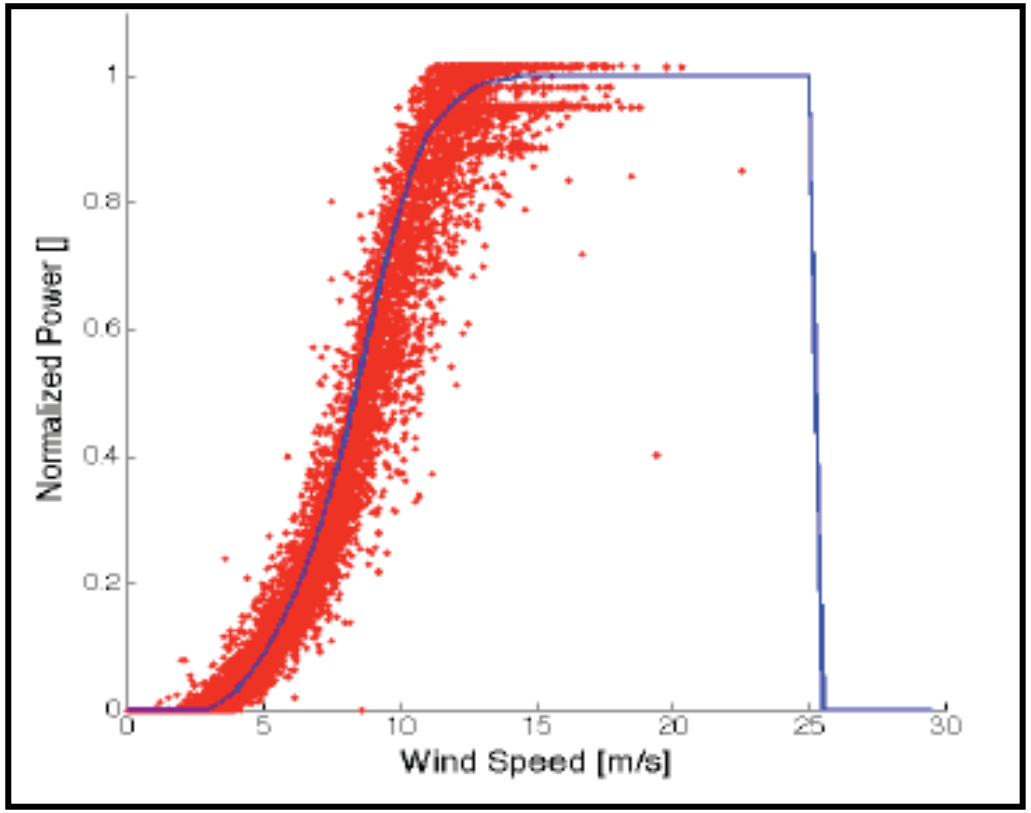
Concentrating solar power system concepts illustrate significant variations in conversion efficiency, scale-up risk, commercial readiness, etc.



Conversion Efficiency

PV deployment involves cost/efficiency trade-offs

Wind speed/power output relationships are not fully deterministic.



Source: 3TIER

Enabling Technologies

Expect future solar and wind plants to include energy storage for purposes of economic optimization

End Product or Service

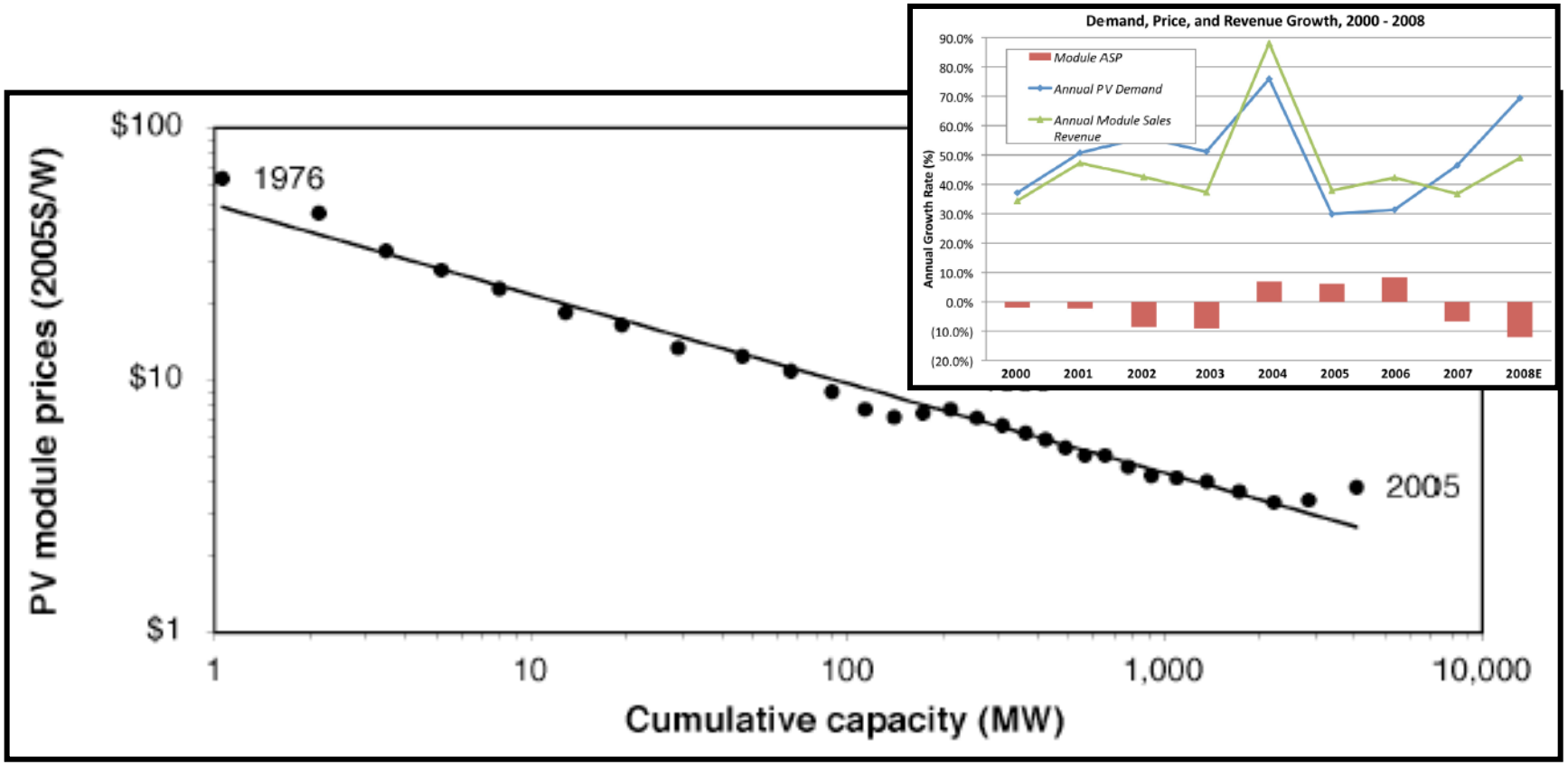
Bio-energy illustrates the potential of most renewable resources to serve multiple energy end uses. The most profitable end use will drive learning and innovation and thus industry growth.

Category	Biomass (Million BDT/year)	Energy in Product (Trillion Btu/year)	Total Capacity
Electricity CHP Heat	32	118 (35 TWh) 230	4,650 MWe 9,050 MWt
Heat	32	350	11,700 MWt
Biochemical Biofuel	32	188	1.5 BGY gasoline equivalent
Thermochemical Biofuel	27*	250	1.7 BGY diesel equivalent
Biomethane	5 + Landfill gas and WWTP	106	106 BCF/y methane
Hydrogen (bio + thermal)	32	305	2.5 Million tons/y

California BioEnergy Potentials (Source: California Biomass Collaborative)

Manufacturing – Scale

Manufacturing scale can drive learning curves, as with PV. Thus, market size and growth can be significant cost drivers.



Sources: http://www.iea.org/textbase/work/2007/learning/Nemet_PV.pdf, and Prometheus Institute

Manufacturing – Materials

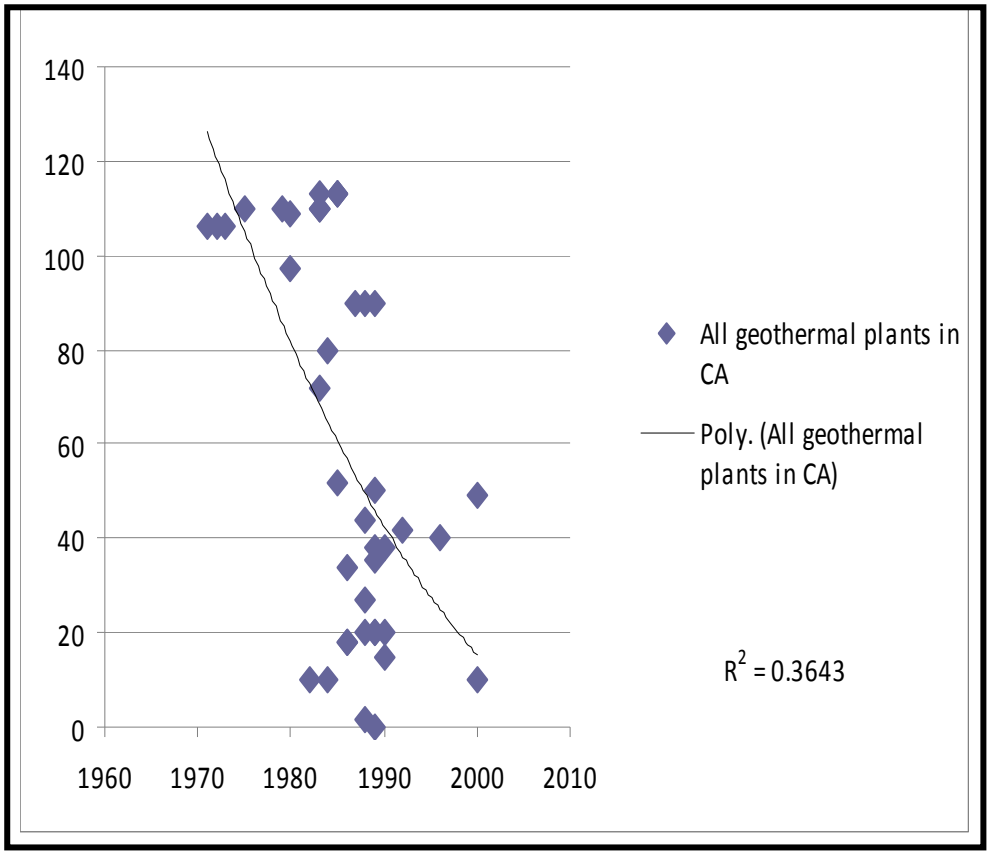
Renewable energy plants and components are materials intensive. Global supply and demand constraints may impact both short and long term costs.

Classification of PV Manufacturers for Cost Modeling					
Number	Technology	Supply chain concentration	Location	Distinguishing feature	Example companies
1	Multicrystalline Si	Polysilicon-to-module	Global	Sources own polysilicon meaning lower-than-average feedstock price	REC, SolarWorld
2	Multicrystalline Si	Module	Europe	High contracted polysilicon position	BP Solar
3	Multicrystalline Si	Module	Asia	Lower labor, utilities costs	Suntech Power, Sharp
4	Super Monocrystalline Si	Module	N/A	High efficiency	SunPower, Sanyo
5	CdTe	Feedstock-to-module	N/A	Technology	First Solar
6	CIGS	Feedstock-to-module	N/A	Technology	Nanosolar, Miasole
7	A-Si	Feedstock-to-module	N/A	Technology	Moser Baer, Kaneka Silicon PV

Source: Prometheus Institute

Plant Scale

Costs and efficiencies of thermal power plants improve with scale, but resource delivery and project development costs may tip the balance toward smaller plants.



Source: California Geothermal Energy Collaborative

Plant Functionality

Configuring renewable energy plants to minimize overall electric system cost will be enabled by a range of technical integration solutions, e.g. thermal energy storage.

Equipment Modularity

Some emerging renewable energy technologies may require profitable entry and intermediate markets in order to gain a commercial experience leading to cost reductions.

50kW Walnut Shell Gasifier

25kW Solar Dish w/Stirling Engine

Economic Context

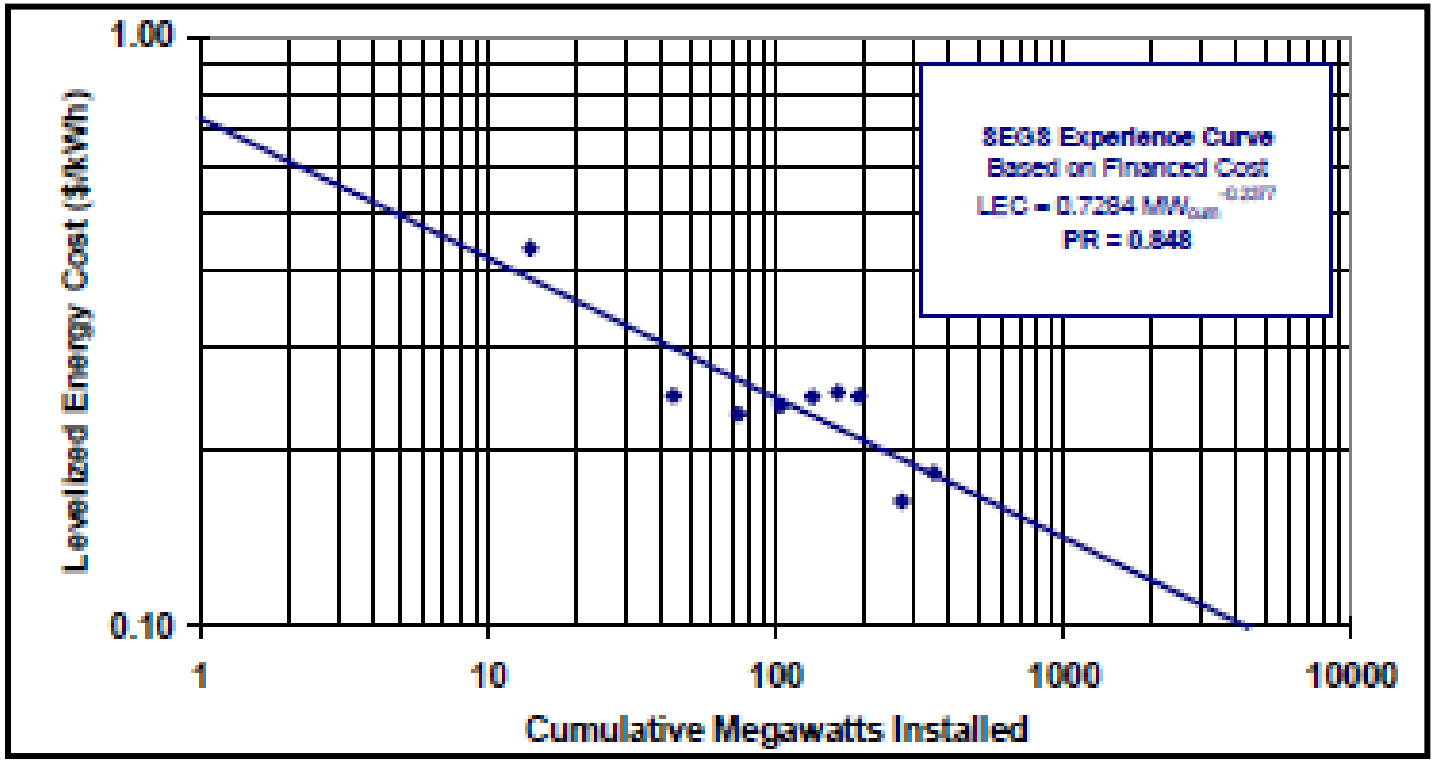
User finance

Project finance – wholesale avoided cost purchase

Installer finance – retail avoided cost purchase

Deployment Experience

A tale of death and taxes, solar thermal power deployment experience in California also illustrates a cost reduction strategy based on plant replication, incremental innovation and scale-up.



Research Context - 1

Recommendations:

- Need for systemic cost optimization
  - Optimize within current market structure
  - Optimize future market structure
- Need more robust energy system economic models
  - Consider contributions from community and building scale
  - Understand electricity and natural gas delivery implications

Research Context - 2

Recommendations:

- Need in-depth future oriented cost analysis
  - Identify major contributors to least cost future mix
  - Understand global market trends and dynamics for major renewable energy contributors
- Expect analytical contributions from California Renewable Energy Collaborative
  - Commission-funded through PIER
  - Cost analysis included in 2 year work scope

COG Project Data Development

- Study design:
  - Simplify by focusing on commercially established options
  - Assess potential for future technology shifts
  - Sanity check cost estimates using pricing data
  - Model evolutionary changes and consider future challengers
  - Preliminary look beyond utility scale

Summary

- Deployment to date:
  - Utility scale – substantial base plus project development
  - Community scale – pilot projects and regulatory barriers
  - Building scale – PV approaching energy significant phase
- RE resource and technology base – diversity and endless variation
- Consultant study is designed to both:
  - Support EAO IEPR efforts
  - Bridge to more comprehensive analysis of future costs