Economics of New Reactors and Alternatives

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How Did Keystone Address Economics?

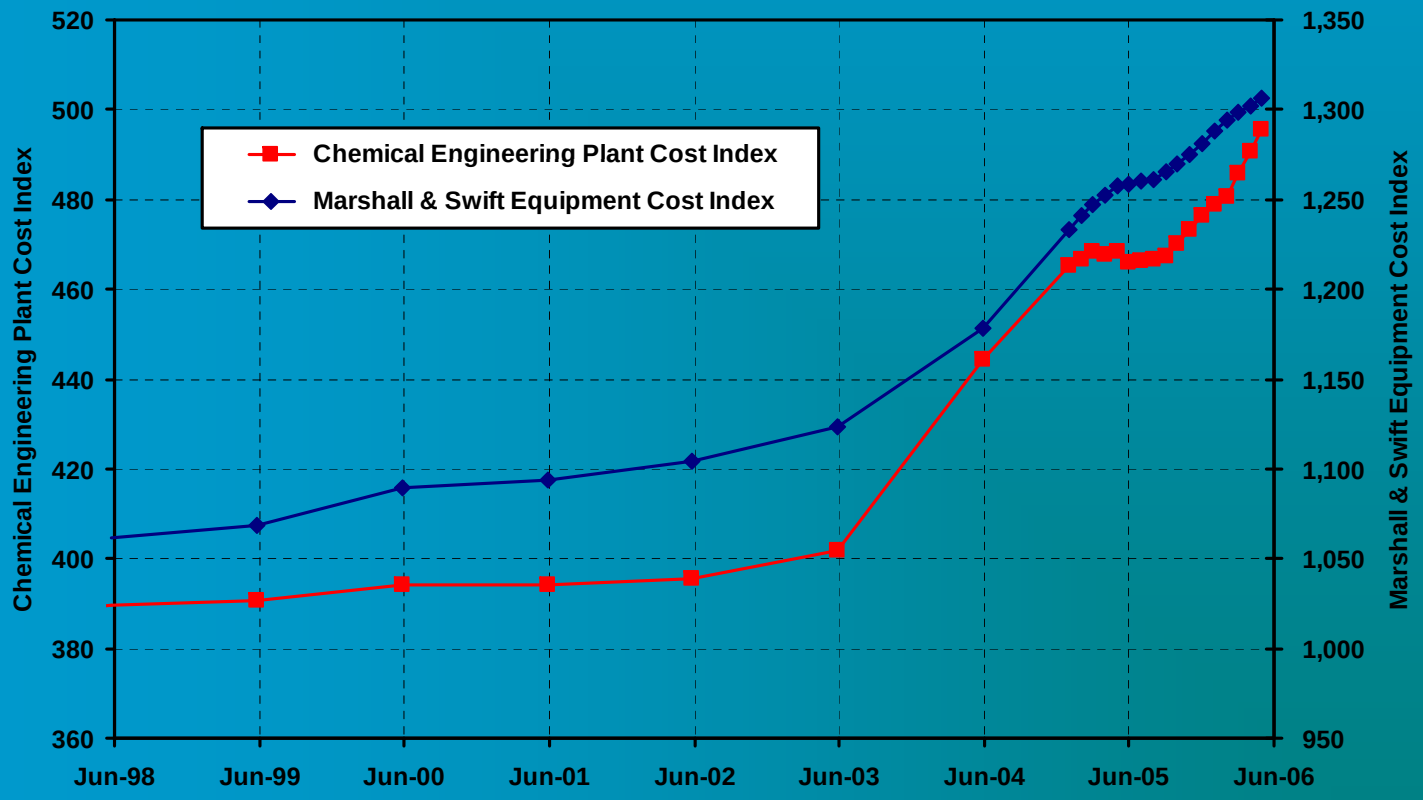
- We started with recent Asian experience
  - Escalated at 4 percent real based on chemical plant experience
  - After publication, we found 8-15 percent real more correct
  - Borne out by new estimates from utilities and investment banking firms

Asian Experience

Plant	MWe	COD	Yen@COD	2002$s/kW	2007$s/kW
Onagawa 3	825	Jan 2002	3.1 Billion	2409	3332
Genkai 3	1180	Feb 1994	4 Billion	2643	3656
Genkai 4	1180	Jul 1997	3.2 Billion	1960	2711
KK 3	1000	Jan 1993	3.2 Billion	2615	3617
KK 4	1000	Jan 1994	2.2 Billion	2609	3608
KK 6	1356	Jan 1996	4.2 Billion	2290	3167
KK 7	1356	Jan 1997	3.7 Billion	1957	2707
Y 5 (SK)	1000	Jan 2004		1700	2352
Y 6 (SK)	1000	Jan 2005		1656	2290
Average				2354	3257

Cost data from MIT 2003 study. Average does not include South Korean units, owing to labor rates. Real escalation from 2002-2007 at 4 percent/year. Avg is $2950/kW w/SK.

We Estimated 4% Real Escalation Per Year, 2002-2007



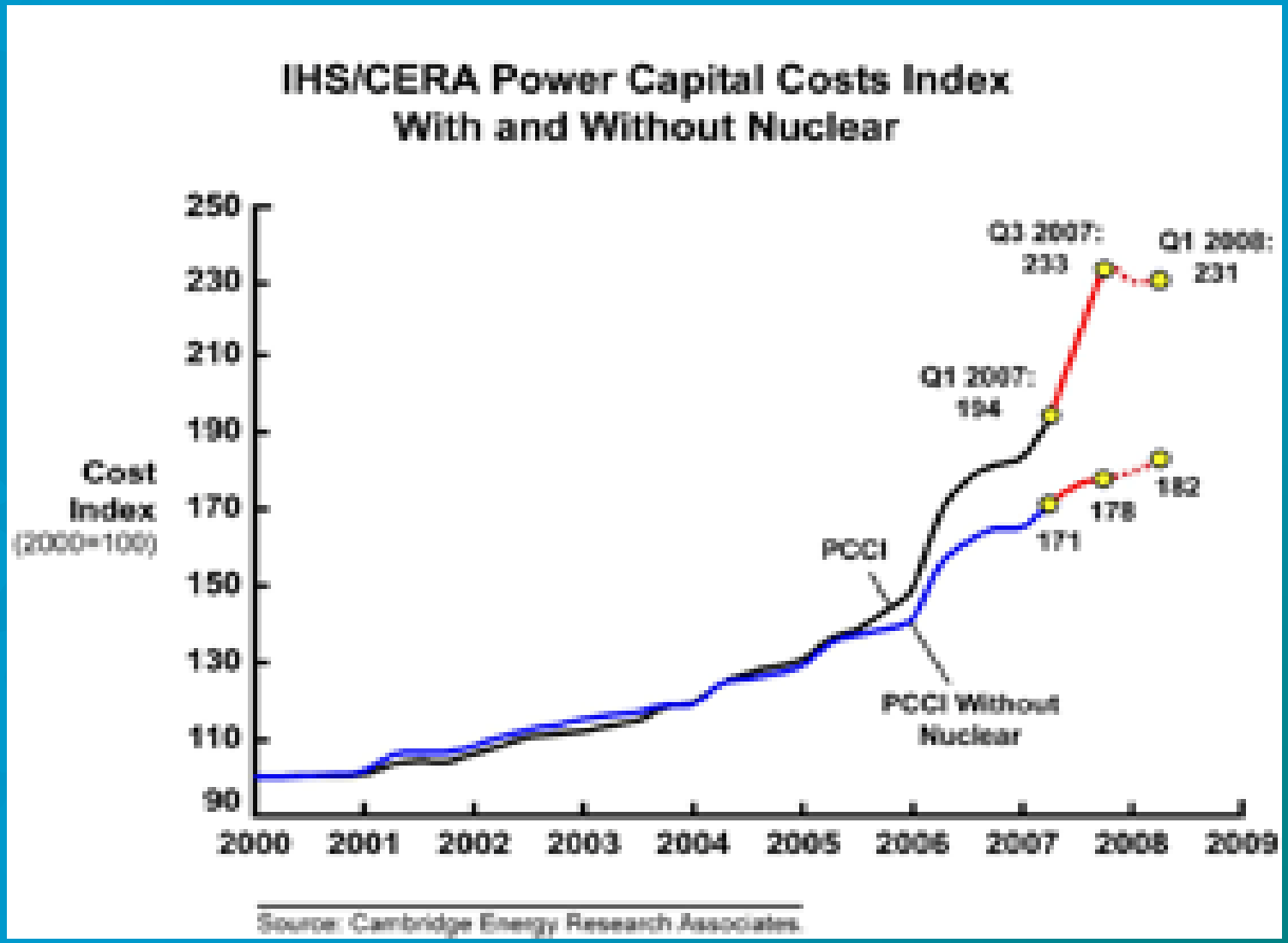
Provided to Keystone panel by EPRI

Utility Data Suggests 8% Real Might Be More Realistic

Commodity	Esc 86-03	Esc 03-07	Ratio vs. History
Nickel	3.8%/yr	60.3%/yr	15.9x
Copper	3.3%/yr	69.2%/yr	21x
Cement	2.7%/yr	11.6%/yr	4.3x
Iron/Steel	1.2%/yr	19.6%/yr	16.3x
Heavy construction	**2.2%/yr**	**10.5%/yr**	4.8x

Source: American Electric Power

Nuclear-Specific Data Suggests 14% Real/Year



The Differences are Significant

	0% Real	4% Real	8% Real	14% Real
Med overnight	$4050/kW	$5400/kW	$7100/kW	$9050/kW
High overnight	$4540/kW	$6050/kW	$8000/kW	$10150/kW
Med overnight	10.7 c/kWh	13.4 c/kWh	16.9 c/kWh	20.7 c/kWh
High overnight	11.7 c/kWh	14.7 c/kWh	18.6 c/kWh	23.0 c/kWh

Future overnight cost estimates are in 2007 dollars, and are based on FP&L's recent Turkey Point 6/7 estimate. Electricity costs are levelized lifecycle costs, with interest and operating costs.

Recent Estimates

- Keystone - $3600-4000/kW; 8-11 cents/kWh
  - Real 2007 dollars, 5-6 years of construction, for operation in 2012/2013. Would be $5600/kW (16-17 cents/kWh) at AEP escalation rate to 2013.
- Standard & Poor's - $4000/kW; 9-10 cents/kWh
  - Basis not stated; levelized fixed charge rate
  - Life cycle costs reflect Keystone O&M and fuel costs
- Moody's - $5000-7500/kW
  - Basis not stated; operating and fuel costs not estimated
- Florida Power & Light - $4200-6100/kW
  - Current dollars at COD converted to real 2007 dollars
- Puget Sound Energy - $10,000/kW
  - Basis not stated, but consistent with FP&L plus AEP escalation rate through completion.

Estimated Life Cycle Costs for Major Supply Options (2007$s)

	Pulverized Coal	**Gas (CCCT)**	**Eastern IGCC**	**Wind**	**Nuclear**
Capital Cost ($/kW)	3000-4000	1000	???	1700-2500	5000
Capital charges (cents/kWh)	6.3	2.1	9.0	7.1-13	10.4
Delivered Fuel (cents/kW)	4.0	8.8	4.0	0	1.7
O&M (cents/kWh)	2.2	1.1	2.2	1	2.9
Cents/kWh	***12.5***	***12.2***	***15.2***	***8-14***	***15.0***

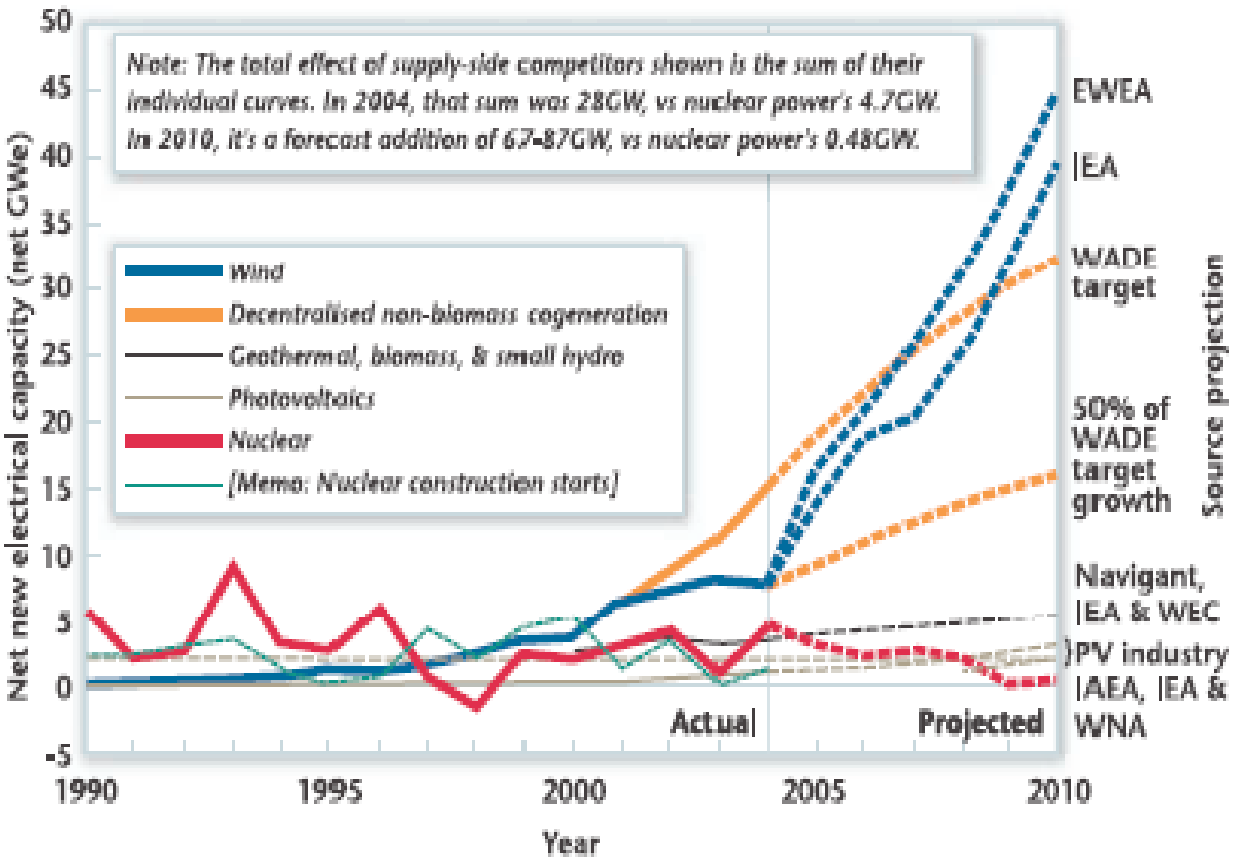
These are Standard & Poor's estimates, not mine. Essentially all the bottom line numbers have doubled in three years!

So What Happened to Solar Over this Period?

- It went down in cost, despite rising materials costs and supply-chain imbalances. Roughly 30 percent – 9 percent eaten away by materials cost escalation
- Perceived as a disruptive technology (i.e., potentially cheaper than marginal operating and fuel costs of the existing system) in many parts of the world
  - How many new phone lines did MaBell build after the cell phone?
- Only disruptive technologies have unlimited growth potential – they can cannibalize the existing system and grow quickly enough to address climate problems
- Efficiency resources meet that definition – cost less than gas or coal. 3x more carbon savings per dollar than new supplies.
- Photovoltaics are now disruptive in high cost regions – grid parity may be a few years away for most of the world

Rapid Renewable Growth Worldwide

Figure 2:
Global additions of electrical generating capacity by year and technology



Recent worldwide annual growth in PV production capacity is +50% per year. Note that PV industry projections for 2005-2010 were nearly flat.

The Vendors Underestimated

	2001	2002	2003	2004	2005	2006	2007	*06 to 07 Growth*	Capacity YE07	Capacity YE08
US	100.3	120.6	103.0	138.7	153.1	179.6	266.1	*17.3%*	318.0	616.0
Japan	172.4	252.6	365.4	604.0	833.0	926.9	920.0	*11.3%*	1,482.5	1,707.5
Europe	73.9	122.1	200.2	311.8	472.6	680.3	1,062.8	*43.9%*	1,742.4	2,916.0
ROW	25.9	43.5	75.4	141.5	312.5	687.0	1,484.1	*119.8%*	2,633.0	5,009.5
	372.5	538.7	743.9	1,196.0	1,771.2	2,473.7	3,733.0	*50.9%*	6,175.9	10,249.0
% Thin Film	4.8%	3.2%	5.1%	5.1%	5.4%	6.9%	10.0%			

- Not flat through 2010, but 50% annual global growth
  - More poly-silicon available than commonly thought.
  - Increasing production of thin film
- Much growth has shifted to China, Taiwan, Malaysia
- US expansion is mainly thin film; also growing rapidly

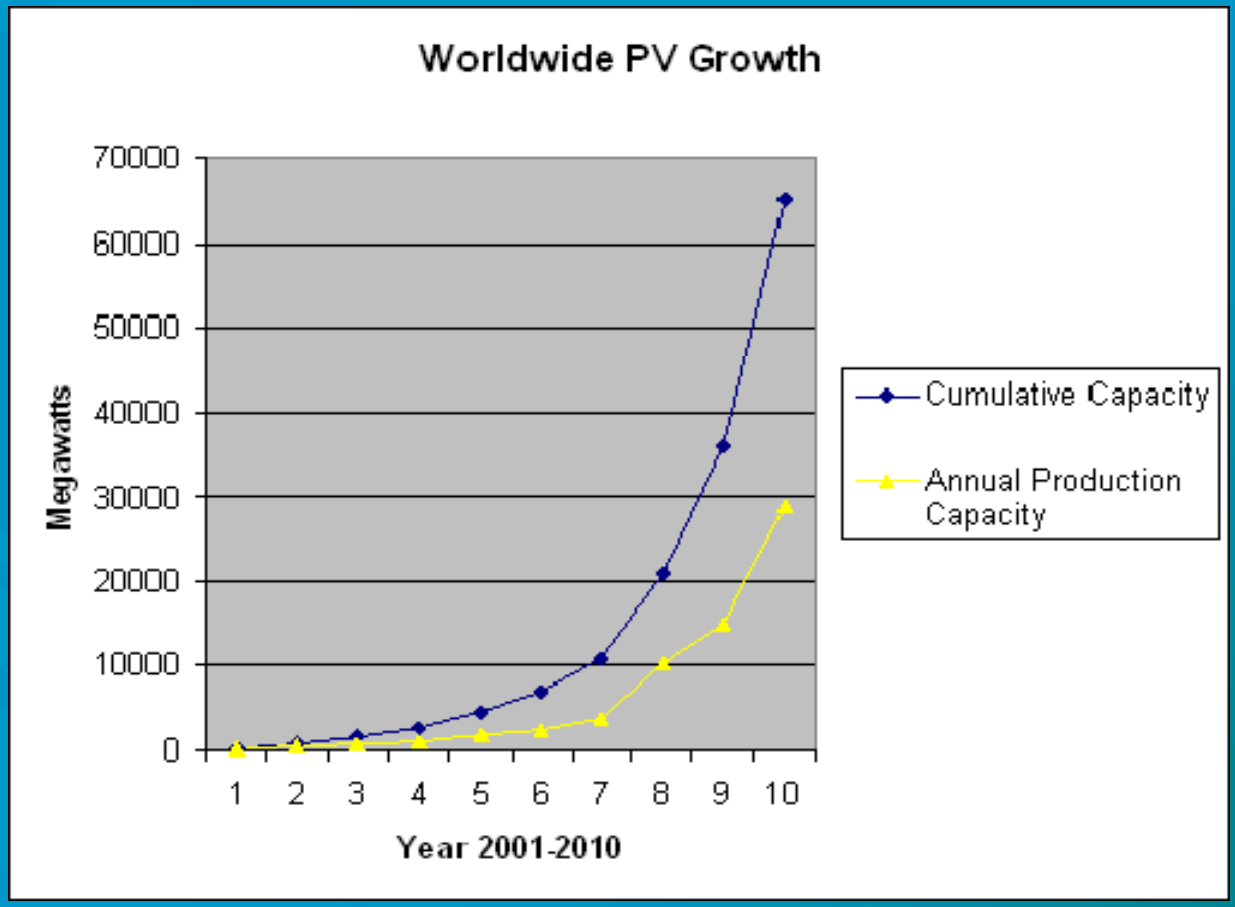
Source: Travis Bradford, Solar Energy Market Update, April 2008. Units are MW of annual production capacity.

Fast Growing Production Capacity

- **Massive Plants expected through 2010:**
  - Sharp – 2 GW (2010)
  - Kyocera – 500 MW (2009)
  - Sanyo – 350 MW (2008)
  - First Solar – 450 MW (2009)
  - United Solar – 300 MW (2010)
  - SunPower – 500 MW + (2010)
  - Suntech – 1 GW + (2010)
  - Q-Cells – 1 GW? (2010)
  - Conergy – 250 MW (2008)
  - Ever-Q – 300 MW (2010)
  - Solland – 500 MW (2010)
  - Schott – 480 MW (2010)
  - SolarWorld – 1 GW (2010)
  - Yingli – 600 MW (2010)
  - Motech – 450 MW (2010)
  - Trina – 660 MW (2010)
  - E-Ton – 300 MW (2009)
  - JA Solar – 275 MW (2008)

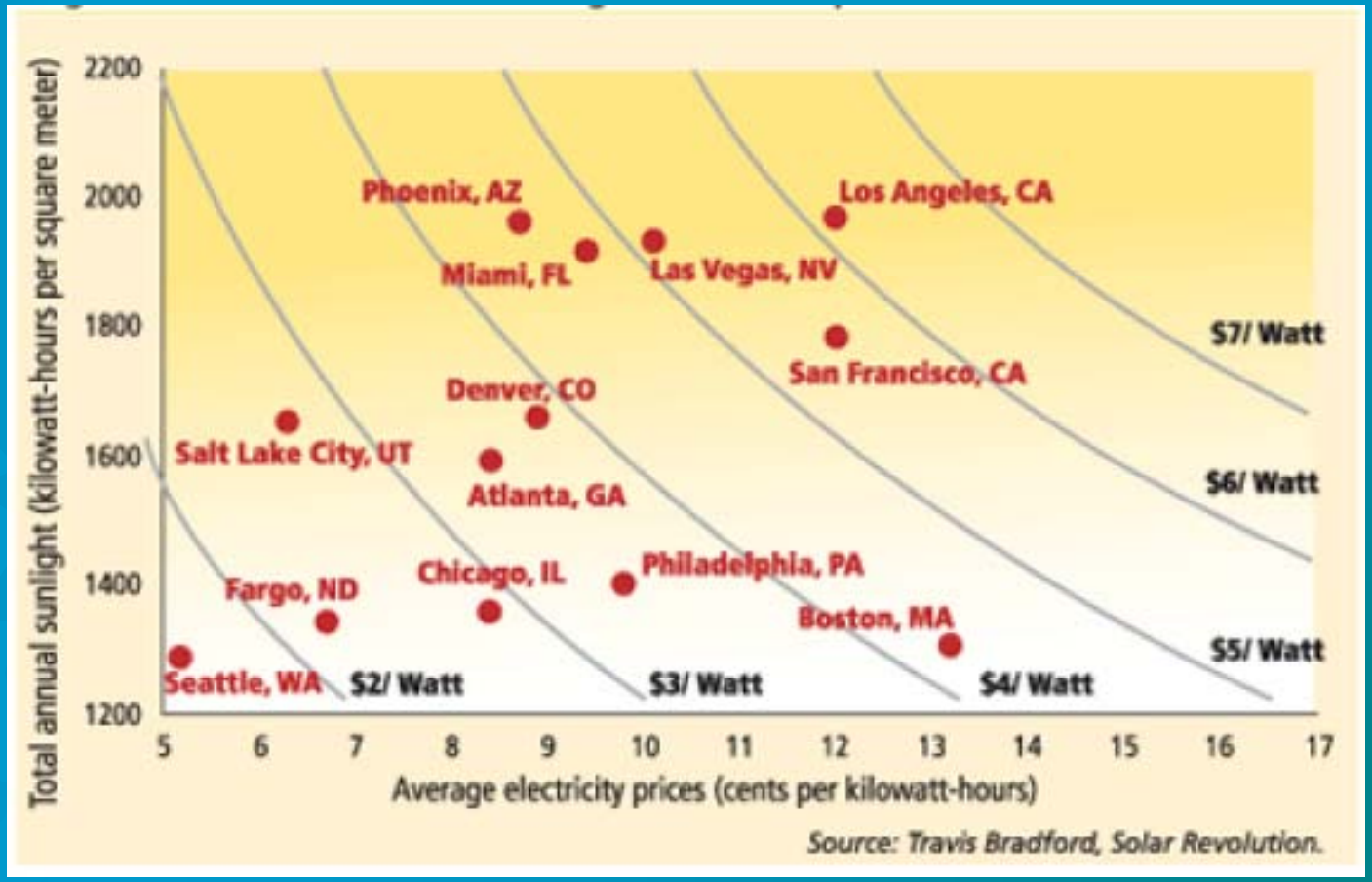
Source: Bradford, ibid. April 2008

PV Production and Installed Capacity Are Taking Off



Source: Prometheus Institute and Photon Magazine numbers for worldwide capacity and projects underway. Let's go back to slide 12 – off the chart! Plus 60%/yr annual average growth rate; much faster in recent years

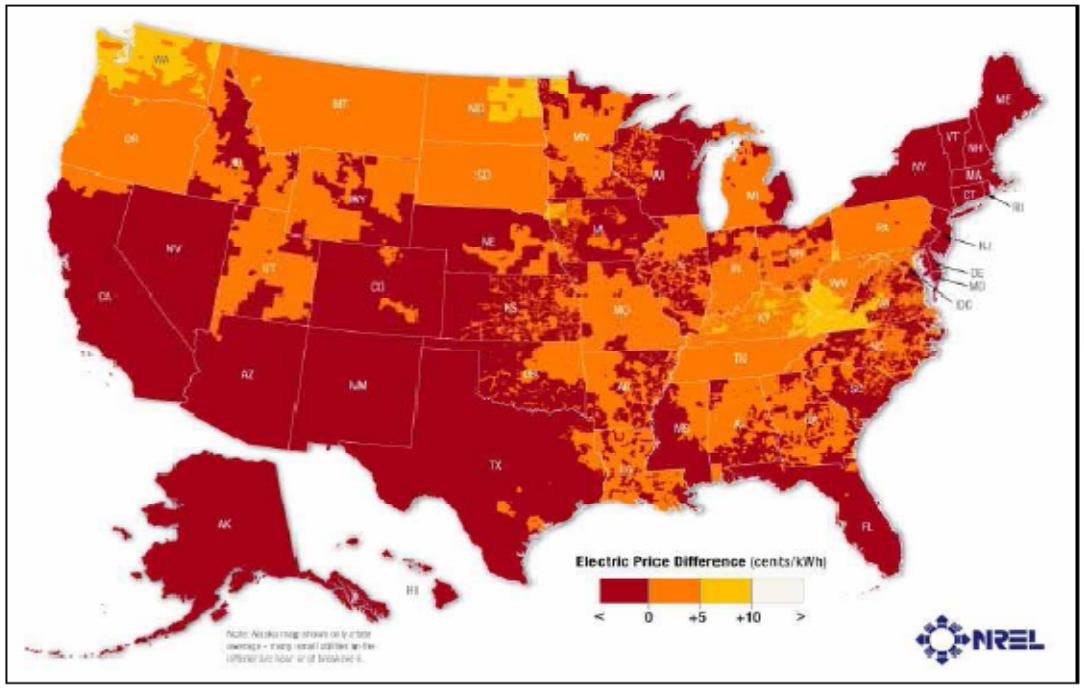
Grid Parity Accelerates at $4/Watt



Note: if new resource options – like nuclear – cost 12-16+ cents/kWh, then Seattle and Fargo look like Boston!

2015 residential installations without incentives and aggressive increase in electricity prices

- Attractive in about 450 of 1,000 largest utilities, which provide ~50% of U.S. residential electricity sales.
- 91% of sales (in nearly 950 utilities) have a price difference of less than 5 ¢/kWh between PV and grid electricity.
- Across most of the highest U.S. population areas, PV is cheaper than grid electricity.



Ibid.

In the last six months…

- Nearly all major PV manufacturers are sharing quantified plans for achieving grid parity ~ 2010
- Nanosolar announces 1 GW/yr CIGS production tool for $1.65 million (10-30 MW/yr is typical)
- Big utilities are jumping in
  - Iberdrola builds wind, PV, and solar thermal (Spain)
  - Eon/Schuco and Enel/Sharp building thin-film plants in Germany and Italy, respectively
  - Endesa building PV plant with Isofoton in Spain
  - Electricite de France takes major stake in Nanosolar
  - PG&E announces 800 MW PV project for 12 cents/kWh
  - SCE rate-basing 50 MW/yr at $3.50/watt installed
  - Long Island Power Authority 50 MW solicitation
  - PSE&G announces major PV financing program

The Bottom Line

- Coal and nuclear power are expensive
- Financial crisis hurts all large capital intensive options
- Efficiency remains the cheapest supply option
- PV is at or near parity with new resources in most of the world, and is rapidly nearing grid parity
  - Utility eligibility for solar ITC is big, especially with collapse of tax equity market
  - Every utility and policy maker needs to stay on top of this technology

Supplemental Slides

Reprocessing Is Still Expensive

Fuel cycle steps	MIT	This analysis
Uranium	$30/kg	$300/kg
Enrichment	$100/SWU	$140-340/SWU
Fabrication	$275/kg	$275/kg
Disposal	$400/kg	$400/kg
Reprocessing	$1000/kg	$1500-2000/kg
Fuel cycle cost		
Open	0.5 cents/kWh	1.6-2 cents/kWh
Closed	2 cents/kWh	3.4-4.3 cents/kWh
Differential	4x	2-3.5x

Approximately 5.25 kgs of spent fuel must be reprocessed to obtain 1 kg of MOX.