



Status and Technology of Solar Power Generation

**McIlvaine Hot Topic Hour
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General solar basics

The market for all solar technologies (PV, CPV, CSP) into the grid connected application is incentive driven – this means that 97% of the market is vulnerable

Solar is sold either in kilowatt hours or as a system, which generates kilowatt hours.

Utility scale (multi-megawatt) is a commodity biz ... meaning cheap wins

New business models are emerging in the U.S. that eliminate the need to own the means of production out of the electricity consumers hands ... as renting electricity remains the paradigm this is good news.

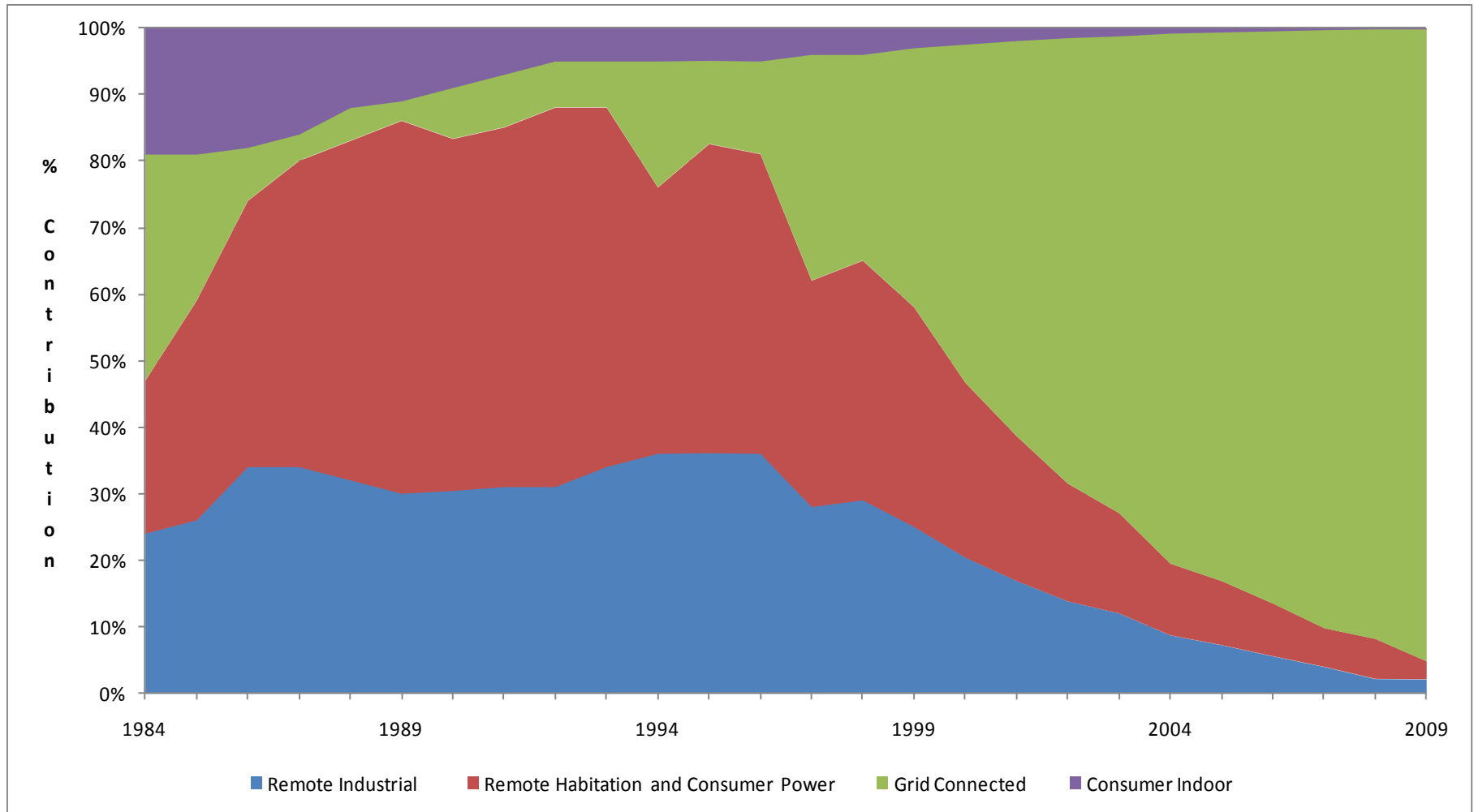
Grid parity is a generic term used primarily for marketing purposes – basically, all it means is that solar competes with other energy technology (including coal) at the same price, market by market – it also means that solar is expected to compete with conventional energy (which will remain subsidies) without receiving subsidies itself. It continues to be important to pursue it because, basically, we promised. However, all it does is even the playing field.

Lower cost and higher efficiency is the industry mantra – ALL technologies must follow a path towards these twin goals. Thin films face a difficult uphill battle and OPV can learn from these technologies:

- When prices for crystalline technologies fall, prices for thin films must fall by ~12%. This is because higher efficiency technologies are cheaper to install (the area penalty affects BoS and land and installation time)
- Technologies with <10% conversion efficiency are non-competitive in grid connected applications for the above reason
- ****Currently in the U.S. the biggest roadblock to utility scale solar is outside interference**

Application Contribution, 1984 to 2009

In the early days, demand was into the off grid applications, remote industrial, habitation and consumer power. Consumer indoor (watches, calculators) grew rapidly in the early 1980s, matured rapidly, with growth slowing to ~8% a year. In the late 1990s growth in the grid connected application accelerated and now dominates.



CSP, CPV and PV Competitors and Allies

Technology	Optimal DNI	Land	Install time	Current Bankability (3)	Storage	O&M	Water Req.	Roof	Ground	Average Install cost
CSP	High	High ~8-acres/MW to ~10-acres/MW with storage (1)	Long, 18 to 24 months, technology dependent, dish stirling can be faster	low	Dispatchable High/storage potential medium	High	High	no	yes	\$6.00/w to \$8/w with storage(4)
CPV	High	Low 3.5-acres/MWp (DC) (2)	low one or more months	low	Low	medium	low	no	yes	~4.00/w dc-stc(5)(6)
c-Si flat plate	low to high	Medium ~4.5-Acres/MW , tracking ~6 to 7-acres/MWp, azimuth tracking 9 to 10-acres/MWp	low one or more months	high	Low	low to medium	Low	yes	yes	≤\$3.25/Wp
Thin Film flat plate	low to high	Medium 5 to 6-acres/MW	low one or more months	low	Low	low to medium	Low	yes	yes	≤\$3.00/Wp

1) Field size can be increased to capture more revenue later in the day (oversizing the field at peak so that the plant produces at peak output early in the day and later in the afternoon. Field size can also be compressed.

2) 4.5-acres ac-nameplate (interconnect size) or around 5-acres ac-ptc.

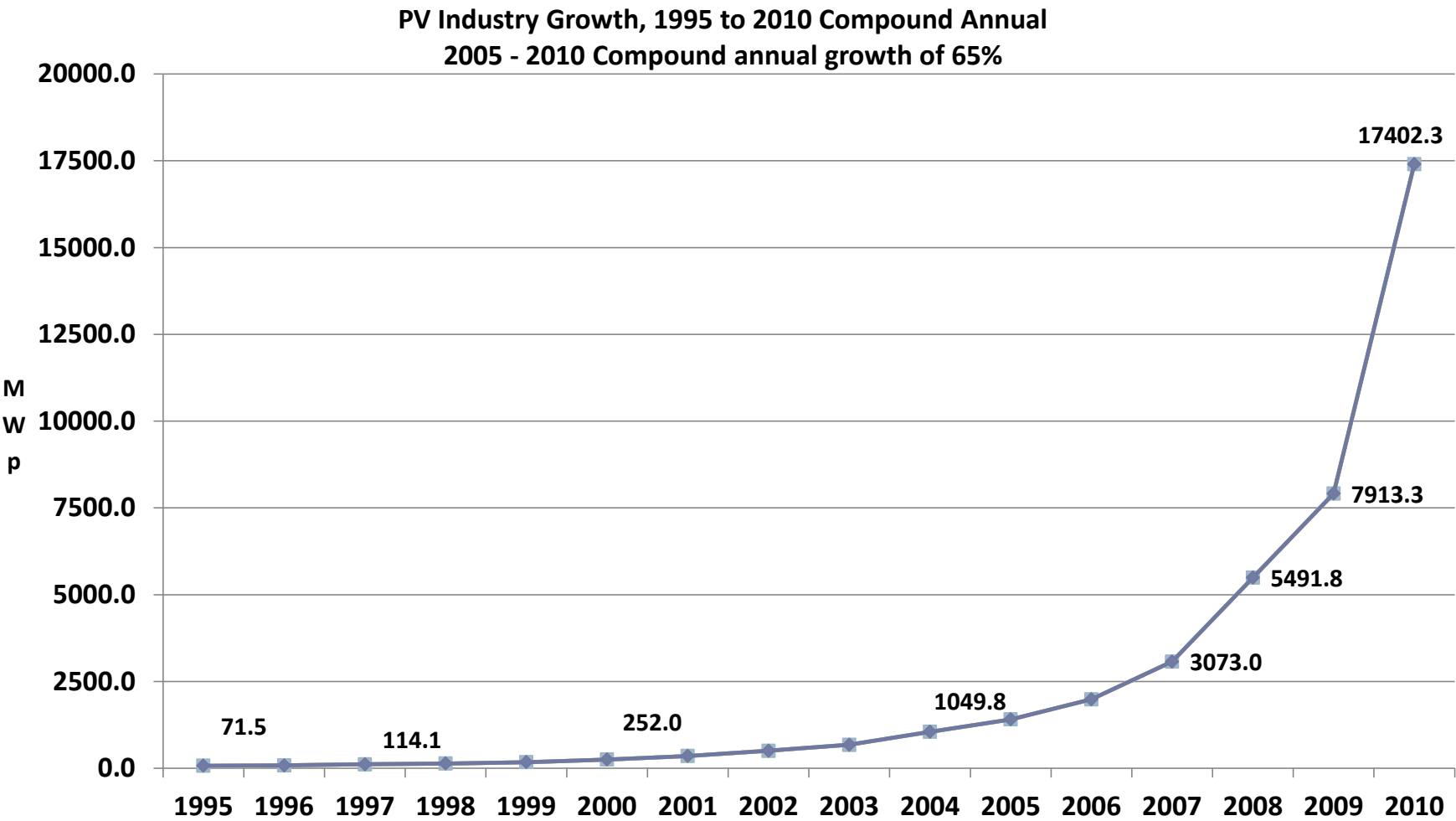
3) Bankability is a variable as it relies on understanding of the technology and industry, along with experience of the contractor

4) Costs for CSP installations ~250-MW would be <\$6.00/W

5) DG, no interconnect costs

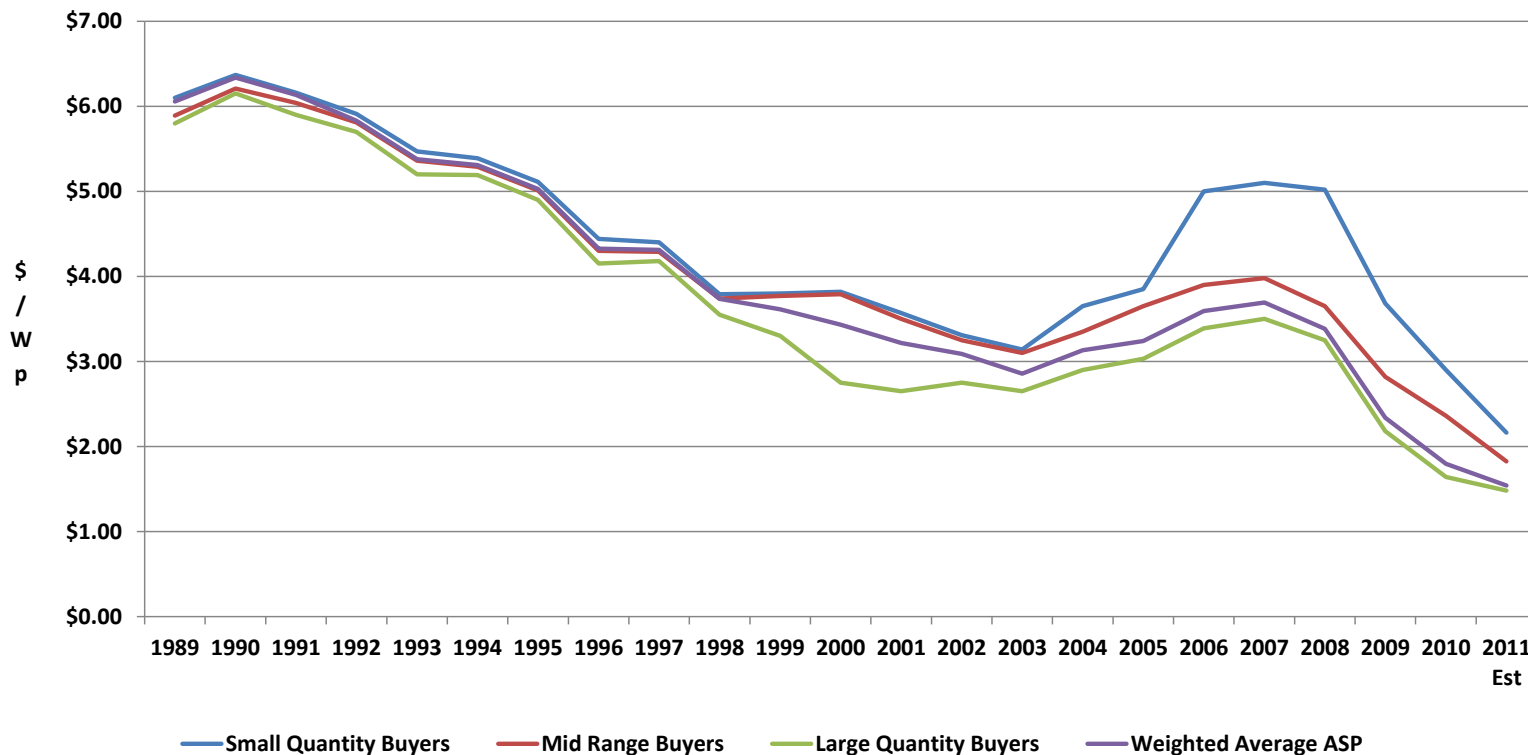
6) Fully installed system cost for CPV is < \$3.50/W dc at scale above 2MW, due to different installation methods involving cranes that significantly decrease field labor

PV Industry Growth: 2005 to 2010: five year CAGR to 2010 65% with growth in 2010 over 2009 at 120%

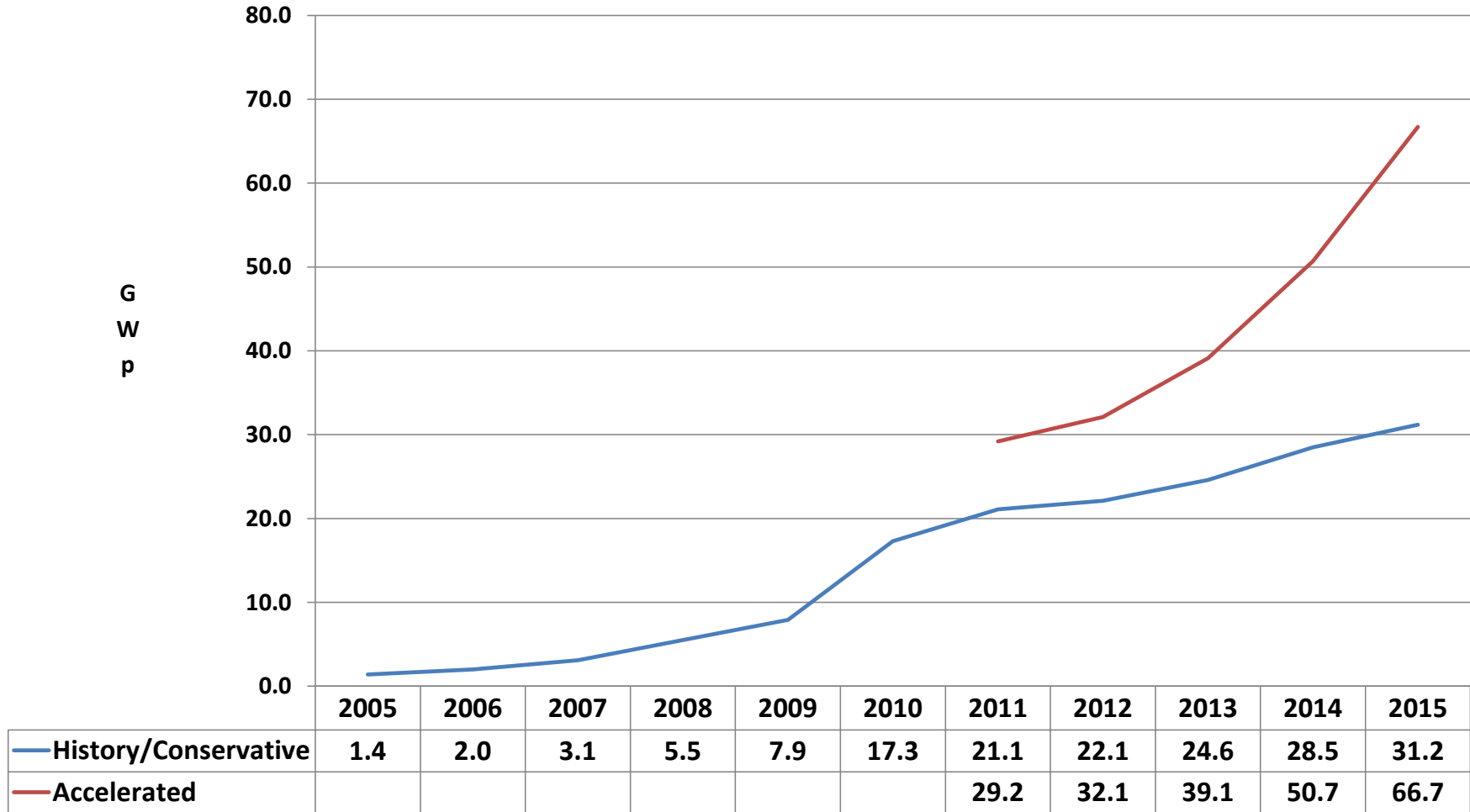


PV biggest advantage over CPV and CSP – it is cheap.
CPV's biggest advantage, system focus
CSP's biggest advantage, dispatchability

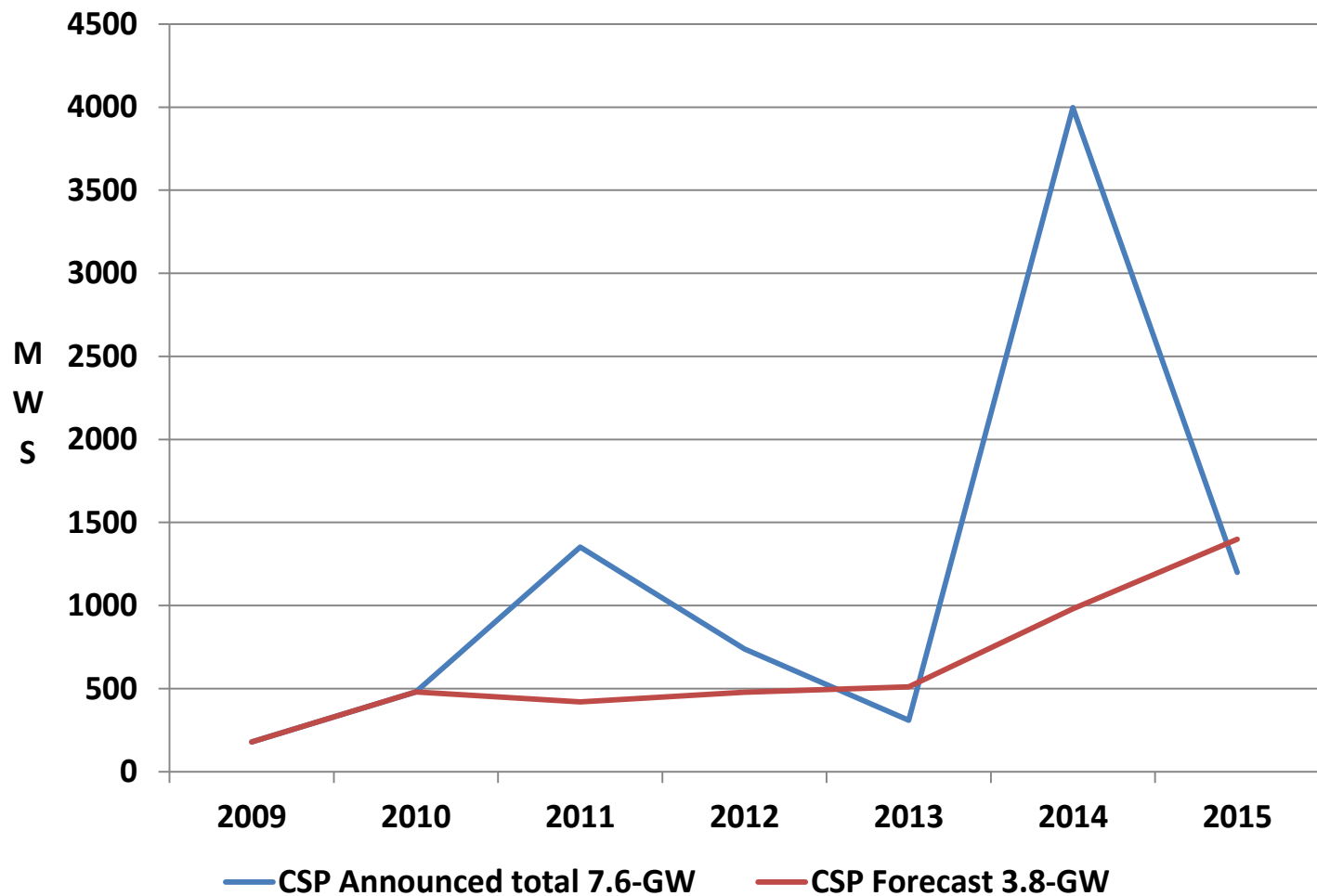
PV average prices, 1989 through 2011



PV Forecast (all PV technologies and all applications)

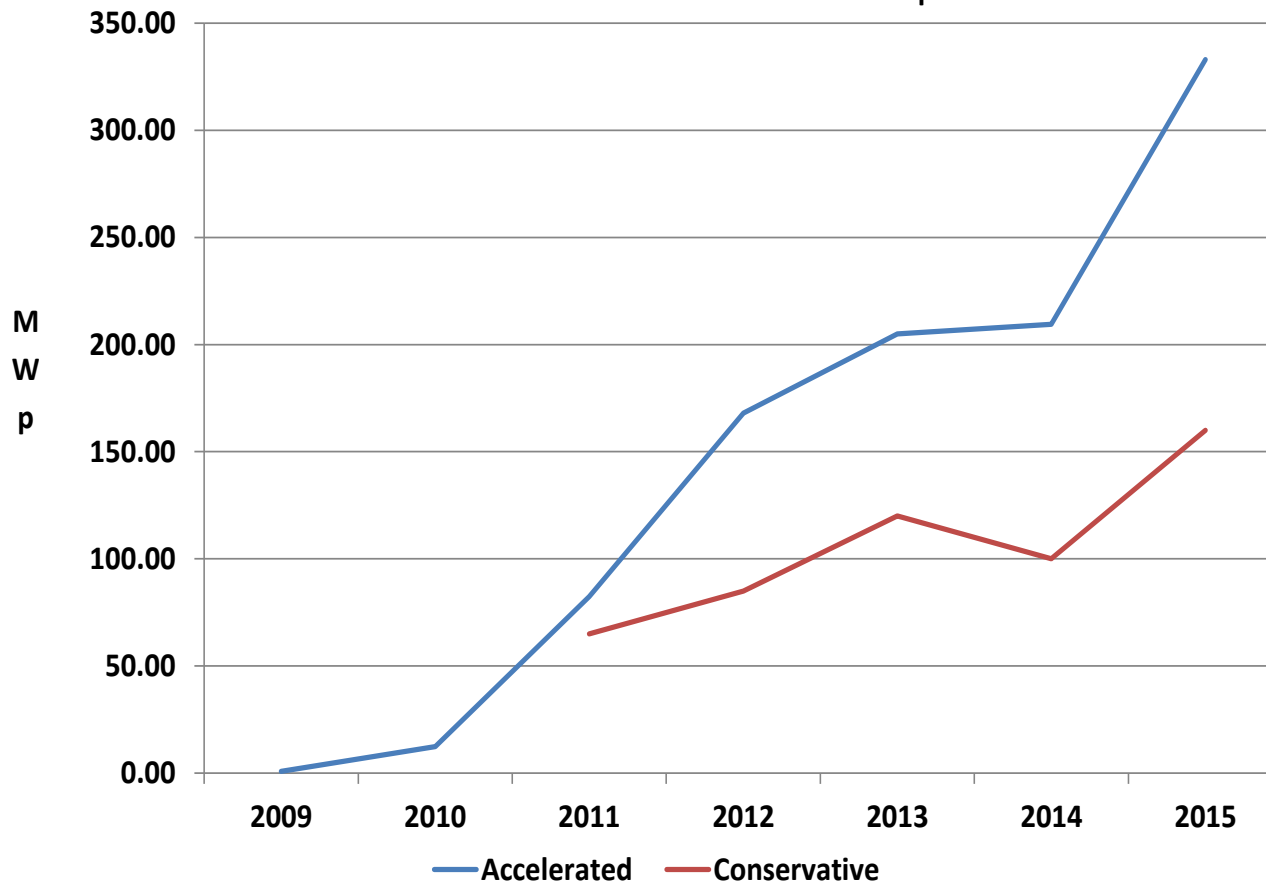


CSP Forecast, lots of GWs announced, but ~60% will not come to pass because of cost and frankly, interference from outside parties

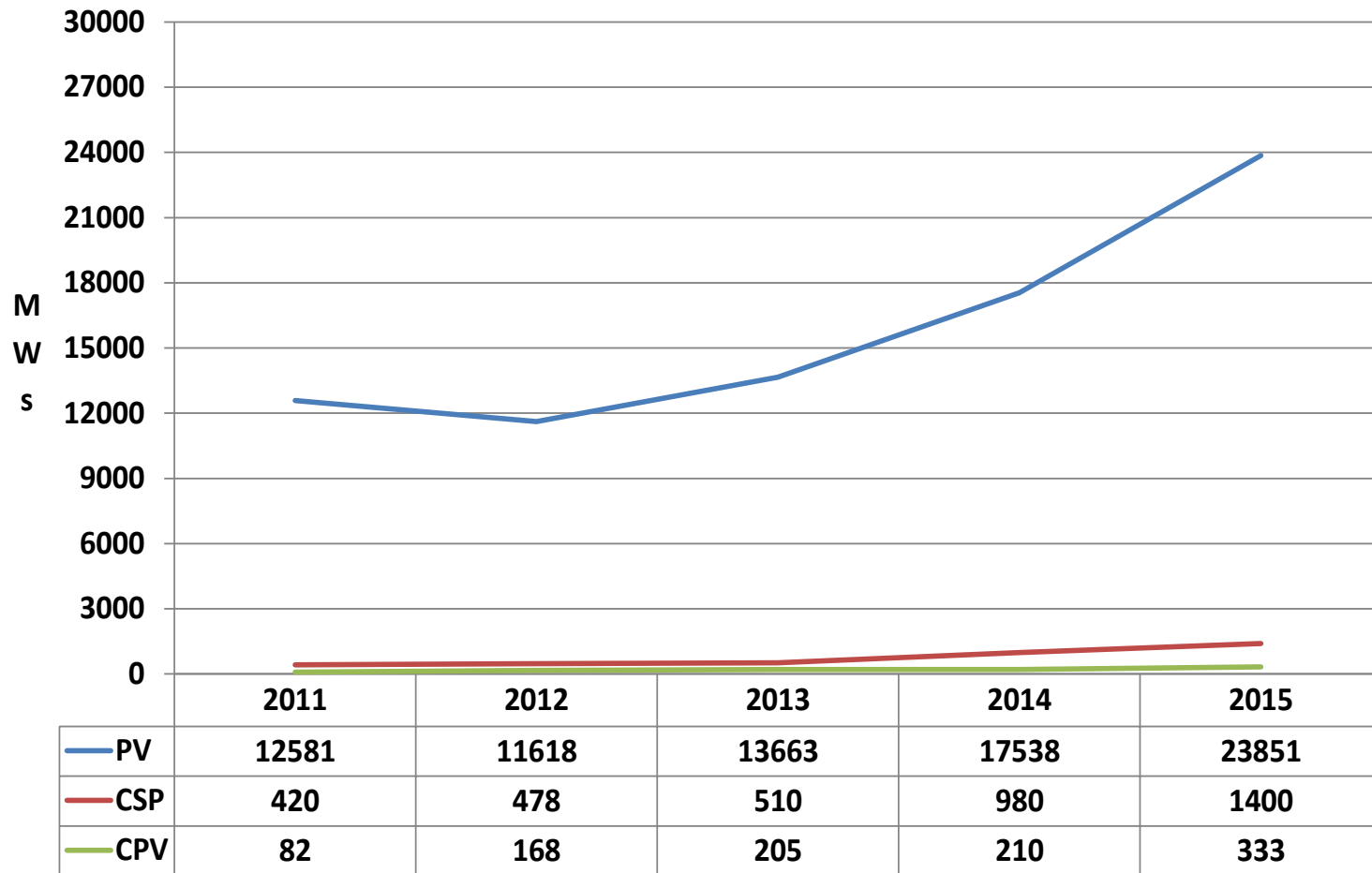


CPV Forecast

CPV announcements total ~2-GWp
Accelerated Forecast total: 1-GWp 2011 through 2015
Conservative Forecast total: 530-GWp



All Together now ... forecast only for applications appropriate for all three technologies: 500-MWp to 20-MWp (CPV and PV) and >100-MWp, all three



Thank You!

Let's not count our megawatts before they are connected to the grid because we will have to get used to lower, or perhaps no, incentives in just a few years.

We need to think not just of where to put it (markets) – we need to think of how (installation and BoS innovations) and into what application (what is the electricity used for?)

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