

Silicon photovoltaics: Global retail parity and beyond

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As of the preceding FTM-2012 workshop, the photovoltaic (PV) module industry had achieved remarkable progress [1] but also was under threat of financial collapse due to manufacturing overcapacity and resultant cutthroat pricing. In fact, the #1 worldwide PV manufacturers for 2008 and 2010–11 both subsequently filed for restructuring. One could therefore reasonably ask whether there was a sound basis to project any trends at all for this industry.

Fast-forwarding to today, even though module prices have fallen another 20% (to even < \$0.60/Wp for some formats and regions) [2], the top PV manufacturing companies have achieved financial stability. Prices had already reached the tipping point of retail parity in many markets [1] so that global demand remained strong. And since 2012, production costs came down *faster* than prices – to < \$0.50/Wp for the top multi c-Si module producers [3]. As a result, PV installations have continued to grow at a rapid pace to a total worldwide capacity of 200 GWp [4] or about a factor of 3 greater than at the time of FTM-2012.

Underlying this progress has been continued improvement in silicon PV technology, both in cost and conversion efficiency. In fact, multi c-Si efficiencies have improved another absolute 1% in production over the past 3 years [3], and silicon has grown in total PV market share to ~ 90% [5]. There are high confidence paths to improve silicon PV further, with module costs projected to decline another 40% over the next 3 to 4 years [6].

In this presentation we will review the economics, industry trends and technology roadmap for PV, contending that despite the persistent allure there is little opportunity left for a non-silicon based solution to be competitive for mainstream applications. We remain confident in our predictions made at FTM-2012 that unsubsidized, cost-effective PV electricity will be delivered to > 95% of the world's population by 2020.

1. M. R. Pinto, "Silicon Photovoltaics: Accelerating to Grid Parity", chapter in: S. Luryi, J. M. Xu, and A. Zaslavsky, eds., *Future Trends in Microelectronics: Frontiers and Innovations*, New York: Wiley, 2013, pp. 194–209.
2. PVinsights, Weekly Spot Prices, <http://www.pvinsights.com>, Feb. 6, 2015.
3. Yingli Solar Investor Day Presentation, Oct. 2014.
4. IHS/Solarbuzz, Solarbuzz Quarterly Report, Oct. 2014.
5. Fraunhofer ISE Photovoltaics Report, Oct. 2014.
6. Deutsche Bank 2015 Solar Outlook, Jan. 2015.