# ITRPV 4th edition review: Materials matter

**Mark Osborne**, Senior News Editor, Photovoltaics International

ABSTRACT

Over the past two years the PV industry has been in disarray as massive global overcapacity has sent prices tumbling. In this context, technological innovation to reduce the costs of base materials and products has become increasingly important. The latest edition of the International Technology Roadmap for PV published in March offers insights into the latest developments as manufacturers continue to seek ways of cutting costs. This paper explains some of the key dynamics identified in the roadmap.

## Introduction

The 4th edition of the International Technology Roadmap for PV (ITRPV) [1] was introduced at the 2013 PV Fab Managers Forum in March after a second year of industry turmoil. Chronic structural overcapacity throughout the supply chain has further shaped an industry that has been chasing rapidly declining average selling prices (ASPs) with manufacturing cost-reduction strategies. However, ASP declines have continued to outstrip cost declines, resulting in the majority of companies remaining loss making (Fig. 1). The latest edition of the ITRPV reflects current industry dynamics with further

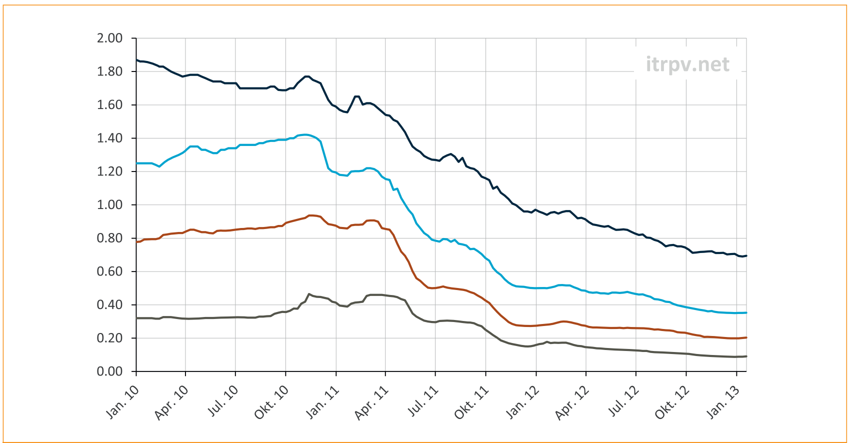


Figure 1. ASPs of different product types.

**Increase your efficiency with our glass powder additives.**

**SOLAR METALLIZATION PASTE ADDITIVES**

- Front Side Silver
- Back Side Aluminum
- Back Side Silver
- Customized Glass Formulations

ceradyne, inc.
VIOX
Visit our website for more information
VIOX.COM

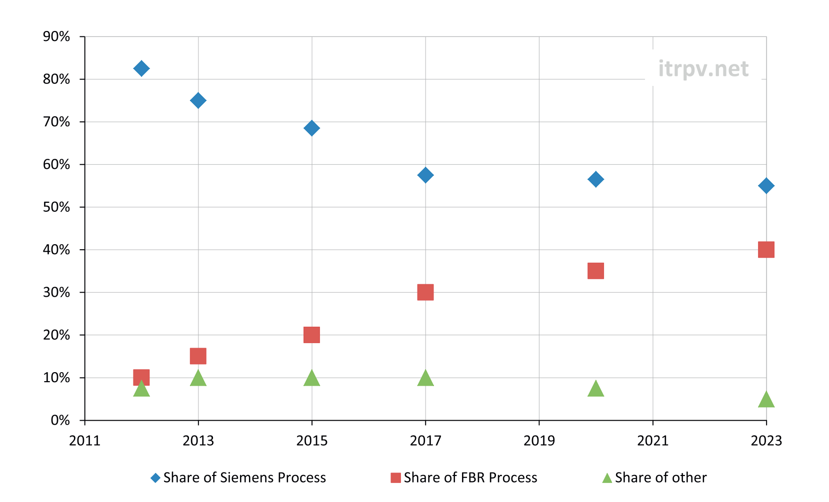


**Figure 2. The changing share of polysilicon production methods.**

acknowledgment that cost-reduction strategies dictate technology adoption. Where new technology is adopted, notably in cell efficiency gains, the mantra is 'implementation without production cost increases.'

Much of the cost reductions seen at the wafer, cell and module stages of PV production over the last two years have been material based. Not surprisingly, the rapid reduction in polysilicon ASPs has been a significant contributor.

> "Much of the cost reductions seen at the wafer, cell and module stages of PV production over the last two years have been material based."

Vertically integrated PV module manufacturing leader Yingli Green saw its overall silicon costs (multi and mono) fall 50% in 2012, down from US$0.30/W in the first quarter of 2012 to US$0.15/W in the fourth quarter.

However, non-silicon costs (multi and mono) fell from US$0.57/W in the first quarter to US$0.47/W in the fourth quarter, an approximately 15% annual reduction. The latest ITRPV notes that module ASPs declined to US$0.69/W in mid-January 2013, still below manufacturing cost levels even for one of the leading low-cost producers.

## Polysilicon

Polysilicon ASPs fell below production costs for all but the large-volume suppliers in 2012. Though contract prices hovered around the US$25/kg level, small producers had costs around US$10/kg higher, while spot market prices plummeted to below US$17/kg at the end of 2012.

The result has been a short-term rebalance of polysilicon supply and demand. Bernreuter Research has forecast that PV installations could reach between 35GW and 37GW in 2013, driving a renewed demand for polysilicon that could push polysilicon spot prices to between US$20/kg and US$25/kg by the end of 2013. Significantly, many smaller suppliers would still be unable to restart production if prices rebounded to the forecast range.

The scenario also indicates that cost-reduction strategies for major polysilicon producers remain crucial to profitability and acceptable margins to reinvest in the future should PV demand growth continue without being impacted by potentially crippling polysilicon price rises.

The ITRPV acknowledges that further purity level gains of polysilicon would not lead to significant cost reductions. Major polysilicon producers already exceed purity levels required (6N) for p-type multicrystalline solar cells in such quantities that 9N polysilicon is priced lower than 6N material, negating any cost reductions.

The ITRPV instead expects that the fluidized bed reactor (FBR) technology, as used by REC and soon to be produced by MEMC and Samsung under a joint venture facility in South Korea will increase its share against higher cost and higher purity 'Siemens' processing (Fig. 2). GCL-Poly, China's largest polysilicon producer, also has plans to produce FBR-based material in the near future.

REC recently stated that the FBR polysilicon cash cost was US$12.5/kg in the fourth quarter of 2012, when its plants were fully utilized. The company said that it was targeting a cash cost of US$11.5/kg by the fourth quarter of the year, yet management acknowledged that the target would be tough to meet. Like GCL-Poly, REC expects FBR cost saving to come primarily from improved utilization of the silane gas capacity.

REC's FBR-based polysilicon production continues to run at an annualized capacity of about 16,500MT. Polysilicon nameplate capacity at GCL-Poly remained at 65,000MT in 2012, although the company produced 37,055MT of polysilicon, an increase of 26%, compared with 29,414MT produced in the preceding year.

It is still early days for FBR adoption and the potential for further cost reductions. The ITRPV forecasts that FBR technology is expected to account for only around 15% of polysilicon production in 2013, increasing 30% in 2017. By 2023, FBR production's share is expected to have climbed to account for 40% of polysilicon production.

## Wafering

In tandem with polysilicon price declines, solar wafer ASPs declined in excess of 50% year on year. GCL-Poly, the largest producer by nameplate capacity (8GW), recently reported its solar wafer ASP in 2012 was US$0.25/W, down from US$0.54/W in 2011. The price decline year on year was 53.7%.

Wafer producers not shielded by the significant technical know-how barrier and high upfront building costs of polysilicon plants are under extreme pressure to reduce production costs, which have failed to keep up with ASP declines in 2012.

According to the ITRPV: "A significant improvement in cost reduction in the wafering process is expected by the introduction of diamond wire sawing, especially for mono wafers. Diamond wire sawing is expected to become widespread for mono-Si wafering, however the field is open for mc-Si wafering. Other new wafer manufacturing techniques, especially kerf-loss technologies, are not expected to show notable market shares due to the maturity of the established sawing technologies."

Much emphasis is being placed on the introduction of diamond wire sawing to reduce wafer costs, as traditional cost-reduction routes such as crucibles, graphite parts, slurry and sawing wires are only expected to decline in price by between 5 and 10% per annum, forcing the pricing level of diamond wires to be reduced 25% by 2023 from today's pricing level.

Efforts by major suppliers such as Meyer Burger and Applied Materials are ongoing in this field. Wafer producers have championed diamond wire, but improvements in slurry recycling techniques, for example, have proved to be lower hanging fruit to date.

> "The ITRPV projects diamond wire-based sawing will become the dominant sawing technique for mono wafers from 2017."

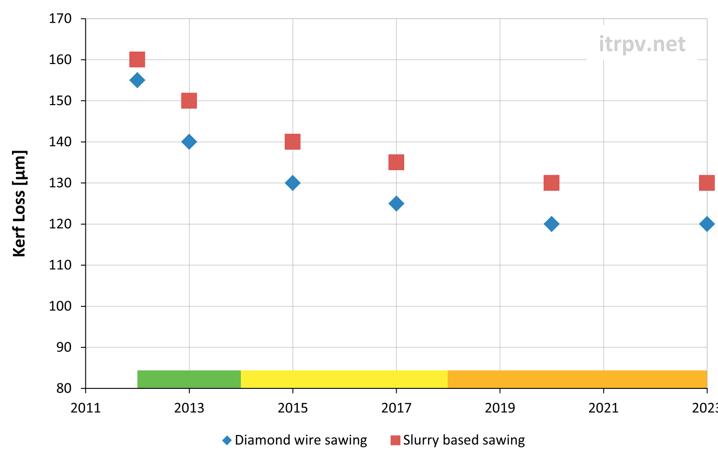


Figure 3. The changing thickness of wafers.

However, the ITRPV projects diamond wire-based sawing will become the dominant sawing technique for mono wafers from 2017. The key problem for multi wafers has been the lack of enthusiasm by module manufacturers to adopt thinner wafers.

The ASP declines for polysilicon, and the need to add processing steps and better align wafer handling at both the cell and the module processing stages, offset material savings. Previous editions of the ITRPV expected wafer thicknesses to have been reduced to 160 microns in 2013. The latest edition acknowledges this would not happen, as the vast majority of wafers remain around 180 microns (Fig. 3). One of our reference models, Yingli Green, ended 2012 using 180 micron-thick wafers and 130 micron-thick saw wire.

Structured wire, a more evolutionary technology compared to diamond wire, is seen by the ITRPV as having significant throughput advantages, though remains slurry dependent.

The gap between wafer manufacturers' desire to reduce thickness and that of cell and module manufacturers to limit processing costs remains a challenge to be overcome.

One area within the wafering segment that is seeing fast adoption because of ASP declines is the move to larger ingot sizes. The latest ITRPV edition acknowledges an accelerated trend to 'Gen 6' ingot size for multi wafers (Fig. 4), which can lead to 1,000kg ingots. The Yingli Green reference model employs a variety of ingot sizes from 400kg to 500kg in 2012. The ITRPV noted that Gen 6 ingot technology had already been commercialized in 2012, increasing throughput by around 250%, compared with Gen 5.

## The rise and fall of quasi-mono

Quasi-mono casted ingots and wafers gained a lot of attention in 2010–11. The lower-cost multicrystalline ingot process was billed to offer mono-like quality and performance characteristics without the associated higher production costs of conventional mono techniques. However, quasi-mono was not included in the second edition of the ITRPV but was referenced in the third edition.

However, the latest edition is fairly dismissive of quasi-mono technology, noting that its "lack of maturity" would limit adoption. Yet manufacturers such as ReneSola have continued to develop and ramp the technology in 2012, while selective module suppliers have continued to display quasi-mono modules.

Yet the exit from the DSS market by GT Advanced Technologies in December 2012 puts further doubt on the viability of the PV industry's migrating to quasi-mono wafers, which was seen by the company as a key driver of future furnace sales and upgrades from the struggling wafering sector.

Instead, the ITRPV is banking on a conventional mono wafer production increasing significantly in coming years, taking 50% of the market by 2023. Other niche mono-like combinations are not expected to gain traction.

N-type mono wafers are a key part of the driving force for mono wafers. The ITRPV expects this wafer material to account for over 30% of the market by 2023, as it offers a better path to advanced cell designs and higher efficiencies.

The latest edition of the roadmap also continues to acknowledge the efforts by wafer producers to incrementally increase the p-type wafer efficiencies, a trend expected to continue for several more years and take p-type high-performance wafers to over 30% of the market by 2015.

On the mono wafer front, a key driver emerging is the adoption of full-square mono wafers around 2015.

"Continuous innovation is set to continue to meet cost-reduction goals and higher cell/module efficiencies."

Overall, the latest edition of the ITRPV continues to recognize the significance of cost-reduction drivers of base materials and products, while understanding that continuous innovation is set to continue to meet cost-reduction goals and higher cell/module efficiencies. However, ITRPV co-chair and REC Silicon vice president for R&D, Dr. Stein Julsrud, was recently cited by SEMI to have wanted more silicon suppliers to engage with roadmap efforts to gain industry-wide alignment.

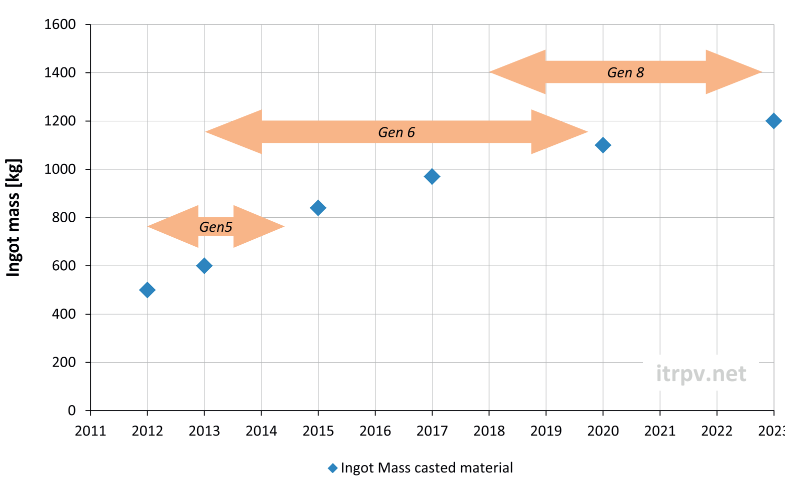


Figure 4. Ingot size trends chart.


### Reference

[1] SEMI PV Group Europe 2013, "International technology roadmap for photovoltaic (ITRVP): Results 2012", 4th edn (March) [available online at http://www.itrpv.net/Reports/Downloads/].