Challenges for the PV materials supply chain

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ABSTRACT
The cost of PV modules manufactured and sold in 2012 is highly reliant on the materials used in the construction. A significant part of the market price is driven by the bill of materials, while other direct costs and depreciation form a small proportion of the total cost. Changes within the supply chain, and in the cost of the materials needed and used, are extremely important influences on the module cost and the end market price. In 2012 we have seen a slowdown in growth in the installation of both commercial and residential PV, despite dramatic falls in module costs. Some of the trends and effects of these changes on the materials supply chain for PV modules will be examined in this paper.

Introduction

Economy

As is painfully documented each day in the financial press, the world economy is in a poor shape. GDP growth in all the major markets for PV is weak, with the USA and Japan achieving only 2.1% each, the euro area shrinking by half a per cent, and even China growing at a relatively meagre 7.8% in 2012. Driven in part by these low growth rates, long-term government bond rates have dropped to near-historic lows. With internal rates of return higher than the long-term bond rates, this makes borrowing cheaper and increases the attractiveness of solar installations. In the USA and Europe 10-year bond rates are currently at 1.6 and 1.4%, respectively: a low investment return bar to overcome.

An obvious obstacle to the growth of the PV industry is the relative scarcity of investment capital; nevertheless, attractive projects are finding funding, and installations are proceeding.

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Cleantech

The entire cleantech industry remains at the mercy of the political process in each region and country. Changes in government in the USA and China have generated uncertainty as to the willingness of the new administrations to continue earlier policies. In the USA there is new optimism that there will be ongoing support for the cleantech industry, but in China the new leadership has yet to indicate its intended direction. In Europe the continued adoption of severe austerity measures plays against the momentum of the cleantech industry for continued adoption of PV if funding is available.

An interesting twist to the situation in the USA is the recent report from the International Energy Agency (IEA) [1] that predicts the USA could become the largest producer of energy in the world and produce 90% of its own energy requirements through the adoption of new extraction technologies. This has been the stated goal of Congress for several years now, and efforts to implement such energy independence may be at the cost of renewable sources.

These unknowns continue to generate uncertainty in the future trajectory of solar PV, which in turn discourages strong investment from value chain participants, local administrations and national governments. While consistent, long-term strategies will help to reduce this uncertainty, economic conditions are unlikely to improve enough to allow the luxury of such strategies in the medium term.

The bill of materials

Clearly, solar module manufacturers have exercised parallel strategies to maintain competitiveness in the market through 2012. On the one hand, rapid adoption of new technologies – such as the formation of selective emitters, reduced silver pastes and narrow contact grids and busbars to increase cell efficiency – have improved the output of each module sold. On the other hand, relentless pressure has been exerted on the supply chain to reduce costs, while maintaining material properties and quality. At all levels of the supply chain, aggressive cost-cutting and efficiency improvements have been implemented in an attempt to meet customer expectations; this has not, however, prevented significant reductions in profit margins at all levels of the chain. At a time when major suppliers have had to commit to significant capacity increases to meet the rapid demand in growth, reducing margins and cutting costs have challenged the business model assumptions of the suppliers.

	Cost ($/Wp)
Silicon	0.0841
Gases	0.0043
Wet chemicals	0.0150
Dopants	0.0296
Pastes and inks	0.0992
c-Si EVA	0.0236
c-Si backsheet	0.0477
c-Si glass	0.0488
Stringers	0.0202
Framing	0.0578
Total	0.4303

Table 1. Material costs for c-Si modules (2012).

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	Cost ($/Wp)
Mo	0.0009
Cu	0.0002
In	0.0099
Ga	0.0181
Se	0.0012
H_2Se	0.0066
CdS	0.0006
DEZ	0.0002
EVA	0.0222
PVB	0.0001
Edge seal	0.0008
Glass	0.2084
Total	0.2692

Table 2. Material costs for CIGS modules (2012).

Supply chain trends

To those visiting PV exhibitions and conferences in the last 12 to 18 months, the trends within the supply chain have perhaps been very obvious. There has been a steady reduction in commitment to the PV industry from larger companies, coupled with high-profile bankruptcies of suppliers and module manufacturers alike, evidenced by the declining number of exhibitors. These problems are also evident in the financial statements of players at all levels of the value chain, and financially weaker players continue to experience poor performance in this market. While the diversified suppliers can offset PV segment performance with other segment results, pure-play PV suppliers have significant ongoing challenges.

Against the background of continuously reducing the price per watt of finished PV modules, the downward cost pressure is unlikely to relent, and any expectations of some recovery in module pricing will only be met by howls of protest from installers looking for cheaper modules.

Crystalline silicon

Crystalline silicon (c-Si) cells and modules still comprise more than 80% of module sales and have been the focus of most technology improvements and cost-cutting efforts. A significant proportion of module price cuts have been achieved on the back of reducing polysilicon costs and increasing the efficiency of material use. A cost of silicon between the mid-20s and high teens is currently reported. Prices in this range still afford a narrow profit margin for the most efficient suppliers, but will probably not be sufficient for reinvestment in the long term; many smaller suppliers, however, have mothballed production, being unable to compete at this price level.

The adoption of new technology in leading-edge modules has been accelerated in 2012 by the use of novel materials such as nanocrystalline inks, dopant pastes, printable etchants, pastes with reduced silver content, and enhanced adhesives and backsheets. Most leading manufacturers have developed high-efficiency modules with monocrystalline silicon, reaching conversions of 19 to 20%, while improvements in processes, materials factory automation and process control have helped push up median cell efficiency numbers for all cell types. Material suppliers have helped implement many of the technologies that have led to these efficiency improvements while also aggressively reducing their selling prices through cost-cutting, operational efficiency improvements and margin reductions. Following a significant period of market growth and capacity addition, many suppliers have reported financial losses in 2012 at the same time as having to digest increased depreciation due to plant additions for capacity increases. Many companies have publicly stated that they are reviewing the strategic options for divisions serving the PV industry, and a consolidation of the supply base is expected over the next 12 months.

The rapid expansion of demand for many materials has been addressed by larger manufacturers through strategies of scale. To serve Tier 1 and Tier 2 cell and module makers, suppliers have had to develop robust large-scale manufacturing operations, often at multiple locations. In the case of many materials – for example polysilicon and backsheet polymers – investment in new manufacturing capacity is hugely expensive and has to be done on a large scale to remain economic. The wisdom of capacity addition in such large blocks is currently open to question, since the growth in material demand has declined in many segments, making it difficult for these investments to meet their planned returns.

The most common polymers used in module manufacture are almost all oil derivatives. Although the majority of these polymers have been manufactured in the USA, the increasing availability of cheap shale gas in North America is shifting the chemical industry away from oil as a raw material. In the medium to long term this will probably favour North American chemical manufacturers as suppliers of encapsulation polymers and backsheets, as long as conversion capacity to gas feedstock is developed.

The main exceptions to this are fluorinated materials, which continue to be supplied predominantly by the USA and Japan. The driver for fluorinated polymers is the increased lifetime available with these UV-resistant materials. The price premium for such improved performance is, however, becoming less and less popular, and module makers are evaluating alternative materials for backsheet cladding. Anecdotal evidence exists which indicates that some of these lower-cost backsheets may be resulting in early returns of installed modules, although this has not been widely confirmed.

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Thin film

The promise of thin-film modules to deliver very low-cost modules has not been universally kept by the competing manufacturing technologies employed. With the exception of First Solar and their CdTe absorber technology, other thin-film technologies have struggled to develop reliable manufacturing methods and large-scale production capacity. Many of the thin-film deposition precursors are gaseous and supplied through the major gas suppliers. Since 2008 the high price of polysilicon, and the promised low cost of thin-film technologies, have persuaded gas suppliers to invest in large-volume supply capability for materials such as silane, germane, cadmium selenide and other bulk gases. Similarly, manufacturers of sputter targets have committed resources for developing copper-alloy targets and supply chains for the rare metals used in CIGS absorbers. All of these suppliers have been frustrated by the lack of growth in these markets, and to a great extent have disassembled, at considerable cost, the business units designed to supply the demand.

The supply chain environment

As discussed, practically all of the material supply chain has experienced a range of financial challenges in 2012. These challenges include profit margin collapse, combined with slowing demand, and the continued concentration of manufacturing in China, Taiwan and Korea. Most suppliers are hardly profitable or losing money in supplying to the PV industry. Many of them entered this segment from other electronics industries or other specialty markets, and, although familiar with demand volatility, are not meeting their financial expectations. This has led to a change of strategy in addressing opportunities in the PV market: the reaction has been an almost across-the-board reduction in resource allocation to this market. This includes moving managers and other personnel to other business units and reducing sales and marketing efforts for PV products, while R&D focus has shifted to segments with higher perceived returns. These changes will result in reduced focus by many of these companies on the market, and slowing of the pace of innovation for the PV market.

In China there has been an increase in the number of companies offering materials for module construction, but the learning curve is steep and new entrants have a lot to learn before offering world-class products. Domestic Chinese suppliers who spotted an opportunity in the PV market five to ten years ago have certainly been able to improve their product offering to world-class standards, but these companies are now experiencing the same difficult financial conditions and will struggle to invest at the rate required to continue innovation.

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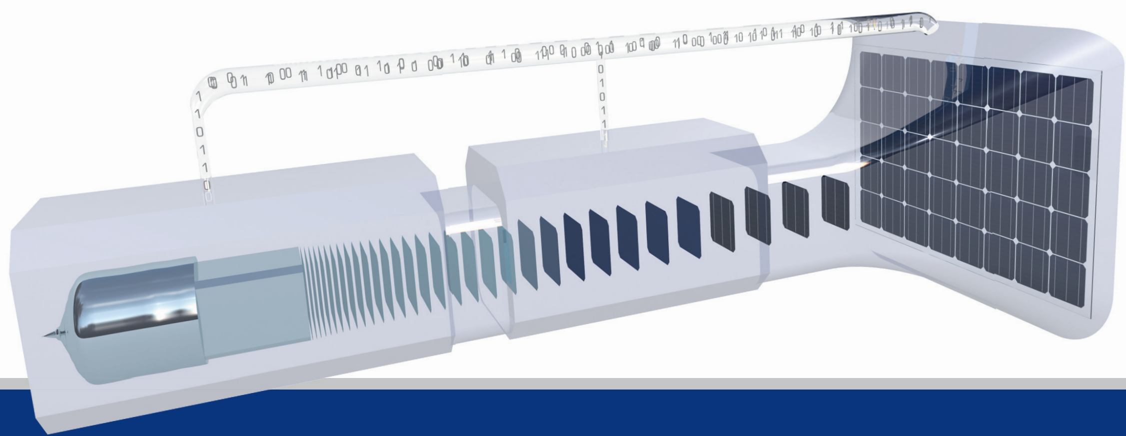

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Materials

The turmoil in the PV industry over the last 18 months has taken place at a time when raw material prices have been relatively stable. Price fluctuations in oil and precious metals, such as silver, have meant that, while these raw materials have a significant impact on overall cost, no price spikes have been passed on to the end customers. However, history tells us that this will change, and, with narrow margins, suppliers will struggle to maintain end-market prices if raw material prices spike in the global commodity markets. Price increases in cell- and module-making materials will also lead to price increases of the finished modules, upsetting the perception of monotonic reductions of cost per watt for modules.

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The bottom line

What, then, is the conclusion for watchers of the PV industry? We are seeing continued rapid change in the PV industry. The steep module price declines of the last 12 to 24 months have resulted in more-competitive PV installations that are approaching economic competitiveness with other forms of centralized generation, but probably still have some way to go. Assuming that sufficient governmental and popular support for PV continues, the industry will continue to develop.

Supply chain participants will make strategic and tactical decisions on the basis of current and past situations. The migration of the materials supply segment from a high-margin, specialty industry to a large-volume, low-margin segment will change the character of this market. We would expect three major effects from this migration:

1. In the medium to long term it is likely that there will be a decline in pure-play material suppliers. We would expect these suppliers to be acquired by others (or merge their operations with them) to develop larger businesses more adapted to conditions in the PV industry.

2. The industry will move to more closely resemble a global commodity-supply chain, with material sourcing and production located for maximum efficiency, and scaled to meet the expectations of the customer base. There will be a reduction in the number of specialty players in the supply chain, and many of those companies that may have brought innovative technology will exit if their margin expectations are not met.

3. As margins decrease, barriers to adopting innovation will increase and budgets for the development of novel materials will decline. It will become increasingly difficult for new solutions to gain traction and scale quickly enough for large-volume adoption, unless those innovations are supported by large companies.

In making these predictions it is assumed that crystalline silicon will continue to be the product of choice for large-scale PV installations. In the short term this will very likely be the case. However, the material efficiency and the manufacturing benefits of thin-film technologies should not be neglected – these may still offer significant opportunities for material and process innovation and business growth.

Reference

[1] IEA 2012, World Energy Outlook 2012 - Executive Summary [available online at http://www.iea.org].

About the Author

Mark Thirsk is a managing partner and co-founder of Linx Consulting, which provides market-defining analysis and strategic insights across major markets in electronic materials. He has over 25 years' experience in economic and business forecasting, strategic planning, technical marketing, product management and M&A, spanning many segments and processes in electronic materials. Mark has served on the SEMI Chemicals and Gases Manufacturers Group (CGMG) since 1999, acting as chairman between 2001 and 2003. He holds a B.Sc. (Hons.) in metallurgy and materials science from Birmingham University and an MBA from The Open Business School, and has authored multiple publications in both academic and trade publications, as well as contributing to several patents.

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