On one hand, many pro-solar tariff and subsidy programs have been reduced. Some of these programs were eliminated because solar prices have come down and are no longer needed, a sign that the industry is maturing. Market growth, although a positive trend, has created a big challenge: Solar projects are larger, and now with more money at stake, investor expectations are higher and manufacturers who fall short may not get a second chance. This pending consolidation is a natural outcome of an industry going mainstream.

At the same time, solar technology is advancing at its fastest pace in decades. Double-printing, selective emitter, back contact and other new designs are moving from development labs and high-end niche products into large-scale mainstream production. To compete, manufacturers must meet the market’s demand for more efficient cells, while also controlling or reducing overall cell costs.

It’s an uncertain time. Businesses that fail to control costs may not survive. But it’s also a thrilling time, too. Solar energy is approaching grid parity, on the verge of establishing itself as a critical component of the world’s energy mix. Businesses that fail to invest in technology upgrades may not be able to take advantage of the tremendous opportunities ahead.

Strong partnering across the supply chain is critical in balancing technological innovation and cost containment. Strong partnering can help each company succeed but weak ones can drag each other down. Materials and consumable suppliers can optimize their products for the needs of a particular cell design and process flow. Innovative equipment suppliers can help cell manufacturers integrate new processes in the most cost-effective, least disruptive way.

For example, many important developments in solar cell technology involve new contact structures: double printing, selective emitters, back contacts, and so forth. As Suketu Parikh, director of Display and Energy Service Technology for Applied Global Services, explained, each technology requires an integrated solution for material paste, screen, printer alignment and film deposition. For example, double printing demands silver paste to form a good contact with a high aspect ratio involving special screens and printers that deliver very precise alignment between the first and second paste layer. Selective emitter technologies require advanced pattern recognition and alignment to print metal over the selective emitter to get high efficiency. Screen printed dopant selective emitters require the optimization of compatible materials including dopant paste screens and squeegees.

It isn’t yet clear if these structures will become the new standard. Some approaches may be more cost effective than others, but pursuing each possibility will likely be manufacturer dependent. Manufacturers need flexible equipment that supports current needs while offering an upgrade path as new designs emerge. Applied Materials is working with paste and print screen suppliers to develop best known methods (BKMs) and recommended consumables for advanced cell designs. On the equipment side, Applied’s Baccini Esatto Technology™ upgrade package adds a printer/dryer unit and a high precision alignment kit, allowing existing lines to implement new cell designs at relatively little cost. Such drop-in upgrades limit the expense and line disruption of technology upgrades.

Strong partnering with equipment suppliers is equally valuable in managing overall factory operations. Key performance indicators for a solar cell factory include absolute efficiency, material cost, utilization, throughput, and yield. Effective monitoring can help manufacturers see how to improve all of these metrics. For instance, conductive paste in cell manufacturing is a major material expense,
second only to the cost of silicon wafers themselves. Comparing paste consumption across shifts and between lines can highlight wasteful consumption patterns. According to Alex Schwarm, senior global product manager for Solar Automation Products, a 400MW factory with 2% paste usage variability from shift-to-shift and line-to-line potentially wastes as much as $210,000 per year on paste alone.

Similar examples can be found throughout the factory. Line bottlenecks cause work-in-progress to accumulate, adding to inventory carrying costs and putting more product at risk when excursions occur. Variations in incoming wafer quality and process quality cause fluctuations in the efficiency of finished cells. One batch of wafers might have more defects, for example, or one line might produce less consistent contacts. Since cell selling prices depend on efficiency, a wider distribution represents lost revenue. Statistical Process Control (SPC) charts help engineers to examine the process and reduce variability. Factory level charts for uptime, utilization and real-time tool states help factory managers to reduce line bottlenecks and optimize each process step to maximize output. Process parameters and performance data allow engineers to set up controls to minimize excursions due to poor print quality. Small increases in bin yield can make a big difference: if responding to product quality excursions more quickly increases yield by just 0.1%, Schwarm said, a 400 MW output factory would realize an additional 4MW of cell output, worth about $3,120,000.

Cell quality variability, yield loss and process bottlenecks all represent “hidden” capacity—improvements to these areas allow the factory to produce more without additional equipment investments. For this reason, investments in productivity improvement tools pay for themselves many times over. Applied Global Services’ c-Si factory productivity services along with the Applied E3™ Baccini Print Process Monitor App puts process and excursion control, wafer and print quality control, yield analysis, and tool uptime and utilization monitoring tools together in one place, helping to improve efficiency distribution, line yield, and overall output. E3 customers can also consult with Applied Global Services’ factory productivity experts. A fab audit can help identify bottlenecks and material waste, and can suggest the most cost effective process flows.

It’s an exciting time to be a solar cell manufacturer. With the right investments and the right equipment and materials partners, manufacturers can position themselves to be first and take advantage of exciting market opportunities ahead, ready to exploit new technologies and challenges.

Author: Nanochip Staff. For additional information, please contact Suketu_Parikh@amat.com or Alex_Schwarm@amat.com.