The Hype has settled, prices remain stable: Free road for the rehabilitation of the polysilicon industry in China

2014 started with a new solar boom that revived both the upstream and downstream industries along the PV value chain. The Polysilicon price rose to a refreshing 22USD/kg and is currently stabilizing at around 20USD/kg. The reasonable price prompted polysilicon producers around the world to announce new projects and capacity expansions. Alone in the first half of 2014, more than 260.000 tons of new polysilicon projects were announced for ramp-up in the next couple of years.[1]

In China, in H1 of 2013, 41.000 tons of polysilicon were imported.[2] In H1 of 2014, 45.932 tons had to be imported to meet the strong increase in domestic demand for high quality polysilicon.[3] At an import price of 21.78USD/kg, it is clear that importing 50% of its domestic demand is not feasible in a long-term perspective. Leading Solar analysts as well as institutions like EPIA see China as one of the top solar hubs by 2018 with a corresponding flowering polysilicon industry.

In China, the new and more reliable market situation in 2014 prompted a host of activities. To become independent of import prices and reduce costs to stay in tune with the new moderate polysilicon sales margins, polysilicon plants have to be upgraded bottom up. Chinese investors eye building sites in regions like China's Xinjiang Province. There and in Inner Mongolia, electricity prices are the lowest in China. Other plans aim at producing electricity in-house with power generation solutions based on coal or hydropower tacked directly to the polysilicon production site.

The decisive factor to cut costs remains the question of which production technology to choose. In the wake of rising PV demand, the fluidized bed reactor (FBR) based on Monosilane is being discussed lively in the solar media. Of the new projects announced in China, some will include FBR technology, which needs less energy than the Siemens rod reactor process, and produces more silicon per cubic meter of reactor space at lower costs than the Siemens process.[4]

On the other hand, experts see two critical disadvantages of the FBR: can the technology reach the industry's demand for silicon purity nearing electronic grade level (9N+)? A second concern is scalability. [5] Johannes Bernreuter, Bernreuter Research: "Silicon deposition in an FBR is difficult to control (…)"[6] . Experts fear that the handling of the FBR reactor might turn out to be more of a challenge than previously thought. The only FBR reactors currently in operation have been developed and are being handled by two of the most experienced global polysilicon players. Transfer of the technology so far has not succeeded.

It will be difficult for the FBR to establish itself as a new mainstream technology; most probable is that granulate and chunk material will complement each other. Jon-Frederick Campos, IHS Analyst: "Cell manufacturers are requiring higher-quality polysilicon to meet their efficiency road maps, such that the lower material costs and potential for improved margins presented by FBR along with other polysilicon technologies are overshadowed by industry standards having shifted

[1] PV Magazine, July 2014
[2] Ed Cahill, LUX Research, Aug 15th 2013
[3] China imported 9,566 tons of polysilicon in June, the historically highest monthly level with on-month growth of 37.7%, Nuying Huang, Adam Hwang, Digitimes 5 Aug 2014
[4] Fluidized Bed Reactor Technology Stakes Its Claim in Solar Polysilicon Manufacturing, Solar Daily, May 13 2014, www.solardaily.com
[5] Fluidized Bed Reactor Technology Stakes Its Claim in Solar Polysilicon Manufacturing, Solar Daily, May 13 2014, www.solardaily.com
[6] New Polysilicon Technology – Promise or Hype? J. Bernreuter, Bernreuter Research, 27 Feb 2014

toward higher-purity polysilicon, namely 9N and above, because higher-purity polysilicon can boost solar cell efficiencies."[7]

The demand from solar-cell manufacturers will dictate the future for polysilicon.[8] TCS Siemens technology is capable of meeting the current and future PV industry's quality requirements, although at still higher costs of about 14USD/kg polysilicon. For Chinese polysilicon producers, TCS Siemens currently seems not a feasible option for the re-vamp of silicon plants and new projects, both for solar silicon and for niche production like semiconductor grade material due to the large invest costs. The FBR with currently 6-9N[9] doesn't meet all quality standards as required by industry regulations for the PV industry in China regarding new polysilicon facilities.

Producers in China face some sort of dilemma, especially as investors in the country still hold back with financing for new projects. Despite sharply rising wafer demand[10], funds are still not flowing easily into new silicon projects: invest costs of a polysilicon plant are high, and the years of overcapacity from 2011-2013 still linger fresh in everybody's memories. Looking for a way to go is the only option though, considering the rapid rise of China's end-market demand, from below 20% share of global PV demand in Q4'2011 to over 40% in Q4'2014.[11]

An alternative for Chinese producers to keep pace with the rushing market development could be to blend different polysilicon production methods to reach maximum efficiency and best product quality. The Monosilane-Based Rod Reactor Polysilicon Production Technology is a modification to the traditional Siemens process and uses Monosilane as the feedstock instead of Trichlorosilane (TCS) for rod reactor deposition. The main advantage of this process is the higher quality of the final product and a relatively lower power consumption.[12]

This is achieved because of the reactive distillation, which combines the two main reactions of the disproportionation in one single reactor. This disproportionation system consumes significantly less thermal energy per kg Monosilane compared to conventional systems and operates on a low and constant pressure; and because of the high efficiency Siemens type CVD system for Monosilane which operates at significantly lower electricity consumption and produces material from solar grade to Float Zone grade material. With reactive distillation and Monosilane CVD deposition the energy consumption level is about the same as with a 2-step disproportionation and Monosilane FBR deposition.

Between 2011 and 2012, more than 80% of China's 63 polysilicon producers stopped production. Since 2014, some resumed operation, but today still about 75% lack the necessary funds to upgrade and regain competitiveness, or they are undecided about which technology to choose.[13] Partial equipment substitution, step-by-step upgrading and complementing different technologies might be a solution to re-introduce Chinese polysilicon players into the market. The one-step disproportionation as well as the Monosilane-based rod reactor deposition can both be easily and individually integrated into existing TCS Siemens or FBR plants. Especially attractive is the usage of the by-product Dichlorosilane from a TCS Siemens plant. With this combination one can produce high quality Polysilicon from Monosilane, and at the same time achieve a quality improvement of the Siemens TCS process. Upgrading a polysilicon plant with high purity production technology equipment can enhance FBR granulate to solar grade of 9N and above, or facilitate access to niche markets like semiconductor and high power applications.

Thus, technology upgrades facilitate more than just the possibility of re-entering the polysilicon market: they help producers to diversify, which makes polysilicon companies in China and around the globe more resilient for future market fluctuations.

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[7] J.-F. Campos in: Fluidized Bed Reactor Technology Stakes Its Claim in Solar Polysilicon Manufacturing, Solar Daily, May 13 2014, www.solardaily.com
[8] Fluidized Bed Reactor Technology Stakes Its Claim in Solar Polysilicon Manufacturing, Solar Daily, May 13 2014, www.solardaily.com
[9] Fluidized Bed Reactor Technology Stakes Its Claim in Solar Polysilicon Manufacturing, Solar Daily, May 13 2014, www.solardaily.com
[10] Solarbuzz, June 2014
[11] M. Barker, China Dominates Crystalline Silicon Solar PV Chain End-to-End, SolarBuzz, Sept 9 2014
[12] S. Chunduri: The Monosilane Way in: Innovations in Inertia, Photon International, Apr 2013
[13] Nuying Huang, Adam Hwang, Over 70% of China-based polysilicon makers unable to resume production, DIGITIMES, Sept 16 2014