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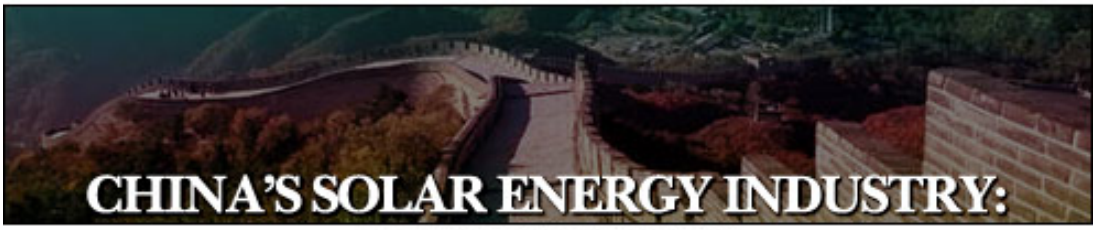

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Humble beginnings: semiconductor waste

China's solar energy industry began in the mid-1980s when Semiconductor companies in Wuhan, Ningbo, Kunming, Xining, Chengdu and other Chinese cities began manufacturing solar cells using a P-N knot diode process with waste raw material from wafer production.

Equipment acquisition: 1985-1990

During the early stages of industry development, China companies began to acquire solar cell manufacturing equipment.

- Ningbo and Kaifeng were the first two professional solar cell manufacturers in China, introducing key equipment into their solar cell manufacturing with government support.
- Next, Qinghuangdao Huamei purchased new solar cell manufacturing equipment and began production.
- Yunnan Semiconductor bought second-hand solar cell manufacturing equipment for its site.
- Last to enter the industry were Haerbin Keluona and Shenzhen Yukang, both of which set up non-silicon-crystal solar cell manufacturing production lines.

By 1990, Chinese companies had established a primary solar cell industry with a total of 4.5 MWp manufacturing capacity.

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Technology advances: 1990-2000

Beginning in 1990, the industry entered a decade of development.

Following the period of equipment import and technology adoption, the industry leaders began to adapt and innovate solar technology. Production of solar cells increased as technology and manufacturing processes developed and improved.

By 2000, the industry could almost fulfill China‘s domestic market demand, although there was very little export.

2000: Rapid growth and development of solar energy supply chain

Beginning in 2000, China’s solar energy industry entered a period of rapid growth:

- Baoding Yingli Solar became the first company to manufacture using single crystal instead of crystal silicon solar cell manufacturing technology. It built a 3MWp polysilicon solar cell manufacturing production line in 2001.
- Wuxi Sun Tech built a 10MWp solar cell manufacturing production line.

Between 2003 and 2006 market demand in Europe (especially Germany) began to grow rapidly. Wuxi Sun Tech and Tianwei Yingli Solar expanded their capacity to meet demand, and more companies began to build solar cell manufacturing production lines.

Solar cell	Crystal-silicon solar cell	Non crystal-silicon solar cell
1673 MWp	1629 MWp	44 MWp

Table 1: China solar cell capacity, year-end 2006
Source: THT Research

With solar cell manufacturing as its starting point, China began to develop a comprehensive solar industry supply chain, which includes polysilicon material, ingot or wafer manufacture, solar cell manufacture, cell module and cell system, etc. In addition, the solar cell industry supply chain brought with it the development of related industries such as materials, equipment, and components for solar cells.

The rest of this whitepaper will focus on China’s efforts to advance its solar energy industry by developing and promoting an independent supply of polysilicon, the raw material for the industry.

Global polysilicon industry overview

In 2006, global polysilicon material production stood at about 36,000 tons, with the top seven manufacturers contributing over 90% of production. Of that, over 18,000 tons of polysilicon were supplied to the solar industry, with the rest supplying the semiconductor industry.

Because of rapid development of the world solar industry, the shortage of polysilicon material is becoming increasingly tight.

- Of a total global solar cell production of 1,818 megawatts in 2005, including about 1,700 megawatts of crystal-silicon cell.
- 1 megawatt of solar cell production requires 11 tons of polysilicon.
- Therefore, global solar cell polysilicon demand is about 18,700 tons. Global

supply of solar grade polysilicon stands at around 11,000 tons and silicon waste from the semiconductor industry is around 4,000 tons, resulting in a shortage of approximately 3,700 tons of polysilicon per year.

As a result of the tight global polysilicon supply, polysilicon prices are rapidly increasing. From 2001 to 2003, the semiconductor polysilicon purchase price was about US$40 per kilogram and the solar grade polysilicon price was about US$25 per kilogram in China.

In 2005, the average contract price of polysilicon was over US$50 per kilogram and the average retail price was over US$100 per kilogram. In 2006, the contract price was about US$100 per kilogram and the retail price was over US$300 per kilogram in China.

Currently, polysilicon manufacturing is dominated by seven global leaders. The output of these companies has long lagged behind solar cell demand for numerous reasons, including technology and market monopolization and time required for production expansion. The polysilicon shortage has become the bottle-neck of the solar industry development.

We do not expect the shortage of polysilicon to be resolved before 2011. The shortage not only limits the development of solar cell production, but increases solar cell manufacturing costs, thus having an overall seriously negative effect on the development of the global solar industry.

China polysilicon industry overview

At the end of 2006, China's polysilicon production capacity was about 500 tons.

Company	Capacity (tons)
Luoyang Zhonggui	300
Sichuan Emei Semiconductor	200

Table 2. China polysilicon capacity (2006)
Source: THT Research

However, production only reached around 230 tons, while demand reached 4,380 tons. As a result, over 95% of China's polysilicon demand was imported in 2006.

	2004	2005	2006
Semiconductor demand	910	1060	1260
Solar industry demand	585	1596	4000
Total demand	**1495**	**2656**	**5260**
Polysilicon production	57.5	80	230
Polysilicon shortage	**1437.5**	**2576**	**5030**

Table 3. China polysilicon production and demand, 2004-2006 (tons)
Source: THT Research
Notes: Solar cell polysilicon demand is calculated as:
2004: 12tons/MW; 2005: 11tons/MW; 2006: 10tons/MW.
2006 crystal-silicon solar cell productions is about 400MW

Development potential of China polysilicon industry

If China is to develop the capacity to fill its polysilicon demand, it will need to overcome several obstacles:

- Poor manufacturing technology. The most efficient polysilicon manufacturing technology is based on Siemens' methods, but China vendors use inferior technology processes, leading to energy consumption of two to three times international standards.
- Small scale manufacturing. The ideal economy of scale for polysilicon manufacturing is 2,500 tons per year and the minimimum economy of scale is 1,000 tons per year. The two China polysilicon production lines each produce less than 300 tons per year, which increases production costs and makes it difficult for the companies to develop any competitive advantage.

The major challenge of China's solar energy and information technology industries is developing polysilicon manufacturing technology. The major international polysilicon manufacturers who monopolize the advanced technology required for polysilicon production have to date not been willing to transfer production technology to China. As a result, China polysilicon manufacturers have been forced to invest in developing their own production technologies.

Nevertheless, several Chinese companies have begun investing in polysilicon production technology and capacity expansion.

As of 1Q07, Luoyang Zhonggui and Emei Semiconductor have begun their planned polysilicion manufacturing capacity expansions.

Sichuan Xinguang Silicon Industry began manufacturing solar and semiconductor polysilicon on February 26, 2007 and now has the largest polysilicon production line in China. As a result, China is on its way to becoming the fourth country to achieve polysilicon manufacturing capacity of over 1,000 tons per year, following Germany, Japan, and the United States.

Other polysilicon production projects are also currently under way in China, including construction projects at Yunnan Qujin, Hubei Yichang, and other companies.

If all of the currently planned projects come to fruition, China's polysilicon manufacturing capacity will reach 12,660 tons in 2011 and China's polysilicon shortage will be resolved.

China Production	Sichuang Xinguang Silicon Indutsry	Emei Semiconductor plant	Luoyang Zhonggui	Total
2004	0	57.5	0	57.5
2005	0	77	3	80
2006	0	130	100	230
2007 (e)	600	200	200	1000
2008 (e)	1100	200	300	1600
2009 (e)	1260	300	300	1860
2010 (e)	1260	600	400	2260
2011 (e)	1260	700	900	2860

Table 4. China polysilicon vendors' production (tons): 2004-2011
Source: THT Research, March 2007

	Ningxia solar (Ningxia Shuizuishan)	Asia Silicon (Qinghai Xining)	Shenzhen NanBo (Hubei Yichang)	Jiangsu Shunda (Jiangsu Yangzhou)	Jiangsu Zhongneng (Jiangsu Xuzhou)	Chaolei Industry (Sichuang Guangyuan)	Aixin Silicon Tech (Yunnan Qujin)	Tongwei and Juxing (Sichuang Leshan)	Total
2004	0	0	0	0	0	0	0	0	0

2005	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0
2008	100	200	300	200	300	300	0	0	1400
2009	700	750	800	500	700	600	500	200	4750
2010	1000	1000	1300	1000	1000	1000	1000	500	7800
2011	1000	1000	1500	1500	1000	1500	1800	500	9800

Table 5. Polysilicon construction plans and planned capacity (2004-2011)
Source: THT Rresearch, March 2007

Conclusions

We expect China's government to continue to support the development and expansion of polysilicon local technology development and production. China's 2005 Renewable Energy Law called for the country to increase its renewable energy consumption to 10 percent of the total by 2020. Without sufficient supply of domestic polysilicon, this goal, as well as solar cell export goals, will be difficult to meet. Going forward it appears clear that polysilicon will remain a good investment in China in the near future.

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