Polysilicon Manufacturing in India: Go or No-Go

POLICY NOTE

Executive Summary

- At present, India consumes ~2% of global polysilicon production. However, given India's ambitious solar targets, it is expected to consume 15-20% of global production by 2022.
- The present spot price of polysilicon is USD 13 per kg. However, this is likely to change in future given rising global demand.
- The study estimates that an indigenous plant of 24,000 Tons Per Annum (TPA) will cost about INR 5,500 crore. It can support about 5 GW of solar Photovoltaic modules. The cost of polysilicon works out to USD 20/kg. The two main components of cost are Interest and depreciation (50%) and energy (20%).
- The cost of indigenous polysilicon (USD 20 per kg) is higher than the prevailing spot price (USD 13/kg) and also cost of manufacturing in US (USD 18/kg).
- However, there is a good case for domestic manufacturing of polysilicon in India given the ambitious solar targets. It will require two main policy incentives to make it competitive with international prices: low interest finance (6%) and cheaper electricity.

Introduction

The Government of India has announced an ambitious solar power target of 100 GW by 2022. In addition, the government has also launched the "Make in India" program to facilitate domestic manufacturing. As of now, India has an installed capacity of 1,386 MW and 2,756 MW for making cells and modules, respectively. However, there is no facility for production of polysilicon, ingots, and wafers; hence they are fully imported. Keeping in mind the ambitious solar programme and the "Make in India" initiative, this note examines two questions:

1. Should India go for polysilicon manufacturing?
2. What policy framework is required to promote such manufacturing?

Background

The present solar installed capacity is about 5.1 GW; most of it is from crystalline silicon (c-Si) modules. As of now, the c-Si technology is most cost-effective and therefore, we have assumed that c-Si will account for 85-90 GW of installed capacity by 2022. The material balance suggests that 5 grams of polysilicon is required per watt of c-Si PV Module. This translates into about 4.5-5 lakh ton of cumulative polysilicon requirement by 2022.

In 2014, the global polysilicon manufacturing capacity was 3 lakh TPA. This industry was dominated by five major manufacturers contributing about 72% of the total market share. At present India consumes ~2% of annual global polysilicon production. However given India's ambitious solar targets, India is expected to consume 15-20% of the global polysilicon production by 2022.

Figure 1 shows the international spot price of polysilicon for the last 15 year period. Prior to 2006-07, a majority of the polysilicon production was consumed by the semiconductor industry. In 2006-07, there was a significant increase in the demand for polysilicon by solar industry. Consequently the price had touched USD 475/kg and many new manufacturing facilities were being established around the world. However, in subsequent years, a slump in the demand due to recession along with overproduction, led to a crash in the spot price to USD 20/kg in 2013. By January 2016, it had reached USD 13/kg.

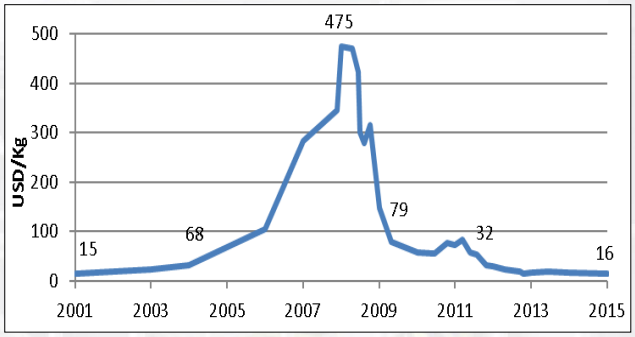

Figure 1: Historical Spot Price of Polysilicon (USD/kg)

Manufacturing in India

There are three main processes to manufacture Polysilicon - Siemens, Fluidised Bed Reactor (FBR), and Upgraded Metallurgical Grade (UMG). The Siemens process produces the highest quality of polysilicon (9N-11N) that can be used in both, the semiconductor and solar industries. FBR produces a moderate (6N-9N) level of purity that can be used in solar but not in semiconductor sector. As of now, Siemens accounts for 90% of the global polysilicon manufacturing. Table 1 provides a comparison between Siemens and FBR (Bye & Ceccaroli, 2014).

Table 1: Comparison of Siemens and FBR Polysilicon Manufacturing Processes

Characteristics	Siemens	FBR
Purity of polysilicon	9N–11N	6N-9N
Energy Intensity (kWh/kg)	60–80	~55
Operation	Batch	Continuous
Cycle time (of one batch)	60 – 150 hours	60 – 120 days
Capital Cost (USD/kg)	~45–74	~75–100
Operating Cost (USD/kg)	12–20	7–11.5
Commercial application	>30 years	~30 years
Scalability	Scalable	Issues
Global production (MT/year)	275,000–300,000	~25,000

Based on the expert opinions, the optimal size of the Siemens type plant is currently 24,000 TPA. For smaller manufacturing facilities the capital cost per unit of output will be higher. In our analysis, we assume that India establishes a 24,000 TPA polysilicon manufacturing facility based on the Siemens technology. This translates to about 5 GW of c-Si PV modules. Table 2 provide the assumptions used in the cost model (Michael Woodhouse, 2015).

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Table 2: Key Assumptions used to Estimate Polysilicon Manufacturing

Manufacturing Capacity	24,000 TPA
Technology	Siemens Trichlorosilane
Raw Material Costs	167 INR/kg
O&M Costs	1.5% of Capital Cost
Energy Costs	5.5 INR/kWh
Interest rate	12.5%
Return on equity	20%
Debt to equity	80:20
Life of plant	30 year
Capacity Utilisation	75%
Capital Cost	India- 38 USD/kg USA- 46 USD/kg

Results

Based on these assumptions we estimate that a 24,000 TPA facility will cost around USD 900 million (~INR 5,500 crore). This facility will produce Polysilicon at USD 20/kg. Figure 2 shows the cost break up. Interest and depreciation account for about 50% of the cost. Energy accounts for 20% of the cost. As we can see, the Indian cost at USD 20/kg is higher than the corresponding cost in US (USD 18/kg). The main difference is in the cost of interest and energy. Indian cost is also higher than the international spot price of Polysilicon which is USD 13/Kg.

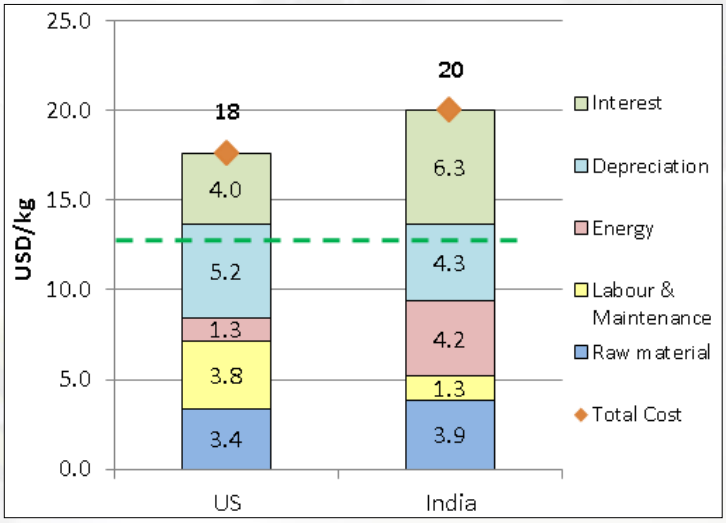

Figure 2: Cost Break-up of Polysilicon Manufacturing

We now examine two scenarios to illustrate the impact of energy costs and interest rates on production of polysilicon in India.

1. Energy costs: We assume two cases;
   - A dedicated coal power plant is established in the vicinity of polysilicon plant and the cost of electricity is around INR 3.5/kWh.
   - Government provides subsidised electricity equivalent to the cost of dedicated hydropower plant (INR 0.75/kWh)
2. Interest rates: We examine cheaper finance options available at interest rates of 10% and 6%.

Figure 3 shows that the polysilicon cost decreases from base case of USD 20/kg (grid power) to USD 18/kg (dedicated coal power plant) and USD 16/kg (subsidised hydropower).

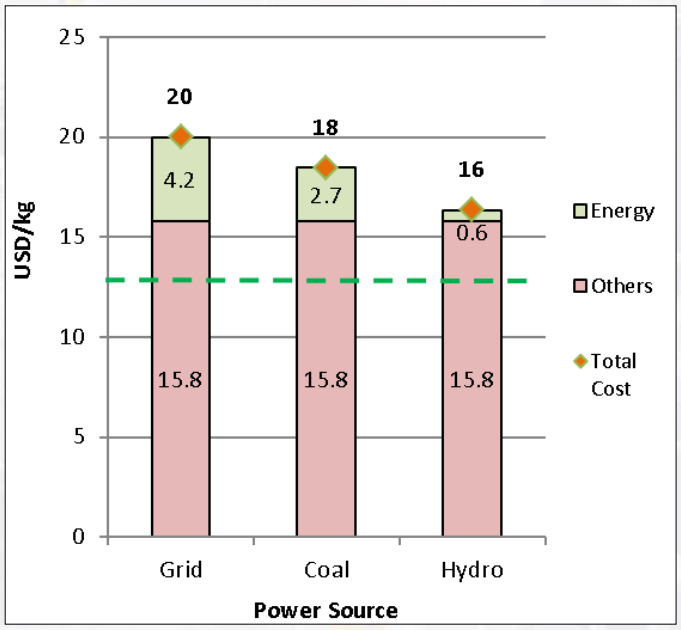

Figure 3: Effect of Energy Costs on Polysilicon Manufacturing Costs in India

Figure 4 depicts that polysilicon production cost decreases from a base case of USD 20/kg to USD 19/Kg and USD 18/Kg with an interest rate of 12.5%, 10% and 6% respectively. Finally, a combination of low interest rate (6%) and cheaper electricity (INR 0.75/kWh) can make polysilicon production cost in India competitive with the current global spot price of USD 13/kg.

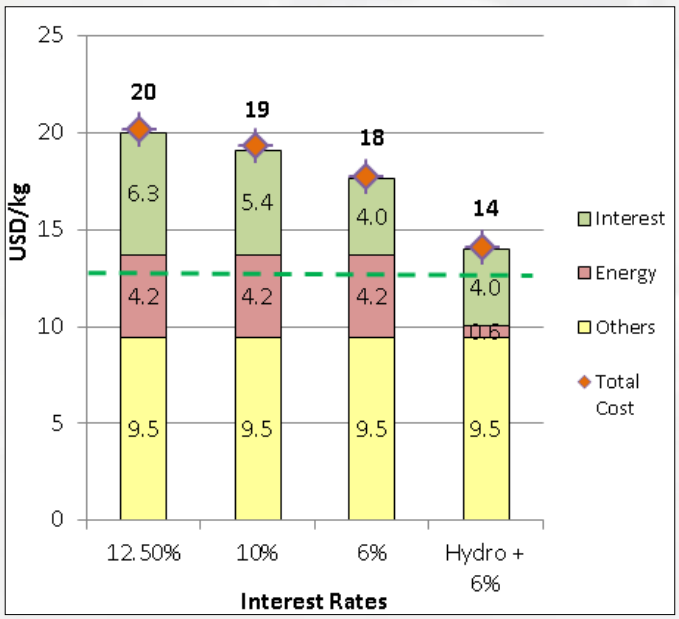

Figure 4: Effect of Interest Rates on Polysilicon Manufacturing Costs in India

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Should India go for indigenous manufacturing of polysilicon? One line of thinking is that India should not venture into polysilicon manufacturing and continue to import it as the global production is sufficient to cater the demand in India. However, based on the following points we believe that there exists a case for domestic manufacturing of polysilicon in India:

- The present consumption of India is only ~2% of the global polysilicon production. However, given the ambitious 100 GW solar target, it is expected to consume around 15-20% of the annual global polysilicon sales. Moreover, after achieving the 100 GW in 2022, India will raise its solar targets further. Therefore, there is a possibility of supply vulnerability in future, considering the consumption by other countries might also increase.

- Studies indicate that growing global demand could lead to an increase in international spot prices and a possibility of USD 20/kg by 2017 end is not ruled out.

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Recommendations

Based on the points mentioned above, we recommend that India should establish some indigenous polysilicon manufacturing capability. A 24,000 TPA plant can potentially support 5 GW of solar panel and this could be a good starting point. Since, the capital cost is high (INR 5,500 crore), private investors could form a consortium and venture into domestic manufacturing.

The interest rate and cost of electricity are the two factors which significantly affect the viability of the project hence these need special attention.

1. Government should facilitate low cost financing to promote such facility in the country. Government should provide low-cost finance using special financial packages such as green bonds and assistance in getting cheaper dollar linked loans

2. Government could also provide a dedicated power plant facility to supply reliable and low-tariff power similar to China

3. The total vertical integration of indigenised PV module manufacturing could further reduce solar prices. Very few polysilicon producers are integrated downstream into ingot and wafers, cells, or modules. The 'Skill India' platform can aid in training the workforce required to set up and operate the plant.

Authors: Bhupesh Verma, Ganeshprasad P. and Dr. Sharath Rao
CSTEP, Bangalore

For more information contact cpe@cstep.in