

## ABSTRACT

In the perpetual struggle to reduce the costs associated with PV energy generation, one aspect of the manufacturing process has potential to shine. To date, the PV sector is dominated by crystalline silicon wafers (90%), which largely use silver as the conducting medium for the front side grid, and to a lesser extent the backside contact. The conducting media are crucial to the overall efficiency of the cell by providing the means for current to flow when sunlight strikes the doped silicon wafer. This paper presents silver as a vital factor in the PV process, and discusses the future industry requirements as well as a projection for the overall silver market for the next eight years.

As the PV efficiency measure is probably the most important consideration when purchasing a solar system, it is difficult to see a substitution for silver since its superior conductivity and ease of use betters that of all other potential materials that are currently available.

New regulations, technological innovation and a paradigm shift in consumer behaviour will likely propel the renewable energy sector to record levels of growth over the coming years. As a direct consequence, growth in the photovoltaic sector is tipped to increase rapidly and with it a marked rise in the demand for silver metal.

The application of silver metal onto the silicon wafer typically comes in the form of a paste, which is screen-printed on the front surface in a grid-like pattern consisting of fine fingers and thicker busbars. In addition, but to a lesser extent, silver is also screen-printed as a paste on the backside contact, which generally covers the entire underside of the silicon wafer. For the paste to aid current flow, it is fired at several hundred degrees Celsius to form metal electrodes in ohmic contact with the silicon. After the metal contacts are made, the solar cells are interconnected in series (and/or parallel) by flat wires or metal ribbons, and assembled into modules.

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One consideration to silver's dominance in the PV cell industry is the rapidly growing thin-film PV market, which uses little of the metal in its makeup. Thin-film technology currently holds a 10% share in the total PV market, and despite significantly lower efficiencies than crystalline silicon-type cells, its lower cost of production should see it expand its market share to 25% by 2012.

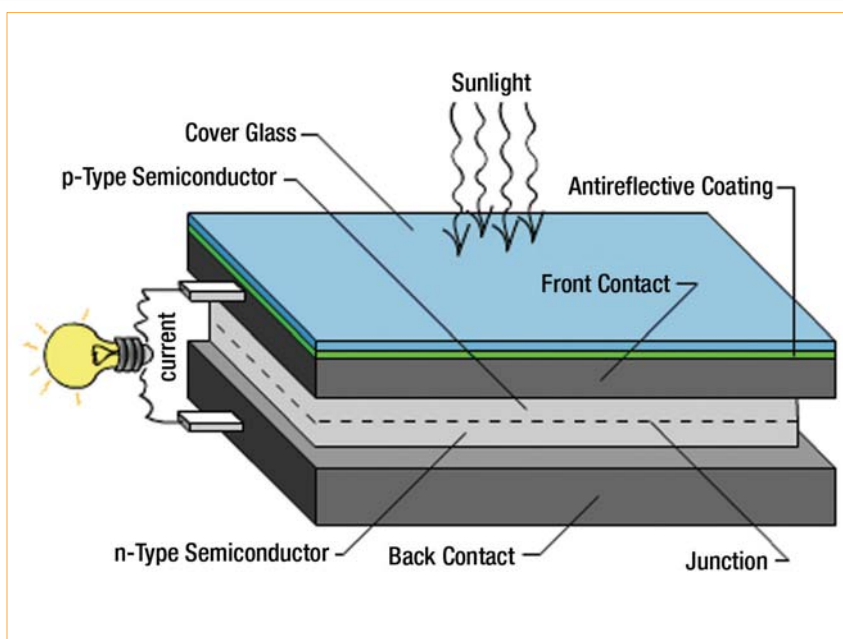


Figure 1. Schematic showing typical crystalline silicon solar cell composition.

Year	Silver consumed (metric tonnes)	Total PV Cell production (GW)
1999	43	0.4
2000	58	0.5
2001	78	0.7
2002	105	0.9
2003	140	1.2
2004	187	1.6
2005	250	2.2
2006	327	3.0
2007	432	4.0
2008	516	5.2
2009	647	6.8
2010	811	8.8
2011	1016	11.4
2012	1270	14.9
2013	1651	19.3
2014	1997	23.4
2015	2417	28.3
2016	2924	34.2

Table 1. Silver consumption report and forecast vs. PV cell production to 2016.

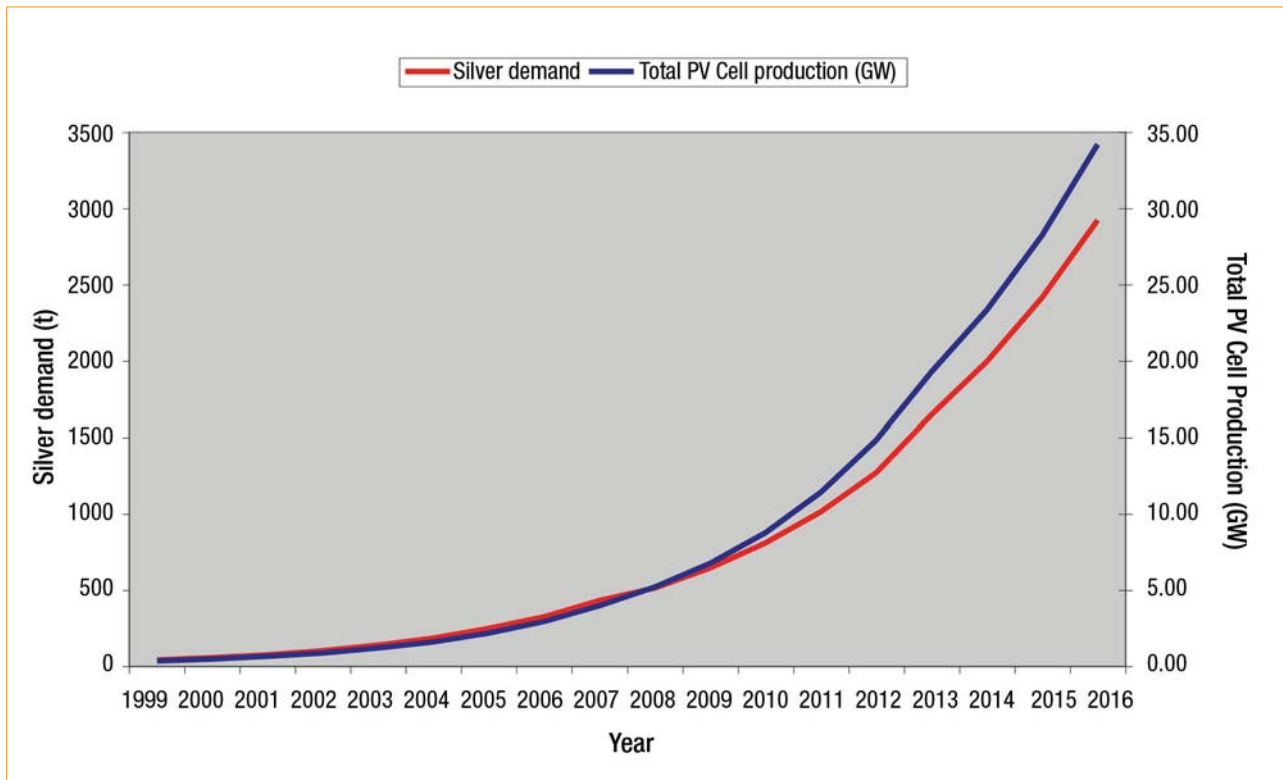


Figure 2. Global silver demand forecast.

So how does this affect the silver market? Assuming maximum silver loadings of 0.12g/W, 4GW production (2007), and taking into account a 10% market share of non-silver containing thin-film PV units, only 432t of silver metals was required in 2007. This equates to 13.9M/oz at a total value of US\$170m, using the average Comex settlement price of US\$13.38/oz in 2007. But by 2012, some 1,270t of silver could be consumed – a threefold increase compared with 2007. This assumes that the PV market grows at a compound annual growth rate of 30% to 2012, a 5% annual decrease in silver loading per watt as efficiencies improve and a ramp-up in market share of thin-film technology to 25%.

A conservative industry outlook for PV sector growth predicts 13GW of PV cell production in 2012, which brings the estimate for that year down to 1,111t, but the most aggressive forecast is 52GW, which would imply 4,446t of silver. Like any high and low forecast, the truth will probably lie somewhere in between; nevertheless, the PV industry is going to represent a robust and growing item in the future silver supply/demand balance.

So does the supply of silver represent a potential bottleneck to future crystalline silicon PV cell growth? In 2007, the PV market consumed just 432t of silver out of a total global silver supply of 34,450t. By 2012, the PV market will still only

consume a small fraction of total supply; however, by 2016, almost 3,000t of silver may be consumed (see Figure 2). This could put pressure on the crystalline silicon PV sector depending on the then levels of mine supply and total recycling, and hence silver price. In addition, there should be little relief from the direct supply of secondary silver from the recycling of PV systems due to the relative youth of the industry, long life of the PV units (typically 20-25 years), and the huge cost and logistical effort needed for the collection of these panels.

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Therefore, as things stand, the PV market looks likely to be dominated for many years by crystalline silicon cell technology, and despite improved efficiencies and increased thrifting, silver consumption could potentially increase seven-fold by 2016. This implies a cost of almost US\$1bn using an average price of US\$10/oz in 2016. The question is whether the industry will be large enough to be able to absorb this cost.

**About the Author**

**Carl Firman** joined VM Group as a Metals Analyst in 2008. He holds a degree in geology from the University of London and has worked as a petroleum geologist and later as a geotechnical engineer in the Far East. He also has experience in the Information Technology sector having spent several years at IBM during the dotcom boom era. Carl joined *Mining Journal* in 2002 and later became editor for the Production and Markets section of the weekly newspaper. In 2007, he launched the highly successful mining and energy focused *Global Capital* magazine at Pro Publications.

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