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How low can they go? The drivers and uncertainties of future cSi PV module cost

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The cost of Si PV had decreased remarkably quickly in the past 20 years, and projections using the learning curve suggest that the rate of decrease will continue into the future. However the learning curve is an abstraction that incorporates many factors that influence manufacturing cost, such as economies of scale, performance (cell efficiency) improvement, improved material utilisation, changes in materials to achieve lower cost or improved performance, changing labour intensity/automation, labour costs and electricity costs. Typically the learning curve is also calculated based on selling prices, which adds a further layer of market forces on top of the underlying cost factors.

In this work, we use the historical cost evolution of key factors in cSi PV manufacturing to quantifiably model future evolution of these in the next 5 years. For historical data, we reference two detailed bottom-up cost reports. The first (Powell, 2013) assesses the cost of producing multi-crystalline Al-BSF cell and modules in the US. The second (Woodhouse, 2019) uses a similar cost model, but focuses on mono-crystalline PERC cell and module manufacturing in China.

For the future modelling, we employ a Monte Carlo analysis approach (Chang, 2018). This method allows us to predict the likely future cost of module manufacture, identify the key drivers expected to influence the future cost of silicon PV, and also assess the impact of uncertainties in key cost factors such as labour, market growth, Ag price, raw material availability and electricity price. In many cases these costs are very much outside the influence of the PV industry.

This work is currently underway, so the detail of the inputs and results are not finalised. The following discussion is based on preliminary results and is subject to change by the time of the conference.

As an input analysis example, silver (Ag) used per cell was almost halved from 230 mg/cell in 2013 to 130mg/cell in 2019. At the same time cell/module performance increased leading to a dramatic decrease in module manufacturing cost. However, it is difficult to predict if similar drastic reductions in Ag use will eventuate in the next 5 years, it may even be that there are no further reductions as practical limits are reached. In our model, we estimate a further 15% reduction in silver per cell but also include scenarios where silver per cell is again halved (eg a large technology change is realized), as well as scenarios where no further Ag reduction is realized.

Our initial results suggest that prices will continue to decrease as much as 35% in the next 5 years for many different scenarios. Figure 1 shows the relationship between four of the most significant uncertainties on the future cost; each data point is an iteration of the Monte Carlo analysis. The key variables shown here are the future industry scale compared to today, the average annual cell efficiency increase, the average annual electricity cost increase, and the future labour cost as a ratio to current labour cost.

These results illustrate that while the costs will decrease, there is significant amount of uncertainty in future costs with respect to these key factors. There are many scenarios where the future cost may decrease only as much as 10%-15%; such as when the industry grows more slowly.

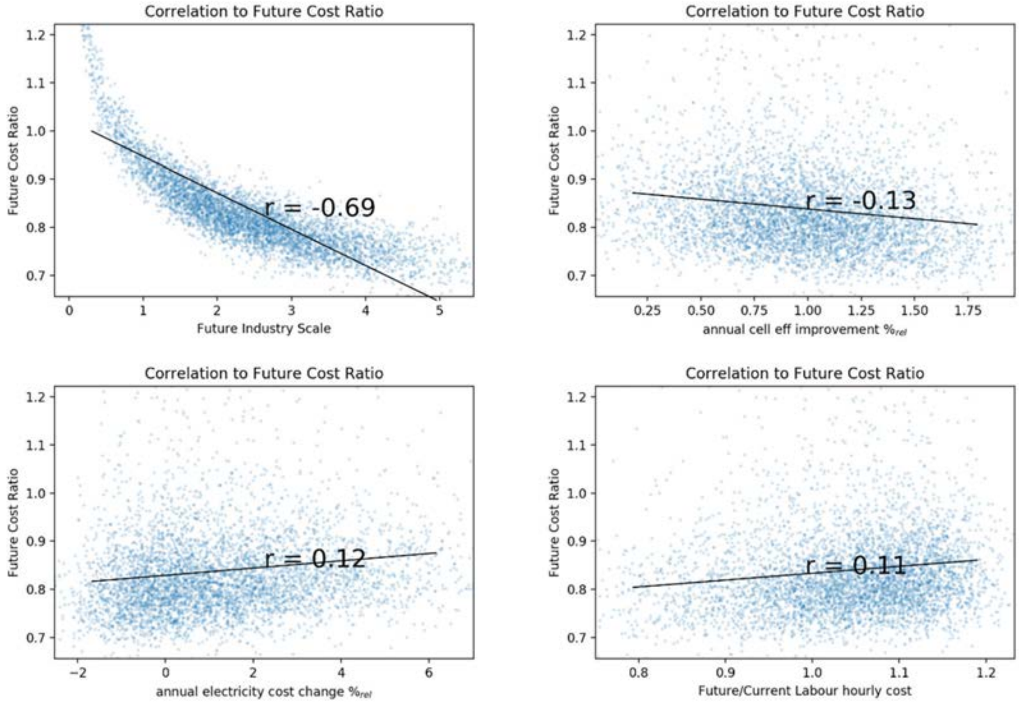

Figure 1. The impact of key parameters on the future cost of PV (preliminary results). The linear regression and correlation co-eff r value is shown

Assuming the industry continues to grow quickly, uncertainty in cell efficiency improvements (often expected as a key driver in lower cost), have a similar influence as uncertainty in both electricity and labour costs. As the PV cell and module industry grows, the location of new factories may be a key factor – future low costs may be linked to the colocation of low cost electricity and low cost labour for industry expansion.

We will also discuss other key factors including: (i) the expected reductions in silver per cell from technology developments and the cost of silver which is highly volatile and may be driven higher by increasing demand from the growing PV Industry; and (ii) the ongoing reduction in polysilicon required per wafer, driven by decreasing wafer thicknesses.

References

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