August 2019

Abstract Study
"Competitiveness of a European PV Production Chain"

Today, solar power is one of the cheapest ways of providing energy internationally, especially due to the excellent research and development work in Europe. By the end of 2018, more than 500 GW of solar capacity had been installed worldwide, 120 GW in Europe and 46 GW in Germany. Power generation costs in many highly sunny regions around the world were in the range of 2 cents per kilowatt hour (kWh). In less sunshiny Germany the costs were located below 5 cents per kWh. Prices for modules have fallen by half in the past three years and the usage of solar power is steadily increasing. In Europe alone, 11.5 GW of capacity was added in 2018. Experts predict an increase of another 24 GW of installed capacity for the EU in 2020. Considering the need for sector coupling, an annual increase of more than 100 GW is expected in Europe between 2025 and 2030, which is a significant market size. The increased use of solar energy in Europe and Germany is essential if the climate goals of the Paris agreement are to be achieved.

While equipment manufacturers from Germany and Europe still supply machinery and equipment to produce highly efficient solar cells and modules around the globe, the production of cells has almost completely migrated to Asia. The VDMA commissioned a study by the Fraunhofer ISE to evaluate whether the production of solar modules at competitive costs could be realized in Europe again.

The study compares the manufacturing costs of a complete PV value-added chain (ingot-to-module production) located in Europe with production in China based on a 1 GWp vertically integrated model factory. It is demonstrated that a module produced in Europe for the European market can be produced at competitive costs if

- the necessary transport costs for finished modules or materials from China to Europe are considered.
- European production has the necessary economies of scale, i.e. a factory size in the range of more than 5 GWp production capacity per year.

Ideally, due to the high market potential within the EU and the establishment of several production sites at GW level, the materials supply chain to produce ingots, wafers, cells and modules could return to Europe and essential materials could be sourced locally at competitive prices.
Short overview of the results of the study

Different production scenarios were considered for the cost comparison. The technology selection is based on the latest edition of the annual ITRPV 2018 published by the VDMA (German Engineering Federation). This enables to keep up with current technology and market trends.

The benchmark is a Chinese 1 GW PERC production. Otherwise there is a European factory with individual economic regional advantages, such as low electricity costs from hydropower in Scandinavia for particularly power-intensive value-added processes. In addition, different boundary conditions within Europe are also considered, for example the comparison to the location Germany and the location Poland, as an example for the influence of the different wage levels within Europe.

The figures show the investment required to set up such a 1 GW greenfield PV production facility in Europe (here Germany) compared to China. The European factory is calculated as a fully automated production facility, which leads to a lower manpower requirement.

The all-in module cost comparison for the different scenarios of a PV value chain of 1 GWp leads to a difference between a European production (EU,pl - Poland) and a production in China of 1 €ct/Wp. The distribution of the value chain as well as the ancillary costs (SG&A, capital costs) are shown in the following figure.
In the hypothetical scenario "EU Recovery" it was assumed that due to a European volume production a supply chain would again be established in Europe, which would produce materials at similar costs as in Asia. Overseas transport costs can thus be avoided as far as possible. This can result in an overall reduction of the all-in costs for the manufacture of PV modules in Europe of up to 3 €ct/Wp.

The effects of a recovered EU supply chain on manufacturing costs are shown by the example of glass prices. Based on the current glass price of 3.58 €/m² from a Chinese supplier as a benchmark, this material component alone leads to a cost reduction of almost 0.5 €ct/Wp in the module.

The still strong research landscape and the innovative strength of the companies, especially in the equipment industry in Europe, create good conditions for the rapid transfer of new technologies and techniques into industrial mass production. Since 2007, when Europe was still the market leader in PV production, efficiency has increased by 40%, productivity by 400% and global production capacity by a factor of 40.

Smart, fully automated production concepts will help to implement necessary optimizations of production processes faster and thus to realize up-time, yield and finally quality in the form of higher efficiencies and improved module performance in production.

A 0.5% improvement in the average cell efficiency results in a cost reduction of 0.6 €ct/Wp for an all-in module.

Economies of scale arise with increasing production capacity and are reflected in lower unit costs. The economies of scale to be considered in this study were investigated in the following three steps:

1) Optimal capacity adjustment of process steps, reduction of standby times, increase of plant utilization and decrease of volume-specific equipment numbers,

2) Lower prices for consumables, which account for the biggest part of operating costs,

3) Lower administrative, sales, marketing and R&D costs while increasing production capacity.
These combined effects show that German production with full supply chain coverage from Europe compared to Chinese competitors can produce modules at similar costs if production capacity is between 5 and 10 GW. Such a scenario presupposes that the essential consumables are available on the European market in large quantities at competitive prices. The all-in costs determined in this study already include the (low) margins on equity capital gains of 10% and debt capital of 5%, the calculated all-in costs can therefore also be regarded as a calculated "price" for the respective product.

Overall, the results show that scaling production capacity brings considerable competitive advantages.