Information paper

Background on low prices for solar modules

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Executive Summary: Background on low prices for solar modules

Introduction

Photovoltaics is a central and indispensable cornerstone of the EU's supply of green electricity. Without solar energy, neither the supply of cheap electricity nor the climate targets can be achieved. Solar energy has experienced an unparalleled global boom in recent years, driven by innovations, efficiency improvements and strong competition. In the EU in particular, the rapid development of the solar economy has created hundreds of thousands of jobs and has become the decisive instrument for decarbonizing the energy supply. The European and therefore also the German solar economy are integrated into global supply chains. Following political decisions to the detriment of the production of solar components, the German solar economy has developed its strength in the profitable marketing of solar systems, where it occupies a leading position worldwide with high added value. Raw materials, preliminary products and components, especially modules, which are used to build solar systems in Germany, are largely imported from third countries in the EU following the loss of European solar production, because they are much cheaper or even available there. The situation is somewhat different for inverters, where a German company has also shown itself to be resistant to the political decisions of the last decade. The German and European solar economy, and especially the companies in the downstream sector, which dominates the European solar economy, are clearly committed to diversifying their sources of supply. Trade restrictions or even tariffs on these products, on the other hand, would cause the greatest possible damage, the first victims of which would be the few solar component manufacturers themselves, as they are dependent on upstream products from EU third countries. As the customs measures of 2013 to 2017 have shown, even the announcement of the review of such measures would slow down the market considerably and the imposition would have a massive impact on supply chains and significantly damage the expansion of photovoltaics. Downstream value creation and jobs in Germany and Europe would be jeopardized and the expansion targets would no longer be achievable, with significant consequences for electricity prices and climate targets.

For some months now, there has been an intense debate about the extent to which manufacturers from EU third countries are offering and selling solar modules below the manufacturing price in Europe. These accusations of dumping are serious and have in the past led to protectionist measures that have almost completely halted the expansion of solar energy in Germany and Europe.

This paper analyzes the competitive conditions and pricing in the global solar market. It shows that the latest price developments are not due to unfair practices such as dumping, but rather to normal market mechanisms and technological progress.

Summary

1. The average cost reductions continue to follow the familiar learning curve: there has been a significant reduction in prices for solar modules, which lies within the learning curve that has been observed for many years. This is mainly due to the increased economies of scale, technological improvements and further strengthening of the supplier ecosystem.

2. A longer-term view does not show dumping. In order to prove dumping, it is not sufficient to consider a snapshot of the market. Rather, prices must be averaged over a longer period of time. The price decline this year corresponds approximately to the significant price increases of recent years in the context of supply chain problems. It is only by looking at the overall picture that it is possible to see whether manufacturing costs have been undercut. Individual periods of a few months or the use of individual offers do not provide any reliable data.

3. **Stocks reflect sales expectations:** an expansion of 115 GWp was forecasted for the EU market in 2023 (+144% compared to 2022). Order volumes increased dramatically in line with the expected market development, in some cases even exacerbated by experiences with disrupted supply chains in previous years. Due to high inflation and increased interest rates, the market is continuing to grow, but probably only half as much as forecasted (approx. 80 GWp). Due to the reduced forecast, there are currently too many modules in circulation. Importers and wholesalers are reacting accordingly (e.g. through reduced order quantities, sales and discount campaigns).

4. **A change in cell technologies is currently taking place:** Technologies such as PERC ("Passivated Emitter and Rear Cell"), TOPCon ("Tunnel Oxide Passivated Contact") and HJT ("Heterojunction") have contributed significantly to cost reductions. New technologies, in particular TOPCon and HJT, are currently gaining acceptance. This is currently leading to cost reductions in manufacturing costs and electricity generation costs and additional negative sales effects for predecessor technologies.

The current market conditions in the solar sector are the result of market mechanisms and technological advances- not unfair trade practices. Recognizing this is an essential foundation for building resilient solar component production across the value chain. Only a dual strategy that focuses on both the expansion of solar energy and the creation of a resilient solar industry can secure the expansion targets and thus favorable electricity prices and climate targets. It would be disastrous if the mistakes of the last decade were to be repeated now through new tariffs with foreseeably devastating consequences.

We trust that this analysis and our recommendations will help to objectify the discussions and promote forward-looking decisions in the interests of a sustainable and competitive solar economy.

We welcome the fact that COP28 came to the same conclusions in its final declaration.

> 30. *Welcomes* that over the past decade mitigation technologies have become increasingly available, and that the unit costs of several low-emission technologies have fallen continuously, notably wind power and solar power and storage, thanks to technological advancements, economies of scale, increased efficiency and streamlined manufacturing processes, while recognizing the need to increase the affordability and accessibility of such technologies;

Cost-effective photovoltaics will be one of the main pillars for the EU to achieve its climate targets. The same applies to achieving the 42.5% expansion targets for renewable energies set by the EU for the member states by 2030.

Background on the cost reduction for solar modules

Introduction

The rapidly growing mass production of solar cells and solar modules, together with technological advances, has led to a steady decline in production costs. The learning curve has been particularly steep in recent years, which has been overshadowed in the meantime by supply chain bottlenecks in the context of the coronavirus crisis.
The strong cost reductions were passed on to customers due to the highly competitive pressure, which has led to a significant increase in installation rates. On this basis, a solar economy with over 600,000 jobs has emerged in Europe in recent years and has helped shape the energy and climate policy goals of the EU and its member states.

The European solar economy is struggling with a sharp fall in market prices for solar modules, while at the same time benefiting massively from falling costs for raw materials and components such as solar cells.

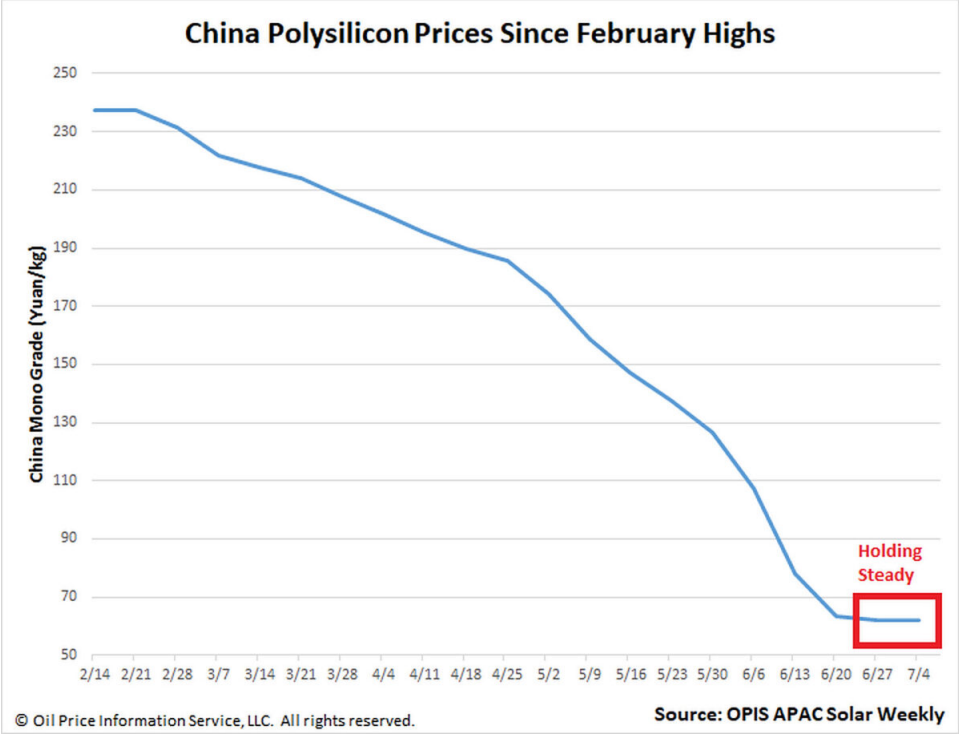


Fig. 1: The graph shows the sharp fall in the price of polysilicon in China from February to July; source: PV-Magazine

This is a development that puts small producers in a difficult situation, as they generate less turnover for the same volume and are less able to allocate their fixed costs without growth. This development without growth harbors the risk that production capacities will be permanently lost and that the goal of building a resilient European solar economy will at least be delayed.

While there are many reasons for the market development, the debate is currently being distorted by a monocausal argument: Chinese manufacturers are selling their modules below production costs and thus deliberately flooding the European market. At times, it is claimed that this is happening to hinder the reconstruction of European solar production. This argument has been artificially strengthened by controversial estimates from a market analyst on current stocks of photovoltaics (PV) modules. However,

anyone who takes a differentiated look at market developments will quickly realize that such an argument is unfounded and is not suitable as a basis for deciding on appropriate measures.

With this paper, we want to show the background to production cost reductions. We also want to examine the validity of dumping allegations, which can quickly lead to false conclusions.

The costs of photovoltaics have fallen significantly in recent years. Mass production and technological advances are driving the solar industry forward. Chinese companies have taken over market and cost leadership at most levels of the manufacturing value chain. Apart from polysilicon production, European manufacturers are orders of magnitude smaller than the large Chinese manufacturers in the module production chain. The latter produce at high scale on state-of-the-art machines and now even have a head start in terms of cell and module efficiencies.

The cost differences to European manufacturers are so great that there is virtually no incentive to generate competitive advantages through dumping measures. European cell production can currently only cover 1 to 2% of the European market. In turn, European module production largely sources its cells from China. From a Chinese perspective, European module producers are therefore primarily customers. However, European module producers are disadvantaged by tariffs on Chinese solar glass and other components, as these additional costs are included in their production costs.

Photovoltaics costs- learning curve as the basis for the sharp cost reductions

In the solar industry, the cost reduction in the past was 20% for every doubling of production volume. From 1976, when the watt peak still cost 100 US dollars, to the present day, the price learning curve has remained largely constant. Since 2006, the learning curve has become even steeper and in recent years in particular, economies of scale and technological advances such as TOPCon, HJT, bifaciality and half-cells have caused production costs to fall sharply. According to the pvXchange price index, prices for mainstream modules were EUR 0.21 per watt peak. This year, the cumulative installed capacity amounted to 1,500 gigawatts.

The following is the learning curve from the presentation of the VDMA's ITRPV Report 2023 (diagram, slide 5).

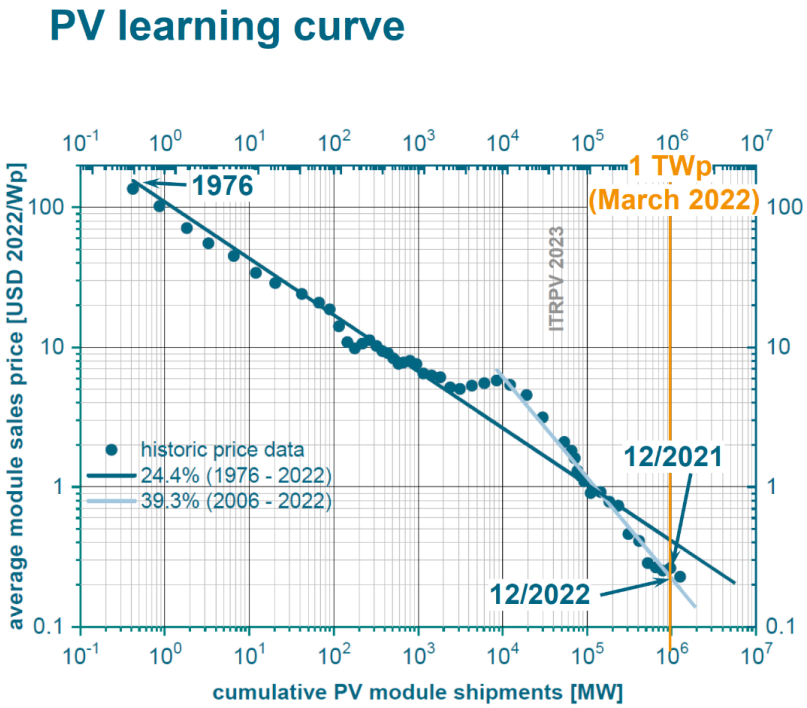


Fig.2: PV learning curve. This shows that the cost reduction for solar has been proportional to volume for decades. Accelerated in the last 10 years by technological advances. Source: ITRPV 2023 (https://www.vdma.org/international-technology-roadmap-photovoltaic).

It is also easy to see that module prices stagnated in 2021. This was attributed to supply chain disruptions resulting from the coronavirus crisis, exacerbated by heightened demand due to the war in Ukraine and increased energy costs. This crisis continued in China until 2022. The latest module price reductions are catching up with and continuing the cost reduction curve. The sharp fall in module prices in 2023 is therefore reflected in the learning curve.

Strong growth in the EU market and claims regarding inventories

All stock figures are highly speculative. There is no reliable data basis for determining EU stocks of modules even as a reasonable approximation. All performance data presented to date on Chinese module exports is incorrect, as the official Chinese export data does not contain any information on exported output in gigawatts. EMBER's interpretation of the Chinese export data contains such large error bars that it is unsuitable as an input variable.

Furthermore, there are currently no official figures on the development of the EU market in 2023, i.e. the module outflow from the warehouses; the assumptions made in this regard, including those made here, are based on rough estimates.

As neither the data basis for the module inflow nor for the off-take in 2023 is known, the stock levels cannot be recorded either. As there are no reliable figures on stock levels, no conclusions can be drawn from this.

Recommendations:

- In the short term, the Commission should establish a valid database on real stocks and EU markets in 2023 in the EU
- In general, the database for imports, but also the EU solar markets, must be improved quickly and continuously in the EU (as also called for by analysts EUPD, Heynen in publications on the topic)

The EU market for new photovoltaic installations will grow very rapidly in 2023. Growth of over 70% is expected, from 46 GWp in 2022 to around 80 GWp in 2023.[1] The real figures may also deviate significantly from this. Due to the growth forecast, exports have risen accordingly- but have slowed since July, as the market has grown less rapidly than originally forecast.

Controversial assessments of stock levels by the consulting firm Rystad Energy have led to accusations of dumping by Chinese manufacturers. However, Rystad Energy has since had to correct its estimates several times.[2]

[1] The expectation for the EU PV market in 2023 of around 80 GW is based on the mean value between the 54-60 GW of the market forecast of the SPE Global Market Outlook 2023-2027, as well as analyst figures from pv-infolink and Bloomberg New Energy Finance (BNEF), for example (115 GW, 110 GW). A market analysis by Rystad (58 GW) would correspond to a low expansion of only 12 GW compared to 2022, which does not correspond to the real visible expansion figures in the EU countries and is not taken into account. Because some players/importers have oriented themselves to the high market expectations in the rapidly growing market, but the actual growth will be lower, more was imported to Europe than can be installed in the short term.

[2] Alleged module glut in the EU- a rebuttal to the figures from Rystad Energy- pv magazine Deutschland (pv-magazine.de)

The size of the current stock levels must be clarified independently of dumping allegations. Large delivery quantities can be explained by high sales expectations. At the beginning of the year, the analyst InfoLink (a renowned analyst in the industry) predicted a European PV market of 115 GWp[3] in its "Solar market overview for 2023".

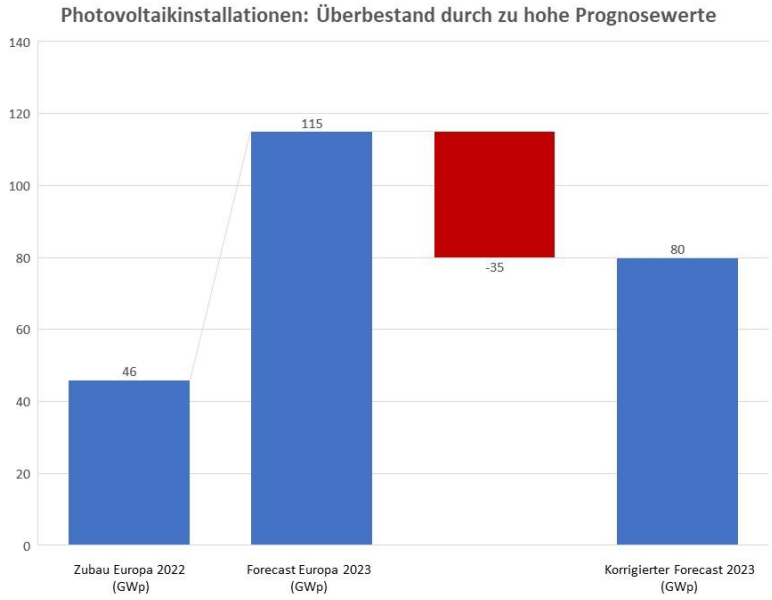
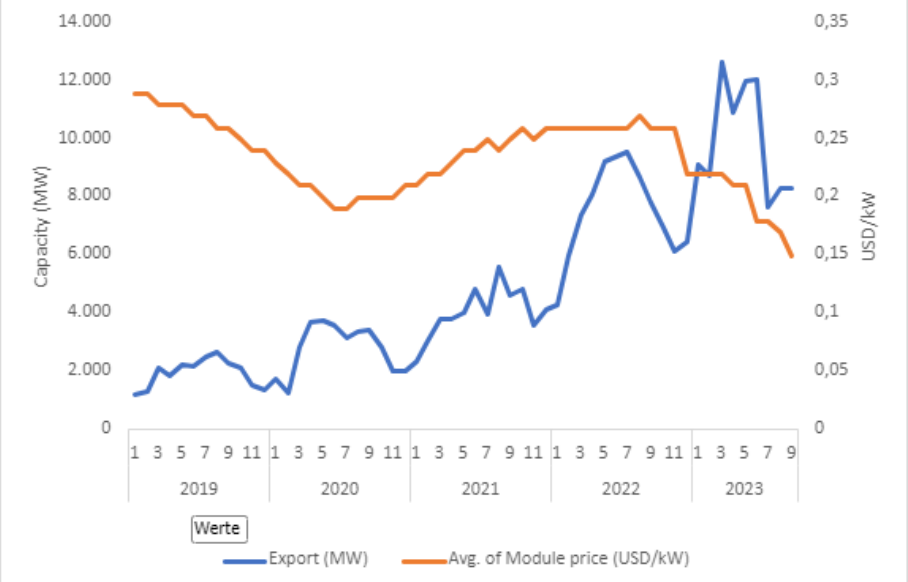


Fig. 3: Solar market development 2023 in Europe shows strong increase compared to 2022. However, the forecast at the end of 2022 was too high, which now has to be corrected and has led to high overstocks in the supply chain (source 1: PV InfoLink (forecast for European PV market in 2023 of 115 GW), source 2: 80 GW correspond to the average of realistic market expectations of various analyst sources, see footnote 1).

With the experience of massive supply bottlenecks and long delivery times in 2022 (COVID-19, container bottlenecks, shutdowns) and the market forecast, many installers and wholesalers have placed very high and sometimes oversubscribed order quantities with their suppliers to ensure their ability to deliver.
It would therefore come as no surprise if increased volumes had been delivered due to the rise in orders. Since then, the European market has shown that it will grow strongly in 2023 (possibly 80 GW) but not as strongly as expected (115 GW). This is due to higher inflation and interest rates as well as lower energy prices.
In the meantime, export volumes have been adjusted in line with real market developments. Since July, the export figures from China among others show that European customers have massively reduced their orders (-30% since July 2023).

[3] https://www.infolink-group.com/energy-article/solar-topic-2023-pv-industry-overview



[4]

Fig. 4: Delivery volumes and module price trends over the last few years. Module prices rose during the pandemic but are now falling again. The effect is reinforced by higher inventories due to overly high forecasts for installation figures in 2023, as well as by the sale of discontinued module technologies (switch from PERC to TOPCon and HJT). Source: https://ember-climate.org/data-catalogue/china-solar-pv-exports/, own illustration

As growth in the EU market has weakened and fallen short of last year's high expectations, some manufacturers and large dealers in the EU are currently being forced to adjust module inventories to demand or increase their liquid funds. This is resulting in low-price sales and inventory devaluations. The faster than expected PV technological transition from "PERC" to "TOPCon" and "HJT" is also accelerating such sales ("fire sales").
As stated at the beginning of the chapter, there are no clear conclusions about stock levels due to the great unreliability of all available input data. In addition, high shipping and storage costs also make high stock levels appear unrealistic. The lack of data alone means that speculative stocks cannot be used as a basis for trade restrictions.

Selling off old goods is not dumping

In the current market situation, every company offering solar modules on the EU market - both Chinese module manufacturers/exporters and European wholesalers - are trying to reduce inventories and increase liquidity, if necessary, by accepting short-term losses. "Cash flow before profit" is the principle on which this standard market behavior is based. This is a common business practice in every industry during a tight market situation. Stock clearance for new goods is also a completely normal business behavior, as is the case with any sale. This will certainly be followed by a stabilization of prices.

Technology transition to TOPCon reduces costs and leads to significant sales of PERC technology

The development of the PV learning curve is constantly accompanied and driven by leaps in technology. The current rapid transition from the PERC to the TOPCon technology is increasing the efficiency of each individual module by 20% to 25%. This is associated with a corresponding reduction in costs. The total costs for glass, frames, foils, junction boxes, cables, frames and packaging per unit remain the same, which is why they specifically fall by up to 25% per kWp. When selling a solar module, the manufacturer

[4] Source: China solar PV exports | Ember (ember-climate.org)

therefore receives up to 25% more due to its higher output, while the total costs fall by 10% to 15% per unit. In recent studies market researchers describe that pure PERC providers will not be able to keep up with the cost structure after this transition. A similar technological leap from polysilicon cells to monosilicon cells with PERC took place in the industry in 2018. After a very short time, polysilicon technology, once the market leader with a 90% market share, was replaced as PERC was able to achieve massive advantages at the time due to its significantly higher efficiency. Five years later, PERC is being replaced by TOPCon and HJT and the market is reacting as it did in 2018. This market behavior was already predicted in 2021 for the year 2023[5] .

PERC manufacturers can and must switch to TOPCon soon. This means that they must get stocks of PERC cells into circulation quickly. With the rapid switch to TOPCon and HJT, the prices for PERC modules are naturally falling. Some manufacturers are therefore being tempted to organize "fire sales" (see above)-clearance sales in which the capital tied up in the modules is released again. The longer you wait, the higher the losses could be. On the other hand, some manufacturers need liquidity to remain solvent.

In addition, there is stockpiling of older modules that were ordered in advance at times of supply bottlenecks and that can no longer keep up with the costs of modules that were manufactured and delivered after the supply bottlenecks expired. None of this has anything to do with dumping, not even when individual suppliers offer older goods at sale prices.

Price development in the European vs. Chinese market

According to the definition in the EU General Anti-dumping Regulation, a product is considered dumped if the price exported to the Union is lower than the comparable price of a similar product intended for consumption in the exporting country and traded ordinarily.
It is therefore relevant whether manufacturers charge prices in the countries to which they export that are comparable to those in their home market. This is the case, as various statistics show that similar and, in some cases, even lower prices are charged on the Chinese market. Furthermore, current business figures from listed manufacturers such as Jinko and Trina Solar show that even at the current price level, large Chinese manufacturers are making profits.
"The gross profit of USD 840.6 million was achieved with a gross margin of 19.3%. The increase in gross margin from 15.6% in Q2/2023 and 15.7% in Q3/2022 is due to the decrease in raw material costs. Net profit improved by 140.7% year-on-year to USD 181.4 million." [6]

"Separately, Trina Solar also recently announced its results for the third quarter and first half of 2023. The company reported that its third quarter operating income increased 41.25% to RMB 31.736 billion ($4.34 billion), while net profit increased 35.67% to RMB 1.537 billion ($210 million). In the first nine months of 2023, the company's operating profit increased by 39.38% to RMB 81.119 billion ($11.08 billion), while net profit increased by 111.34% to RMB 5.077 billion ($693.82 million)."[7]

2018- 2023 Extreme cost fluctuations in logistics

In the period from 2018 to 2023, prices for global container freight fluctuated at unprecedented levels. An increase in freight rates of around 800% was observed. This had a significant impact on the cost structure of solar modules. At the peak, container freight rates were 3.5 cents/Wp higher than at the

[5] Microsoft PowerPoint - PV InfoLink-Cell and module technology market overview_EN (pv-magazine.com)
[6] https://taiyangnews.info/solid-financial-results-for-jinkosolar-in-q3-2023/; See also Jonkosolar Holding Co, Ltd (10/2023): JinkoSolar Announces Third Quarter 2023 Financial Results. Available at: /C O R R E C T I O N -- JinkoSolar Holding Co., Ltd./ | JinkoSolar (last accessed: November 21, 2023).
[7] https://taiyangnews.info/china-solar-pv-news-snippets-117/;

beginning of the period and now. This price spike therefore amounted to 15 to 25% of the production costs of solar modules and subsequently had a significant (temporary) impact on their prices.
EU solar module suppliers, who have relied on permanently high container loads from 2020 despite numerous warnings, now see that their calculations are no longer valid in some cases.

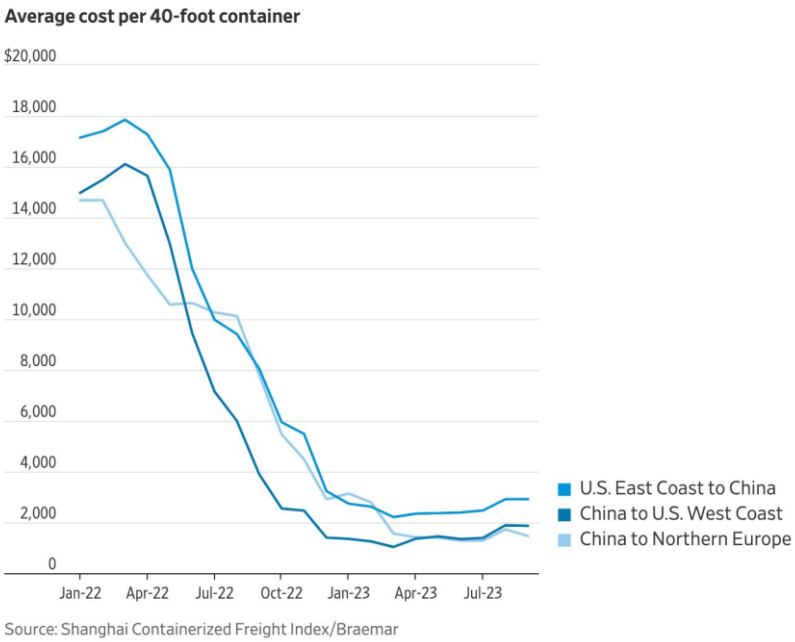


Fig. 4: After the supply chain bottleneck was resolved, the costs for containers have returned to the normal range. The high transportation costs have determined module prices by 20 to 30%. This price reduction from Jan 22 to today accounts for a price development of more than 15% at module level alone.

These combined factors influence prices in the EU but are the result of market developments and not an effect of unlawful dumping by manufacturers in China.

Conclusion

In this paper, we trace the market trend for PV modules and identify the reasons for price declines. Our aim is to offer a fact-based analysis of the current market situation which enables us to show that the underlying mechanisms are multifaceted and in no way linked to dumping.

The steep PV learning curve and technological leaps in recent years alone have led to a significant reduction in costs. In addition, installers and wholesalers have placed high order volumes with a view to the forecast growth of the European market to 115 GWp in 2023 and the supply bottlenecks of 2022 in mind. Due in part to higher inflation and interest rates, the European market is now heading for continued strong growth of around 80 GW, albeit significantly lower than the original forecast. Both the resulting sell-off of old goods and the low-price sale of module inventories have led to a considerable oversupply and thus a fall in prices. Importers have already reacted to the market development and massively reduced their orders. Finally, the extreme fluctuations in logistics costs between 2018 and 2023 are also contributing to the price trend.

Overall, our analysis shows that dumping allegations against Chinese manufacturers, who continue to make profits even under the current market conditions, are not tenable. It should therefore serve as a starting point for moving the debate away from harmful trade restrictions and towards sensible, positive measures for building a resilient European PV industry through CAPEX and OPEX promotion and resilience promotion.