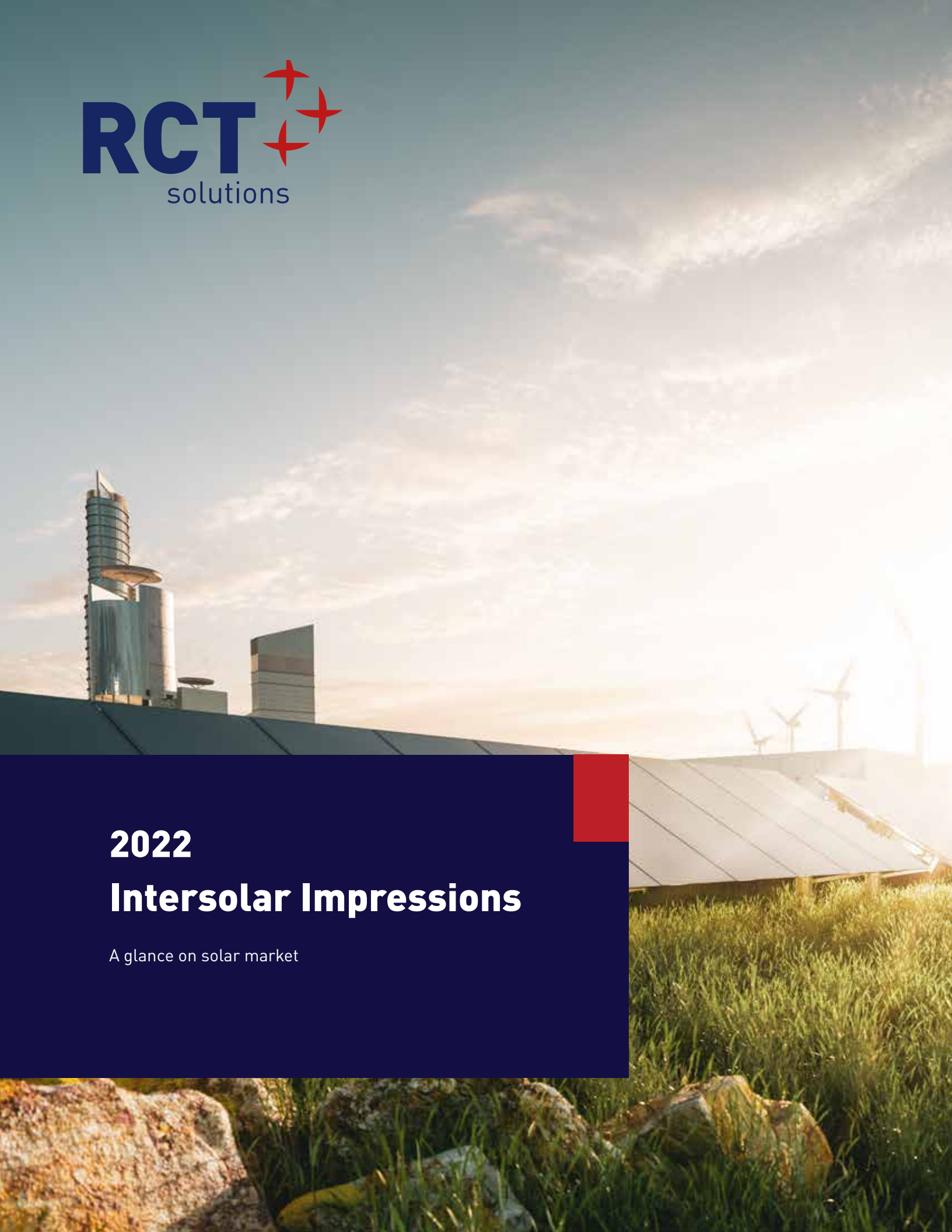
RCT solutions



2022
Intersolar Impressions

A glance on solar market

INTRODUCTION

Welcome to the RCT Solutions GmbH solar update report, including important findings, market research and recent trends.

This report has been prepared with the intention of providing a strong inside to our partners about recent developments on new technologies, help them to identify their sales targets and ultimately providing a better decision making for the consumer market.

TABLE OF CONTENT

As of May, total global installed solar capacity has passed the 1 TW threshold. After achieving 1 TW of global solar early in the year, the forecast for the rest of 2022 is similarly install more than 200 GW in one year for the first time.

THE FAIR

More than 65,000 visitors from 149 countries exceeded expectations for this year's The smarter E Europe – an increase of 33 percent compared to the last regular event in 2019.

The solar industry has come a long way in just the last few years. The latest developments and breakthroughs in solar technology include longer-lasting solar cells, solar cells that you can print onto flexible surfaces, solar panels that track the sun from east to west throughout the day, and solar power plants that work at night.

Globally, forecast additions for 2022 and 2023 have been revised upwards by 8% from December last year, thanks to strong policy support in the People's Republic of China, the European Union and Latin America, and despite downward forecast revisions in the United States.

RCT Solutions GmbH @ Intersolar

RCT Solutions Exhibiton Team

Booth A5.270

Spotlight on the key topics at the heart of sustainable energy and mobility industries. Once again we attended - the world's leading exhibition for the solar industry - Intersolar Europe 2022!

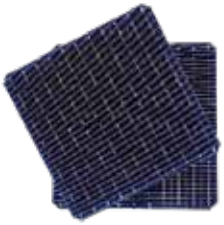
About Us

- We are on a mission to prove that cleaner energy is available worldwide since 2012.
- Our teams of experts combine hundreds of years of solar experience.
- More than 30 GW owner's engineering and factory installations worldwide.
- Our headquarters is located in Konstanz, Germany.
- Offices in India, Turkey and China.
- The technology solutions partner of Giga scale solar investors worldwide.

Raising the Bar

Covering an integrated range of photovoltaic consultancy from production technology and equipment selection to PV systems and energy storage.

A global workforce dedicated to sustainable energy.



SHAPING THE FUTURE TOGETHER

Renewable energy means the world to us.

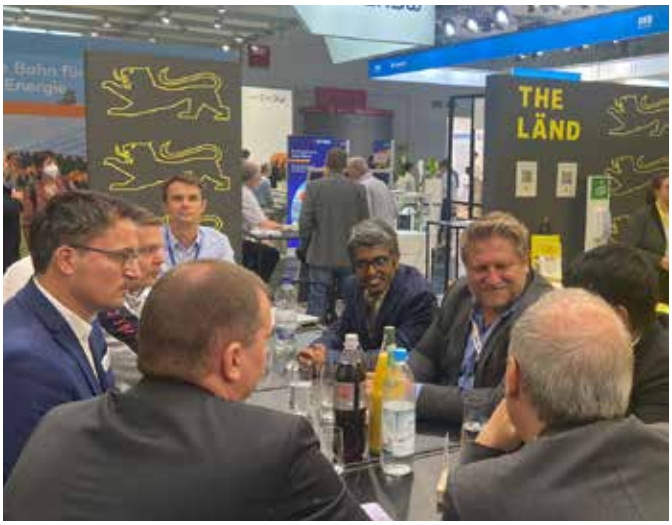
This is why we are on a mission to prove that cleaner energy is available worldwide.

Protecting our world, our planet and taking action!

Thank you to all our visitors, partners and collaborators visited RCT Solutions GmbH in Baden-Württemberg International (BW_i) at Intersolar Europe 2022!

RCT Solutions Team

INTERSOLAR 2022

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THE LÄND


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THE CONFERENCE

How to Manufacture Wafers, Cells and Modules Competitively

DR. PETER FATH

Founder & CEO

A year of difficulties has shown that now more than ever, we must accelerate the deployment of renewables to provide our economy with reliable, low-cost, and clean energy.

RCT Solutions GmbH Founder & CEO has been one of the keynote speakers for this year Intersolar Europe on May 11, 2022

Encouraged by solid solar market demand in Europe, recently, the first new cell/module factories started production in Germany and some of the existing module facilities expanded.

Dr. Fath's session covered the following topics;

- Overview of local manufacturing of solar silicon supply chain in Europe

- European solar technology 'leadership' in a global comparison

- Cost competitiveness of local production

- Overview of regulatory and financial support schemes

At the Intersolar Europe Conference, investors and decision makers are networking and learning more about global market trends, technologies and financing of PV projects.
In addition to the market development in Europe, each year the focus is on individual markets. Another focus is on large-scale PV power plants, especially with regard to Agri-PV and Floating PV.

Photo credits: Intersolar Europe

RECENT FINDINGS

An intelligent, sustainable and integrated energy mix consisting entirely of renewables available 24/7, all year round.

Photovoltaic is booming around the world: At the end of 2021, 940 gigawatts (GW) had already been installed, which means that PV has more capacity than all other types of renewable energies taken together. By 2025, the total capacity is set to be two tryouts, according to the Global Market Outlook for Solar Power presented by Solar Power Europe, the European solar association, at the Intersolar Europe Conference. Within Europe, Germany remains the most important market for PV, followed by Spain, the Netherlands, Poland, France and Italy. The government gives momentum: The German government plans to increase the installed PV capacity from just over 60 GW today to at least 215 GW by 2030, and at least 400 GW by 2040.

Intersolar Europe 2022 brings industry trends to the fore: The combination of PV and storage systems is gaining traction, with smart control technology for charging e-cars or feeding electricity into the grid playing a strong part.

Some technologies, such as agricultural PV, floating PV, or building-integrated photovoltaics (BIPV) have moved out of their niches because they can contribute to maximizing space and cushioning usage conflicts. As far as business models are concerned, Power Purchase Agreements (PPA) are gaining importance. Direct electricity supply contracts help finance the construction and operation of PV installations and decarbonizing the energy industry.

According to the IEA's latest report, annual renewable capacity additions broke a new record in 2021, increasing 6% to almost 295 GW, despite the continuation of pandemic-driven supply chain challenges, construction delays and record-level commodity prices for raw materials.

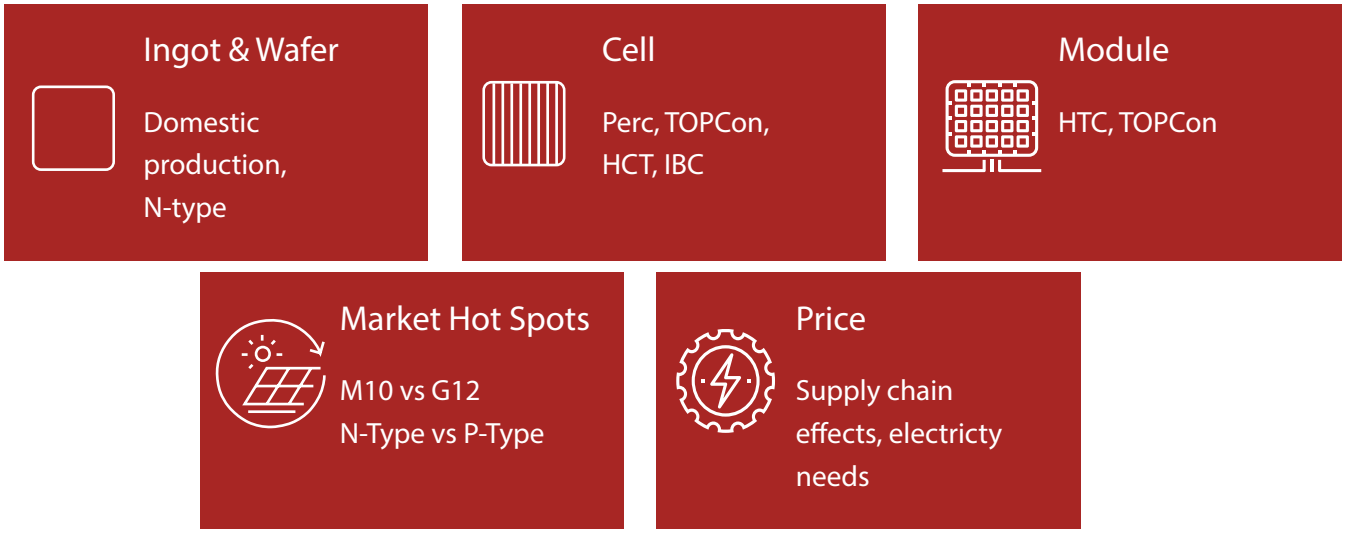
All in all, Intersolar Europe 2022 made one thing clear: The technology is ready, the industry is thriving – the only obstacles now are the lack of qualified workers, supply shortages for materials and components, as well as regulatory hurdles.

PV is the king of energy

Based on our research and findings, we have collected during the fair its clear than ever that photovoltaic technologies are the king of energy. The year of 2022, will continue to become the perfect year for both governments, investors, researchers and installers. Annual plans for clusters are as follows; European Union - 70 GW, US - 70 GW, China - 80 GW. Combined, this year the estimated installation of photovoltaic panels will reach 230+.

The blooming market for production factories is increasing as well. More players, factories, investors wants to invest to the factories with more technology and efficient modules.

Following pages based on RCT Solutions Expert's observes, disgussions and forcasts. As we forward this message to our key partners, our purpose is to make decision making clear and provide a market forcast on a global perspective.



VALUE CHAIN

Ingot & Wafer

The mono crystal is at the center of all new capacity expansions of for ingot and wafer factories. Now it's clear to say that monocrystalline silicon is the only choice to produce first step of the value chain.

Main players didn't participate in the exhibition due to corona policy in China. The only source of ingot and wafer products in Europe, happens to stay at Kalyon PV Solar Technologies Factory in Turkey.

However, one thing stays clear. Mono's share of the market now close to 90%. According to the Global Market Outlook report published by Solar Power Europe, multicrystalline silicon ingot and wafers are now serving niche markets and applications and is expected to fade away over the years to come.

N-Type variant on the rise

Monocrystalline wafers leaded to a new and on the rise variant. The N-Typed, negatively doped products are on the rise and due to the high efficiency options, many IBC, HJT and TopCon products has been intrucuded with the end customer. With more and more companies are joining the N game, now the market share of n-type wafers reached 10%. It is our prediction that the market share in 2023 will rise rapidly. By the year of 2030, the share will be around 70%.

Larger wafer formats

M10 Wafer formats are still stays the dominant, mainstreamed wafer format when it comes to producing commercial panels.

According to ITRPV 2022, M10 wafers will stay in this way but the slighly rise with G12 wafers with an expected market share of 20%.

Our estimation is that even bigger wafers sizes can be expected in upcoming years.

This year we have observed a high increase on Indian companies joining on board of manufacturing ingot and wafers. Up until the year of 2025, more and more Indian companies will appear with new technological enhancements into the ingot&wafer market.

One of the important observation was that CETC, the China's semi government company was in present with a booth as turnkey provider for Ingot and wafer factories including own eqipments. It is clear that CETC would like to expend its reach into new markets.

ATAW Autowell with their new wafer inspection eqipment for G12 was intrucuded.

Creadits: Kalyon PV Solar Technologies

VALUE CHAIN

Cell

The next evolutionary technology TOPCon unrecorded by the big players. The highest ultimate efficiency will continue its rise in the upcoming years.

Increasing efficiency and reducing costs were the two main discussions during the fair. Our industry is evaluating many technologies like HJT, TOPCon and IBC to find the perfect balance between cost and performance. But as of the first half of the year, the dominance hasn't changed. - The PERC-

Passivated Emitter Rear Contract cell structure is still preferred as a sector standard. However, the change is here to stay. TOPCon has been unrecorded by the big players exceeding more than 22% efficiency and bigger than 600 W capacity by Trina, Jolywood, Q-Cell. On paralel, work in progress with TOPCon as well and new line of products expected on the second half of the year from several providers.

The New Face of Photovoltaics - TOPCon

Now seems than more than ever, the future of the industry is shifting from PERC to first TOPCon since it reqires only a few additional processing tools over PERC. TOPCon shows the highest ultimate efficiency potential of all crystalline silicon (c-Si) cells at 28.75%. But in practice, research institute ISFH has achieved a record performance level of 26.1% with its POLO structure, which is passivated contacts in combination with IBC architecture adapted on a p-type base wafer in lab scale. In the industrial environment, JinkoSolar remained at the top in record efficiencies for commercial cell size last year, reaching 25.25%, and even 25.4% in October.

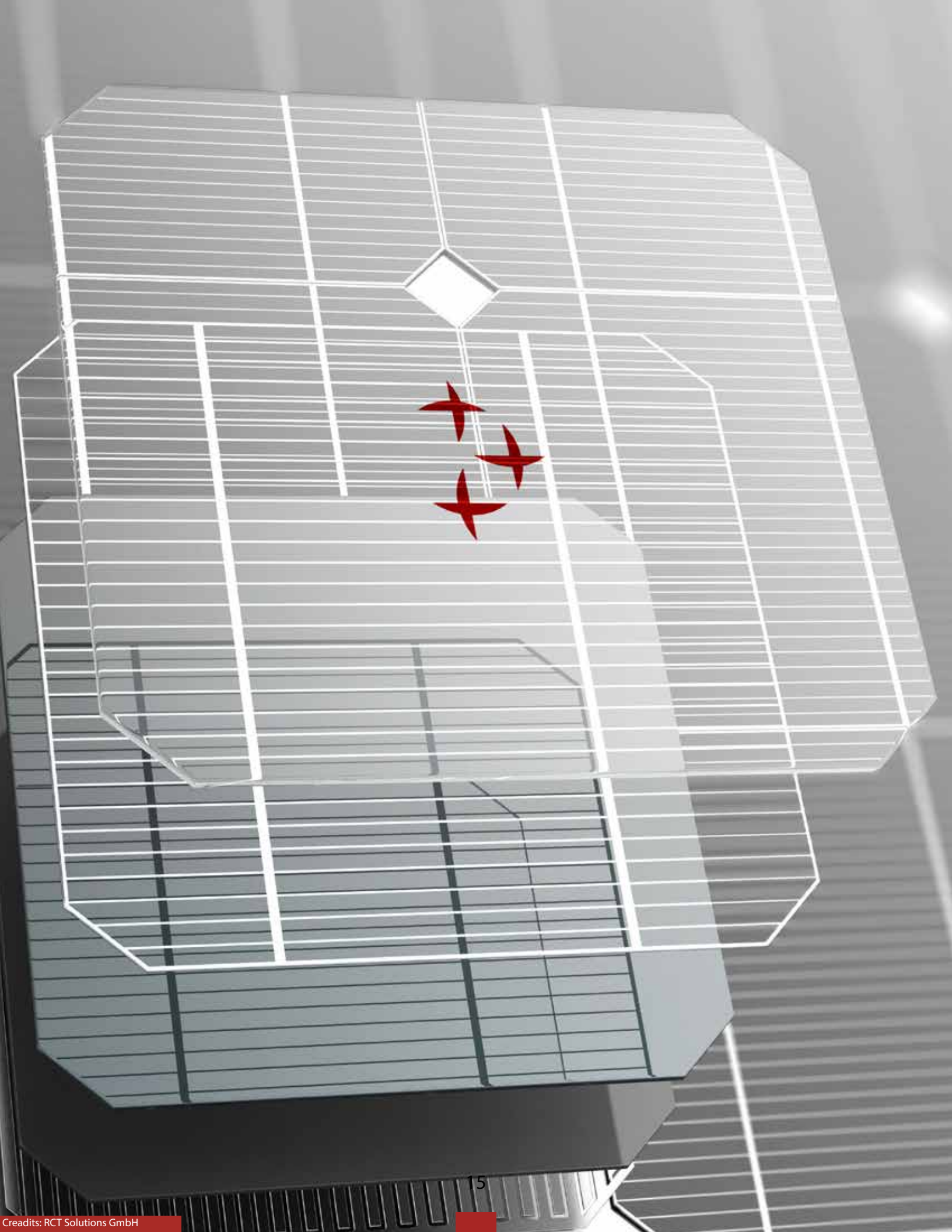
While Trina Solar topped this level with an efficiency record of 25.5% in late March 2022, Jinko reclaimed the crown in April, reaching 25.7%.

Hight Efficiency - HJT

Many industry players have expressed significant interest on using heterojunction technology during the Intersolar Europe 2022. Beside the risen works on TOPCon, focus on HJT panels of 710 Wp is on track as well. On In early 2022, Meyer Burger announced the construction of a 400 MW cell/module line, to be completed by the end of year in Arizona. This is in addition to its 400 MW capacity in Germany, which is being expanded to 1 GW during 2022. One of the most recent developments in the HJT arena is Enel Green Power's (EGP) 118 million EUR grant agreement with the European Commission.

While a few companies, such as HuaSun, have entered commercial production with HJT in China, several leading Chinese module manufacturers have also started R&D and process development lines with HJT.

The latest HJT news comes from India's Reliance which, after acquiring Norway's REC last year, has now gone on to order 4.8 GW HJT cell production equipment from China in April.



VALUE CHAIN

Module

Towards throughout the higher wattages is the key when it comes to module production. This year, residential and industrial GB models with M10 TOPCon technology was the stars of the exhibition.

Main players introduce TopCon Panels with the efficiencies exceeding 22% with more than 600 W.

TopCon panels are on the rise, however the new HJT panel's are having a special focus on the market as more and more companies started to launch their new 710 up products. Jinko's M10 TOPCon, N-Type, 144 half cells, 555-575 Watt module gathered interest from the consumers. This module has an efficiency rate of 22.26%. As a counterpart, Jinko's M10 TOPCon, N-Type, 158 half cell, 590-610 Watt, Bifacial module was the center of attention especially for industrial users.

N-type panels introduced as Zero LID. Or No B-O LID.

Mainstream demand and production continues as M10 cell modules. We have seen an increase on G12 modules as well.

Zero gap and shingled modules are seen. Increased wafer and module size calls for better utilisation of the module area. PAcking solar cells as densely as possible makes sence in order to reduce the module area. That is why shingling is one approach that eliminates the spacing between the cells in a solar module and more companies are using this approach.

Sunport produces Metal Wrap Through Modules, the main focus on it diffirentiation and sales point is it is made of lead free.

DHASH-J boxes was also one of the interesting j-boxes on seen. Those made in India, IP68, 3-split j-boxes also offer low shadowing and 8 GW capacity.

Borosil glass made in India and now expanding in Germany. 3 GW capacity in May.22, 5.5 GW capacity in August.22 and 13 GW capacity by 2023. Surfaces is matt-matt, matt-prismatic, anti-glance. In our observation, finishing progress seems efficient. We have been informed that a white ceramic painting will be included in the expansion.

Some of the other findings on module eqipments can be seen below;

Bürkle laminator

- 6 stacks, 2 modules each means 12 modules/ cycle
- Overpressure for process at higher temperature means short cycle time (GB 6.5 minutes, GG 2x7 minutes)
- Flat press for GG modules, but still compatible with GB modules
- 7 pcs for 3 GW mass production (conventional 12 pcs)
- Low footprint area wise, low energy consumption
- Membrane/ sheet change takes max. 30 minutes

Creadits: RCT Solutions GmbH

VALUE CHAIN

Module

Eternalsun spire Xenon flasher

- Good spectrum coverage
- Long pulse length: up to 160ms. In 22s cycle time up to 100ms.
- One tube lamp good uniformity via 4 mirrors and hence, good thermal stability

Autowell stringer

- Up to 20 busbars

UL certification

- Key material can only be from UL certified companies
- Quarter yearly factory inspection
- They can issue IEC certificate for little extra cost

Creadits: RCT Solutions GmbH

MARKET HOTSPOTS

As we move forward into year, some of the aspects are still in discussions in the market, as the biggest institutes are leading for a clearer look, we have analyzed the most important trends on the current situation.

M10 vs G12

Starting in 2019, and for a short period of time, it appeared that M6 was going to be the largest wafer size for the foreseeable future. But within a few months, a full square format with 210 mm side length called G12 was introduced, which is the largest commercially available wafer size today. By the end of 2019, modules based on this size had started making their presence. In 2020, another alternative size was introduced, the M10, with a side length of 182 mm and in a pseudo-square format. During the initial days as these new formats came into being, the market was flooded with multiple wafer sizes. Today, M6, M10 and G12 are considered mainstream sizes. And while it is almost certain that the M6 is going to fall off the mainstream soon, its successor remains undecided yet — M10 or G12.

Integrated companies are generally promoting M10 and companies with no strings attached to wafer production are usually jumping directly to G12.

According to ITRPV 2022, M10 wafers will become the dominant this year with a share of greater than 30%. G12 is supposed to reach a 20% share this year as well, taking over the lead at the beginning of the next decade, by which time no smaller formats than the two will be available anymore. The roadmap anticipates the introduction of even larger formats than G12.

N-Type vs P-Type

PV industry's increased focus on high efficiency Crystalline silicon cell technologies has resulted in yet another monocrystalline wafer variant being introduced to the market: the 'n-type', or negatively doped products. Doped inversely to today's standard p-type substrates, these wafers are the preferred choice for high efficiency crystalline cell technologies, such as interdigitated back Contact cells (IBC), heterojunction (HJT) and passivated contacts, often referred as 'TOPCon'. With a few companies now producing these advanced cell architectures in volumes, n-type wafers gained close to 10% market share in 2021, but are expected to be even stronger in the coming years — increasing to around 20% in 2022, and over 70% by 2032, according to the 13th edition of the International Roadmap for Photovoltaic (ITRPV) released in April 2022.

Based on our observation, we have seen more and more n-type modules are available on the market now. And the cell technology is HJT, IBS and TOPCon.

Source: Global Market Outlook 2022


WS 1 HENNECKE MEASURING SYSTEM 1
1. WAFER SINIFLANDIRMA MAKINASI
Entry
Exit
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User
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Date
Wednesday 23-Jun-2021
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Market Pricing

In 2021, the PV supply chain has been majorly impacted by price increases. Inflation has resulted in various levels of price increases at all stages of the value chain. On the other hand, some components have experienced supply and demand imbalances, especially with regard to polysilicon. This supply shortage has driven polysilicon prices up by more than 200%.

The first quarter of 2022 started with a lock down situation in China. Just like many other sectors, solar sector effected by the new regulations by China. Therefore, the most important raw material in order to produce modules Poly-Si was effected as well due to the ristrictions on the transportation and lojistic issues. Poly-Si price increases continuously effects the supply chain and it is expected the price levels will go up and highest level until the end of 2022.

Another important development was the energy price increases across the globe and Europe. The strengths of solar PV remain, and more countries are turning to renewable sources to protect their economies from high electricity prices caused by natural gas, as well as to increase their energy sovereignty, after the invasion of Ukraine the dynamics of the energy policies has been reshaped.

Based on Solar Power Europe outlook and our own conclutions, we expect the pricing growth to continue with the paralel of market growth, reaching 21 GW-scale markets in 2022, 29 GW-scale markets in 2023 and at least 34 GW-scale markets in 2024.

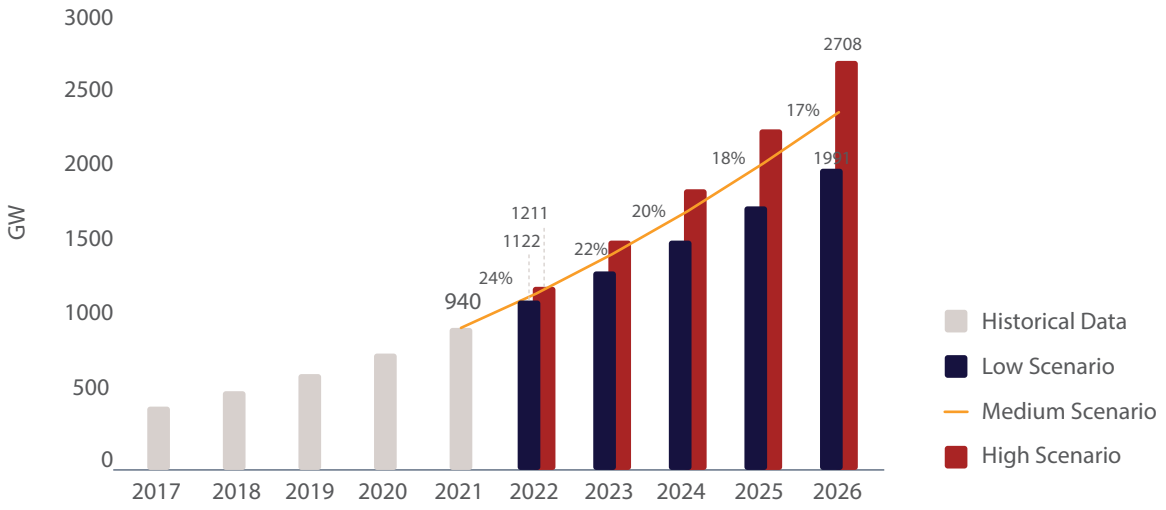
For the upcoming quarters of the year, investment costs for PV systems have steadily declined in China. In 2021, however, with the price increases across the supply chain, the prices of PV systems and components have also increased.

Reducing solar investment costs while keeping it competitive is a challenge that needs to be solved.

CONCLUSION

Zero Carbon and Carbon Neutral policies are the part of almost every countries' agenda. Now, more than ever, renewable energy sources are in high demand and towards to a Carbon Zero world, photovoltaics will be one of the key players.

The mid-term global economic outlook is hard to predict and will depend a lot on the development of the war in Ukraine. The IMF forecast in its April-released World Economic Outlook 'War Sets Back the Global Recovery' that global growth will slow from 6.1% in 2021 to 3.6% in 2022 and 2023, and further decrease beyond. But one thing is clear, renewable solar sources will be in massive demand.



GLOBAL TOTAL SOLAR PV MARKET SCENARIOS 2022-2026

SOURCE: GLOBAL MARKET OUTLOOK FOR SOLAR POWER 2022

The report, published by Solar Power Europe predicts the scenario's on the growth of solar pv industry at a glance. According to the report, strong growth on the demand side will be facilitated by massive new production capacity expansions across the solar value chain coming online, including silicon. Every leading PV manufacturer seems to invest in additional capacities, while new factories are entering the space, and investors.

RCT SOLUTIONS GMBH

Line-Eid-Strasse 1
D-78467 Konstanz

info@rct-solutions.com

www.rct-solutions.com