

THIN FILM ON GLASS AND WEB | CONCENTRATED PHOTOVOLTAICS
CONCENTRATED SOLAR POWER



Solar Technology

A company introduces itself



Grenzebach has achieved a leading position as an outstanding partner for line automation. At the same time the group has successfully researched the renewable and solar energy markets.

The fast growing solar market has focused on cost reduction, increased efficiency and throughput. With these targets in mind, Grenzebach has developed sophisticated automation and process equipment to provide a maximum of yield, throughput and quality. Starting with individual layout concepts with yield and buffer simulations, Grenzebach has established an enviable reputation as a provider of equipment and services from the start of a project, through commissioning of the line to after-sales support.

Grenzebach experience embraces all practical thin film and web technologies such as CIGS, a-Si/ μ c-Si and CdTe and has installed such lines all over the world. Combining all depo-

sition processes with reliable conveying and buffer technology in a clean room atmosphere is key to Grenzebach's expertise. Complicated interfaces and data communications are coordinated by Grenzebach's material flow controller and MES software.

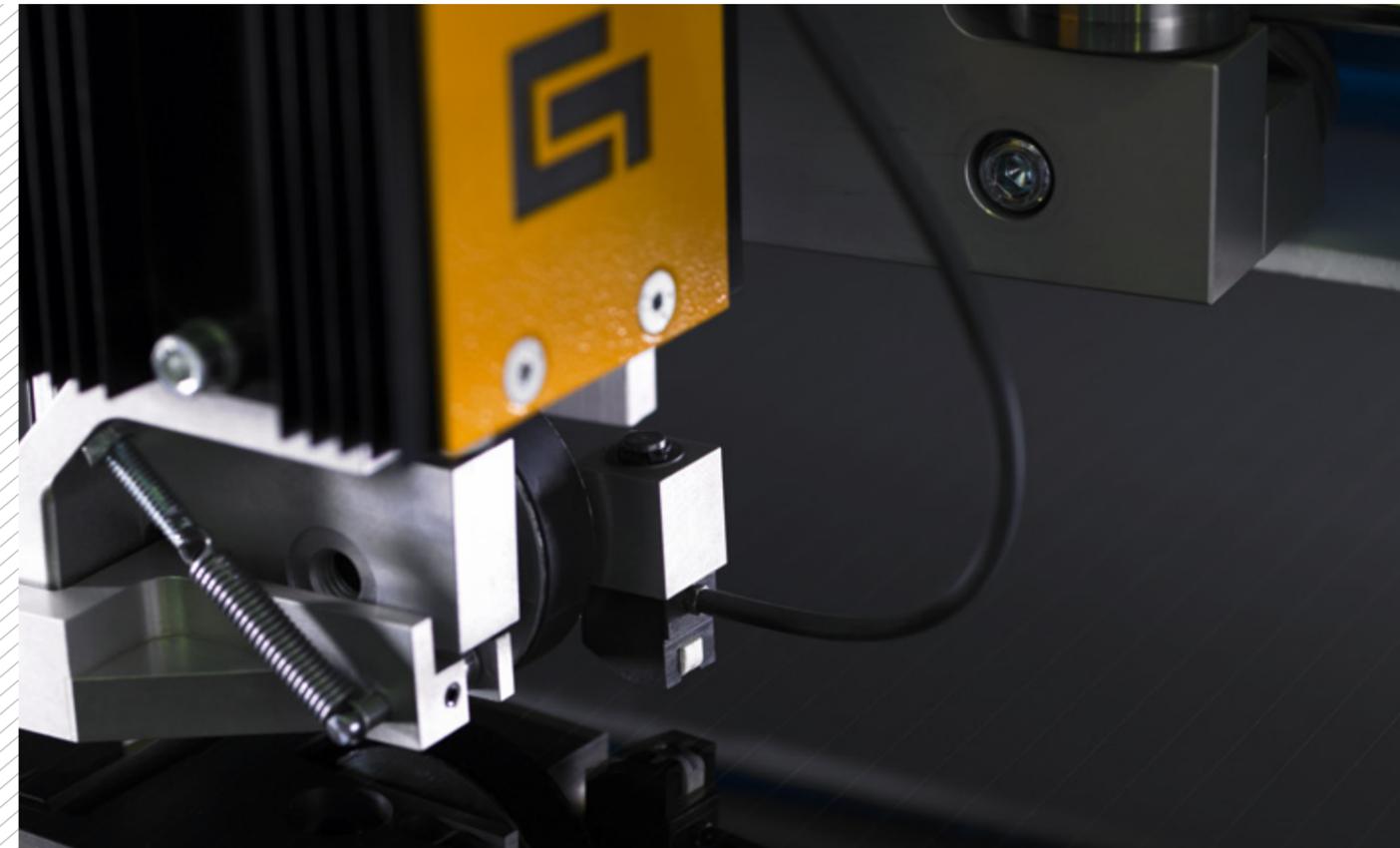
Our focus targets software solutions which support the customers' needs and expectations.

Grenzebach's surface inspection systems take account of all necessary process steps in order to receive instant quality data regarding the product.

CSP is another alternative energy solution with different challenges. Grenzebach expands the product portfolio with production lines for linear Fresnel and parabolic trough collectors. Full or semi automatic production lines assemble precisely frame and these collectors to a high efficient technology.

Concentrated Photovoltaic CPV creates an increasing demand for high efficient PV modules. Grenzebach integrates complex dispensing technology and combines it with a sophisticated mounting system to achieve maximum efficiency.

A competent Partner for the Solar Technology



Leading global players count on Grenzebach's experience in line automation and employ our line simulation to optimize process utilization and production throughput.

When deciding how a new production line will be set up the client can incur a major financial investment particularly in respect of deposition processes and buildings. Investors prefer well simulated production lines to eliminate potential risk for future investment. Global industry is constantly searching for experienced partners with a spotless reputation, offering development capabilities with layout planning and line simulation to provide an optimized production line. Grenzebach has proved a highly reliable partner for top global players in the thin film business. More than 40 of our thin film lines are producing over 2,2 GWP of thin film modules every year.

With its roots in the glass business, Grenzebach calls on 40 years of high level technology experience, thus ensuring, that our customers achieve full satisfaction as far as reliability and life span of the line are concerned.



Service at Grenzebach: Round the clock. Round the world. The 24/7 principle applies – availability 24 hours a day, 7 days a week.

Grenzebach always finds a solution for the customer's needs. The entire group is focused on the client's requirements. We know that smoothly running plants and machinery form the basis for success. Reliability, expertise and rapid action are key Grenzebach maxims. The production plants we supply are a vital cornerstone in ensuring our customer's success. We take this responsibility very seriously. Therefore, service at Grenzebach is concentrated in a separate division. From the initial machine design right through production, Grenzebach engineers ensure long-term serviceability and the highest possible quality and precision. We support our customers through all operating phases of the plants. Grenzebach companies located all over the world employ qualified employees to provide installation, start up and training services in that

region, so that customers can be supported in their own language, their own culture and their own time zone. We never leave anything to chance; we use the latest technology and media to keep in permanent touch. Grenzebach is able to access the customers' control system remotely, monitor operations and intervene with corrective action if required. We always keep a close eye on the plants we have supplied, and respond immediately when needed – anywhere in the world. Far-ranging vision, expertise, preventative action and close cooperation with customers make it possible for us to guarantee that our plants will operate safely and precisely over decades. It is often the case that our customers' requirements and their products will change over time. Software updates enable our engineers to adapt the functions of the plants accordingly. We offer a comprehensive package with integrated spare parts supply which is very popular with many customers. This ensures the plants are always maintained in peak condition both now and for the future.

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Photovoltaic works

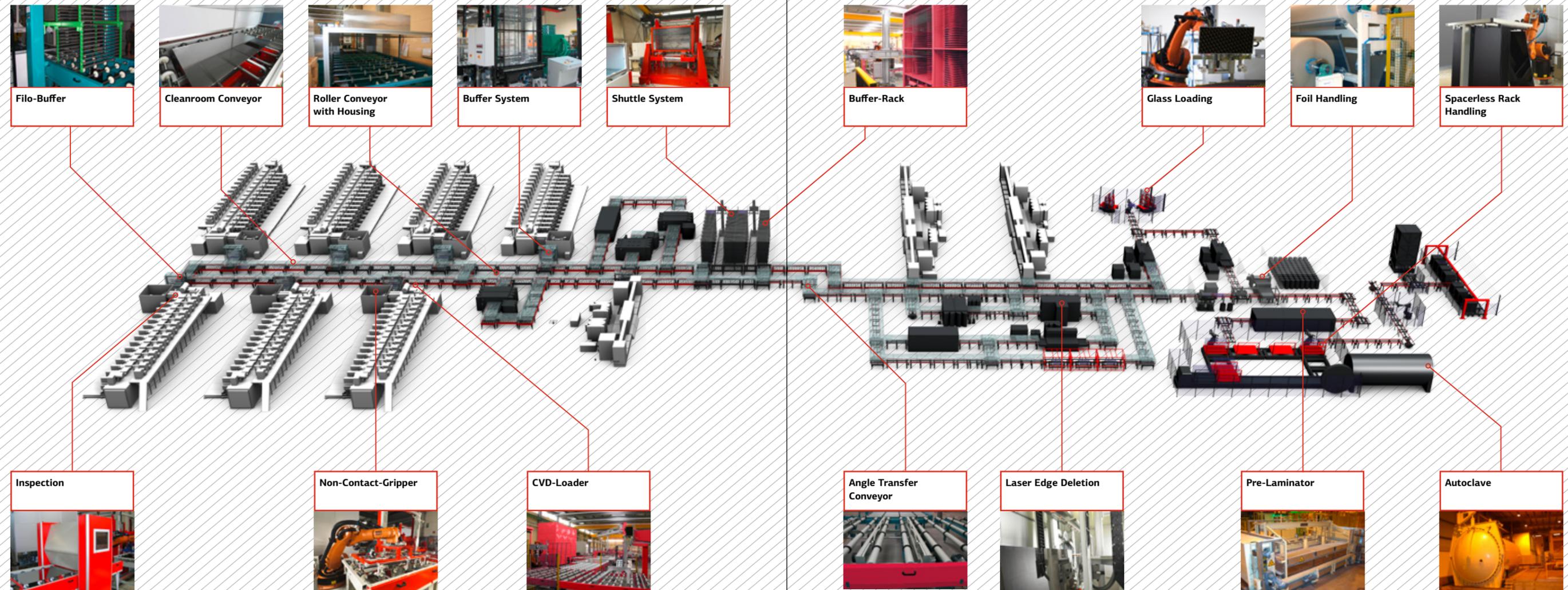


Thin Film Technology on Glass a-Si / μ c-Si

The most practical way of applying Thin Film technology has been accomplished with amorphous silicone. Grenzebach's automation equipment provides an integral part of it.

At an early stage Grenzebach recognized that leading process suppliers need a strong automation partner to share the responsibility of achieving efficiency, yield and throughput. Grenzebach equipped front- and back ends for production lines all over the world. A unique seaming application by means of a robot offers our customer

a two-in-one system for de-stacking the glass and seaming the edges. For the deposition processes Grenzebach engineered sophisticated loading tools to ensure load locks are open for as short a time as possible. Air conditioned stations and buffer systems improve the yield of the line and the efficiency of the substrates. FILO, FIFO, cassettes and trolley system are part of our product portfolio capable of operating in a clean room atmosphere. Splitting larger sizes into handy sizes is just one step in product diversification. Our Laser Ablation System warrants a module life time and security to satisfy market needs.



Thin Film Technology on Glass Back End / Encapsulation

The quality and life time of the PV-module will be determined by the automation degree of the back end.

The handling of back glasses and lamination foils are part of our glass experience with all global glass producers. Therefore paper or string removal applications are an option for our de-stackers. Climate rooms for PVB coils are routinely planned and installed by Grenzebach. Bus bars – and butyl applications are part of our supply scope

at the back end. Sophisticated foil trimmers prepare the module for the lamination process. Grenzebach offers the two step lamination process by integrating a nip roller furnace followed by an autoclave system specifically for the use of PVB foils in the BIPV market. Grenzebach provides fully automatic solutions for module handling around the autoclave. JBox applications attach the JBox semi- or fully automatically on the back glass and connect the contacts with the bus bar. Flasher, HiPot and Labelling satisfy the demanding requirements of the industry and provide quality differentiation for Grenzebach sorting and packing systems.

Thin Film Technology on Glass CIS / CIGS

CIS/CIGS – Best in class in terms of performance efficiency. Grenzebach has raised automation standards with its clean room conveying technology.

The cleanliness of the product was Grenzebach top motivation to move the sensitive substrates carefully through the sputter and deposition processes. Temperature treatments for buffer

systems have been excellently accomplished. Integrated carts and trolleys prepared for a Nitrogen or inert gas connection became of crucial importance for this sensitive deposition technology. A perfect option for an infinite buffer scenario with lots of flexibility. The decision whether central or de-central buffer scenarios are more economical will be established by our simulation system. Special handling systems using non-contact grippers lift the substrate from the top side without touching the deposition side. Grenzebach's LAS deletes the edges of the substrate and eliminates all particles by means of a vacuum system. On demand a side edge deletion LAS-S or selective layer ablation down to the Molybdenum can be tested upfront and integrated.

Thin Film Technology on Glass Back End / Encapsulation

Back glass deposition has different requirements at the Back End. Positioning of Jboxes is a important issue for the module design. Grenzebach offers the necessary solutions.

Keeping in mind that the back glass has been processed through the front end, the back end has to drill holes for the Jbox. Grenzebach supplies state-of-the-art laser drilling

systems to insure the highest quality of glass. This new technology offers a micro-crack-free glass edge.

Integrated solutions for bussing. Integrated solutions for bussing systems in combination with sealant tapes and smart Jbox connections are important modules of Grenzebach's back end concept. Light soaking tunnels increase the efficiency of CIGS modules before flashing. A wide variety of flasher suppliers offer our customers a tower or table flasher to prove the efficiency of the module. Manual or automatic framing stations can be easily integrated in the Grenzebach back end.



Packing



Foil Trimming



Foil Lay Up



Turn Conveyor



Barcode Reader



Carrier Handling



Seaming Robot



Laser Edge Deletion



Shuttle with Wireless Energy Transmission



Lifter



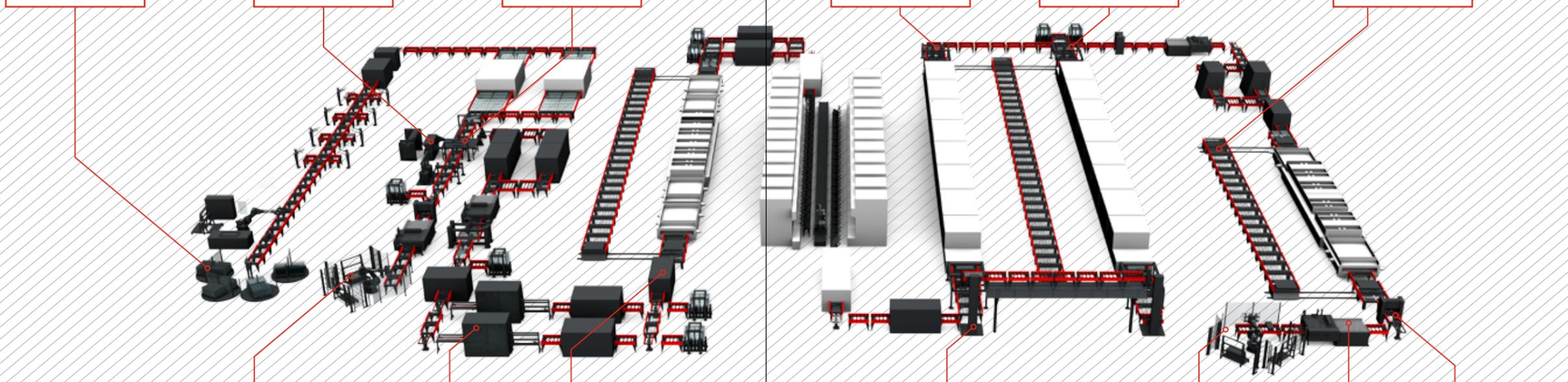
Destacking with Paper Rejection



Washer



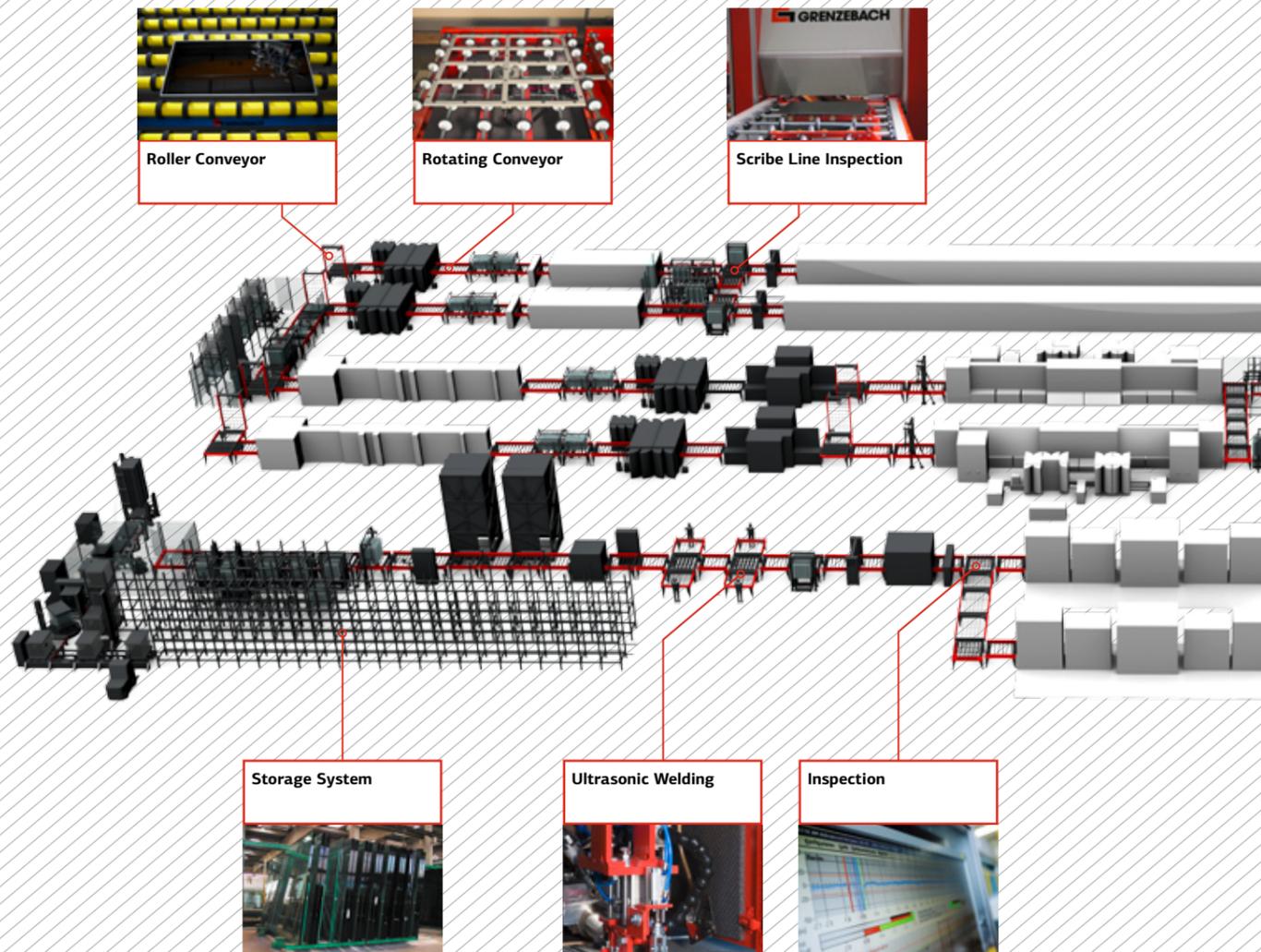
Inspection



Thin Film Technology on Glass CdTe

CdTe Technology has the largest market share among worldwide thin film module production systems. The high number of modules produced can only be attained with a fully automated production line with Grenzebach material flow technologies.

Optical and electrical inspections systems are of prime importance for the effective protection of a consistent quality in your production. Fully automated inspection systems are essential for every photovoltaic production line. Grenzebach offers extensive solutions. Optical systems equipped with CCD Cameras and intelligent LED-illumination inspect Front- and Back glass, Coating and layer deposition, P1 – P3 structuring, as well as the result of lamination. Electrical systems like IV-Curve, resistance measurement after LAS and HiPot ensure consistent quality in production as well as a high yield.

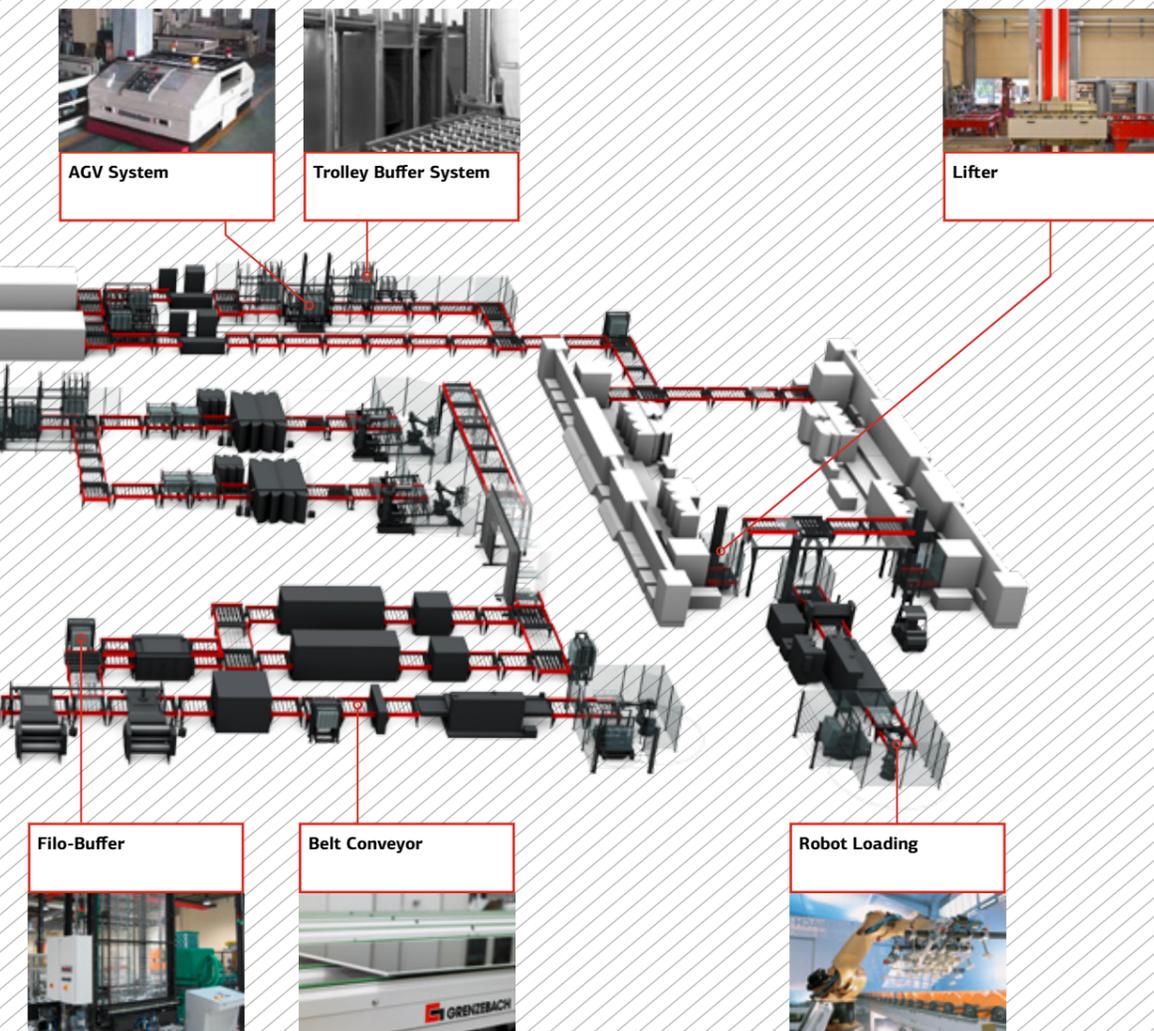


Thin Film Technology on Glass Back End / Encapsulation

BIPV and module stability: Different installation areas demand different module adapters – Larger modules require mechanical support.

and handling of 2K material are just a few of the possibilities for connecting modules with installation materials. All material used will be tracked by our Grenzebach-MES system. The operator is always kept up to date with production by means of a material management tool.

Grenzebach offers multiple solutions for back rail or bracket applications. Our fully automated systems clean, prime and adapt different materials to the back side of the module. Complex systems with material magazines, dispensing stations



Thin Film Technology on Web

The merging of thin film with crystalline module technology by printing thin films on flexible foils is the result of web technology. This offers infinite options for size and product diversification.

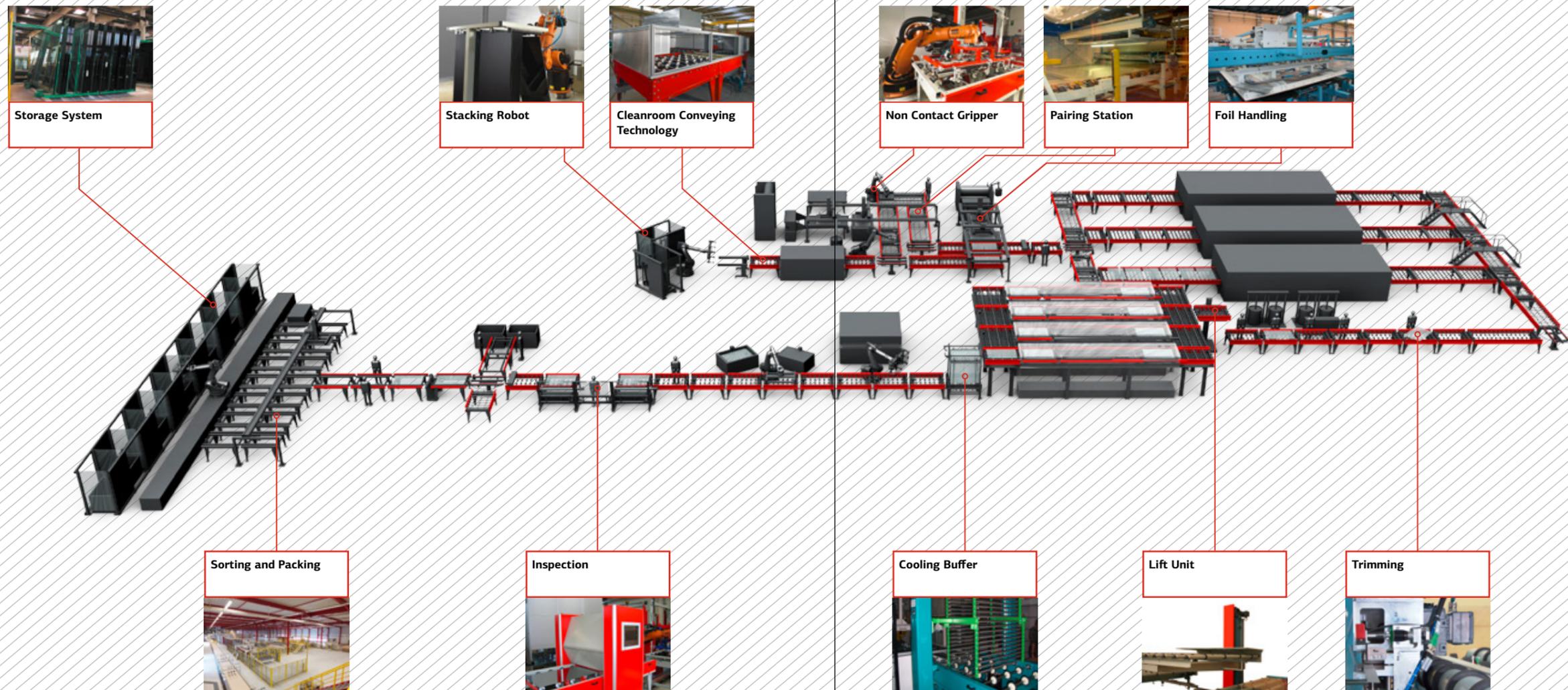
Grenzebach's focus in this technology is directed to the application and marriage of glass with glass, glass/Tedlar or flexible foils in combination with established web technology. The development of a non-contact gripper system enhances the machinery around the back end positions. Grenzebach's experience from the building material industry provides a variety of solutions for coil handling at the front end. Coil changers load and unload the roll-to-roll process and warrant safe transport to the next process step via AGV shuttles. Complete AGV systems, built to the highest industry standard, are provided through the Grenzebach Group.

Back End / Encapsulation

Whether flexible or on glass – Web technology fits in between, no matter what size is needed at the end.

The parallel bus connection of serially connected modules is a further challenge and creates yet another challenge for packing automation. Grenzebach provides solutions for inline and offline systems.

The lamination process has different requirements when it comes to the differentiation between flexible and glass modules. Handling multiple coils for different foils is the most important aspect.



Concentrated Solar Power Technology CSP

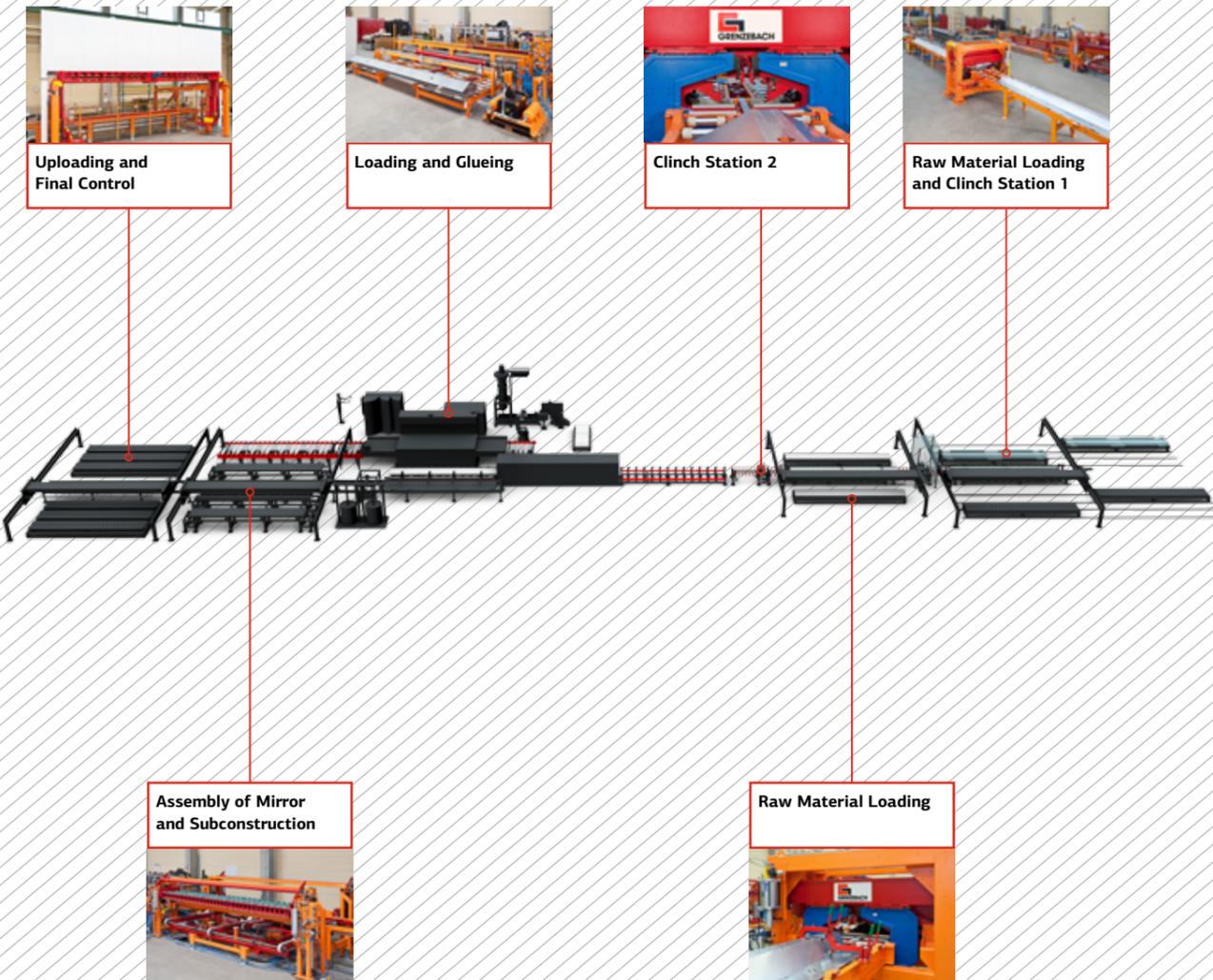
The development and materialization of a CSP mirror module production plant is the latest asset in the Grenzebach Maschinenbau GmbH product portfolio.

This new market emerged from the experience gathered on thin-film photovoltaic module production lines and especially focuses on the Fresnel and parabolic trough technologies, that create the prerequisites for automated production. New process steps were developed as required and known

processes were aligned on thermal solar technology. This resulted in a CSP mirror module production plant built to the latest technical standards.

Principal benefits of this plant

- Semi-automatable to reduce the investment volume
- Fully automatable to achieve a high output and low labor costs
- Modular design
- Quick disassembly and reassembly for high flexibility as to the production location
- High accuracy
- Customized concepts



Concentrated Photovoltaic Technology CPV

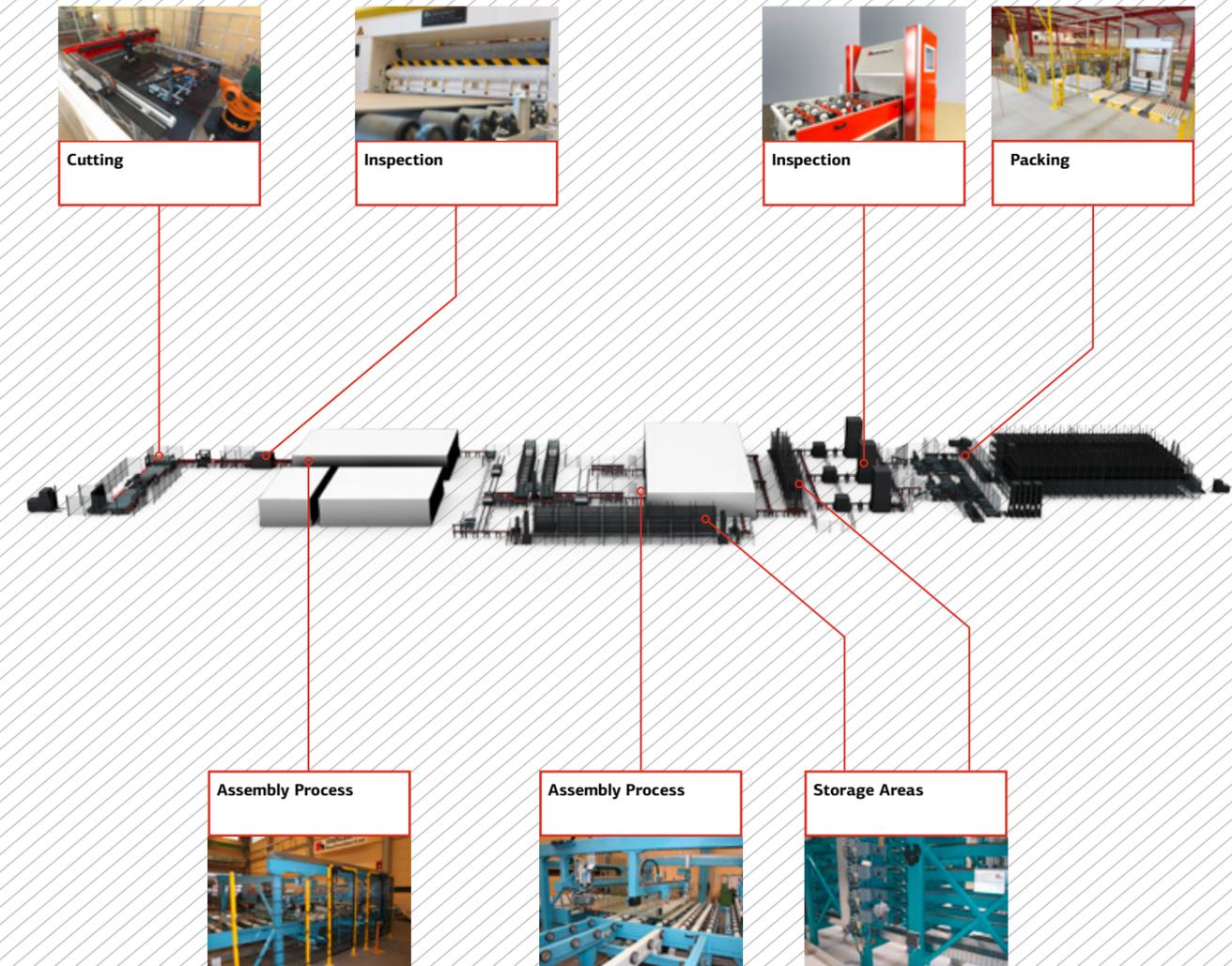
A second pillar for Grenzebach Maschinenbau GmbH in the Concentrator Power sector is CPV Technology. This product field started with the development of a fully automated CPV production line.

Experience gathered from CSP and Thin Film Technology provided the critical advantage needed for the assembly

process steps and the very high accuracy required. High accuracy is especially important as it runs parallel with the high standard of equipment which brought Grenzebach to their leading position in this market. As a result, Grenzebach is ideally qualified for further growth in the Concentrator Power sector.

Principal benefits are

- Experience in all major technologies (CSP, CPV and Thin Film)
- Very high accuracy and requirements in quality
- Fully automatable
- Modular and flexible for different model sizes



PLC, MFC, MES, Line Simulations

Visualize, determine and realize your production flow from project start to production start. Grenzebach supports with line simulations and ends the job with its highly sophisticated PLC, MFC and MES systems.

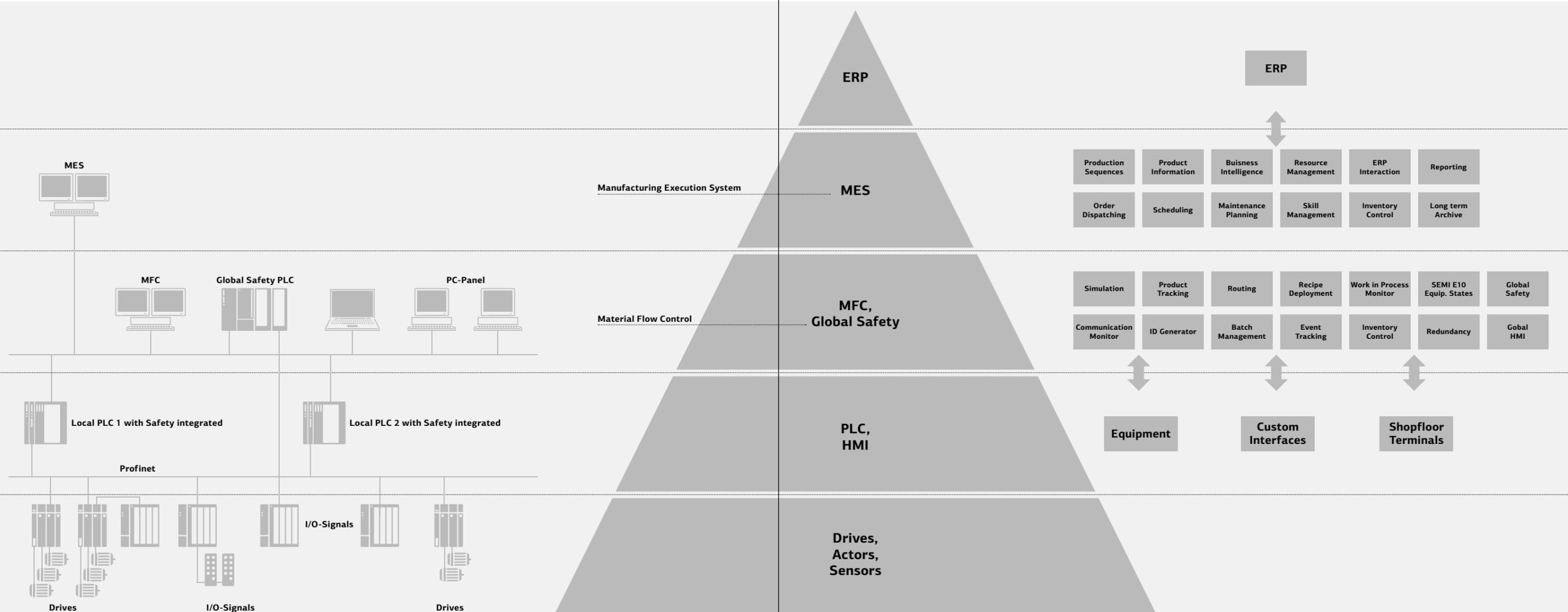
Grenzebach's simulation team provides to our customers a simulation of the future line which is very close to reality.

Based on SEMI E10 standards, all unscheduled and scheduled downtimes will be considered in order to determine the optimal buffer space and production equipment. Control of the production process at all times, quick reaction and full use of the line capacity – the Grenzebach control system meets all these requirements in full.. Grenzebach offers a complete range of machine controls, specifically designed for individual applications - from PLC control up to complex controls for robot movement. The graphic operation concept is clearly structured and all stations are fully linked with each other. Grenzebach offers a vast range of control technology for every level of automation.

Maximize and simplify your production line by means of synchronization and transparency of your processes with Grenzebach customized MES system.

As an instant decision maker, Grenzebach's MFC handles all relevant decisions of the entire line automation. ID - generation, production tracking, WIP , recipe deployment as well as event tracking, all feature our high reliable MFC system. A later integration of our MES system is also

possible. I. Teleservice and 24hour service support the operating staff. Grenzebach's experience with world wide operating host computers enhance the efficiency of the entire process chain. The modularized architecture of our MES system incorporates a long term archive of the production sequence with a flexible reporting tool, production scheduling, business intelligence and resource management. Scheduled production maintenance in combination with inventory control and skill management are further highlights designed to fulfil customers' needs and prepare the line for future optimization.. Integration into an existing ERP concept is a matter of course for Grenzebach.



Innovation made by Grenzebach



Laser Ablation System LAS

Thin solar module manufacturers have been yearning for such an application in their efforts to cope with undesirable power transmissions.

Grenzebach have strived to develop a high flexibility system. This has resulted in a system for any module size. Benefits of our laser-based edge ablating process:

- non-contact process to avoid glass damage
- no additional process media such as shot or chemicals needed and thus no extra recycling costs

Another feature, offering extra benefits, is the vertical process arrangement:

- fit for processing different glass sizes
- fit for BIPV module centre ablating
- efficient extraction system

Our system can ablate all usual front and back contacts, semi-conductor coatings and TCO coatings.



Non contacting glass handling

Our non-contact handling systems benefit from the gripper's ultrasound air bearing. 6-axis industrial robots or multi-axis gantries are tailored to the needs of the handling application. The gripper's ultrasound air bearing (made by Zimmermann & Schilp) is fit for all atmospheric applications. It generates a load bearing gas film (air or process gas) between gripper and substrate. This avoids mechanical contact. The substrate floats friction-free either on or beneath a gas film. The equilibrium between repelling ultrasound and downward forces on the one hand and the attracting vacuum forces on the other hand allow the equipment to grip the glass from the top side and to handle it contact-free and floating upside down. The glass is side aligned against freely configurable adjustable mobile stoppers.



Surface inspection systems

Grenzebach's new Group member ALGOSCAN has developed new surface inspection systems for the thin film market.

The state-of-the-art camera inspection systems detect typical glass defects especially on the edges of the glass as well as at the perimeter of the hole. Another specific system is able to detect all typical coating defects even on structured surfaces. The system also checks the scribe line geometry and quality.

The finished modules run on the conveyor through the final camera inspection system which is able to detect all typical finishing defects such as bubbles, excessive glue or scratches. Benefits of this inline application: Automatic inspection is essential for each solar module line, as a consistently high quality is needed for maximum yield of production and for the quality of the final product.



Ultrasonic bonding unites metal and glass

Wherever metal meets glass, the connection has previously been of rather short duration. However, interfaces of this kind are widely used in such practical applications, as in facade elements or brackets for solar modules. Grenzebach has addressed this topic and already registered a patent for ultrasonic welding.

The process makes possible a lasting bond between glass and metal. At present, the technology for ultrasonic welding is still being improved and refined; a test machine is already running. There are many interesting potential applications for this process, representing new markets which the Grenzebach Group are keen to exploit,



Shuttle systems

Grenzebach's participation in the company LJU has further enhanced its product portfolio.

The pooling of both companies' know-how has given birth to a new shuttle system with exceptional properties. Grenzebach's experience with telescopic and lifting systems combined with LJU expertise with AGV's has produced an all round winner for the solar industry. The shuttle system excels by its modularity. It combines the four primary components carriage, lifting axis with telescope and wireless power and data transfer. This makes the shuttle system completely versatile.

Benefits:

- Straightforward design
- Individually adaptable axes
- High payloads up to 1000 kg
- Accommodating individual sheets or complete cassettes
- Individual cassette applications are also available for inert atmospheres
- Harmless to persons fitted with a pacemaker



Laser cutting

The operation of laser cutting is similar to the conventional cutting process. Its absolute advantage, however, is the total lack of micro cracks on the glass surface. The Grenzebach laser cutter uses a CO₂ laser with a specific wave length that is absorbed by the top glass layers and where it is converted into heat. A set of special and adjustable mirrors deflect and focus the laser beam over a specific length along the score line. This is done several hundreds of times within a second and heats up the glass surface in a controlled way. The heat is applied in a way that avoids negative effects to the glass structure.

BUILDING MATERIALS | GENERAL INDUSTRY | SERVICE



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