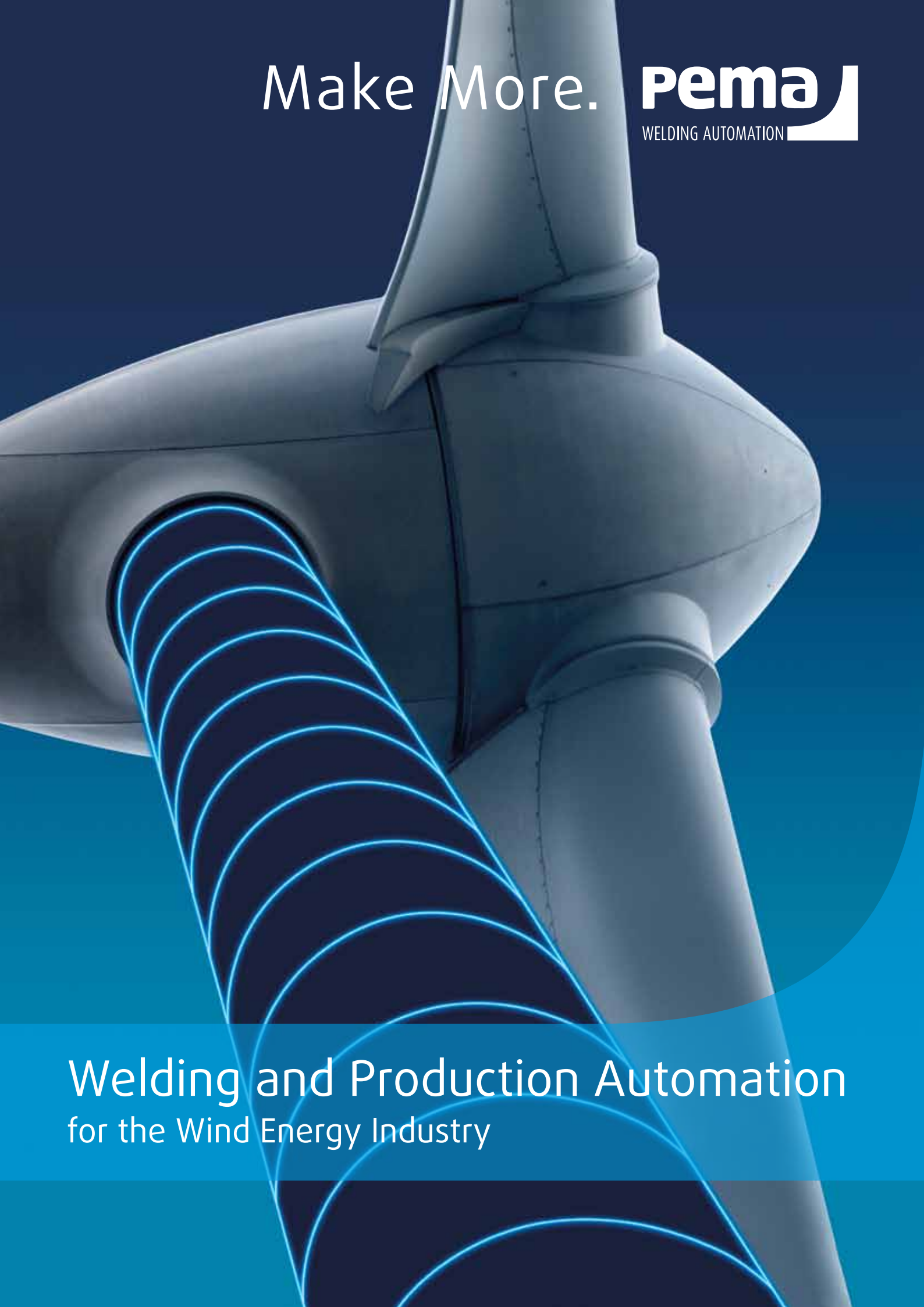
Make More.

Pema
WELDING AUTOMATION



Welding and Production Automation

for the Wind Energy Industry

Production Automation for Wind Towers and Foundations

— Solutions for Offshore and Onshore Demands

The best productivity rate and premium quality in onshore and offshore demands are reached using hi-tech and modern welding and production automation. PEMA solutions for wind tower and foundation production have been proven to increase overall efficiency in production plants.

Radical Improvements in Production Efficiency and Quality

PEMA wind energy solutions are designed especially for steel structure welding and production automation for wind towers and wind tower foundations. We are able to provide you with tools to increase the capacity and quality of your end product and thus raise your level of competitiveness. All lines are modular and designed based on the customer's production capacity needs.

From Single Solutions to Complete Lines

- Multi-arc welding solutions
- Edge preparation
- Workpiece handling and transportation
- Integration and material flow
- Production line — complete solution

To ensure your production capacity from raw material to an inspected final product, you can rely on PEMA's fully integrated systems. The integrated system from one supplier does not only ensure capacity, but also gives you guaranteed quality.

PEMA's integrated production line provides high quality with minimum repairs and productions stops, which is the key to a successful project. Greater control at all stages of mass production means higher quality and fewer repairs, which means to higher profits for our customers.

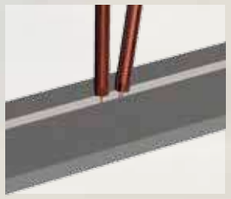


Onshore and offshore windmill tower foundation types (from left to right): Onshore, Offshore Monopile, Tripod, Jacket and Floating. PEMA has the ability to supply welding automation for manufacturing all these product types as well as for turbine towers.



50%

shorter assembly time from one shift to 2–4 hours/shell with heavy wall material or from 2 to 0.5-1 hours with thin material



35%

faster welding speeds with 3-wire square wave technology compared to traditional tandem welding

With Welding Automation, You Get More

- Capacity
- Quality
- Cost-effectiveness and better ergonomics

Complete Solutions for the Entire Manufacturing Process

PEMA is a reliable and experienced partner for large-scale welding automation investment projects. The company's global presence, strong engineering force, focused business lines and active and continuous R&D provide flexibility to create innovative welding automation solutions for the wind energy industry.

From Concept to Life — Cycle Support

PEMA's support service extends far beyond the delivery of its solutions. The company invests in long-term relationships to ensure that customers get the support they need and the business results they deserve. PEMA provides maximum support to minimize the downtime of the delivered solutions. Its maintenance packages ensure extended product lifetimes and reduced, estimable operational costs. Service packages such as remote diagnostic services and process data logging further optimize the productivity of customers' processes.

In PEMA Wind Energy production lines, premium quality is standard. As safety and quality are critical factors both onshore and offshore, PEMA uses its decades of experience to offer high-quality products.

Understanding the needs of our customers, reliable equipment, modern processes and the constant development of our products are key when it comes to securing business.

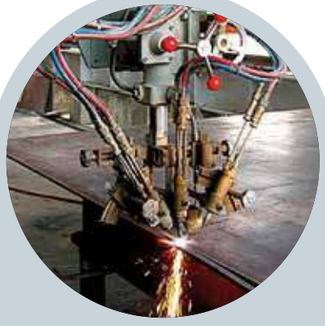
Constantly developing our solutions and close cooperation with our customers helps us to create even more flexible and efficient equipment for wind energy fabrication needs.

PEMA is recognized for its long-term cooperation and key-customer thinking. This concept includes full lifetime support services and retrofit projects. The fact that some of our very satisfied customers have included PEMA products in their production lines for over twenty years is a testament to this.

PEMA is able to provide lay-out and productivity studies right from the early stages of your investment plans. Close cooperation with the customer guarantees that the equipment, solution and services will be provided according to specific customer needs.

Turn-key delivery enables radical changes and the shortening of production start-up times when integration is planned and tested in one place with one supplier.





1. Plate cutting



2. Beveling



3. Plate joining



4. Roll bending



5. Long seam/Flange welding



6. Section assembly



7. Section welding



8. Section transportation



9. Blasting



10. Painting



Cutting-Edge Technology and Solutions

Laser-based seam tracking is a key technology for efficiency and high-quality multi-pass welding, used in heavy wall thickness digitally controlled welding with PowerWave square wave technology, integrated control multi-heads and multi-arc welding. Integrated controls, intelligent seam tracking and user-friendly interfaces make it possible to control bigger deposit rates and higher speeds to increase efficiency.

Integrated Control Systems – PEMA WeldControl

PEMA WeldControl systems release you from the complicity of different controllers to use a simple, one panel control system. The WeldControl has three levels of operation and provides the right controls for every user – from operator, welding engineer and service up to a real management tool. PEMA WeldControl is an efficient user interface for integrated machine and welding process control.



Integrated Edge Milling

Milling forms an important part of the plate preparation and joining process. PEMA provides both integrated and independent stations for plate edge milling as well as for plate side-edge profiling. Proper plate edge and side preparation ensures the high-quality welding and fitting of shells in tower section or monopile manufacturing.



Heavy Workpiece Handling

Heavy workpieces of up to 1500 tons in offshore foundations can be handled efficiently at floor level with PEMA's intelligent rail movement solutions. This increases efficiency in production and the need for heavy lifting crane capacity.



Laser Seam Tracking

Laser-based seam tracking is a key component to increase productivity in heavy thickness material used in offshore foundations.



Offshore Wind Tower and Foundation Manufacturing

Monopile is the most commonly used foundation type for offshore wind turbines today. A simple design typically driven into the seabed or grouted into sockets drilled into rock, the monopile supports the wind turbine tower either directly or through a transition piece.



Full Section Assembly

PEMA solutions are able to rotate and transport monopiles of up to 1500 tons.

Small Section Assembly and Welding

Small section building increases the productivity of the full line.

Shell Manufacturing

Fully integrated welding column and boom and special rollers for efficient long seam and flange welding.

Groove Machining and Outside Welding

Circular milling is integrated into the production line and welding is applied externally to the milled groove using multi-head platforms.

Plate Prefabrication

The blasting and cutting of plates.

Plate Joining

Complete production line with conveyor, plate clamping, integrated milling and welding on both sides.



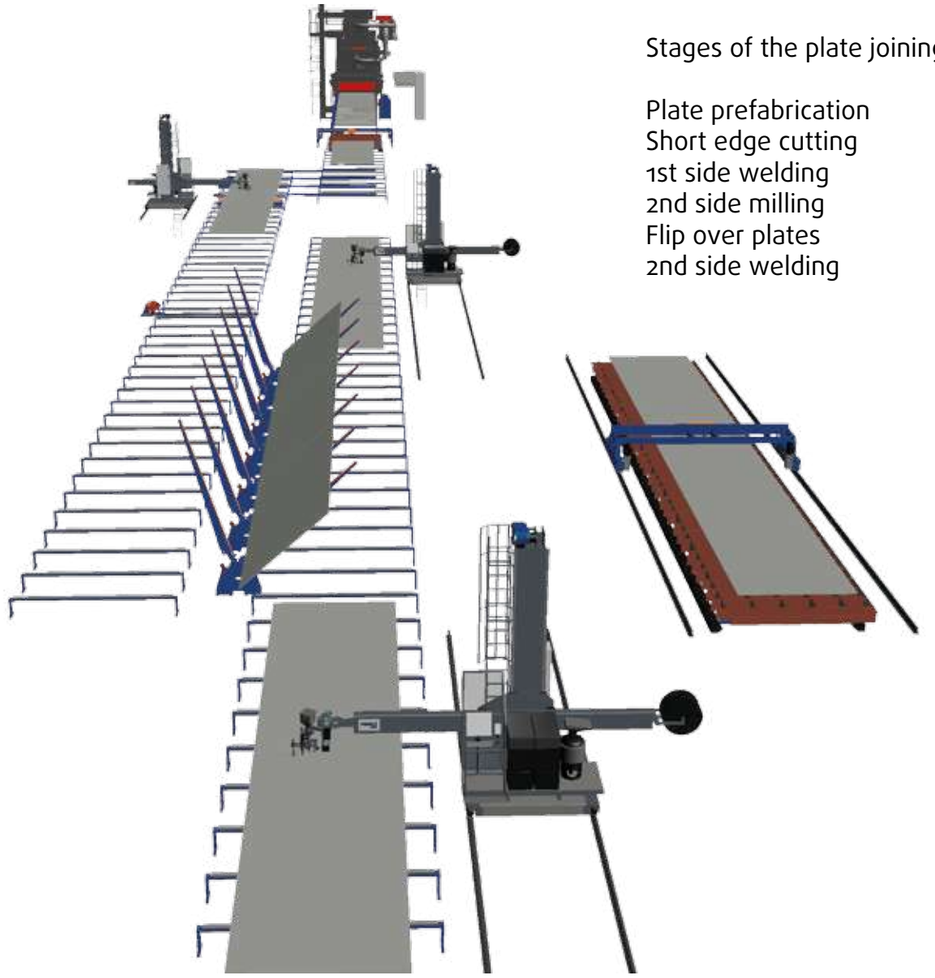
Offshore — Plate Joining

Monopile foundations are the most common offshore wind tower foundations. Regarding foundations, the diameter and thickness requirements for monopile and transition pieces have increased due to the growing size of turbines. The newest designs are up to 9 m diameter and 120 mm thickness. With the PEMA plate prefabrication line, you can manage new demanding structures and even make more.

Large diameters and material thicknesses demand effective prefabrication and plate joining solutions. PEMA solutions integrate everything from plate conveyors to groove milling and welding.

The plate production line can be delivered as a turn-key package including plate prefabrication, cutting and conveyor transportation.

After prefabrication plates are joined in PEMA's welding station, which includes a magnetic bed to align and keep the plates together during welding. Once the plates have been welded on one side, they are milled, flipped over and welded on the other side.



Stages of the plate joining process:

Plate prefabrication
Short edge cutting
1st side welding
2nd side milling
Flip over plates
2nd side welding





Assembly and fit-up of foundation sections

Offshore – Shell and Section Fabrication

Specially designed solutions for shell and section manufacturing ensures efficiency and quality through the production line. PEMA solutions cover all welding and material handling needs during these phases. Solutions can be used from monopile, transition piece, tripod and quadripod subassembly production to full length monopile joining.

Building the Structures

Monopile type of foundations includes two heavy weight section monopile itself and transition-piece that connects pile to turbine tower. In order to first build and then join these huge sections together, you can either use a single-can process or utilize sub-stations for joining multiple cans. Whatever process is chosen, PEMA has the equipment to carry it out. PEMA's range of solutions include welding stations, for internal end external longitudinal and circumferenfial welding. The productivity of external welding can be further improved by employing PEMA WS welding platforms for the simultaneous welding of multiple or more joints.

Handling the Structures

Drawing on its experience in supplying extremely heavy applications for shipyards and offshore industries, PEMA developed special carriers for the sideways transportation of wind energy structures. Combined with PEMA roller beds on rails, these carriers allow the completed monopiles and transition pieces to be transported both within and away from the production area. This limits the need for high-capacity overhead cranes.



Long seam welding of heavy wall thickness material.

Offshore – Outside Welding of Sections

The welding platform is a solution for simultaneously welding multiple joints. This method makes it possible to manufacture even the heaviest offshore structures in reasonable timeframes.

The platform can be made double sided to serve two lines and it can replace 2–6 column and boom type welding machines.

Edge preparation is milled after interior welding is complete. Integrated milling ensures defect-free welding and the ability to produce semi-narrow gap joints. When welding heavy wall thickness material, semi-narrow gap joints can radically reduce the amount of time spent and consumables used.

Major Benefits of a Welding Platform

- Less space required
- Faster welding times
- Fewer man hours
- It is possible to control the demanding semi-narrow gap joint welding used for heavy wall thicknesses
- Smooth integration of control technology
- Efficient consumable feeding

Benefits of Integrated Circular Milling

- Improved quality
- Faster operation
- Space efficiency
- Semi-narrow gap joints



The anti-creep function in PEMA roller beds ensures the stability of heavy structures during multi-pass welding.



Offshore – Jacket Fabrication
for Wind Turbines, Substations and Converter Platforms

The Jacket Manufacturing Process

A jacket structure has a much more complex geometry than a monopile foundation. Essentially, a jacket consists of three or four legs diagonally and horizontally braced against a transition piece in the center. The legs are also interconnected with bracing to provide the stiffness required. Depending on the height of the jacket, the number of cross bracings normally varies between 3–5. At the end of each leg, there is also a pile transition piece to connect to the straight piles that are being piled into the sea bed.

Due to the geometry of the jacket, its manufacturing process cannot be automated to the same extent as a monopile production process. A basic condition for successful welding automation is the accurate cutting of the individual structure components.

During Jacket Manufacture, the Following Joints can be Automated

- Welding leg nodes
- Welding bracing nodes
- Joining first bracings to nodes
- Welding leg pieces
- Joining leg pieces to leg nodes
- Welding piles
- Welding the top transition piece

The remaining joints have to be welded manually or semi-automatically using, for example, orbital welding equipment.

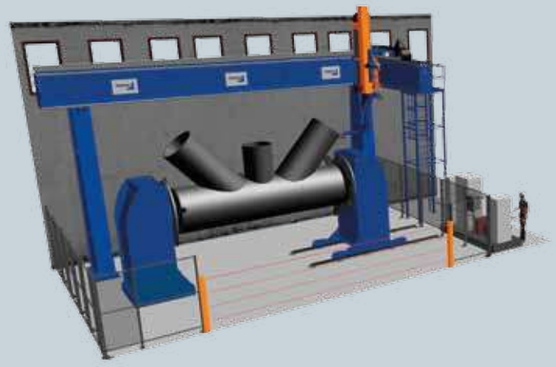
The primary welding methods are SAW and GMAW. The manipulators can be standard column and booms utilizing the SAW welding process, and robots that use the GMAW process.

High Level of Automation

The share of the cost of the foundation relative to the complete wind turbine installation is considerably higher than with onshore foundations. It is extremely important to optimize every part of the foundation production flow to minimize all associated costs. PEMA offshore foundation manufacturing lines are always specially engineered for the manufactured foundation type, ensuring the highest reasonable automation level. Therefore, the productivity and quality produced by PEMA solutions is superior to that of other manufacturing lines.



Robotized Node Welding Station for Jackets



The automation of node welding is one possibility for increasing efficiency in jacket production. Demanding weld shapes can be handled with parameterized robot programming and laser-based seam tracking.

Production Lines for Jacket Legs and Piles



Jacket legs and piles are made from relatively thick material but have smaller diameters than other offshore foundation structures. PEMA has specialized solutions for leg production with submerged arc welding.

Onshore Wind Tower and Foundation Manufacturing

Structures and manufacturing techniques for onshore towers have been established during the last decade and competition in the manufacturing industry has become more and more intense. Investing in welding and production automation is the only way to maintain profitability. PEMA innovative solutions provide you with more competitiveness, productivity and quality in onshore production and enable you to do more.

Double Can Assembly and Welding

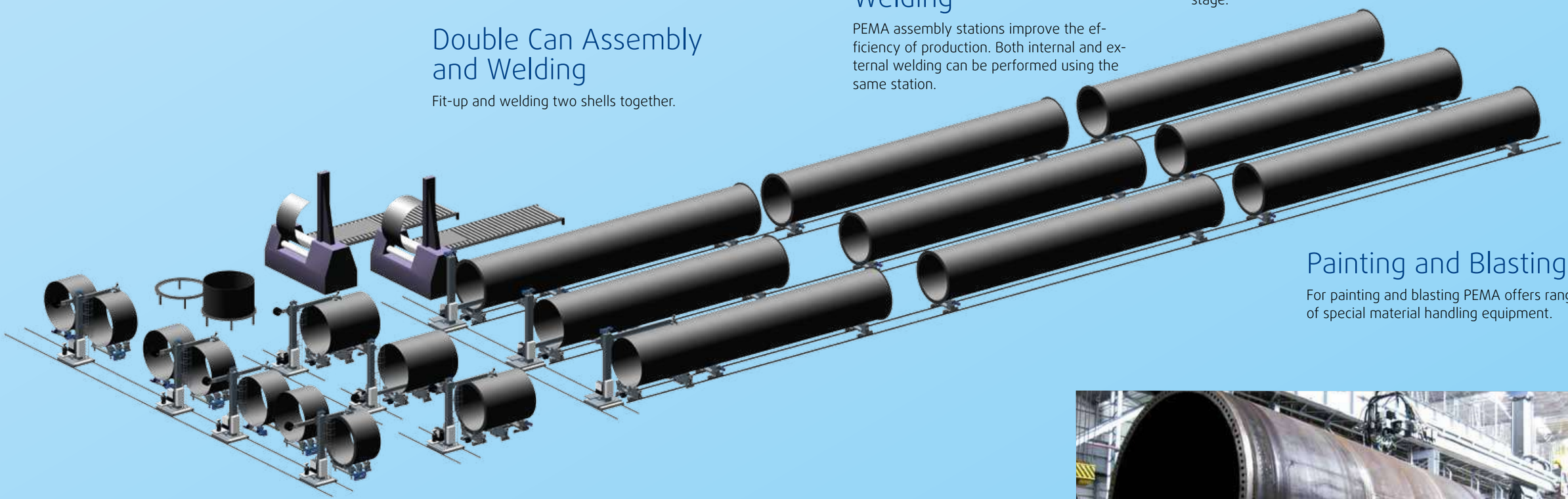
Fit-up and welding two shells together.

Section Assembly and Welding

PEMA assembly stations improve the efficiency of production. Both internal and external welding can be performed using the same station.

Quality Control and Section Transportation

Sections are transported via rails and it is not necessary to lift heavy workpieces during the quality control and internal fitting stage.



Painting and Blasting

For painting and blasting PEMA offers range of special material handling equipment.



Prefabrication and Rolling

In turn-key solutions, PEMA can deliver a complete production line that includes rolling.

Shell Manufacturing

Fully integrated column and boom welding and special rollers for efficient long seam and flange welding.



Flange welding

Onshore – Shell Fabrication

With PEMA onshore shell fabrication solutions, you can dramatically decrease the welding time spent during production. Special functions have been designed to make the workflow even more agile.

PEMA's solutions for shell and flange fabrication in onshore wind tower manufacturing ensures customer competitiveness in the market through excellent efficiency.

Solutions increase the arc-on ratio as well as the welding output during arc-on.

Special Functions to Increase Efficiency

- Multi-arc SAW welding with automated functions
- Conical shell tilting
- Fully auto-adjustable special PU rollers
- Fast rotation from internal to external welding in long seam welding
- End support rollers in flange welding
- Integrated grounding



Longitudinal seam welding station

Onshore – Tower Assembly and Welding

A PEMA tower assembly station and a small section assembly station can decrease fit-up and tacking time by up 50%. When the station is integrated with modern PEMA column and booms, it combines to create a station to join and fully weld circular seams of an onshore tower. It is based on a user-friendly, self-aligning roller bed technology and can be used with tubular and conical sections.

Transporting Shells and Sections

If the factory shop floor overhead crane capacity is limited, the PEMA TC side transportation carriage system can be added to keep the movements on the floor level. With systems like rail-guided roller beds and sideway carriages, PEMA is able to provide the equipment for transporting workpieces through production lines in the most efficient way. In floor transportation, the need for heavy and sometimes risky lifts is minimized and efficient transport between separate fabrication shops is facilitated.

Quality Control

During quality control, the use of PEMA control roller beds is recommended to ensure the easy and safe handling of shells or tower sections. A wide range of sizes is available to suit all loading needs.

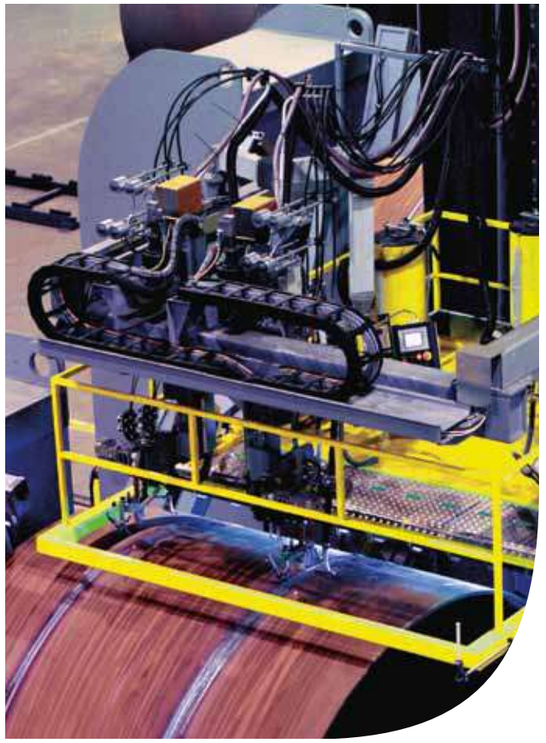
Section Assembly and Welding Lines Consists of the Following

- Hydraulically operated fit-up roller beds for aligning shells
- Accessories to help tack welding
- Column and boom with fully integrated Lincoln Electric Power wave welding machines
- Set of self-alignable rollers integrated with the station

PEMA external welding platforms, with a roller bed line or head and tailstock manipulator, provide a solution for the highest efficiency and production rate requirements. The welding platform allows you to reduce welding time when welding three shells together rather than two.

Benefits of a Welding Platform

- Less space required
- Faster welding times
- Fewer man hours
- Smooth integration of control technology
- Efficient consumable feeding

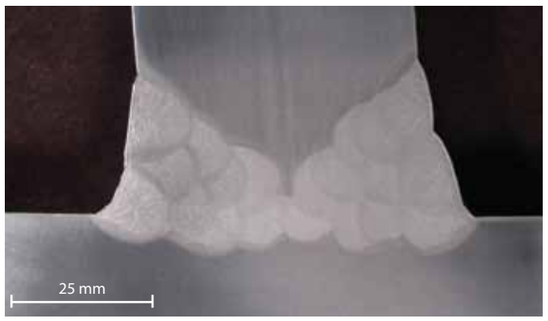


Onshore – Transportation, Surface Treatment and DoorFrames

Cutting and welding door and ventilation frames for tower sections is a surprisingly time-consuming task. As the world-leading welding automation and robotized application supplier, PEMA brings more value to its customers in the wind energy industry by providing a robotized door cutting and welding station.

Precise Cutting and Fast Welding

With extensive experience in automated panel production lines and robot welding applications for shipyards and heavy engineering workshops, PEMA has developed an automatic solution for cutting and welding tower door and ventilator frames. With its unique scanning method, the system ensures precise cutting and an extremely fast fitting. High-speed robotic welding dramatically shortens the welding time.



A Robotized Welding Station for Tower Door Frames Consists of the Following Units

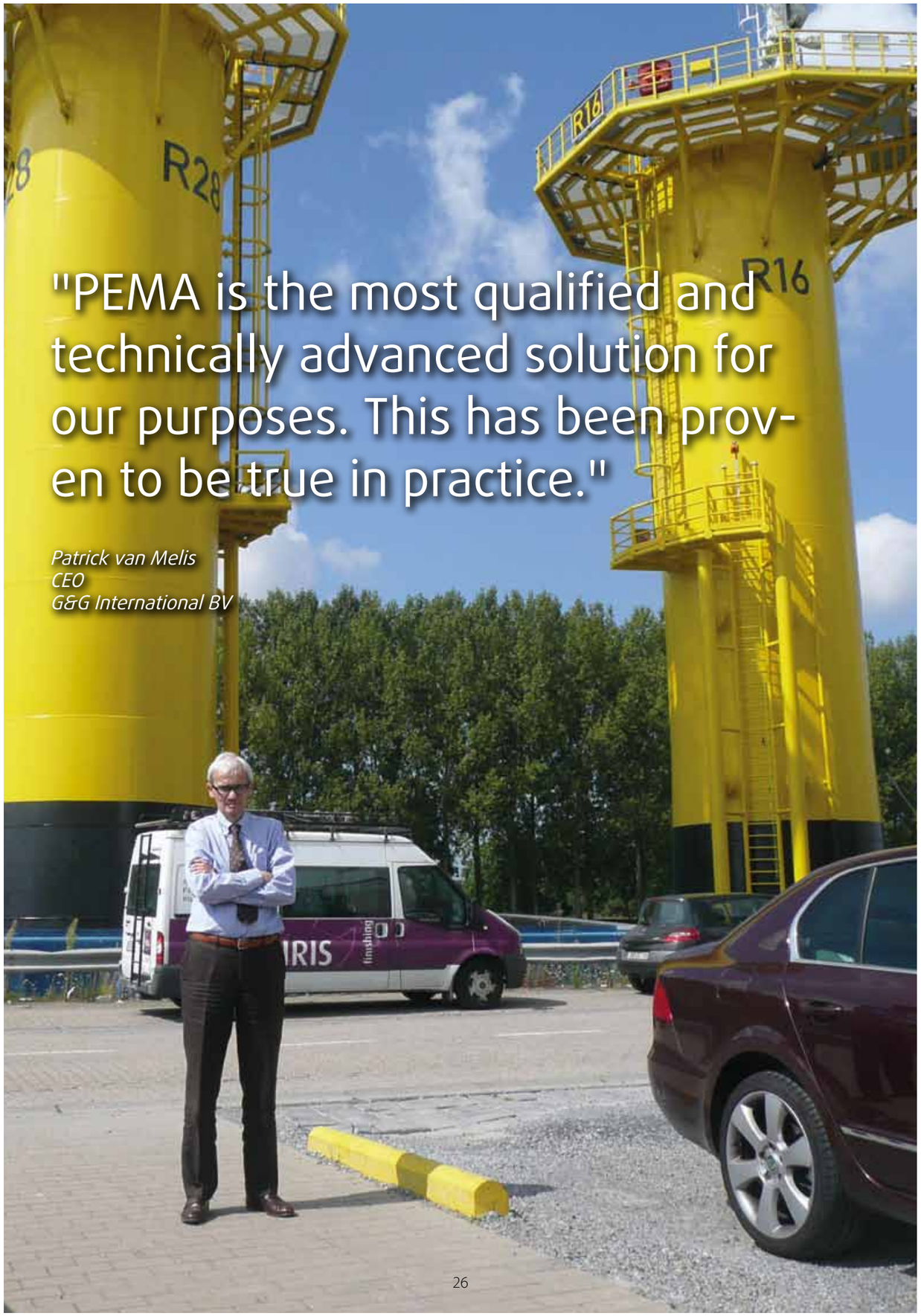
- Robot with automatic tool changer for laser measuring, plasma cutting and welding installed in heavy duty column and boom
- Special rotator for sections
- Suction table for plasma cutting
- Transport and lifting tool for door frames

The operating environment of the wind energy plant towers is harsh. Proper tower surface treatment is essential to achieve adequate durability for cost-effective service life cycles. PEMA offers functional and efficient tower section handling solutions for all surface treatment stages.

Handling Equipment for Shot-blasting and Painting Facilities

In hazardous working areas, it is important that the working equipment meets ATEX safety regulations to reduce risks to both personnel and the environment. PEMA provides a range of solutions for handling tower sections in automated and robotized blasting, metalization and painting stages with, for example, wireless control and electric power supplies to avoid cables on the surface treatment area floors.





Accredited Offshore and Onshore Solutions

G&G International BV

PEMA Windmill Tower Sections Assembly Lines and PEMA Offshore Foundation Welding Lines include a complete external welding station for heavy offshore structures and a 300-ton roller bed line with anti-creep functionality.

"We continue to work with PEMAMEK due to their provision of the most qualified and technically advanced solutions for our purposes," states Mr. Patrick van Melis, CEO of G&G International BV. He continues: "PEMA's project management and customer-oriented approach to solving our challenges has been very satisfying."

G&G entered the offshore wind market with successful deliveries of foundations to wind farms. A new production capacity further strengthens G&G's position in the offshore foundation market and also makes it possible to fulfill major orders in the future.



Alstom Brasil Energia e Transporte Ltda

A turn-key delivery with start-up, training and supervision of welding automation equipment for wind mill tower production. The delivery includes a PEMA wind tower fabrication line: PEMA column and boom, roller beds and Lincoln Electric PowerWave submerge arc welding machines integrated with the PEMA Weld Control system.

Mr Roberto Varela, Welding Process Engineer of Alstom Spain, who acted as specialist in the windmill tower production consulting in Alstom Brazil, states that: "Pemamek was chosen because of their great technical solutions, value for money and delivery times. Pemamek's references were also very positive. My experience of PEMA products in Spain convinced me to continue working with PEMA. In addition, increasing productivity solutions, specific details and the quality of PEMA products helped us to decide in their favor. "

Mr Roberto Bochi, Production Manager of Alstom Brazil in Canoas adds: "PEMA's customer service has been exceptionally good, starting from the first offer and continuing throughout the project execution. PEMA met the agreed delivery times punctually, which was very important to us."





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