

# ENVIRONMENTAL ENERGY

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# CREATING A FUTURE IN ENVIRONMENTAL ENERGY MEANS INNOVATING IT TOGETHER TODAY

Welcome to the world of Yaskawa Environmental Energy, where innovation and technology leadership capture the potential of environmental energy for wind, marine and special industrial turbo applications. This is where we maximize the output for high-quality power generation and efficient energy use.

Yaskawa Environmental Energy / The Switch is your specialist in advanced drive train technology, adding value by collaborating and networking to lower the cost of new energy for the market. Our proven engineering designs enable you to transition to advanced technology, scalable production and engineering capacity, and agile business models.

## **Now is the time to switch to the right technology and partner for a brighter future**

Our success has been built from making the most of new energy. With innovative people and cutting-edge technology, our mission is to make sure that no potential power gets lost.

Customers come to us because they know we have the passion and skill to make things happen. Our proven concepts ensure reliable future-proof grid compliance and maximized energy output.

## **Switch up to permanent performance**

What makes us different is that we guarantee great results through genuine collaboration. As part of the big switch to new energy, we empower you to move ahead with greater profitability.

**1 | Switch to smarter technology**  
Built-in simplicity, robustness and reliability

**2 | Switch to permanent performance**  
Revolutionary solutions, unlimited production capacity and extended system lifetime

**3 | Switch to a flexible business approach**  
Ultimate customer satisfaction with our 100% focus on your business



We have delivered over 15 GW  
of installed capacity since starting in 2006.





We delivered the world's largest direct-drive PMG a decade ago.





# PERMANENT PERFORMANCE ANY POWER. ANY SPEED

*Today, we're delivering electrical machines based on permanent magnet technology for generators or motors to world-class leaders in selected environmental-energy conscious industries.*

## **Widest portfolio of permanent magnet machines (PMMs)**

The Switch PMMs cover all power applications from 1 MW to 10 MW and higher. Our product portfolio includes direct-drive, medium-speed and high-speed PMMs.

## **Energy efficiency**

A PMM delivers high-efficiency performance of up to 98% over the entire operating range. The true strength of a PMM is in partial load situations, where wind turbines, seafaring vessels and other equipment operate most. A PMM is typically 2–4% more efficient at full load and 10% more efficient at partial load compared with traditional machines.

## **Compact size, design flexibility**

Thanks to improved density, a PMM is more compact and lightweight, leading to greater design flexibility with limited space restrictions.

## **High power density**

A synchronous PMM contains Neodymium-Iron-Boron (NdFeB) magnets, materials with a very high flux density. This makes them ideal for various speed generators throughout the entire speed range. The magnet field is created with almost zero losses. Each PMM is designed with special, patented magnet shapes and arrangements to match specific application conditions.

## **Operational reliability**

Our PMMs provide exceptional availability and productivity. By eliminating cogging and taking advantage of advanced thermal management, we have reduced mechanical stress, improved reliability and extended overall lifetime.



# FULL POWER FORWARD

## OPTIMIZED AS A PERFECT PACKAGE

*The Switch full-power converters are optimized to work with the entire range of PMM concepts. This ensures that you effectively capture all power from highly variable sources of environmental energy and can operate efficiently in fluctuating operational conditions.*

### **Future-proof your electricity quality**

Designed for the highest level of performance, our robust line of converters ensures future-proof electricity quality to meet ever-stricter network requirements for harmonics, flicker and fault ride-through (FRT). In distributed power applications, our full-power converters create a stable grid with a THD of <1.5%, the lowest in the industry.

### **Easy power factor control**

Our full-power converters enable easy power factor control, which allows a fast response to steady and transient grid disturbances.

With active front end (AFE) frequency drive technology, The Switch converter enables Power Take In (PTI) and Power Take Out (PTO) modes in marine applications, allowing a PMM to be operated either as a motor or a generator.

### **Rugged design for exceptional operation**

Lightweight construction, modular power packs and customizable software allow our converters to match all design specifications and environmental conditions. The rugged design and FRT functionality provide exceptional fault tolerance and grid support.

### **Reliability in the harshest conditions**

Not as sensitive to changes in the network as traditional converters, The Switch full-power converters offer advantageous control flexibility to adapt to ever-changing operating conditions. The panel is designed for the harshest conditions and can be easily accessed for installation and maintenance.



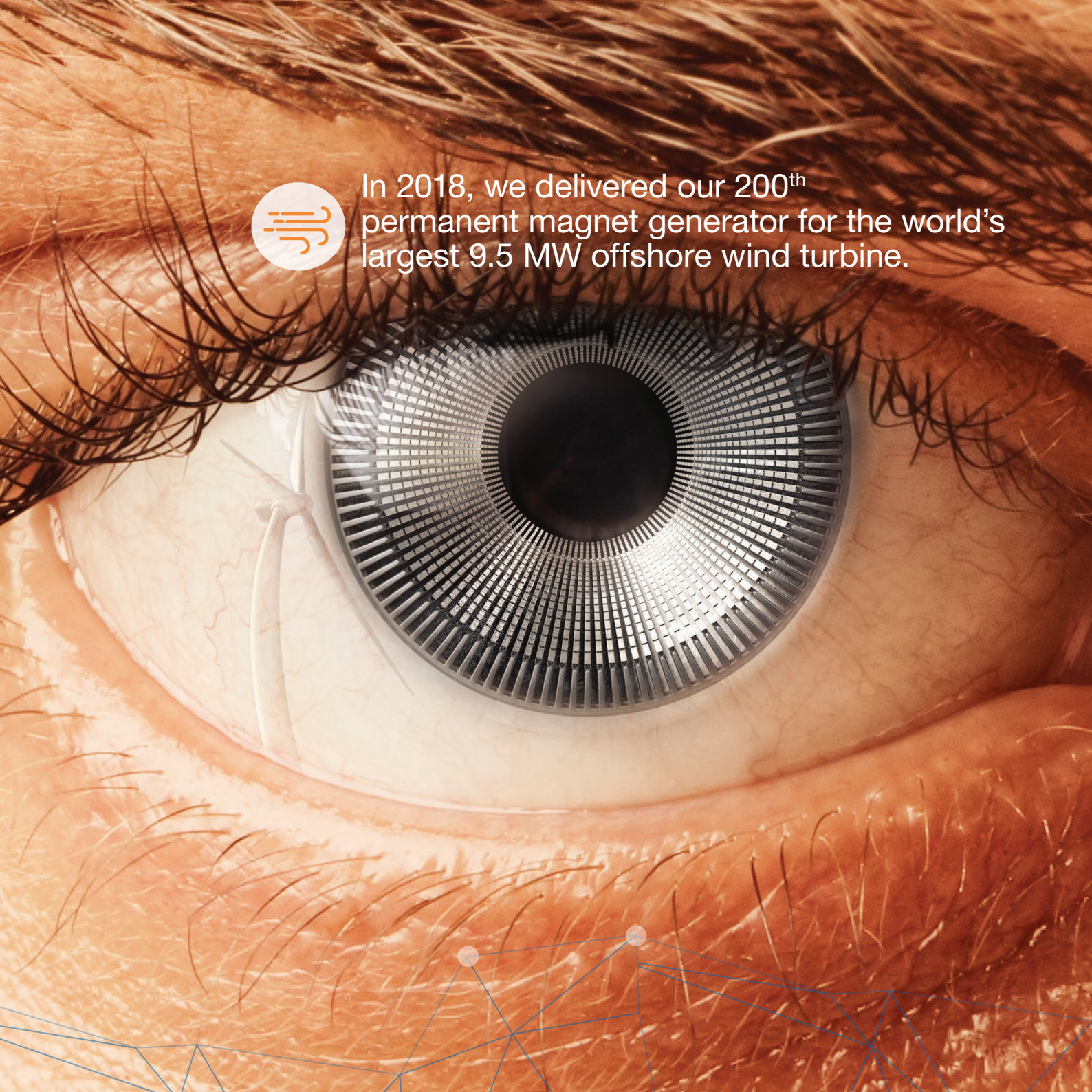
To date, we have delivered  
6,000 full-power converters.







In 2018, we delivered our 200<sup>th</sup>  
permanent magnet generator for the world's  
largest 9.5 MW offshore wind turbine.





# VISION FOR WIND

*Have your sights set on reaching higher power or better performance with your next design? Delivering 10 MW class PMGs is everyday business for us. We look forward to creating the next vision of wind with you.*

## Raise annual energy production

**High availability** – We have pioneered PMG technology for wind. PMGs ensure fewer failures since they have no wearing parts, are more compact and require only minimal maintenance. The Switch PMG drive trains typically ensure an average turbine availability of 97% or higher in all operating conditions.

**Great efficiency curves** – PMGs demonstrate higher efficiency at partial loads, resulting in higher efficiency curves for wind and other renewable energy applications. They start producing power at lower speeds.

## Boost electricity quality

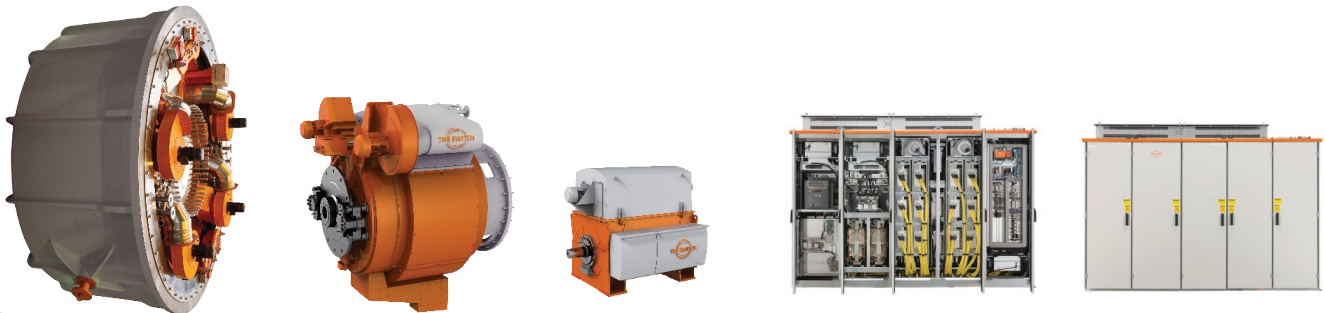
**Superior grid connection** – Our FPCs support fault ride-through (FRT) and fulfill the world's strictest grid code requirements. They also have low flicker, minimal electrical noise emission and a THD of <1.5%, the lowest in the industry.

## Minimize total life-cycle costs

**Capital investment** – We seek to minimize total life-cycle costs by optimizing designs through close cooperation with our customers. Every solution is purpose-built for its specific operating environment to significantly lower lifetime O&M costs.

**Operation and maintenance** – All of our solutions feature a highly serviceable design to speed up maintenance routines. Our 24/7 technical support with remote access allows you to implement a proactive service plan, avoiding unexpected downtime and costly failures.

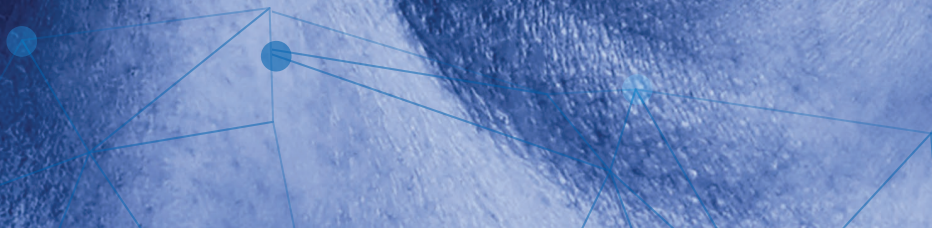
**Extend equipment lifetime** – Our current designs are already calculated to last more than 25 years. Lengthening the average lifetime of conventional technology by an additional three to five years can lower your cost of energy dramatically.







During the past 10 years, we have delivered over 1,000 Power Drives to hundreds of vessels around the world.





# MIND FOR MARINE

*Ready to cut emissions and future-proof your vessel? As masters of DC distribution, we'll help you switch to absolute endurance.*

## Boosting energy efficiency

PM technology provides unmatched power density, energy efficiency, design flexibility and operational reliability.

## Cutting fuel consumption

We offer all types of vessels the opportunity to take advantage of exceptional energy efficiency, also at partial loads. This enables ships to lower their operational costs by optimizing the fuel consumption of the main diesel engine.

## Flexible design superiorities

A PM solution is compact with lower weight. It offers unsurpassed flexibility and a smaller footprint for all kinds of design configurations, especially when space is a critical factor.

## Lower emissions

PM technology significantly reduces SOx and NOx emissions, as well as noise.

## Applications

**PM shaft generator** – With The Switch PMM and Power Drive, you can keep the auxiliary generators off most of the time and operate at variable speed while generating electricity. Eliminating constant speed means true fuel savings.

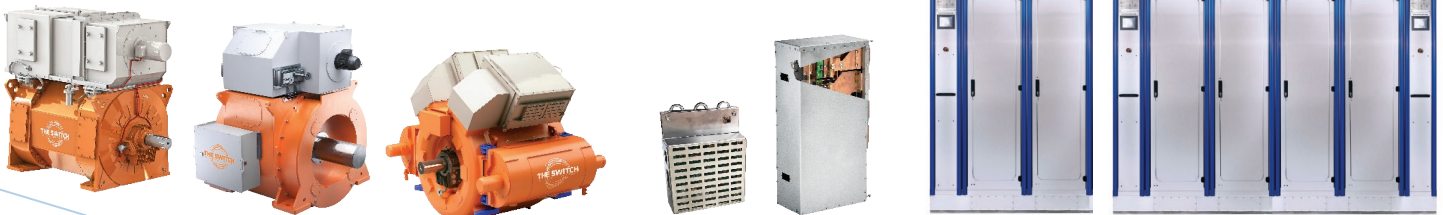
**Electric propulsion** – Our PMM driven by a Power Drive offers the accurate and adjustable speed control needed for dynamic positioning in offshore and special vessels.

**Masters of DC distribution** – We offer the world's smartest solution for a multi-megawatt DC power system using a unique DC-Hub and an Electronic Bus Link (EBL) or Electronic DC Breaker (EDCB) that ensure stable and secure operation. These increase system availability and redundancy while eliminating the use of an AC main switchboard.



## INTRODUCING POSEIDON POWER

Become the master of DC distribution with our Poseidon Power Portfolio and achieve future flexibility.





In 1997, we delivered our first solid induction motor to a water treatment facility. Today, we have continuous volume orders for paper machine vacuum systems running at over 10,000 rpm.



# PASSION FOR SPEED

*Switch up to standalone drive train technology for turbo applications and reach speeds of up to 20,000 rpm with power ranging from 100 – 600 kW. This is now possible with our proprietary solid rotor motor technology, which is available as standardized packages.*

## **No gearbox. No problem.**

The Switch direct-drive, high-speed motors allow you to eliminate the mechanical gearbox. Our robust solid rotor motor eliminates the need for a gearbox, while allowing the application to reach higher speeds and unmatched energy efficiency. Together with frequency converter control, you also get variable speed over the entire operating range.

## **Simply solid results**

A solid rotor induction motor is a special type of induction machine with a non-laminated rotor construction. The advantage of its stiff construction is unmatched stability and balance, offering exceptional rotating system reliability for demanding high-speed applications, such as blowers, compressors, pumps and vacuum systems.

## **Unsurpassed efficiency**

Full speed control ensures operational efficiency and energy savings.

## **50% more compact**

The structure is more compact and lighter in weight, requiring up to 50% less space than a conventional design.

## **Superior durability and reliability**

The solid rotor construction provides high mechanical integrity, rigidity and stability, including exceptional thermal durability, to reach higher motor efficiencies.

## **Fewer components, lower maintenance needs**

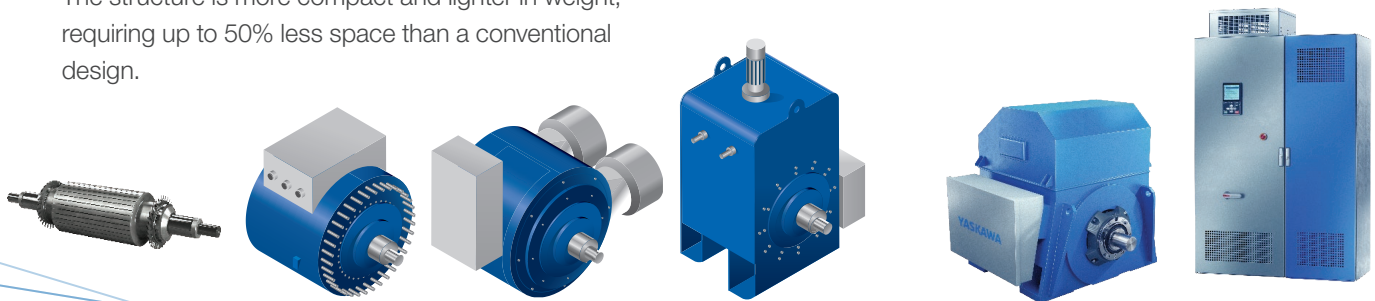
Gearbox problems are no longer an issue. Fewer components also reduce the need for extra parts and maintenance.

## **Complete package with variable speed drive**

The Switch offers a complete package, including the variable speed drive and motor filters in panels, along with the electrical machine.

## **Investment payback in 2 years**

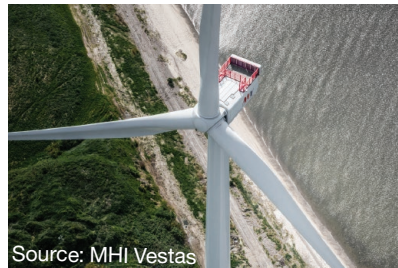
Each application takes advantage of full speed control over the entire range, ensuring system efficiency and energy savings. Companies have realized a return on their investment in just 2 years.



# SOLID TRACK RECORD REFERENCES

## Wind

With 200 units delivered in serial production, we are now a sole supplier of PMGs for the world's largest 9.5 MW offshore wind turbine.



Over 6,000 liquid-cooled full-power converters have been delivered since 2008 to Goldwind's 1.5 and 2.5 MW wind turbines.

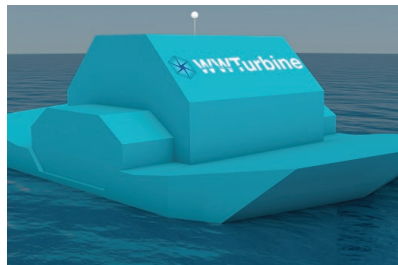


Our first high-speed 5 MW drive train packages, installed in 2013, have continuously operated successfully for Chongqing Haizhuang Windpower Equipment's offshore wind power projects in China.



## Wave and tidal

Water Wall Turbine Inc. selected our 500 kW converters for its innovative self-floating power plant to extract potential and kinetic energy from large, fast-moving water currents to convert into electric energy.



## Marine

Our largest marine contract to date is to provide 16 DC-Hubs and 32 frequency converters for a revolutionary new shuttle tanker concept developed by Teekay and Wärtsilä. The four tankers will be built by Samsung Heavy Industries in South Korea.

North Sea Giant, one of the world's largest subsea construction vessels (OSV), installed an innovative solution based on our unique Electronic Bus Link (EBL). The new solution enables the vessel to run just 1 of its 3 diesel engines for many operations, as well as reduce fuel, emissions and maintenance costs significantly.

Eidesvik's offshore supply vessel (OSV) Viking Princess now operates with only 3 generators instead of 4 after a pioneering retrofit of an energy storage solution with an advanced The Switch DC-Hub at its heart. The move helps the 5,381 GWT ship save around a ton of fuel every day.

To date, over 40 PM shaft generators have been ordered and delivered through WE Tech, cutting costs when powering onboard electric networks. The direct-drive PM shaft generator on Terntank eliminates any step-up gearing.



# THAT ARE SWITCHED ON

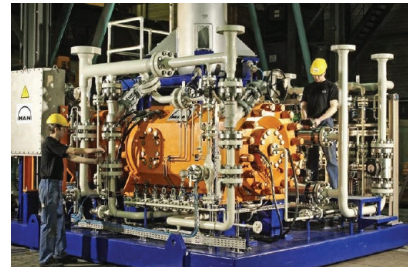


## Turbo

Runtech of Finland has placed continuous orders with us for high-speed motors to be used in its paper machine vacuum systems that run at over 10,000 rpm.

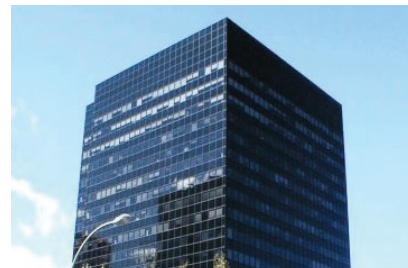


Swiss MAN Turbo chose our solid rotor technology for its high-power compressor of 8 MW, 10,000–12,000 rpm, for a gas application that survives subsea installation with aggressive gases.



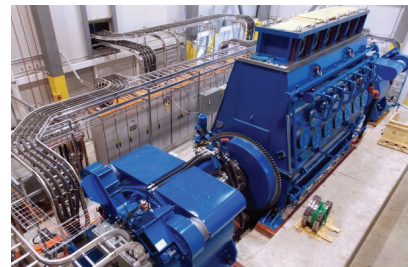
## CHP

The 18-storey Gateway building in White Plains, NY, chose three of our CHP converters running in parallel to provide energy efficiency and unfailing reliability.



## Energy storage

US-based SustainX chose our 1.65 MW electrical drive train for its megawatt-scale isothermal compressed air energy storage system, the first of its kind in the world.



# AGILE PRODUCT AND PRODUCTION

## LOWER YOUR RISK

*How flexible and responsive are you to market change?  
We bring you two unique advantages: our agile product and  
production – and our agile way of working with you.*

### Continual market disruption

Today's business needs to constantly build on uncertainty. And for environmental energy companies especially, we have seen enormous shifts in the past few years from a mass-production manufacturing focus to a more customer-centric approach.

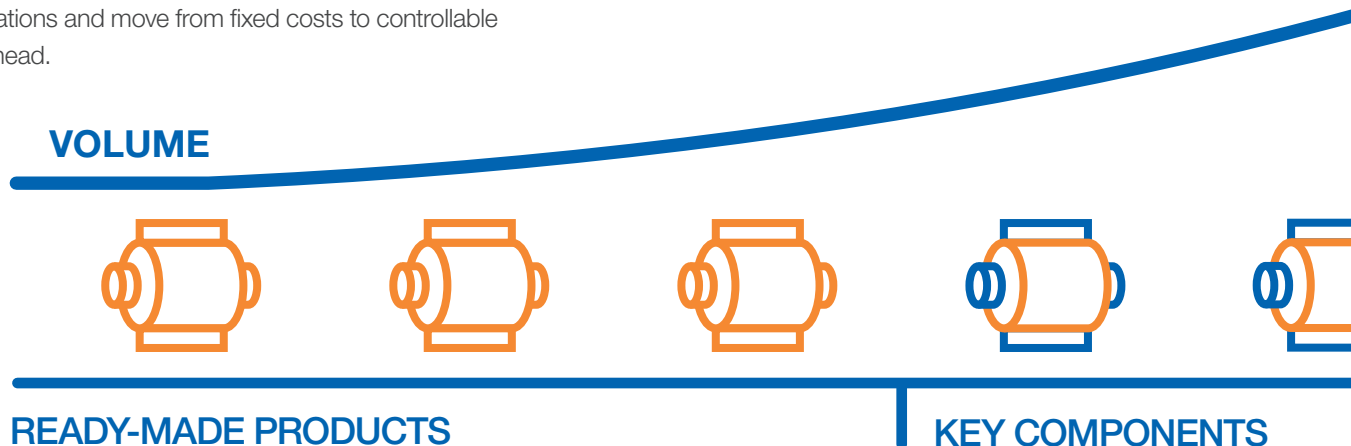
The way forward demands a new type of flexibility and mobility never seen before in manufacturing-based businesses. It requires a rapid transfer of technology into new growth areas, often with local content from OEMs.

Embracing a networked approach has been a hallmark of our company from the start. You can scale your operations and move from fixed costs to controllable overhead.

### Agile positioning and product

We offer you a new model based on agile positioning. It allows you to go beyond vertical integration and embrace a flexible and asset-light model built on financially sound principles that better respond to changing needs.

This method engages our customers to promote product discovery and innovation. And helps us engineer the next generation of technology together by tailoring it to suit specific operating conditions or breakthrough ideas for greater energy production. It creates a more dynamic way of collaborating by sharing in the ultimate results.

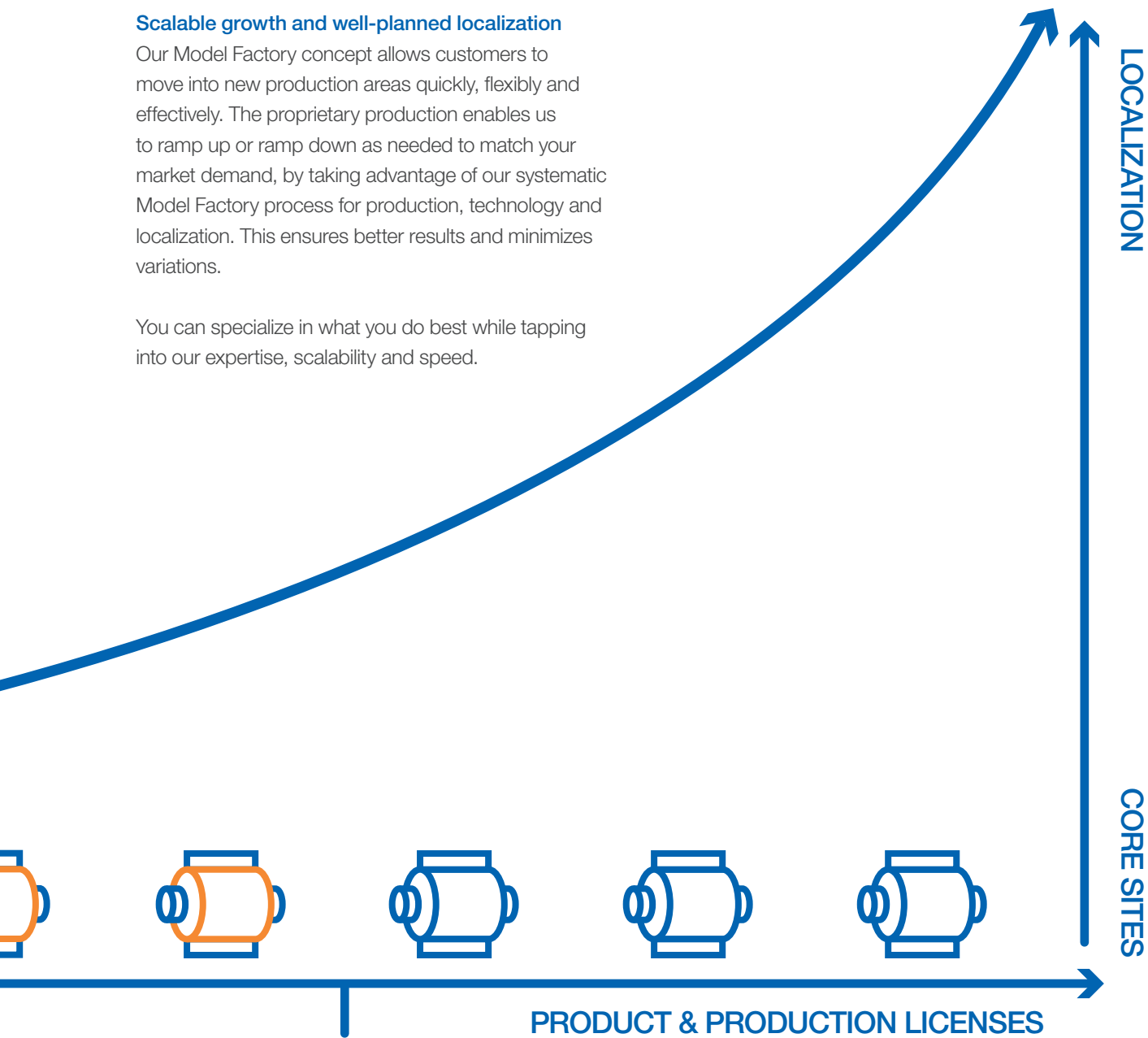




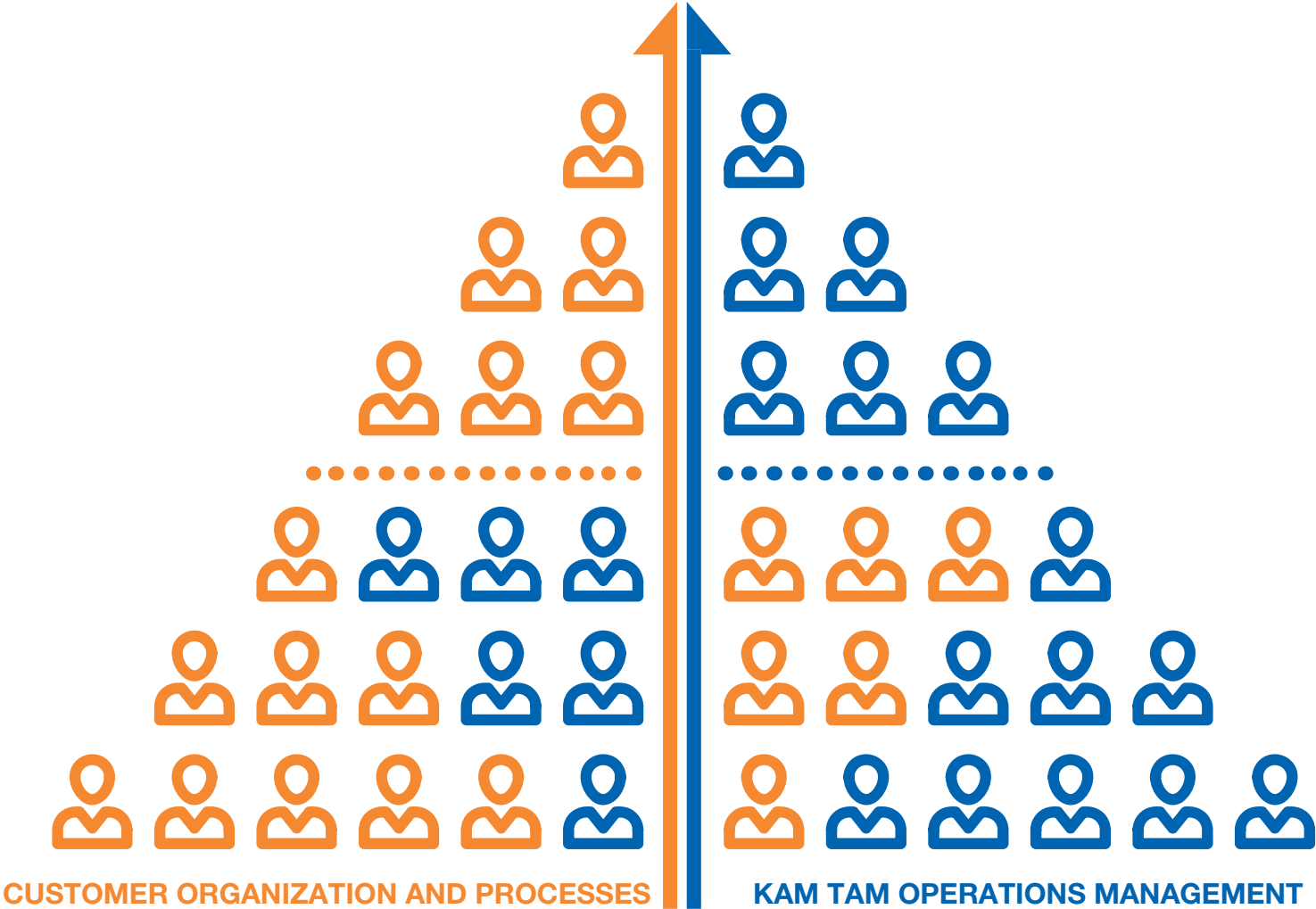
**Scalable growth and well-planned localization**

Our Model Factory concept allows customers to move into new production areas quickly, flexibly and effectively. The proprietary production enables us to ramp up or ramp down as needed to match your market demand, by taking advantage of our systematic Model Factory process for production, technology and localization. This ensures better results and minimizes variations.

You can specialize in what you do best while tapping into our expertise, scalability and speed.



CUSTOMER INTIMACY  
BRINGS JOINT SUCCESS





# AGILE WAY OF WORKING

## BE READY AND RESPONSIVE TO CONSTANT CHANGE

*Thanks to our unique and flexible business model, we can complement your strategy to manage risks, add capabilities – and grow confidently.*

### **Agile business model innovation**

Agile positioning means creating the best way to work together and focus on each other's core expertise and added value.

Our customers can buy designs, components, generators, full-power converters, motors – or complete systems.

We can manufacture a full ready-to-use product, either one that is already commercially available or a solution that is tailored to your needs. You can insource specific components and even acquire licenses.

### **Whatever suits your business best**

Whichever business model you choose, we provide a platform for collaboration that allows you to advance step by step with production and processes that support you with the greatest profitability.

### **From core sites to localization**

When starting out, tapping into production at our core sites offers you the benefits of low risk, high efficiency, quality assurance and sufficient capacity. When you need more localized content, we can support you with preplanned localization so you gain from favorable labor costs and simplified logistics.

### **Flexibility every step of the way**

We're there to support you with every step. Our flexible approach shortens time-to-market and allows you to focus on the areas of your business that bring you the greatest value.

### **Services to help you reach your goal**

Our person-to-person services are tailored to your needs to extend the system lifetime of your equipment. Component simplicity, fewer mechanical and electrical parts, and less maintenance ensure exceptional availability. We guarantee you the highest achievable reliability and productivity.

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