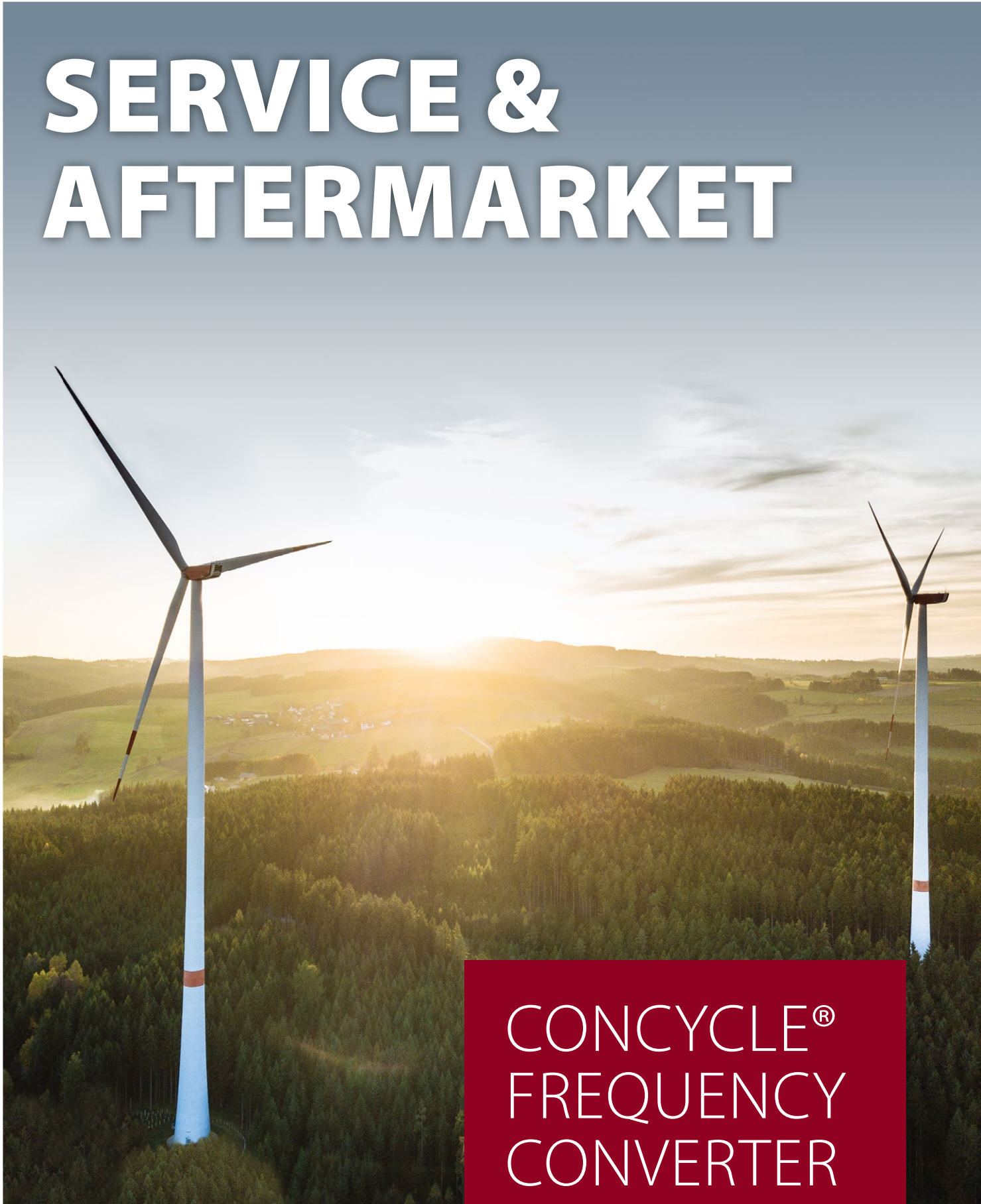


SERVICE & AFTERMARKET



CONCYCLE®
FREQUENCY
CONVERTER

WOODWARD: INNOVATIVE SINCE 1870

Woodward has been actively shaping the wind energy industry for more than 20 years. The company has shown consistent development, and the name Woodward has been synonymous with innovation since 1870. Today, more than 7,000 members in 17 countries develop and produce energy control solutions for aircraft and industrial engines, turbines and power plants. Leading OEMs (Original Equipment Manufacturers) use our products and services worldwide.

The Woodward brand stands for excellent quality in both technical design and aftermarket support. Woodward's CONCYCLE® Wind System sets technical and commercial standards in the efficient use of wind energy. This technology has made a significant contribution to the success of wind turbines in the megawatt class, ensuring operators a high level of availability and the best possible efficiency for their facility.

More than 17,000 Woodward frequency converter systems are currently in use globally in onshore and offshore projects, with a total output of approximately 36 gigawatts. That makes Woodward one of the leading independent frequency converter manufacturers for wind turbines.

The frequency converter is one of the key components in a wind turbine. With a service life of 20 years and more, wind turbines are a large investment. So it is good to have a partner that you can count on for the long term. Profit from our expertise and experience – Woodward is your reliable supplier and development partner for wind turbine converters.

WOODWARD MILESTONES WIND CONVERTER SERVICE

Until

- 1995 – Development of the variable-speed CONCYCLE® generators and power conversion technology for use on ships, in UPS and wind power plants
- 1996 – Installation of the first 500 kW CONCYCLE® wind converter system in Germany
- 1996 – Long-term technical support established for customers
- 2000 – First installation in the USA
- 2000 – Opening of service centre in the USA
- 2000 – First 1.5 MW offshore installation
- 2000 – Launch of the liquid-cooled IGBT module
- 2000 – Start of customer training
- 2001 – First installation in India
- 2001 – First 1.5 MW installation in Japan
- 2002 – First installation in China
- 2002 – Delivery of the 1000th CONCYCLE® converter system
- 2003 – Launch of the 'Soft Ride Through' solution
- 2004 – Opening of service centre in Japan/ Chiba; later Makuhari
- 2004 – 3.6 MW offshore installation in Ireland
- 2004 – First 5 MW installation

- 2007 – Opening of service centre in China / Tianjin
- 2008 – Launch of the CSC4 control for the CONCYCLE® converter on the NGx platform
- 2008 – DC-Limiter available for 'Low Voltage Ride Through' performance (active FRT™)
- 2011 – Opening of service centre in Bulgaria / Sofia
- 2011 – Opening of service centre in India / Pune
- 2011 – Opening of Niepolomice production site for converter production in Poland / Krakow
- 2013 – First high altitude installation in Ethiopia (2,750 m)
- 2013 – Start of local Woodward production in Brazil / Campinas
- 2014 – Opening of service centre in Brazil / Campinas
- 2014 – Installation of new generation MP1 CONCYCLE® wind converter
- 2016 – Presentation of 4MW CONCYCLE® full size converter
- 2017 – Woodward Upgrade to CSC4
- 2017 – Woodward Service Stack 4.x
- 2018 – Delivery of 1500th CONCYCLE® MP1 with Woodward own IGBT design
- 2018 – Universal Woodward Service Stack
- 2018 – Woodward Condition Monitoring



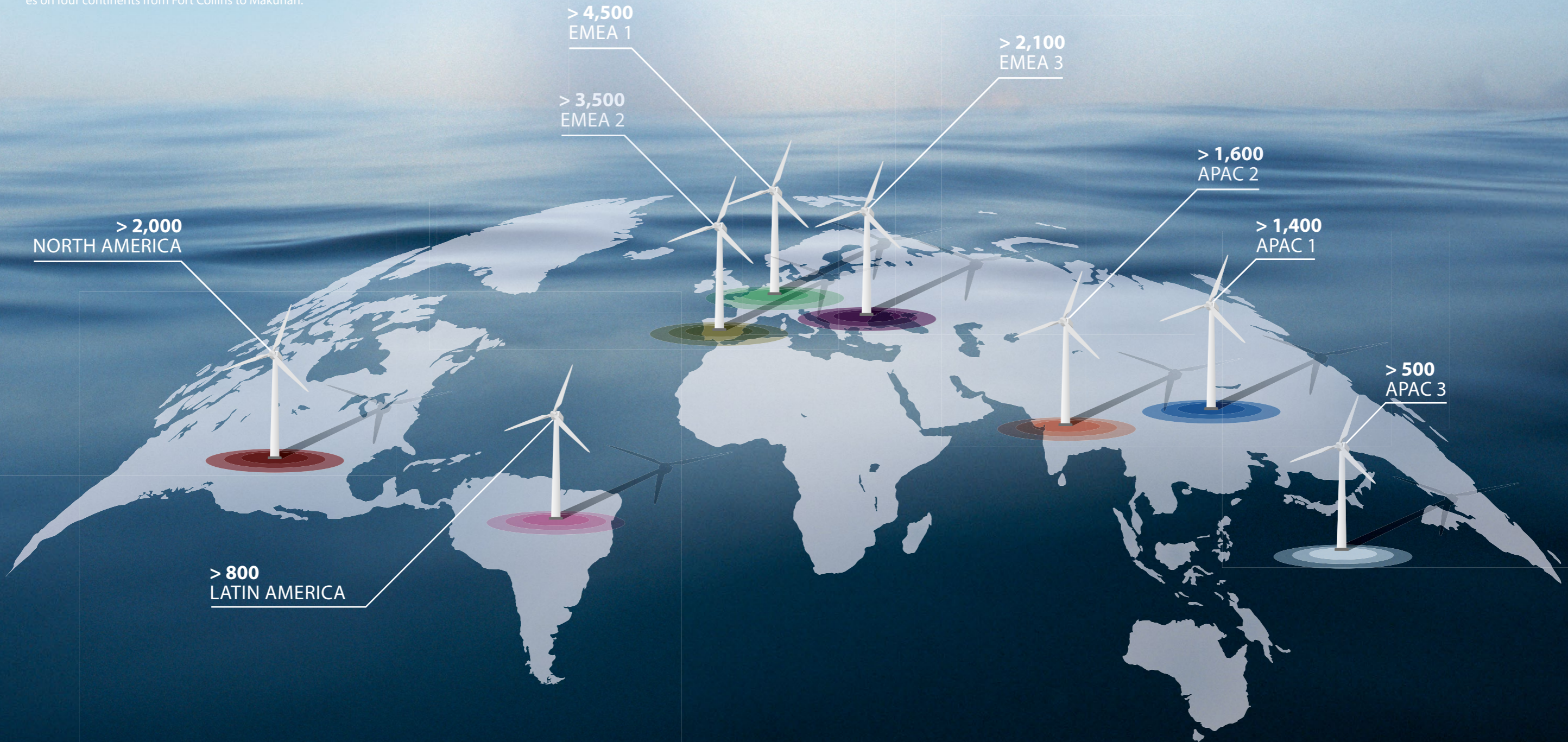
WOODWARD: WIND ENERGY WORLDWIDE

Woodward converters are operating successfully worldwide: in Europe, Asia, Africa, Australia, North and South America.

In all these regions, Woodward frequency converters are subject to varying conditions and requirements. We are also there to support you in eight wind energy support centres with eight branches on four continents from Fort Collins to Makuhari.

EXPERIENCE & EXPERTISE

- More than 20 years onshore experience
- Over 17 years of offshore experience
- More than 17,000 converter systems shipped
- Installations in 50 countries
- Local support in 8 countries on 4 continents



status: May 2018

THE WOODWARD SERVICE PROMISE

With a service life of over 20 years and similar investment obligations, you need a strong partner that offers excellent service. You can always rely on Woodward. We are there whenever you need us – be it now or in 20 years.

We offer support during the commissioning phase and throughout the entire service life of your wind turbines, enabling you to operate your wind turbines without any disruption, cost-effectively and with maximum productivity.

SUPPORT

Availability is a key factor for the reliable operation of a wind turbine, which is why Woodward's experienced technicians are available around the clock. Our experts offer technical support and help with commissioning and maintenance of your system.

We measure our success as a service organization based on customer satisfaction: While we will have in-depth discussions during annual handshake meetings, we are happy to discuss any ideas or concerns you may have at any time.

CONTRACTS & TRAINING

Select the appropriate elements from the Woodward contract portfolio that best suit your needs. Depending on the required service intensity, we can offer guaranteed repair or response times, manage spare parts inventory and make recommendations for future service.

With the right training you will be able to carry out your own maintenance work and troubleshooting. Modular training courses to cover everything from basic technical information about frequency converters, to commissioning and maintenance, through to extensive error analysis.

PRODUCTS

Woodward invests in product upgrades and retrofits in order to maintain high availability and to ensure improvements. This primarily focuses on the main components of the converter and involves close cooperation between the CONCYCLE® development department and the Woodward Aftermarket department. The development team also uses knowledge gained from this service to develop new converter technology.

An overview of Woodward products:

- Woodward Upgrade to CSC4
- Woodward Service Stack – One Universal Solution
- Woodward Converter as Field Exchange
- Improving Performance

DIGITAL SOLUTIONS

Unleash the full potential of monitoring and analytics to benefit from insight and historic information to improved performance and support.

The Woodward Condition Monitoring Solution provides centralized access to data at a glance and enables performance optimization of the installed assets. As retrofit for CONCYCLE® systems equipped with a CSC4 controller this solution is available for more than 12.000 installed converters.

YOUR SERVICE-PACKAGE



Support



Contracts & Training



Products



Digital Solutions



"As a service partner with more than 20 years experience in the wind converter business we provide rich technical expertise combined with fast response times enabling the highest productivity and price certainty throughout the lifecycle of your investments."

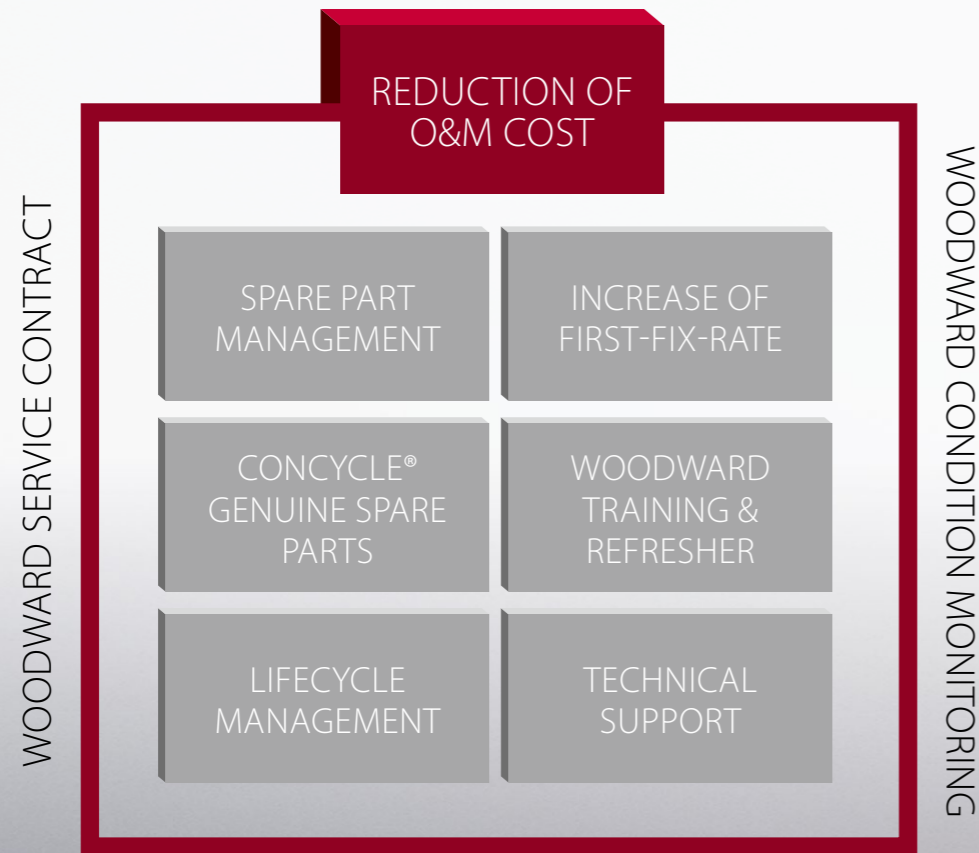
Our Woodward RPS service promise



WOODWARD AFTERMARKET & SERVICE PORTFOLIO

The wind turbine converter plays a decisive role as major system component. All integral parts of a Concycle® system have been specifically designed to meet highest reliability and runtime requirements. Woodward is your strong partner when it comes to operate converter systems efficiently over 20 years and beyond. Based on established standards derived from our aerospace business we focus on system optimization and interaction of all selected component.

We have developed a full portfolio to support you during the lifecycle of the converter. Spare Part Management including Concycle® Genuine spare parts, repair as well as a lifecycle and obsolescence management. To increase your first-fix-rate we provide specific and in-depth training and refresher as well as a highly qualified technical support – remotely or on-site. A Woodward Service Contract as well as our brand new Condition Monitoring Solution (CMS) safeguard your assets or systems under service – all aiming to reduce your O&M costs.





MAINTENANCE

Ensure that the converter is always operating to its full potential by carrying out regular maintenance work on your CONCYCLE® systems.

Simply use the maintenance components that meet your needs. You are free to choose from a performance review, safety and function expansion packages, through to preventative measures including replacement recommendations.

MAINTENANCE PORTFOLIO

Performance review

Inspection of the installed CONCYCLE® systems in terms of performance, and recommended action for further optimisation.

Safety package

Inspection of all safety relevant functions and recommendations for actions.

Performance improvement package

Performance improvements and extended functions of CONCYCLE® systems using upgrades and retrofit kits. Lifecycle management engineering based on our practical experience.

Preventive maintenance

Preventive maintenance of Woodward systems can help you extend your converter's useful life and to avoid unplanned downtime at your wind farm.

Emergency support

In the case of unexpected operating conditions, we can support you quickly and competently on site through our international service centres.

COMMISSIONING

Woodward engineers can support your on-site teams during the commissioning phase. If required, we can carry out the entire commissioning process for you.

To ensure that everything runs smoothly during and after the commissioning phase, we recommend our initial spare part package – tailor-made to suit your project.

SERVICE PERFORMANCE

We are a reliable partner and are able to support you throughout the entire lifecycle of your wind farm. Our service performance on-site shows a first fix rate of > 99 percent and an average response time of < 2 hours for the technical remote support.

We are continually improving our service performance and regularly incorporate your feedback into our future service offerings. We always aim to ensure that your wind farm reaches its full potential.



WOODWARD TRAINING

Build your team's skills: For a high first-fix rate, more flexibility and optimized costs. Our modular training program shares the expertise of a Woodward expert and allows you to commission, perform maintenance and troubleshoot CONCYCLE® converter systems – professionally and safely.

From the basics all the way to a train-the-trainer program: select the right level to meet your individual needs in combination with a Service Contract. The training modules offer both courses at Woodward or at your company site – either in German, English or Turkish language, whatever suits you best.

MODULES 1 TO 4

These modules systematically build upon each other and contain information about technical components and installations, how to use the software, commissioning and maintenance of frequency converters. The modules are also conceptualized as a

'train-the-trainer' version. That means that you can participate in a separate qualification program to receive a train-the-trainer license by Woodward. This program is available to Fast-Contract customers exclusively.

MODULES 5 TO 8. x

Our expert training: these modules cover much more than just the basics. For example, you will gain expert knowledge about extensive troubleshooting or you can even make use of our exclusive offer for a tailor-made training. We will be happy to suggest the right training modules to you.

MODULE 1: THE BASICS

Components & installation of the converter

Optimized adjustment with technical support through basic technical knowledge of the frequency converter.

MODULE 2: SOFTWARE

Software usage & data analysis

Structure, use and options for the individual programs – Goal: independent troubleshooting.

MODULE 3: COMMISSIONING

Commissioning, fault clearance & replacing components

Independent commissioning of the system including practical troubleshooting & replacing components.

MODULE 4: MAINTENANCE

Independent maintenance

Maintenance theory including maintenance manual & maintenance protocol, practical implementation of maintenance work.

MODULE 5: TROUBLESHOOTING

Extended troubleshooting

Methods for troubleshooting + practical part including connection establishment, evaluating data and measurements, handling faults.

MODULE 6: COMPACT COURSE

Refreshing modules 1 to 4

CONCYCLE® basics, functions of frequency converter systems, software, commissioning, maintenance.

MODULE 7: CUSTOMIZED TRAINING

Content tailor-made to suit you

Define the theoretical and practical focus of the training course for the converter or related areas.

MODULE 8.1: WOODWARD UPGRADE TO CSC4

Controller Upgrade

Specific Training to Upgrade an installed CSC3 controller to CSC4

MODULE 8.2: WOODWARD SERVICE STACK

IGBT Stack Upgrade

Specific training to upgrade installed IGBT stacks to the universal Woodward Service Stack





SERVICE PACKAGES

Woodward offers comprehensive service performance packages. You can select the basic variant 'solid' or the premium variant 'fast', which offers even faster and more extensive service.

Our service program includes guaranteed response times, spare part management or longer support periods by our technical hotline – even around the clock if desired. Please view the following table for all our services.

SERVICES & BENEFITS

Handshake meetings

- Optimizing economic viability and operation by reducing the probability of unexpected events
- Optimized technical support and training preparation due to expert knowledge of the installed technology
- Dual optimization of partner's service performance utilizing KPI analysis
- Improving the partner service strategy throughout the entire service life of the converter
- Early planning in terms of future demand for material and personnel
- Regular systematic overview of your installed fleet as well as any possible modifications and recommendations

On-call technical support

- Fast and accurate support by our technical hotline – reducing possible downtime and service costs
- Direct, precise and helpful instructions make it easier for you to repair any faults through our remote support
- Unlimited number and duration of phone calls

Software access level

- Ensuring that any errors are reliably fixed on-site or by remote access
- You receive a clear picture of the converter's performance
- Allows error diagnostics by remote access

Performance review

- Optimized technical support through improved system knowledge
- Recommendations for preventative replacement of individual components in order to reduce downtime

Spare part management

- You can reduce your initial material investment
- We take over the handling and storage costs for spare parts
- Your inventory space is reduced
- Avoiding parts becoming obsolete due to extended storage periods
- Limited risk of defects through non-compliance to storage requirements / conditions

Response times for corrective maintenance

- Experienced Woodward service engineers travel to your site to quickly resolve errors on site.
- Fast solutions for unplanned converter downtime
- Woodward experts have excellent first time fix rates

Repairing components

- You can reduce your stock due to our guaranteed repair times
- The Rapid Exchange Program guarantees a fast and cost efficient replacement of defect components with comparable used parts – with the same guaranteed quality

Training

- With expert training you can perform the maintenance independently, thereby reducing downtime and operational costs
- An overview of our training program can be found on the next page

PORTFOLIO OVERVIEW

PORTFOLIO	WITHOUT CONTRACT	SOLID	FAST
Handshake Meeting	–	1 x / year	2 x / year
On-call technical support	Limited*	Access 16/7 including public holidays**	Access 24/7 including public holidays
Software access levels	Limited****	CSC4: levels 1 & 2 CSC3: access	
Performance review	–	Is flexible in terms of planning but limited to once per converter during the contractual period (2 years)	
Spare part management (ensuring optimal availability)	–	Definition and administration of a recommended customer-specific spare parts list	
	–	Optional: Selected parts can be dispatched within 24 hours from the WW warehouse*	
Corrective maintenance (excluding spare parts)	Dependent upon availability	Service engineer is ready to travel within 3 working days	Service engineer is ready to travel within 24 hours
Repair of components	–	–	Guaranteed repair time for WW components: internal repair time of 20 days
	–	Rapid Exchange Programme gives you the option of receiving spare parts quickly (used spare parts dispatched within 24 hours)***	
Access to training	Introduction & raising awareness	Maintenance, commissioning, basic troubleshooting	Extended troubleshooting

* limited to receiving orders and any technical questions relating to this
 ** during local and on-call times from 6:00am – 10:00pm
 *** based on assigned spare parts list
 **** CSC4 read only access, CSC3 no access



WOODWARD UPGRADE TO CSC4

Improve the operational availability of your wind farm. The Woodward CSC4 upgrade also significantly extends the functional scope.

Further advantages include a significant reduction in the number of components used and reliable supply of spare parts during the lifecycle. This upgrade solution is suitable for all "non-island" CON-CYCLE® systems with a CSC3.

ALL THE BENEFITS AT A GLANCE

Service Friendly

- Software installation and upgrades can be carried out by your trained technicians
- Prefabricated adapters for installation
- Multi language tool

Improved Troubleshooting

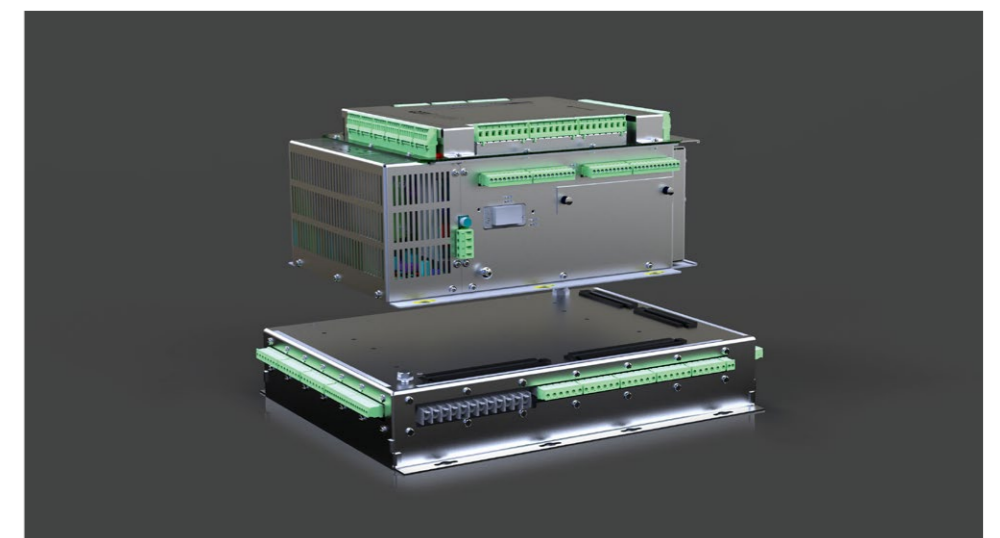
- Possibility to connect to Woodward Condition Monitoring Solution
- Faster and more stable remote access to the converter's control and analysis unit

Reduced Service Costs

- Reduced system price
- Reduced storage cost due to less variants in hardware and software
- Higher system availability

Improved Operating Characteristics

- State-of-the-art control technology
- Higher operational reliability proven in > 6,500 systems worldwide

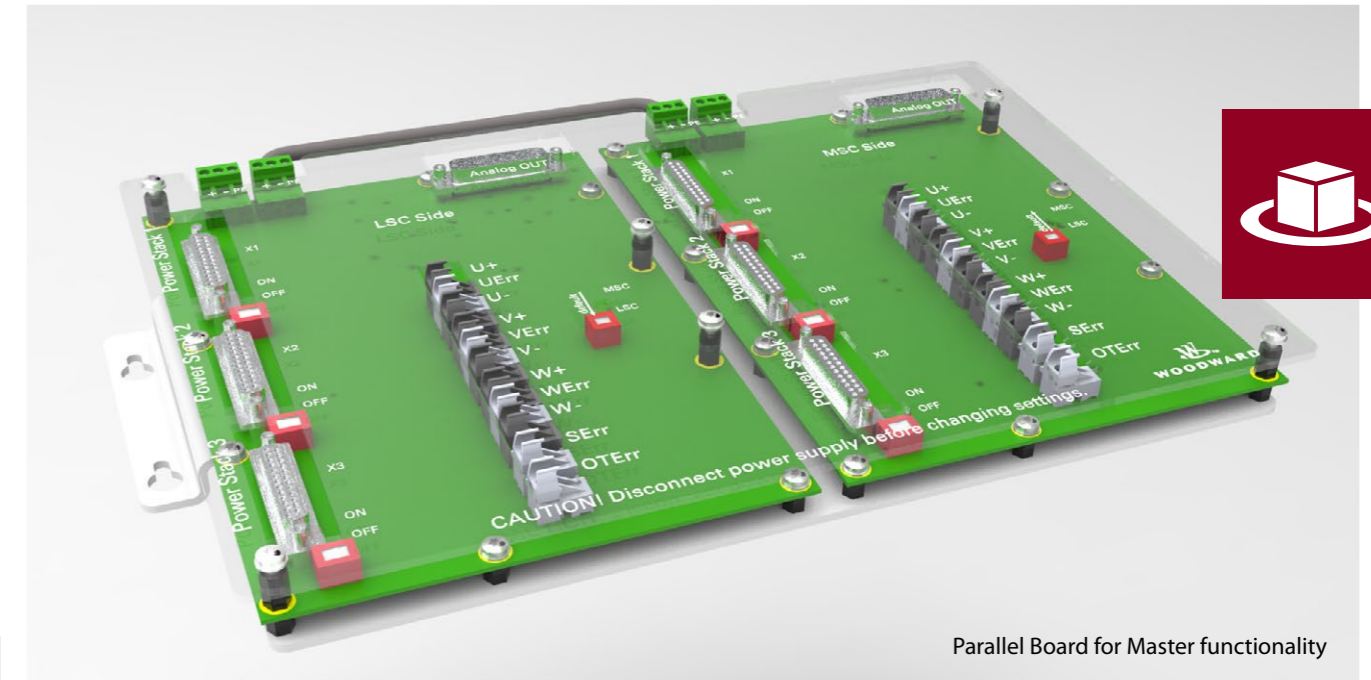


WOODWARD SERVICE STACK ONE UNIVERSAL SOLUTION

Discover the latest generation of IGBT technology and benefit from significantly improved performance and savings.

The cutting-edge retrofit solution is now available for RAC 3xx as well as Infineon ModSTACK™ PS300 installed in CONCYCLE® Systems. Numerous benefits like One-All-Purpose Stack to reduce more than 50 variants down to two, reduced service costs, simplified troubleshooting, optimized operating characteristics, a service friendly composition and long term provision of spare parts are only a few improvements based on our long-lasting experience.

And in addition:
The Woodward Service Stack is available at a much more attractive price. Replace your existing installed IGBT technology with the latest generation to leverage all benefits, get your system future proof and unleash the potential of flexible usage in different applications.



Parallel Board for Master functionality



Woodward Service Stack – Air Cooled

ALL BENEFITS AT A GLANCE

One Solution Fits All

- Universal solution to service RAC 3xx and Infineon ModSTACK™ PS300 in CONCYCLE® systems
- Reduction of more than 50 variants down to two – reduces storage costs by one universal solution for water and air cooled systems
- Application specific communication boards (4.x and 8.x)
- Optional Parallel Board for Master functionality (8.x)

Reduced Service Cost

- Reduced product price
- On-site repair with defined exchange components
- Improved shelf life using film capacitors – no formation needed for long term storage
- Improves turn-around time for repairs

Improved Troubleshooting

- Operation status at a glance by LED indicator
- LED error codes to support on-site troubleshooting without additional tools
- Sporadic errors are logged per IGBT

Improved Performance

- State-of-the-art IGBT technology
- Woodward IGBT driver boards
- Higher system stability, optimized component selection
- Extended temperature range due to optimized cooling
- Symmetry supervision





WOODWARD CONVERTER AS FIELD EXCHANGE

Woodward provides a broad portfolio of exchange converters for the Service & Aftermarket. Take the advantage of CONCYCLE® performance and our know-how.

As one of the leading, independent converter manufacturers we have gained broad experience in replacing installed converters with a Woodward CONCYCLE® solution. Benefit from our long lasting expertise even in the aftermarket and get your turbine equipped with a state-of-the-art Woodward converter.

We offer a full replacement of the existing converter including on-site installation and commissioning. This offer applies regardless of an upgrade of Woodward legacy converters or upgrading non-Woodward converters to a CONCYCLE® system – contact us.

WOODWARD MCA4

The MCA4 is a reliable protection relay specialized for the global grid compliant interconnection of distributed energy resources (DER). Just select from the Interconnection / Intertie menu those interconnection and mains decoupling elements (FRT, HVRT, Q->&V< (QU), Vector surge, ROCOF, Pr, Reconnection module, ...) that are mandatory by your local directives or by your local Distribution System Owner (DSO).

All protection relays from the HighPROTEC series offer all protective elements right from the start on board that means "all inclusive". No need to buy additional licenses or function points. Save money for the voltage transformers in LV applications. The MCAs voltage inputs will measure up to 800 Volts.

Flexibility in hardware (like 1A and 5A current inputs always on board), software, application, user interface and communications makes the MCA4 adaptable to your needs. Integrated IT security (hardened interfaces, encrypted communication between your PC and the device,...) as well as the compliance with latest interconnection standards like VDE AR-4110 are making the HighPROTEC relays ready for the future.



CONCYCLE® GENUINE SPARE PARTS

By choosing Woodward's CONCYCLE® Genuine Spare Parts, you not only benefit from our decades of in-house expertise in IGBT and control technology, you can also be certain that the converter system remains in compliance with existing grid code certifications.

With a strong background in the aerospace industry, the fulfillment of quality standards has always been of central importance to Woodward. The interaction of all Woodward products, spare parts, upgrades and replacements have been tested and validated to ensure high quality and system interaction.

Purchasing Woodward Genuine Spare Parts will also allow your continued access to our highly experienced technical support center to assist your field technicians with remote technical support. Safeguard your business as well as your company's reputation by choosing CONCYCLE® Genuine Spare Parts.



WOODWARD CONDITION MONITORING SOLUTION

Unleash the full potential of monitoring and analytics to benefit from insight and historic information to improved performance and support.

The Woodward Condition Monitoring Solution provides centralized access to data at a glance and enables performance optimization of the installed assets. As retrofit for CONCYCLE® systems equipped with a CSC4 controller the solution is available for more than 12.000 installed converters.

By monitoring CONCYCLE® converter systems, Woodward supports you to optimize your energy yields and save service expenditures. The Woodward Condition Monitoring Solution is an effective O&M tool to support decision making in service. Data based.

BENEFIT FROM

A Centralized and User Friendly Access

- Browser based access to all converter information
- Easy to understand at a glance
- Globally available via browser based portal access
- Central customer and user administration

Improved Monitoring

- Know more about your systems to make better decisions
- 24/7 monitoring of Sensor Data and Event Information
- Access to all historic operational data
- Active Alert management to reduce reaction times

Analytic Capabilities

- Analyze operation data and Event Information
- Analytics support on-site Service Planning
- Early stage detection of malfunction (e.g. contactors or fans etc.)
- Supports improvement of spare part logistics

Performance Optimization

- Retrofit solution for all CSC4 CONCYCLE® systems
- Detection of deviations between converters or entire fleet
- Reduction of downtime by Active Alert Management and data driven Service Management





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