

# Offshore Wind Farm Arkona

AWE-Arkona-Windpark Entwicklungs GmbH  
On behalf of E.ON and Equinor  
c/o E.ON Climate & Renewables Services GmbH  
Steindamm 98  
20099 Hamburg, Germany

[www.eon.com](http://www.eon.com)

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**e-on**

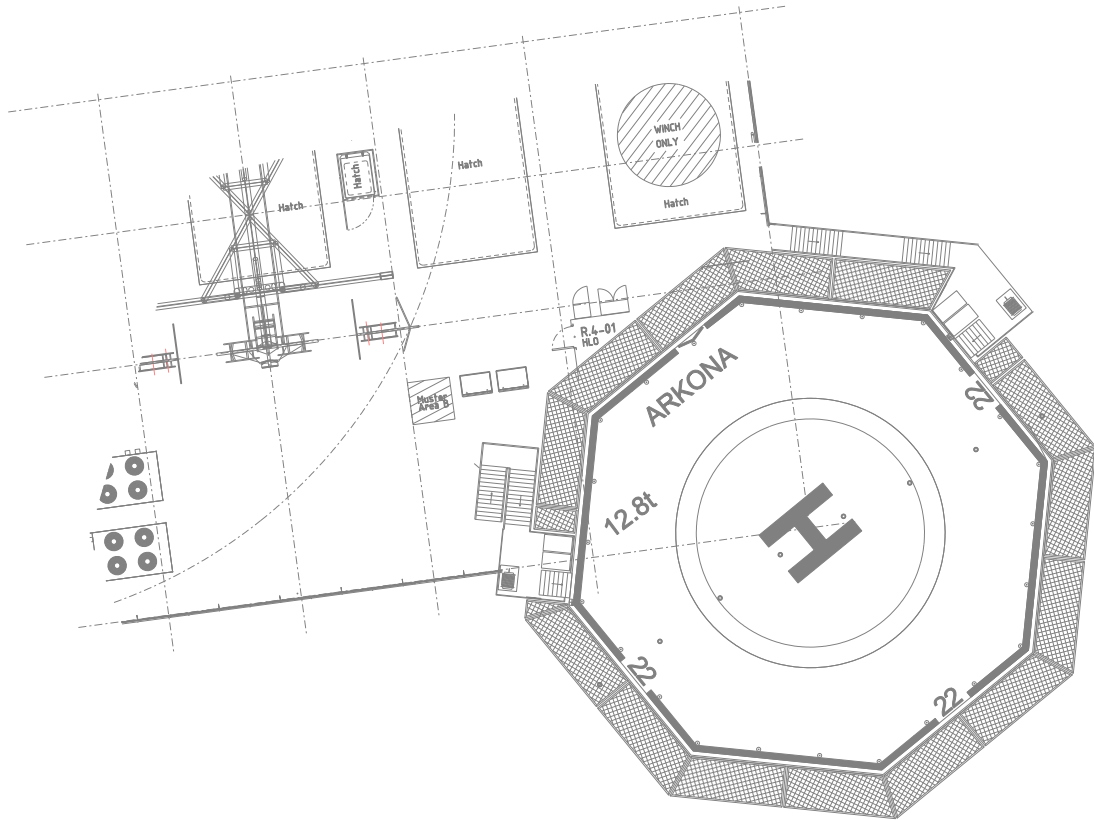
 **ARKONA**

  
**equinor**



*“They said  
it was impossible  
and couldn’t be done,  
until someone  
came along  
and just did it.”*

Goran Kikic



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# Mission Completed



**Holger Matthiesen,**  
Project Director Arkona

The project team is extremely proud and satisfied to have contributed to such a landmark offshore wind project. The construction phase of the largest Offshore Wind Farm in the entire Baltic Sea has come to a successful conclusion. A number of innovative solutions were implemented, some were a first ever in offshore wind. The wind farm has been handed over to our operations team and has now moved into the production phase.

In order to retain our positive memories and to display the achievements to interested parties we have gathered photographs and conducted interviews to provide an insight into the diversity of the challenges the project team mastered together. An offshore wind project is an enormous infrastructure development project, that is very demanding and requires the utmost dedication and professionalism from the whole team. It also serves as a proving ground for creativity and swift, accurate decision making.

Following the shareholders' decision to invest in the project back in 2016, offshore wind has developed rapidly into a prospering, mature industry and is well on the way to becoming a global trend. The development of technology and increasing sizes of turbines respectively are showing the enormous potential to contribute significantly to the goals set out in the Paris Agreement on climate change of 2016, by reducing CO<sub>2</sub> emissions.

I express my sincere thanks to all members' of the project team and to all the support functions for their dedication and drive to ensure the project's success. Particular thanks to all the team members supporting families and friends who suffered the absence of the Arkona team members who were elsewhere ensuring the success of the project. The interface and collaboration with the Transmission System Operator 50Hertz has been established over the years and worked very well. Also, the exceptional cooperation with our project partners who provided both materials and services has worked out superbly and enabled us to complete Arkona successfully, ahead of time and under budget!

I joined the project in 2012, my motivation was to be part of a professional team and deliver an excellent project, I feel confident that both targets were achieved and I am very grateful to have been given this opportunity from both shareholders E.ON and Equinor.

The Arkona project will now provide clean, renewable energy, according to high safety standards for the next twenty-five years minimum – and we wish continued success in the future.



# Joint Venture

After the successful development of Arkona, E.ON Climate & Renewables (ECR) decided to partner with a strategic investor for the construction and operations phase. In various exploratory talks with interested parties Equinor offered the best strategic fit. Both parties entered into a number of Joint Ventures and operational agreements for the Arkona project company AWE-Arkona-Windpark Entwicklungs GmbH (AWE). ECR was awarded the provision of service for the construction and operation of the Arkona Wind Farm based on approved project design and timeline.

Since the successful transaction, the close cooperation between the two industry market leaders built up a key element for the smooth construction of Arkona. Based on the already existing attractive business case, both parties supported quite strongly the successful project implementation and even further improvements. Equinor contributed on all levels with straight forward management decisions and high quality of expertise to the excellent project results.

And important project decisions were still jointly to be made: The acceleration initiative for the turbine and substation installation and commissioning contributed significantly to a de-risking of the project timeline. Innovations like the foundation corrosion protection or the cable surface lay concept was driven by the philosophy to constantly create value to the project and the society. The latter was also addressed by the change in the foundation installation concept to a very successful customised noise mitigation approach.

Highlight events for the Joint Venture were the high-quality delivery of supplies and the fast-track and smooth technical installation campaigns like the industry record in turbine installation. But also HSSE (Health, Safety, Security and Environment) or strategic relationships with key stakeholder like the Transmission System Operator (TSO) 50Hertz or the competent permitting authority Federal Maritime and Hydrographic Agency (BSH) were handled with high care and respective management support.

Overall, the excellent project results on all levels were an outcome of a great team effort including the support from all interfaces from both shareholders. The decent and prudent management approach built up trust and reliable relationships also to external stakeholders of the project.



**Christoph Altmeyen,**  
Project Office  
& Commercial Manager

*"Strong Joint Ventures are founded on common grounds. Very shortly after the transaction, the high dedication and very fruitful exchange between E.ON and Equinor proved the case that strategic partnerships can make the difference.*

*From Day 1 high alignment between the shareholder, responsible for common goals and quick responding, joint expert working groups and joint venture management formed the basis for sound steering and fast execution of the project.*

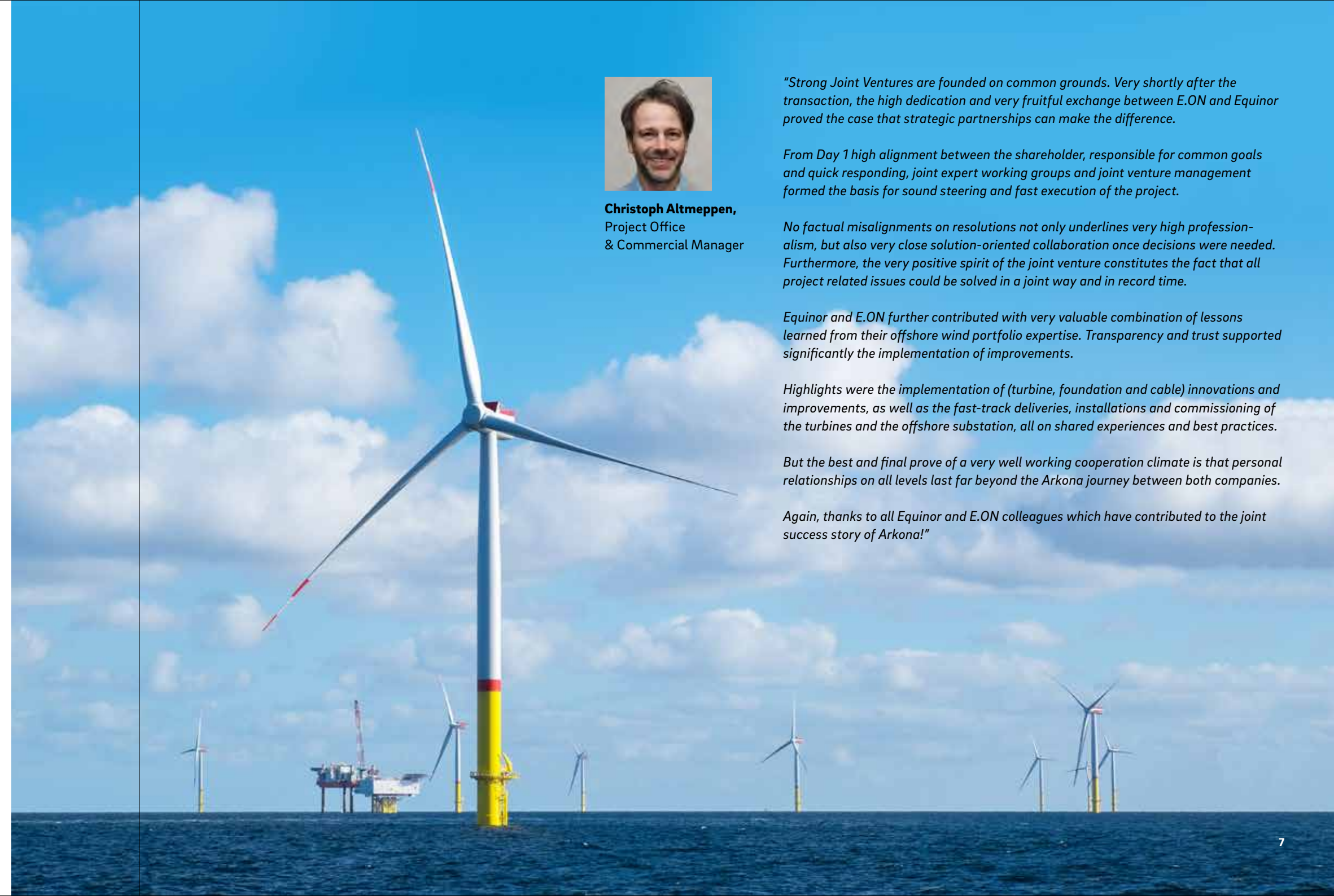
*No factual misalignments on resolutions not only underlines very high professionalism, but also very close solution-oriented collaboration once decisions were needed. Furthermore, the very positive spirit of the joint venture constitutes the fact that all project related issues could be solved in a joint way and in record time.*

*Equinor and E.ON further contributed with very valuable combination of lessons learned from their offshore wind portfolio expertise. Transparency and trust supported significantly the implementation of improvements.*

*Highlights were the implementation of (turbine, foundation and cable) innovations and improvements, as well as the fast-track deliveries, installations and commissioning of the turbines and the offshore substation, all on shared experiences and best practices.*

*But the best and final prove of a very well working cooperation climate is that personal relationships on all levels last far beyond the Arkona journey between both companies.*

*Again, thanks to all Equinor and E.ON colleagues which have contributed to the joint success story of Arkona!"*





# Many stakeholders were involved in the fulfillment of the Arkona Wind Farm



**Romana Hartke**, Managing Director for E.ON  
**Michael Mollenhauer**, Managing Director for Equinor

*"Arkona was the first Joint Venture between E.ON and Equinor in offshore wind and an unprecedented success. The cooperation was well balanced and both partners engaged their strengths to deliver outstanding results. There were many emotional highlights, but if pushed to choose a particular highlight there were two that stand out specifically."*

Romana: *"My highlight was the ceremony of the delivery of the substation, where I acted as the God Mother of the EOS."*

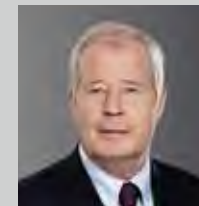
Michael: *"My highlight was the first visit in Mukran at the cornerstone laying ceremony, where I could oversee the entire "greenfield" and got an impression of the future Operations and Maintenance (O&M) harbor."*

Beside the outstanding project work, we also must highlight the good relationship with the local stakeholders. There was a lot of attention from the people in the area and intense cooperation with local partners. We received optimistic and cooperative feedback, both about Arkona and the future opportunities with offshore wind.



**Dr. Frank Golletz**,  
CEO 50Hertz

*"The commissioning of the Baltic Sea wind farm Arkona is a huge step towards a successful energy transition in Germany. By connecting the platform to the grid, 50Hertz will ensure that 385 megawatts of offshore wind energy is safely fed into our extra high voltage system. A trustful cooperation with our project partners E.ON and Equinor – developed already during the planning phase of the platform – and a positive climate at all project levels contributed to this success-story right from the beginning. We are proud to having been able to manage a first partial test feed-in of wind power into our grid already since the end of 2018. I want to thank every colleague involved for their hard work and deep commitment: This is true teamwork!"*



**Jörg Kuhbier**,  
Charitable Foundation  
Offshore Wind

*"My highlight was, as an outside observer, to witness the high level of professionalism and enthusiasm of everyone involved in the Arkona offshore wind farm project from the first planning stage to completion, in order to achieve a "just in time" technical masterpiece."*



**Petter Ølberg**,  
Ambassador of Norway  
in Germany

*"Anyone who has ever sailed across the Baltic Sea knows that Germany has an abundance of one renewable energy resource: wind. Thanks to the new Arkona offshore wind farm, wind will in the future not only move yachts and yawls but also increasingly be used to generate electricity. Norway is an important and reliable supplier of energy to Germany and has been so for years. With the inauguration of Arkona, two large companies from both countries, namely E.ON and Equinor, open a new chapter in German-Norwegian energy cooperation. We are pleased that Norway, thanks to this cooperation, will contribute to Germany's ability to generate more CO<sub>2</sub>-free electricity."*



**Michael Westhagemann**,  
Minister for Economy, Transport & Innovation Free  
& Hanseatic City of Hamburg

*"E.ON sets another milestone for the German Energy Transition. Managed from Hamburg, Arkona is not just a wind farm. Moreover, it is an important signal, especially in the current time, that offshore wind energy will be an important pillar for the decarbonization of our energy system. Continuous advancement plays a significant role here: for the Siemens Gamesa turbine foundations, an efficient and eco-friendly protective coating against corrosion was used which merited the German Renewable Award 2017 for E.ON Climate & Renewables. Seeing such innovations coming from Hamburg makes me very proud."*



**Harm Sievers**,  
General Manager  
of Mukran Port

*"I sincerely congratulate E.ON and Equinor for the successful completion of the Arkona Wind Farm. The offshore works have been finished in record time. The 385 MW wind farm can now supply renewable energy to roughly 400,000 households. Mukran Port has supported the project as an active partner all the way through. The construction of the wind farm was achieved within the given time frame and budget which is why Mukran Port is delighted to have contributed to the successful completion of the project. I am wishing the Arkona Wind Farm an all-time failure- and incident free operation phase and always sufficient wind powering the turbines' rotor blades – so that they create a lot of power!"*



**Frank Kracht**,  
Mayor of Sassnitz

*"The installment of the offshore wind farm Arkona will stay in my mind, particularly, for its fast realization; maybe it was even a bit "too fast" for us as the City of Sassnitz. Speaking as the mayor, I am very grateful for the pleasant cooperation and the open-minded willingness to communicate at all times. And I would also like to thank you for sponsoring of various events in our city. With this in mind, I am looking forward to our continued collaboration in the next 25 years and beyond."*



**Christian Pegel**,  
Minister for Energy, Infrastructure & Digitalization  
Mecklenburg-Vorpommern

*"E.ON and Equinor have set new standards through Arkona, whether in terms of the speedy installation or the new corrosion protection process. These innovative approaches make an important contribution to the reduction of both the environmental impact and the cost of offshore wind farms. Exemplary projects like this confirm and increase the importance of the Baltic Sea as an offshore location. This benefits plant manufacturers, the maritime industry, suppliers, and last but not least – the ports. In addition, this business triggers considerable increase of employment and industrial opportunities for the state of Mecklenburg-Vorpommern."*



# Introduction

The Arkona Offshore Wind Farm with a capacity of 385 MW is currently the largest project in the entire Baltic Sea. The farm is situated 35 km northeast of the island of Rügen, within the Exclusive Economic Zone of Germany and half-way to the Danish island of Bornholm.

With 60 wind generating turbines the project is able to supply approximately 400,000 households with renewable energy and saves approximately 1.2 mio. t of CO<sub>2</sub> emission every year.

The project was executed in a very efficient manner and confirms that a large infrastructure project can be built well in time and within the budgetary restraints. This is also important in the context of transferring offshore wind technology to the next level and providing a sustainable future.

The Arkona team is delighted to take you on a journey through the different construction phases of the project contained in the next pages of this book.



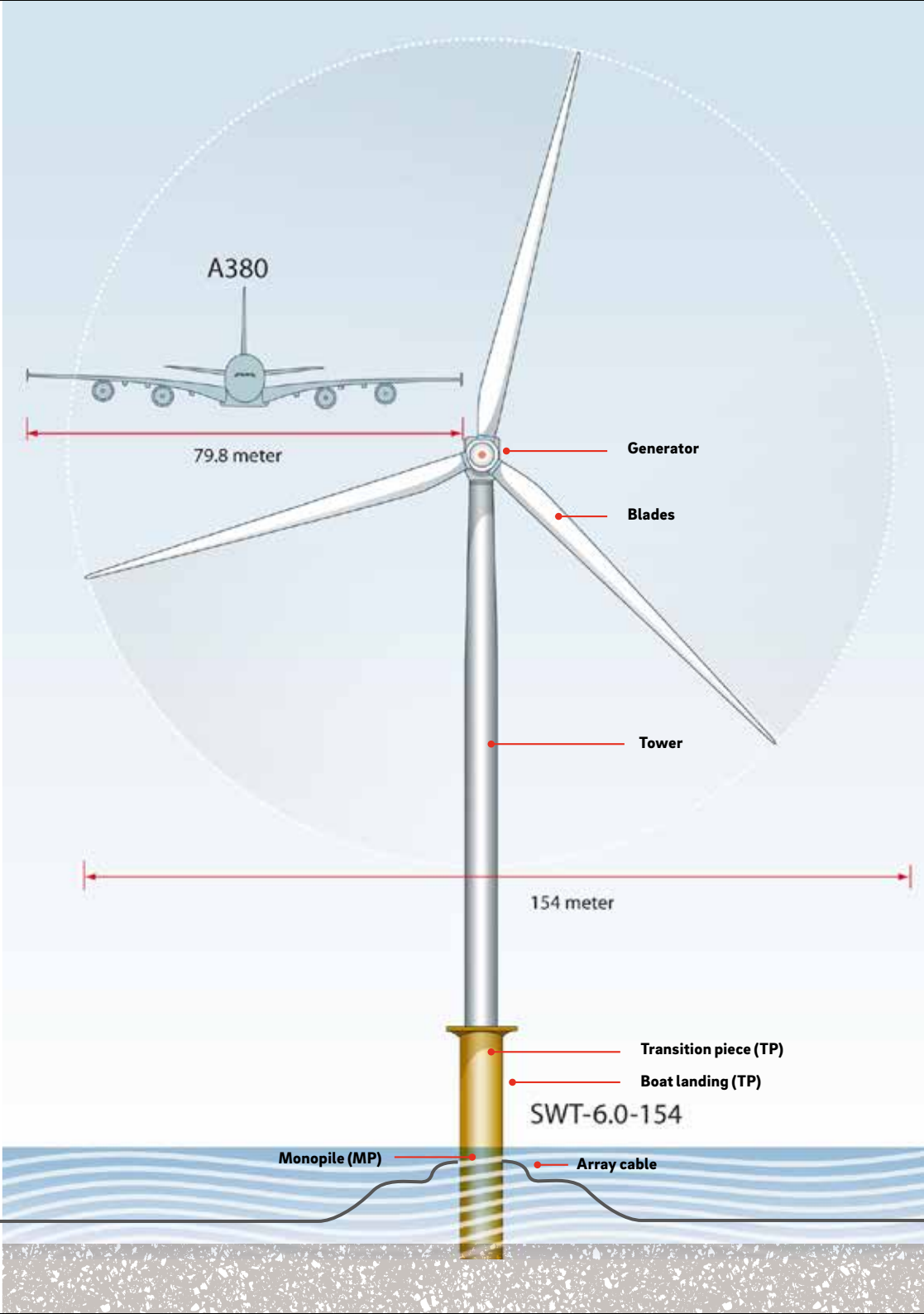


# Facts & Figures

The size and weight of the components used in offshore wind projects has been growing in recent years. In comparison to one of the first Offshore Wind Farms, Scroby Sands/UK, with a turbine size of 2 MW and a 4,5 m diameter of the foundation monopile, the Arkona Wind Farm has installed 6,4 MW turbines with 81 meters long foundations, having a diameter of up to almost 8 meters.

Project details			
Final Investment Decision		April 2016	
Start of operation		September 2018	
Park name	Arkona		
Developer	AWE Arkona Windpark Entwicklungs GmbH		
Installed capacity	385 MW		
Number of turbines	60		
Turbine type	Siemens SWT-6.0 154 PB HWRT		
Rotor diameter	154 m		
Hub hight	102 m		
Foundation type	Monopile		
Region	Baltic Sea (German Exclusiv Economic Zone)		
		Distance to shore	35 km
		Surface area	39 km <sup>2</sup>
		Water depth	23–37 m
		Soil	heterogeneous
		Net full load hours	>4,000 h
		Grid connection point	Ostwind 1–2 and 1–3 (offshore), Lubmin (onshore)
		Transmission System Operator	50Hertz Transmission GmbH
		Export technology	High Voltage Alternating Current (HVAC)

Weight of main components	Total
Topside substation: 4,000 t	4,000 t
Jacket substation: 1,000 t	1,000 t
Transition piece: 270 t (60x)	16,200 t
Monopile: 800–1200 t (60x)	approx. 60,000 t
Nacelle with hub: 334 t (60x)	20,040 t
Tower: 443 t (60x)	26,580 t
3 Rotor blades: 78,3 t (60x)	4,698 t
Piles substation: 212 t (4x)	848 t
Inner array cables	77 km

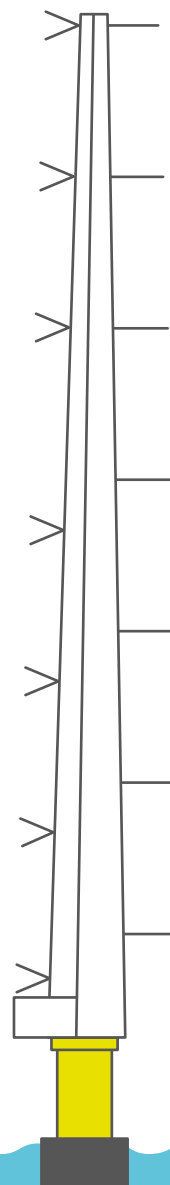




# Milestones

Arkona is the first offshore project in the Baltic Sea in Germany that E.ON and Equinor have built to date. It was executed in record time with one of the shortest construction periods in the industry. Thorough project planning by a dedicated team coupled with very favorable weather conditions facilitated this outstanding result. Lessons learned have been incorporated from several previous projects. Lessons learned collected during this project will be transferred to future projects to further increase E.ON's knowledge base.

## Project Milestones 2006–2019

- 
- 2019** • Start Operations and Maintenance from Port Mukran/Sassnitz (Rügen)
  - 2018** • Turbine commissioning completion  
• Grid Connection  
• Turbine installation  
• Array Cable installation  
• Electrical Offshore Substation (EOS) installation
  - 2017** • Transition Piece installation of transition piece  
• Monopile installation, covered with Thermal Spray Aluminium  
• Electrical Offshore Substation's jacket piles installation
  - 2016** • Business plan and agreement with Equinor (Statoil at the time)  
• Final Investment Decision (FID)  
• Geophysical Surveys, Unexploded Ordnance (UXO) clearance
  - 2015** • Soil investigation programm (3-D seismic survey)  
• Grid capacity allocated
  - 2012** • Start of project team in Hamburg
  - 2006** • "1st permit" of BSH (Federal Maritime and Hydrographic Agency)



# HSSE

## Health, Safety, Security & Environment

**"It is all about the people."**

Having the right persons at the right place at the right time, this is what makes a difference. Their mindset and commitment to HSSE is what is needed to deliver a safe and successful project. Understanding HSSE as a core value being an integral part of everybody's daily work and something that we all live up to – this is what we wanted to achieve in our project. That is why we did not only rely on a strong basis – being built via an integrated HSSE Project Management System with procedures defining our goals and requirements.

In addition, we were seeking to establish strong binds with our stakeholders and contractors to demonstrate that we take HSSE seriously and that we want every individual to take care of themselves & others. Having conducted numerous safety campaigns, making a project team personal safety message video, creating online

inductions to our sites onshore, offshore and setting the requirements for training qualifications – was only the start. Creating a joint understanding of HSSE together with our partners and contractors, was what we all strived for. We were fortunate to have had great partners in our project, emphasizing and embracing HSSE as a core value of their business practices. Driven to create a better tomorrow by building a safe project that we can be proud of. "We want everyone to get home safe to their families and friends."







**Mark Rapson,**  
Construction  
HSSE Manager



**Sabrina Luitjens,**  
HSSE Manager

*"Coming directly from an offshore construction project was an advantage that allowed me to carry on the good work and expand this into the Arkona project. Working with the project team we set out common goals and committed to proactively engaging with all contractors at an early stage."*

*Expressing the message that a team effort was required by all to ensure success. Visiting the various sites with our multi-national contractors during the manufacturing and offshore installation phases was essential for me to demonstrate our commitment to the project. The overall success was only achieved by having a professional, dedicated HSSE team (Sabrina, Volker, Roger, Gregory & Ulrich) who endeavoured to provide a "hands on" approach throughout the project."*



# Humans & Enthusiasm

During a successful construction and commissioning period of the Arkona Offshore Wind Farm, challenging and complex processes had to be tackled. It became more and more obvious, that beside the dimensions of the enormous technical complexity, the interaction of all involved human beings played the most important role.

One of the impressive success factors of the Arkona project was the Arkona team spirit and the diversity of our team members with so many different nationalities. Every one of our international team (about 100 people) committed themselves with huge competence, responsibility and empathy for their personal project duties and for their team colleagues, irrespective of the individual project level and private situation.



Additionally, the multilateral stakeholder management generated an intensive involvement of relevant project authorities. Detailed and regular project updates, as well as several offshore excursions to the Arkona Wind Farm created an enormous fascination and have been an „eye-opener“ to our stakeholders. This information and knowledge transfer led to clear processes and in time project milestone releases in a harmonic cooperation with all involved authorities.

The German & Norwegian Joint Venture between E.ON and Equinor has been the third impacting factor on all involved humans. A confidential cooperation, competent discussions and intensive monthly project steering meetings brought a strong drive to the project right from the beginning of the construction phase.

Concluding the important impact of humans to our project, journalists and television broadcasting teams assisted to spread the positive Arkona messages and spirit to the international public. The journalists' positive attitude and informative articles helped to open public minds regarding renewable energies and supported to overcome obsolescent opinions. Looking back by delivering the successful Arkona project, periods of tough workload are forgotten.

This complex team work, across the Arkona project packages, authorities, stakeholders and the Arkona Joint Venture Management, all involved people played their individual and important role to make the “Energiewende” happen.

Please enjoy the huge number of pictures, including the Arkona team, technicians at work, stakeholder trips with the authorities to the wind farm, journalists and last but not least the Arkona & Equinor Joint Venture partners.























# Wind Met Mast Arkona

## Long Term Employee

The Arkona wind met mast was installed in 2006 on a gravity based foundation and has an autonomous power supply. More than 10 years of wind and wave data were collected as valuable input for the wind farm design. In 2016, the met mast was successfully recertified for another 10 years.

With the start of construction activities, it was upgraded to a communication platform and equipped with additional devices such as radio (UHF/VHF and Tetra), Automatic Identification System, Real Time Kinematic, Line-of-Site Communication and others. Following the end of the construction phase, the met mast will continue to gather and provide data on different environmental parameters, allowing for an optimized operation of the Arkona Wind Farm.







# Pre-Construction Activities

The whole wind farm area was finally investigated geophysically and geotechnically in 2016, completing the available data sets from the main soil investigation and multi-channel seismic. The survey works were followed by an Unexploded Ordnance (UXO ) clearance and boulder removal campaign. In total, 3,000 potential UXO were investigated and about 40 were salvaged and handed over to the authorities.

Several boulders were relocated. All activities were used to select the right installation tools, engineer anchor patterns and jacking positions for the installation vessels and to determine the final cable routes.





# Project Engineering

In each of the three main technical packages, foundations, electrical and wind turbine, the teams have to take care about the package related design, manufacturing and supply processes in the best state-of-the art manner to ensure a robust and innovative offshore power plant which is at the end an efficient, safe and environmentally friendly producing wind farm.

Especially in these days of fast commercial and technical changes it is required to implement validated technical innovations combined with proven, certified technology and according to highest quality in the products and the processes of each technical package.

All technical package products are under-layed and connected via a complex data transmission network based on fiber-optics and partly Line-of-Site for redundant and safe communication. Also condition monitoring systems are applied and transmitting data for various electrical and mechanical components and structures. Finally the data infrastructure is the core for the control and steering system of the individual turbines and also the complete power plant (SCADA System).

As an example for innovations within the foundations we introduced a new corrosion protection system for the outside wall of the monopiles by using Thermal Spray Aluminium instead of organic coating and massive zinc anodes – this new approach was triggered by easing the offshore installation process and to save costs and to protect the environment.

The Electrical Package took care of the design and manufacturing, as well as the installation of the huge combined Electrical Offshore Substation which is used by AWE-Arkona-Windpark Entwicklungs GmbH (AWE) and the Transmission System Operator (TSO) 50Hertz – again a very cost-efficient way of keeping the balance of a slim and effective plant – even here innovations have been introduced on various technical levels. The electrical team also designed and safeguarded the internal wind farm array cable manufacturing and the delivery to Mukran Port/Rügen as well as the electrical outfitting and interfaces in the turbine foundations.

Finally, the Wind Turbine Generator Package was assessing two generations of wind turbines ending up with the >5 MW size of proven technology plus the latest upgrades and features in hard and software to provide maximum possible and reliable energy production. Due to new processes and contractual adjustment agility the turbine manufacturing, commissioning and energization went very well in time and at the end ahead of schedule.



**Martin-Oliver Ros,**  
Engineering Manager

*"When I was asked to take over the role as Engineering Manager for the Arkona Project at the beginning of this exciting project, I was first full of respect towards the complexity of this role but more dominantly attracted by the challenge to have the chance to be part of realizing an Offshore Wind Farm. Having been part of the offshore wind industry from its early days on, it was my ambition to be part of a full offshore wind project life cycle. With the Engineering Manager role in the Arkona project I got the chance to contribute my capabilities and to go for the management and coordination of the technical packages (Electrical, Foundation, Wind Turbine) including modern, digital communication and the data monitoring/transmission based on wireless and fiber-glas network infrastructure.*

*The timely, good quality and cost-efficient delivery of the balance of plant and wind turbines has only been made possible and realized by swift and professional reactions of an outstanding team which I had the pleasure to work with. For me, the human factor and the professionalism as well as the respectful communication and cooperation with the project team are some of my main motivators and the success factors of delivering the outstanding Arkona Offshore Wind Farm project to our stakeholders."*



# Prototype Assembly Onshore (PAO)

Before the serial production of the foundations and turbine towers started it was decided to test the mechanical, technical interfaces of our structure as well as installation and commissioning procedures. This kind of mock-up test we called Prototype Assembly Onshore (PAO) test, which was a temporary assembly of the upper section of the monopile including top flange, the first fully equipped transition piece and a dummy of the turbine tower bottom.



After a validation of our design drawings for the monopiles, transition pieces and turbines/towers in a virtual 3D model, the first set of these components was produced and installed in a yard in Aalborg/Denmark to test the technical interfaces and installation procedures also with regards to health and safety.

Modifications to the main components including all design changes which had been identified, were applied. The validation of mechanical interfaces is very important in that phase of a project, the major benefit from the PAO is the testing of the core technical interfaces and processes for installation, commissioning and operation.

As one result from the PAO, we could implement more than 200 improvements to all core processes before we shipped the first turbine components to the assembly area in Mukran Port/Rügen and later to the offshore installation.

Another important benefit was the validation and improvement of all HSSE relevant processes and equipment which were tested by executing safety drills. Here we reduced the rescue time from the air tight deck of the transition piece by more than 80 % by implementing a new rescue device into our procedures.

Overall the PAO was very beneficial and a major success factor for the fast, smooth and safe offshore installation activities of the Arkona construction project.





## Foundation Design and Manufacturing

Arkona has set new standards for the design of monopile foundations. The company is protecting all 60 steel foundations of the wind farm in the German Baltic Sea with a special anti-corrosion coating. This was thus the first time to completely assemble the monopiles of an Offshore Wind Farm with the environmentally-friendly corrosion protection technology. During the 25-year operating period, the metal-dissolving corrosion process is significantly reduced and deposits into the sea are reduced by several hundred tons.

Arkona has developed the Thermal Spray Aluminium (TSA) process for coating of the monopiles with engineers' contractor Rambøll Germany in coordination with the competent authorities. The companies EEW SPC and Krebs then developed innovative solutions on behalf of Arkona to implement the process industrially at their locations in Rostock/Germany. To this end, existing coating halls were also expanded and the world's first fully automated coating line was developed.

During the coating process, a robot with two arc burners sprays a several hundreds  $\mu\text{m}$  thick layer of molten aluminum onto the foundations. The process is carried out under the most stringent safety and environmental protection standards and is largely dust-free. The surface is then sealed with epoxy resin. The TSA process has hitherto mainly been used as

corrosion protection for smaller steel components under water or for larger components above water, for example in offshore substations. The process is being applied for the first time on an industrial scale for the foundations of the Arkona turbines. Because the process is automated, this alternative coating method can lead to significant cost savings compared with conventional corrosion protection.

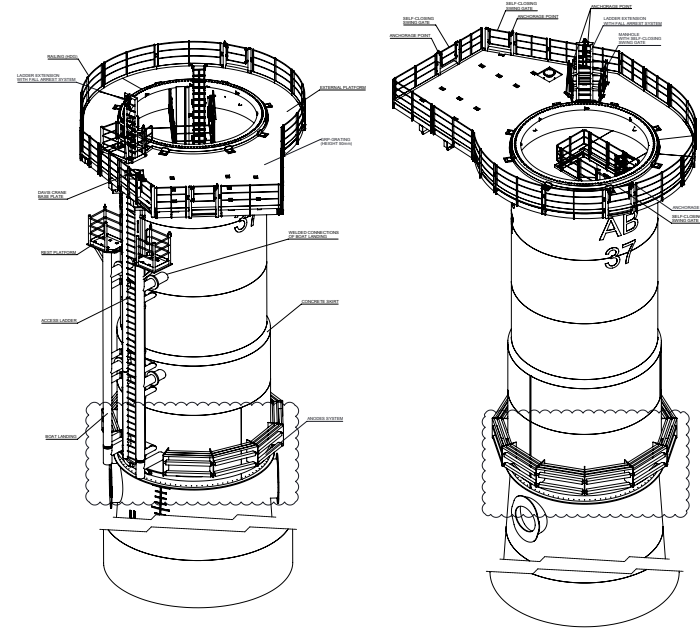
Arkona has won the German Renewables Award for the innovation of the year 2017.





The transition pieces (TP) by Bladt Industries have been manufactured in Aalborg, in the north of Denmark and have been shipped fully outfitted and pre-commissioned to the interim storage area in Mukran Port/Rügen at the Baltic Sea.

The secondary steel components were partly manufactured outside of Denmark as well as some larger steel components like flanges and delivered to Denmark to completely assemble the TP structure. Further the TPs were fully equipped with low and medium and voltage components (switchgear) as the TP is the technical interface par excellence electrically as well as mechanically.



**Marc Roder,**  
Foundation Package Manager

*"We have managed to deliver the monopiles and transition pieces well ahead of schedule and in outstanding quality. This was only possible due to the engagement, high professionalism and motivation of my colleagues from the Foundation Package. It was a pleasure having the chance to work with them together and because of them I must admit it was an easy job!"*





**Kristian Høy-Thomsen,**  
Deputy Electrical Package Manager

*"In the center of Lower Saxony the two different copper cable sizes with continuous length were produced according to the latest state-of-the-art. You may think the cable is rather a simple item but you will be surprised that the manufacturing of array cables is one of the highest complex processes and requires many years of experience. Since cable repairs offshore are coming always with high cost, we had a high focus on the array cable production, its transport and installation to ensure a reliable operation of the cable for the next 25 years and more."*



## Array cable manufacturing and delivery

The Electrical Array Cables with an operating voltage of 33,000 Volt collect the energy from the wind turbines towards the Electrical Offshore Substation.

In total, 77 km array cable with a copper conductor cross section of 300 mm<sup>2</sup> and 800 mm<sup>2</sup> have been manufactured, factory tested and delivered from the cable manufacturer Nexans in Hannover. Since the cable has a weight up to 47 kg per meter, special care had to be taken during the handling and transport of the cable via train wagons from Hanover to Murkan Port/Sassnitz. After electrical testing, the cables were stored in large coils at the quayside and were ready for collection by the cable laying vessel Stemat Spirit from VBMS.

High quality cables, proper handling of the array cables and experienced personnel are a prerequisite for the success of an Offshore Wind Farm.





# Electrical Offshore Substation – Design & Construction

The Electrical Offshore Substation (EOS) is a joint project of E.ON/Equinor and the Transmission System Operator 50Hertz Transmission GmbH and is consequently used simultaneously by both parties.

The construction of the substation and jacket started in July 2015 at the Chantiers de l'Atlantique (STX France at the time) yard in Saint Nazaire. The construction process required 500,000 working hours and about 300 involved contractors until its completion in March 2018. The substation was constructed in three major blocks and was later on being welded to one single block making it to one of the biggest single-block Alternating Current (AC) substations ever built.

Overall, 155 km of cables were installed, more than 22,000 cable ends terminated, approximately 150 km of welds were carried out and about seven football fields of painting applied.

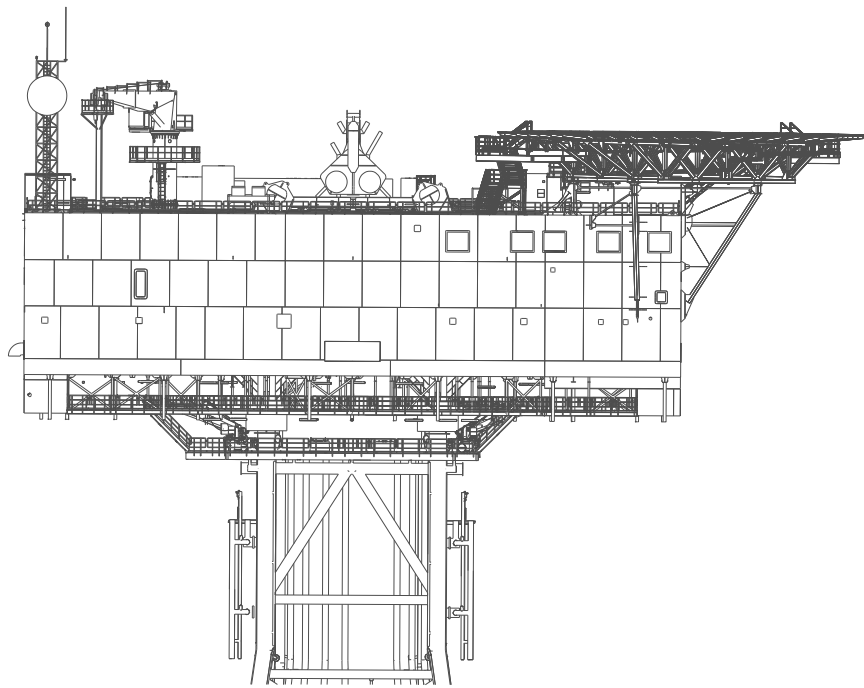
The EOS is located in the middle of the Arkona Wind Farm and bundles the energy produced by the 60 Siemens Gamesa wind turbines. On the EOS the system voltage level will be increased from 33,000 Volt to 220,000 Volt via two main transformers, before the energy gets transmitted from the EOS to the mainland via the export cables, which have been installed by the Transmission System Operator. The EOS will be operated unmanned. It will be controlled and monitored from the control room onshore.

Nevertheless, if attendance offshore is needed, the EOS has all important ancillary facilities on board such as helicopter landing deck, accommodation, workshop with an extensive spare parts storage room, emergency power supply via diesel generators and batteries. Furthermore, it has a control- and monitor room to operate and maintain the EOS also from offshore.

As a special feature, the substation is equipped with an electrically heated boat landing system for automatic deicing, which is installed on the eastern side of the substation allowing crews to access the platform via vessel transfer even in harsh winter conditions.







**Peter Arp,**  
Electrical Package Manager

*"Surrounded by thousand tons of steel, hundreds of kilometers of cable, numerous electrical systems and sub-systems each one more important than the other and by a world-class team of highly dedicated individuals from around the world – this has been my work-place for the last years.*

*The substation, array cables and the managed energization works have formed the key to a highly effective grid connection of the Arkona Wind Farm. We have successfully faced the challenge to not only deliver the product in the best possible quality – the goal every engineer is striving for – but we have also managed to meet the set milestones and given budget as well – factors becoming increasingly important in an economically competitive offshore environment.*

*Throughout the whole journey of the design phase, onshore construction and offshore installation followed by the commissioning and energization of the Electrical Offshore Substation, I've highly enjoyed working with each member of my team, because everyone has shown their dedication and commitment to give their very best. Especially in challenging times, the team has grown even closer together willing to work even harder and pushing the project to the best possible results. This remarkable enthusiasm and team spirit I have experienced will be something I will certainly take with me and hope to inspire in my future projects and teams to come.*

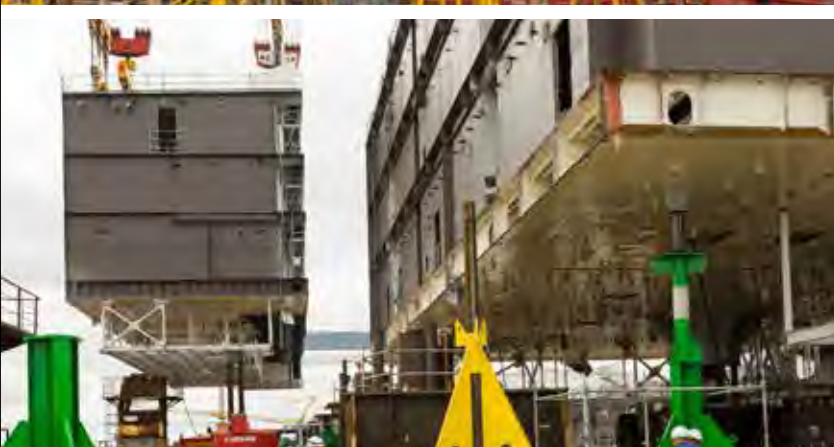
*I am proud to have been a part of the Arkona project and thankful for the experiences made."*















## Keel Laying and delivery of the Electrical Offshore Substation

On the 12<sup>th</sup> of July 2017 Chantiers de l'Atlantique (former STX France) together with E.ON and Equinor invited their own employees as well as representatives out of the industry and politicians to the yard in Saint Nazaire to celebrate the Arkona substation topside Keel Laying and Coin Ceremony. On this date the three separate substation blocks were welded together to one huge structure directly on the transportation barge. This event was certainly a well-attended milestone in the manufacturing of the EOS as only 9 months later the Arkona topside was declared ready.

After the official delivery ceremony has been performed on the 1<sup>st</sup> of March 2018 at the Chantiers de l'Atlantique yard, the jacket and the topside started their journey to the Baltic Sea.





*"Strategic cooperation is primarily about building trust and reliability. When managing the relationship with the TSO 50Hertz, the primary focus was on the understanding of each other positions and identifying win-win-situations and corridors of acceptable solutions. Any consensus was flanked and secured by acceptance on all levels involving company and project management as well as the execution levels including all the internal and external stakeholders.*

*Since the early days in 2014 these principles were the key to rapidly establish common grounds and facilitate sound steering and fast execution of both*

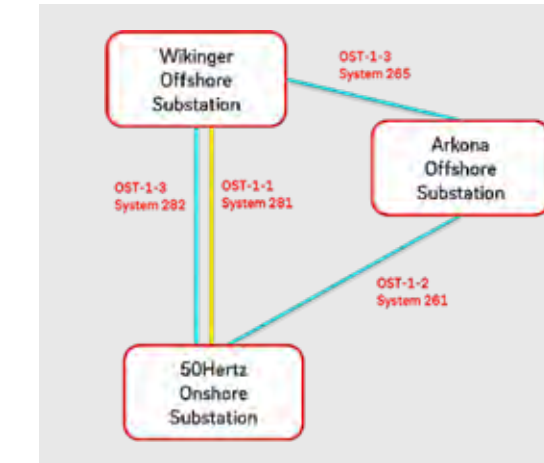
*the windfarm and its grid connection. I am proud that all targets have been achieved – not only for the Arkona windfarm but also as a result for the grid connection from our strategic partner 50Hertz.*

*Highlight events are the in-time joint technical realization of the offshore substation in the yard in Saint Nazaire (France) and the smooth offshore installation and commissioning. Further the pro-active execution of the grid connection ahead of schedule by our colleagues at 50Hertz. Last but not least as pre-condition to all of this, the very efficient and constructive negotiations of more than a dozen of balanced cooperation agreements.*

*Taking into consideration the very different incentive scheme of both parties, the export of first power one year ahead of the original plans sets a very exceptional industry-wide benchmark! All this was only possible due to the pro-active approach from both parties avoiding major frictions. Even in the most intense final execution phase both partner still found sound and prudent solutions.*

*A great team effort from all 50Hertz and E.ON colleagues, suppliers and sub-suppliers from various disciplines!"*

**Christoph Altmeppen,**  
Project Office & Commercial Manager



## Grid Connection and Cooperation Management/50Hertz

All power produced from the Arkona Wind Farm is exported by the high-voltage grid of the Transmission System Operator 50Hertz. Three HVAC export cables with an operating voltage of 220 kV (total 750 MW capacity) and an interconnection cable connect the Offshore Wind Farms Wikinger (350 MW capacity) and Arkona (385 MW capacity) to shore. At the landing point in Lubmin (onshore substation) 50Hertz transforms the electricity to the maximum voltage level of 380 kV and feeds it into the German onshore grid system.

E.ON Climate & Renewables (ECR) on behalf of the Arkona project company AWE and 50Hertz decided in 2014 for a close cooperation on the planning and realization of the individual and joint infrastructure. Both parties concluded in the early days to save one (the forth) export cable and to

share a joint offshore substation which integrates both sides offshore components.

Through the interconnection of the grid connection of both wind farms, 50Hertz avoids point-to-point inefficiencies and achieves redundancies if one export cable fails. 50Hertz sub-supplier Prysmian produced the sea cables in its supply factory located in Pikkala/Finland, and supplied them directly by the cable installation vessel "Cable Enterprise" into the field. All cables have been installed offshore in two deep water and two shallow water sections with a total length of some 90 km and 3 km onshore each to the converter station in Lubmin.

With the joint offshore substation ECR/AWE and 50Hertz decided to host all major components like

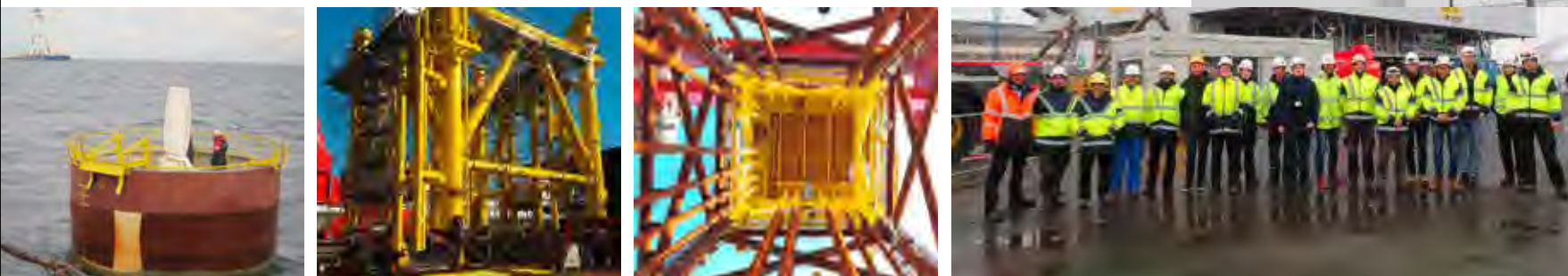
33 kV switchgear, 220 kV transformer (both AWE assets) or the 220 kV gas-insulated switchgear (50Hertz) on the same structure – again with significant savings to the benefit of the society. ECR on behalf of the cooperation partner took the responsibility as EPCI service provider for the joint substation. This included the tasks to provide AWE's own assets and an overall safe and fit-for-purpose offshore platform including the structure, media and ancillary facilities. 50Hertz contributed with its design and operations requirements as well as the supply of its own assets.

The strong cooperation of the partner facilitated a very successful outcome with an early feed in of power of more than one year in advance to the initially planned grid connection dates.



# Quality Assurance & Control

The Arkona Quality concept is set up on the principle of early involvement into the different components' manufacturing with dedicated quality experts in order to avoid severe problems in later project phases. Following this principle and based on prior internal risk assessments and supplier evaluations, continuous manufacturing supervision on the contractor's sites was set up directly from the start.



The sites with permanent quality supervision included

- The Chantiers de l'Atlantique (former STX France) yard in Saint Nazaire (Substation),
- Bladt in Aalborg (Transition Pieces),
- EEW in Rostock (Monopiles and EOS piles),
- Ambau in Cuxhaven (Turbine towers),
- Valmont in Rodekro (Turbine towers)
- the Siemens sites in Brande (Hub and Back-end), Esbjerg (Nacelle assembly) and Aalborg (Blades),
- the Mukran Port (all logistics activities, hand-overs and assemblies there) and
- the Arkona site offshore (Foundation installation, EOS installation and commissioning, Turbine (WTG) installation and Service)

For other key components such as the Electrical Array Cable or the EOS main crane, several audits, inspections and checks have been performed to minimize quality related risks. In order to optimize the quality process, all activities have been done in close cooperation with the certifier and in alignment with the different contractors.

With this early and risk based supervision and the support of all project packages, the Arkona team was able to identify, process and solve all quality problems in such a way that impacts on the schedule or other critical project parameters have been avoided.



# Logistics & Offshore Construction



**Malte Paul**, Logistics & Construction Manager

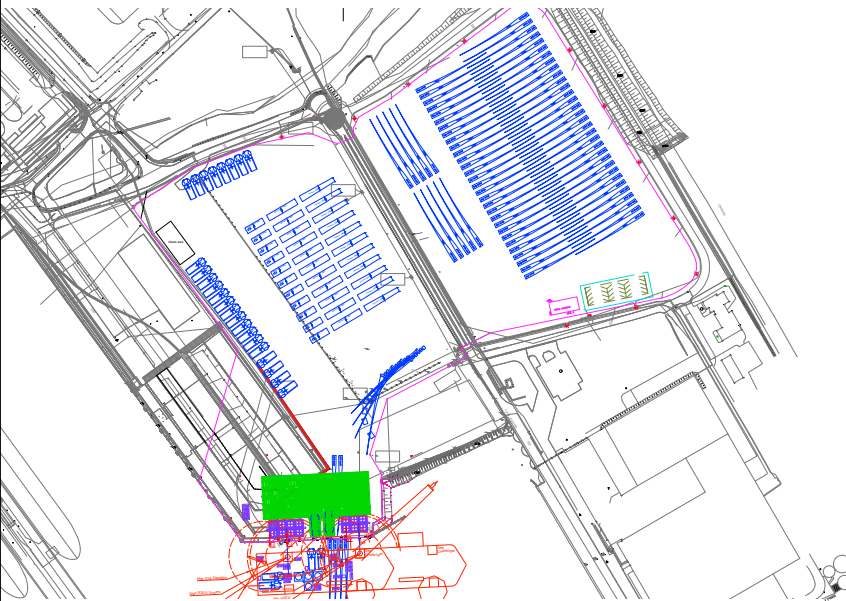
*"Logistics & Construction includes plenty of topics and interfaces and a very close liaison with supply chain and the operational responsibility from survey works to installation and commissioning and finally the hand over to operations. From the first monopile blow to the last turbine installed it took just 14 months. In my eyes, the key to a successful implementation of Arkona is the right people, the right contractors and the right planning and management of those. I am very proud to head such a diverse team of experts in all areas of offshore wind construction. Spot on and a great team effort."*





## Base Port Sassnitz

Mukran Port in Sassnitz has been the base port for the main installation activities. Crew transfers to the site have been realized in a bit over an hour, saving time and costs with each trip. The port did not only provide the berth for all crew transfer and major construction vessels, but was also used as storage and pre-assembly area for the transition piece, array cable, and wind turbine installation campaigns. In addition, the Arkona Operations & Maintenance building, providing permanent work spaces for more than 50 people during the construction and operations phase, has been set up.



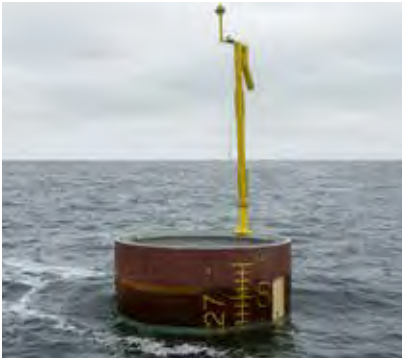
*"The base port represents the crucial hub for all offshore construction activities for every offshore wind project. Mukran Port was the ideal choice in that respect for the Arkona project. The proximities to the offshore construction site and the possibilities provided by the harbour helped a lot making this project the success it became. It is amazing to see how different areas of the port were modified to fulfil the needs of the project. Arkona was the first project to use the newly built North Terminal including an extended and fortified berth and a RoRo ramp, meeting the demands of the industry. We are happy to continue the collaboration in the operations phase."*

**Malte Paul**, Logistics & Construction Manager



# Monopile Installation

For the Arkona project, 60 steel tubes with lengths of up to 81 m and weights of up to 1,200 metric tons were transported and installed. For transportation, the piles were sealed with custom tailored plugs and brought to site floating, using tug boats. Upending and installation was carried out by the installation vessel Svanen, needing less than a day per pile on average. Using this floating feeder concept, installation time of the Svanen could be reduced drastically, leading to a very cost-effective campaign.



**Dr. Tristan Lippert,**  
Foundation Installation Manager

*„Driving large monopiles with a diameter of almost 8 m almost 40 m into the seabed represented a major challenge, especially given the complex, layered bottom structure in that area of the Baltic Sea. After a long preparation phase, involving several sea bed and seismic surveys, geotechnical modelling and a careful choice of a capable hammer, the Arkona project managed to install all monopiles to final depth, without having to use a drilling procedure as a back-up measure.“*



*„Complying with the official noise limits set by the Federal Maritime and Hydrographic Agency (BSH) represents a major challenge for every offshore wind project. At Arkona, detailed studies of the noise to be expected led to the choice of several Bubble Curtains in combination with a*

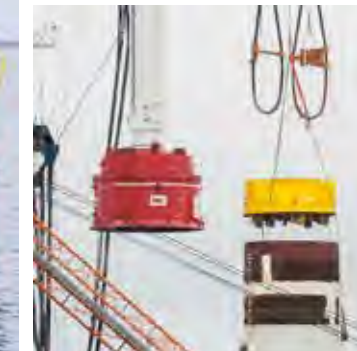
*Hydro-Sound-Damper (HSD) system. With this setup, Arkona successfully managed to comply with all set limitations of the authorities. In addition, the innovative Fauna Guard system was successfully used as a deterrence device in German waters for the first time, leading to an even less intrusive deterrence than with previous measures.“*

**Dr. Tristan Lippert**, Foundation Installation Manager



## Noise Mitigation

Driving a pile into the seabed using a hydraulic hammer produces an impulse, which induces high sound pressure levels in the water. To protect the marine environment, extensive measures are taken to trap and dampen the noise as effective as possible. Strict noise limits set by the authorities, resulted in the use of a best-in-class noise mitigation system, consisting of different combined systems, as well as a parallel measurement campaign.

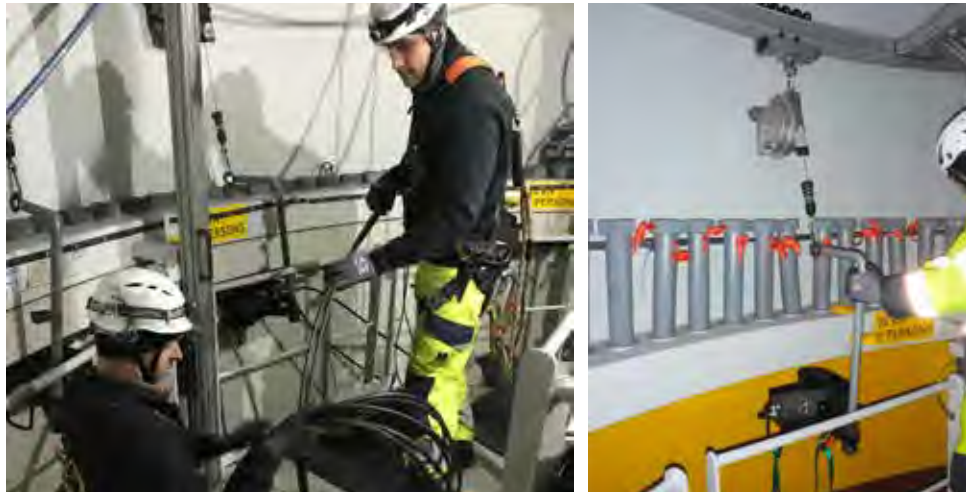




# Transition Pieces Installation

After the successful installation of all monopiles (MPs), the corresponding transition pieces (TPs) were installed in a separate campaign. Using a floating installation approach, all TPs were landed and connected to the MPs using a customized guiding system.

Using an innovative, bolted MP-TP connection, the major part of all loads to the connection is taken on by the bolts. As a second innovation, an ultrasonic measurement approach for the actual tension of all bolts was used to ensure sufficient load.

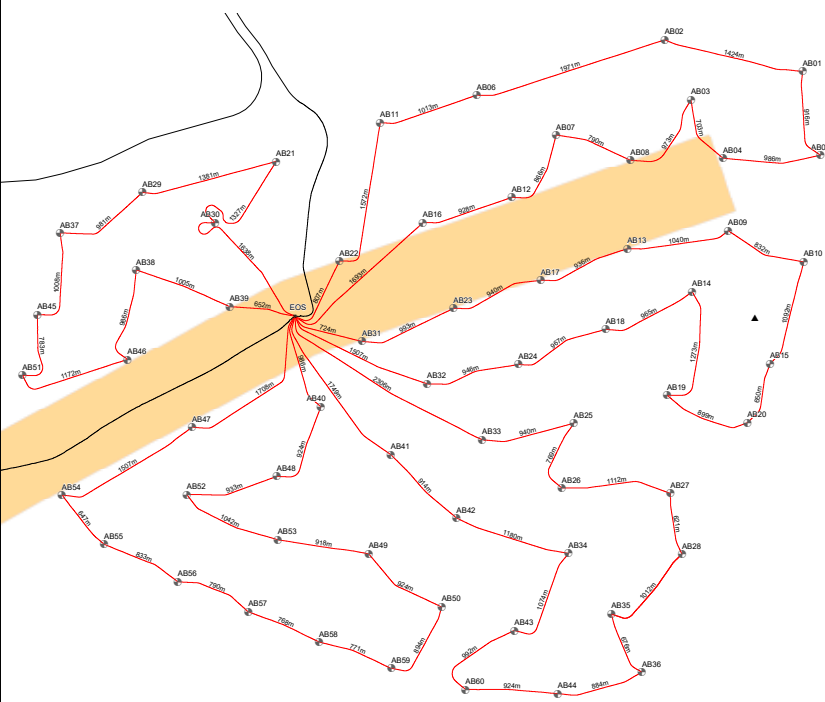


**Christian De Bruyne,**  
Deputy Logistics &  
Construction Manager

*„Even though, all transition pieces were installed towards the end of the year in less favorable wind, wave and temperature conditions, the campaign could be successfully finished as planned and in time. De-coupling the MP and TP installation campaign, led to a significant reduction of risks from potential fabrication delays. The combination of an innovative, bolted flange connection between monopile (MP) and transition piece (TP) with a novel ultrasonic measurement approach for the bolt tension led to a reliable and cost-effective solution, which proved to deliver very quick turnaround times.“*







## Array Cable Installation

Firstly, the cable routes were cleared from boulders by a purpose-built tool, in combination with stone picking. Ahead of the cable installation, the routes were further examined by subsea video and multibeam survey campaigns, to ensure the maintained integrity of the seabed for cable installation.

The installation of the array cables was carried out using the dedicated DP2 cable layer Stemat Sprit, in conjunction with the offshore support vessel Vos Stone. The offshore spread installed 65 cables within 42 days, equivalent to a total 77 km of cable, cut-to-length on site. The cables were eventually stabilized by selective rock placement, using the fallpipe vessel Rockpiper.



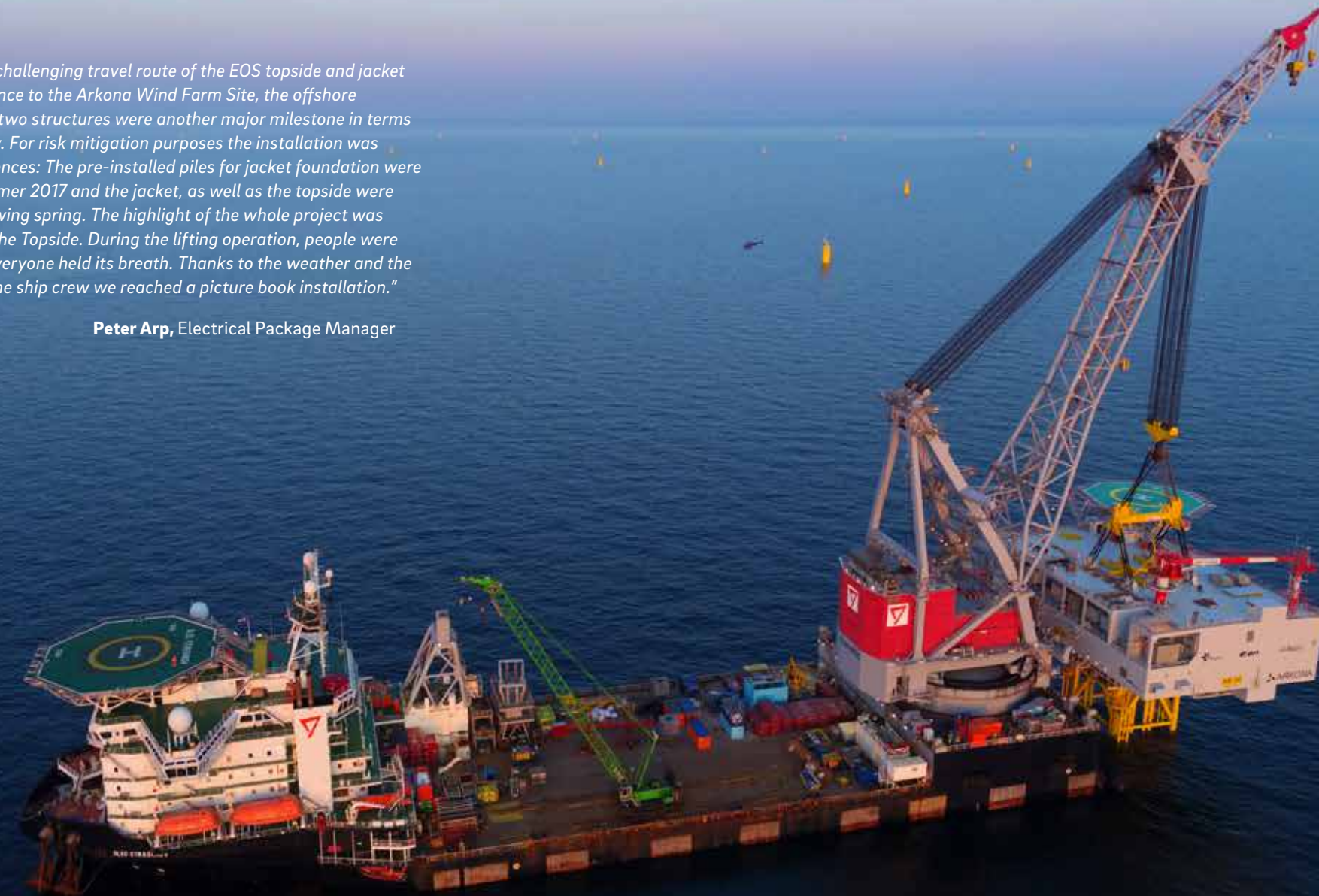
*"Array cabling traditionally includes a wide variety of interfaces to foundations, substation and turbines, linking them together. The seabed poses additional challenges. It was reassuring to see how the early involvement of both the contractor and internal stakeholders paid dividends in shaping a unique design solution, culminating in a well-planned and timely completion of cable installation, despite operational challenges. Drawing on lessons learned from previous projects and cross-utilizing knowledge from previous projects was clearly an added benefit. Personally, my first project where the originally planned date for cable loading never shifted by a single day. Spot on and a great team effort."*

**Malte Paul**, Logistics & Construction Manager



*"Beside the already challenging travel route of the EOS topside and jacket foundation from France to the Arkona Wind Farm Site, the offshore installation of these two structures were another major milestone in terms of timing and quality. For risk mitigation purposes the installation was splitted in two sequences: The pre-installed piles for jacket foundation were installed in late summer 2017 and the jacket, as well as the topside were installed in the following spring. The highlight of the whole project was definitely the lift of the Topside. During the lifting operation, people were barely talking and everyone held its breath. Thanks to the weather and the professionalism of the ship crew we reached a picture book installation."*

**Peter Arp**, Electrical Package Manager



## Jacket Installation – Topside Installation

The jacket with a height of 53 m was installed on a pre-piled foundation. Each of the piles is up to 60 m long and embedded into the sea bed. The piling took place in a separate campaign in a water depth of around 27 m just a couple of months before. The topside was installed by the impressive vessel Oleg Strashnov – being currently the largest crane vessel available to the renewable industry in the Baltic Sea. The installation of the topside from the barge on top of the jacket structure forms the heaviest lift of a single block Alternating Current (AC) platform ever. Furthermore, it was the heaviest lift carried out by Oleg Strashnov on dynamic positioning so far. Rising 37 meters above sea level, the substation has a size of an eight-storey apartment building with a total area of almost 4,000 m<sup>2</sup> distributed on 3 levels.





## Jacket and Toppide Transportation

With a weight of more than 4,000 t the topside sailed out from the port of Saint Nazaire just three days after the jacket substructure sailed out from the same port of Saint Nazaire. While having challenging weather conditions, the weather window was perfectly chosen for the sail out. On its journey to the Baltic Sea the jacket and the topside passed through the Bay of Biscay, then over the English Channel into the North Sea, and past the northern end of Denmark through Skagerrak and Kattegat to the construction site, 35 km northeast of the German island of Rügen.





## Electrical Offshore Substation Commissioning

For the commissioning of the Electrical Offshore Substation (EOS) a new, much safer commissioning strategy was implemented. Instead of bringing the commissioning technicians and engineers to the EOS by Crew Transfer Vessel (CTV) every day, a large Jack-up vessel was placed alongside the EOS connected each other via a permanent bridge. This accommodation vessel hosted up to 112 offshore workers and guaranteed a safe and time saving way to ensure an efficient array and export cables installation on the EOS, the commissioning works of the EOS, and its energization.





# Wind Turbine

After thorough evaluation of different wind turbine (WTG) types and suppliers we selected the Siemens Gamesa 6.0 MW Direct Drive-154 turbine. The turbine is equipped with additional features to improve the annual energy production and the long-term availability of the system.

The turbine received High Wind Ride Through functionality which allows energy production in up to wind speeds of 28 m/s and a Power Boost functionality which enables additional power generation in wind speed between 10 m/s and 18 m/s.

The 75-meter-long blades received aerodynamic upgrade with vortex generators, dino tails and a leading-edge protection system. This upgrade improves the power generation capability of the turbine in wind speeds below 10 m/s and improves the reliability of the blades by protecting the tip section of the leading edge from erosion effects.

The turbine consists of an innovative direct drive concept with a full-scale converter system. It allows turbine operation at variable speed, while supplying power at constant frequency and voltage to the grid.

The rotor diameter is 154 m. The 36 kV transformer with a capacity of 6,8 MVA is located at the base of the nacelle, connected to a switchgear, which is situated in the transition piece. The tower consists of three tower

segments equipped with a service lift for three persons. Each nacelle is fitted with a helicopter hoist platform, in order to increase accessibility by helicopter.

The turbine is equipped with a complex sensor system which allows via a SCADA system the control and steering of all functions and components of the turbine from a remote onshore location.



**Frank Fuhrmanneck,**  
Wind turbine  
Package Manager

*"The 1<sup>st</sup> of July 2018 was a warm and sunny morning on the island of Rügen. I was sitting with my family on the terrace of Café Peters for breakfast with a perfect view on our quayside and assembly area. We saw the first load out of these awesome huge components onto the installation vessel. It was an impressive picture. The next day my family followed the transit/sail out of the wind turbines into the wind farm as the next step of the construction from the observation platform in the National Park Königsstuhl. In the evening we met for dinner and I heard how amazed they were about seeing the activities to construct the wind farm. When I felt their enthusiasm, saw their shining eyes, I realized that we did something great."*





## Wind Turbine Generator (WTG) Supply

The process from contract signature to the time when a nacelle, blade and tower were ready for shipment to the assembly harbour has been challenging. A thorough review process of design documentation and detailed planning of inspections for all the different components delivered mainly from Europe are the major success factors for a good quality Wind Turbine delivered in time for the Arkona project.

All different components used in the wind turbine had to be purchased, casted, welded and machined. Parts of varying size and shapes had to be mounted, pre-tested, controlled and shipped to the pre-assembly area in Mukran Port/Rügen with the final objective to install the WTGs on the offshore foundations, commissioning them and to finally produce energy as fast and reliable as possible. Looking into the tower and nacelle of a completed WTG which is the major component of the wind farm after putting all bits and pieces together, it fascinates with its complexity.

The assembly areas for the major WTG components are similar to a construction site where a masterpiece consisting of many parts will be assembled according to detailed assembly instructions – and even this is a technical, complex challenge, which requires expert knowledge and a highly skilled team to finally deliver the end product.





Arkona has obtained a huge bank of knowledge from the previous wind farms built and from lessons learned workshops from other projects, where the WTG team has been involved. These experiences have been discussed with suppliers and caused several improvements to the components. An amazing process due to the fact that wind turbine, in the origin, was expected as an "off the shelf" product. For the tower, the part of the WTG which requires a project specific design, several analysis iterations have been executed by experts in the Netherlands and Denmark, to find the optimum design for the different load cases in the Baltic Sea like ice, waves, wind and collisions.

All design modifications have been followed by the project team with Design Reviews and Change Control procedures. The "Clicking process" of nacelle with generator and hub was done at the test site in Esbjerg where also a first test run of the nacelle was performed.

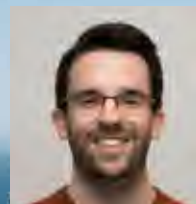
The tower was fully assembled and received a functional test for all systems in Mukran Port. All manufacturing and assembly processes have been followed up by our Arkona Quality team. As a consequence of these properly monitored activities, the good planning and the motivated partners and employees, we experienced a very smooth installation and commissioning process.

### Many Siemens locations contributed to the turbine

Components have been produced and machined in many different countries. The assembly of each generator, hub and nacelle has been done in Denmark. Towers were produced in Denmark and Germany, while blades and spinners have been manufactured in Denmark.







**Markus Kleine-Finke,**  
Turbine Installation Manager

*"The erection of the turbines is certainly the most visible phase of the wind farm construction. When the installation vessel arrives on site, the wind farm finally gets its face. At the same time, E.ON and Equinor generate the first income after years of development and construction already during the installation campaign."*

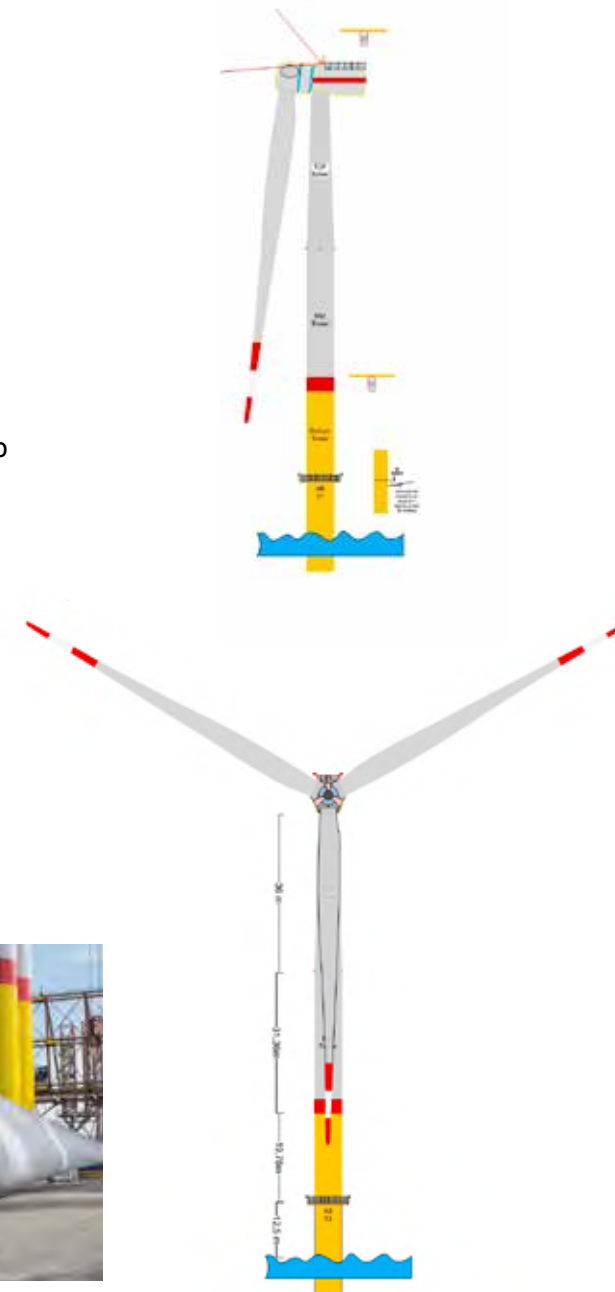
*"Being aware of all the exposure and time pressure connected to this construction lot, I am very proud that we managed to erect all turbines in a safe manner and ahead of schedule. It was just fantastic to see that all involved parties worked hand in hand with extraordinary experience and professionalism."*



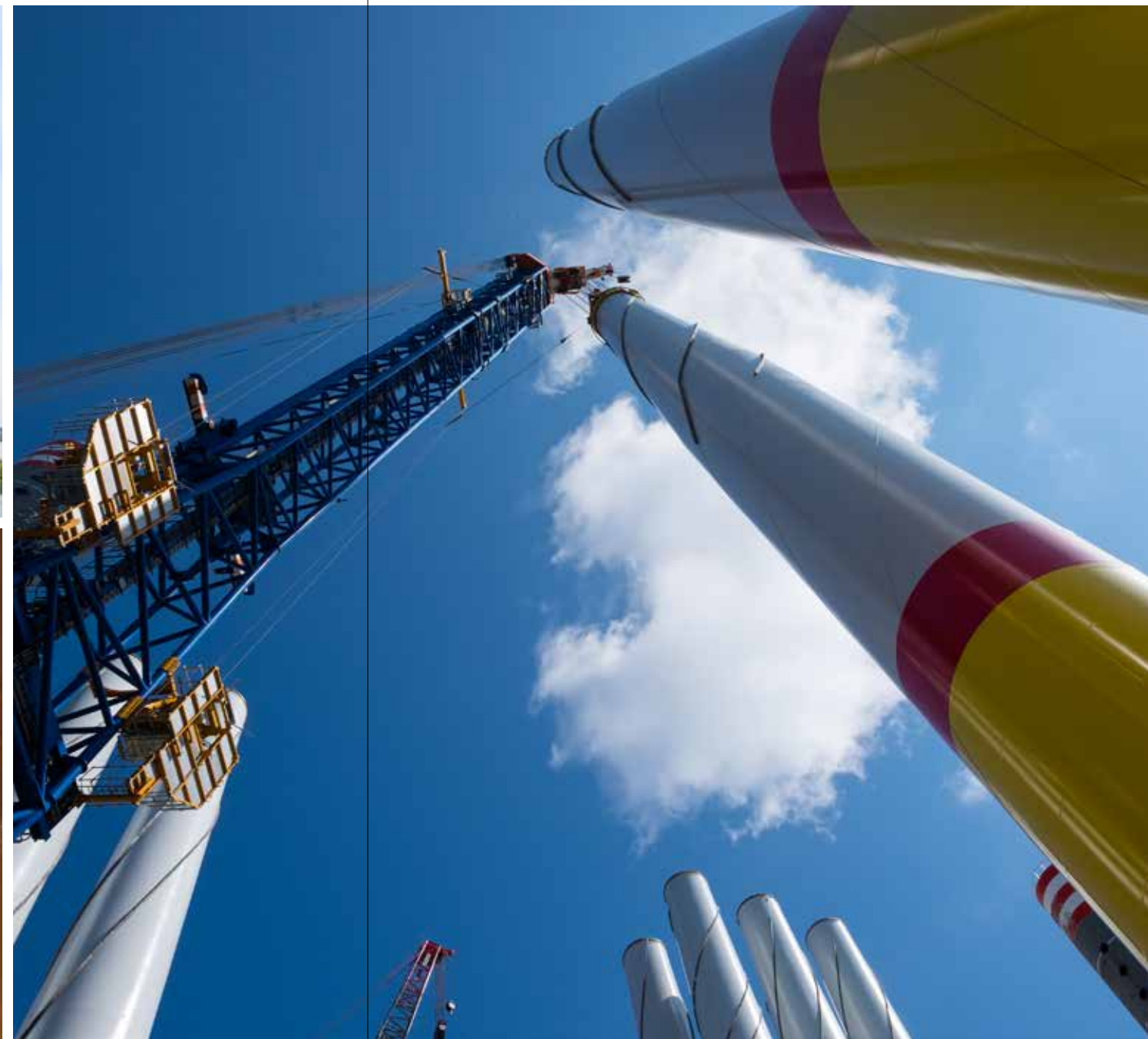
## Wind Turbine Installation

By nature, the installation of the wind turbines is the last big step of the wind farm construction. To minimize offshore works, all turbine components were shipped to Mukran Port for final assembly works and inspections. The towers were delivered to the Mukran Port in three segments and then assembled to full towers before load-out to the installation vessel.

In Arkona, the installation was done by the installation jack-up vessel A2SEA Sea Challenger which can carry four full sets of components per round trip. Lean processes and favorable boundary conditions made it possible to conduct the installation of 60 towers, 60 nacelles and 180 blades within 114 days, making it less than two days on average per turbine installation including weather, transit and load-out.













# Commissioning

At the final stage of the construction phase, the interfaces of the electrical, mechanical and hydraulic systems were successfully connected offshore, triggering the production of the first electrical power only a few hours after turbine installation.

Using the "Walk to Work" (W2W) vessel Vos Stone, an accelerated commissioning concept was implemented, minimizing the commissioning time to less than one day. Key technical factors of the concept were a thorough onshore testing program, a fast and safe energisation procedure, and a robust logistic concept, maximizing the utilization of the offshore resources.



**Enrique Otero Nieto,**  
Turbine Commissioning Manager

*"The collaboration between all personnel involved in the works taken place from the "Walk to Work" vessel was extraordinary. Many persons with different characters and technical background lived in a limited space and worked fully committed to deliver their link in the chain of efforts.*

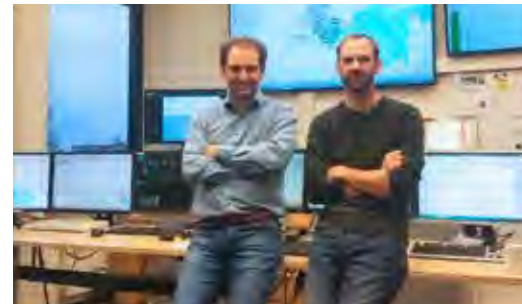
*The common goal of producing energy in a sustainable manner materialised in a safe way and in record time, when the permanent magnet generator of the first commissioned wind turbine coupled electrically to the inter-array grid. I am proud to have been part during years of the Arkona Team."*



# Marine Coordination Center

The Marine Coordination Center (MCC) located in Hamburg has been the hub to monitor and track all inner field presence of vessels and personnel, traveling between the installation sites and the base port.

In this respect during a 1,5 years period on a 24/7 shift basis, about 100 vessels and 4,600 personnel have been engaged. Covering the emergency contingency as well, data collection and communication have herewith been shared with the emergency response teams. An MCC Satellite location has been deployed offshore onboard a hotel vessel, to ensure the close link to the offshore operations activities. To secure a high safety and security standard, the MCC personnel have inspected all vessels and introduced their crew to the project, prior to engagement in any operation.

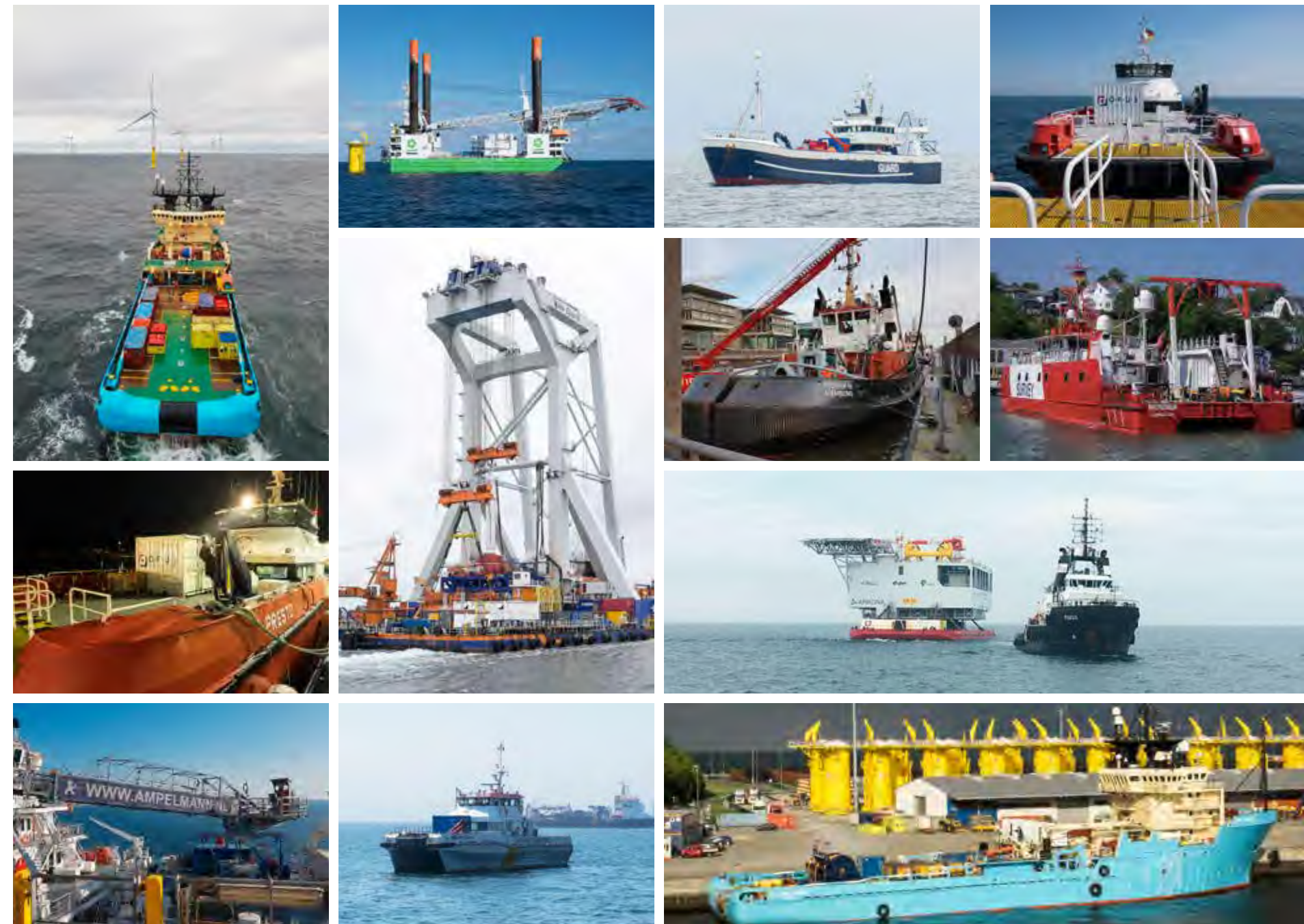
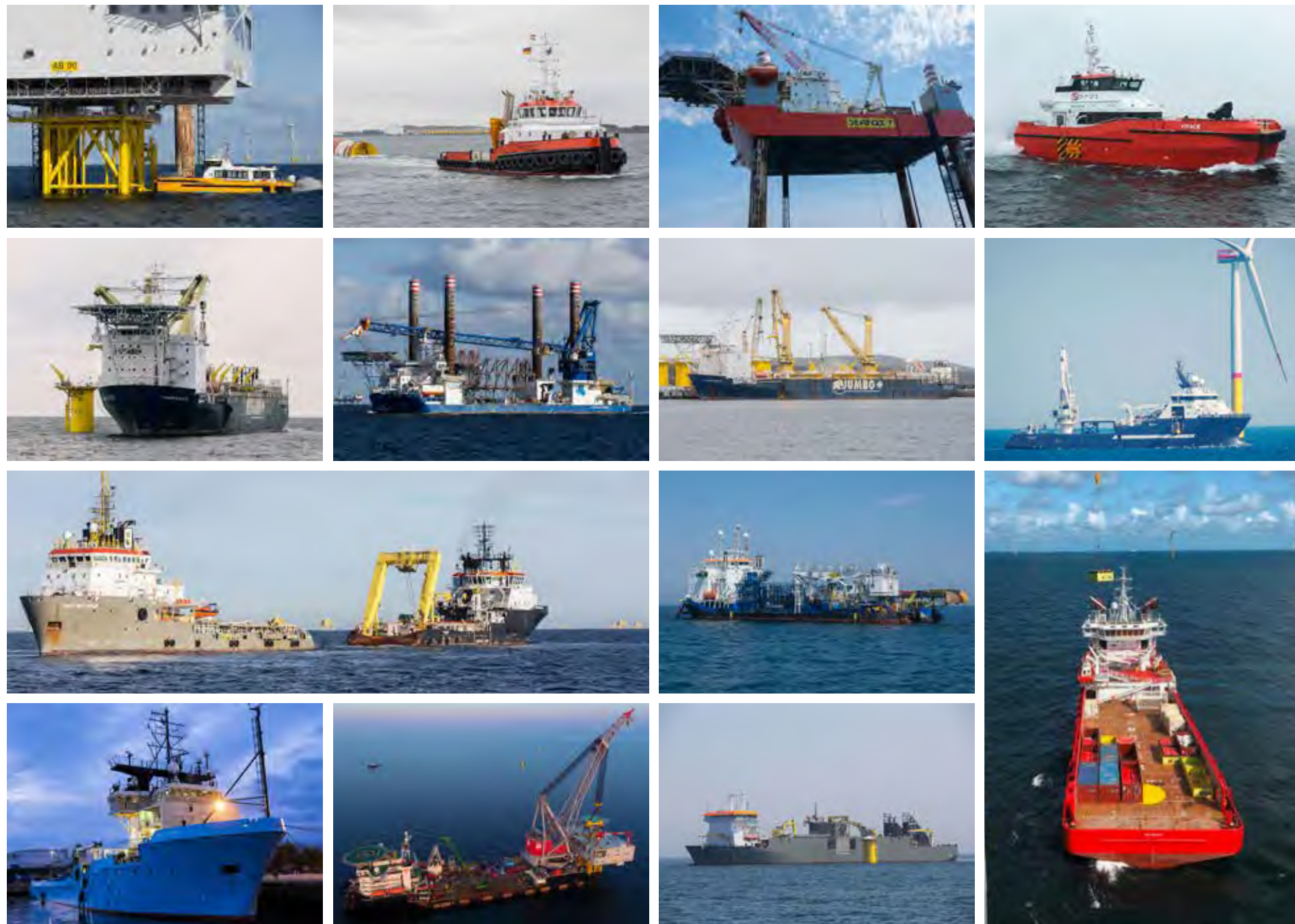


## Additional Offshore Works

In addition to the major installation campaigns using large offshore construction vessels, numerous parallel activities had to be carried out using crew transfer vessels (CTVs), shuttling from Mukran Port on a daily basis, with different teams working in all technical fields. The works involved amongst others maintenance works, HSSE related recertification, the support of the of the MP-TP bolting campaign, and preparation of the already installed assets prior to the installation of the following component.











# Consent & Certification

It was our ultimate goal to obtain all the necessary permits and building approvals in time so that the execution of the preparatory construction measures and the start of the installation of all trades could start on schedule. The fulfilment of all ancillary conditions and requirements imposed by the responsible authority with the granting of permits and approvals had to be ensured and documented throughout the entire construction phase. This procedure could completely avoid severe impacts on the marine environment and meet all requirements relating to marine traffic and occupational health and safety.



**Fabian Broicher,**  
Certification Manager

*"The certification went very smooth in cooperation with all the technical packages and our certification company DNV-GL. Arkona is fully certified to deliver renewable energy."*



**Martin Leniger,**  
Consent & Certification Manager

*"This very complex interdisciplinary task could only be mastered thanks to an incredibly motivated, flexible and competent team. I would like to thank Fabian, Christoph and Michael for their unbelievable commitment, their ideas and not to forget the fun we had together during the project work. I would also like to thank the Federal Maritime and Hydrographic Agency (BSH) as the responsible approval authority and the authorities involved on the part of the BSH. There, our project was always accompanied in a professional and solution-oriented manner. The Arkona project is not only a milestone in our company but also in my personal career."*



# Project Office & Commercial

In 2013 the Arkona project set an ambitious target to develop, construct and operate a wind farm hosting the so-called new generation turbines (5+ MW) together with an ambitious target for levelized cost of energy (LCOE) below industry standard. From Day 1, optimization in terms of cost savings and acceleration initiatives has been driven by the project and its management.

Before the tender and procurement phase, the project executed an intensive pre-qualification round of technologies and suppliers. This included an integrity check of new innovative but already tested technology like the turbines Power Boost-High Wind Ride Through feature or the new XL monopile supply. E.ON Climate & Renewables (ECR) on behalf of Arkona's project company AWE chose a well-balanced risk-and-reward procurement strategy for Arkona and pre-selected very reputable suppliers with the most advanced concepts.

Before the final investment decision was made, the project placed all main supply and installation contracts. They included fast-track delivery schedules which triggered significant savings and increased profitability against traditional planning. In addition, the optimization of the park layout and technical designs further enhanced the project value of Arkona.

Overall, promising project agreements, incentive schemes and project designs formed a very attractive business case which supported also a smooth transaction with the co-shareholder Equinor. Following the final investment decision, both shareholders introduced an improvement

initiative program for the project's implementation and execution phase. The project team achieved further significant value creation from all areas including further turbine upgrades, de-risking of installation and commissioning programs, innovations and cost savings in supply resulted from occasions where bunker fuel costs (installation vessels) or copper prices (array cables) were low.

Overall, the project execution of the Arkona Wind Farm outperformed all targets: Cost savings amount to three-digit million EUR against approved budgets and all turbines generated some four months ahead of schedule and set a new industry-wide benchmark.



*"Commercial success in a project environment largely depends on the dedication to find best solutions, improvements and further optimization at all times.*

*However, any successful steering and execution needs accurate management information which feeds pro-active and educated decisions. The commercial management of E.ON Climate & Renewables was dedicated to success in all areas. High-quality and reliable reporting was only one of the contributions. The definition of very attractive business cases and identification of commercial improvements are another one.*

*Funding and smooth preparation of budget and cash requirements including their formal implementation together with a state-of-the art controlling and risk management system always well addressed the management needs. A large number of improvement initiatives accompanied by well perceived and quick responding commercial and procurement support got only acceptance through the reliable value based management of the project.*

*Finally a very pro-active insurance management together with E.ON Insurance Services not only optimized the lowest ever insurance premium but also enabled smooth execution and once it was needed effective and fast regulation.*

*The level of commitment and quality again on all service levels have been a great facilitator of success for Arkona."*

**Christoph Altmeppen,**  
Project Office & Commercial Manager



# Operation & Maintenance

Having reached the end of construction, Arkona now enters the 25-year operational period. A key decision, made long before now, was the selection and commitment to Mukran Port as the selected location for the operations and maintenance base, thus shaping the entire operational concept for Arkona. Located on the beautiful island of Rügen and next to the white chalk cliffs, Arkona's O&M service base is a highly functional building with all the necessary facilities for our team

and partners, including an efficient warehouse, offices and a high-end control room. The short distance to the quayside of only 30 m combined with the dedicated crane to load and unload crew transfer vessels (CTVs) is the perfect set up for our daily logistics. Furthermore, the building is equipped with a photovoltaic system and three charging stations for e-cars to contribute to minimizing CO<sub>2</sub>.



**Frank Scholtka,**  
Plant Manager Arkona

*"Coming from the wild west of Texas to the wonderful island of Rügen, it is my pure pleasure to bring Arkona into operations and to take over the responsibility for our newest Offshore Wind Farm. My focus as Plant Manager, right from the beginning, was to build and develop a team that ensures operational readiness, takes over from construction and guarantees the highest level of safe and efficient operations."*

*With Arkona, we now operate the largest wind farm in the Baltic Sea and with the Mukran Port, we not only selected an operational base but also a new home where we as a team can grow together. At the same time, with the 6 MW direct drive turbine, we are adding a new technology to our fleet as well as expanding and strengthening our self-perform approach. Furthermore, we are operating the shared offshore substation with 50Hertz and are closely cooperating with our Joint Venture partner Equinor. All*

*these factors make this journey for us as a team as exciting as it is rewarding. Based on the great success story of our wind farm Amrumbank in the North Sea, as well as our offshore fleet in Denmark, Sweden and the UK, it is now our mission to implement the experience gained, lessons learned and established best practices into our day to day Arkona operations. Our main goals at Arkona are: highest possible plant availability, cost consciences operations and zero harm to people and the environment.*

*To successfully deliver these goals and tackle any challenges along the way, I feel privileged to have such a dedicated team of experts around me, all together united by their passion for offshore wind and the ambition to make Arkona a role model for future large scale offshore wind farms. This highly motivated and competent team has now been fully recruited and are working hard already focusing on day to day operational activities."*





## Setting the pace for operations

We have taken the idea of a fleet-wide approach to heart, which includes the close cooperation with our colleagues from the Amrumbank Offshore Wind Farm as well as the wider offshore operations fleet. Common engineering meetings, joining the best of Arkona and Amrumbank, enable us to maximize synergies and share best practices. In addition, many central functions and engineers will support Arkona in technical and commercial topics to ensure a safe and efficient operation.

A unique advantage for Arkona stems from the lessons learned sharing with Amrumbank across the full operation. For example, the layout of the building as well as select tools and processes are all based on Amrumbank and further learnings from our international fleet are taken into account to drive down costs. To make the most of the opportunities for shared learnings, we have from the very beginning placed newly hired Arkona employees first into the Amrumbank team on Heligoland prior to starting at Arkona. Additionally, team members from Amrumbank have moved and more will move over to the Arkona team to transfer first-hand experience. The strong starting position for Arkona operations provides us the opportunity to quickly apply learnings and further develop and improve processes so that they may be transferred back in to the business to further strengthen our offshore operations fleet.

Finally, the early involvement of operations in the planning and construction phase was yet another success factor in ensuring a high technical availability of all turbines and the offshore substation. Examples of this are: electrical engineers and technicians witnessing the construction of our electrical offshore substation in France as well as the ensuing installation and commissioning activities offshore; Our maintenance coordinators acted as senior authorized persons on board the Sea Challenger and we supported the turbine commissioning on board of the VOS Stone as well as onshore activities at the pre-assembly site in the Mukran Port.

All these aspects make it possible for us, as Arkona operations, to operate our windfarm, together with our partners, 365 days a year with the highest standards of safety and quality. As a team we will strive for this every day and consider it in all that we do.





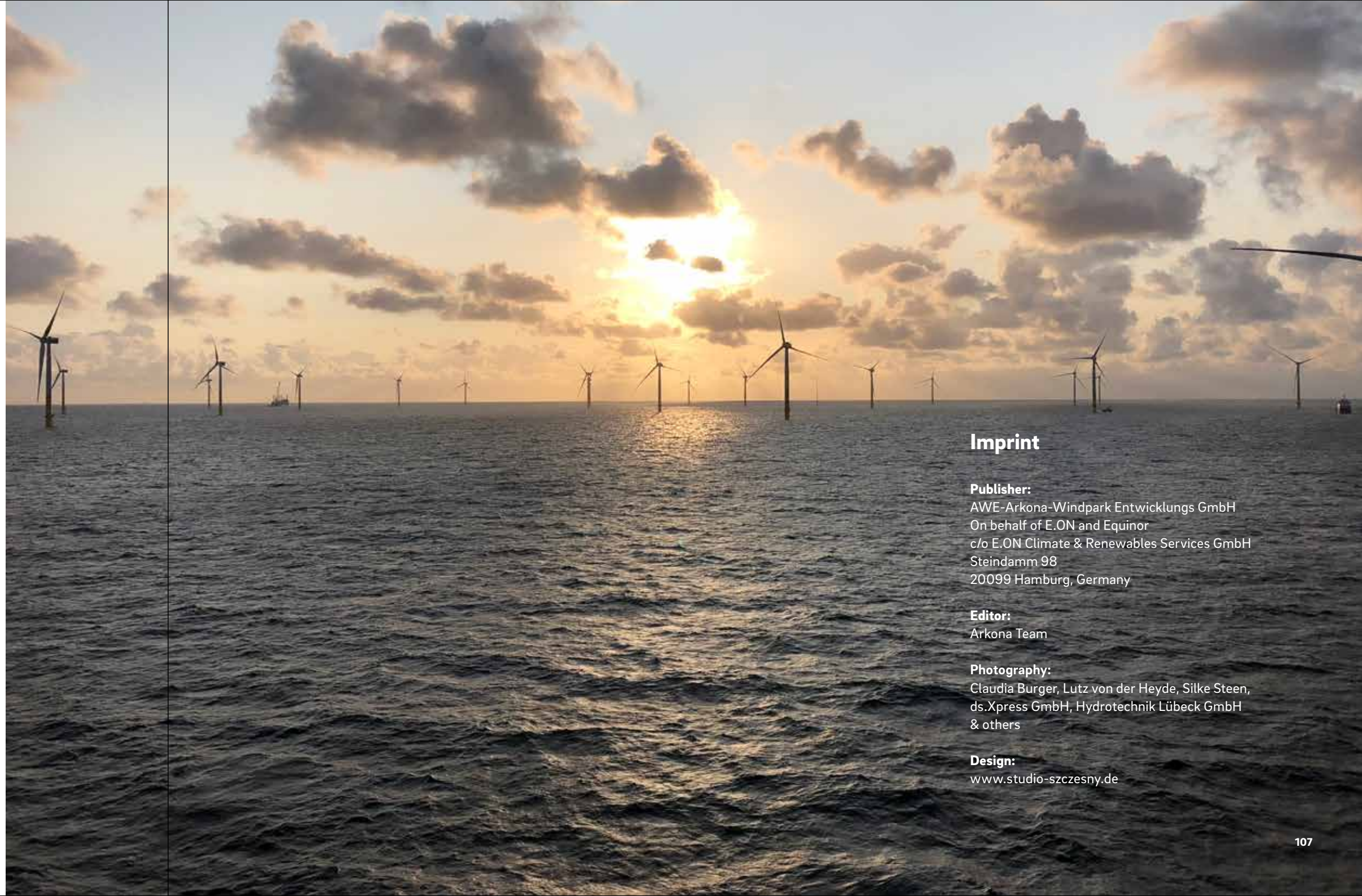
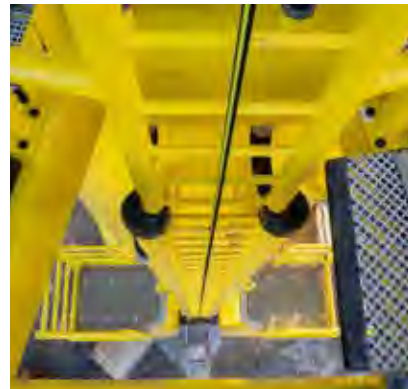
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**Team:** Brain Adair, Jonathan Adam, Chris Akehurst, Yulia Akselrod-Lenz, Stina Albing, Åsa Alström Johannesson, Christoph Altmeppen, Anton Andersson, Niels Thorben Andresen, Peter Arp, Jörg Asmussen, Pia Asp, Emmy Axelsson, Alexander Baalmann, Ander Badiola, Stefan Banas, Carolin Bankowski, Miriam Bardolet-Pou, Oliver Becker, Claudia Behrmann, Tim Bell, Silviya Betovska, Christoph Betz, Philip Birk, Andra-Maria Blindu, Petra Blümel, Stacey Botteau, Per Brännström, Alexandru Brasovean, Claudia Bredenkaamp, Andreas Brockmöller, Fabian Broicher, Joscha Brörmann, Anja Brüggemann, Guido Brümmer, Caroline Bruns, Halfdan Brustad, Olaf Burrow, Arno Buysch, Aret Cezveciyan, Adrian Chatterton, Yasser Chehade, Miriam Chmiel, Vlad-Adrian Ciorca, Pål Coldevin, Ricardo Jorge da Silva Rocha, Sven Dahl, Thomas Danz, Martin Dausend, Erik de Man, Christian De Bruyne, Willem de Jong, Alexander Dembach, Anish Deshpande, Marc Dönges, Michael Doodt, Michael Dörstel, Ralph Drüppel, Nils-Ingo Ebers, Katrin Eckhard, Fabian Eggert, Nadine Eidenschink, Patrick El Murr, Niels Emsholm, Hanna Elisa Engelhardt, Nils Engelke, Alper Esin, Werner Falk, Konrad Fallmann, Eugenio Fasano, Angel Fernandez Sarabia, Julia Fisman, Sarah Marie Fister, Craig Fitzgerald, Jan Fölster, Jürgen Frehde, Frank Fuhrmanneck, Patrick Fuhs, Colin Galer, Dean Gardiner, Manuel Gardt, Adam Gauld, Sonja Gerecke, Nadine Gerhard, Aklilu Ghebreyesus, Diana Giffhorn, Mohamad Bakri Glelati, Christof Glose, Susanne Gödde, Guillaume Godin, Volker Görtz, Per Green, Chris Green, Wiem Gribaa, Jochen Große-Erdmann, Katharina Grüter, Ralf Grzesiak, Daniel Gudopp, Mario Gühlke, Gunnar Gundersen, Mike Günzel, Kai Gurstadt, Marcel Haendler, Andreas Hammar, Bitten Hansen, Romana Hartke, Alexander Haselmayer, Franziska Hennig, Alexander Henschel, Roger Henschke, Alexander Herber, Marc Hermel, Janos Hernicke, Axel Hillbrandt, Stefan Hooge, Steffen Horn, Kristian Høy-Thomsen, Georg Hübl, Jörg Hümmer, Andre Hurtig, Jochen Imhof, Marcel Jackisch, Keith Jackson, Ulrik Jacobsen, Eike Hendrik Jahn, Thilo Jakobi, Allan Brink Jakobsen, Jan Jansen, Leino Johanson, Tim Jones, Jörg Jüngerhans, Maksim Karabanov, Daieub Katrein, Willi Kehl, Ines Kehl, Ines Kehl, Ronny Kimak, Ulrich Klein, Laurens Klein Goldewijk, Markus Kleine-Finke, Dominic Koe, Mehratsch Kohsar, Alexander Konstantinov, Jan Korf, Bernd Kraft, Anne Gunnhild Kraggerud, Richard Krasenberg, Jeannot Krassow, Arno Krist, Daniel Kruse, Leif Kuchenbuch, Matthias Lange, Malcolm Langham, Oscar Lapieza, Mårten Larson, Martin Leniger, Gregory Lenz, Mario Liguori, Tristan Lippert, Katharina Löffler, Alyssa Lord-Hill, Thomas Lorenz, Sabrina Luitjens, David Lukas, Justus Maas, Burkhard Maass, Jesper Mains, Frank Mainz, Lars Henning Markus, Patrick Markworth, Fredrik Martell, Matthias Martens, Dele Martins, Holger Matthiesen, Peadar Mc Nally, Jörn Meyer, Sidsel Milling Eriksen, Jan Moede, Candy Mohr, Michael Mollenhauer, Vincent Montet, Juan Morales, Javier Moreno, Tim Moritz, Blaise Mouchanat, Lee Mrnjavac, Jochen Münker, Julia Nagel, Christian Nestl, Enrique Otero Nieto, Stella Nikolova-Machimada, Kristin Nilsson, Geoffrey Nolan, Geoff Nolan, Wolfgang Normann, Christoph Oelrich, Nico Oelrich, Marc Ostendorp, Ingo Osthues, Malte Paul, Jerome Perrin, Merten Pfeiffer, Frank Plaehn, Frank Polzin, Witilo Kolja Preuß, Lukas Prietz, Hans-Joachim Puls, Jelena Radovic, Mark Rapson, Camilla Rasmusson, Jens Rauschenbach, Rames Rees, Frederieke Reiners, Karsten Reutter, Marco Rieche, Sabine Ritz, Florian Rocktäschel, Marc Roder, Wayne Rogers, Martin Rohte, Alexei Roll, Sergej Romanjuk, Martin-Oliver Ros, Thorsten Rösch, Marco Rummer, Rico Salgmann, Ramesh Sameera, Irina Samorukova, Matthias Sauer, Rüdiger Säurich, Giuseppe Scapeccia, Michael Schäfer, Benedikt Scheel, Roman Schenk, Sharon Schmidt, Udo Schneider, Frank Scholtka, Christian Schrimpf, Christian Schrimpf, Anne Schröder, Björn Schulz, Andreas Schulz, Sven Schulze, Malte Schumacher, Till Schwarzlose, Dominik Schwegmann, Andreas Seibel, Burkhard Seif, Zsuzsanna Sessel-Zsebik, Robin Siemer, Ramona Siemens, Hauke Sievers, Staffan Sjölander, Patryk Skwiot, Nina Sommer, Nina Sommer, Agatha Christy Sonma Okoro, Frederike Sprengel, Anna Maria Staszak-Staszakow, Silke Steen, Maik Stephan, Emil Steuch, Michael Andreas Still, Ingrid Storaker, Christoph Straub, Victoria Sträussler, Benjamin Stuckenschmidt, Andreas Stutz, Scott Sutherland, Michael Szelwis, Farah Sedky Tawfik, David Teichert, Sebastian Thiele, Lars Thode, Trine Ingeborg Ulla, Christoph Urch, Sven Utermöhlen, Hendrik van Ritter, Alejandro Vasquez, Lorenz Vehring, Rubika Venkhatraman, Sonja Voigt, Uta von Thomsen, Almuth Vorndran, Björn Voss, Miles Wakefield, Alexander Walter, Maren Warnecke, Nick Watt, Lars Welander, Dominic Wendel, Dominic Wendel, Frank Wiekhorst, Russell Willetts, Horst Winkelmann, Martin Winter, Michael Wolf, Adrian Wolf, Magdalena Ziemer, Paul Zimmerman, Johanna Zocher, Bernadett Zsibrita-Amen, Mike Zühl & 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