SYNCHRONOUS CONDENSERS

THE SMART SOLUTION FOR MODERN GRIDS

ANDRITZ

ENGINEERED SUCCESS

Maintaining the reliability of the grid is becoming more challenging

Demanding new regulatory requirements and a cleaner, more diversified energy mix are giving rise to new issues for electricity grid operators tasked with maintaining a stable energy supply. The Synchronous Condenser is a reliable, proven, and cost-effective solution.

A CHANGING POWER SECTOR

A power sector dominated by renewable resources is fundamental for the global transition to sustainable energy. However, changes in the generation mix from increasing volumes of widely distributed and intermittent renewable energy generation, coupled with the phasing-out of fossil-fuelled resources, is creating a major challenge for grid operators which have to ensure a stable, reliable and secure transmission and distribution network.

For transmission system operators Synchronous Condensers are able to provide these stabilization capabilities that are being lost from the grid because of the transformation of the generation mix.

Rotating electrical machines operated as Synchronous Condensers are experiencing a renaissance as a result. While continental Europe, the UK, Ireland, Australia and the Americas represent the biggest markets for Synchronous Condensers, the trend is global and is increasing at an accelerated pace.

REACTIVE POWER AND MORE

Synchronous machines in general can be used as generators as well as motors. Typically, a Synchronous Condenser is a classical synchronous machine which is operated to provide reactive power only. Synchronous Condensers are typically installed in existing or new substations though there are alternatives.

Due to the electrical design and the large rotating mass of the rotor, Synchronous Condensers can provide a variety of additional services beyond reactive power for the grid though. In fact, over recent years a distinct shift in the grid services demanded from Synchronous Condensers has been observed.

For instance, Synchronous Condensers are also able to provide dynamic voltage support, additional inertia, and strengthen system short-circuit capacity. Synchronous Condensers are thus capable of supporting Transmission System Operators (TSOs) with multiple grid stabilization services.

"Synchronous condensers are an effective solution for the new requirements of the grid."

PROVIDING INERTIA - IMPROVING STABILITY

In a power system, grid frequency is an indicator of the balance between generation and consumption. Where large imbalances occur, qualities such as the grid frequency can be impacted. However, even if big changes in supply or demand occur rapidly, for example when a generation plant trips off the grid, sufficiently large amounts of inertia can attenuate or avoid any High Rate of Change of Frequency of the Grid (RoCoF) effects. In such cases, TSOs can ensure stable operation and security of supply.

Synchronous Condensers are the perfect instrument to provide such inertia, which can be naturally produced by the rotating mass of the machine or even increased with the addition of external flywheels.

DYNAMIC VOLTAGE SUPPORT

The injection of high reactive currents during and after grid faults is also fundamental to avoid voltage collapse. Synchronous Condensers are designed to deliver such a response and can even provide an extended time-limited overload capability, for example sustaining 200% for 30 seconds.

SHORT CIRCUIT POWER - ESSENTIAL FOR SYSTEM PROTECTION

Short-circuit power plays a vital role in the proper functioning of the protection system of an electricity transmission grid. In fact, in order to be granted a connection permit it is typically mandatory that sufficient short-circuit power is available at the connection point.

Non-synchronous power generation - solar, wind, or HVDC connections for example - cannot significantly contribute to the available short circuit power though. Synchronous Condensers, which are able to provide up to five times more short circuit power than their rated capacity, are therefore able to become a major contributor to the short-circuit power of any grid dominated by renewable generation.

REACTIVE POWER

For decades Synchronous Condensers have been used to provide reactive power, which is needed for static voltage regulation of the grid. Nowadays, this demand for Synchronous Condensers to deliver reactive power remains unchanged.

More than a century of Synchronous Condensers

For more than 120 years ANDRITZ has supplied numerous synchronous and non-synchronous machines, mainly for generation purposes. Today, approximately 5,000 units are still in service all over the world, relying on decades of experience in plant and system integration in the renewable energy business.

The ANDRITZ Synchronous Condenser portfolio covers a range of standardized cylindrical rotor design solutions as well as tailor-made salient pole Synchronous Condenser units. Standardized products are favourable for reduced implementation times, while tailor-made solutions are characterized by reduced losses and optimized operating conditions, for example improved dynamic performance.

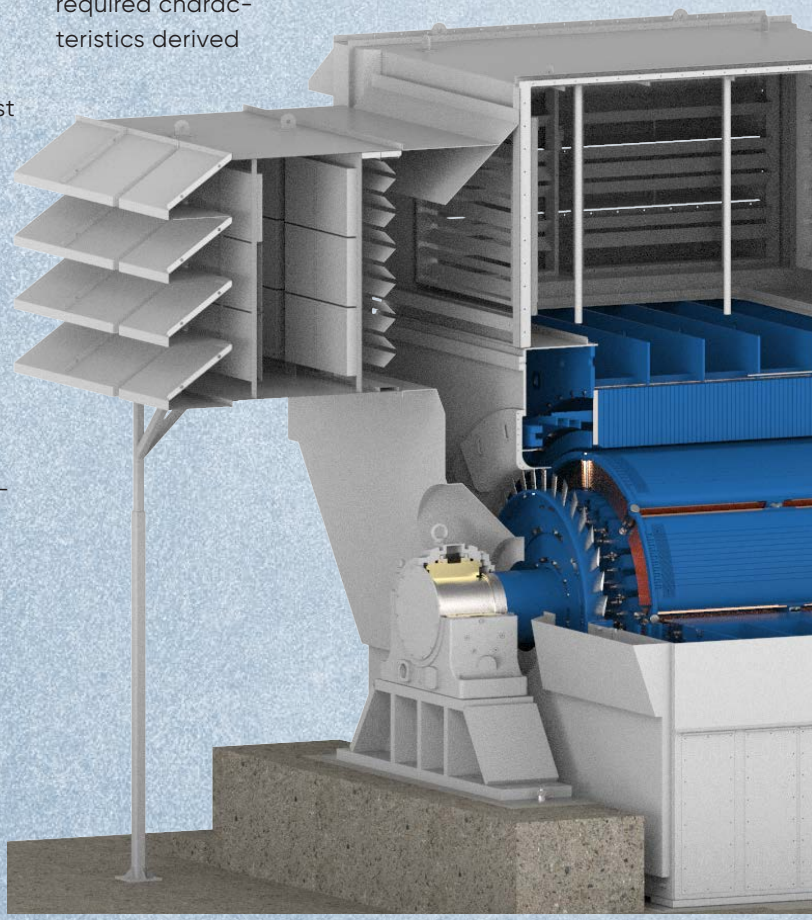
ANDRITZ' engineering excellence is focused on the entire power train, from the Synchronous Condenser unit with its mechanical and electrical auxiliaries right up to the defined Point of Common Coupling (PCC) with the high voltage transmission system.

SPANNING THE WORLD OF GENERATORS

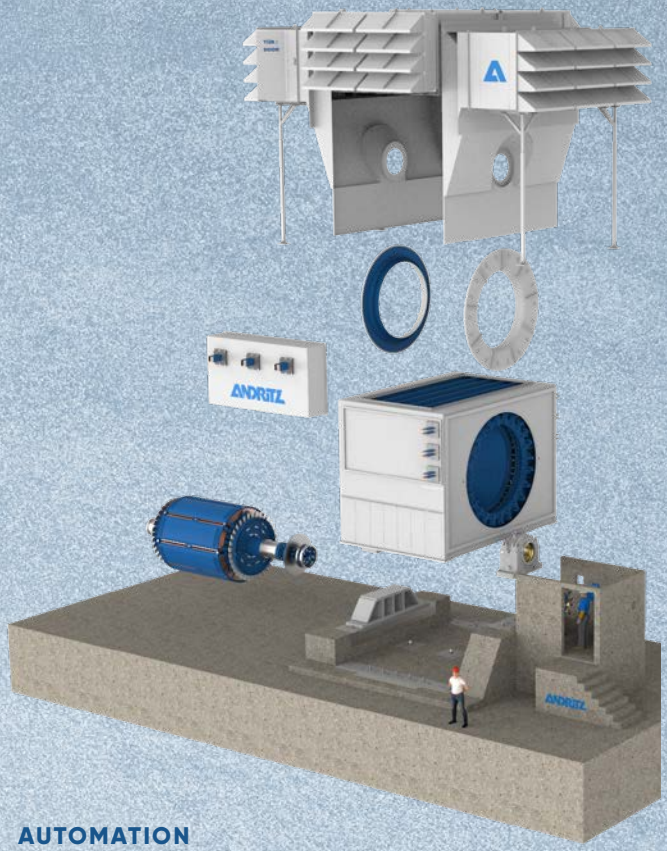
ANDRITZ' synchronous machines portfolio covers a vast and complex range of applications and illustrates a mastery of a large variety of technologies. ANDRITZ provides state-of-the-art Synchronous Condenser designs, such as those featuring flywheels with reduced friction based on vacuum technology, direct air-cooling systems, sophisticated hydrogen/water cooling systems, and Totally Enclosed Water to Air Cooling (TEWAC). Furthermore, the most advanced salient pole and cylindrical rotor solutions, static and rotating high efficiency excitation systems, advanced monitoring systems and other highly reliable and proven technologies allow ANDRITZ to select the optimum Synchronous Condenser solution to meet the requirements of each particular project.

OVER A CENTURY OF EXPERTISE IN ELECTRICAL AND PLANT

With over a century of expertise in plant optimization while taking full account of current and future grid requirements, new technologies and challenging timeframes, ANDRITZ' global references in greenfield and brownfield projects confirm our skill in managing highly complex projects throughout the power industry. Acting as the principal contractor or "from water-to-wire" contractor of large hydropower installations, complex associated high voltage systems, pumped storage projects and many others, ANDRITZ' expertise across the entire span of the power generation sector is unrivalled. To maximize the many benefits of Synchronous Condensers the whole system must be optimized. The starting point for developing a Synchronous Condenser plant is therefore the definition of all critical parameters. These parameters are typically based on simulations of the required characteristics derived

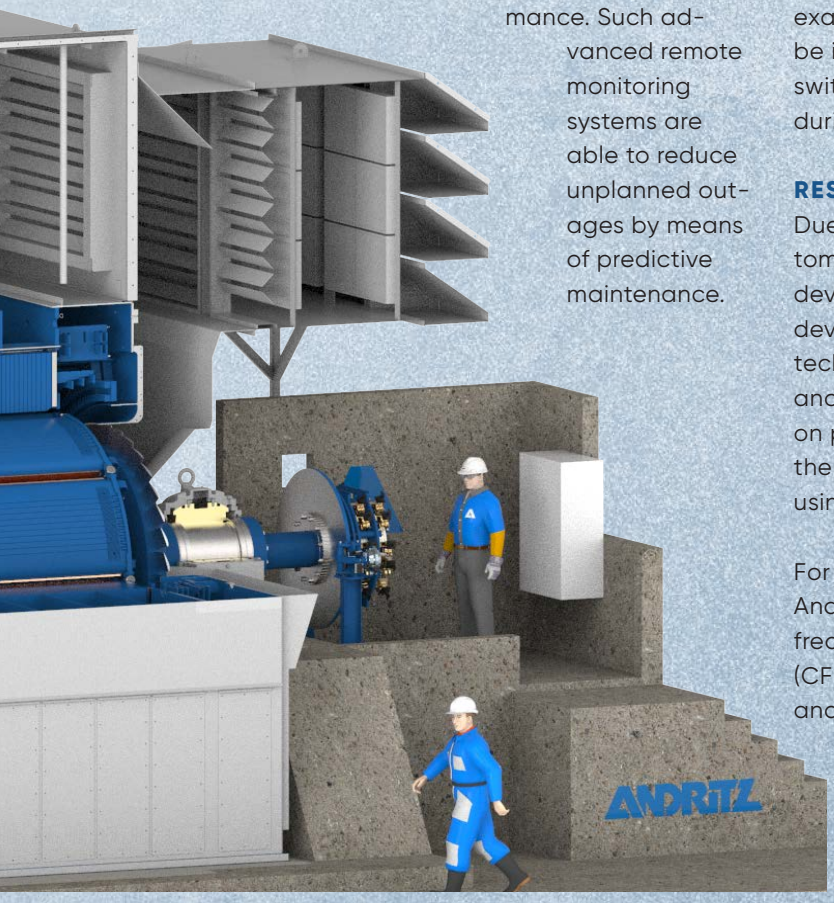


through transient stability studies and performance analyses, for example. By focusing on modern modelling and simulation tools, which are compatible with Building Information Models (BIMs) for data processing and management, our class-leading engineering across the entire power portfolio delivers the most cost-effective solution. As a result, ANDRITZ is a market leader when it comes to delivering global power sector projects, including Synchronous Condenser solutions.



OPERATION & MAINTENANCE COMPETENCE

ANDRITZ' customers around the world also benefit from our long-term operation and maintenance service contracts. Focused on delivering plant reliability, availability and safety, this service reduces the cost of maintenance and operations through optimization. Metris DiOMera, a digital operations and maintenance solution developed by ANDRITZ, helps to support this goal by constantly monitoring and assessing plant performance. Such advanced remote monitoring systems are able to reduce unplanned outages by means of predictive maintenance.



AUTOMATION PROFICIENCY

ANDRITZ's automation, control, protection and monitoring ensures reliable and safe operation and optimized maintenance of a plant. Synchronous Condensers can be operated in various control modes, for voltage or reactive power for example, and any suitable control algorithm can be implemented as required. Furthermore, seamless switch over between control modes is possible even during operations.

RESEARCH AND DEVELOPMENT

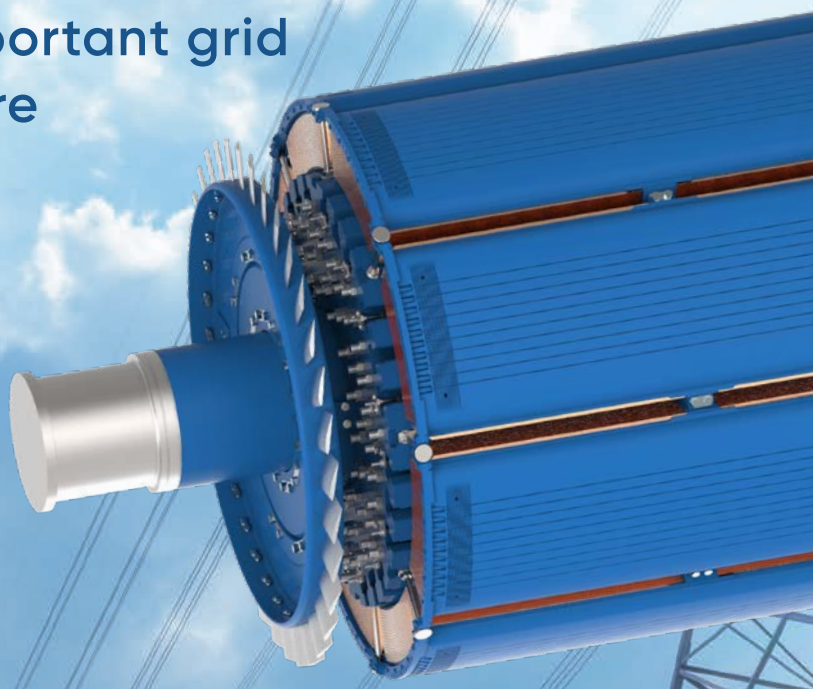
Due to changing market conditions, changing customer requirements and advancing technological developments, there are still many research and development challenges in the fields of generator technology, automation, auxiliaries and grid compliance. ANDRITZ' global R&D activities focus not only on process improvements but also on areas such as the development of new materials and novel designs using the most advanced methods.

For instance, along with tools such as Finite Element Analysis (FEA), 2D and 3D electromagnetic field and frequency analysis, Computational Fluid Dynamics (CFD) tools are used for optimizing cooling airflow and in the investigation of heat transfer.

ANDRITZ' Synchronous Condensers for a secure and stable future

From greenfield projects to modernization and uprating, ANDRITZ provides top-tier solutions for all kinds of Synchronous Condenser systems. An extensive reference list illustrates the breadth of our experience and technical know-how. It proves the competence of ANDRITZ.

ANDRITZ' Synchronous Condensers help balance the increasing volumes of volatile renewable energy and a corresponding loss of system inertia, hence providing important grid stability and a secure electricity supply.



ANDRITZ offers large synchronous salient pole machines with a high capacity and inertia, featuring potentially hundreds of cylindrical rotor units as well as the complete automation system.

In addition, while the global trend to retire fossil-fuelled energy sources has triggered the shut-down of many such power plants these assets can be converted to operate as Synchronous Condenser units. ANDRITZ offers conversion of these existing generation sites which is widely considered the preferred approach to retain the system benefits of a large rotating machine. Reusing existing facilities also results in reduced costs and significantly increases the return on the original plant investment.

Moreover, HVDC substations require exactly the type of system services that can be perfectly provided by Synchronous Condenser facilities. Such systems are already embedded directly within the grid infrastructure and are located precisely where these services are needed.

ANDRITZ technology improves the performance of power generation facilities and grid stability and increases revenue for our customers. For all kinds of Synchronous Condenser systems and from greenfield projects to modernization and uprating, ANDRITZ always delivers top-tier solutions.

Flywheels for increased inertia

ANDRITZ Synchronous Condensers combined with a top modern high inertia flywheel warrant a secure energy supply and a long reliable operational life of your asset.

AMPLIFICATION OF SYSTEM STRENGTH

Synchronous Condensers provides substantial contribution of inertia energy to the electrical network to support system strength. Such property can be amplified by adding a flywheel to the synchronous condenser system enhancing the ability of integrating volatile and intermittent renewable energy sources such as wind and photovoltaic power into the grid. For example, a synchronous condenser with a capacity of 250 MVA having a natural inertia energy of around 900 MWs can be increased up to 4,000 MWs by adding a compact flywheel installation.

The ANDRITZ flywheel is characterized by its compactness. This is achieved by optimizing the flywheel rotor geometry providing maximum kinetic energy at short axial dimension.

ROBUST ROTOR DESIGN

The flywheel rotor is rigidly coupled to the rotor of the synchronous condenser. The rotor is designed to be short-circuit proof and the rotor dynamic behaviour shows high stability. Using appropriate provisions for centering, the shafts and flywheel discs are precisely machined and bolted, forming a compact rotor.

MAIN FEATURES

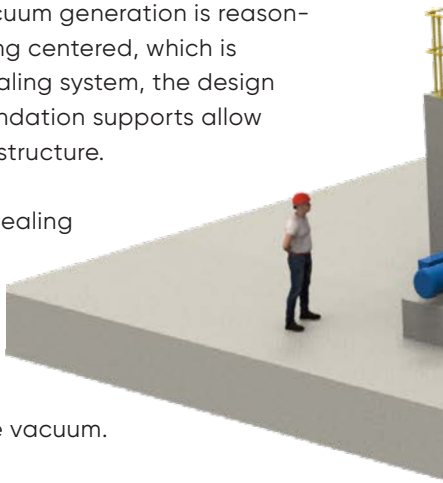
- Compact flywheel rotor with robust pedestal bearings
- Flywheel vacuum housing
- Vacuum sealings and pumps
- ANDRITZ's control system

SIMPLE ASSEMBLY CONCEPT

The dimension and weight of the ANDRITZ flywheel discs are within practicable limits for transportation and assembly. The rotor components of the flywheel are mounted in the pre-assembly area before the entire flywheel rotor is lifted into the bearings. Both, the synchronous condenser as well as the flywheel assembly can be carried out time efficient with an appropriate and temporary crane.

VACUUM TECHNOLOGY

The air friction losses of the flywheel are significantly reduced by running the rotor in a vacuum condition. A vacuum pressure level (below 0.2 bar) shows a significant serious reduction of losses whereas the power consumption for vacuum generation is reasonable. By keeping the housing centered, which is relevant for the vacuum sealing system, the design of the vacuum housing foundation supports allow thermal expansions of the structure.



The non-contact vacuum sealing technology between rotor shaft and housing requires low maintenance. Several energy-efficient vacuum pumps provide the vacuum.

At rated operation, the minimized air friction heat losses can be dissipated by free convection to the surrounding ambient, which requires no additional cooling media or auxiliaries. This is possible due to the appropriately selected vacuum housing surface dimensions. Cooling in the event of malfunction (failure of vacuum) takes place by forced ventilation – flushing of vacuum housing with fresh air.

Vacuum technology and cooling are major features of the ANDRITZ state-of-the-art flywheel system. ANDRITZ is using the most advanced methods like Computational Fluid Dynamics (CFD) and Conjugate Heat Transfer (CHT) for the development process.

OPERATION AND MAINTENANCE

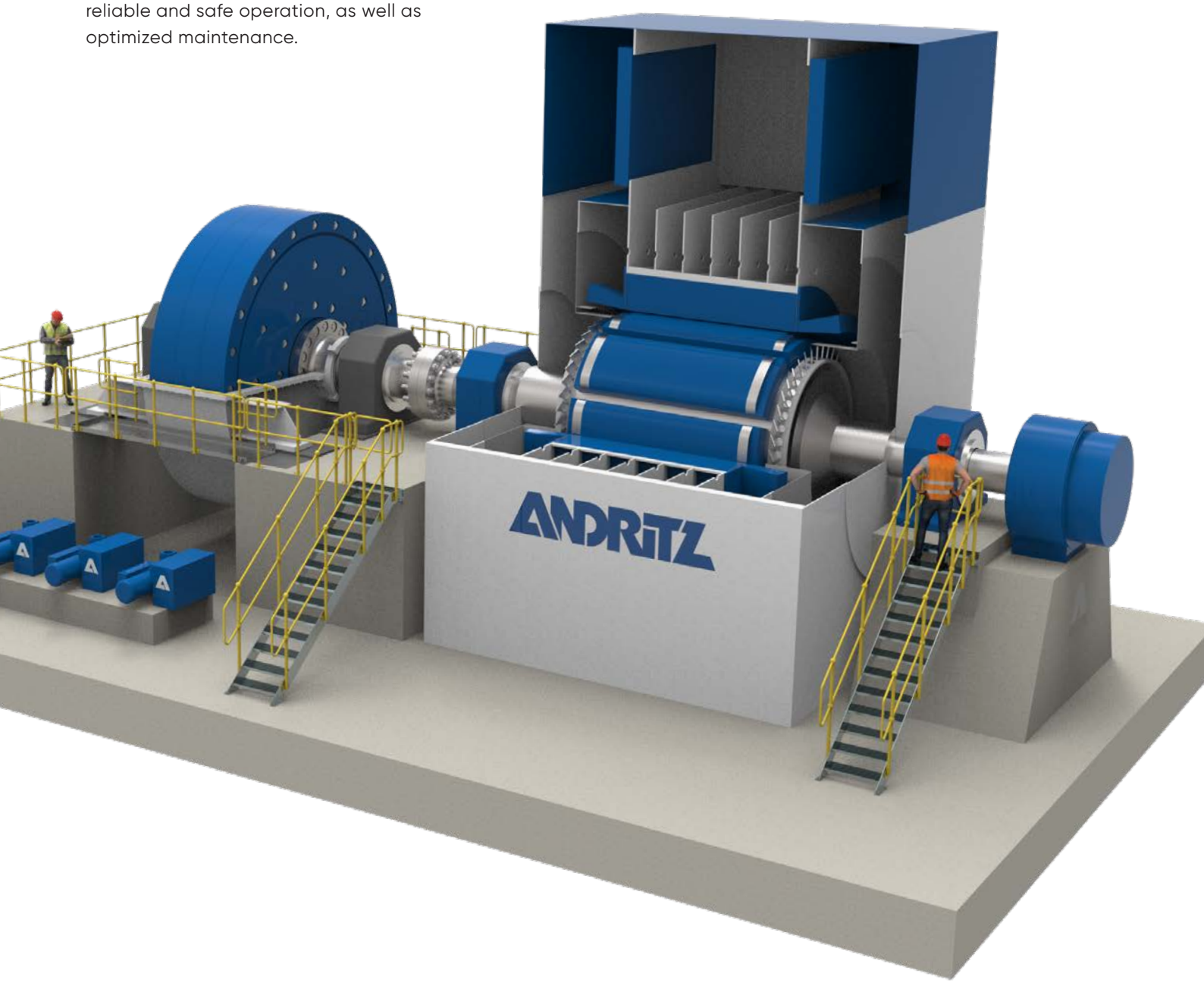
A considerable number of already available auxiliary components of the synchronous condenser can be used for the flywheel operation like the oil supply for the pedestal bearings which generates notable synergy effects, hence reducing costs.

ANDRITZ' additional automation, control, protection and monitoring systems ensure reliable and safe operation, as well as optimized maintenance.

MODULAR FLYWHEEL SERIES

ANDRITZ provides a modular flywheel series to meet all requirements. The modularity is based on standardized discs with constant outer diameter and the number of discs implemented in the system chooses the required stored Flywheel energy.

ANDRITZ is offering not only synchronous condensers to meet a changing generation portfolio, but also state-of-the-art high inertia flywheels with the synchronous condensers. The installation of an ANDRITZ flywheel system is providing a lot of benefits such as synergy effects by using already available components, reliable and safe operation and optimized maintenance.



The World of ANDRITZ' Synchronous Condensers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ENERGYCONNECT, AUSTRALIA

ANDRITZ is supplying four synchronous condenser systems for the Buronga and Dinawan substations operating at 330 kV to provide inertia energy and dynamic voltage support, thereby enhancing the short circuit level. The units will substantially contribute to the system strength in the Transgrid synchronous area located in New South Wales. The contract is followed by an order for a maintenance agreement.

TECHNICAL DETAILS:

Rated Condenser
Output: + 100 / - 50 MVAr
Voltage: 12,0 kV, 50 Hz
Rated capacity of each synchronous condenser: 120 MVA
Inertia contribution to PCC:
7 MWs/MVA (natural)
Nominal system voltage: 330 kV


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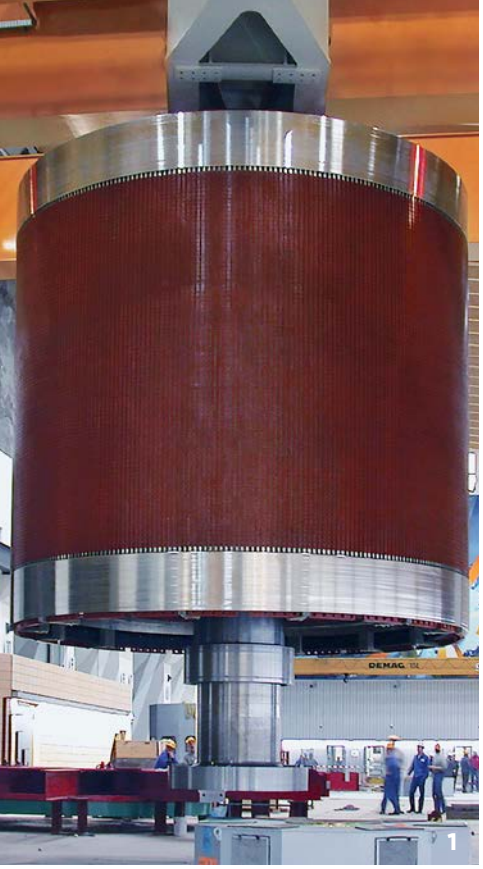
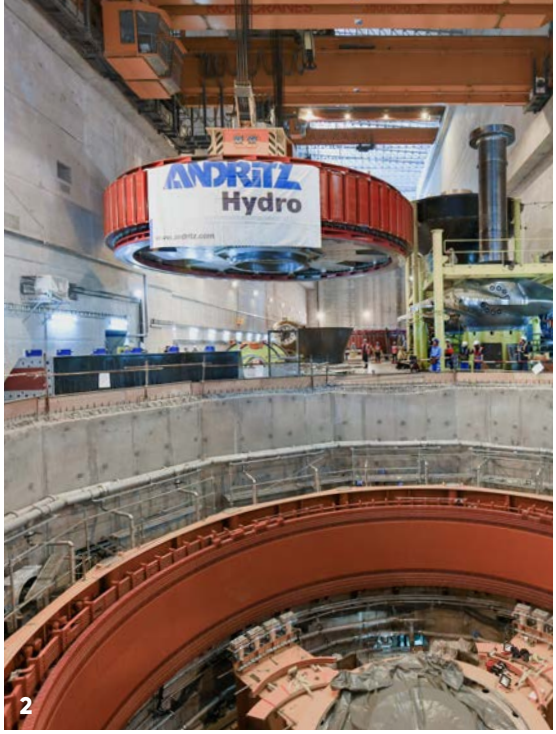
VINEYARD, USA

ANDRITZ is supplying two synchronous condenser systems for the 115 kV Barnstable Switching Station in Massachusetts to enable the integration of the nation's first utility-scale offshore wind energy project. Vineyard Wind 1 is an 800 MW project located 15 miles off the coast of Martha's Vineyard and will generate electricity for more than 400,000 homes expecting to reduce carbon emissions by more than 1.6 million tons per year.

TECHNICAL DETAILS:

Rated Condenser
Output: + 171 / - 133 MVAr
Voltage: 11,5 kV, 60 Hz





1 Goldisthal, Germany - First asynchronous variable-speed unit outside Japan
2 Xayaburi, Lao PDR - Example for a large low-speed generator
3 Frogner, Norway - example of automation modernization project
4 Example of hydrogen-cooled generator

MARMELEIRO 2 AND LIVRAMENTO 3, BRAZIL

ANDRITZ is supplying three synchronous condenser systems to significantly contribute to the integration of the wind energy potential of Rio Grande do Sul. One system will be operated in the Marmeleiro 2 substation at 525 kV and two systems will be operated in the Livramento 3 substation at 230 kV.

The scope of supply also comprises the step-up transformer, circuit breaker, automation, control and protection systems, as well as monitoring systems for the Synchronous Condenser and qualities such as vibration, air gap and partial discharge.

TECHNICAL DETAILS:

Rated Condenser
Output: + 150 / - 90 MVAr
Voltage: 11 kV, resp. 13,8 kV / 60 Hz

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