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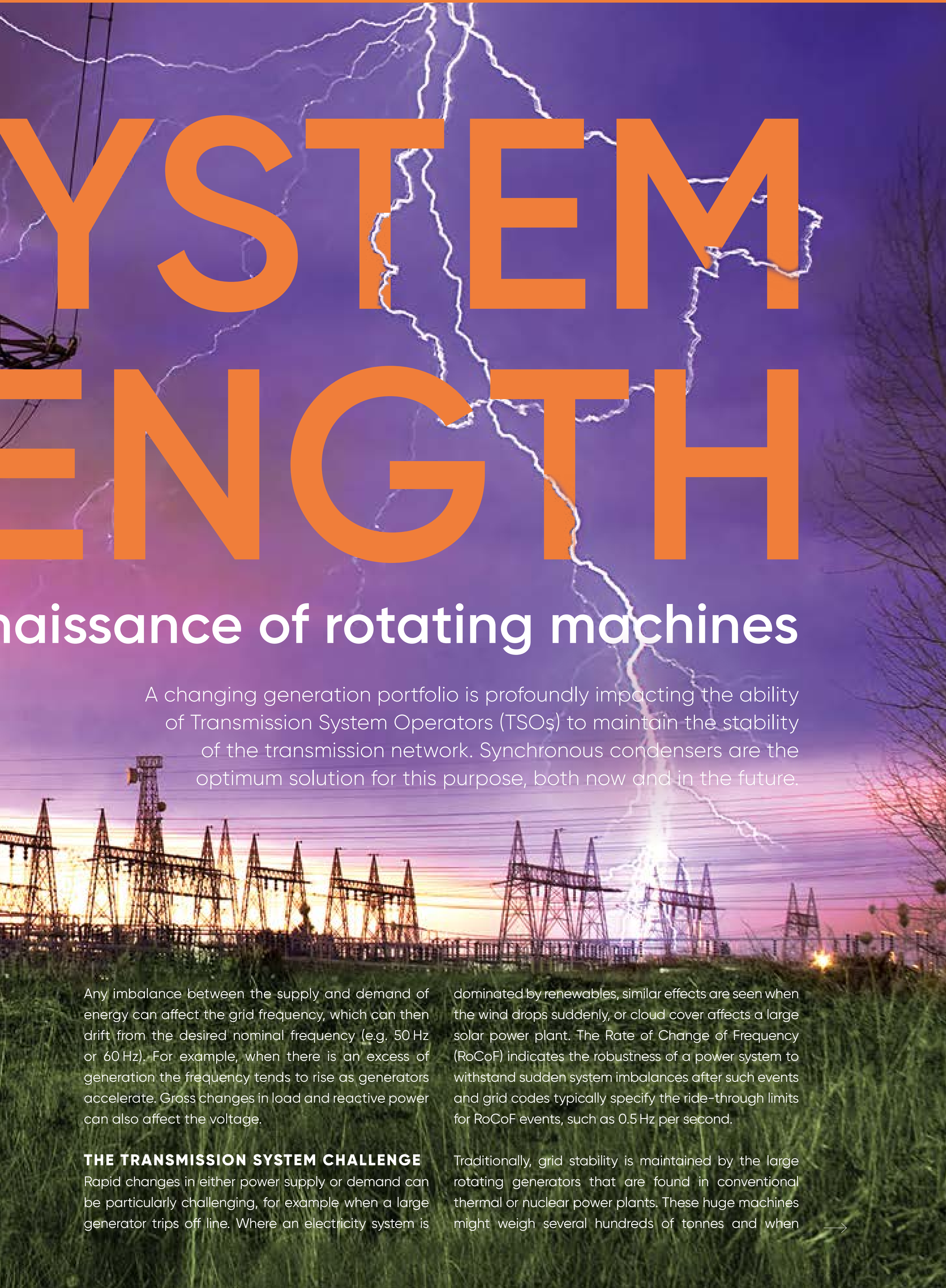
The smart solution for modern grids

Though the clean energy transition offers economic and environmental benefits, it also presents a number of challenges. One of the key mechanisms to reduce climate-changing carbon emissions is through the deployment of renewable electricity generation such as wind and solar. However, the variability of such energy sources can significantly affect the power transmission and distribution grid as well as the quality of the electricity supplied.

For the TSOs tasked with maintaining the stability of the grid, the massive introduction of clean energy to an existing and limited transmission infrastructure is a difficult issue to resolve.

PV and wind parks must therefore be integrated into the grid while considering the conditions and limitations of today's power system. In fact, the requirements for adaptation, expansion and interconnection of the transmission system to better balance the supply and demand of power are going to take years or even decades to realize. The synchronous condenser is the perfect tool to cope with these challenges.



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naissance of rotating machines

A changing generation portfolio is profoundly impacting the ability of Transmission System Operators (TSOs) to maintain the stability of the transmission network. Synchronous condensers are the optimum solution for this purpose, both now and in the future.

Any imbalance between the supply and demand of energy can affect the grid frequency, which can then drift from the desired nominal frequency (e.g. 50 Hz or 60 Hz). For example, when there is an excess of generation the frequency tends to rise as generators accelerate. Gross changes in load and reactive power can also affect the voltage.

THE TRANSMISSION SYSTEM CHALLENGE

Rapid changes in either power supply or demand can be particularly challenging, for example when a large generator trips off line. Where an electricity system is dominated by renewables, similar effects are seen when the wind drops suddenly, or cloud cover affects a large solar power plant. The Rate of Change of Frequency (RoCoF) indicates the robustness of a power system to withstand sudden system imbalances after such events and grid codes typically specify the ride-through limits for RoCoF events, such as 0.5 Hz per second.

Traditionally, grid stability is maintained by the large rotating generators that are found in conventional thermal or nuclear power plants. These huge machines might weigh several hundreds of tonnes and when rotating at, perhaps 3,600 rpm, possess considerable physical inertia. This inertia is invaluable when absorbing potential shocks to the transmission system and any variability between supply and demand. It is very hard to rapidly accelerate or decelerate such large machines, which provides an inherent stability and therefore sufficient time for other reserves to be put in place.

However, the energy transition has seen large volumes of conventional thermal generation decommissioned to be replaced by non-synchronous renewable sources or HVDC connections. These are connected via power electronics and do not provide significant system inertia. In addition, renewable energy typically benefits from dispatch priority when it is available. Correspondingly, conventional rotating generation units are requested to reduce their output and consequently further reducing system inertia.

As a result of these changes, TSOs need to both monitor system inertia and take appropriate action to ensure enough inertia can be deployed when required. Today, TSOs worldwide are seeking out new methods to add inertia to the grid.

THE SYNCHRONOUS CONDENSER SOLUTION

One technology that offers considerable benefits to the grid is the synchronous condenser, a synchronous rotating machine operating as a motor with no mechanical load. As a massive rotating machine, the synchronous condenser is able to provide grid inertia with excellent availability. As synchronous machines are electro-magnetically coupled to the power system, they are a source of system strength.

Indeed, synchronous condensers have been used within the transmission network since the beginning of the last century where they have provided various grid services, like voltage regulation and reactive power services.

After a steady decline in the use of synchronous condensers due to the introduction of solid-state compensation devices – such as the Static VAR Compensator (SVC) that provides reactive power when needed – today, the demand of synchronous condensers is now experiencing a strong resurgence.

Synchronous condensers not only provide inertia and variable reactive power to support the transmission system voltage during events, but they are also able to deliver a range of additional ancillary services for grid operators that increase the robustness of the system.

For TSOs synchronous condensers are able to provide stabilization capabilities that are being lost from the grid due to the the transformation of the generation mix.

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

NOT JUST INERTIA FOR GRID STABILITY

Synchronous condensers are rotating compensators that provide a number of critical services to grid operators. To stabilize the grid during imbalances, synchronous condensers can deliver sufficiently large amounts of system inertia to attenuate or avoid any high Rate of Change of Frequency events. They also support TSOs by injecting dynamic reactive currents into the grid during and after faults, therefore they are able to prevent voltage collapse and have been used to provide this function for many decades.

Short-circuit power also plays a vital role in the proper functioning of the protection system of the transmission grid. It is typically mandatory that enough short-circuit power is available at the connection point for power generators. This is particularly important for non-synchronous power generators such as wind or solar, which contribute only up to their rated capacity (110%) to the available short circuit power.

ANDRITZ Synchronous Condensers, for example, can provide up to five times more (500%) short-circuit power than their rated capacity and can also provide a time-limited overload capability, sustaining 200% for 30 seconds for instance, when responding to reactive power demands.

Short circuit power capacity is so important that some PV project developers have even proposed adding synchronous condensers in order to secure a TSO connection approval for their PV parks.

"ANDRITZ' top-tier synchronous condenser technology improves the performance of power generation facilities and grid stability and increases revenue for our customers."

Last but not least, it is important to note that synchronous condensers can also absorb harmonics caused by inverter-based generation such as solar.

Considering all the benefits that a synchronous condenser can provide with an extensive range of ancillary services to the grid in addition to inertia, synchronous condensers represent an attractive investment with elevated levels of return.

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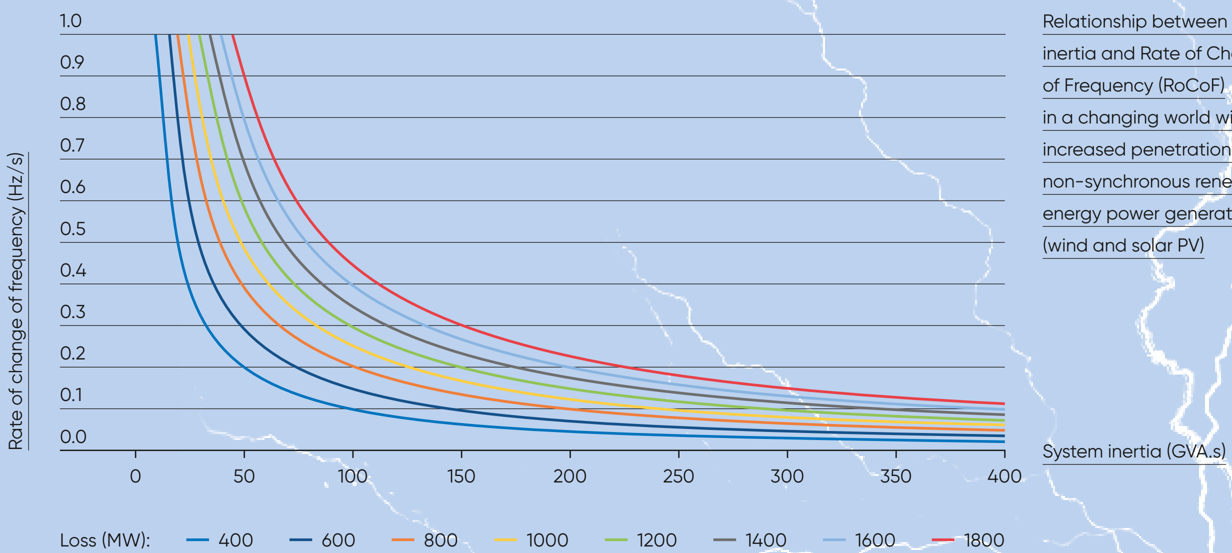


Relationship between system inertia and Rate of Change of Frequency (RoCoF) in a changing world with increased penetration of non-synchronous renewable energy power generation (wind and solar PV)

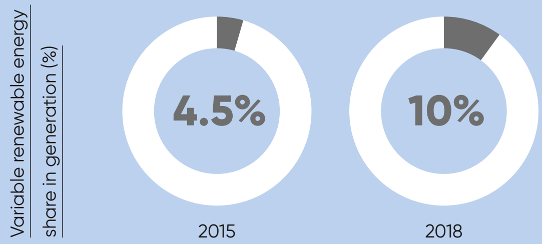
Source: www.nationalgrideso.com

RENEWABLE POWER GENERATION -

“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.”

Current progress

2015 – 2018/2019



NEW BUILD VS EXISTING ASSETS

The global trend to retire fossil-fuelled generation plants is a significant factor in the loss of system inertia, but such facilities may be repurposed to act as synchronous condensers. The conversion process is beneficial as it allows asset owners to retain residual asset value while securing the grid benefits of a large rotating machine. In addition, such facilities are located at appropriate locations with good grid connections. HVDC substations also require precisely those qualities that can be supplied by synchronous condensers and are often co-located with existing generation assets.

ANDRITZ offers conversion services to ensure these benefits are retained, increasing the return on investment. We can also supplement existing facilities with the addition of rotating flywheels or by increasing the rotating mass of the machine.

With well over a century of experience designing, manufacturing, supplying, installing, integrating, operating and maintaining a vast range of rotating electrical machines, ANDRITZ has a comprehensive reference list. Indeed, more than 5,000 synchronous generating units are in service today. For all kinds of synchronous condenser solutions, from greenfield projects to modernization and uprating, ANDRITZ always delivers top-tier solutions.

In Brazil, for example, ANDRITZ is currently supplying three synchronous condenser systems for grid services, three new long-distance transmission lines. One system is being installed at the existing 525-kV Marmeleiro 3 substation with another two systems at the new Livramento 230 kV substation. 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.

Marmeleiro and Livramento 3, Brazil; supply of three synchronous condenser systems for grid services.

A GLIMPSE OF THE DEVELOPMENT

Where we are heading

Planned energy scenario / 2030 and 2050

Where we need to be

Transforming energy scenario / 2030 and 2050

Source: IRENA, Global Renewables, Outlook 2020

THE SYNCHRONOUS CONDENSER RENAISSANCE

ANDRITZ' advanced designs offer a range of technical features such as reduced friction flywheels based on vacuum technology, direct air-cooling systems, sophisticated hydrogen/water cooling systems, and Totally Enclosed Water to Air Cooling (TEWAC), as well as salient pole and cylindrical rotor solutions with static and rotating high efficiency excitation systems. The ANDRITZ portfolio covers a range of standardized and tailor-made synchronous condenser solutions. In addition, advanced monitoring systems and sophisticated analysis of power flow, transients, grounding, insulation coordination, protection coordination, and dynamic performance allow the selection or design of the optimum synchronous condenser solution to meet the requirements of any specific project.

Synchronous condensers are a cost-effective and reliable solution and are able to address issues affecting grid stability when faced with increasing volumes of variable renewable energy and a corresponding loss of system inertia. Furthermore, synchronous condensers are able to supply a host of additional ancillary services. These services are increasingly required by grid operators if they are to maintain system security and stability of supply during the clean energy transition.

As a well-established and proven technology in many global markets, the synchronous condenser is experiencing a renaissance.

BENEFITS

- Reliable proven technology
- Cost-effective
- Increased revenue
- Providing inertia – improving stability
- Short circuit power – essential for system protection
- Dynamic voltage support – overload capability
- Implemented in already existing infrastructure
- Reactive power
- Ancillary services

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