Synchronous Condensers
Part of GE’s Renewable Steam Portfolio
NEEDED MORE THAN EVER FOR RENEWABLE POWERED GRID STABILIZATION
TODAY’S ENVIRONMENT

Over the last years, GE has seen a growing interest and need for synchronous condenser solutions by Grid operators and Utilities. As the grid evolves and the mix of electricity production sources changes, stresses are being put onto transmission and distribution networks, making the need for grid support much more challenging. Globally, operators are facing many new grid challenges and conditions including:

• Changes in generation mix
• Decreases in conventional generation
• Increases in renewable wind, solar and distributed generation
• Environmental and regulatory policy changes, driving the retirement of traditional thermal generating stations

These challenges have an operational impact on the electrical infrastructure, creating an overall deficiency in:

• Reactive compensation support
• System inertia
• Short circuit strength

GE’S SOLUTION

As part of GE’s portfolio of renewable steam offerings, GE can provide grid operators and utilities synchronous condensers to address grid challenges.

GE’s air-cooled High Inertia Synchronous Condenser systems can be rated to 2000+ MWs. Due to the nature of the rotating equipment, the enhanced inertia is system inherent providing instantaneous power feed as a result of a grid frequency drop.

The solution can produce or absorb reactive power, offers unique overload capability and provides significant short circuit strength to the grid network.

The GE standardized approach offers integrated solutions for fast project realization with high reliability and very limited maintenance.

FACTS devices such as SVCs and STATCOMs are good at supplying reactive power quickly. They are not helpful at handling low system inertia, a measure of the stored energy within the mechanical rotating machine as well as low short-circuit strength in the power grid. Synchronous condensers can help meet these reactive power needs and boost system inertia and short-circuit strength.

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<th>GE SYNCHRONOUS CONDENSER TYPICAL OVERVIEW</th>
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<td>Inertia*</td>
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<td>250 ... 2500 MWs with added flywheel</td>
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<td>Reactive Power*</td>
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<td>-100 ... +300 MVAr</td>
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<td>Short Circuit Power Strength*</td>
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<td>500 ... 2000MVA+ at the Point of Connection</td>
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*Inertia, Reactive Power and Short Circuit Strength represent typical values of air-cooled High Inertia Synchronous Condensers. For project specific requirements please contact your GE Representative
**THE GE ADVANTAGE**

GE’s Synchronous Condenser Systems come from 100 years of manufacturing experience, including experience of full speed rotating power plant machines. They are configured to provide the highest optimized solution, for reliability, performance and operational flexibility.

**Proven portfolio for customized project**
- Low Losses flywheel technology for wide range of inertia, installed as part of green field projects or added as an upgrade in existing plants
- Full range of Air-Cooled rotating machines issued from standard portfolio with reliability rate over 99%.
- Intimate Adequacy between flywheel and Synchronous Condenser
- Fast lead time delivery for standardized product
- Adapted auxiliaries, balance of plant and remote-control equipment

**Modular design for flexibility and decreased down time**
GE solution has combined modular component architecture that allow for reduced overall footprint, customized layout and maintenance flexibility for utilities to reduce operational downtime.

**Robust design with effective maintenance program**
GE Synchronous Condensers have superior construction and huge historical operational data from power generation application. This is resulting in an effective maintenance program, monitored and conditioned based, tending to flexible and minimal maintenance over the entire life cycle of the plant.

**Asset and operational cost optimization**
Based on product experience, standardized and modularized approach, GE integrated solutions provide optimum asset and operational cost in a safe manner.

**Extensive experience – Equipment entire life cycle support.**
- GE leads the power industry with more than 100 years of experience.
- GE organization is based worldwide to support the plant equipment over its full life cycle.
- Specific Diagnostic tools, engineering experience, parts, tools and field service processes are maintained and dedicated to match with customer needs.

**SYNCHRONOUS CONDENSING PLANTS**

GE’s Synchronous Condensing Plant solutions are based on a strong standardized and modularized configuration, tailored to meet the specific requirements of each application. GE’s engineering teams has the necessary broad spectrum of design disciplines and depth of experience, and works to ensure that each system configuration fully meets the specific requirements of the application. Provided either as an Engineering Procurement Construction Package (EPC) or as a Stand-alone Component Package (SaCP) solution which includes the system studies, configuration and engineering, installation, commissioning and life cycle services, each synchronous condenser project is assigned to an experienced Project team. This team is identified and involved from the project kick-off through commissioning to ensure project execution excellence.

**TYPICAL SYNCHRONOUS CONDENSING PLANT LAYOUT**
Can GE convert my existing thermal plant generator to a synchronous condenser?
YES.

For the first time in Europe GE converted a large 625 MVA liquid-cooled generator operating in a coal-fired power plant to synchronous condenser. The engineered solution reused many existing components at the plant.

GE was able to execute the project within seven months from contract award to grid synchronization.

Thanks to this project, our customer was able to deliver >500 MVAr of reactive power as demand has been increasing while at the same time thermal assets are retiring.

This is the Power of Yes.
BENEFITS OF GE’S SYNCHRONOUS CONDENSERS

Sustain System Inertia
GE Flywheels and Synchronous Condensers can contribute significantly to grid Inertia. A High Inertia 250 MVar Synchronous Condenser can provide an inertia equivalent or higher than that of a 400 MW Coal fired Power Plant.

Where Renewable generation does not bring rotating inertia or where existing generation is being retired, the benefits of GE High Inertia Synchronous Condensers are improved frequency and voltage regulations to support system’s sustainability.

Short-term Overload Capability
Unlike static solutions (SVCs, STATCOMs, BESS,...) the GE Synchronous Condenser has a large current overload capability, which can provide transient and steady-state voltage support. As seen below, a GE Synchronous Condenser can provide more than two times its rating for up to 10 seconds.

Low Voltage Ride Through
The GE Synchronous Condenser system has the ability to remain connected and to provide the necessary system benefits even under extreme low voltage contingencies. Mechanical inertia combined with state of the art excitation provides smooth reliable support that is naturally compatible with generation.

Response Time
GE Synchronous Condensers provide system inherent, instantaneouse inertia response. Fast dynamic reactive power is provided using modern excitation systems.

Short Circuit Contribution
Synchronous Condensers provide real short circuit strength to the grid, typically up to 1200MVA at Point of Connection.

Minimal Harmonic Generation
By increasing the grid short-circuit power, it even reduces the voltage harmonic distortion, making it friendly for surrounding grid. This makes it a robust system to help operate grids with high shares of renewables.

INSTALLATION AND MAINTENANCE BENEFITS

Fast Project Cycle Time
The system only requires integration of commonly available power delivery components resulting in accelerated project cycle times. The design, manufacture, installation and commissioning of a Synchronous Condenser system can be completed within 16 months.

Proven Configuration and Increased Reliability
The GE Synchronous Condenser is configured to provide trouble-free, reliable service and is a proven solution with more than 200 applications over nearly a century. Advancements in materials and manufacturing techniques, combined with modern control technologies, have greatly improved the reliability and functionality of this robust, time-tested solution. Operators can now utilize the simplicity of electro- mechanical system combined with the benefits of a state of the art excitation and control system in order to meet their grid support needs.

Minimal Maintenance
GE Synchronous Condensers proven configuration requires minimum maintenance which results in minimal operating costs and reduced total cost of ownership. They are configured for robotic inspections allowing no rotor-out inspections and they are connected with necessary sensors for remote monitoring. Both robots and connectivity allow for better condition-based predictive maintenance.

Life Time Expectancy
Synchronous Condensers have a longer service life than any Static Solutions as they consist of generators which are used in Power Plants to produce electricity over a typical period of 40+ years.
**CORE COMPONENTS**

**ROBUST SYNCHRONOUS CONDENSERS CONFIGURATION ELEMENTS**

GE’s Synchronous Condenser system consists of generator components used in electric utilities with proven robustness and reliability.

**Stator**
- Roebel Bars optimized winding
- Class F Insulation
- Robust Stator End Winding structure
- Stress grading material
- Optimized air-cooling system
- Flexible suspension between core and casing
- Low Losses Magnetic Core

**Exciter**
- Brushless or static configuration
- High Ceiling Current capabilities
- Low maintenance requirement

**Full Speed Rotor**
- Uniform Temperature Distribution
- Class F insulation
- Balanced up 120 % Overspeed test
- 18/18 Retaining Ring Material
- High performance winding dampers
- Developed for Heavy Duty Power Plants

**Cooling System**
- TEWAC (Totally Enclosed Water-to-Air-Cooled)

**FLYWHEEL FOR INCREASED INERTIA**

Flywheels can be delivered at the time of the construction of a new plant or added later on during the life cycle of the plant. They can also be added to existing turbogenerators when converting to high inertia synchronous condensers.
Can GE’s synchronous condensers improve grid performance and sustain system inertia from renewable and thermal energy sources?

YES.

GE can procure and construct complete green field Synchronous Condensing Plants.

For these projects, GE has been shipping synchronous condensers from 100MVAR to 330MVAR. The traditional synchronous generators utilized in power plants are also configured to be reliable grid stabilizers. Some of these units are equipped with flywheels in order to cope with the increased system inertia.

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**Typical Applications**

**HVDC**
- Provides short circuit strength
- Dynamic reactive power support (voltage regulation)
- Reduces local harmonic distortion (filter)

**Wind/Solar**
- Improves or increases short circuit ratio (SCR)
- Dynamic voltage support
- Provides inertia to improve frequency regulation

**Generator Conversion to Synchronous Condensers**
- Re-purpose of Use of Fossil Plant assets planned to Retire
- Lower total cost of ownership
- Modern controls and excitation – improved response time
- Support dynamic voltage regulation and inertia as new systems

**Grid Code Compliance**
- Cheapest solution to reduce RoCoF
- LVRT (Low Voltage Ride Through) compliant

**Grid Support**
- Local voltage and frequency support during contingencies and faults
- Provides short term overload capability
Synchronous condensers, with their ability to provide grid stabilizing inertia at low cost, are making a comeback

GE is celebrating its 100-year anniversary of supplying synchronous condenser solutions to utility customers and transmission system operators. As many transmission networks around the world are struggling with weak grid conditions as a result of retiring legacy thermal generation units and the intermitency of wind and solar power, this technology—once considered nearly obsolete—has reinvented itself and now provides critical support to a transforming grid.

Installed at strategic intervals along a transmission system, synchronous condensers are electrical rotating equipment that produce or absorb reactive power to keep the current flowing consistently to the grid – helping to ensure reliable power is available for those who need it, when they need it. The company’s latest synchronous condenser offerings have undergone many developments since 1919, when GE shipped the world’s first high voltage synchronous condenser to Ontario Hydro in Canada.

The original 10 Mvar model has evolved over the past century to meet evolving grid demands. GE now offers the broadest synchronous condenser portfolio in the industry, with units ranging from 20 Mvar all the way up to more than 300 Mvar in a single piece of equipment. As a utility industry leader, GE has supplied more than 200 synchronous condensers to utilities around the globe. Significant technology milestones include:

- **1919**: First GE air-cooled synchronous condenser rated +10 MVARs
- **1928**: First GE hydrogen-cooled synchronous condenser rated +12.5 MVARs
- **2008**: First “modern era” synchronous condenser installed for the sole purpose of “grid reliability”
- **2011**: First synchronous condenser conversion from a 473 MVA generator to a +360/-210 Mvar synchronous condenser, allowing for seasonal conversion between generator and synchronous condenser
- **2014**: First GE air-cooled synchronous condenser rated +250 MVARs
- **2017**: World’s largest GE air-cooled synchronous condenser rated +330 MVARs
- **2018**: First 625 MVA liquid-cooled turbogenerator converted to synchronous condenser in Europe
- **2018**: High inertia synchronous condensers rated 4 x +250 MVARs with world’s largest flywheels