The stable way
Synchronous condenser solutions
Global climate change poses new challenges for power generation and transmission. Innovative solutions will contribute to the reduction in CO₂ emissions and an optimized use of energy resources. The most crucial points in today’s and tomorrow’s power supply are sustainability, security, and efficiency.

Synchronous condenser solutions are being introduced worldwide to support today’s transmission system requirements. The addition of renewables-based power generation to the energy mix, phaseout of conventional power plants, new HVDC systems, and the extension of power supply systems to remote areas influence the stability of transmission networks.

Siemens offers tailor-made turnkey synchronous condensers to address the customers’ needs based on proven, reliable in-house equipment, extensive know-how on transmission system requirements, and project execution experience.
Benefits
• Short-circuit power capability
• Reactive power compensation
• Short-term overload capability
• Inertia to the transmission system
• Leveling out of »grid signals«
• Support of grid to island operation capabilities

Applications
Synchronous condensers support and improve power transmission quality in a wide range of applications:
• Stabilization of grids
• High-voltage DC transmission links based on line-commutated converter technology
• Transmission grids with a high amount of power infeed from renewable sources
• Retirement/shutdown of conventional power plants
Siemens synchronous condenser solutions comprise a horizontal synchronous generator connected to the high-voltage transmission network via a step-up transformer.

Siemens supplies a broad range of generators up to 2,235 MVA. The generators are air-, hydrogen-, and water-cooled.

The synchronous generator is started up and stopped by a frequency-controlled electric motor (pony motor) or a starting frequency converter.

When the generator has reached an operating speed that is synchronous to the system frequency, it is synchronized with the transmission network and acts as a motor providing reactive and short-circuit power to the transmission network.

Synchronous electrical machines like synchronous generators can generally be used as synchronous condensers. Without active power delivery or consumption, the machines can act in the same way as a capacitor or a reactor, depending on the excitation field current.
Generators

A generator is an electric machine that converts mechanical energy into electric power. It operates on the basis of the dynamoelectric principle that Werner von Siemens registered for a patent with the first dynamo generator in 1867. The principle states that an electric generator does not need to have an electric current supplied from the outside to start generating electric power. A self-reinforcing electrical induction can take place due to the residual magnetism of iron.

Today, the mechanical excitation, the generator’s need to generate electricity, is often provided by a turbine. It drives a shaft that is known as the rotor. This shaft rotates in the stator core, in other words, inside the generator. The rotor is equipped with an electromagnet, and the moving magnetic field of the rotor causes a charge transfer in the conductor coils of the stator. The charge transfer generates electric voltage between the ends of the conductors. This is how the mechanical energy, which acts on the rotor, produces electric energy – power – in the stator.

Excitation systems

The generator is equipped with either a brushless exciter or a conventional static exciter with brushes. The two solutions have different characteristics in terms of dynamic behavior, and are selected according to the project requirements.

Contrary to power electronics-based static VAr compensators (SVCs), a synchronous condenser features the major advantages of injecting large amounts of short-circuit power and providing inertia due to its rotating mass. The same generators are implemented for synchronous condenser applications.

Starting frequency converter/pony motor

The startup and breaking system of a Siemens synchronous condenser is either based on a frequency-controlled pony motor or a starting frequency converter. These two methods have different advantages and will be offered from Siemens’ own portfolio depending on the customer’s requirements.

Control and protection system

Generator performance is dynamically controlled by an automatic voltage regulator (AVR), which is an integral part of all excitation systems. In a brushless excitation system, the AVR is separately installed, and in case of static excitation system, AVR software is integrated in the control system of the static excitation system. In addition to the AVR system, a generator control panel is required for start and stop sequences, protection of the generator (vibration and temperature) and for cooling system control.
Project references

Black Sea 3x60 MVAr, Republic of Georgia

Siemens installed three 60 MVAr synchronous condensers at the Georgia Black Sea HVDC station in June 2012. This synchronous condenser solution supports the transmission network between Georgia and Turkey with the required short-circuit power in order to operate the newly installed HVDC back-to-back station.

Bjæverskov 1x250 MVAr, Denmark

In Denmark, Siemens delivered a 250 MVAr synchronous condenser solution that started operation in 2013, providing the transmission system with a short-circuit power of more than 800 MVA in addition to reactive power control. The installation of this stand-alone synchronous condenser solution will enable the transmission system operator Energinet.dk to operate the transmission network without the need for a large thermal power plant. This makes the installation an economically and environmentally advantageous investment enabling the infeed of large amounts of renewable energy into the transmission network.
Fraugde and Herslev 2x200 MVAr, Denmark

These solutions will ensure the transmission system stability in the country’s regions of Funen and Zealand. Siemens’ scope of supply comprises engineering, procurement, and construction of these facilities. The customer Energinet.dk will manage the civil work. Each synchronous condenser solution is capable of delivering more than 900 MVA of short-circuit power and +150 / -75 MVAr of reactive power. The projects are running in trial operation as of August 2014.

Feda 1x200 MVAr, Norway

This solution will secure short circuit power for the NorNed HVDC connection, especially during the planned upgrade of the overhead line in the southern region of Norway. Siemens’ scope of supply comprises engineering, procurement, and construction of these facilities including necessary civil works. The synchronous condenser solution for Feda is capable of delivering more than 750 MVA of short-circuit power and +170 / -90 MVAr of reactive power. The project is scheduled for trial operation at the end of 2014.

Talega 2x225 MVAr, USA

The turnkey supply of two 225 MVA synchronous condenser systems for Talega substation in California will support the California grid with reactive power, short-circuit power, and inertia. Siemens’ scope of supply comprises the complete engineering, procurement, and construction of these facilities including necessary civil works. Each synchronous condenser solution for Talega is capable of delivering +225 / -120 MVAr of reactive power. The units are planned to commence commercial operation in July 2015.