Introduction to ABB Synchronous Condenser offering

A solution to improve grid strength
Housekeeping

During the webinar all participants will be in mute
Questions can be transmitted via the chat box

Some questions will be answered after the presentation

All Q&A’s will be sent out to all participants latest 2 weeks after the webinar
The presentation as well as the webinar recording will be available on the ABB webpage
The link to this page will be sent to all participants together with the Q&A file

If you have additional questions, please use my contact details
Thank you for your participation!

December 16, 2020 | Slide 2
Synchronous Condenser Contact at ABB

Christian Payerl
Area Sales Manager Synchronous Condensers
christian.payerl@se.abb.com
Tel.: +46 21 320475
Mob.: +46 70 2601024

Marketing material:
https://new.abb.com/motors-generators/synchronous-condensers
Topics

Synchronous Condenser wwwww (What/Why/When/Where/Who)
ABB’ s Synchronous condenser options and references (Phoenix UK, Australian projects, ...)
High Inertia Solution
Summary
Synchronous condenser – What

What is a synchronous condenser?
A rotating electrical machine
A motor or a generator?
A motor driving no load or a generator without a driver?
Regulated like a synchronous generator through excitation control
– To produce
– or to consume reactive power (MVAr)
Re-born technology
– Necessary due to changes in electric power generation
  • SynCon’s provide Inertia, Short Circuit Power & MVAr’s
Synchronous condenser – What

1. A small pony motor is speeding up the synchronous condenser to the network synchronous speed with the help of a speed drive.

2. Excitation will be fully connected, the voltage and the power factor regulator will start to operate, based on the voltage and power factor reference.

3. When synchronization is reached between the network and the synchronous condenser, the breaker to the network will be closed. The SC is running on-line.

4. After successful synchronization, the pony motor will be de-energized, and runs idling with the SC.
Synchronous condenser – Why

Traditional grid

- Centralized generation
- Generation with spinning mass
- Few power electronics-based generators
- Strong grid (high fault level and higher SCR)

Future grid

- Distributed generation
- Less generation with spinning mass
- Increased amount of power electronics-based generators
- Weaker grid (low fault level and lower SCR)

Different implications

<table>
<thead>
<tr>
<th>Strong</th>
<th>Weak</th>
<th>Very weak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generation</td>
<td>Transmission</td>
<td>Distribution</td>
</tr>
<tr>
<td>Industrial C.</td>
<td>Residential C.</td>
<td></td>
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</table>
Synchronous Condenser – Why
Inertia support (frequency stability)

Synchronous Condenser supports the grid with instantaneous inertia (rotating mass):

None-synchronous generation:
Wind, Solar, Tidal, Energy Storage (BESS)

Increasing % of non-synchronous generation

RoCoF = \frac{df}{dt}

RoCoF \sim \frac{1}{\text{Inertia}}
Synchronous Condenser – Why

Fault level contribution

**Synchronous Condenser** is strengthening the grid network (seen by other equipment)

Fault current is uncontrolled & defined by the electrical parameters of the synchronous condenser

- High amplitude fault current
- Predominantly inductive fault current
- Significant negative sequence fault current component
- Represented by sub-transient, transient and steady-state time frames ($X_d''$, $X_d'$, $X_d$ reactance)
- Large rotational inertia

Inverter Based Resource:
Fault current is tightly controlled by IBR control scheme
Synchronous Condenser – Why
MVAr support (voltage regulation)

Capability diagram

Capability diagram at cooling water temperature of 48.0° C

AMS 900 LH 14000 kVa 50 Hz 0.01 PF 11800 V 586 A 1500 rpm

Over-excited
Produces reactive power
Absorbs reactive power
Under-excited

Synchronous condenser operating region

Base apparent power 1 p.u. = 14000 kVa

1. Stator heating limit
2. Rotor heating limit
3. Practical stability limit
4. Zero field-current limit
5. Core end heating limit
# Synchronous condenser – Why

<table>
<thead>
<tr>
<th>Customers</th>
<th>Conv. Generation</th>
<th>Renewables &amp; HVDC links</th>
<th>Transmission</th>
<th>Distribution &amp; Microgrids</th>
<th>Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implications</td>
<td>Increased RoCoF, Duck curve</td>
<td>PLL Instability, limitations in power infeed (low SCL)</td>
<td>Decreased SCL (protection problems), PLL instability, inertia planning problems, rapid changes in power flow, system stability, power system split (different inertia)</td>
<td>Big variation of SCL (day/night), deeper voltage dips (reduced SCL), power quality problems</td>
<td>Production problems caused by weak grid (dips – process interruptions), PQ emission issues</td>
</tr>
<tr>
<td>What can SynCon do</td>
<td>Provide Inertia, Off-load MVAr’s</td>
<td>Increase SCL, comply to SCR requirements, Off-load MVAr’s</td>
<td>Increase SCL, Additional available inertia, MVAr for voltage support, decentralized system strength (inertia/SCL - multi-units)</td>
<td>Provide controllable SCL, reduce depth of voltage dips, sink for unbalance, MVAr support</td>
<td>Less impacts from dips from the grid, stronger industry network, Improved pf</td>
</tr>
<tr>
<td>Result</td>
<td>Less interruptions, increased profit</td>
<td>More stable grid, reduced limitations in power transfer, increased profit</td>
<td>Stability improvements, less black-outs, decentralized grid support (SCL &amp; inertia &amp; voltage regulation)</td>
<td>More stable distribution grid, less PQ problems</td>
<td>Reduced dip impact (Less VSD trips), easier to start big loads, Increased profit</td>
</tr>
</tbody>
</table>

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December 16, 2020 | Slide 11 | RoCoF – Rate of Change of Frequency | PLL – Phase Lock Loop | SCL – Short Circuit Level | SCR – Short Circuit Ratio | VSD – Variable Speed Drives
Synchronous condensers – Where

- Conv. generation
- Offshore Wind parks or HVDC links
- Renewable generation
- Transmission grid
- Distribution grid
- MV
- Synchronous condenser

Grid:
- Grid
- Industry and large commercial
- Energy intensive Industry
- Industry/ large commercial

Generation:
- Conv. generation
- Offshore Wind parks or HVDC links
- Renewable generation
- Synchronous condenser

Industry and large commercial:
- Synchronous condenser
- Transportation

Residential and small commercial:
- Synchronous condenser
Synchronous condensers – When & Who

Maps showing some Generic Transmission Constraints in ERCOT
Remedial Action Schemes:
New Generation Interconnection

- Delaware Basin: Reliability-Driven, Stability Constraints
- West Texas Export: Economic-Driven, Stability Constraints
- South Texas Export: Economic-Driven, Stability Constraints
- South Texas Import: Reliability-Driven, Stability Constraints
- Houston/Freeport Import: Reliability and Economic-Driven, Thermal and Stability Constraints
- Northwest Dallas-Fort Worth: Reliability and Economic-Driven, Thermal Constraints

Mining industry

[Image of world map with constraints marked]
Conclusion – centralized or decentralized inertia/short circuit contribution?

Decentralized power generation requires
Decentralized system support
(inertia & short circuit contribution & voltage)
Package solution offering from ABB
Overview

- **Synchronous Condenser**
  - Up to 80 Mvar (higher output with parallel units)

- **Main terminal box**
  - Increased SCC capability up to 80 kA

- **Control room**
  - Control panel for C&P, excitation and monitoring of the SynCon. VSD for the pony motor

- **Lube oil system**
  - Forced lubrication for the bearings on the condenser and flywheel

- **Flywheel (optional)**
  - Total inertia up to 450 MWs with flywheel

- **Pony motor**
  - Start via variable speed regulated pony motor

- **Air cooler units**
  - Air cooling units to cool the cooling media

- **Pump unit**
  - Redundant water pumps
Installation from site Musselroe, Tasmania with two synchronous condensers 14000 kVAr

- Synchronous condenser unit
- Fin fan cooler
- Main terminal box
- Pony motor Lube oil tank unit
References
Synchronous condenser engineered package – Energy Park Australia

Hybrid Energy Park
15MW Solar
43MW Wind
2MW Energy Storage
5MVAr SynCon

Installation from an Energy Park, Queensland first synchronous condenser with CAWA cooling
Synchronous condenser engineered package – Solar Park Australia

Installation from site Borunga S/S, North South Wales, synchronous condensers with water cooling

AMS 1400, 60 MVAR, 11 kV, IP 55, 50kA 3sec
Synchronous condenser package – Darlington Point Australia

Installation from site Darlington Point, North South Wales, synchronous condensers with CACA cooling
# Synchronous condenser engineered package – Canada Copper Mountain

| 2 pcs AMS 1250A, | 25 MVAr/-12.5MVA (45 MVAr / -25MVAr for 30 min), 13.8 kV 60Hz |

## Synchronous Condenser Electrical Data

| Output | +25/-12.5 MV Ar |
| Short-term output (30 min) | +45/-25 MV Ar |
| Voltage | 13.8 kV |
| Frequency | 60 Hz |
| Speed | 1800 rpm |
| Inertia constant | 2.9 Ws/VA |
Synchronous condenser engineered package – Canada – Rainbow Lake

1 pcs AMS 1250, 55 MVar, 13.8 kV 60Hz – Cooling Duct IN / Duct OUT
Special applications
Synch Condensers
High inertia solution
Synchronous condenser systems high inertia setup

To combine a mid size SC with a flywheel (FW) will increase the inertia several times and the losses will be much lower comparing to install the whole inertia as SC

- Unit data: 70 MVA base
  - \( H = 1.3 \text{ s} \) & Inertia 7500 kgm\(^2\) (only SC)
  - 91 MWs stored energy

- SC + Flywheel
  - \( H > 6 \text{ s} \) & 450 MWs stored energy, Inertia 7500+30000 kgm\(^2\)
  - Losses 130% compared with only 70 MVA SC

- One large unit 300 MVA gives approximate same stored energy as SC + flywheel above
  - Losses (98,4% eff) 4800 kW compared to 1300 \(\rightarrow\) >3,5 times higher losses than 70 MVA SC + FW

Preliminary data
ABB – Multiple Synchronous Condenser
Modular to fit changing requirements

Key benefits:
- Redundancy
- Higher inertia
- Control

One example on a system solution:
- Four Synchronous Condensers with integrated flywheels
- 140 Mvar inductive reactive power to 280 Mvar capacitive reactive power
- Provides a contribution to the short circuit power in the range of 900 MVA
- Provides a contribution to the inertia in the range of 1 800 MWs

No need for big 2-POL syncon’s to get high inertia or SCL support
Phoenix – Hybrid Synchronous Condenser System
Innovation combining two technologies

Hybrid Synchronous Condenser – Project Data
- SVC Light HP: ±70 Mvar
- Synchronous Condenser: -35/+70 Mvar
- Transformer: Three winding, separate windings for SVC Light and Synchronous Condenser
- Control and Protection: MACH®
- Simulation Models and System Studies
- Civil Works
- Installation, Testing and Commissioning
- In service: November 2019

Hybrid Synchronous Condenser – Best of both technologies, STATCOM and Synchronous Condenser
Phoenix – Hybrid Synchronous Condenser System
Innovation combining two technologies

Hybrid Synchronous Condenser – Installation at Neilston

Hybrid Synchronous Condenser – Best of both technologies, STATCOM and Synchronous Condenser
Summary
Synchronous condensers

Summary

Synchronous condenser features
- Strengthens the network by adding short circuit capacity
- Rotating inertia provides stability to the network
- Dynamic MVAR’s support voltage control
- High thermal over-load capacity
- Very good ride-through capability

Market view
- Reborn interest due to more renewables
- Market increase
  - Network studies can be required (PSCAD, PSS/E, Powerfactory models available)
- Sometimes turn-key solution requested
- Refurbishment of decommissioned generators to SynCon’s
ABB Ability™ LEAP for HV generators – refurbishment to SynCon’s
Accurate analysis of the stator winding insulation

Offering description
- Advanced service for analyzing the condition and expected lifetime of the stator winding insulation – the most uptime critical component in high voltage motors and generators
- Our service includes condition assessment, expected lifetime and recommendations for operation and maintenance actions

Benefit
- Early warning – provides adequate time for maintenance planning
- Optimize maintenance planning – enables you to move from time-based to condition-based maintenance
- Reduced cost of ownership (COO) – supports efforts to extend lifetime and thereby increase return on investment (ROI)
- Better decision-making – facilitates decision-making on short and long term maintenance and run / repair / retrofit / replace options
- Improved risk mitigation – minimizes unplanned downtime by reducing risk levels

More information
abb.com-ABB Ability™ LEAP
Where we are available

Global service network

- 4 Global technical support centers
- More than 60 service centers
- More than 100 Service providers
Thank you for listening! Any questions?

Christian Payerl  
Area Sales Manager Synchronous Condensers  
christian.payerl@se.abb.com  
Tel.: +46 21 320475  
Mob.: +46 70 2601024

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