ABB MOTORS AND GENERATORS, 2020 CHRISTIAN PAYERL

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!

Synchronous Condenser Contact at ABB

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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 Ciruit Power & MVAr’ s**

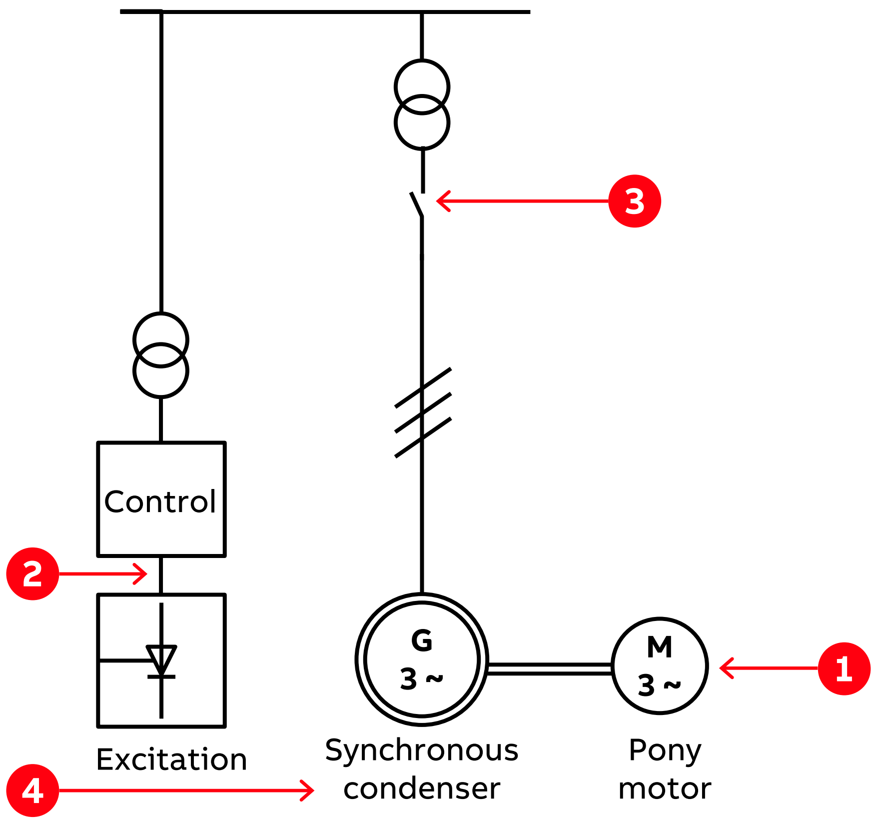
Synchronous condenser – What

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

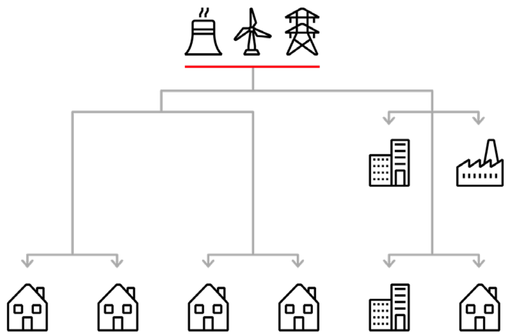
3. When synchronization is reached between the network and the synchronous condenser, the breaker to the network will be closed. The SC is running on-line

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



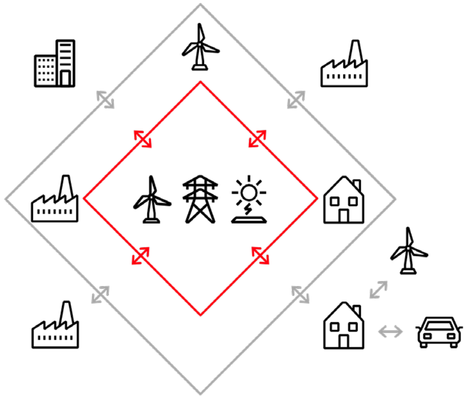
Synchronous condenser – Why

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)

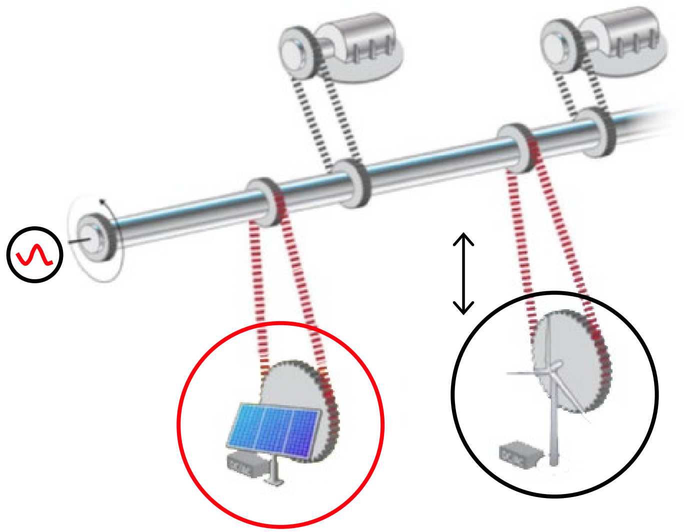
Strong **Weak** **Very weak**

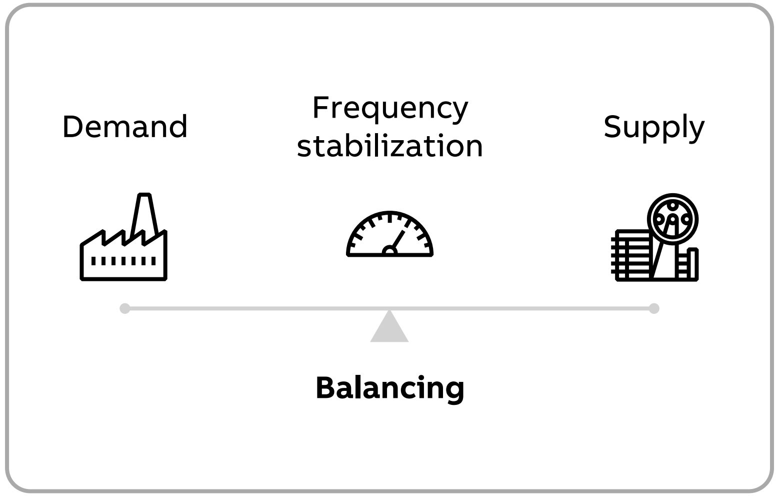
Different implications — **Generation** | **Transmission** | **Distribution** | **Industrial C.** | **Residential C.**

Synchronous Condenser – Why

Inertia support (frequency stability)

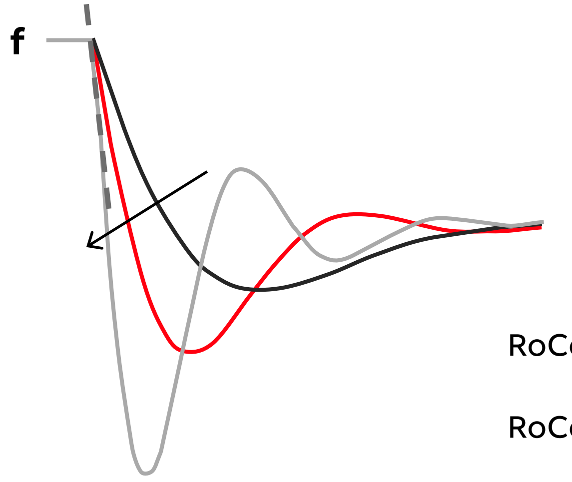
Synchronous Condenser supports the grid **with instantaneous inertia** (rotating mass):





None-synchronous generation:

Wind, Solar, Tidal, Energy Storage (BESS)



$$\text{RoCoF} = \frac{df}{dt}$$

$$\text{RoCoF} \sim \frac{1}{\text{Inertia}}$$

Increasing % of non-synchronous generation

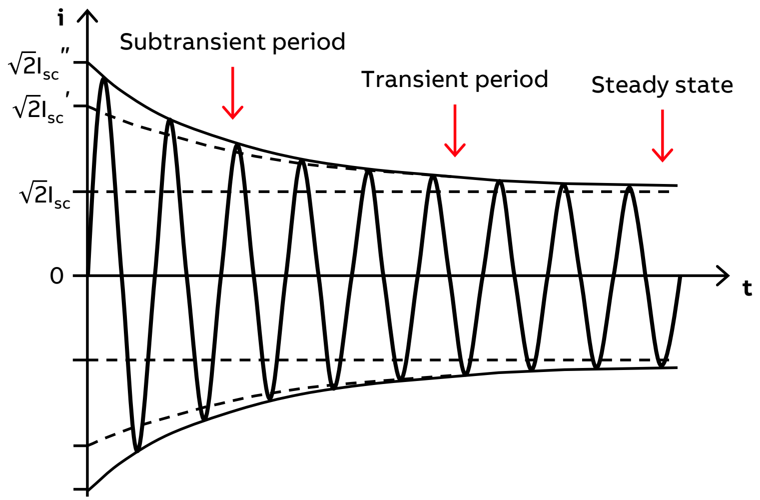
Synchronous Condenser – Why

Fault level contribution

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

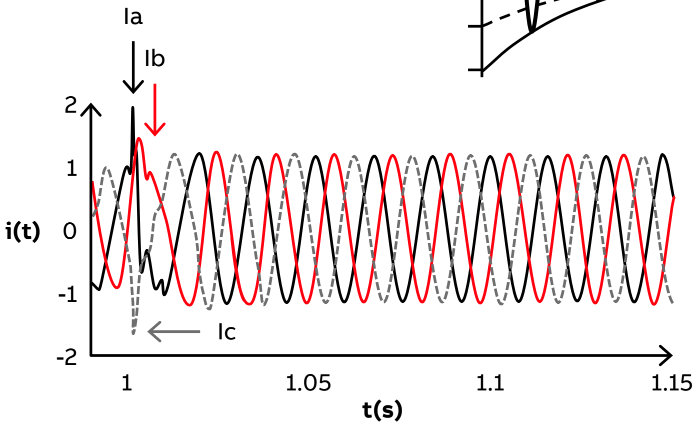
Fault current is uncontrolled & defined by the electrical parameters of the synchronous condenser

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



Inverter Based Resource:

Fault current is tightly controlled by IBR control scheme



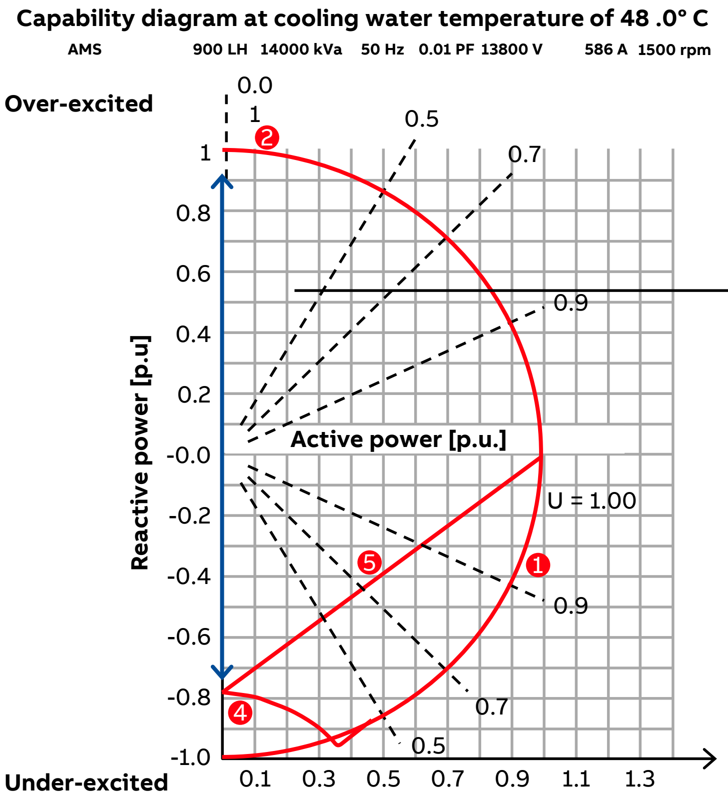
Synchronous Condenser – Why

MVAr support (voltage regulation)

Capability diagram

Over-excited
Produces reactive power

Absorbs reactive power
Under-excited



→ Synchronous condenser operating region

Base apparent power 1 p.u. = 14000 kVa

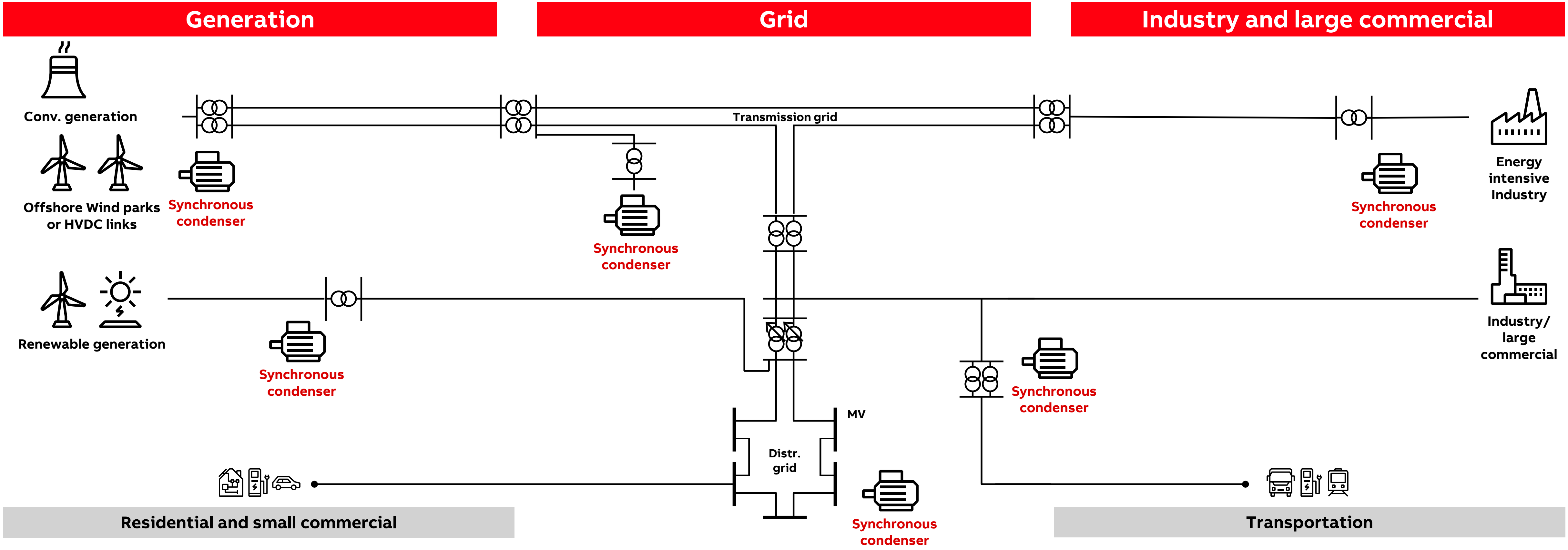
1. Stator heating limit
2. Rotor heating limit
3. Practical stability limit
4. Zero field-current limit
5. Core end heating limit

Synchronous condenser – Why

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

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



Synchronous condensers – When & Who

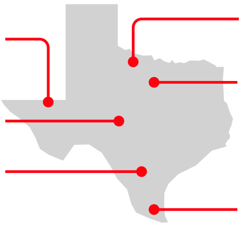
Maps showing some Generic Transmission Constraints in ERCOT

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

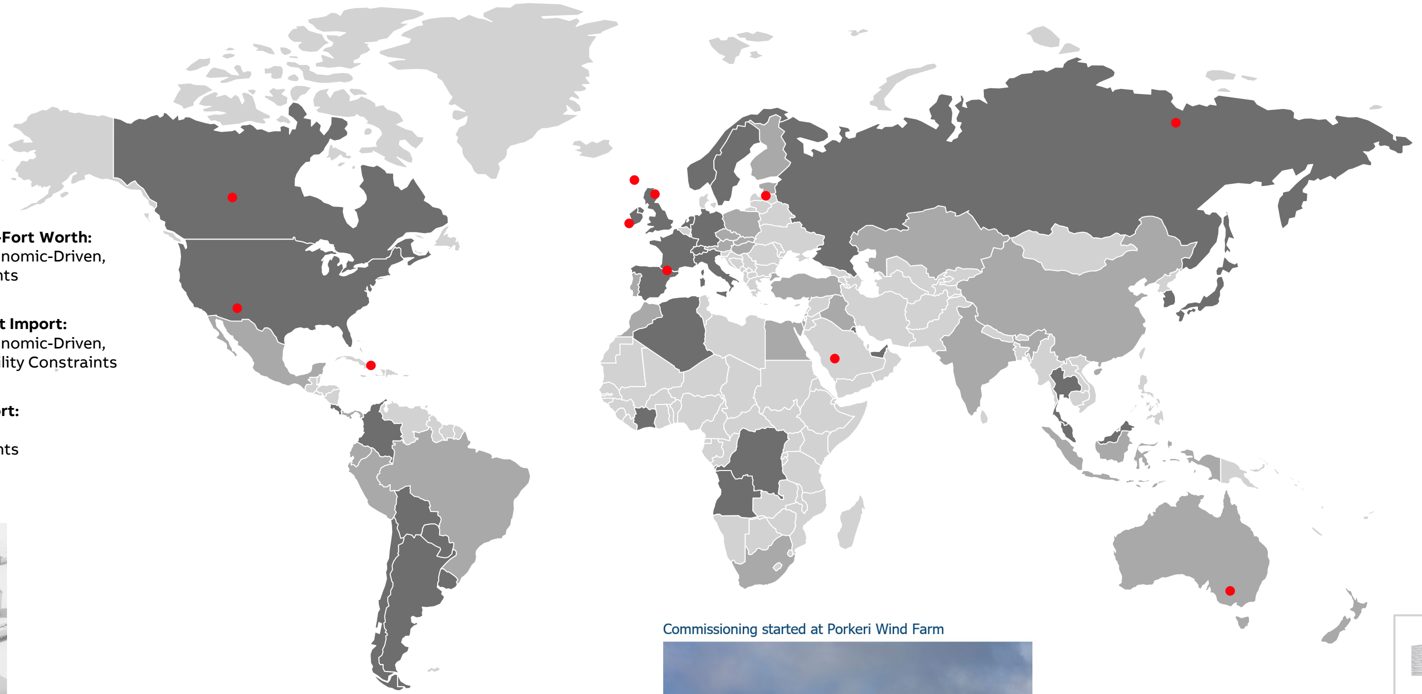


Northwest Dallas-Fort Worth:
Reliability and Economic-Driven,
Thermal Constraints

Houston/Freeport Import:
Reliability and Economic-Driven,
Thermal and Stability Constraints

South Texas Import:
Reliability-Driven,
Stability Constraints

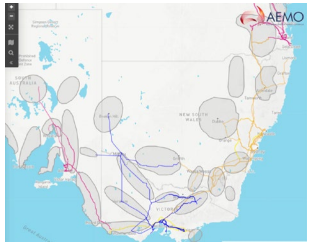
Mining industry

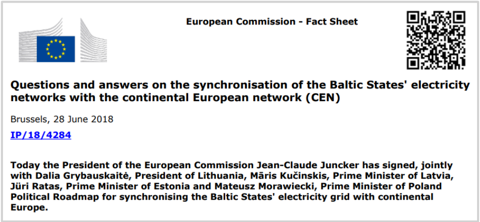


Commissioning started at Porkeri Wind Farm

nationalgridESO

Network Development Roadmap
Progress Update
31st January 2020





European Commission - Fact Sheet

Questions and answers on the synchronisation of the Baltic States' electricity networks with the continental European network (CEN)

Brussels, 28 June 2018

IP/18/4284

Today the President of the European Commission Jean-Claude Juncker has signed, jointly with Dalia Grybauskaitė, President of Lithuania, Māris Kučinskis, Prime Minister of Latvia, Jüri Ratas, Prime Minister of Estonia and Mateusz Morawiecki, Prime Minister of Poland Political Roadmap for synchronising the Baltic States' electricity grid with continental Europe.

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

ABB Synchronous Condenser Package

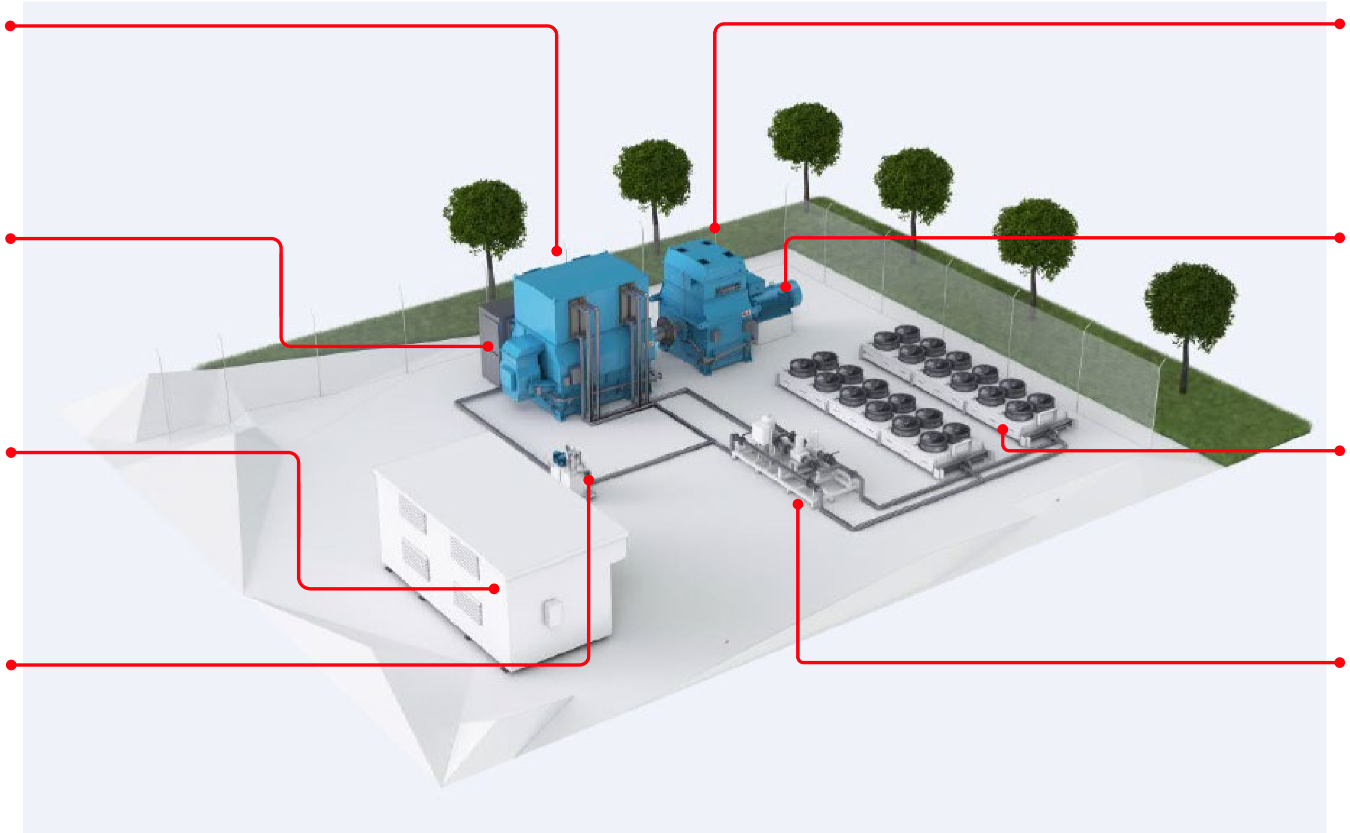
Overview

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

ABB Synchronous Condenser Package

ABB Motion Scope of Supply

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

REFERENCE #1

Installation from an Energy Park, Queensland first synchronous condenser with CAWA cooling

Hybrid Energy Park

15MW Solar

43MW Wind

2MW Energy Storage

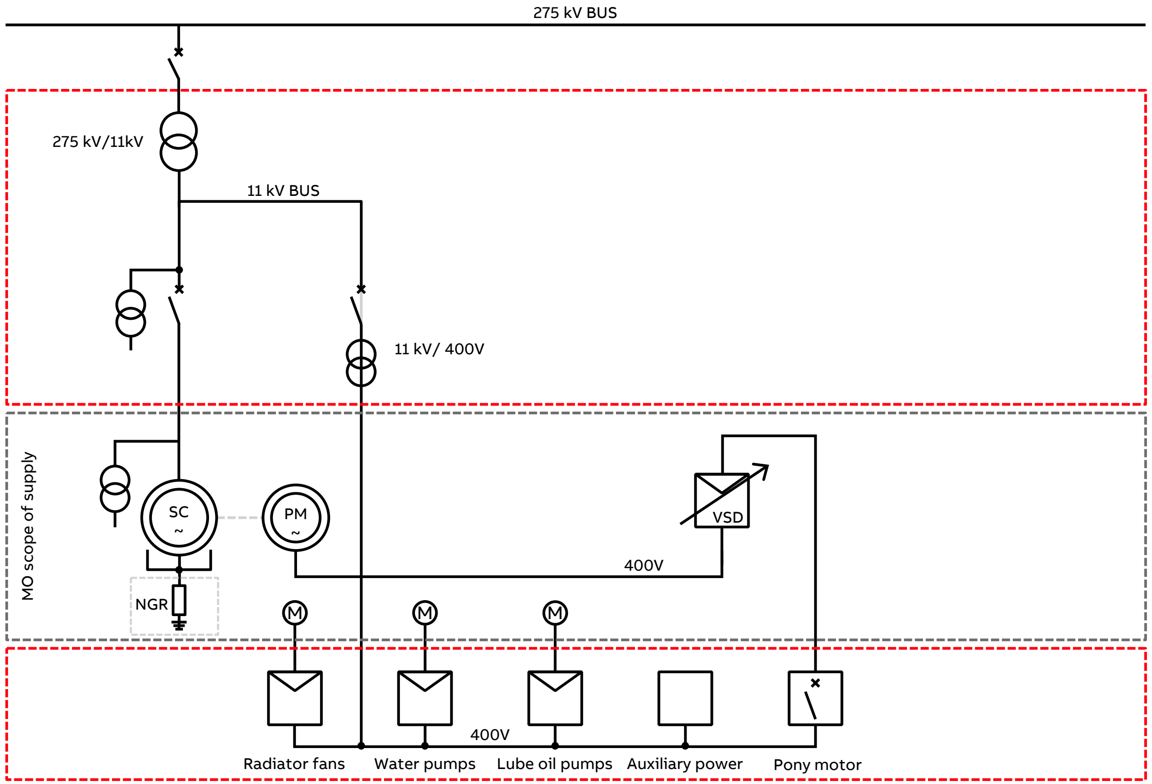
5MVAr SynCon

Synchronous condenser engineered package – Solar Park Australia

REFERENCE #2

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

AMS 1400, 60 MVAr, 11 kV, IP 55, 50kA 3sec



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Synchronous condenser package – Darlington Point Australia

REFERENCE #3

Installation from site Darlington Point, North South Wales, synchronous condensers with CACA cooling

Synchronous condenser engineered package – Canada Copper Mountain

REFERENCE #4

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

REFERECE #5

1 pcs AMS 1250,

55 MVAr, 13.8 kV 60Hz – Cooling Duct IN / Duct OUT

Special applications

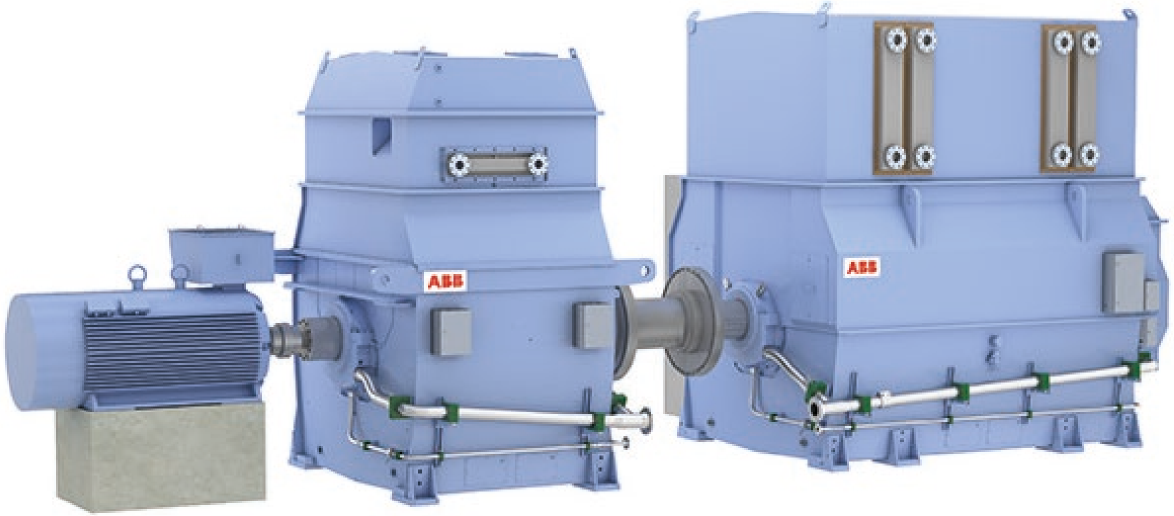
Synch Condensers

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 s & Inertia 7500 kgm² (only SC)
  - 91 MWs stored energy
- SC + Flywheel
  - H > 6 s & 450 MWs stored energy, Inertia 7500+30000 kgm²
  - 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 → >3,5 times higher losses than 70 MVA SC + FW



Preliminary data

ABB – Multiple Synchronous Condenser

Modular to fit changing requirements

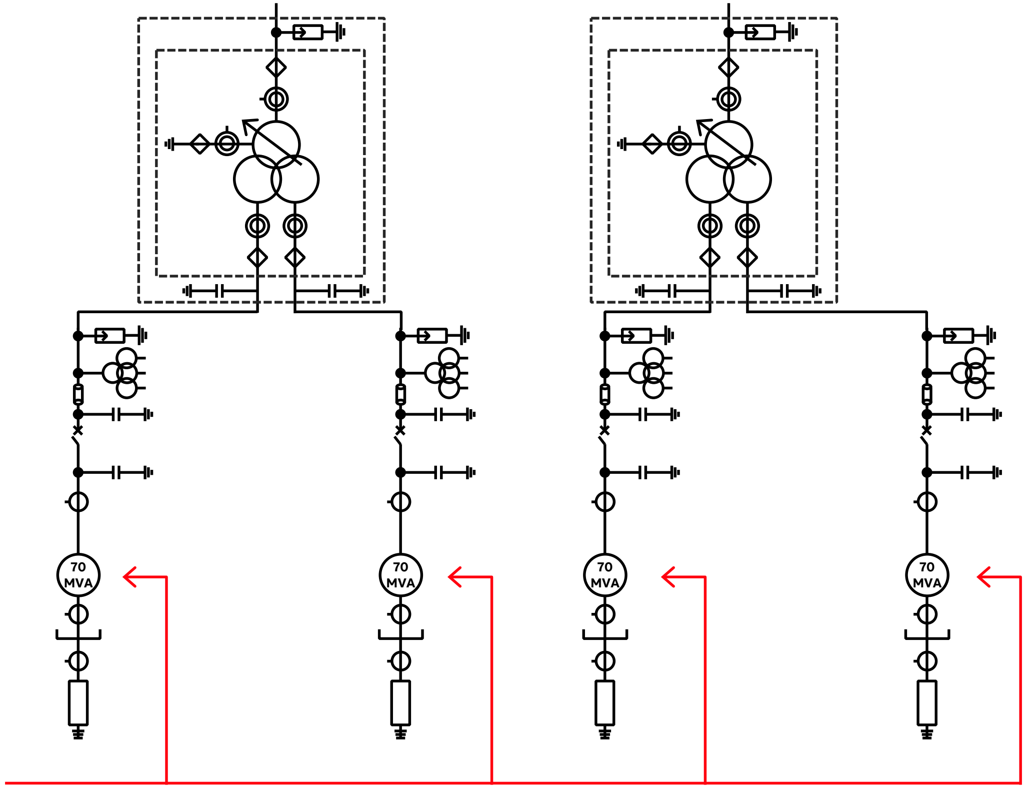
Key benefits:

- Redundancy
- Higher inertia
- Control

No need for big 2-POL syncon´s to get high inertia or SCL support

One example on a system solution:

- Four Synchronous Condensers with integrated fly-wheels
- 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

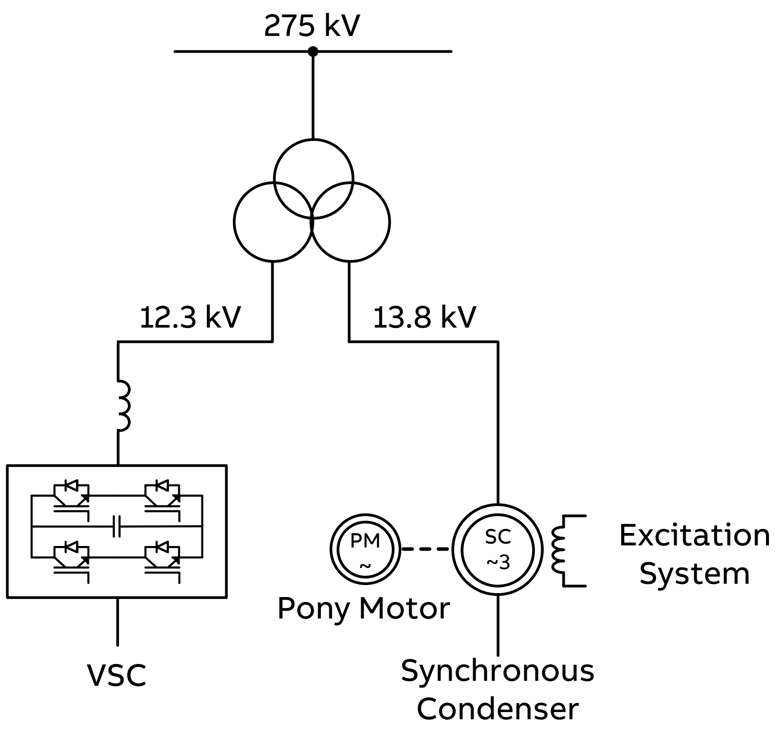


Phoenix – Hybrid Synchronous Condenser System

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

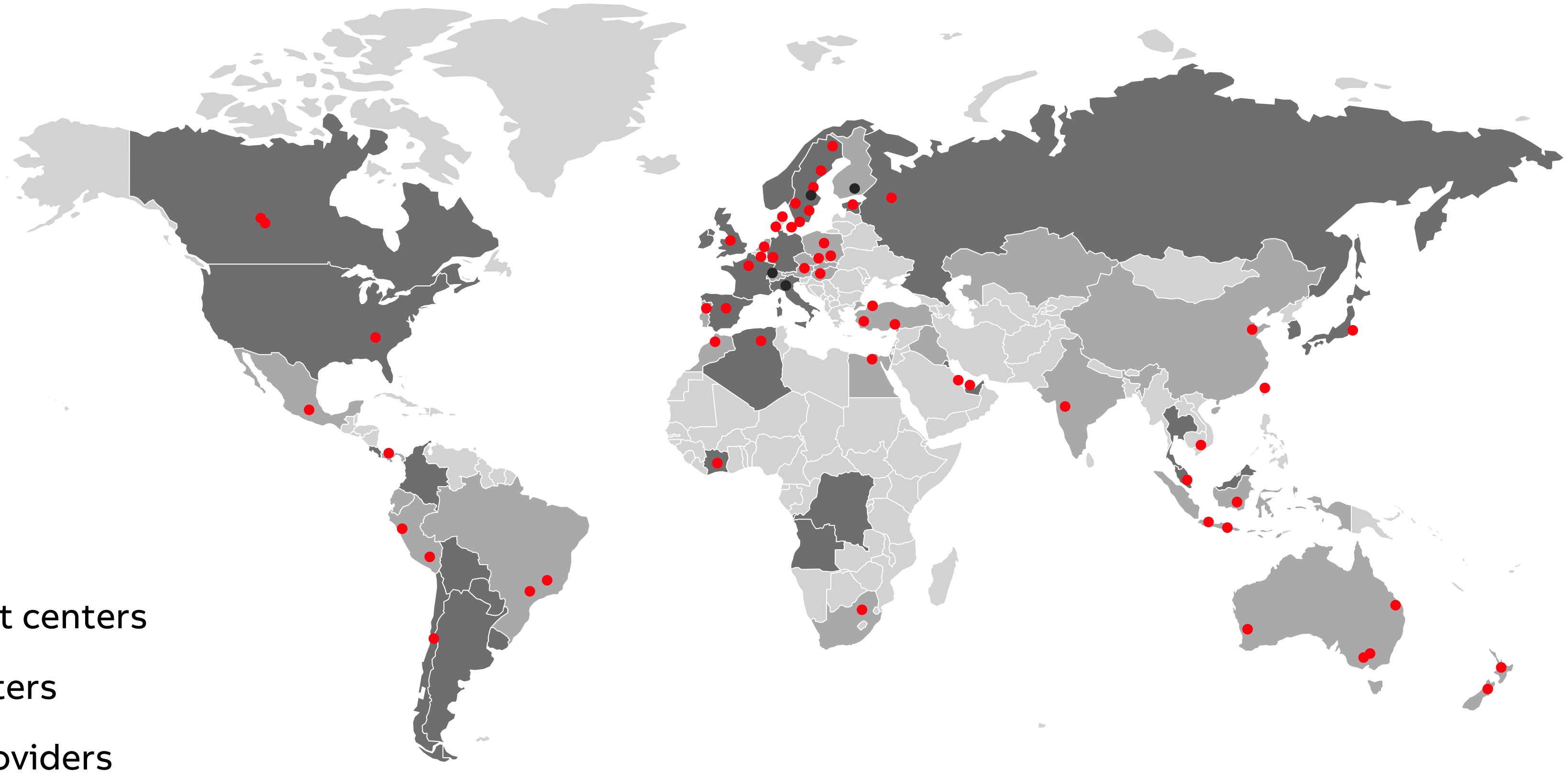
- Early warning – provides adequate time for maintenance planning
- Optimize maintenance planning – enables you to move from time-based to condition-based maintenance
- Reduced cost of ownership (COO) – supports efforts to extend lifetime and thereby increase return on investment (ROI)
- Better decision-making – 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

ABB

Thank you for listening! Any questions?

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