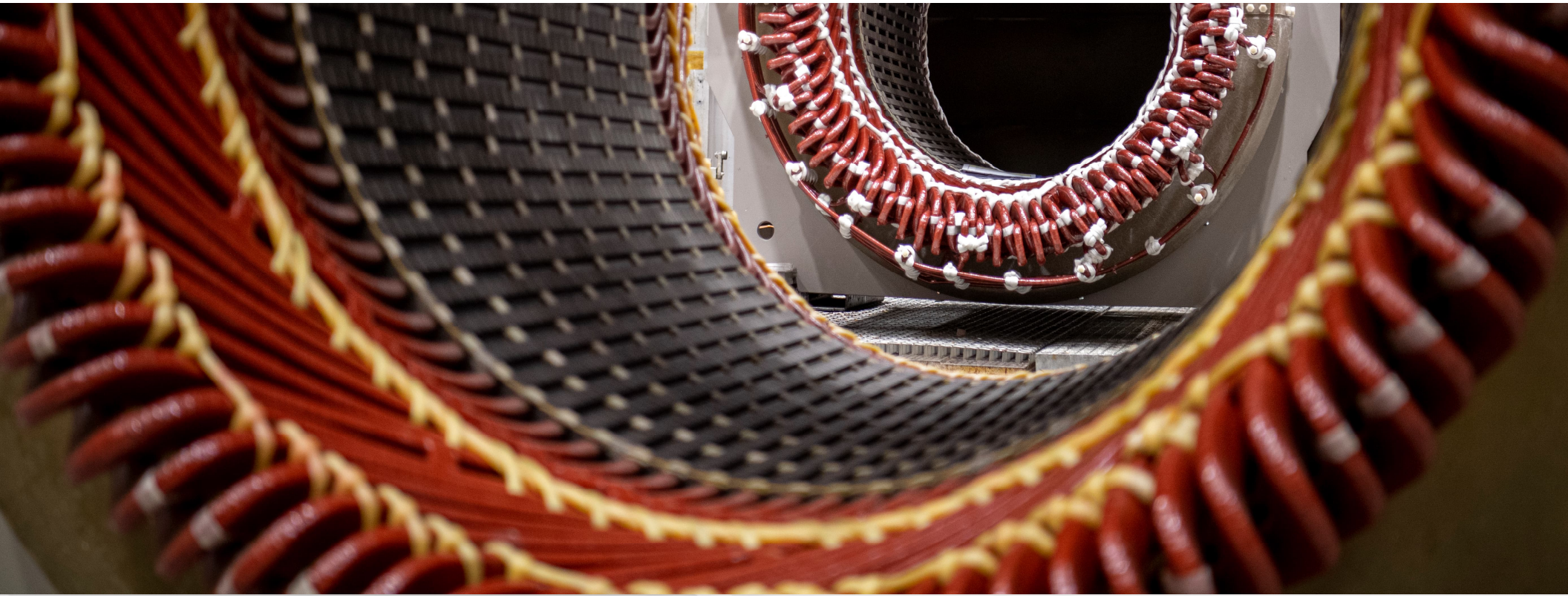

PRESENTATION

Systemtjänster som är viktiga för nätstabilitet i svenska kraftsystemet

 Document ID.: Rev.:

Synchronous Condenser Contact at ABB

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

Fully decentralized business model with 21 Divisions

Business area	Electrification	Motion	Process Automation	Robotics & Discrete Automation
				
Division	Distribution Solutions	IEC LV Motors	Energy Industries	Robotics
	Smart Power	Large Motors & Generators	Process Industries	Machine Automation
	Smart Buildings	Service	Marine & Ports	
	Installation Products	Drive Products	Turbocharging	
	Power Conversion	Systems Drives	Measurement & Analytics	
	E-mobility	NEMA Motors		
		Traction		

ABB Large Motors and Generators, Västerås

FINNSLÄTTEN

450 EMPLOYEES

22 000 M^2

+4000
SYNCHRONOUS
MACHINES GLOBALLY

SYNCHRONOUS MOTORS &
GENERATORS

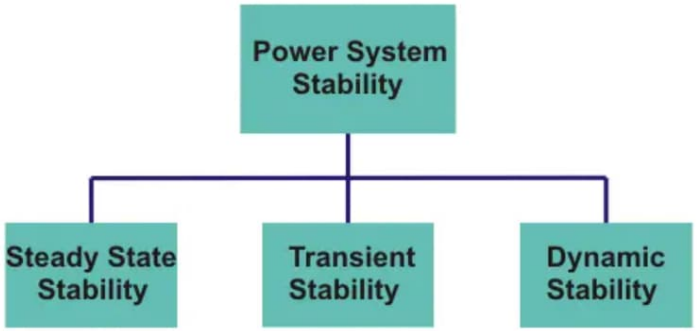
SYNCHRONOUS CONDENSERS

VHV SYNCHRONOUS MOTORS

TRACTION MOTORS

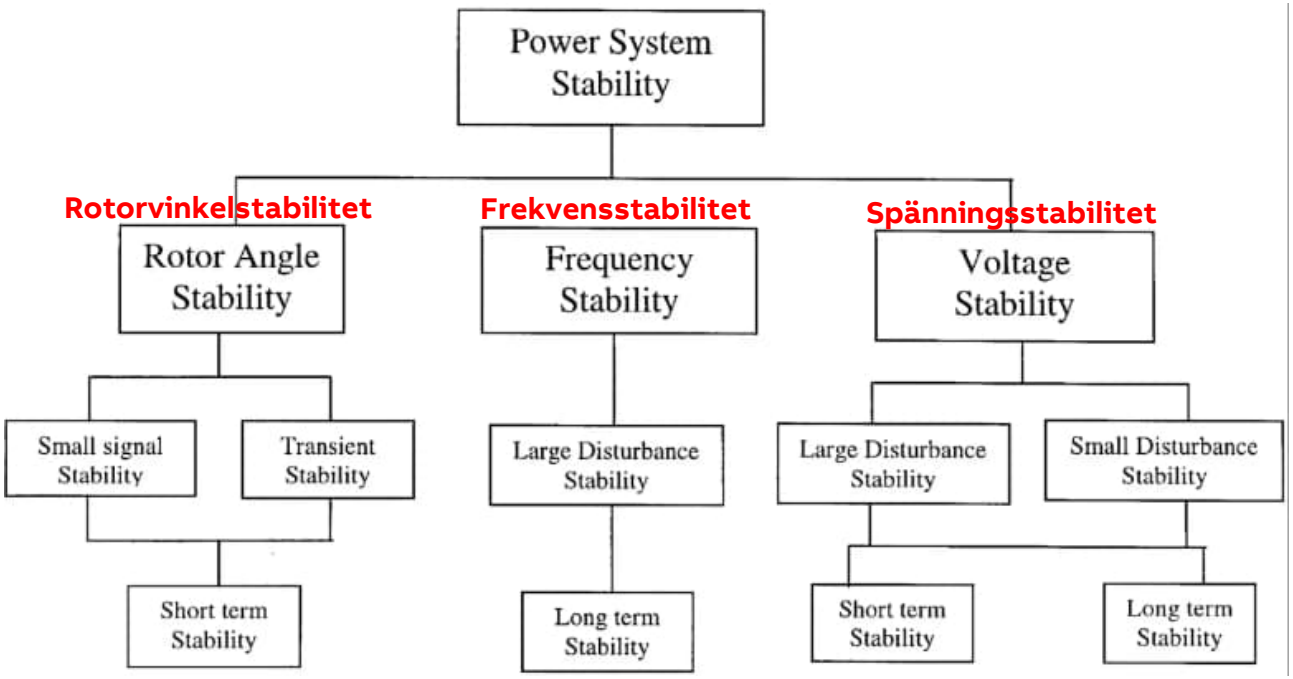
AFTER SALES & SERVICE

Power system classification



- Steady-state stability: the ability of the machine to deliver maximum real power to the loads by maintaining equilibrium even when it experiences a small and gradual variation of load.
- Transient stability: the ability of the machine to deliver maximum real power to loads when it experiences a sudden and large variation of load.
- Dynamic stability: the ability of the machine to maintain stability under continuously varying loads.

Power system classification



Power system classification

Frekvensstabilitet

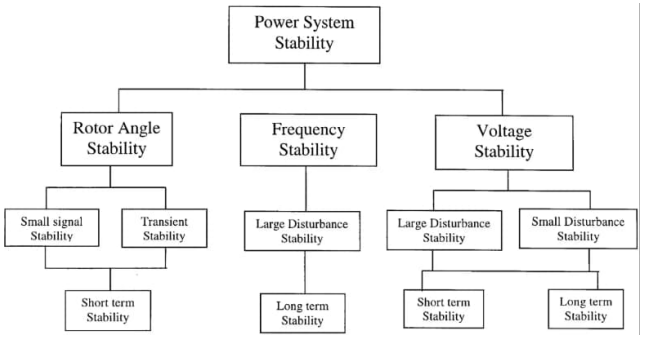
För att elöverföringssystemet ska fungera måste frekvensen hela tiden hållas inom snäva gränser. Det nordiska kraftsystemet balanseras mot en frekvens på 50 Hz.

Frekvensstabilitet handlar om kraftsystemets förmåga att upprätthålla en stabil frekvens efter en störning i balansen mellan produktion och förbrukning.

Störningar uppkommer på grund av fel och bortkopplingar av produktion eller förbrukning. Obalanser kan också uppstå ur den naturliga, slumpmässiga (stokastisk) variation som förekommer i produktion och förbrukning.

Åtgärder för att upprätthålla frekvensstabiliteten

Arbetet med att säkerställa frekvensstabilitet är komplicerat och lösningarna är till del situationsbaserade. Att till exempel kompensera brist på en viss resurs genom att tillföra mer av den resursen, är inte alltid den bästa lösningen på problemet.



Källar: SvK

Ancilliary services in Sweden

Procurement and pricing of reserves

Updated February 1st 2024

Remedial action	Frequency containment reserves			Frequency restoration reserves	
FFR	**FCR-D upward**	**FCR-D downward**	**FCR-N**	**aFRR**	**mFRR**
Fast Frequency Reserve (Snabb frekvensreserv)	Upward Frequency Containment Reserve - Disturbance (Frekvenshållningsreserv -Störning uppreglering)	Downward Frequency Containment Reserve - Disturbance (Frekvenshållningsreserv -Störning nedreglering)	Frequency Containment Reserve - Normal (Frekvenshållningsreserv -Normaldrift)	Automatic Frequency Restoration Reserve (Automatisk Frekvens-återställningsreserv)	Manual Frequency Restoration Reserve (Manuell Frekvens-återställningsreserv)
Upward regulation	Upward regulation	Downward regulation	Symmetrical upward and downward regulation	Upward and/or downward regulation	Upward and/or downward regulation
Procurement Bids on capacity market	**Procurement** Bids on capacity market	**Procurement** Bids on capacity market	**Procurement** Bids on capacity market	**Procurement** Bids on capacity market	**Procurement** Bids on capacity market and energy activation market
Capacity remuneration Pay as cleared. Cleared volumes and prices are published weekly on Aktörsportalen. More information is available in Swedish in the document FFR marknadslösning 2023.	**Capacity remuneration** Pay as cleared. Prices per MW are published on Mimer.	**Capacity remuneration** Pay as cleared. Prices per MW are published on Mimer.	**Capacity remuneration** Pay as cleared. Prices per MW are published on Mimer.	**Capacity remuneration** Pay as cleared. Prices per MW are published on Mimer.	**Capacity remuneration** Pay as cleared. Prices per MW are published on Mimer.
Energy remuneration No energy remuneration.	**Energy remuneration** No energy remuneration.	**Energy remuneration** No energy remuneration.	**Energy remuneration** According to up or down regulating prices. Prices are published on Mimer.	**Energy remuneration** According to up or down regulating prices. Prices are published on Mimer.	**Energy remuneration** Pay as cleared. Remuneration according to up or down regulating prices. Prices are published on Mimer.

More detailed information on the requirements is available in Swedish in the balance responsibility agreeement and associated regulatory documents. They are available for download on Svenska kraftnät's webpage: www.svk.se/aktorsportalen/balansansvarig/balansansvarsavtalet/.

Ancilliary services in Sweden

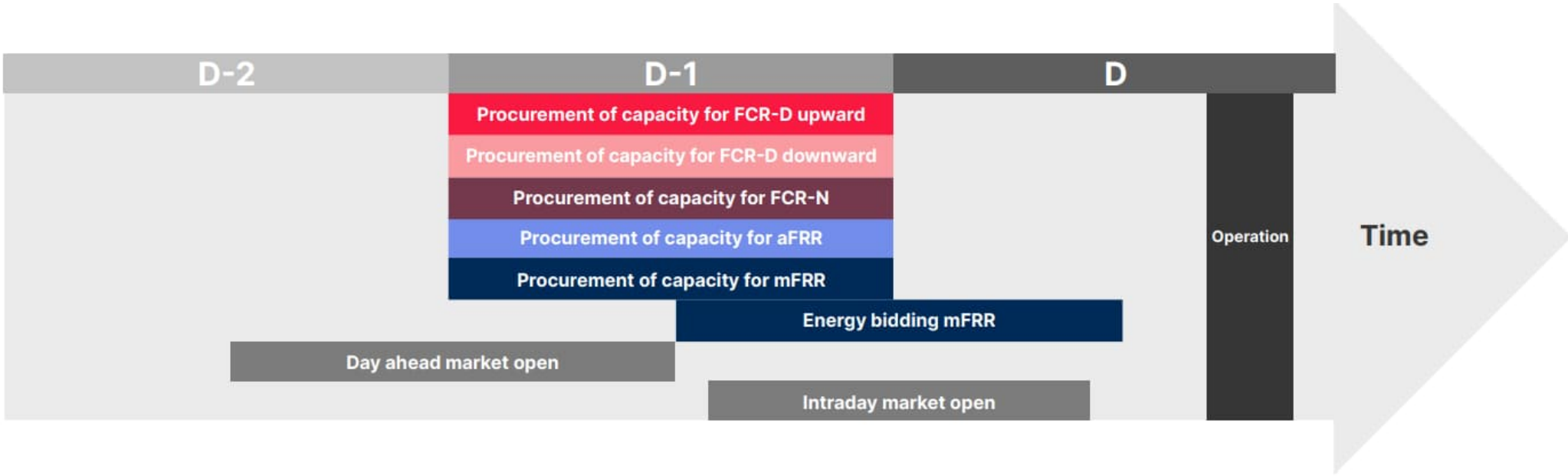
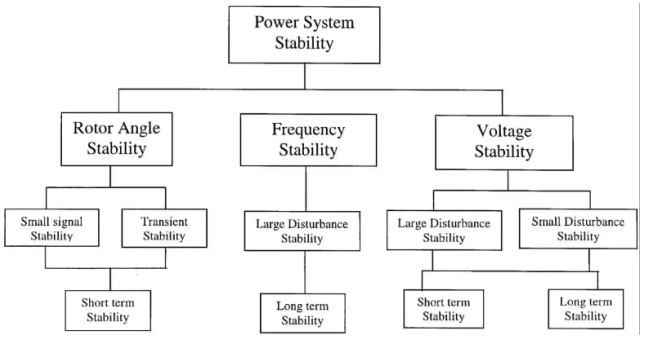


Figure 1. Procurement and pricing of reserves. The reserve FFR is not included in the figure as it is procured on a yearly basis.

More detailed information on the requirements is available in Swedish in the balance responsibility agreeement and associated regulatory documents. They are available for download on Svenska kraftnät's webpage: www.svk.se/aktorsportalen/balansansvarig/balansansvarsavtalet/

Power system classification



Rotorvinkelstabilitet

Rotorvinkelstabilitet handlar om förmågan hos synkrongeneratorer i ett system att förbli samordnade i och efter att systemet utsatts för en störning.

Varje generator har en egen rotorvinkel. När flera generatorer är anslutna till ett nät påverkas de av varandra och samordnas (synkroniseras). Det skapas också en inbördes rörelse mellan de olika generatorernas rotorer.

Rotorvinkelstabilitet handlar om hur rotorvinklarna för de olika generatorerna förhåller sig till varandra.

Åtgärder för rotorvinkelstabilitet

Arbetet för rotorvinkelstabilitet handlar i första hand om att dämpa den inbördes rörelsen mellan generatorernas rotorer. Ett mått på den rörelsen är hur stor variation det är mellan de olika rotorernas vinkelskillnader. Blir vinkelskillnaden för stor så kan det leda till att en eller flera generatorer tappar sin synkronisering med resten av systemet och kopplas bort.

Källar: SvK

Power system classification

Spänningsstabilitet

Spänningarna i ett kraftsystem är av fundamental betydelse för dess funktion. Utan en väl fungerande kontroll av spänningarna fungerar inte kraftsystem.

Spänningsstabilitet handlar om kraftsystemets förmåga att upprätthålla stabila spänningsnivåer och återgå till ett nytt jämviktsläge efter att ha utsatts för en störning.

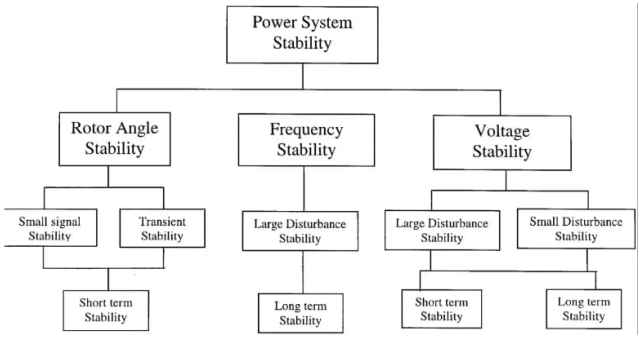
Kriteriet för spänningshållning är att det går att tillgodose systemets behov av reaktiv effekt i varje enskild del av nätet. I annat fall är systemet spänningsinstabilt och marginalerna till spänningskollaps minskar.

En spänningskollaps kan innebära elavbrott för hela eller delar av systemet. Spänningskollaps var upphov till den senaste storstörningen i södra Sverige år 2003.

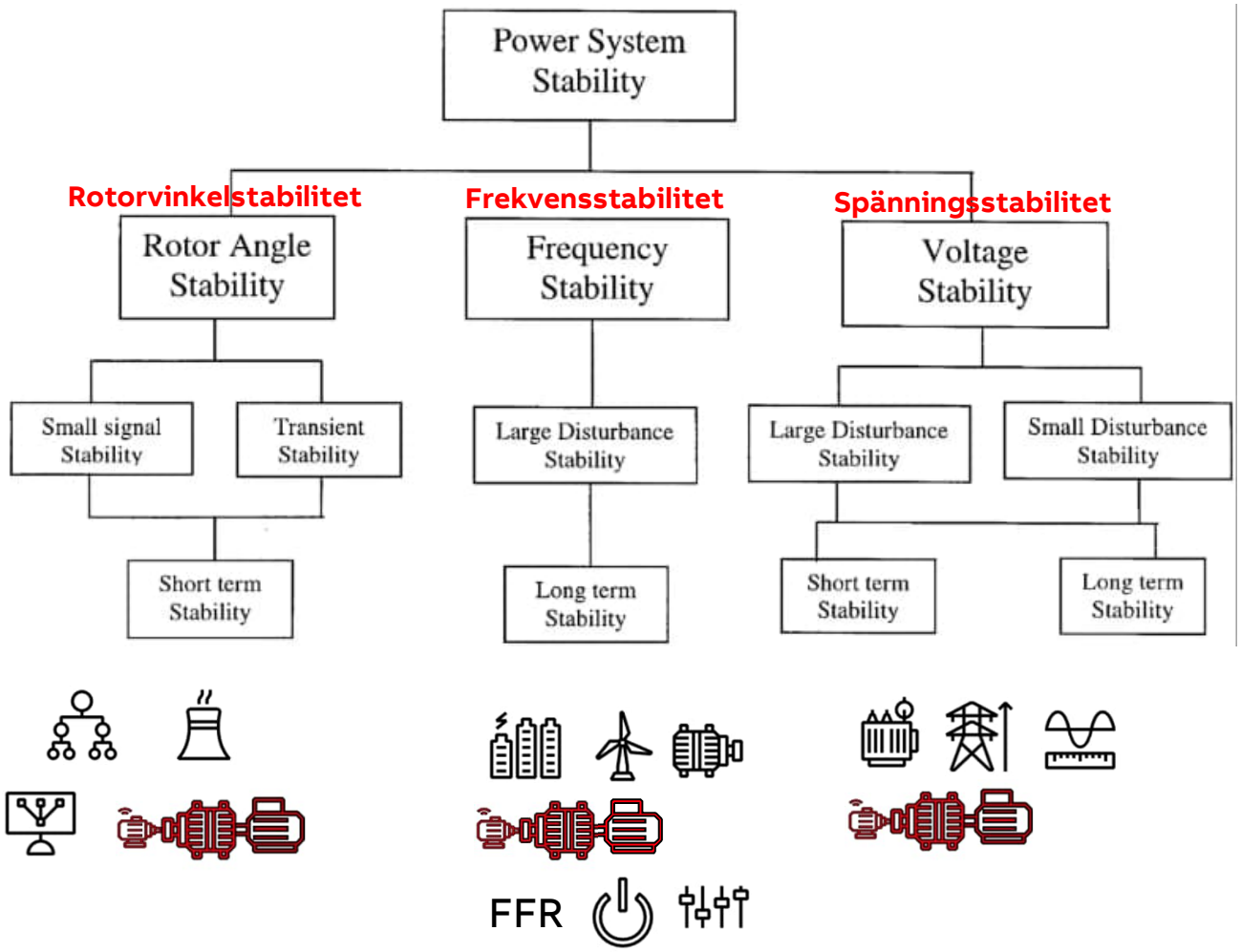
Åtgärder för att upprätthålla spänningsstabiliteten

Spänningsstabiliteten handlar dels om manuell justering av den reaktiva effektbalansen och dels om automatiska reglersystem för spänningen. Det avgörande för kraftsystemets spänningsprestanda att det finns tillräckliga resurser för båda insatserna.

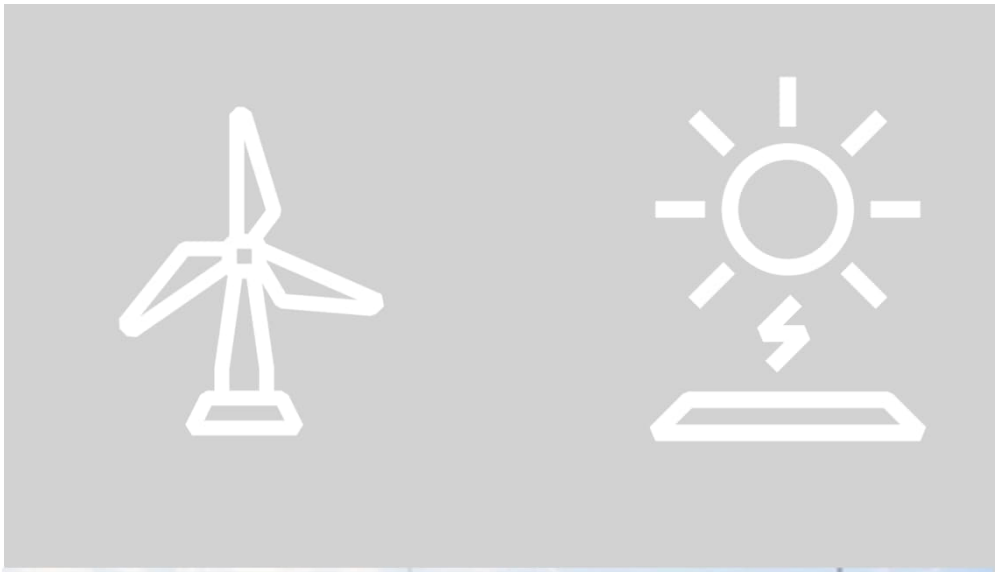
Källar: SvK



Power system classification



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**

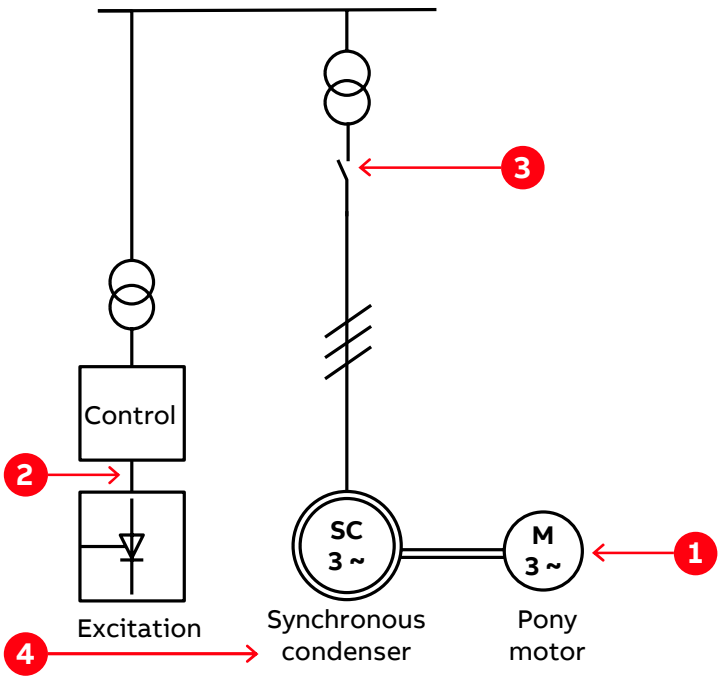
Synchronous condenser – What

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

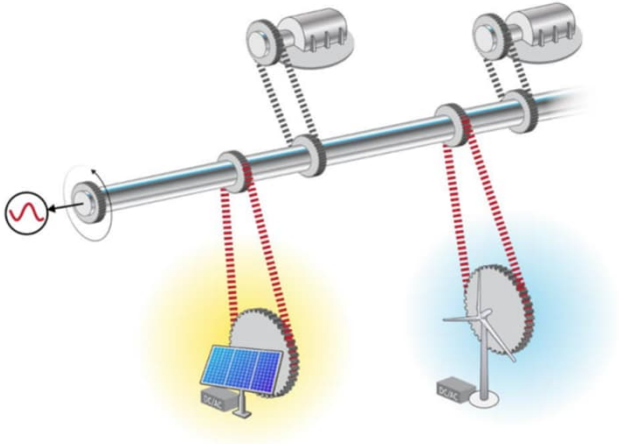
4. After successful synchronization, the pony motor will be de-energized, and runs idling with the SC

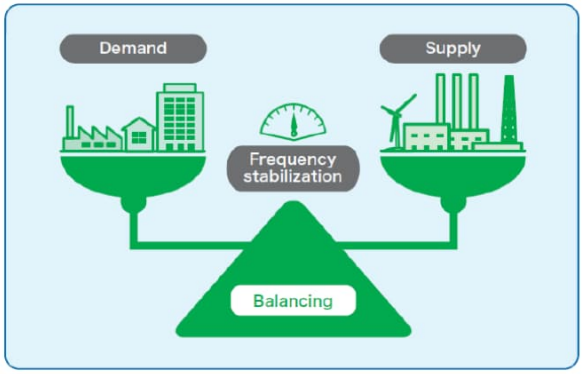


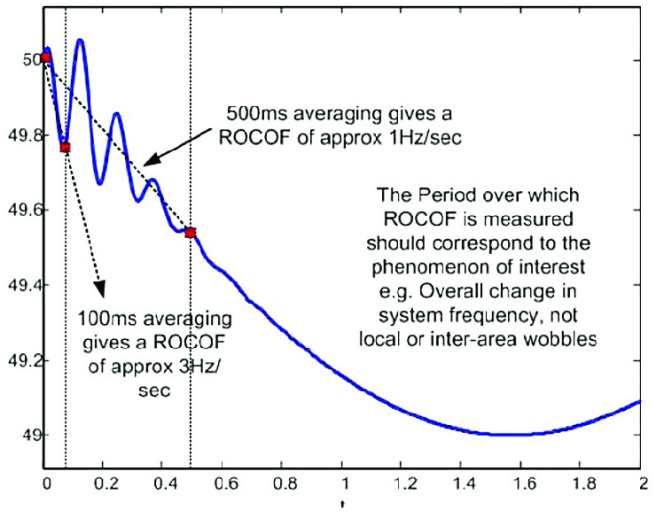
Synchronous Condenser - Why

Inertia support (frequency stability)

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







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

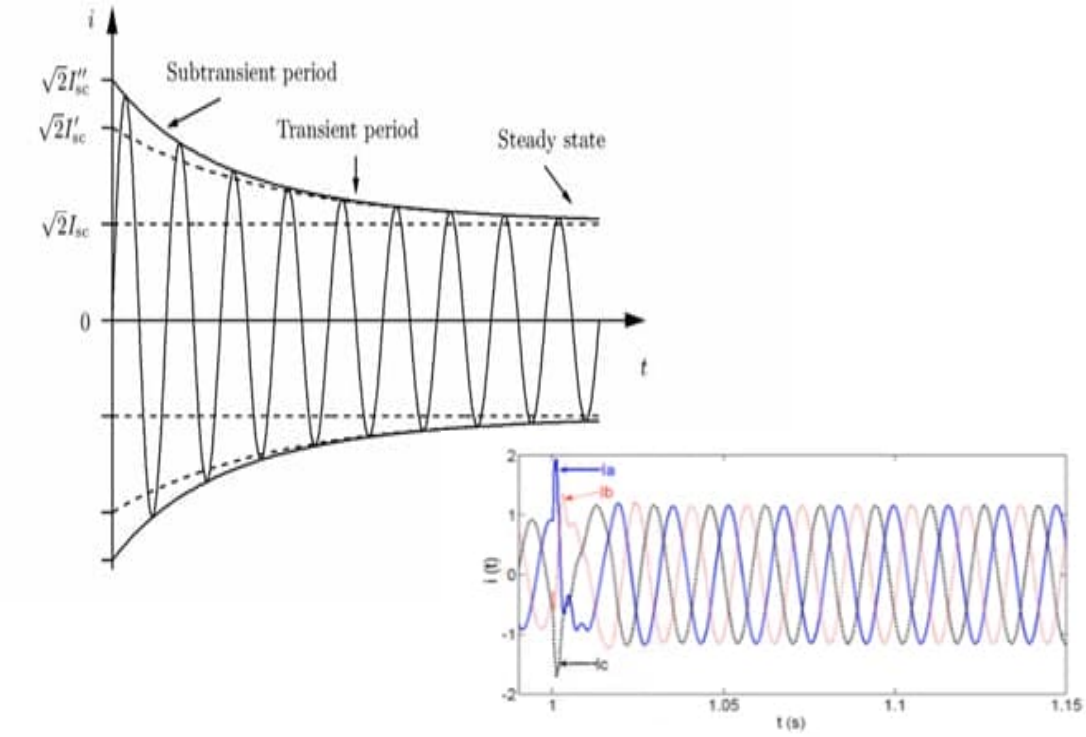
Synchronous Condenser - Why

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

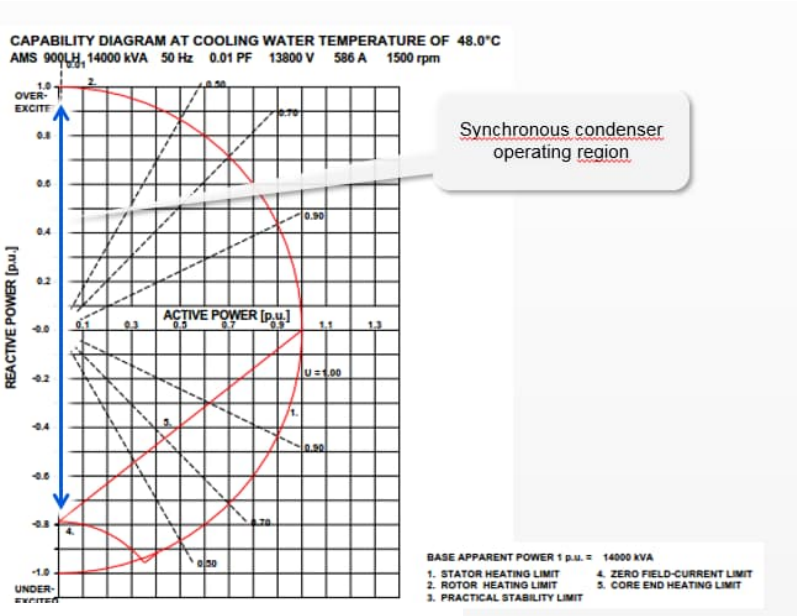
Beer Analogy of Active, Reactive & Apparent Power

over-excited

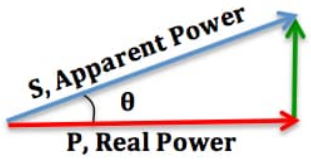
Produces reactive power

Absorbs reactive power

under-excited



Lagging Power Factor



Leading Power Factor

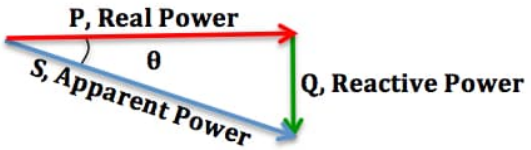


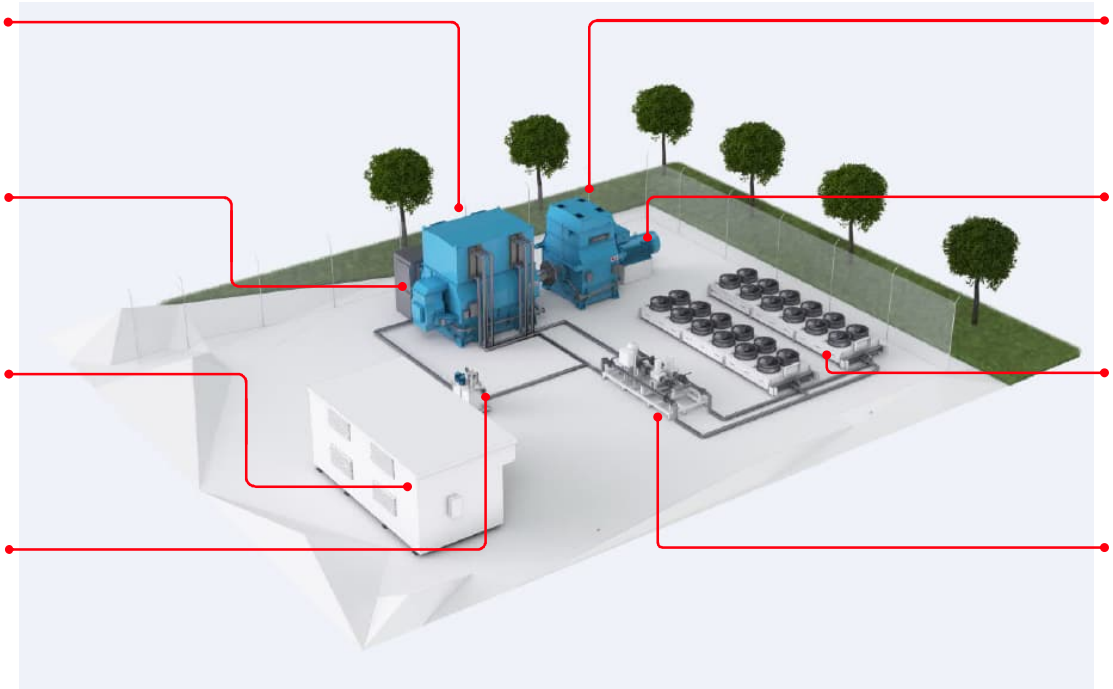
ABB Synchronous Condenser Package
Overview

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

Main terminal box
Increased short circuit current 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

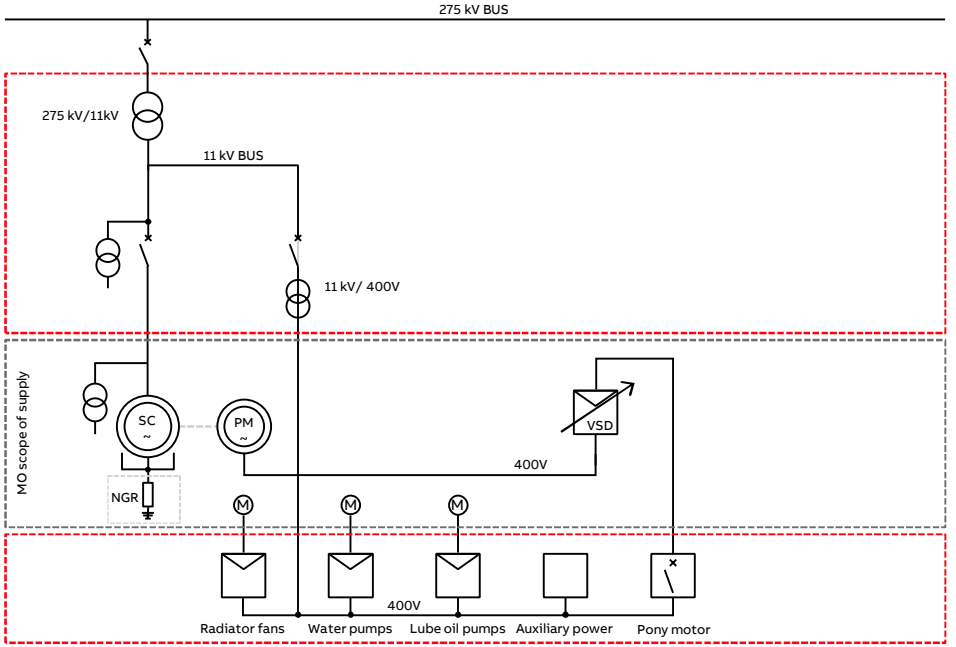
Air cooler units
Air cooling units to cool the cooling media

Pump unit
Redundant water pumps

Synchronous condenser engineered package – Finley 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



Statkraft

Lister Drive,
Liverpool, UK

ABB’s synchronous condensers are being used to stabilize the UK power grid with growing renewable energy. Thanks to a close, trusted collaboration Statkraft have signed a 10-year services contract.

High inertia system

Ensures that network frequency and voltage are stable

Essential for grid reliability

Rich industry experience

Close collaboration