Ancillary Services Provided by Different Technologies

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Ancillary services

- Frequency stabilization (short term)
- Frequency control
- Scheduling and dispatch
- Black start capability
- Voltage stabilization (short term)
- Voltage control
- Reactive power management
- System protection / fault current

Ancillary services

- Frequency stabilization (short term)
- Frequency control
- Scheduling and dispatch
- Black start capability

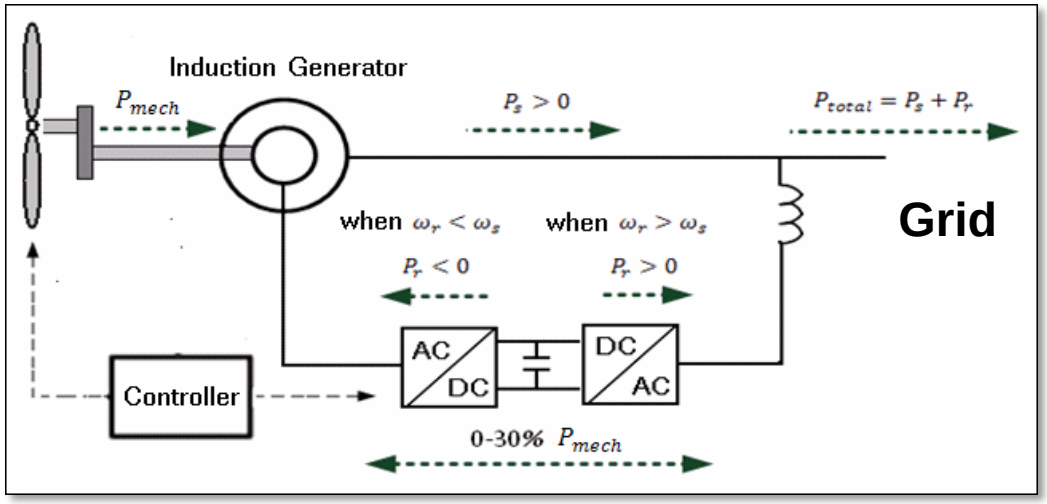
Active power

- Voltage stabilization (short term)
- Voltage control
- Reactive power management
- System protection / fault current

Reactive power

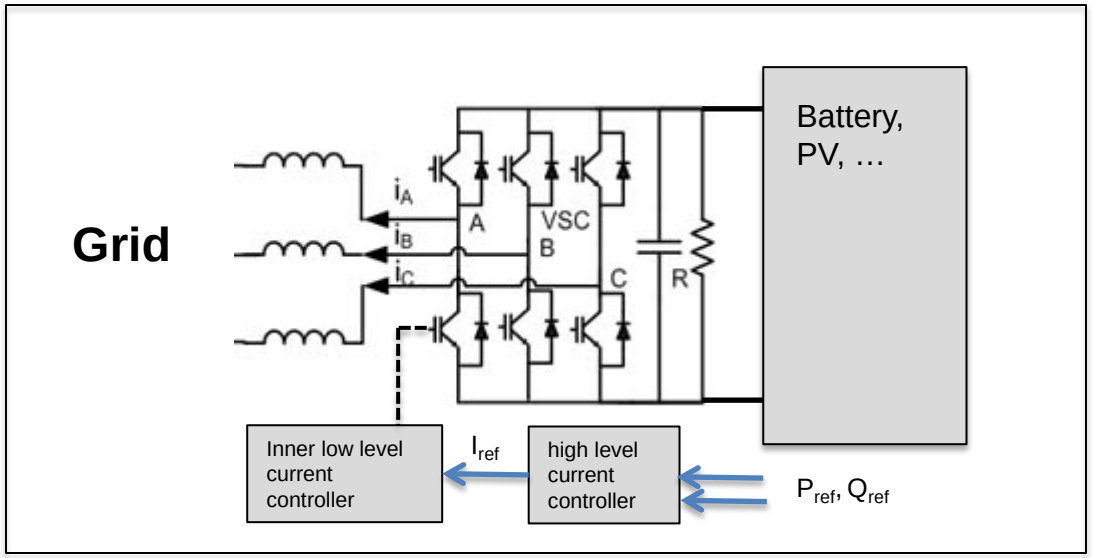
Devices

- Synchronous generator
  - with turbine
  - synchronous condenser
- Double fed induction generator
  - with turbine
  - synchronous condenser
- Inverter (voltage source converter)
  - with power source
  - HVDC
  - with storage
  - static compensator



Double fed induction generator (DFIG)

Voltage source converter (VSC)



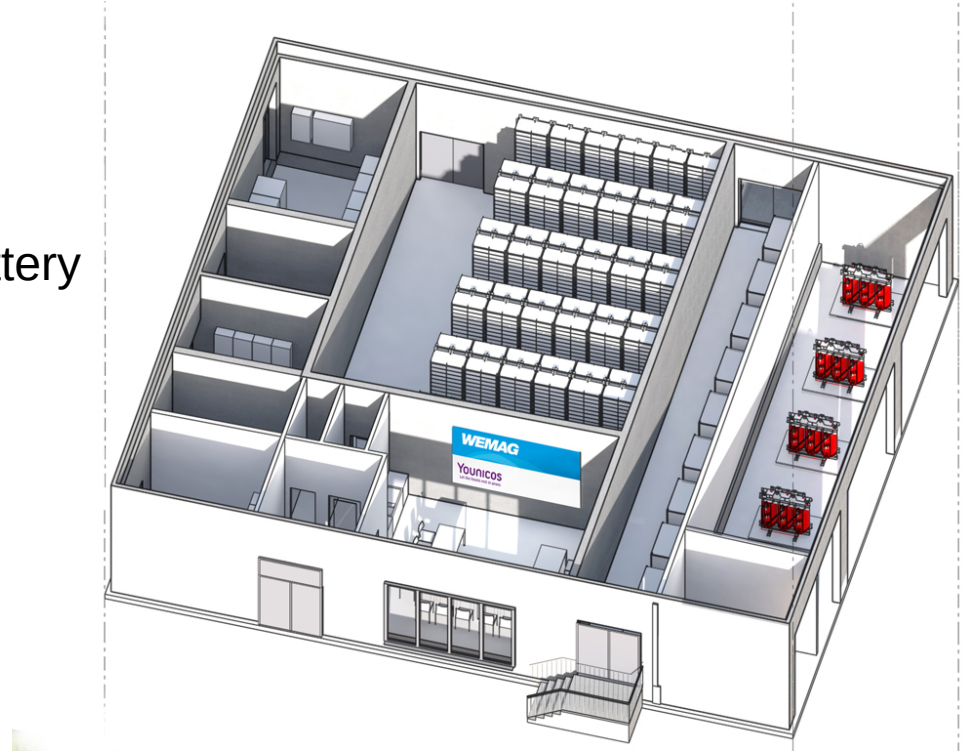
Frequency stabilisation (short term)

	SG	DFIG	INV
ROCOF response df/dt	inherent characteristic limited by allowed frequency band	limited inherent characteristic increased capacity by speed control limited by speed range (converter rating)	no inherent characteristic only with storage
droop response (primary control) Δf	only with turbine, released by governor (unlimited)	only with turbine, released by governor (unlimited)	only with controllable power source or (large) storage released by controller limitation by storage capacity

Battery storage system for primary frequency control reserve

WEMAG (Schwerin)
peak power: 5 MW
capacity: 5 MWh
technology: lithium-ion-battery
commissioning: 9/2014

Further applications:
- voltage control
- black start capability
- peak shaving
- ….



Source: Younicos

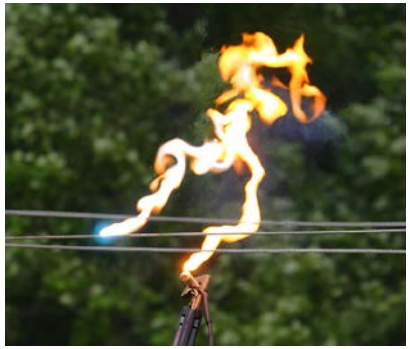
Voltage stabilisation and control

	SG	DFIG	INV
voltage source with low dynamic source impedance	inherent characteristic (subtransient reactance)	inherent characteristic (leakage reactances)	no inherent characteristic fast, inner, low level controller coupling reactor
voltage control, provision of reactive current/power	voltage controller limitation by excitation system and field winding	voltage controller acting on rotor side converter limitation by controller rating and rotor rating	voltage controller acting high level current controller limitation by inverter current rating

Short circuit capacity (ambiguous expression!)

1) Provision of large fault current at **low** remaining voltage

- clear discrimination of fault state against normal operation
- necessary for selective pickup and tripping
- old fashioned technology (?)



Short circuit capacity

2) Low internal impedance to limit power quality disturbances

- rapid voltage changes, flicker
- voltage unbalance
- voltage distortion, harmonics

Short circuit capacity

	SG	DFIG	INV
provision of short circuit capacity, fault currents	inherent characteristic (subtransient reactance) multiple of nominal current	inherent characteristic (leakage reactances) with crowbar pure induction machine characteristics (fault current duration limited) multiple of nominal current	no inherent characteristic, current limitation by controller near rated current
provision of SCC in normal operation = low dynamic source impedance	inherent characteristic (subtransient reactance)	inherent characteristic (leakage reactances)	no inherent characteristic fast, inner, low level controller coupling reactor

Short circuit capacity

Forecast for the future (smart) grid:

- Reduced short capacity in future grids

versus

- Reduced internal impedance in future (distribution) grids

Contradictory ?

Short circuit capacity

Forecast for the future (smart) grid:

- Reduced short capacity in future grids

versus

- Reduced internal impedance in future (distribution) grids

Contradictory ? **No!**

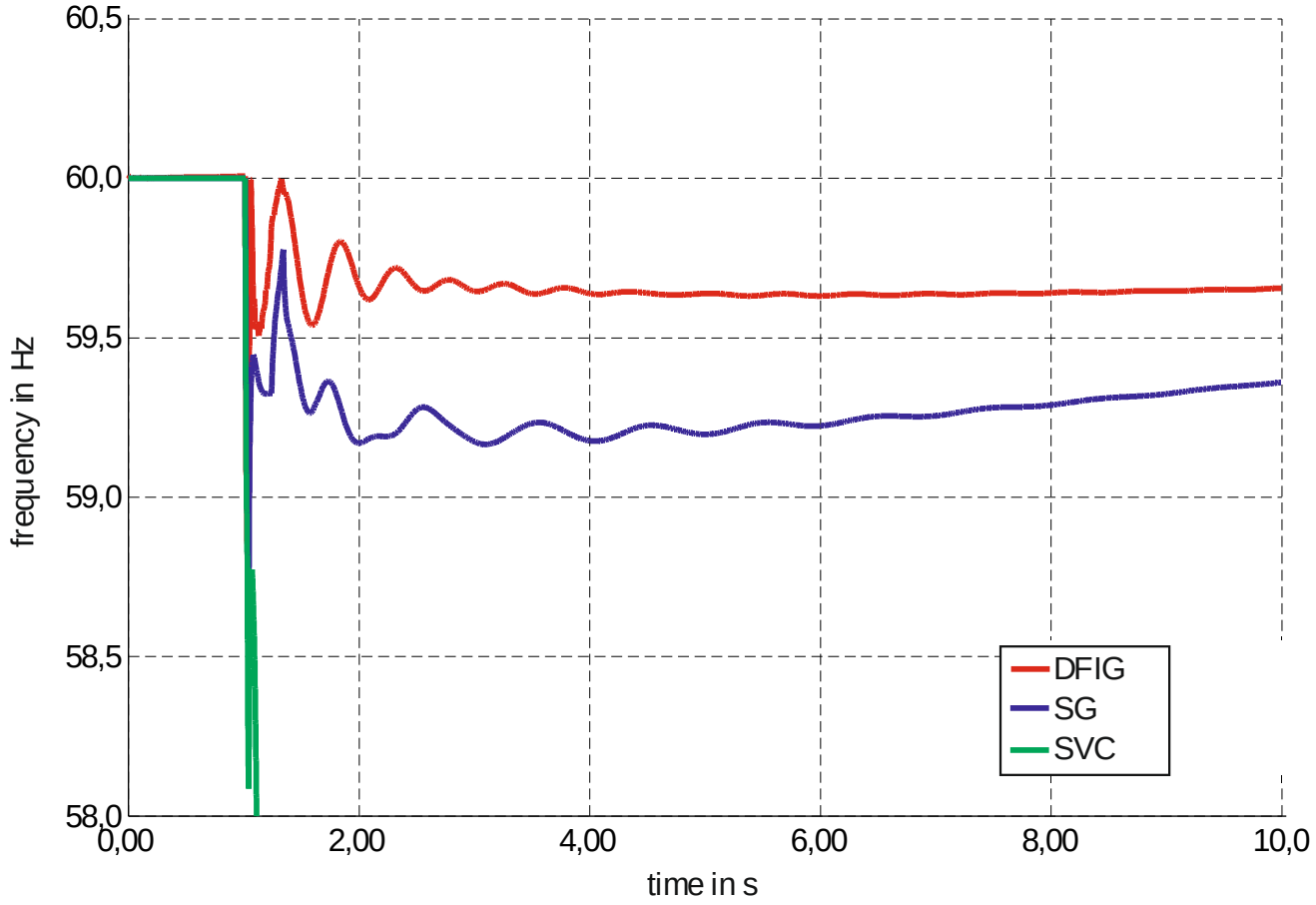
Application study

Source: Nalcor Energy

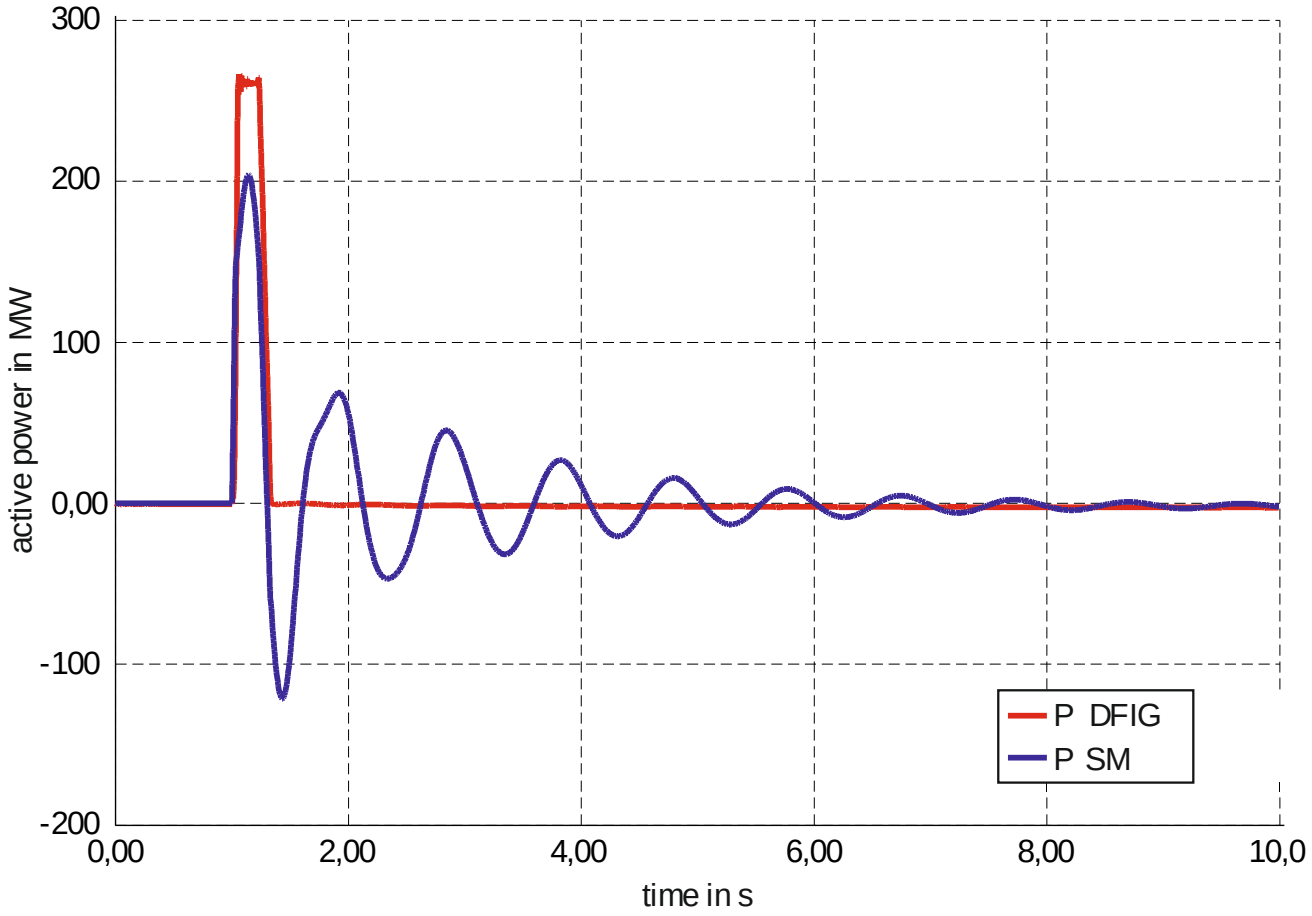
Application study - data

- Installed generation capacity 1500 MVA
- Event: tripping and reconnection of HVDC,
  loss of 800 MW for 300ms
- Requirements: Stabilisation of frequency and voltage
- Devices:
  - Synchronous Condenser, 2 x 175 MVA, H=7.8s
  - Double Fed Induction Generator, 2 x 175 MVA, H=4.7s
  - Static Var Compensator 1 x 400 MVA

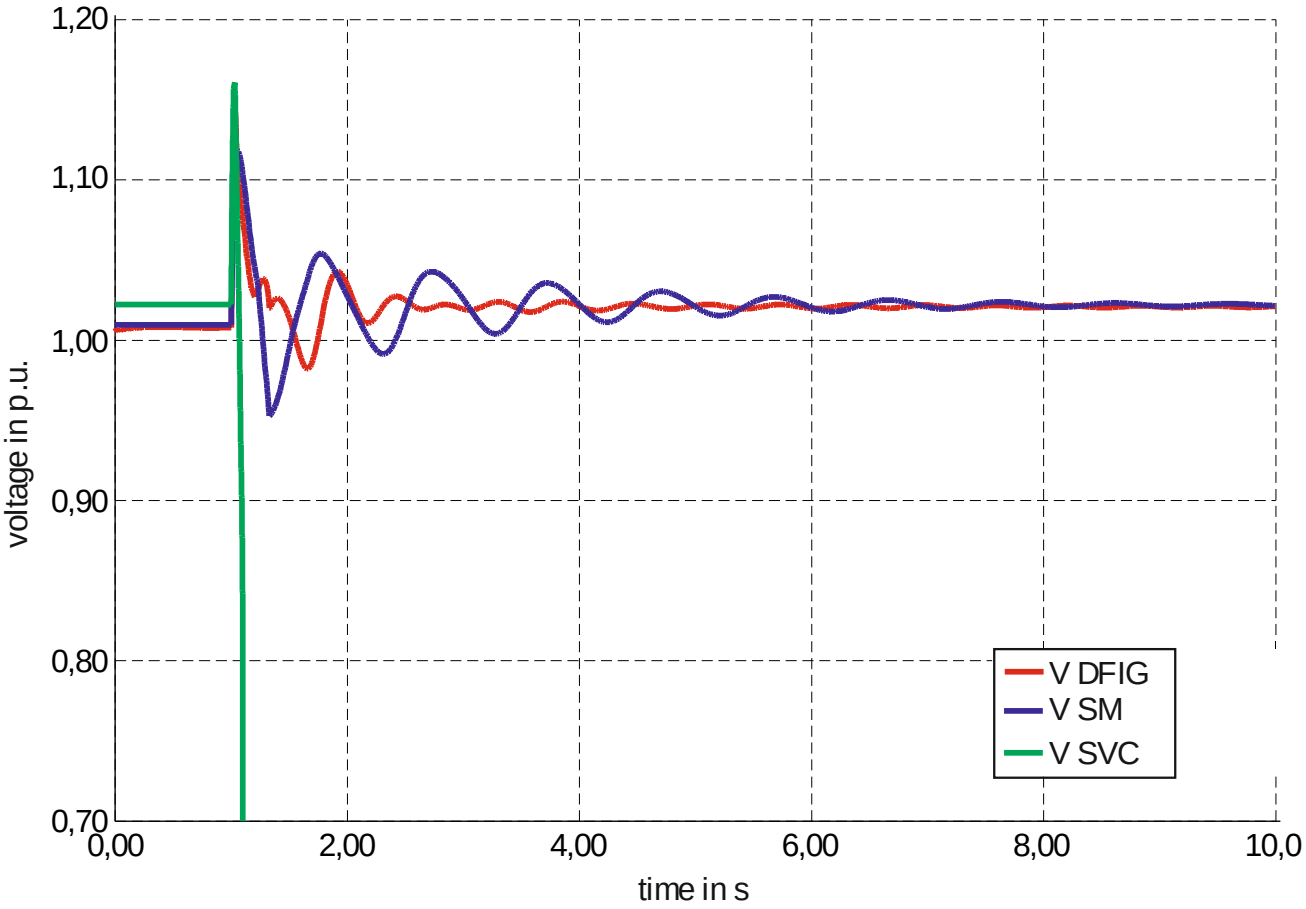
Application study - results



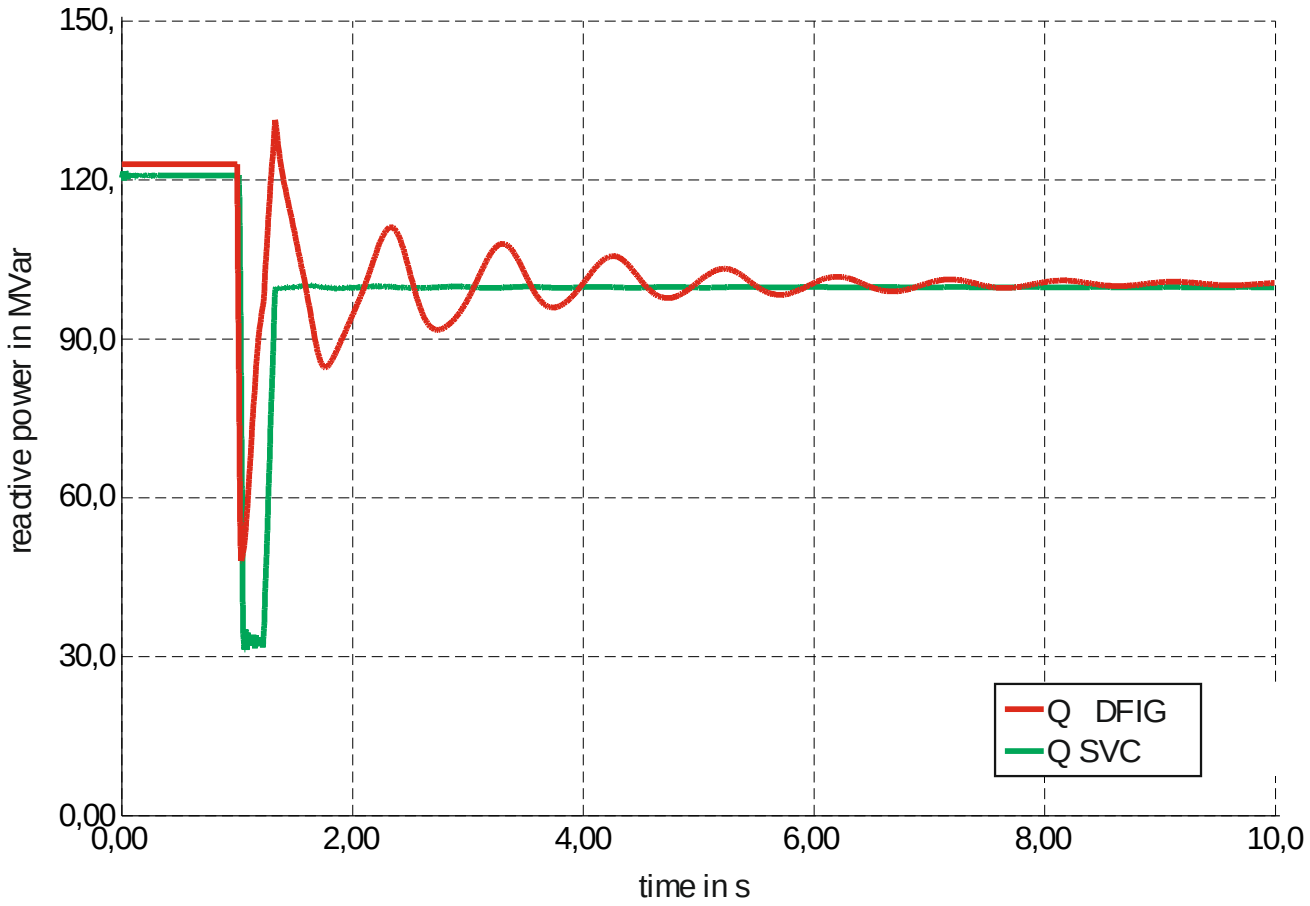
Application study - results



Application study - results



Application study - results



case with reduced fault clearing time

Conclusion

- Ancillary services are essential for secure and stable grid operation
- Traditional generation technology (synchronous machines) provides some services by itself, well-defined by long experience
- New generation technologies are partly able to provide those services, but typically with corresponding control effort (and often with undefined characteristics)
- Grid operators will have to decide about future requirements
- Grid operators will have to select the optimum technology to provide necessary services out of different technologies