



HydroCen Variable speed operation

Hydro power summit

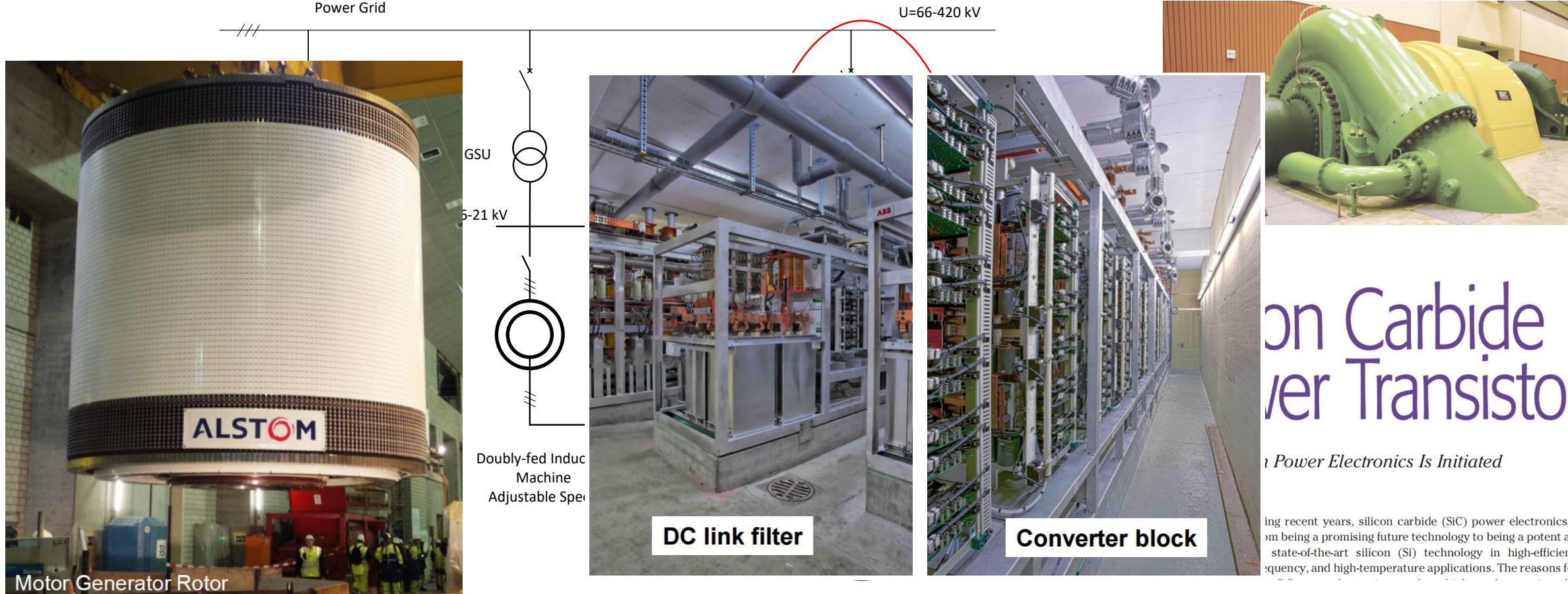
05.02.2020 Trondheim

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Technology: Alternatives



Silicon Carbide Power Transistors

Power Electronics Is Initiated

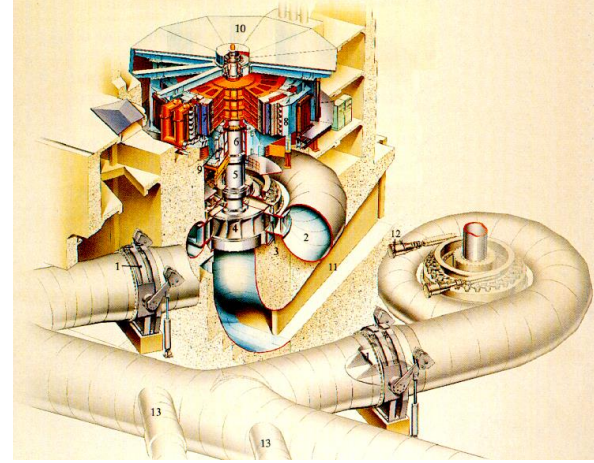
In recent years, silicon carbide (SiC) power electronics has gone from being a promising future technology to being a potent alternative to state-of-the-art silicon (Si) technology in high-efficiency, high-frequency, and high-temperature applications. The reasons for this are

DFIM

CFSM

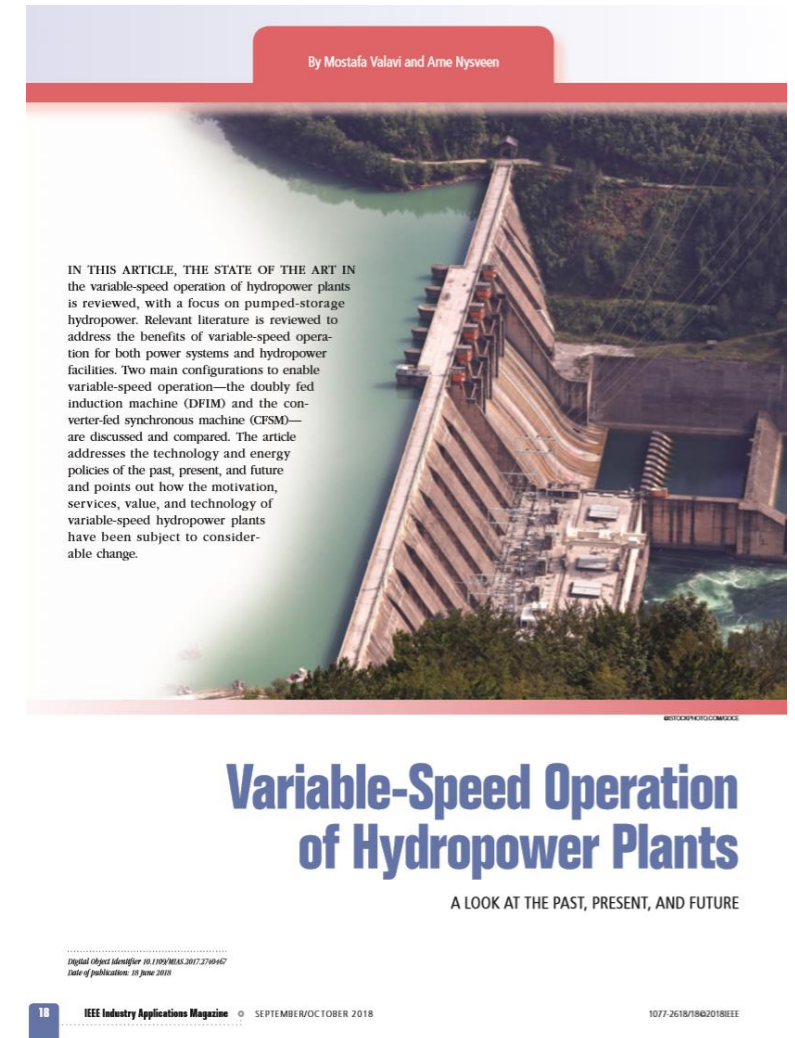
Advantages

- Fast ramping
- Increased flexibility
 - Part load efficiency
 - Investment options
- Reduced load and wear on turbine
- Less design constraints for turbine and generator
- For pumped storage:
 - Fast start-up
 - Load following

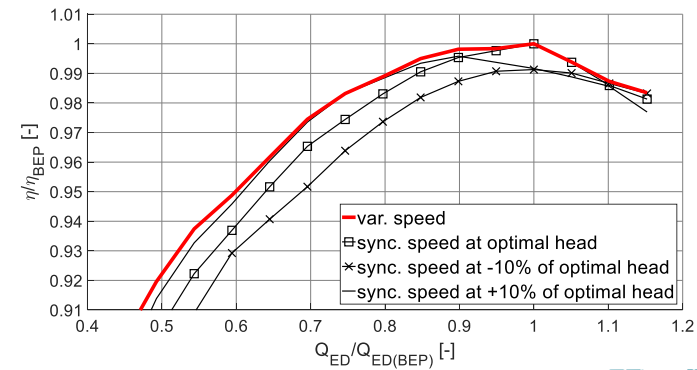
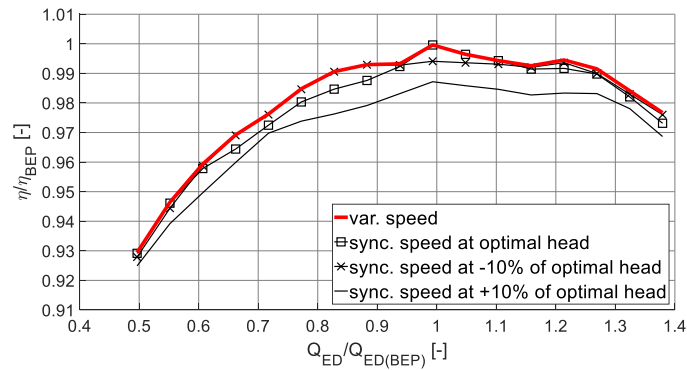
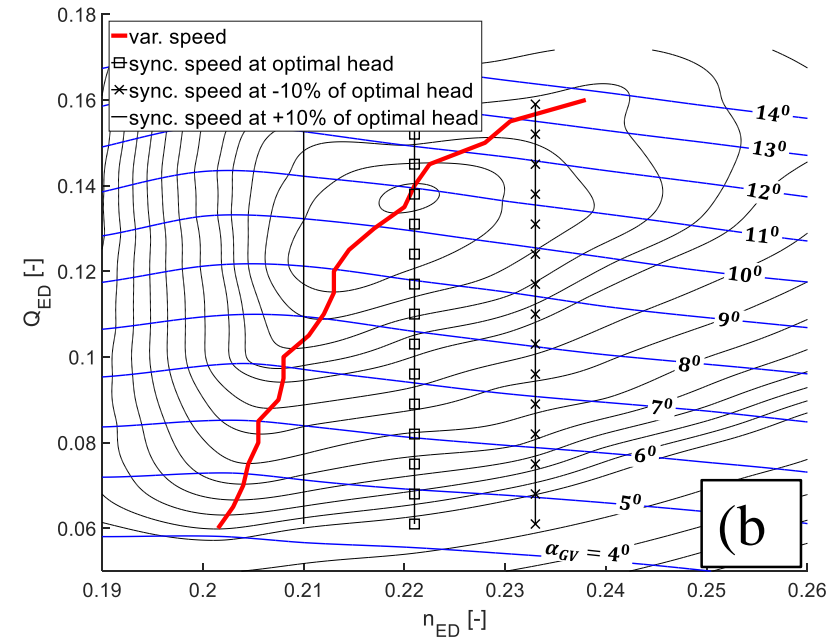
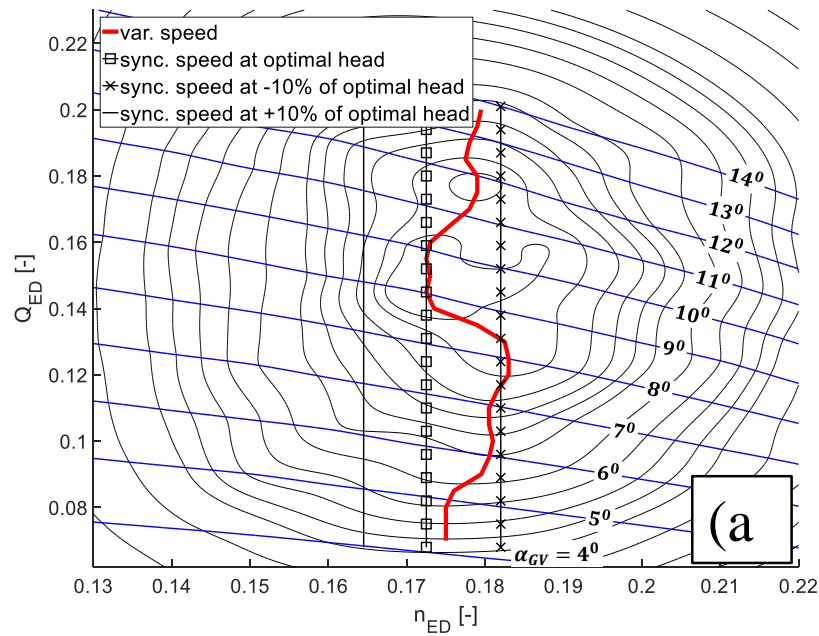


Research Topics— varspeed/electric system

- Optimum design and operation of generators for variable speed
- *Power system stabilization/ancillary services*
- Frequency converter - Design and control
 - Topology
 - Grid interface
 - Synchronous machine interface
 - Control design
- Voltage loading on stator insulation du to voltage switching transients

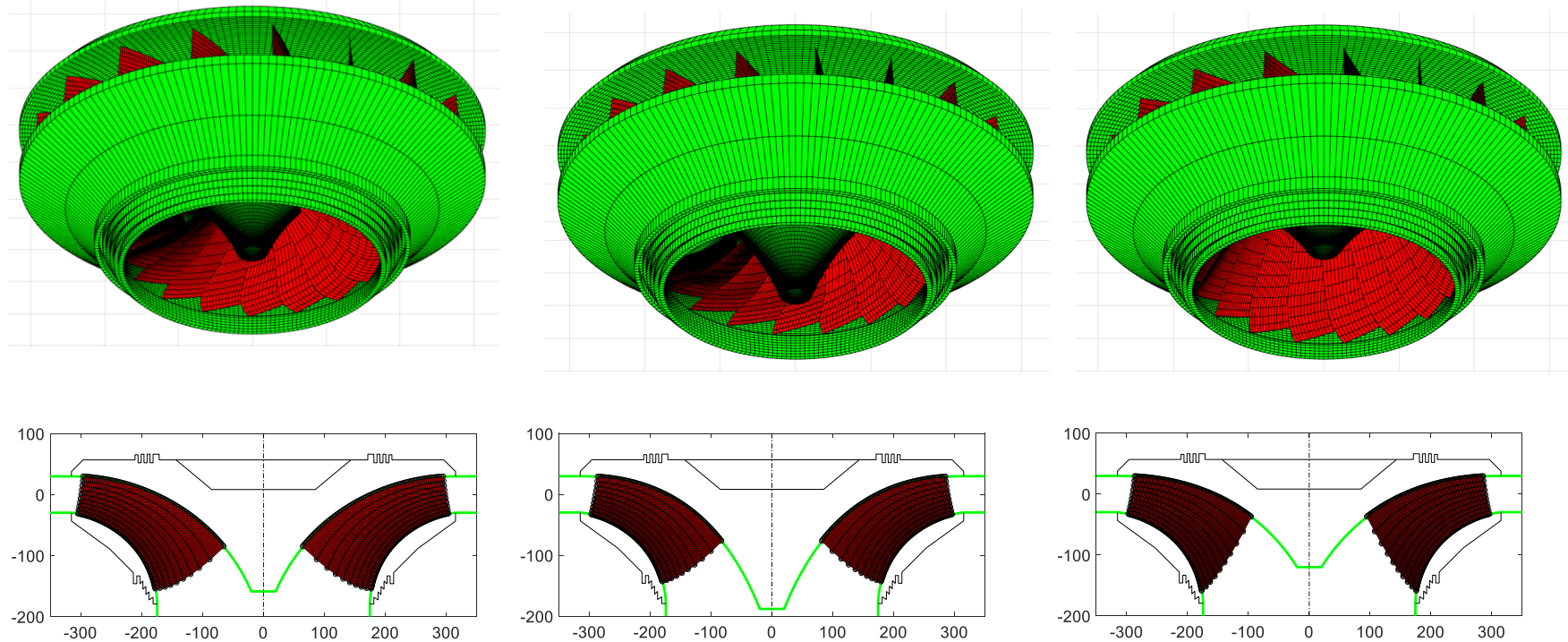


Experimental Study – efficiency at variable speed

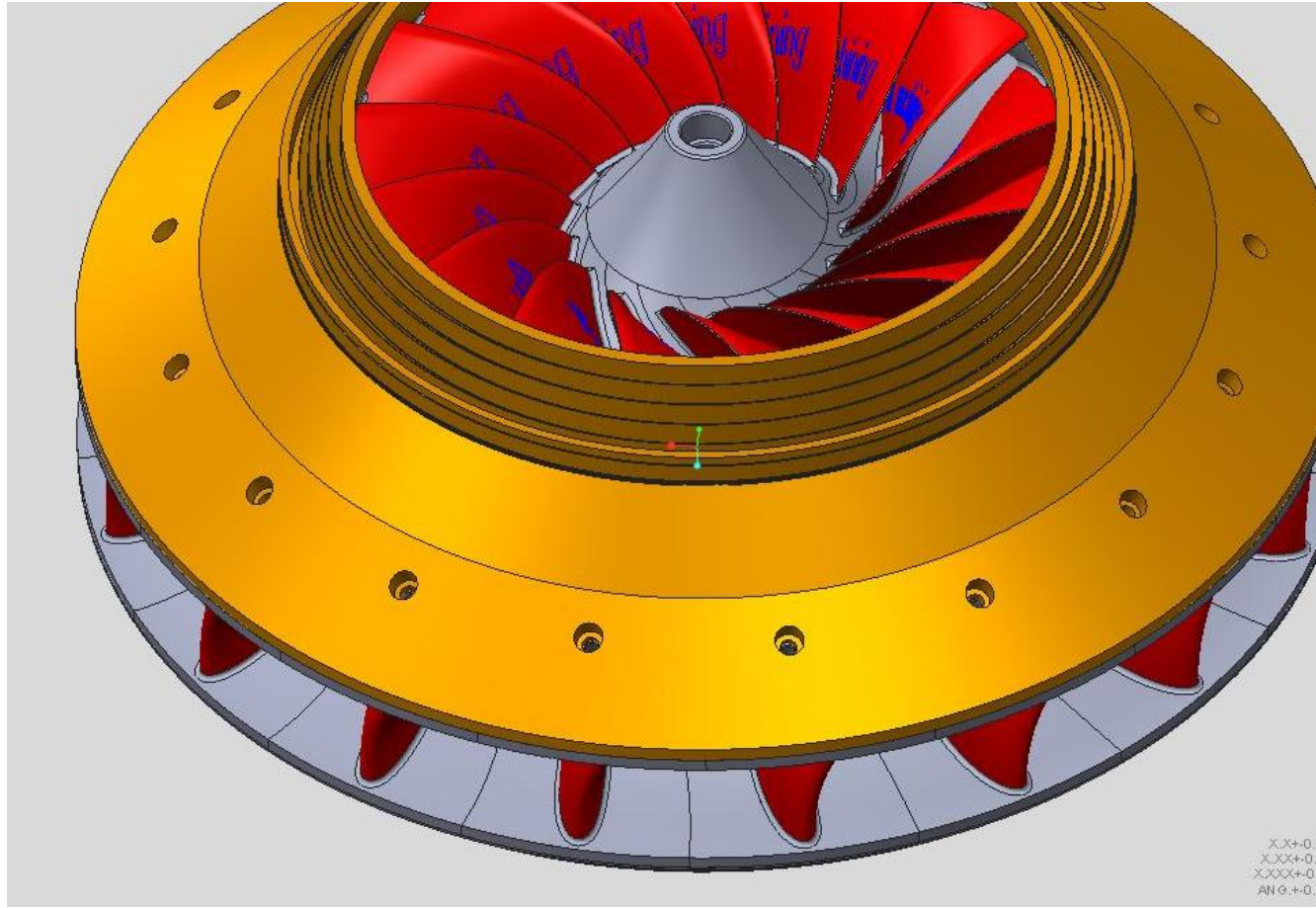


Parametric study

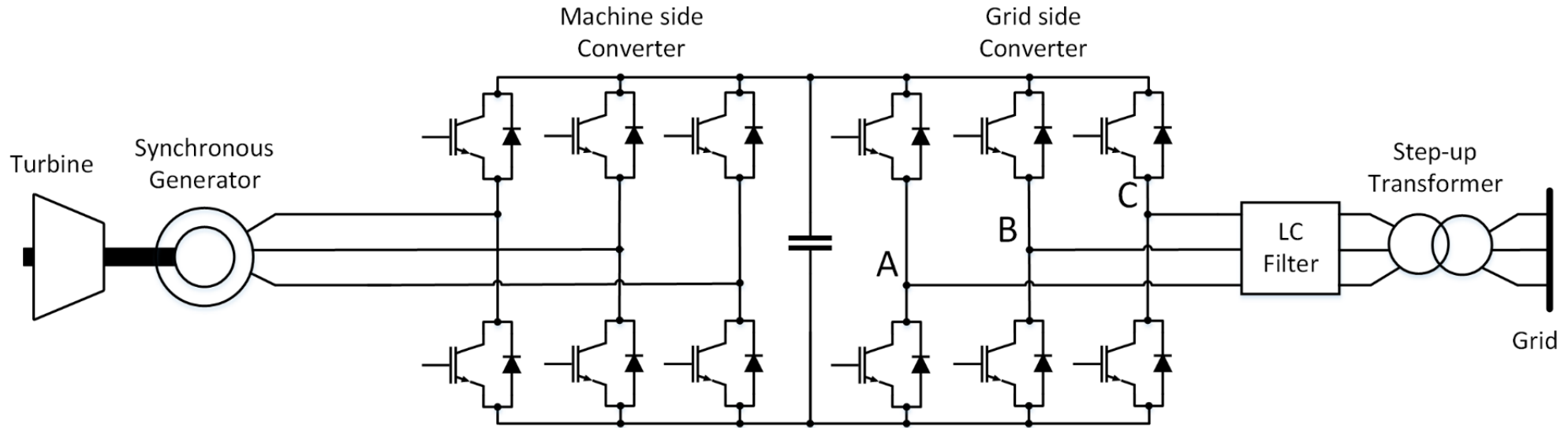
Random designs based on 25 free parameters in the design space:



Prototype build and under testing

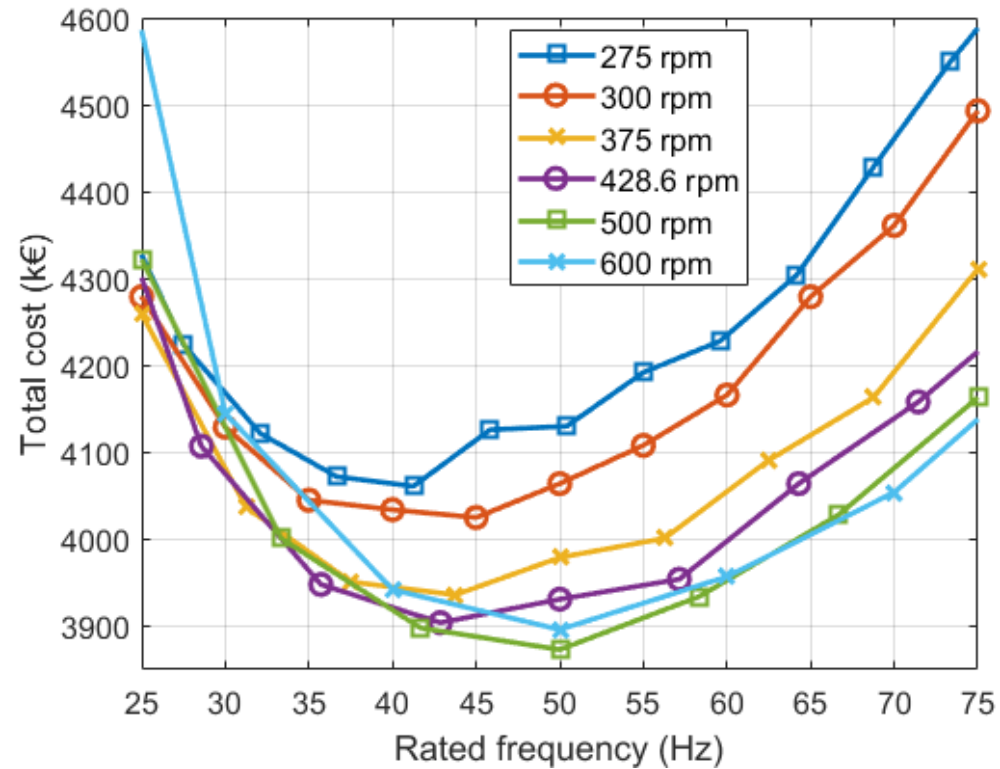


Overview: AC back-to-back converter

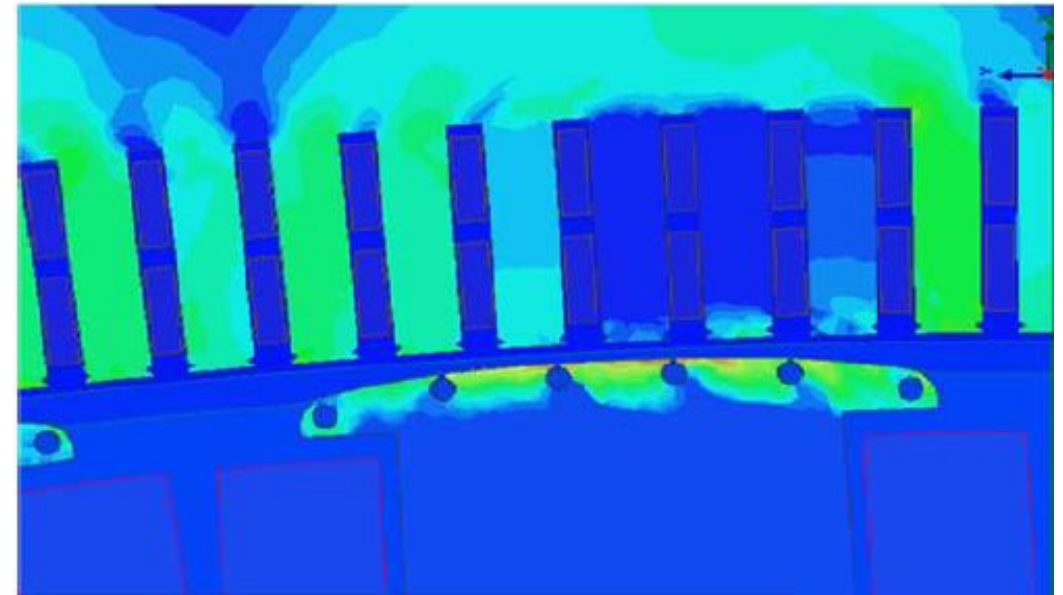


- Develop control philosophy of back-to-back converters for grid connection under variable speed operation.
- Voltage and frequency droop with Virtual Inertia & damping in the converter system
- Contribution to grid stability during pump operation
- Other converter topologies (e.g. MMC) will also be considered for achieving higher output voltage and requirements regarding passive components (filter inductors and capacitors)
- Protection during short-circuit conditions (machine side or grid side)
- Voltage quality improvement (i.e. reactive power support and harmonic elimination, if required)

CFSG – some results



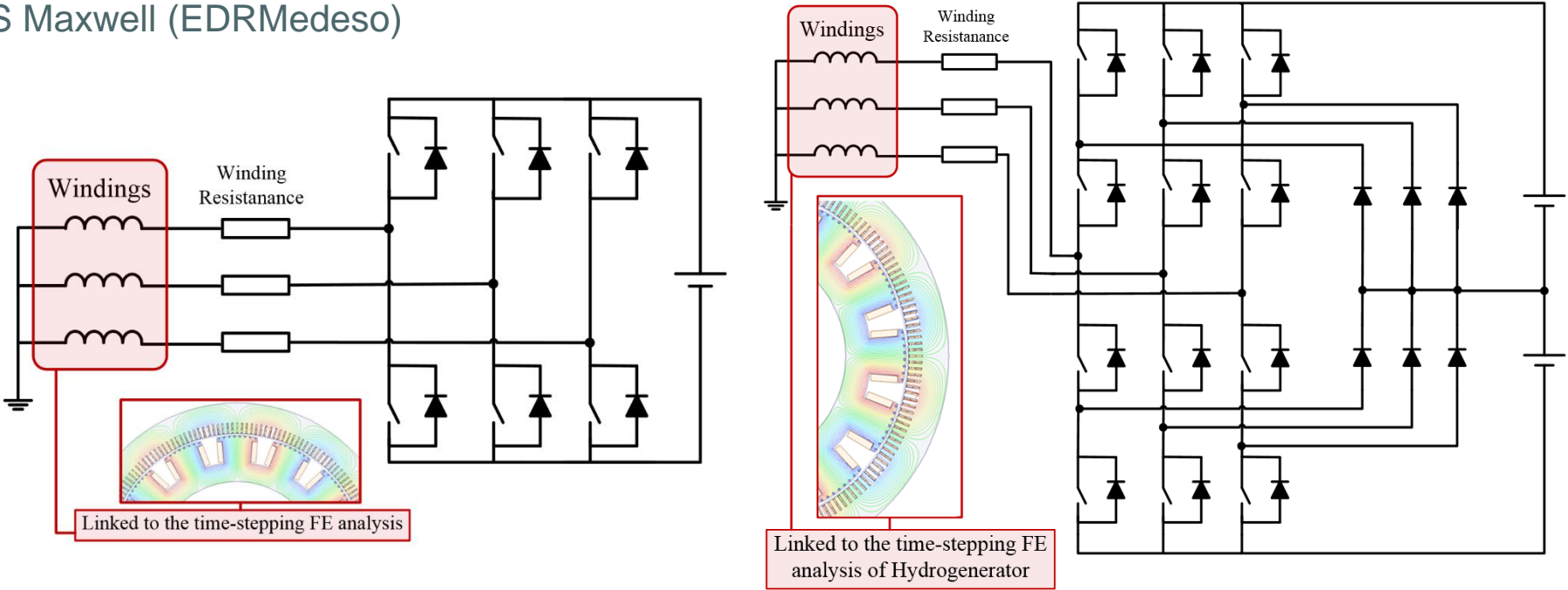
Pole-number variation



Air-gap variation

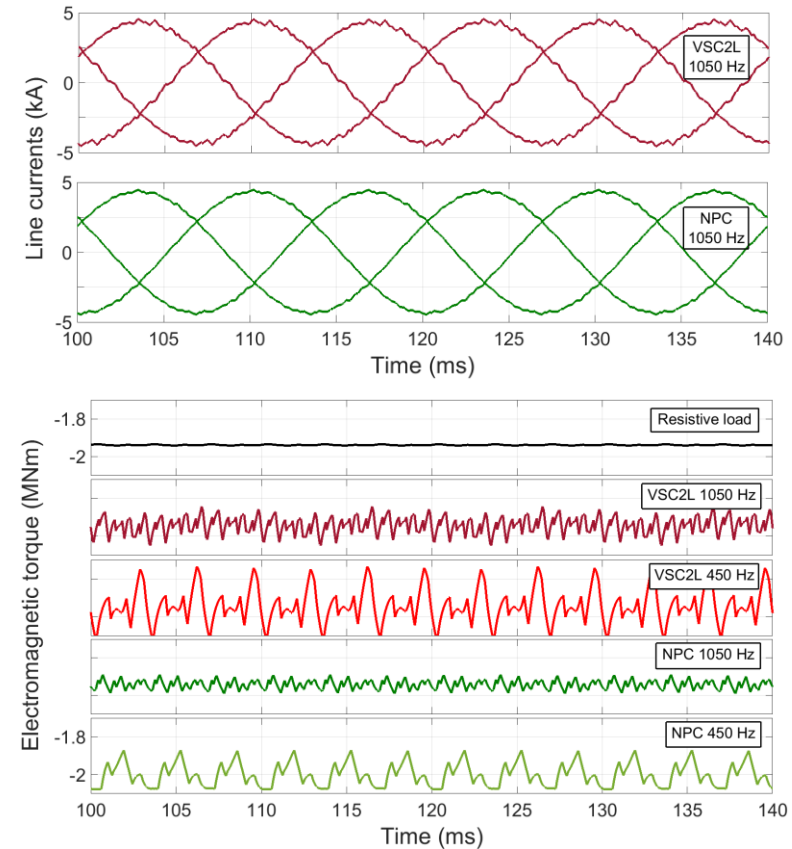
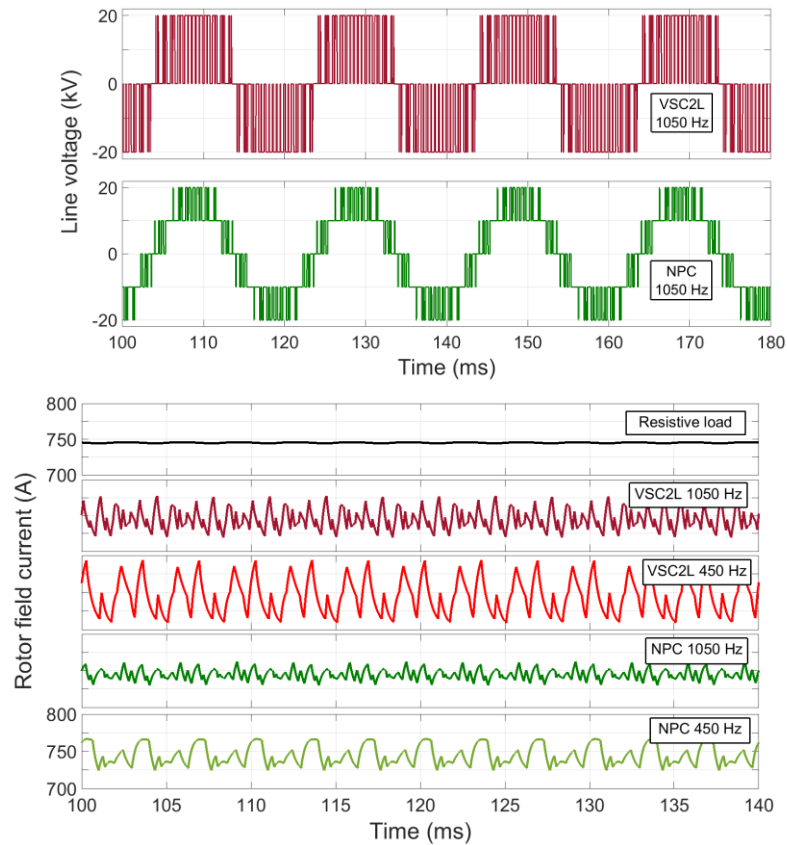
Simulation of converter-fed generator

- Additional harmonics produced by the converter
- Increased level of vibration and losses.
- ANSYS Maxwell (EDRMedeso)



Simulation results (1)

Voltage, currents and torque



Simulation results (2)

- Increased losses in damper bars

