HydroCen

NORWEGIAN RESEARCH CENTRE FOR HYDROPOWER TECHNOLOGY

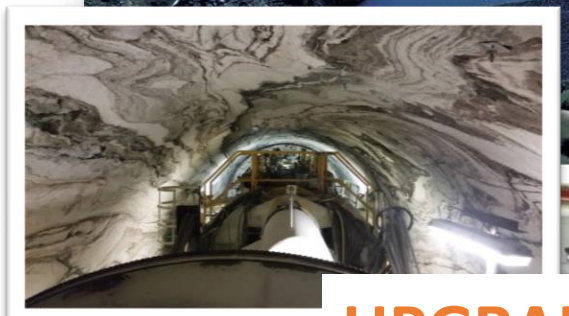
Hydropower Summit

Professor Arne Nysveen

NTNU SINTEF NINA Norsk institutt for naturforskning NVKS NORSK VANNKRAFTSENTER

Future markets?

STORAGE



UPGRAING

MAINTENENCE

RENEWABLES
DIGITALIZATION

FLEXIBILITY

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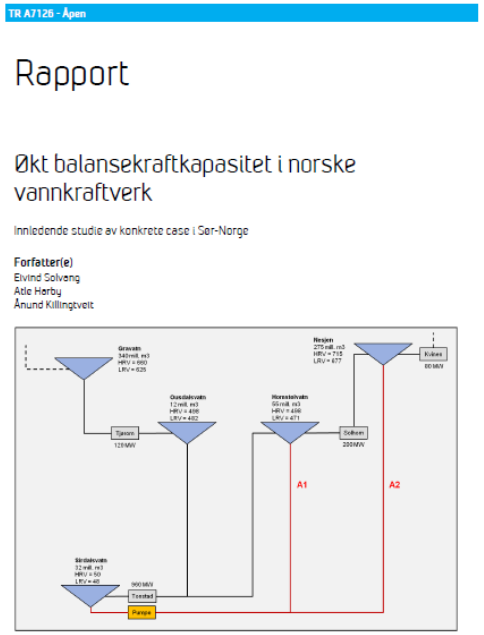
New solutions and challenges


TR A7126 - Åpen

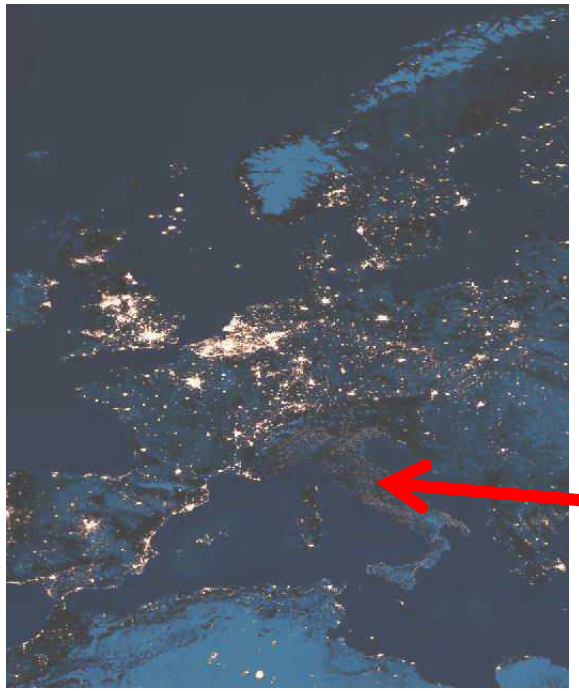
Rapport

Økt balansekraftkapasitet i norske vannkraftverk

Innledende studie av konkrete case i Sør-Norge

Forfatter(e)
Elvind Solvang
Atle Harby
Ånund Killingtveit

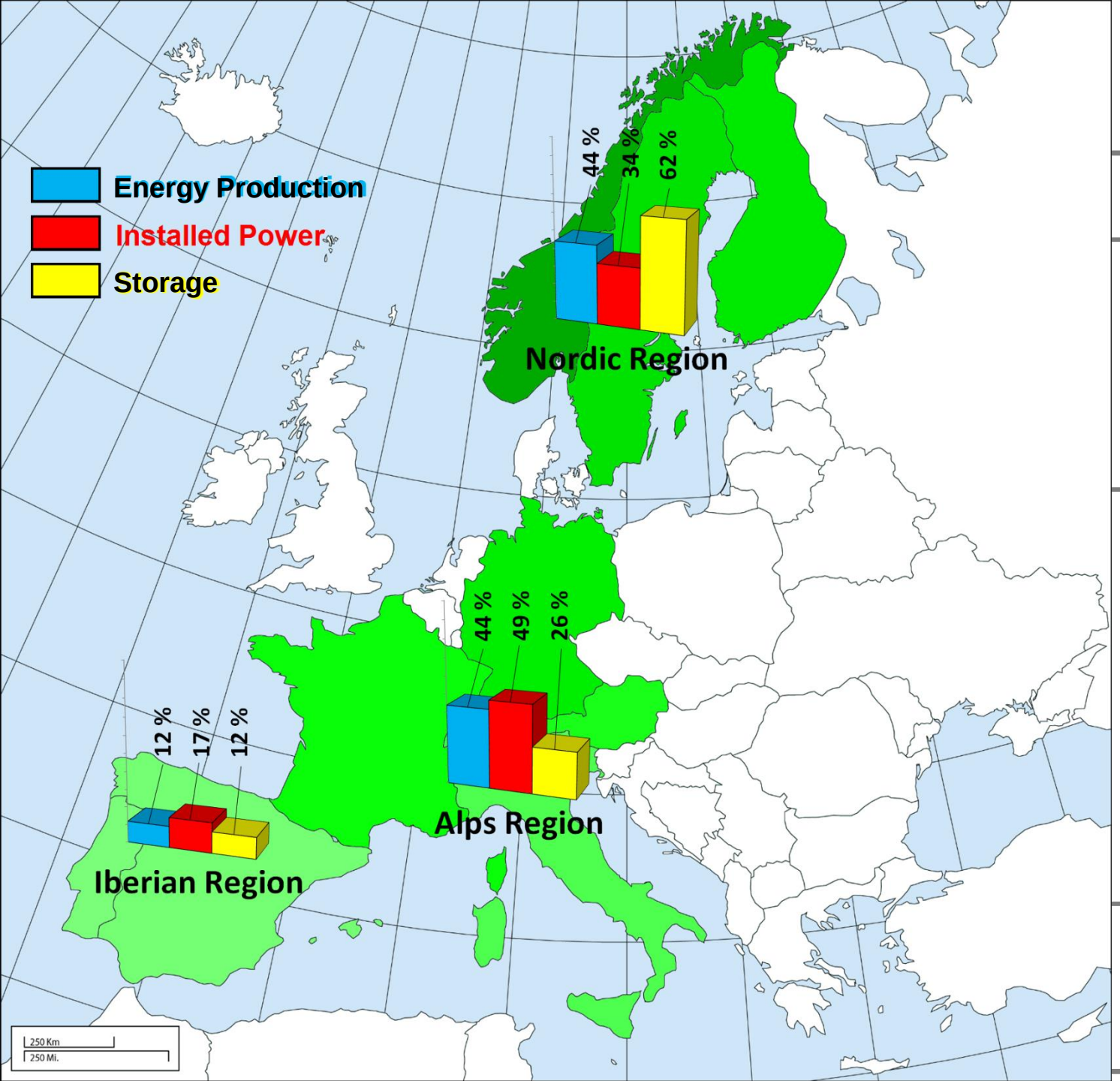
«Green battery»



«Stability and reliability»

«New RenewableS»

Blackout in Italiy



Largest regions of hydropower production in Europe

Region	Country	Energy [TWh]	Storage [TWh]	Power [GW]
Nordic	Norway	**137**	**87**	**31**
	Sweden	**64**	**29**	**16**
	Finland	**13**	**3**	**3**
Alps	Germany	**20**	**2**	**5**
	France	**68**	**13**	**25**
	Austria	**30**	**9**	**6**
	Switzerland	**39**	**18**	**14**
	Italy	**58**	**9**	**22**
Iberian	Spain	**43**	**20**	**20**
	Portugal	**15**	**4**	**6**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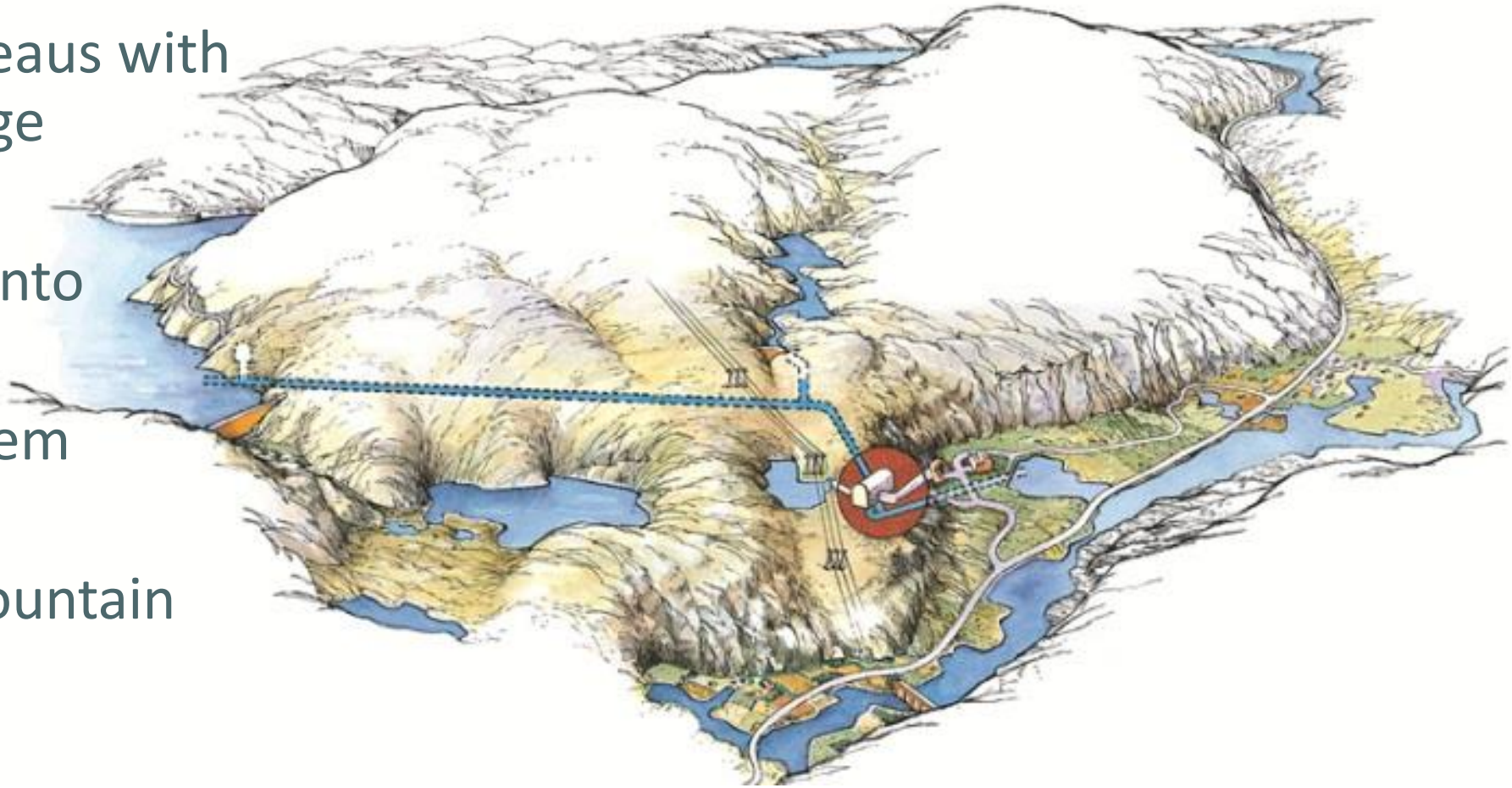
RESEARCH

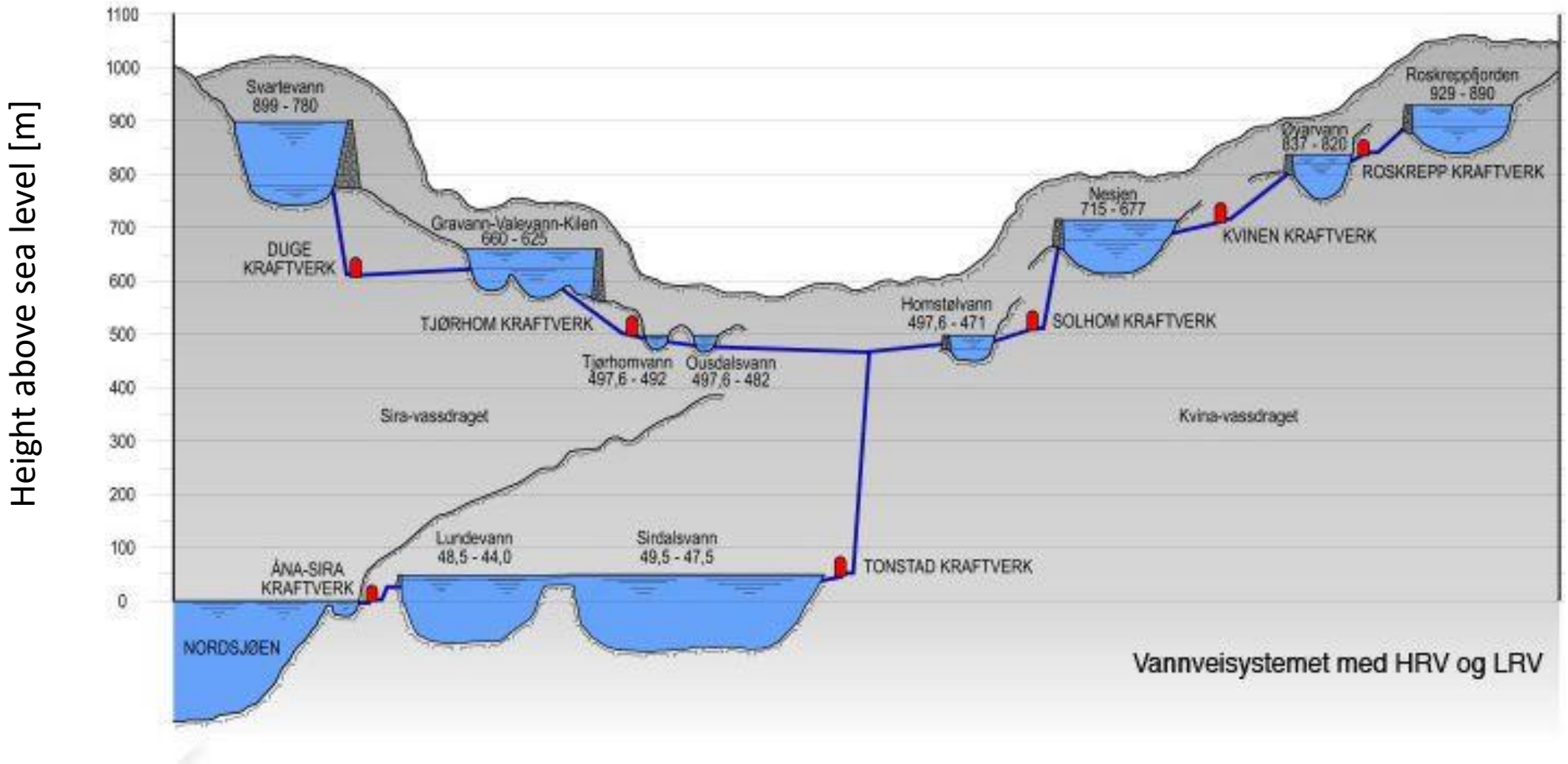
Hydro Power Plant

- Mountain plateaus with seasonal storage capacity
- Fjords cutting into the plateaus
- High head system
- Power stations build inside mountain



Hydropower system in Norway

Sira-Kvina



Hydropower's role in the energy system

- **Power**
- **Energy storage (seasonal, week)**
- **High ramping rates**
- **Stability of frequency and voltage**

- The hydropower plants need to develop more flexibility
- The flexibility and stability will be the future needs in most parts of the world

New Research Challenges

From energy to capacity and frequency? Pump storage and new demands?

Upgrade and expansion

Market design

Competition from new technologies and new demands. How to compete and optimize for new markets and energy systems?

430 hydropower licenses to be revised before 2020. Revisions estimated to cause an annual loss of 2-4 TWh production

Revision of licences

Water Frame Directive

Presently unclear how Norway will balance hydropower production against EU environmental targets

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1. HYDROPOWER STRUCTURES

Foto: Multiconsult

Foto: Norconsult

Illustrasjon: Kaspar Vereide, NTNU

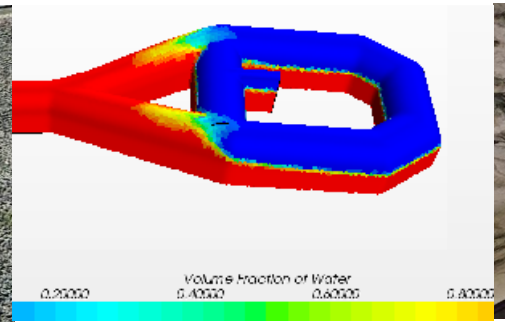


Foto: Marius Madsen

2. TURBINE AND GENERATOR

Foto: Rainpower

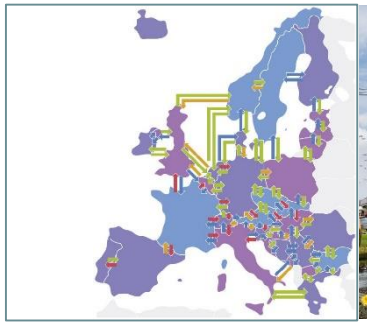
Foto: Helge Hansen/BKK

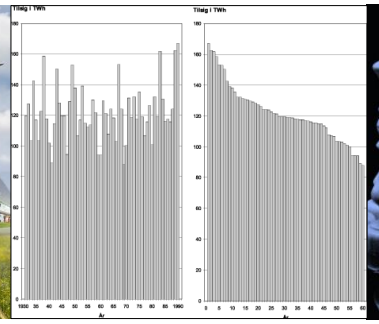
Foto: E-CO

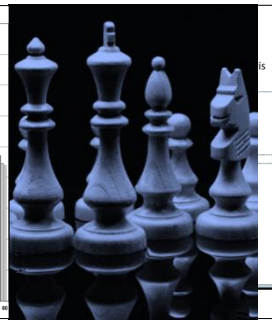
Foto: Elkem ASA

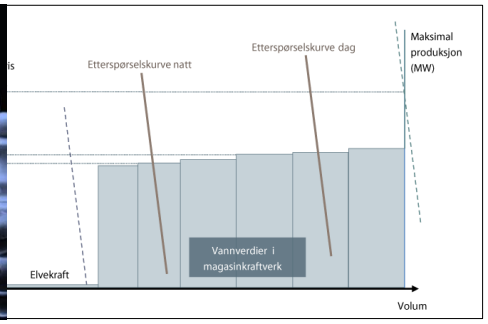
3. MARKET & SERVICES

Illustrasjon: Oxygen/SINTEF

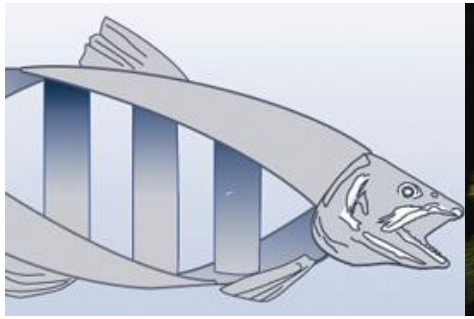




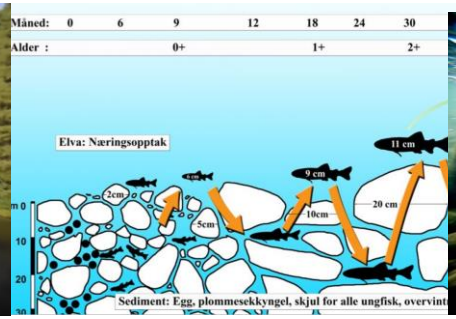




4. ENVIRONMENTAL DESIGN



Videostills CEDREN



Illustrasjon: Ulrich Pulg, UNI Miljø

Foto: Halldor Kolbeins

2. TURBINE AND GENERATOR

Foto: Rainpower

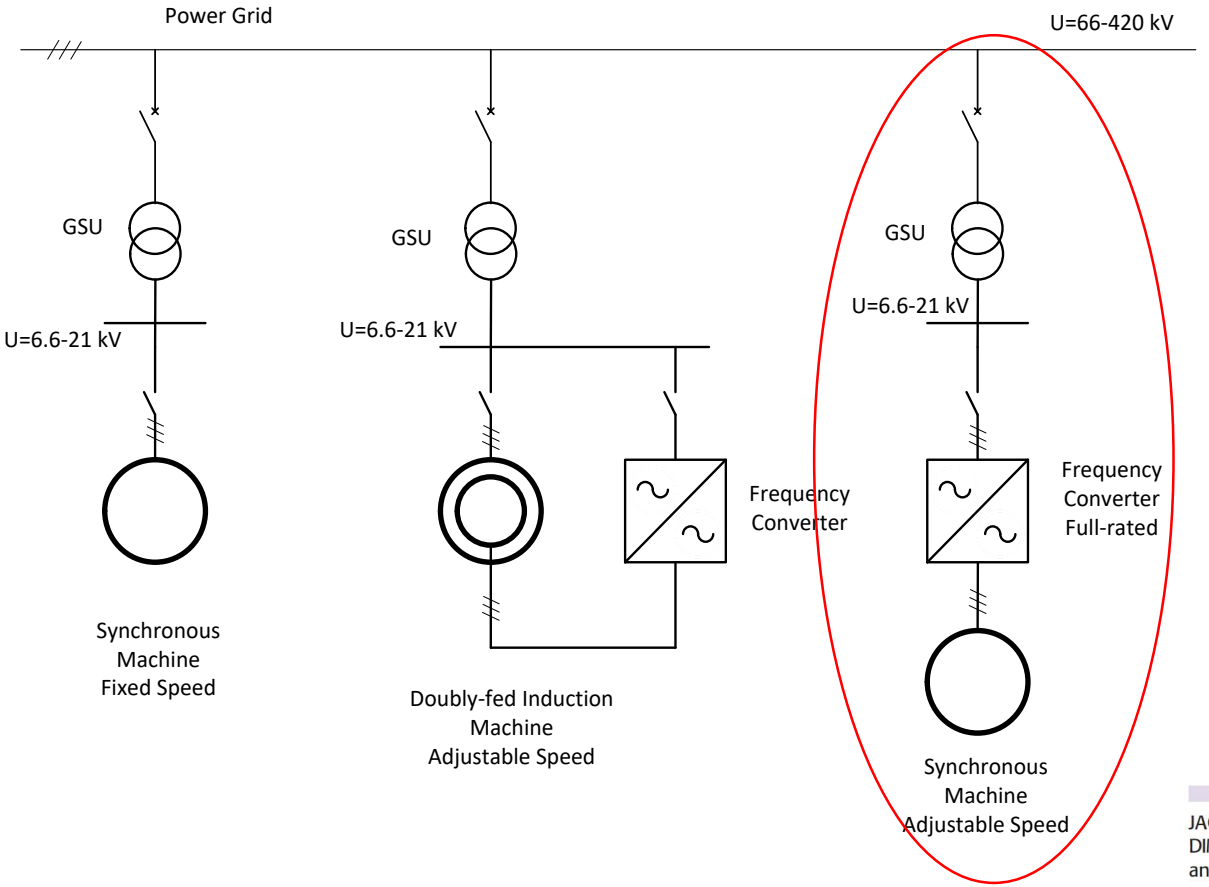
Foto: Helge Hansen/BKK

Foto: E-CO

Work Package Manager: Professor Arne Nysveen

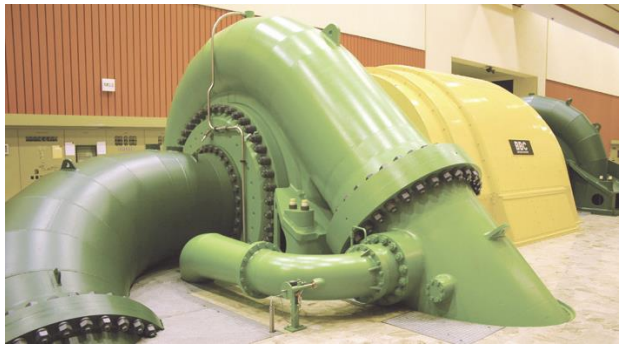
2.1 Variable speed, turbine and generator	Olve Mo, SINTEF Energi
2.2 Turbine fatigue – waterway interaction	Torbjørn Nielsen, NTNU
2.3 Pump turbines (Booster pump)	Pål-Tore Storli, NTNU
2.4 Turbine and generator lifetime	Thomas Welte, SINTEF Energi
2.5 Flexible hydropower unit	Kjetil Uhlen, NTNU
2.6 New design of guide vanes	Pål-Tore Storli, NTNU

2.1 Variable Speed Operation



DFIM

CFSM



Silicon Carbide Power Transistors

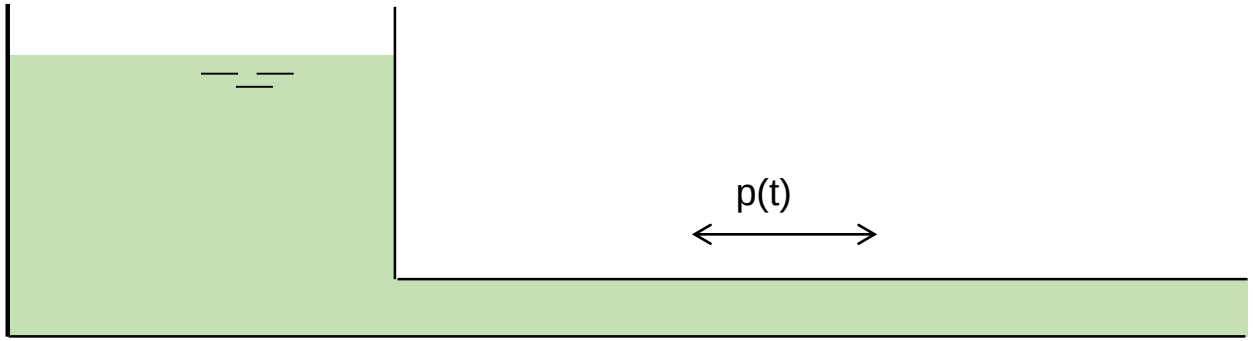
A New Era in Power Electronics Is Initiated

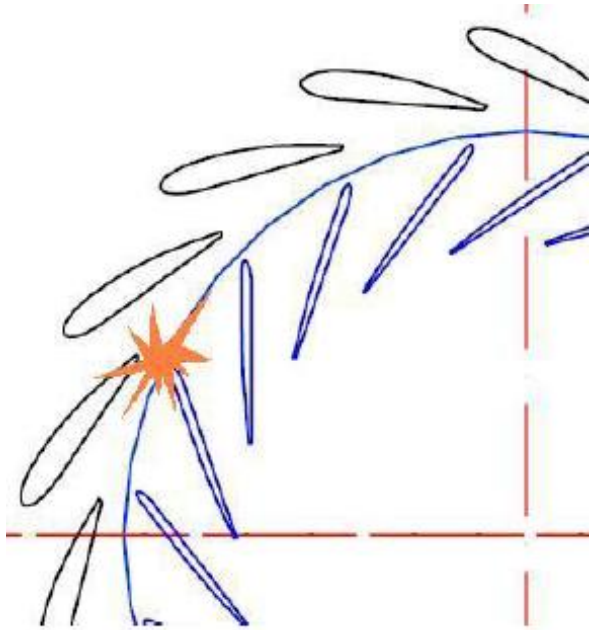
JACEK RĄBKOWSKI, DIMOSTHENIS PEFTITSIS, and HANS-PETER NEE

During 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

2.2 Water-way interaction – pressure pulses and fatigue

- Develop a numerical model combining full 3D transient model of the turbine with 1D model of the complete conduit system.
- Enhance the understanding of the propagation of the pressure fluctuations caused by the turbine dependent on the conduit system geometry.





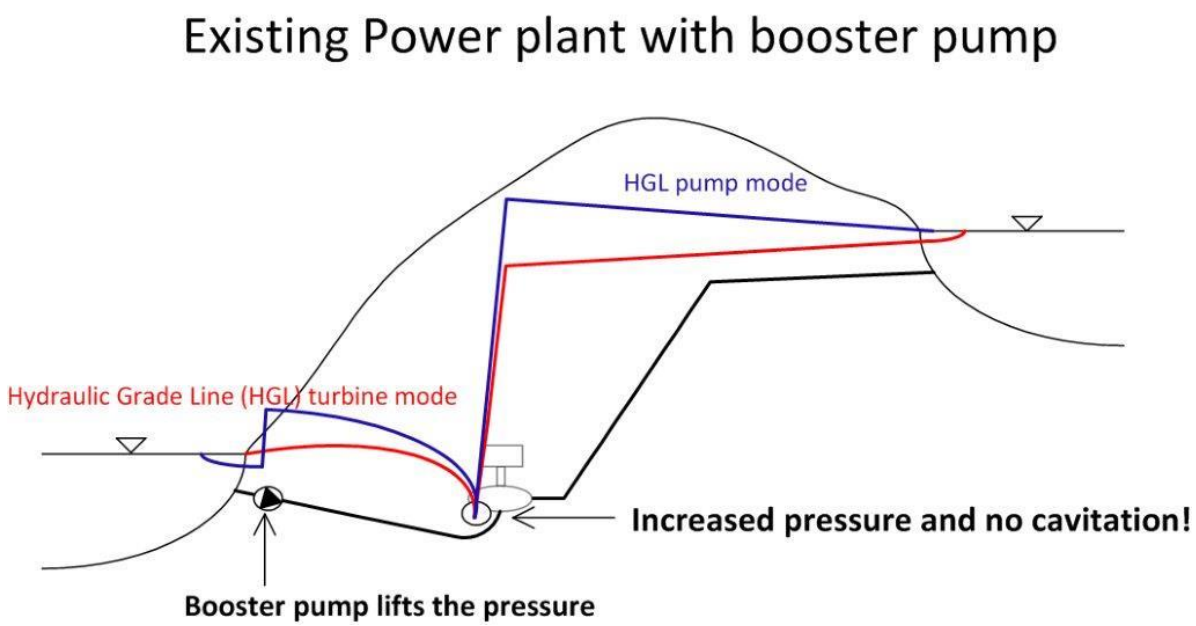
1D - simulations

Fast

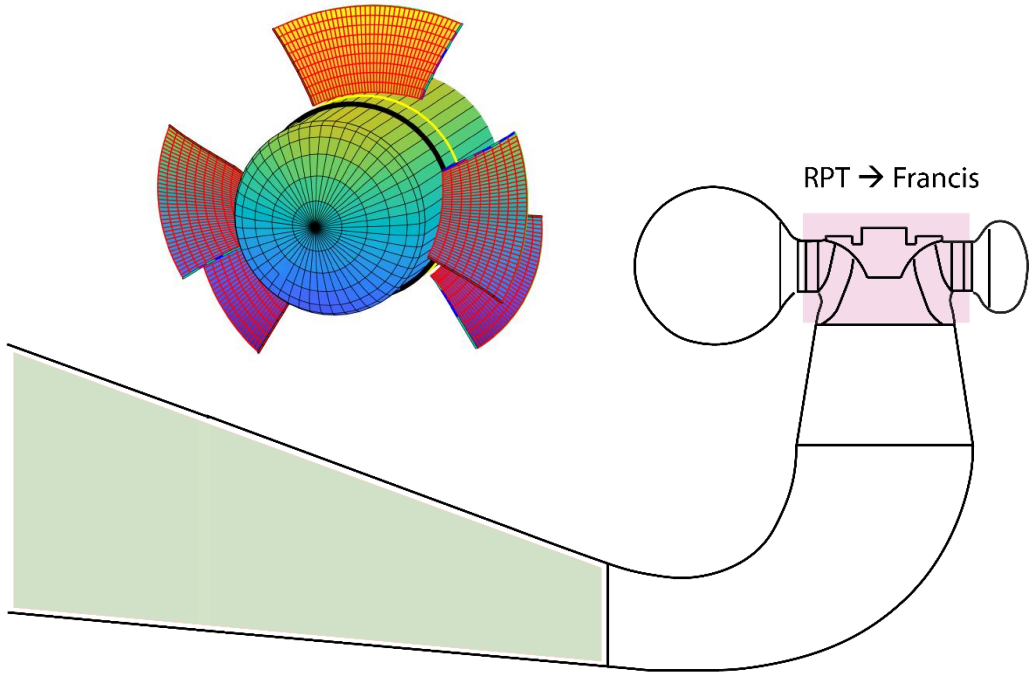
3D - simulations

Slow and accurate

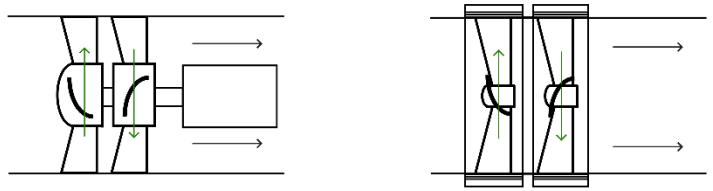
Power plat to pumped storage – «Booster Pump»



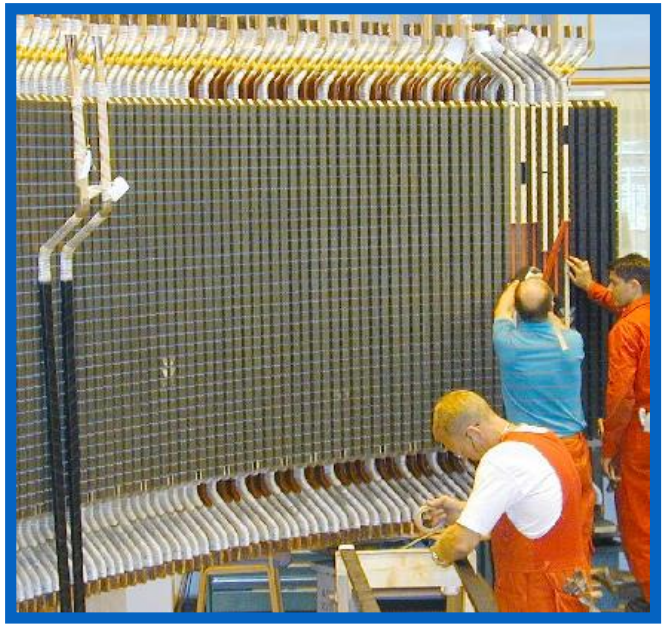
- To low pressure in draft tube in pump mode
- Low-pressure booster pump
- Design of turbine and generator/motor



Kontra-roterende aksialpumpe i sugerør:



Lifetime, ageing and condition monitoring



- Lifte-time models and estimation (Francis, Pelton)
- Condition assessement of spare windings
- Fault simulation – signature from known faults
- Electromagnetic fault detection

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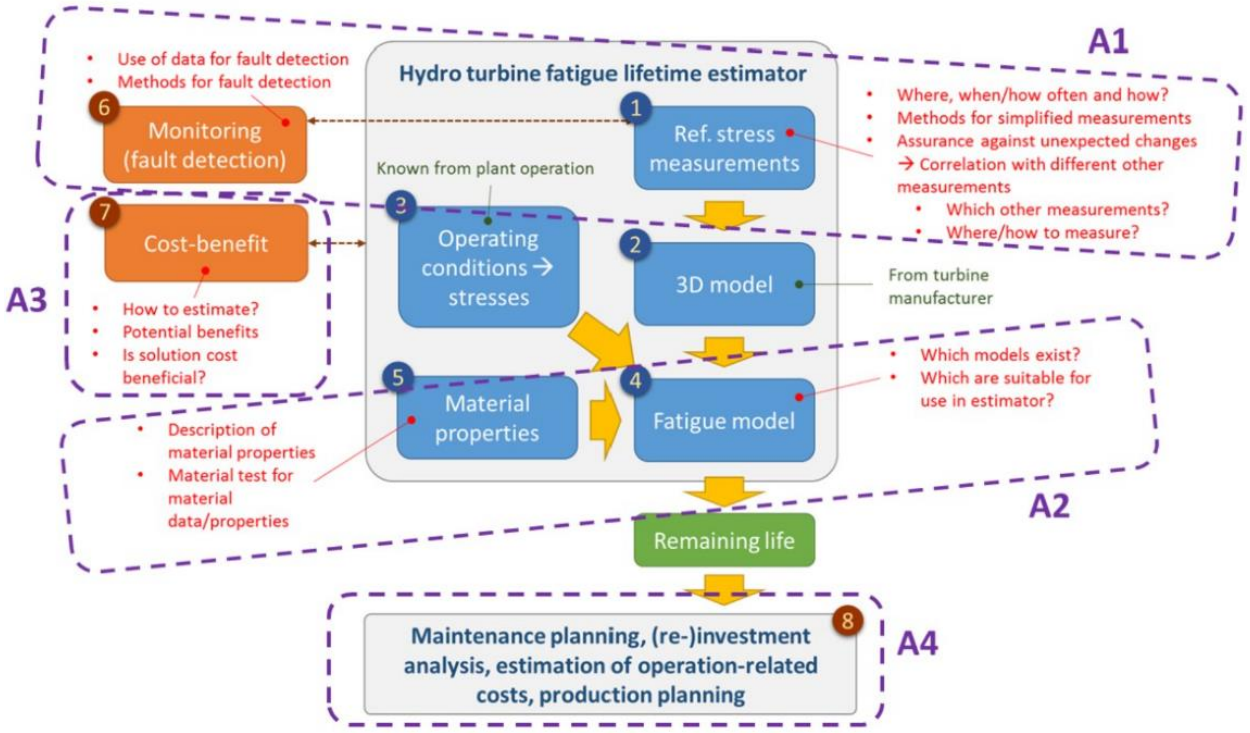
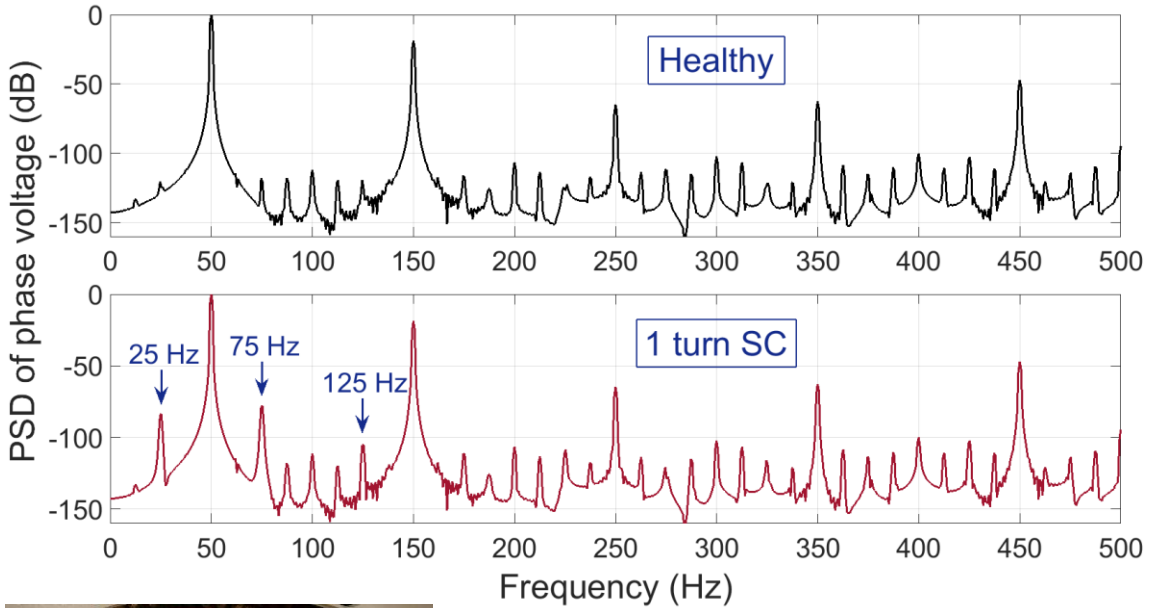
Lifetime model for turbines
Fault detection - windings





- Pre-study completed
- Further implementation in new project with Statkraft

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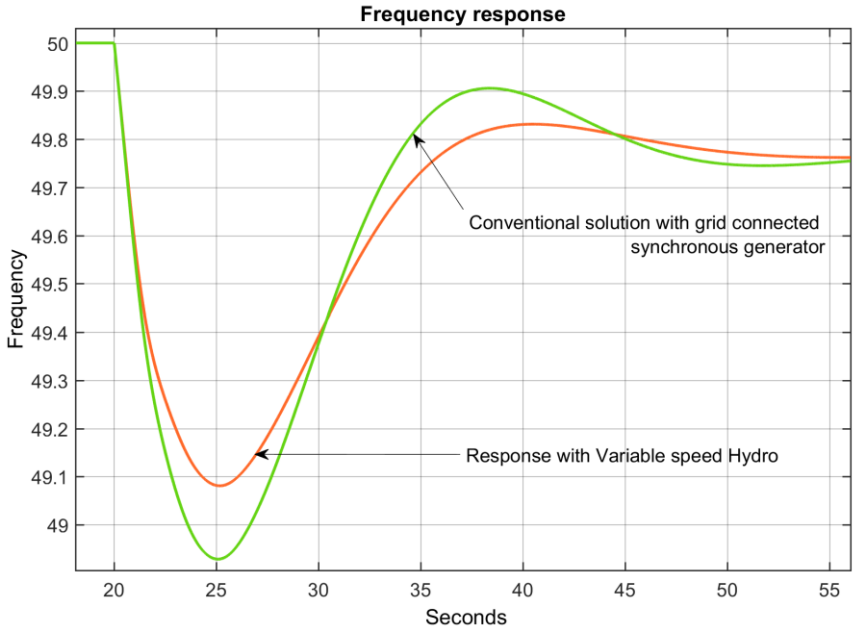
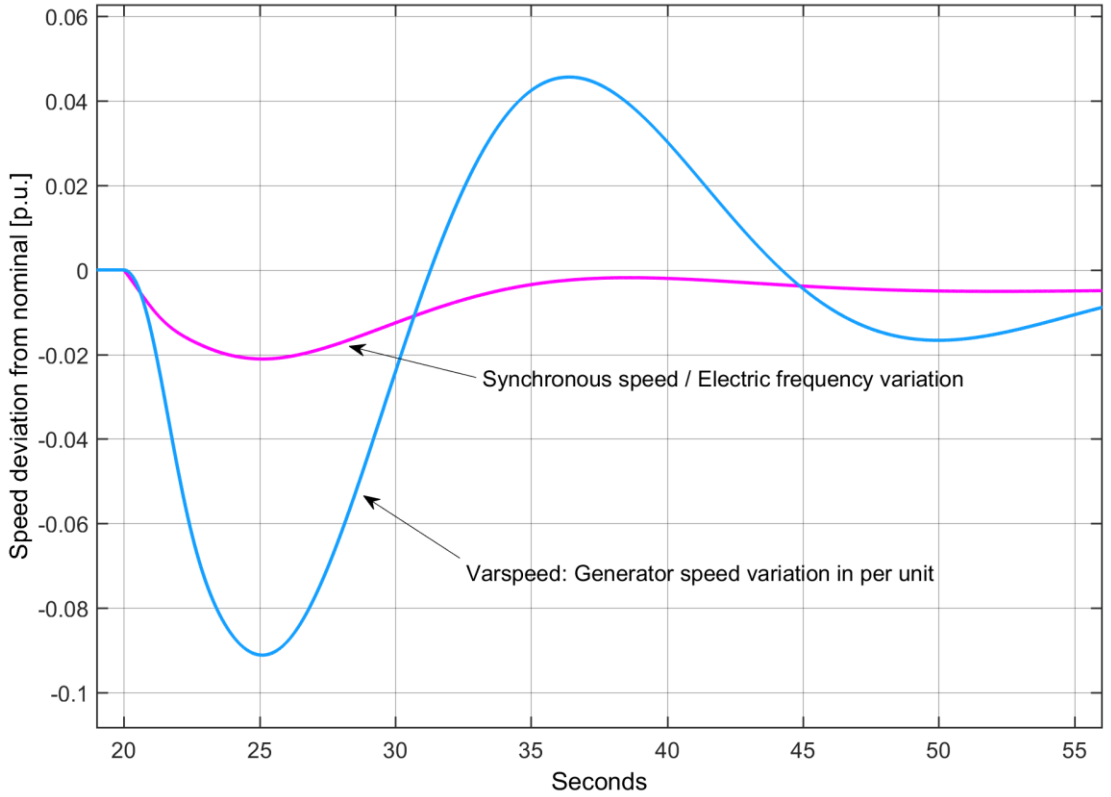
Variable speed – grid interaction and support





- Challenges and opportunities in the power grid
  - "Peak load increased compared to short-circuit power"
  - Primary control of voltage and frequency
  - Improved PSS
  - Synthetic Inertia
- Optimal power flow control

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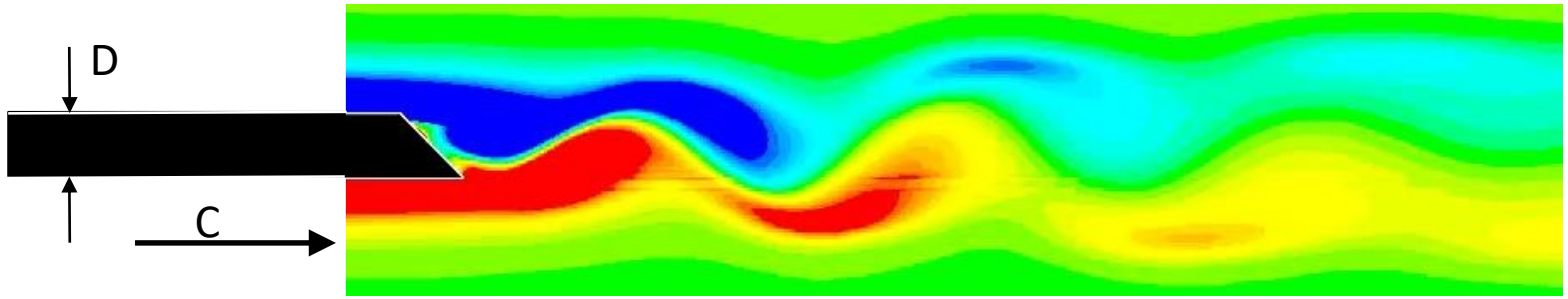
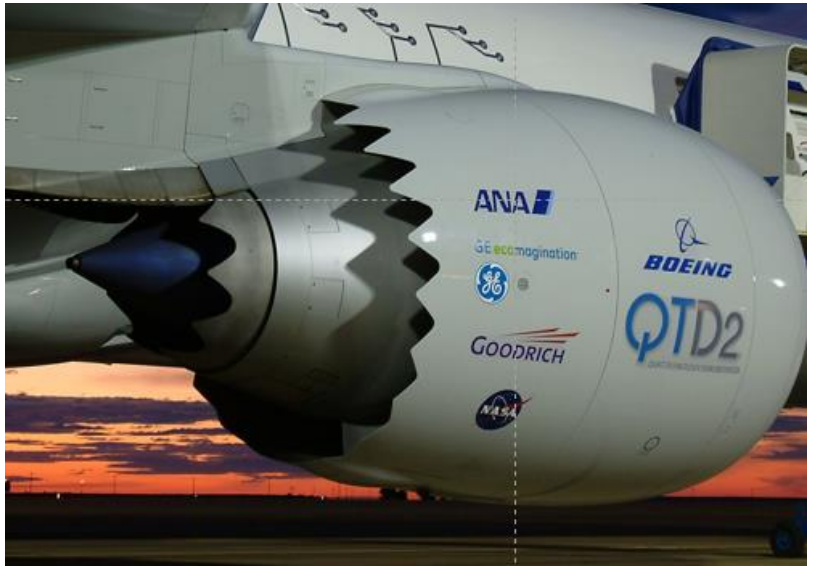
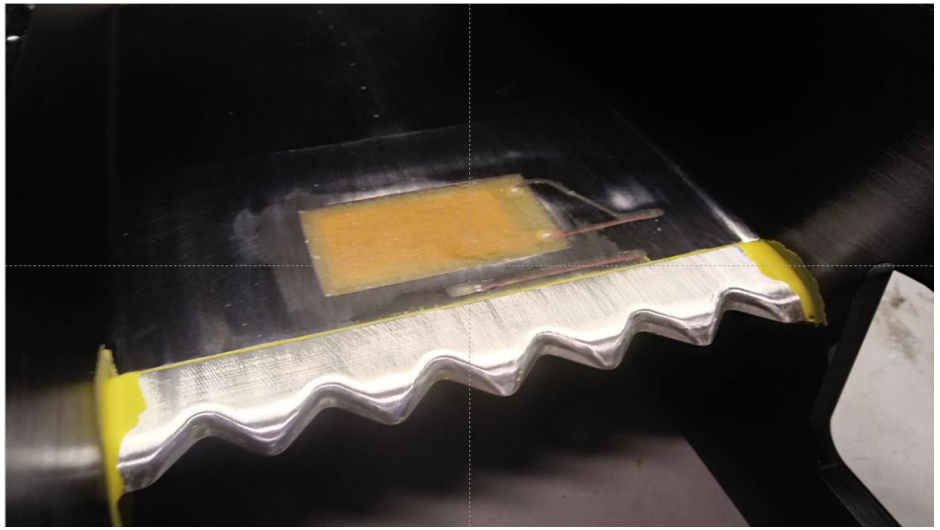
2.6 Reduced dynamic loading – flow manipulations





- Break down the (relatively) regular TE vortex shedding pattern by introducing spanwise variations – Serrations
- Ida patent filed
- Laboratory test set-up
- Different serration design tested

Test samples



Thank You!

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