Ein Beitrag zur aktiven Netzstabilisierung durch Wasserkraft

2. Pumpspeichertagung EFZN, Goslar
20/21 November 2014

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Contribution of hydro power to active grid stabilization

outline

I. Present grid status

II. The role of Inertia

III. Simulations of a test case

FIXED / VARIABLE speed

IV. Conclusion

Contribution of hydro power to active grid stabilization

Present grid status

The Facts:

- Grid frequency = 50Hz à maintained by synchronous machines adjusting power for balancing
- Renewable Energy Sources (RES) like photovoltaics & wind power are substituting existing nuclear and thermal generating units
- RES is not contributing to primary control and Inertia
- Transient System Stability needs Inertia
- Grid with limited extension and high penetration of RES are very sensitive regarding stability
- TSO's in Ireland & UK are faced to a new situation

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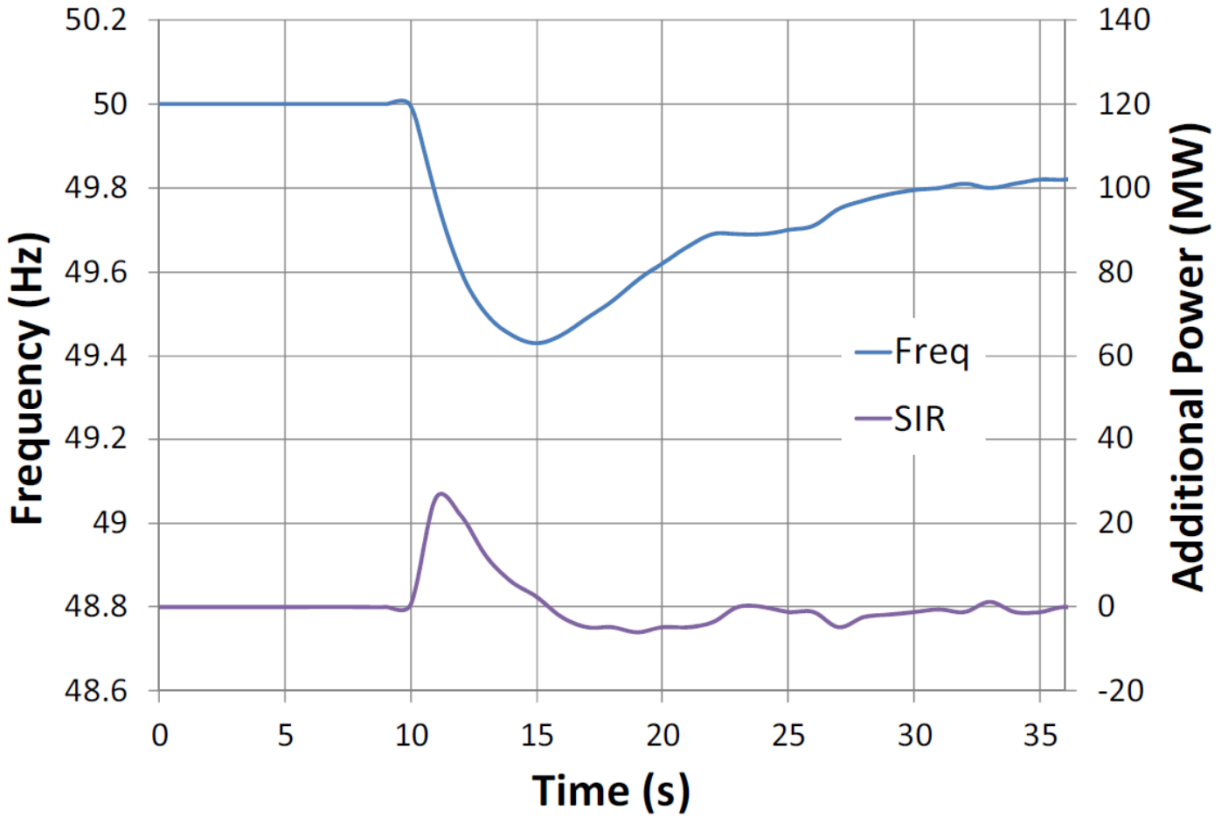
Present grid status

The Facts:

- Electrical system behavior after loss of generation



Freq: Grid Frequency
SIR: Synchronous Inertial Response

source:
EirGrid & SONI

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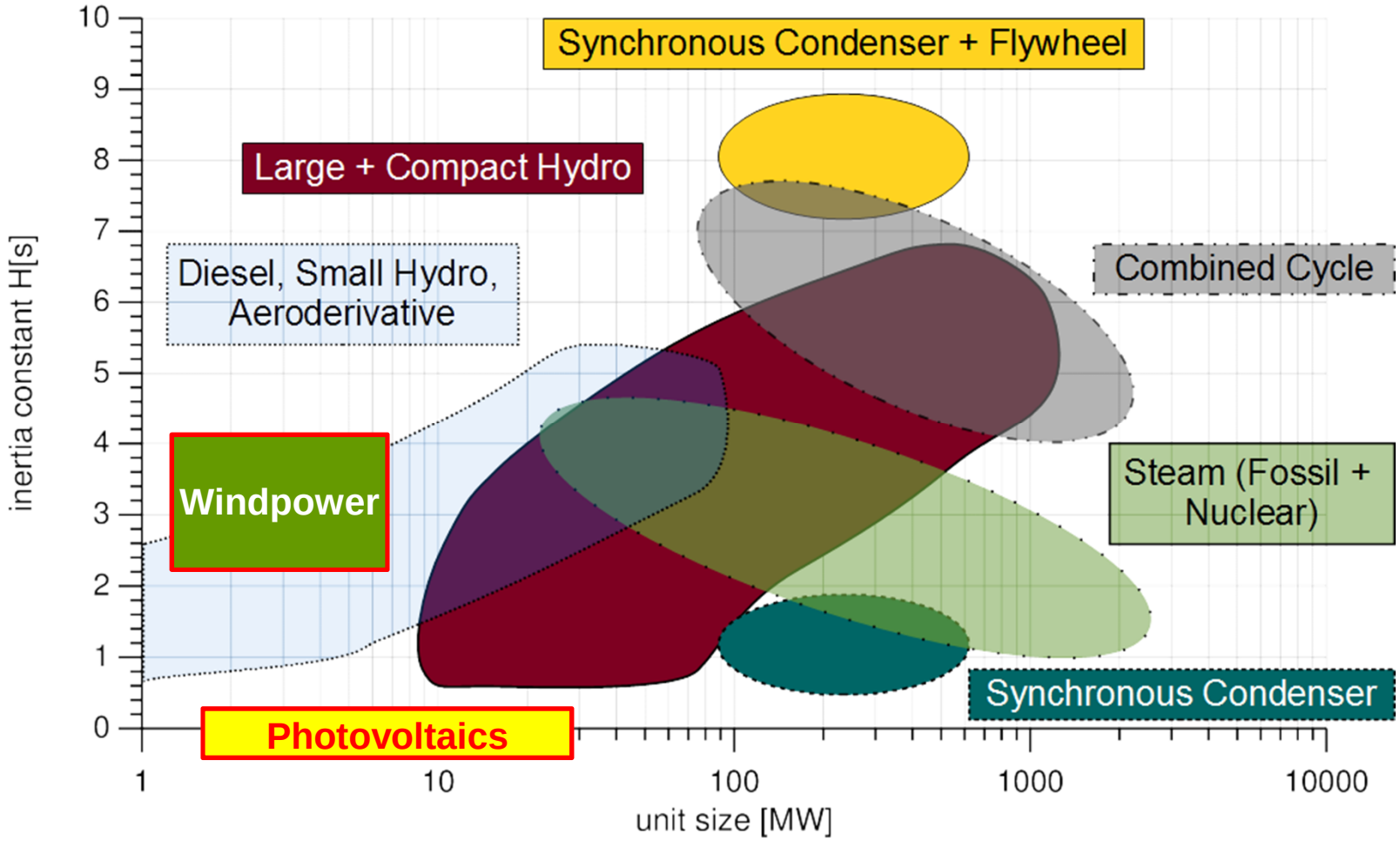
The role of Inertia



Inertia constants for different type of generating units

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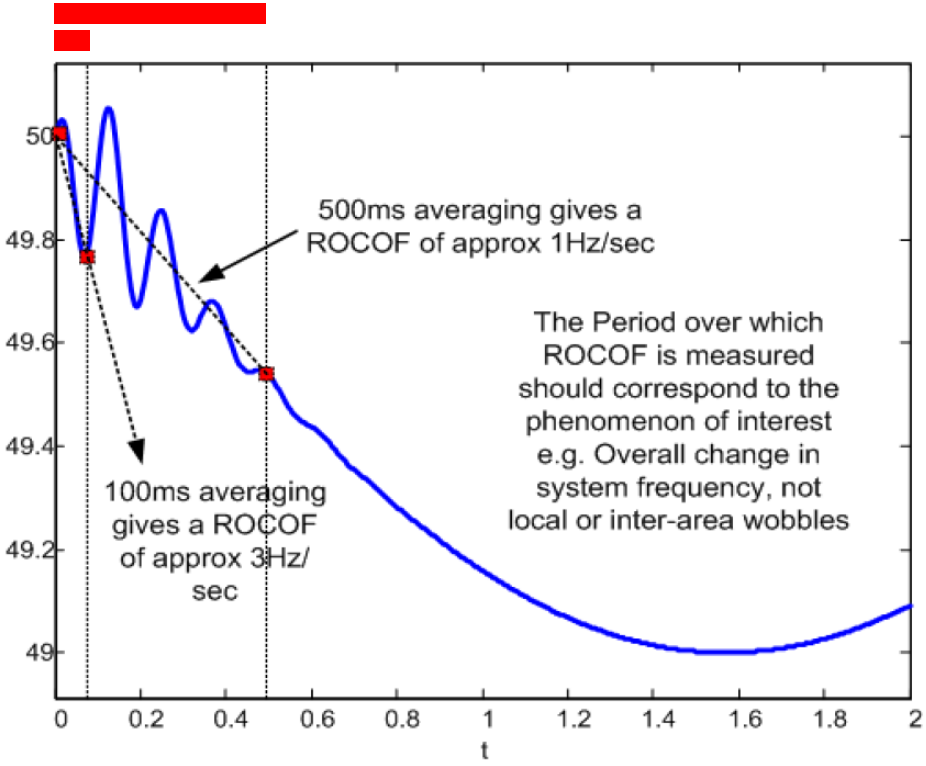
Rate of Change of Frequency (RoCoF)

Definition:

- Gradient of Frequency
- Central Europe: 0.1Hz/s
- Ireland: 1Hz/s – 2Hz/s
- Value depends on average time

Root cause:

- Loss of mains
- Additional voltage dip
- Low system Inertia



Interpretation of "RoCoF"
source: EirGrid & SONI

Proposed new Services

1. Synchronous Inertial Response (**SIR**)

   Synchronous machines FIXED speed

   This is the classical behavior of a synchronous generating unit, a synchronous condenser or any other synchronous load. The amount of injected active power depends on the rate of change of frequency and the inertia constant H.

2. Fast Post-fault Active Power Recovery (**FPFAPR**)

   VARIABLE speed concepts

   Units that can fast recover their output after a grid fault can mitigate the impact of a disturbance to the system. If many units are able to do that, grid security can be improved.

3. Fast Frequency Response (**FFR**)

   VARIABLE speed concepts

   By a fast control system, generating units can provide fast-acting active response to change of frequency.

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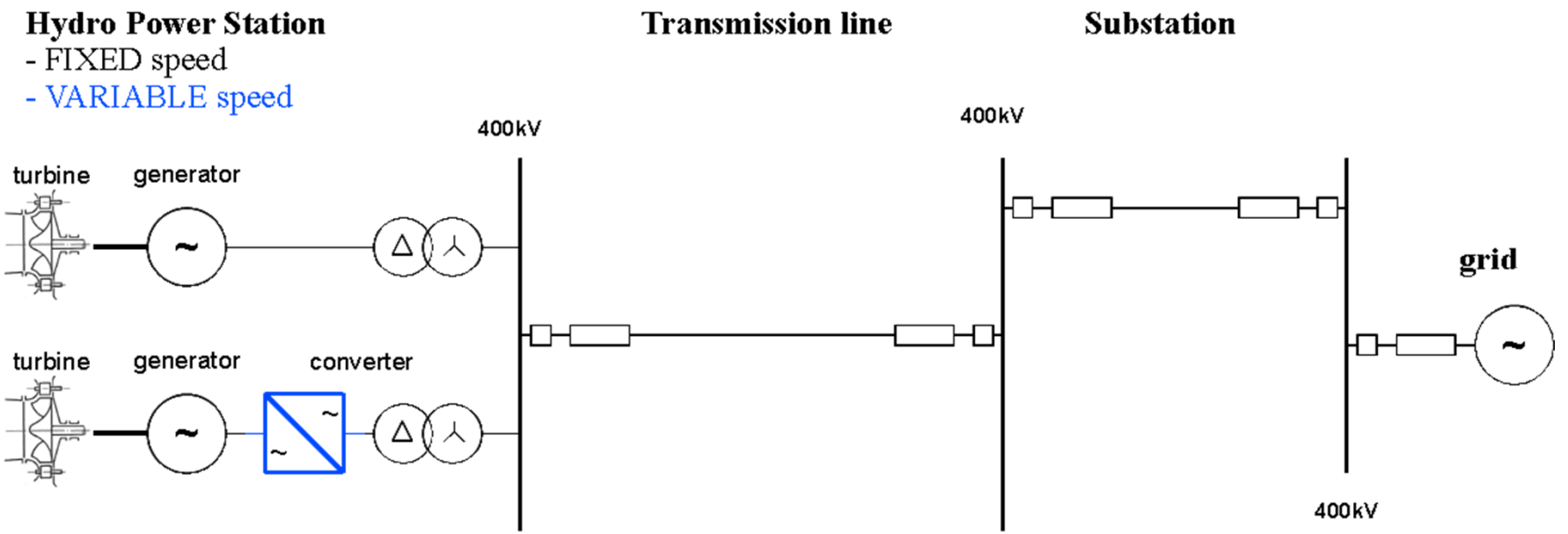
Example – System configuration



285m
36m³/s
400rpm

120MVA
428rpm
H=3.5s

120MVA

120MVA
10%

400kV
100km long

400kV, 50Hz
Infinite SC

Gross head: 290m
Penstock: 730m
Wave speed: 1100m/s

Control:
Exc: ST1A + PSS2B
Gov: HYGOV b_p=0.02

Operating point:
70% = 84MW
p.f. = 1.0 @ PCC

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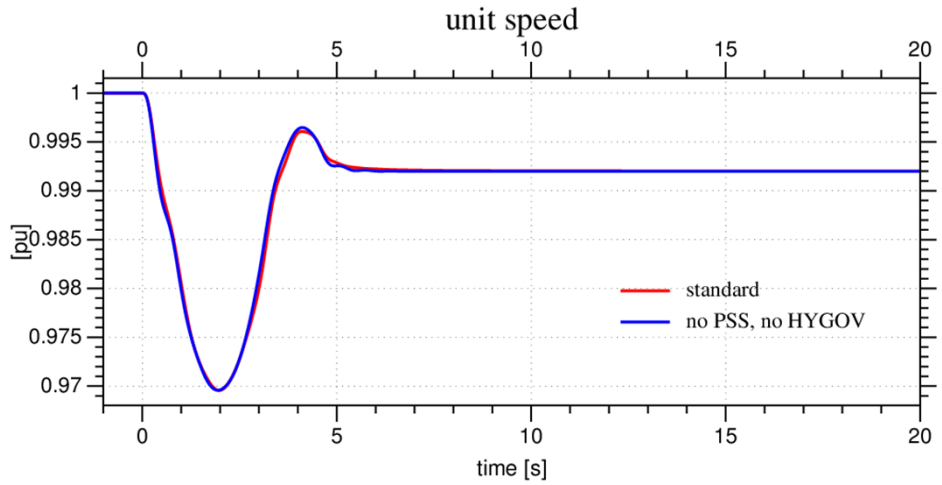
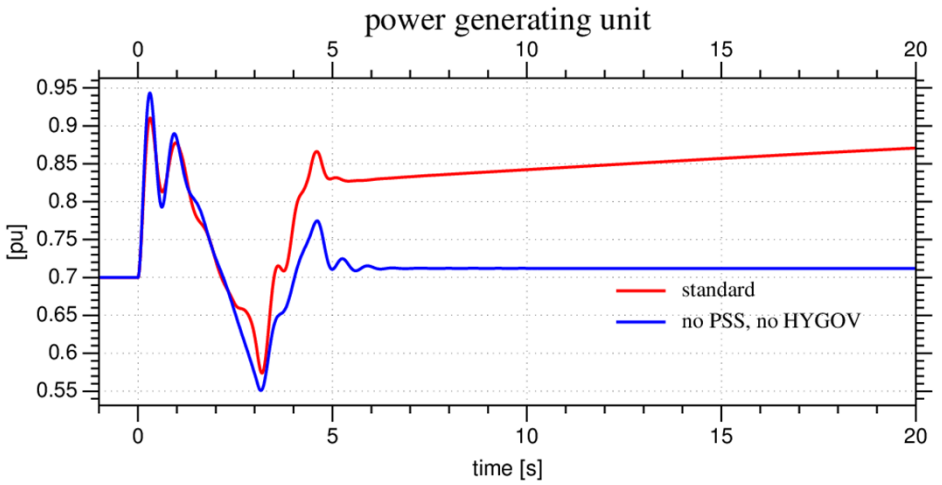
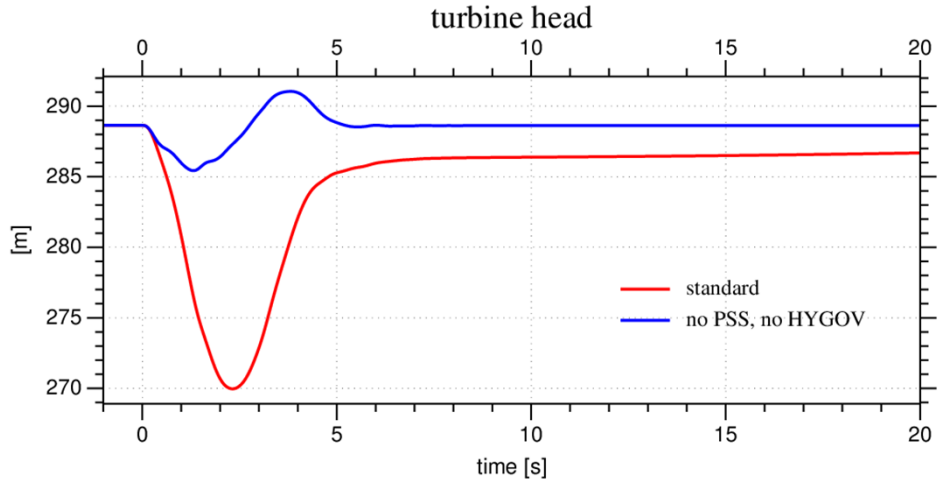
FIXED speed – results

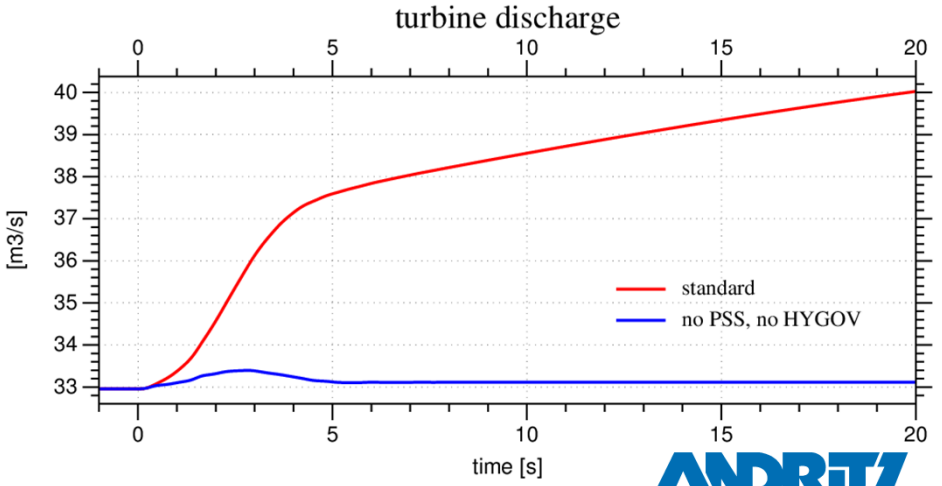
- Standard configuration
- **No** PSS, **No** Hydro governor

RoCoF = 1.0Hz/s









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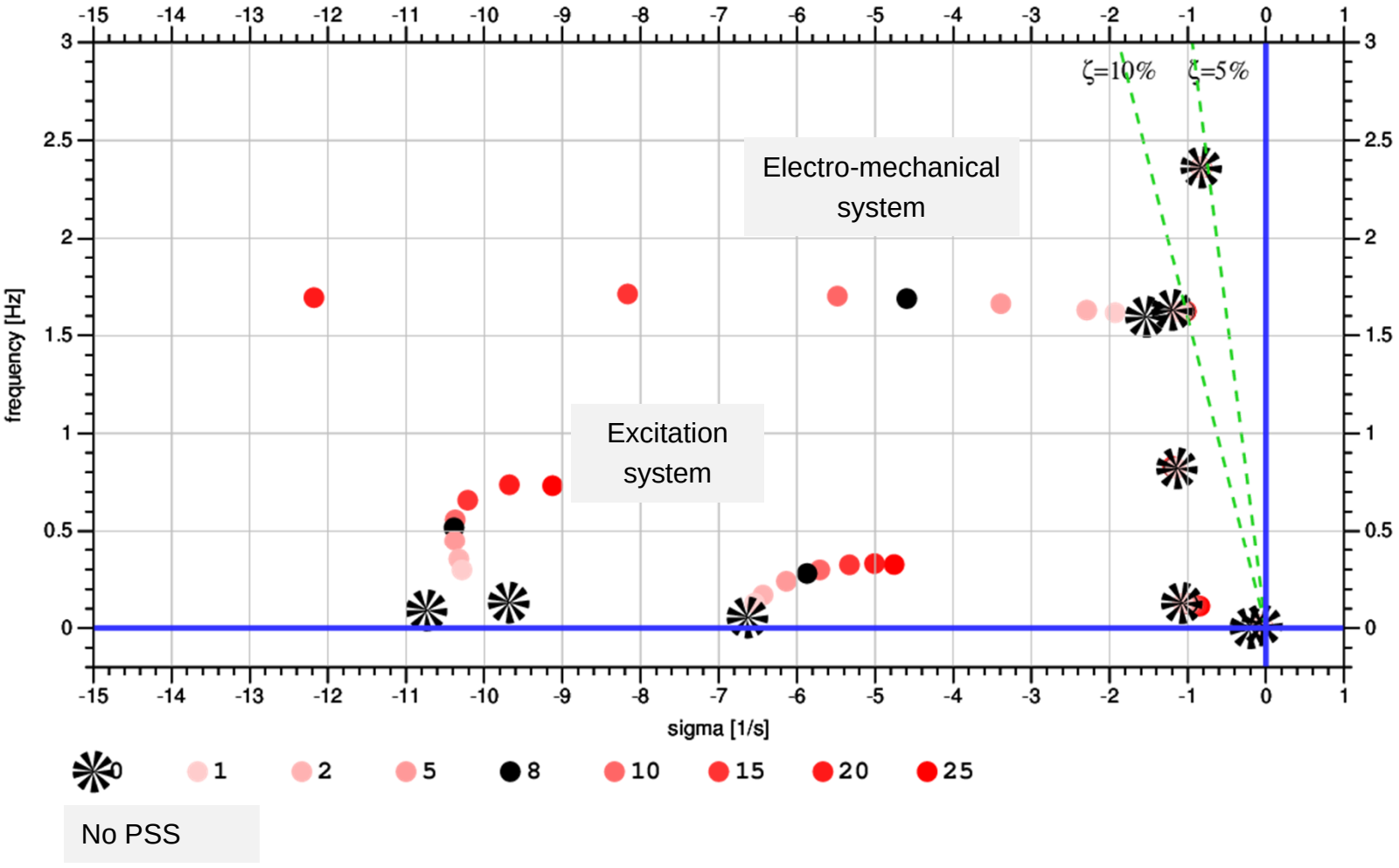
FIXED speed – Frequency response / Eigenvalues



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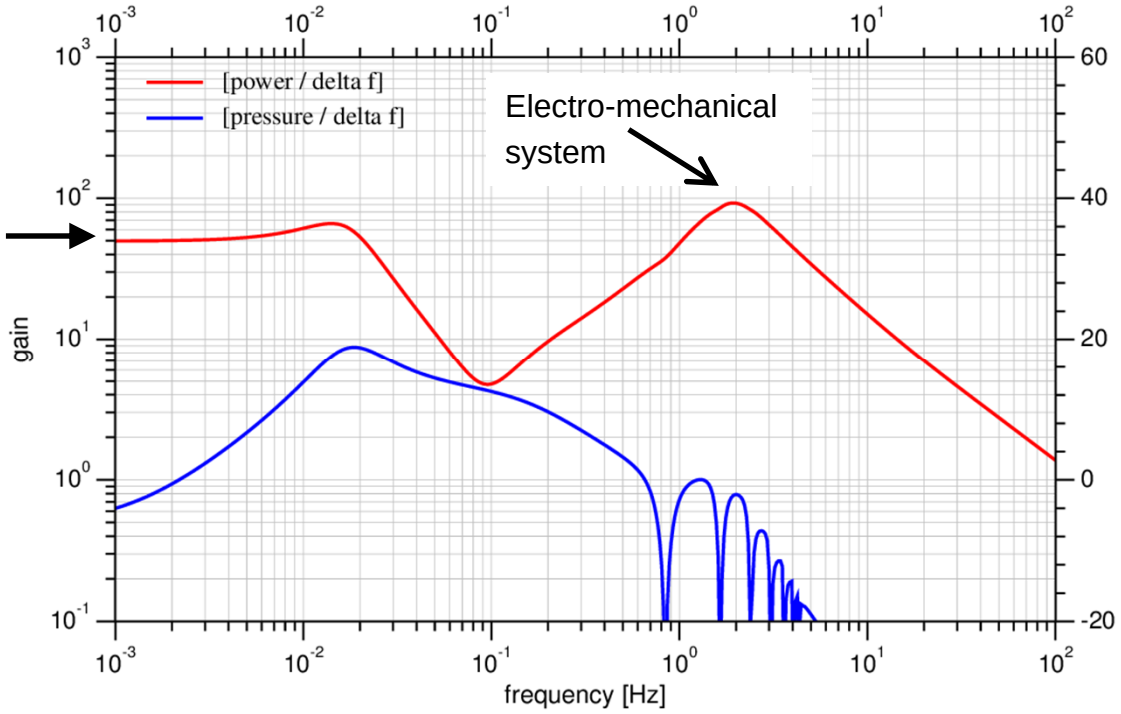
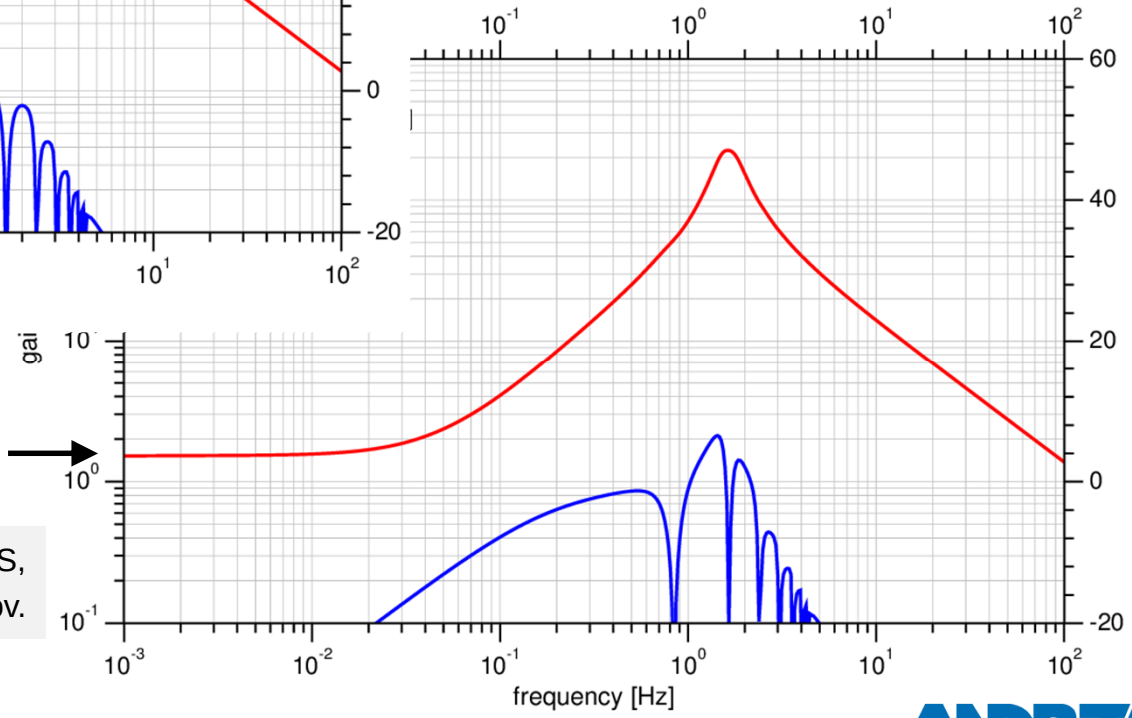
FIXED speed – Frequency response / Transfer-function



Standard configuration



NO PSS,
NO hydro gov.

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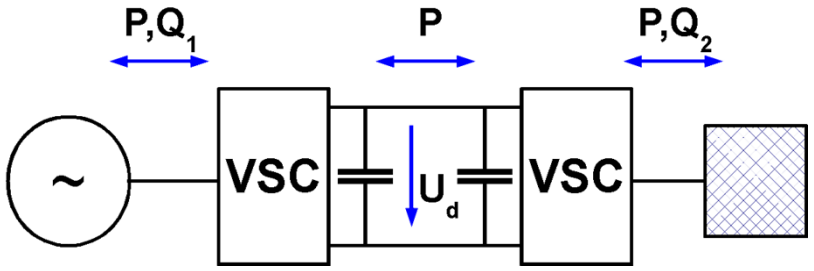
VARIABLE speed – basics

Converter principle:

- 2 controlled voltage sources
- Decoupled systems
- Independent P/Q control
- Very short response time



schematic diagram of a frequency converter

System control:

	Control (1)	Control (2)
Converter	Power	Speed
Governor	Speed	Power
Transient performance	Fast	Slow
Usage	**Practical**	Theoretical

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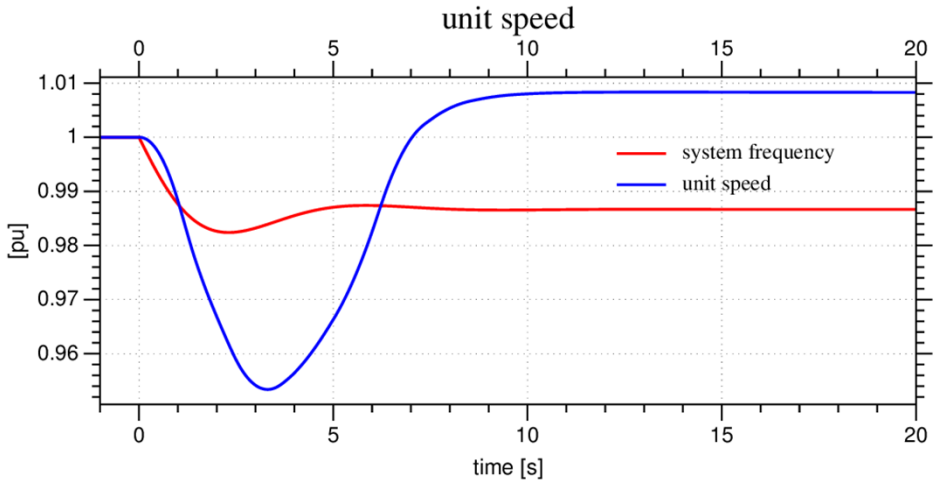
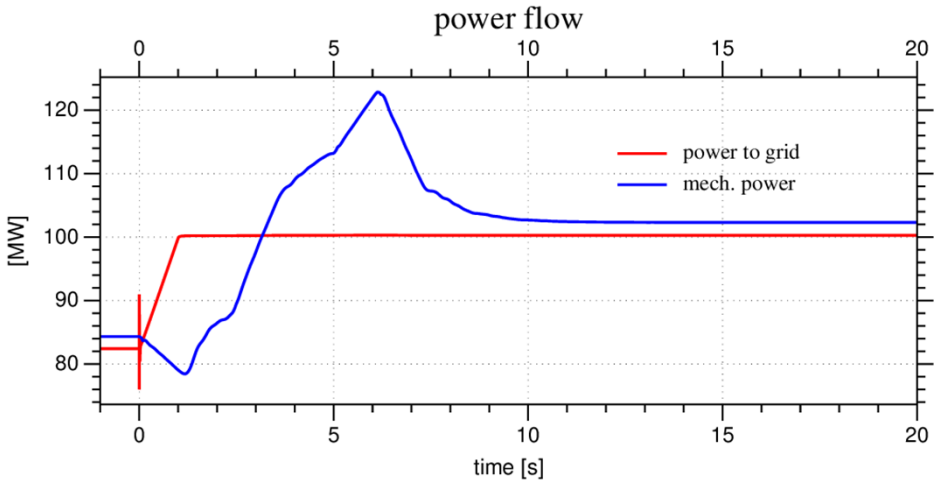
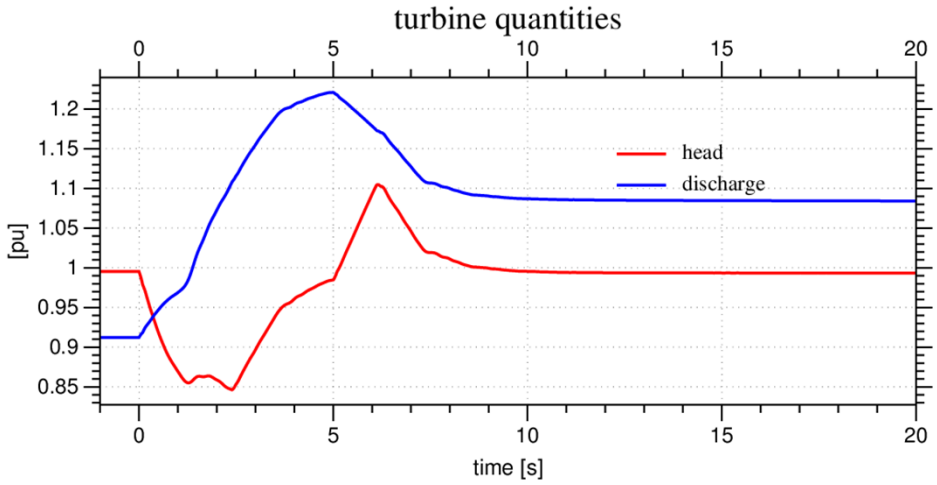
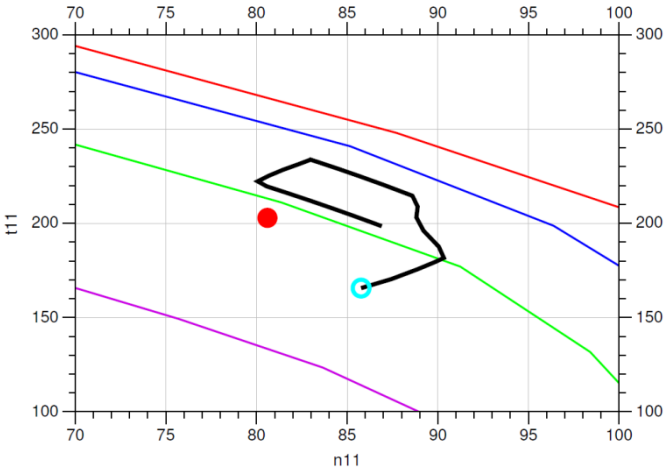
VARIABLE speed – results

Test case: RoCoF = 0.5Hz/s, b_p = 0.04, Power 84MW à 100MW









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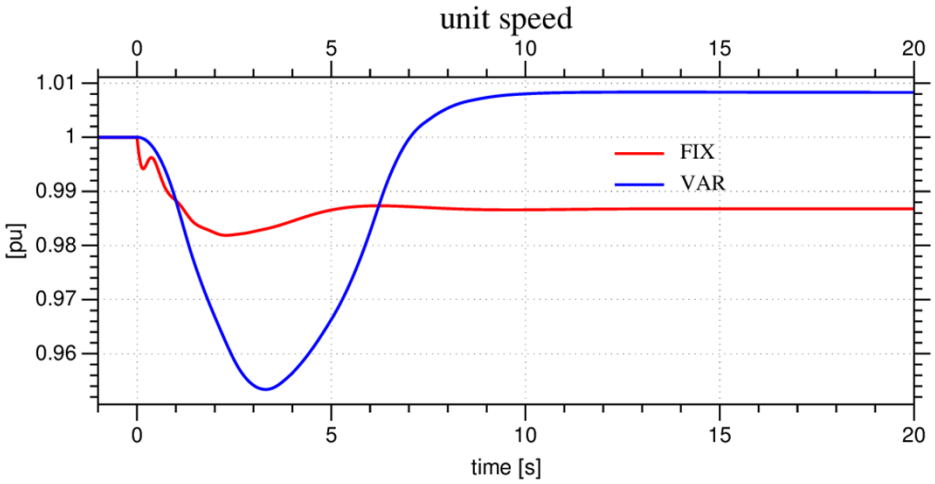
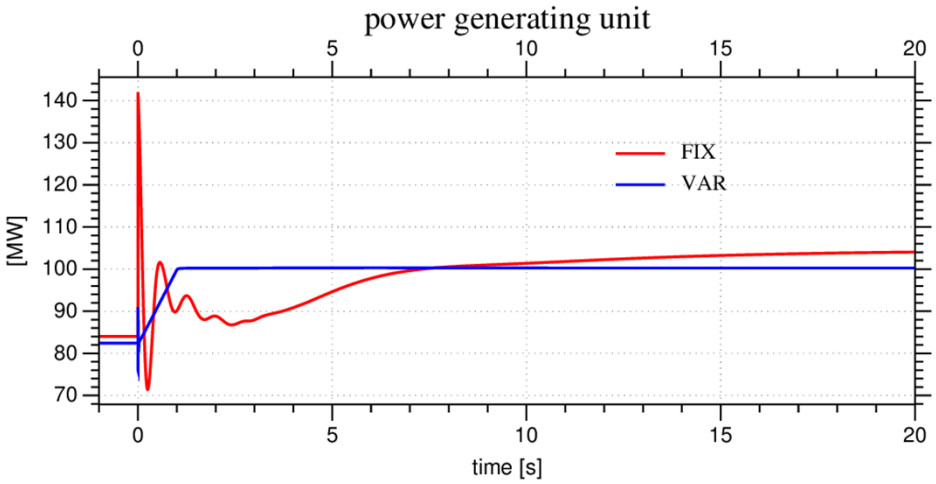
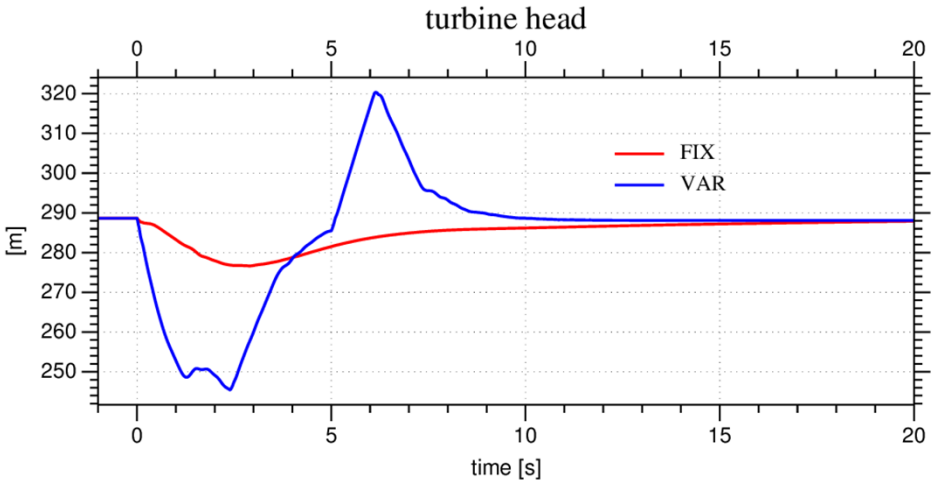
FIXED / VARIABLE speed – comparison

Test case: RoCoF = 0.5Hz/s, b_p = 0.04, Power 84MW à 100MW







Contribution of hydro power to active grid stabilization

Summary & Conclusion

The Problem

- Change of electric energy production mix (high penetration of RES)
- Transient Stability needs Inertia

Proposed Solutions / New system services

1. **High level Primary response**
   New Primary Frequency response is able to react on frequency deviations within tenth of seconds by supplying power to the grid.
2. **High level Frequency response**
   With the kinetic energy stored in the rotating mass of the generator by means of control active power can be supplied to the grid depending on the RoCoF.

The role of Hydro Power

- **Variable Speed concepts (e.g. Pumped Storage installations) can offer service 1.) and 2.)**

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Thank you for your attention!

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