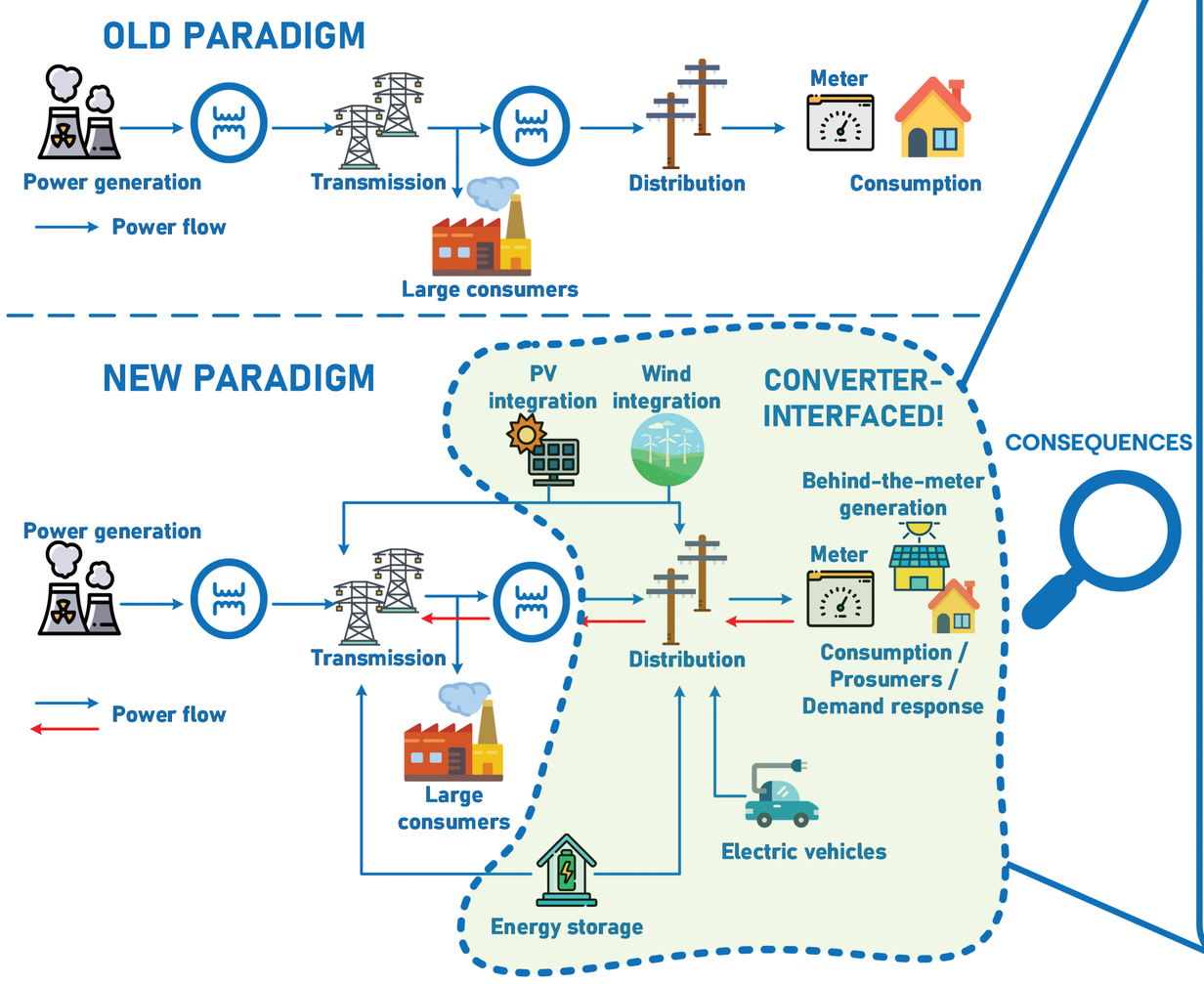
Fast Frequency Control in Low-Inertia Power Systems

Matej Krpan, M. Eng.
(matej.krpan@fer.hr)
mentor: prof. dr. sc. Igor Kuzle,
University of Zagreb Faculty of Electrical Engineering and Computing

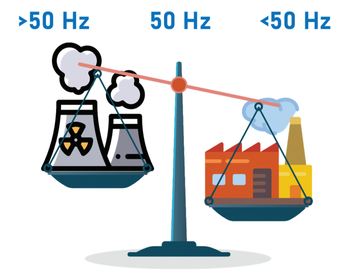
1. Background and Motivation

Massive integration of renewable energy sources based on power electronic converters shifts the power system paradigm of the **last 100 years!**



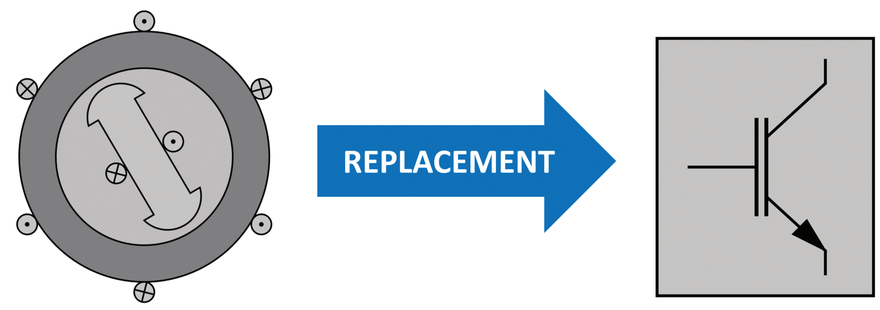
Power system paradigm shift

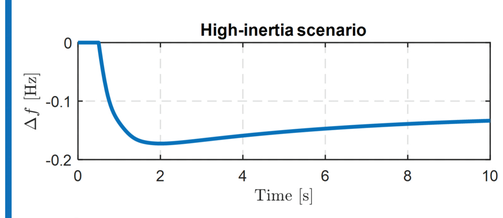
Power system frequency tells us the current disbalance of generation and load which enables us to rebalance them by controlling power plant production



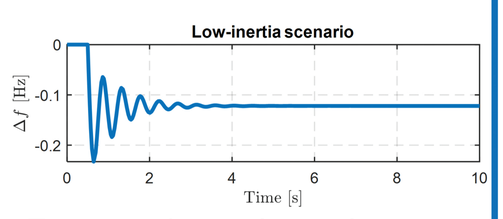
Synchronous generators provide rotational inertia opposing changes in frequency

Converters reduce rotational inertia increasing sensitivity to disturbances





Slower dynamics gives us **more time to balance** generation and load



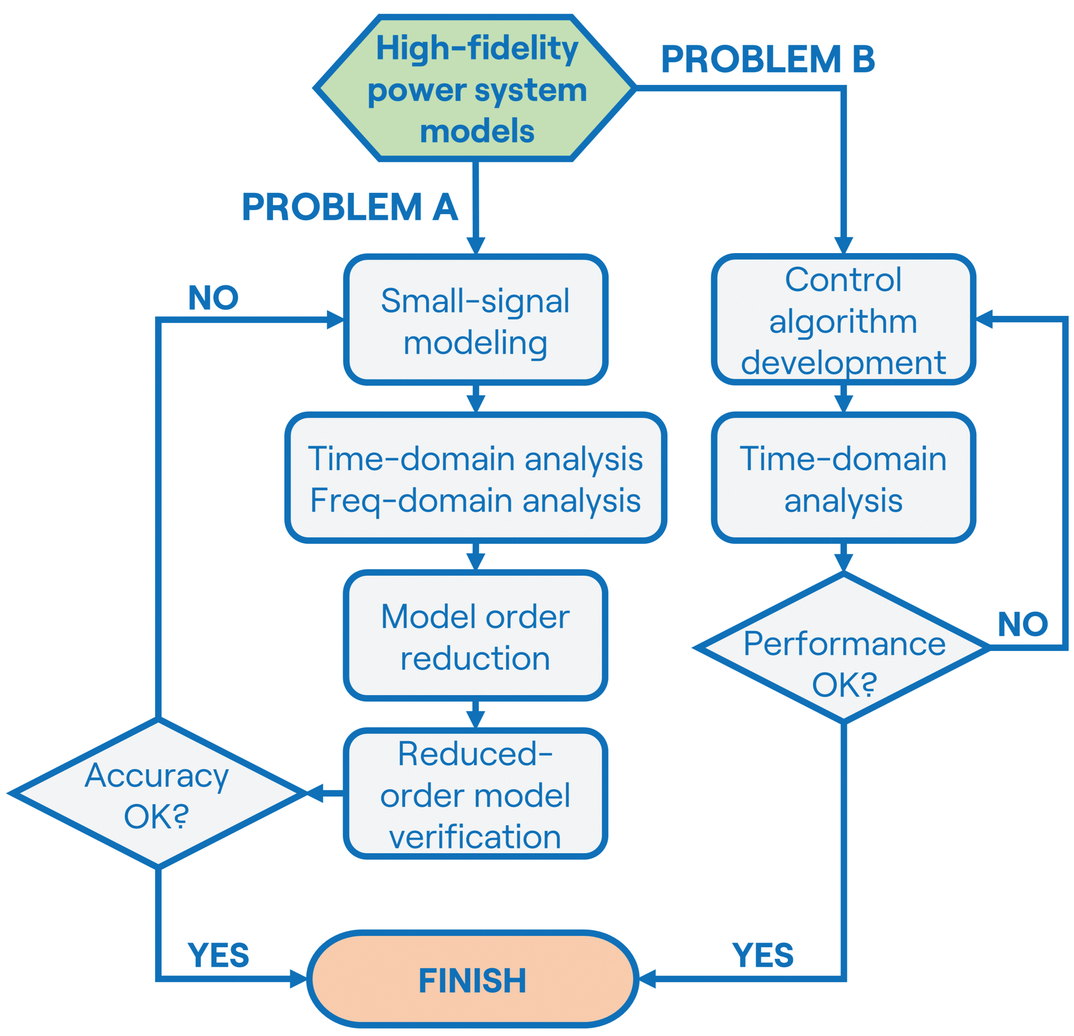
Faster dynamics gives us **less time to balance** generation and load

Consequences of an increasing share of power electronic interfaced renewables

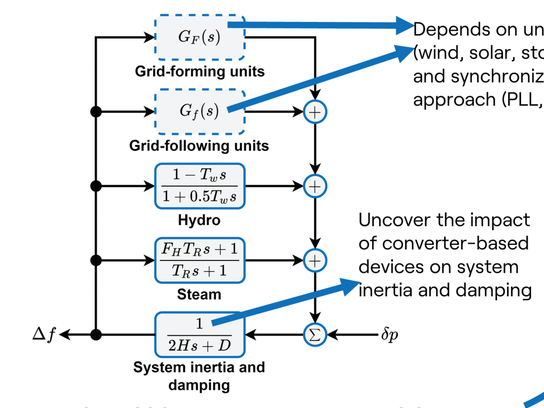
2. The Problem(s)

A. To identify most relevant parameters impacting grid frequency dynamics of converter-dominated power systems and develop reduced-order models
B. To develop novel frequency control schemes utilizing fast response of power electronic converters

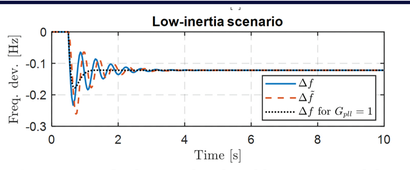
3. Methodology



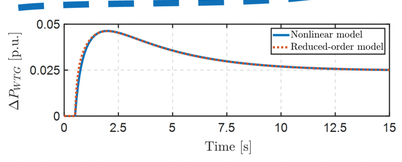
4. Results (some, but not all)



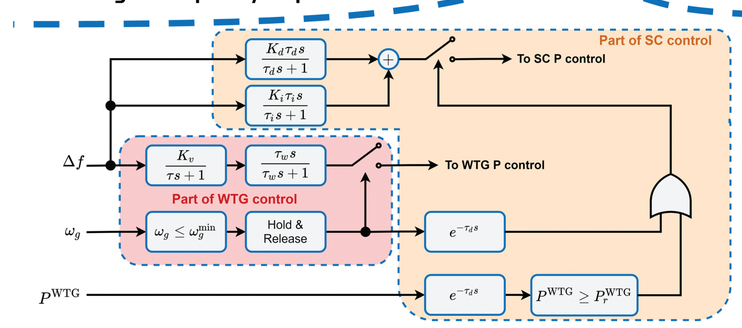
Low-order grid frequency response model



Impact of phase-locked loop on grid frequency



Wind turbine model order reduction for a certain operating range



Supercapacitor – wind turbine coordination for enhancement of wind turbine frequency control performance

5. Conclusions so far

- Converter synchronization techniques in frequency simulation models must be considered
- Device-level dynamics behind the converter (wind, solar, storage) play a role in system response regardless of the decoupling effect
- Load dynamics are generally neglected which must be further investigated
- Supercapacitors can be utilized for enhancement of fast frequency control performance of wind turbines

Acknowledgements

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