



Degrees of freedom for primary control with batteries

Eberhard Waffenschmidt

IRES 2017, Düsseldorf, Germany,

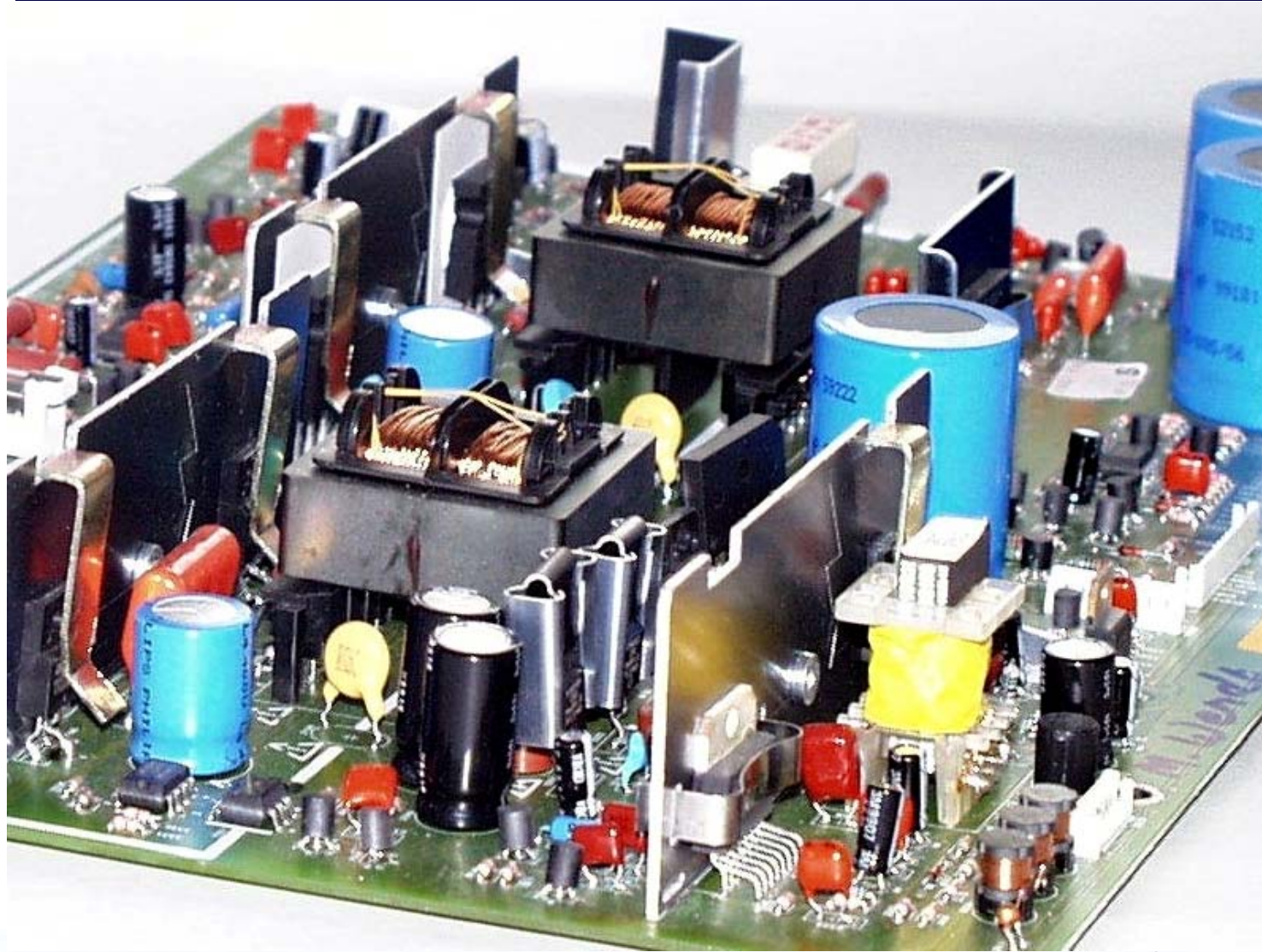
14.-16. March 2017

Acknowledgements to:

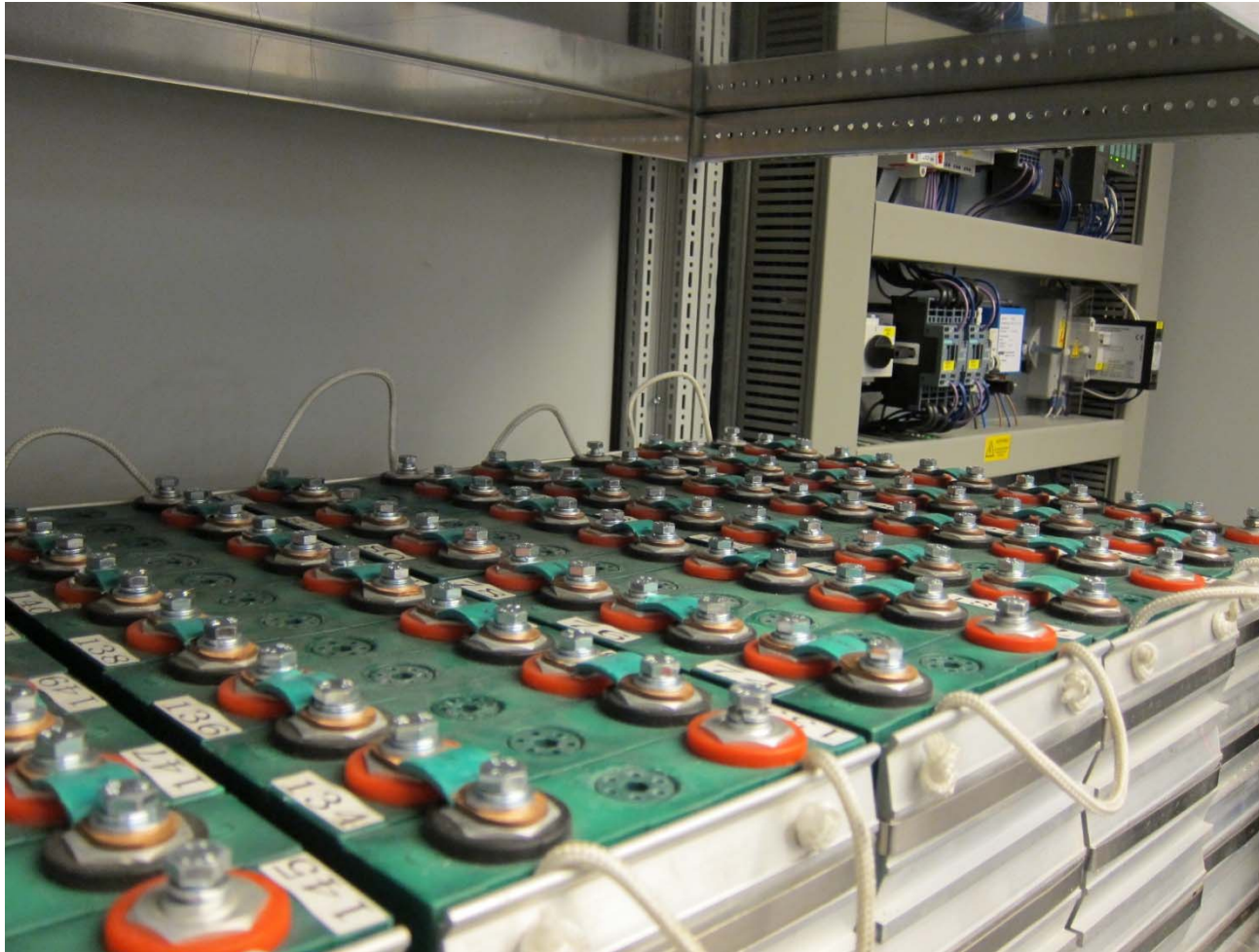
Tobias Scheja, Momoko Kristuf, Fabian Rosenau, Daniel Korber and
Jakob Bähr



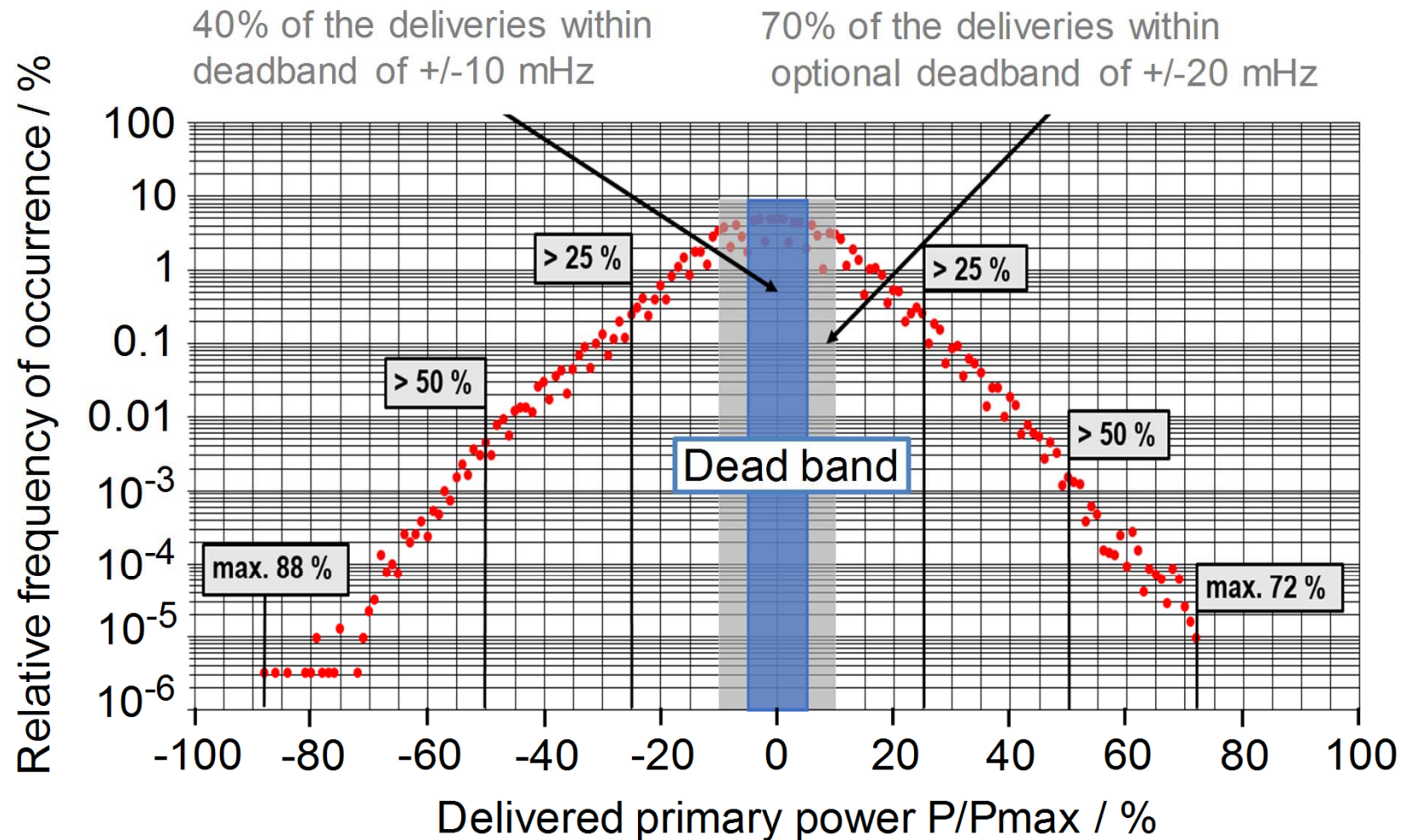
Generators replaced by electronics



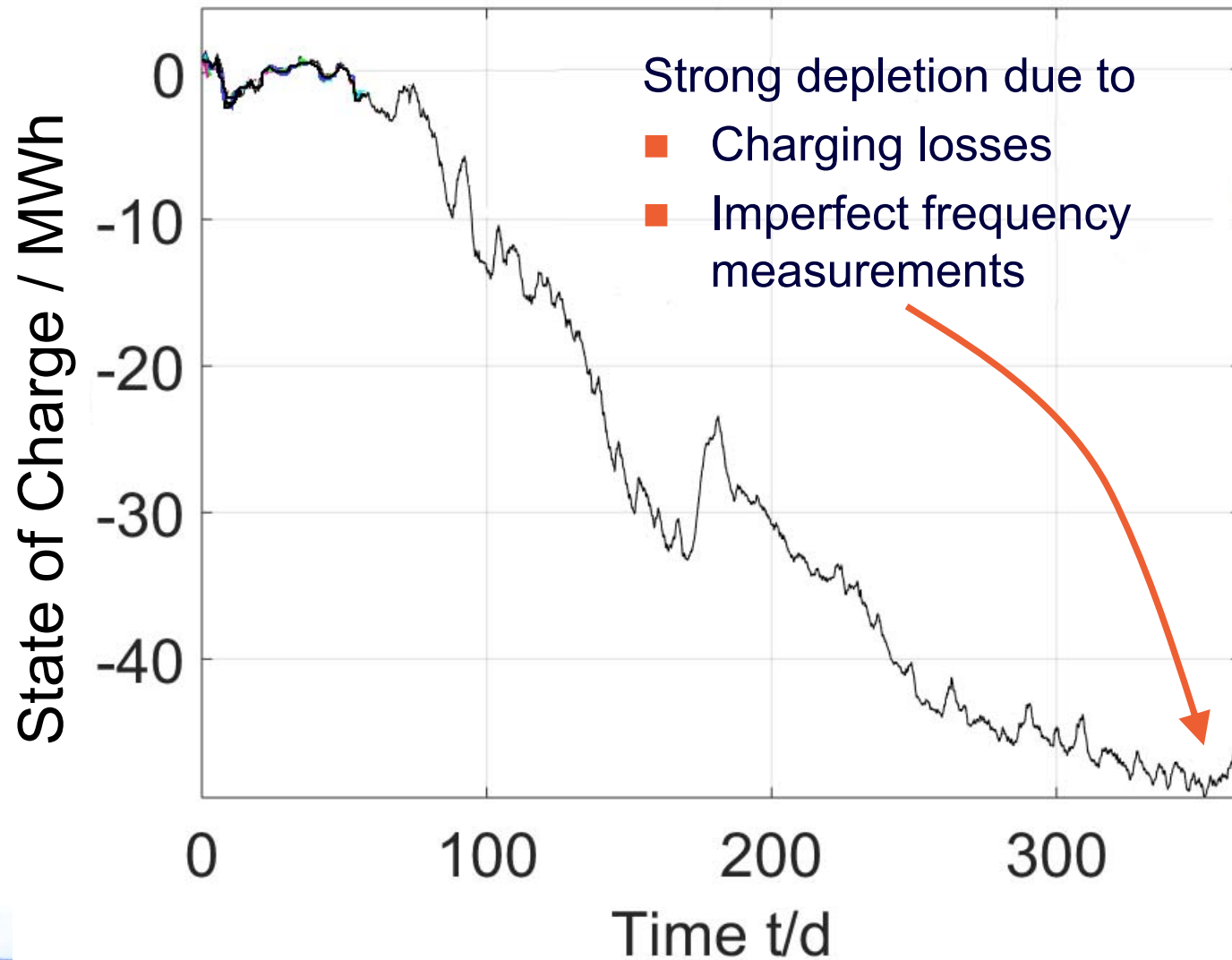
Primary control with batteries



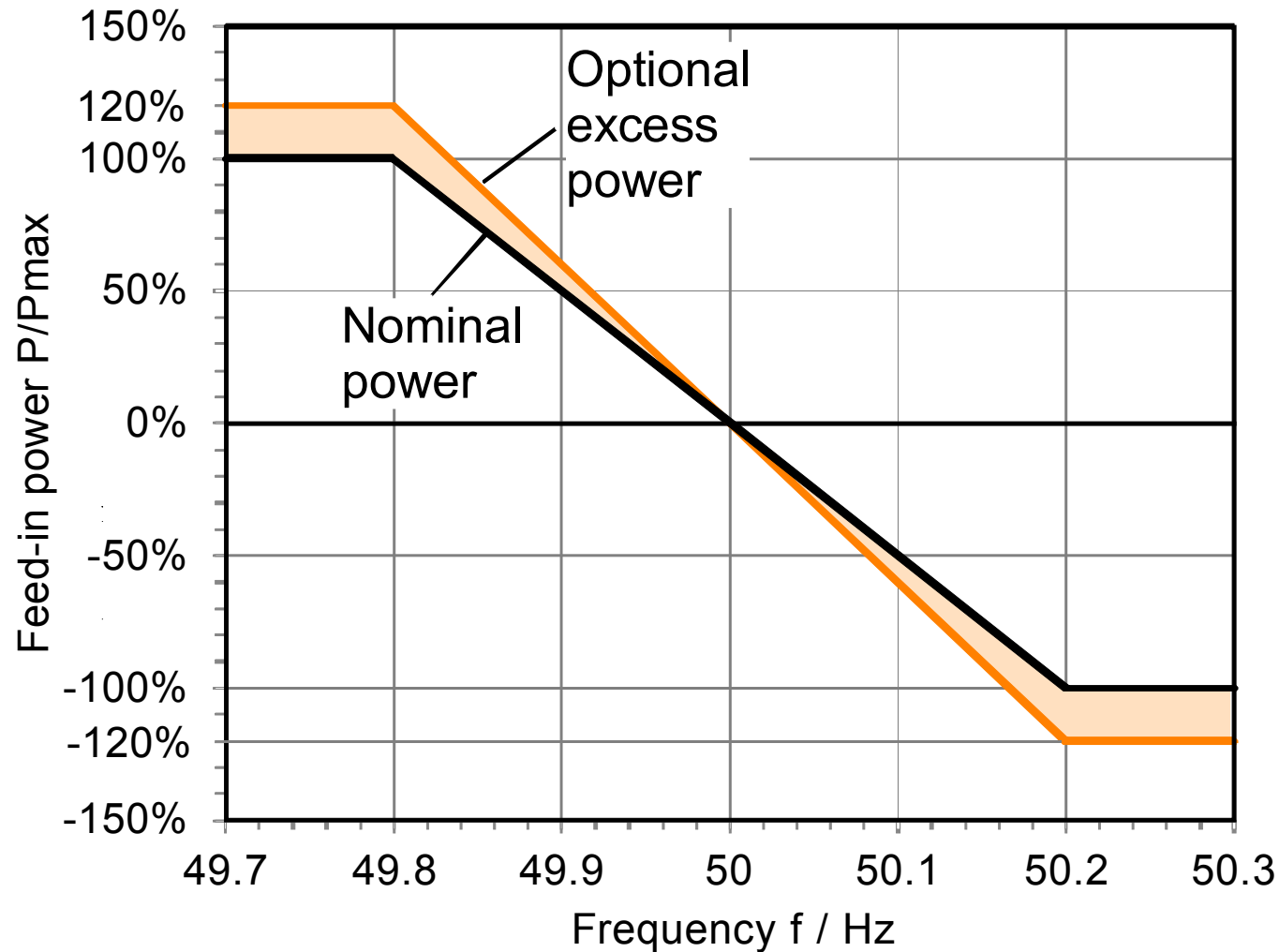
Occurrence of Primary Control Power in 2013



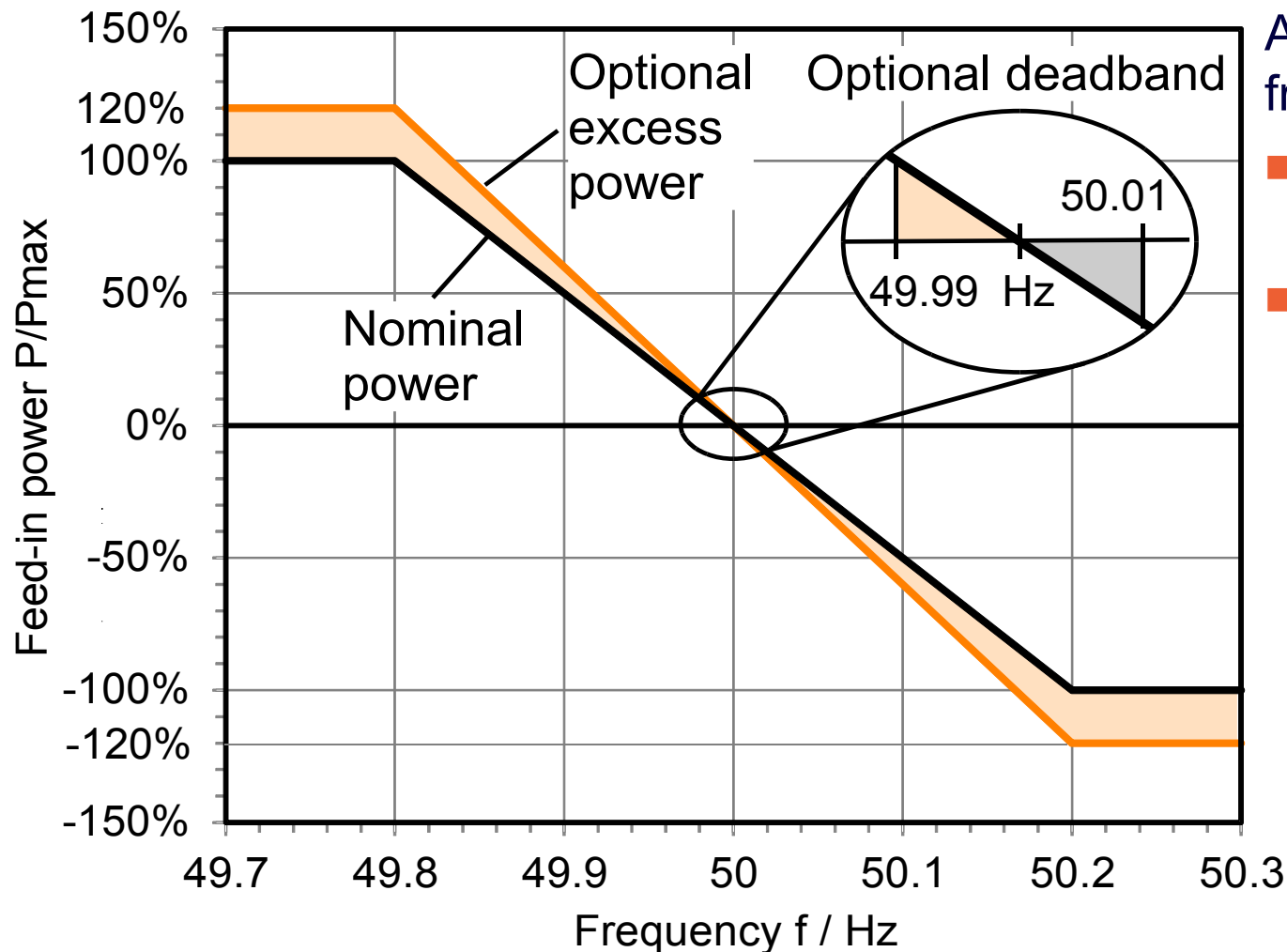
State of charge without measures



Degrees of freedom with Primary Control



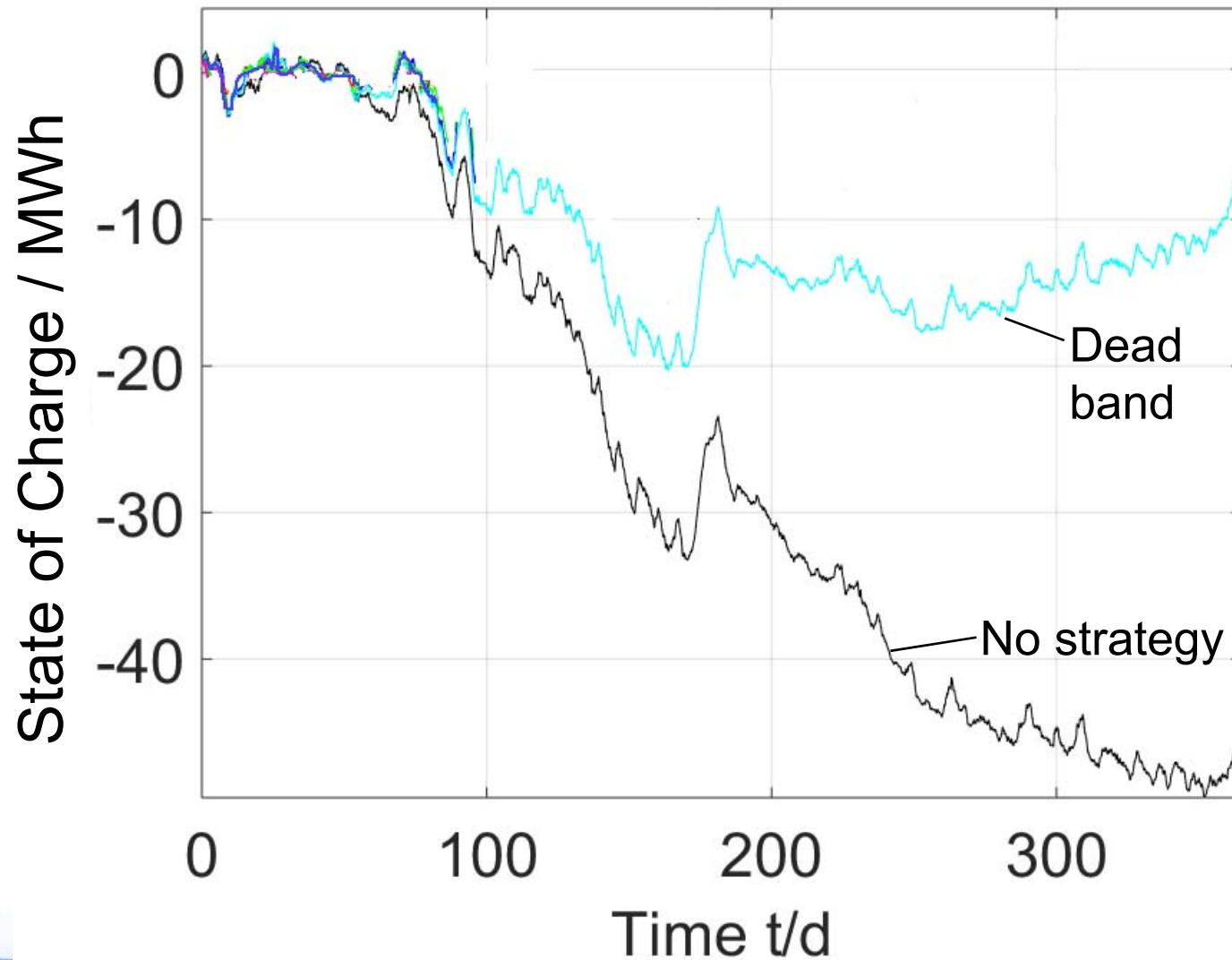
Degrees of freedom with Primary Control



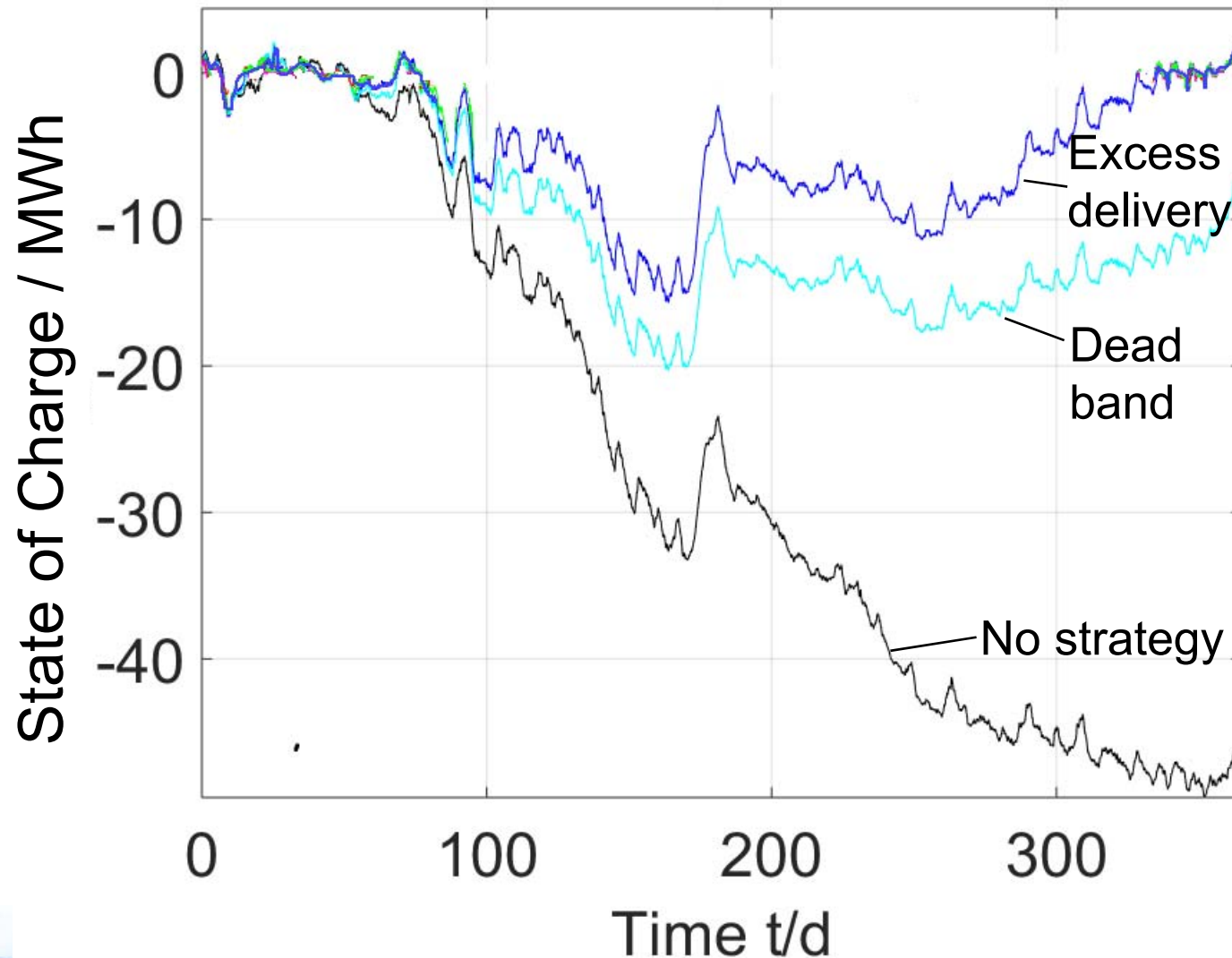
Additional degrees of freedom:

- Delayed reaction: 30s to full power
- Trading of energy

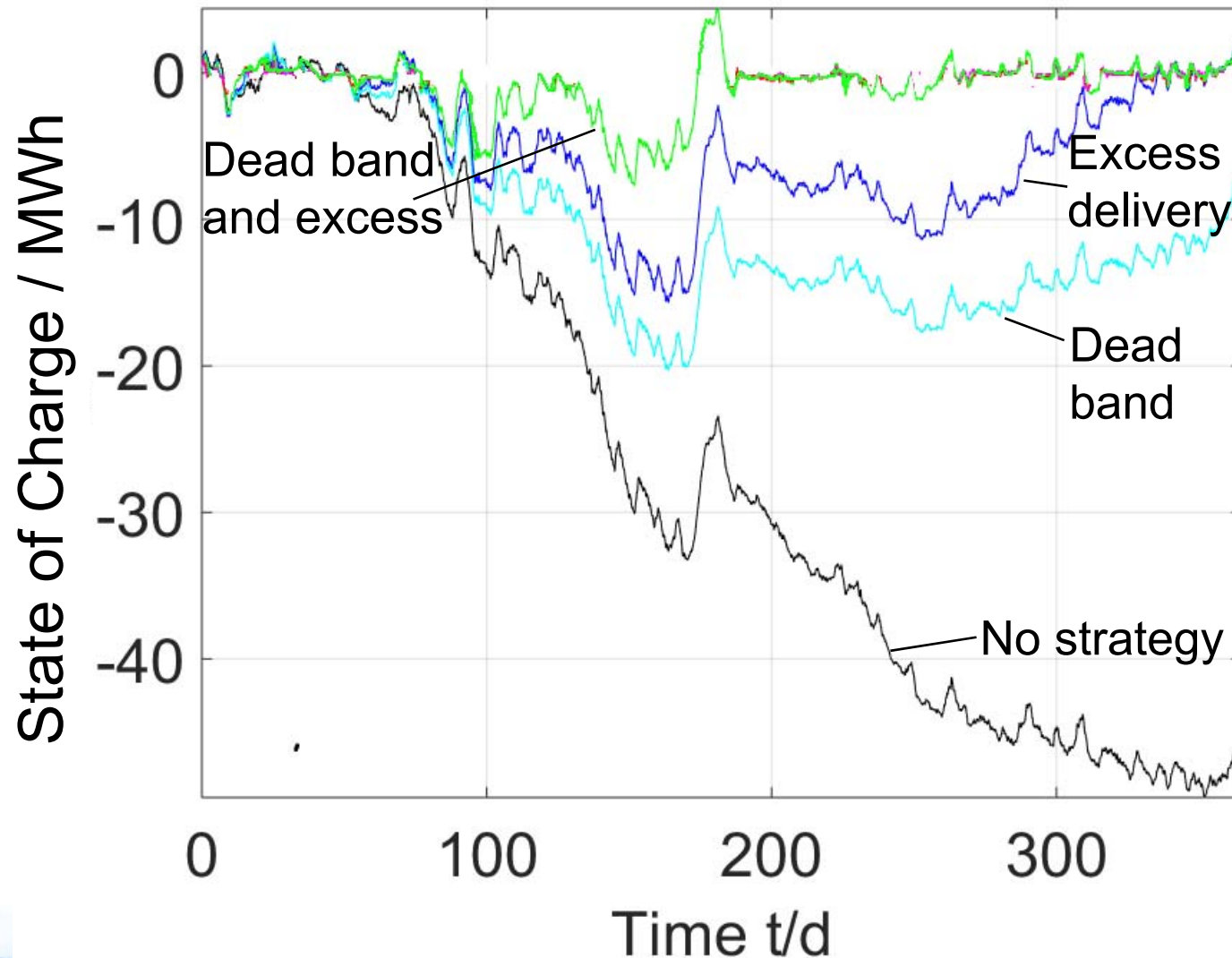
Effect of applying degrees of freedom



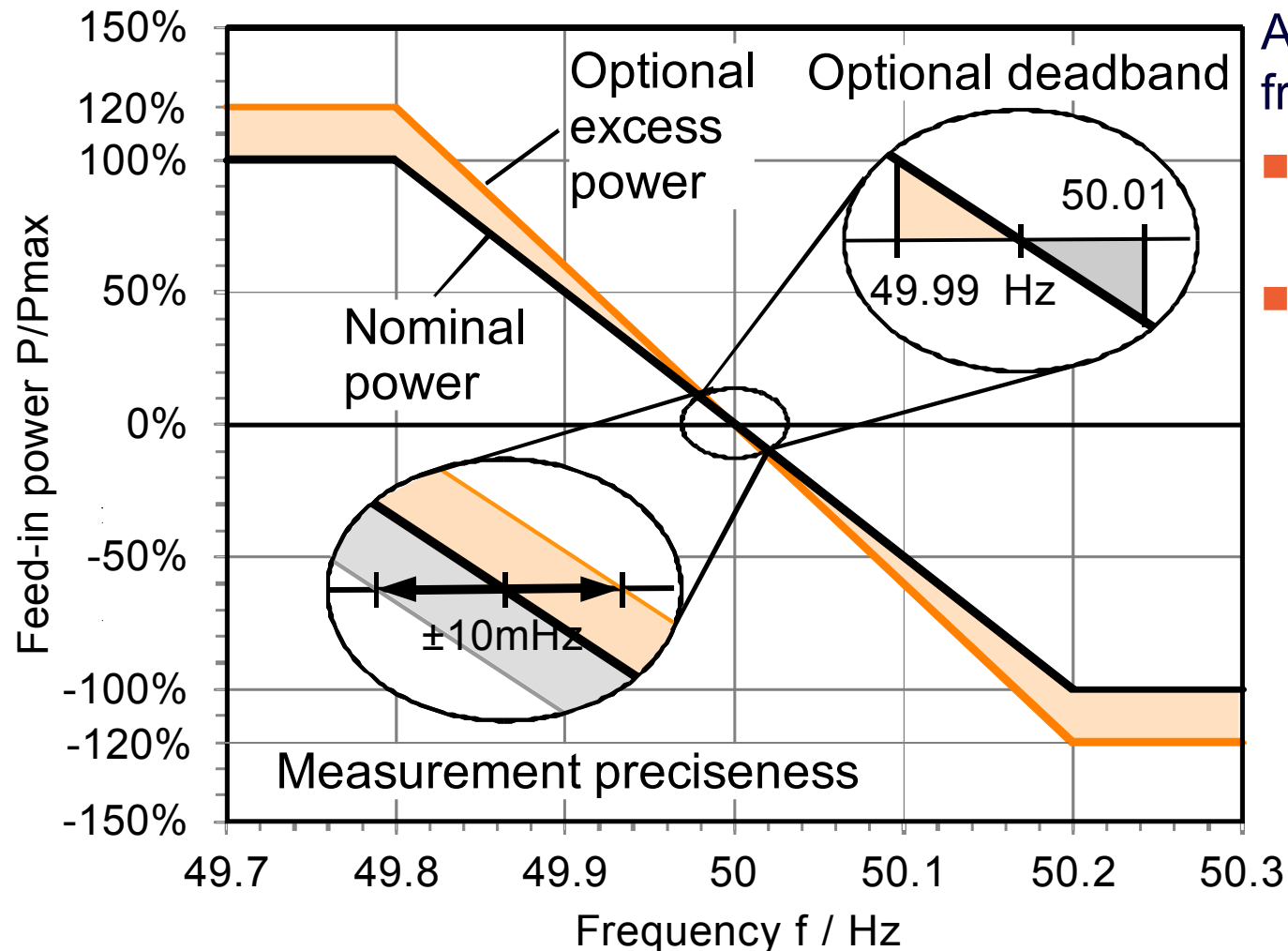
Effect of applying degrees of freedom



Effect of applying degrees of freedom



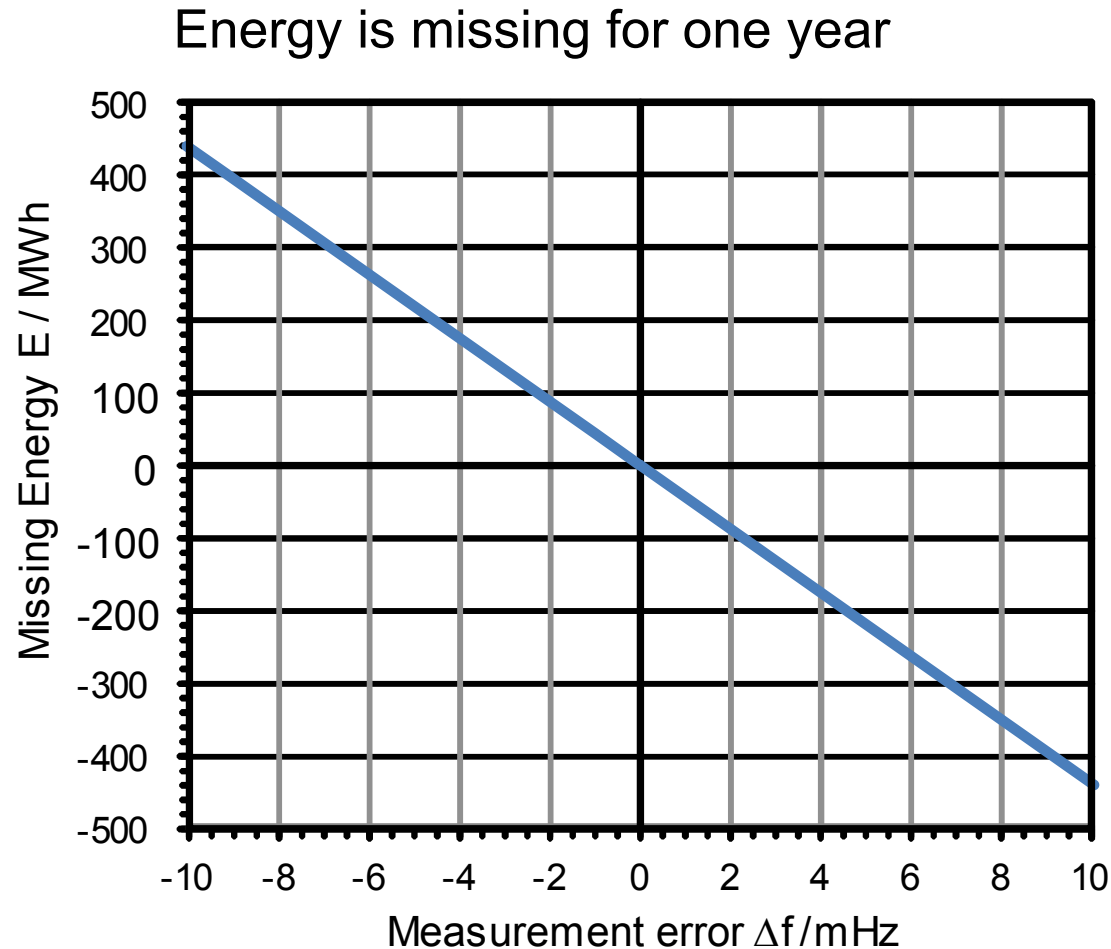
Degrees of freedom with Primary Control



Additional degrees of freedom:

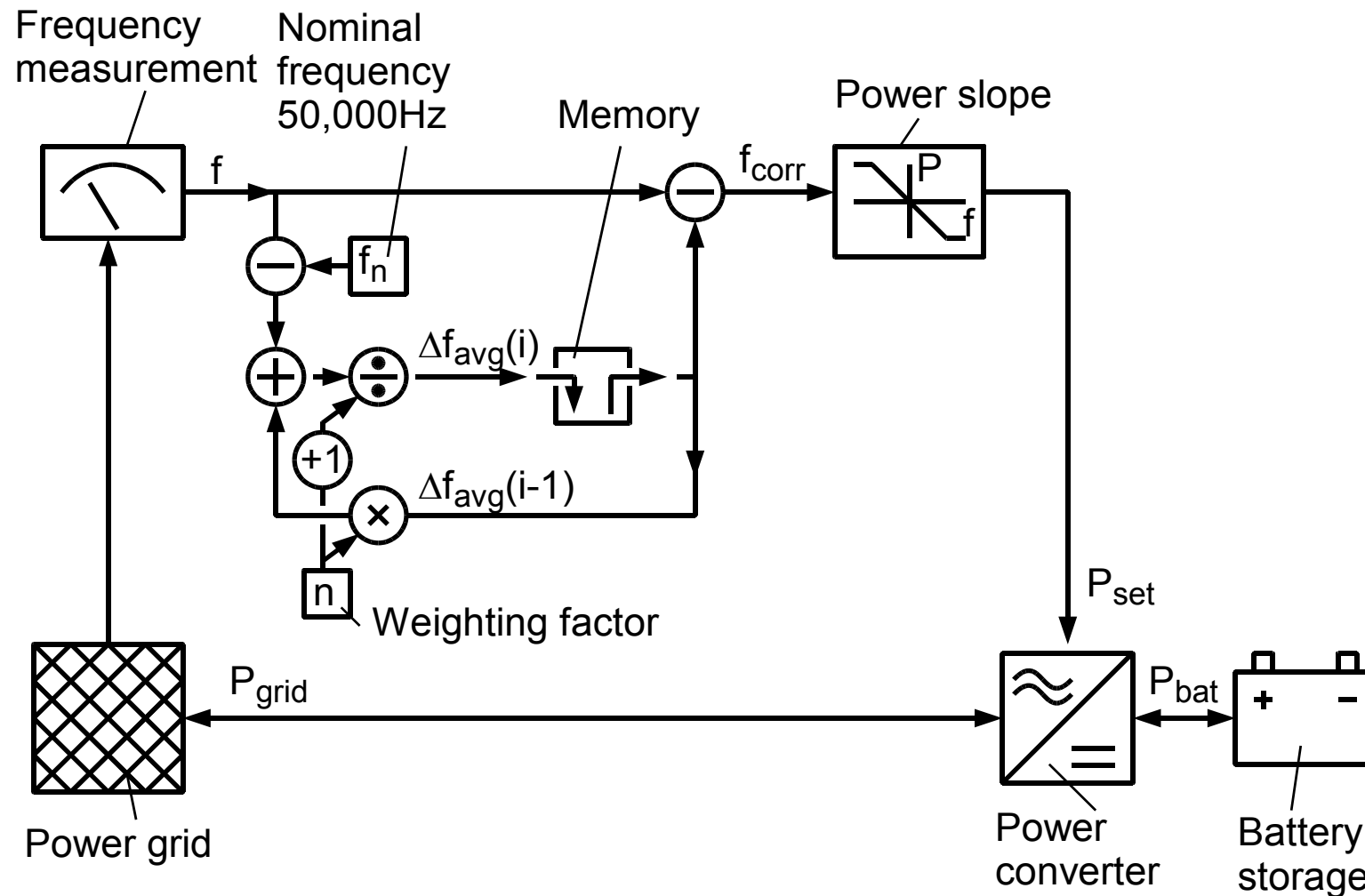
- Delayed reaction: 30s to full power
- Trading of energy

Effect of a systematic frequency error

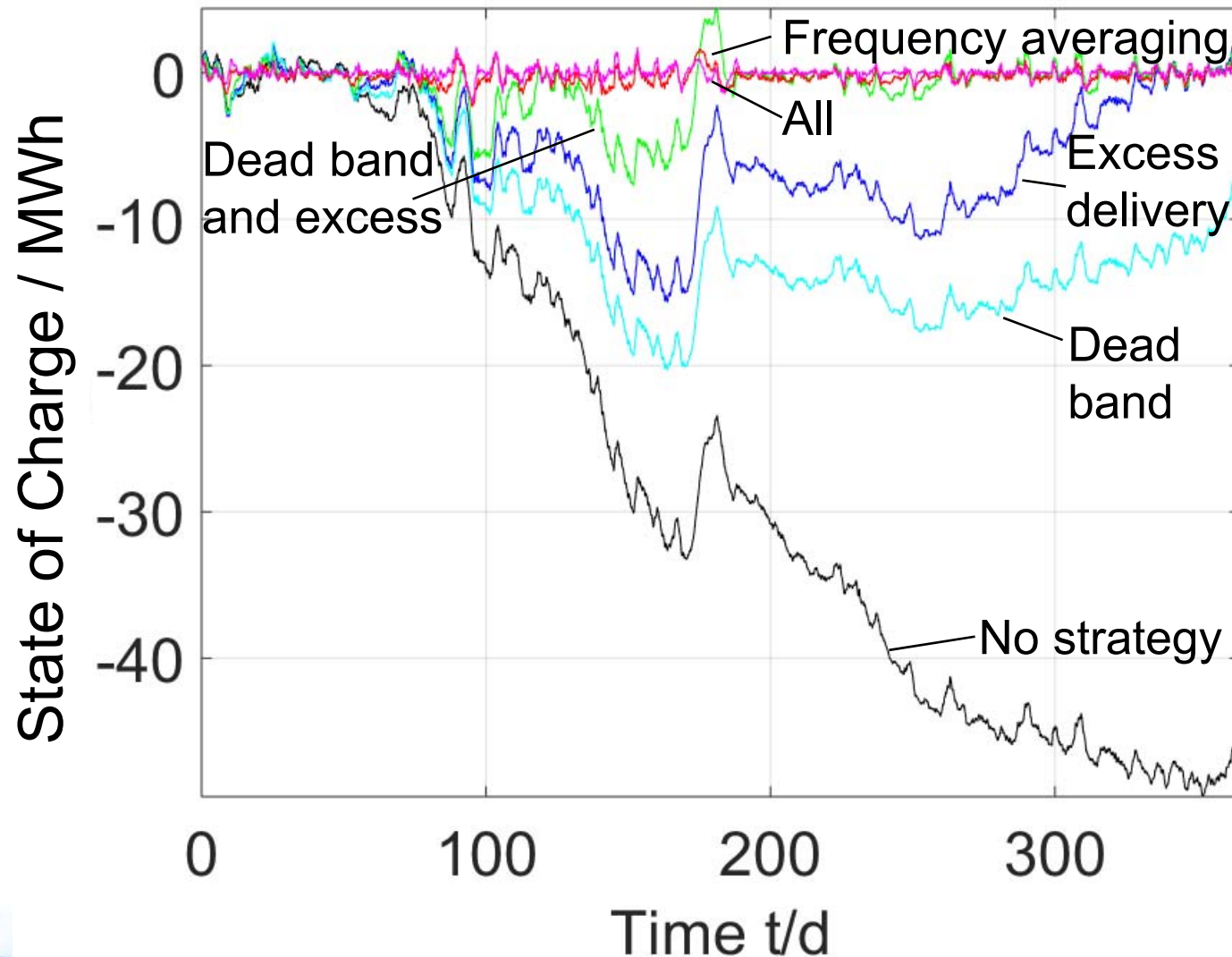


- Allowed frequency measurement error: ± 450 MWh missing
- To achieve missing energy < 1 MWh: Precision required ± 0.023 mHz

The idea: Compensate error by averaging



Effect of applying degrees of freedom



Conclusion



Primary control with batteries

■ *Problem:*

Strong depletion due to

- Charging losses
- Imprecise frequency measurements

■ *Solution:*

Use degrees of freedom

- Excess delivery
- Deadtime
- **Frequency: Averaging**

Contact

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