# Emerging ancillary service products in large-scale renewable energy integrated system

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1st international conference on

Large-Scale Grid Integration of Renewable Energy in India

Wind farm in chitradurga-pic taken from IREDA ppt

# Contents

# Wind turbine history



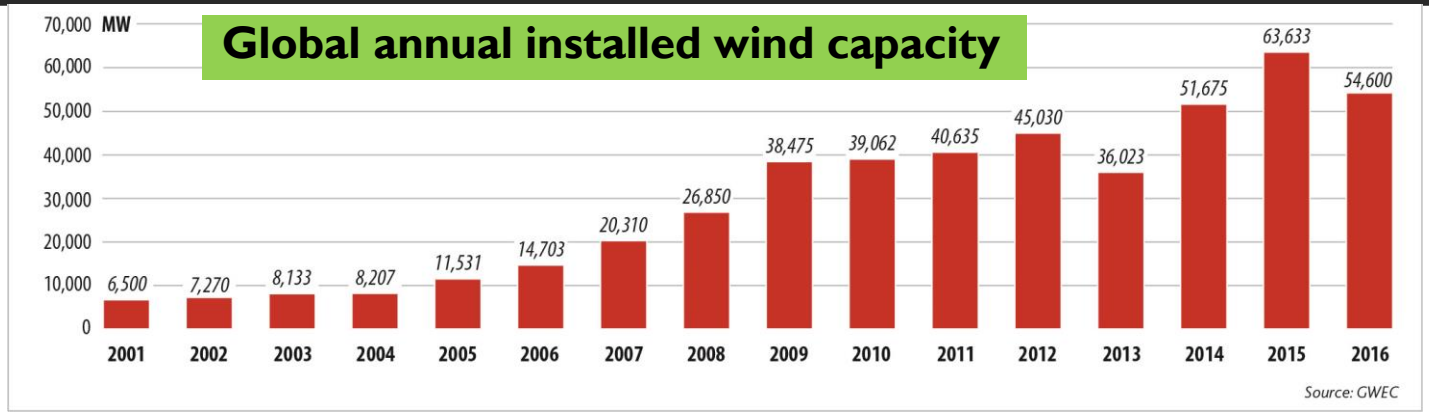
Tvindkraft, oldest operating wind turbine, 42 years old, Denmark,
1 MW capacity

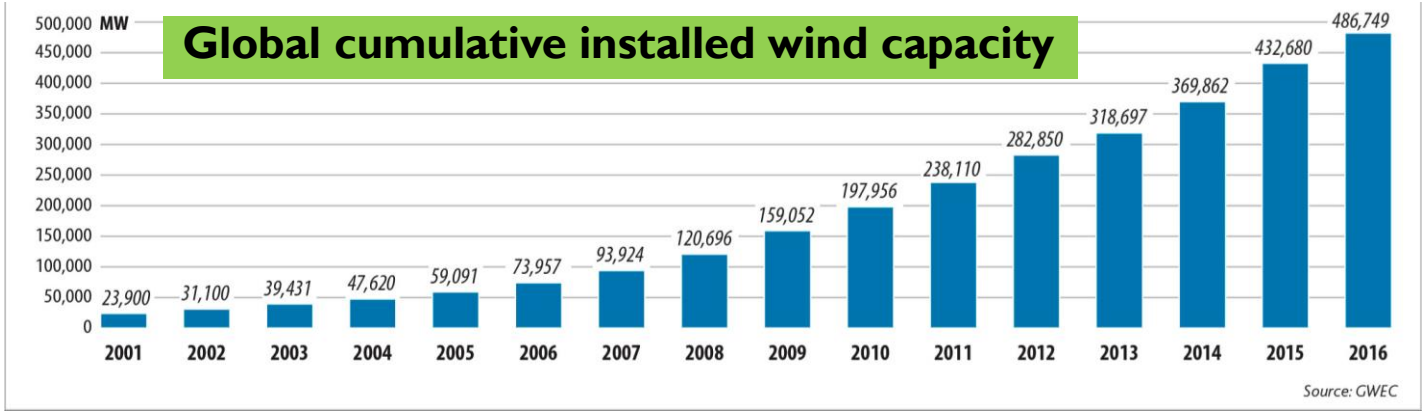
American wind turbines, 1900

Modern wind turbine

# Global installed wind power

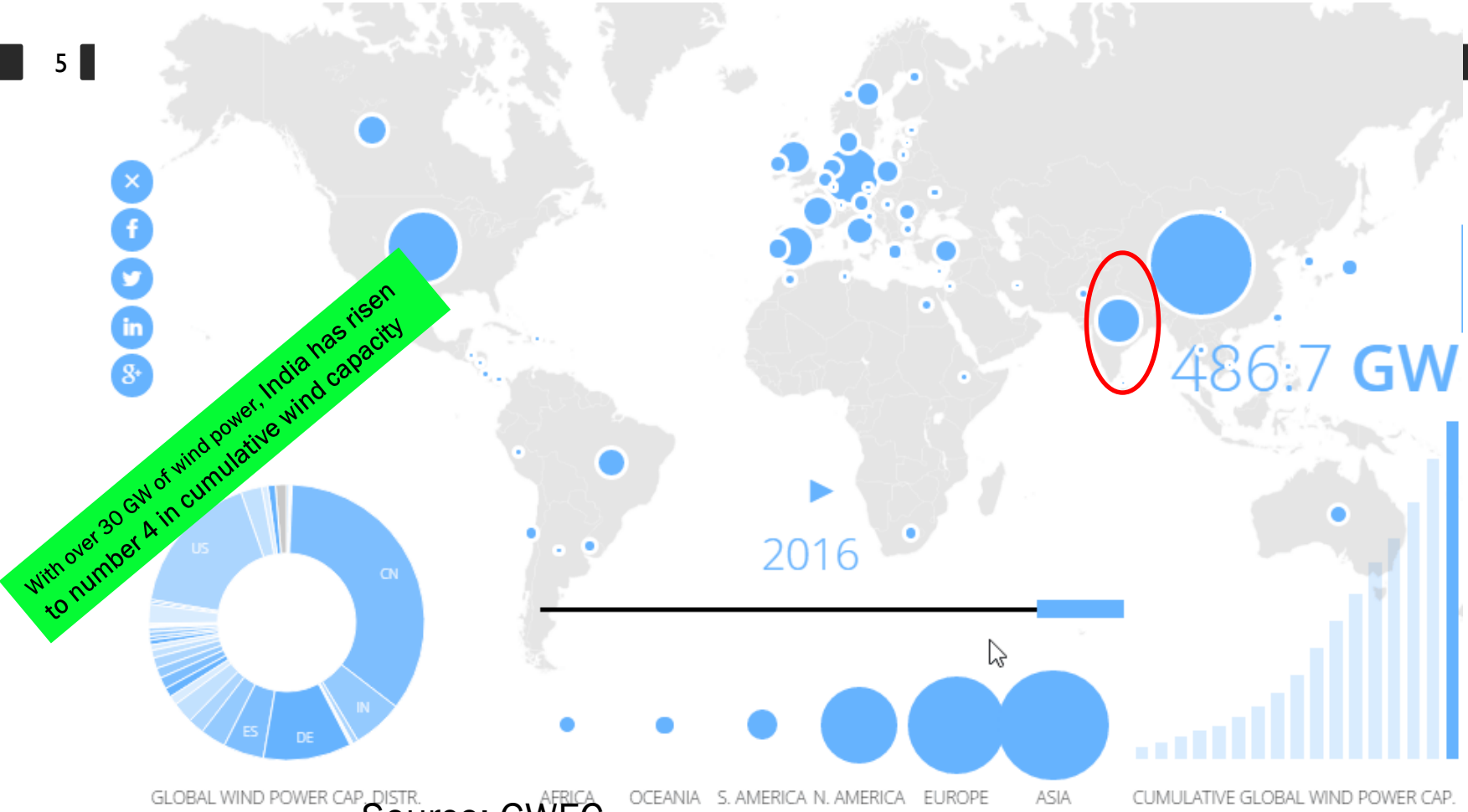




# Journey of wind power at global level






Source: GWEC

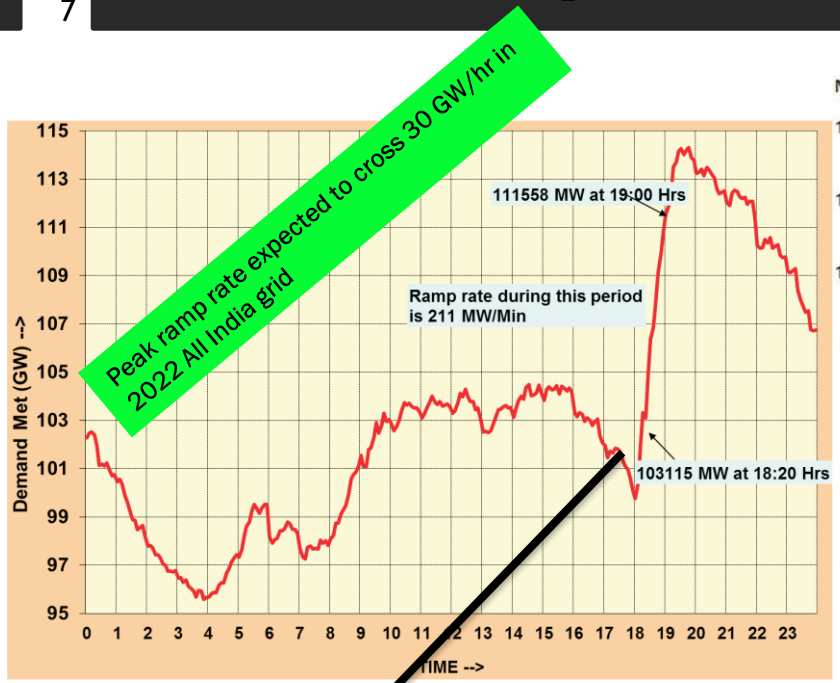
# Wind integration-Technical issues



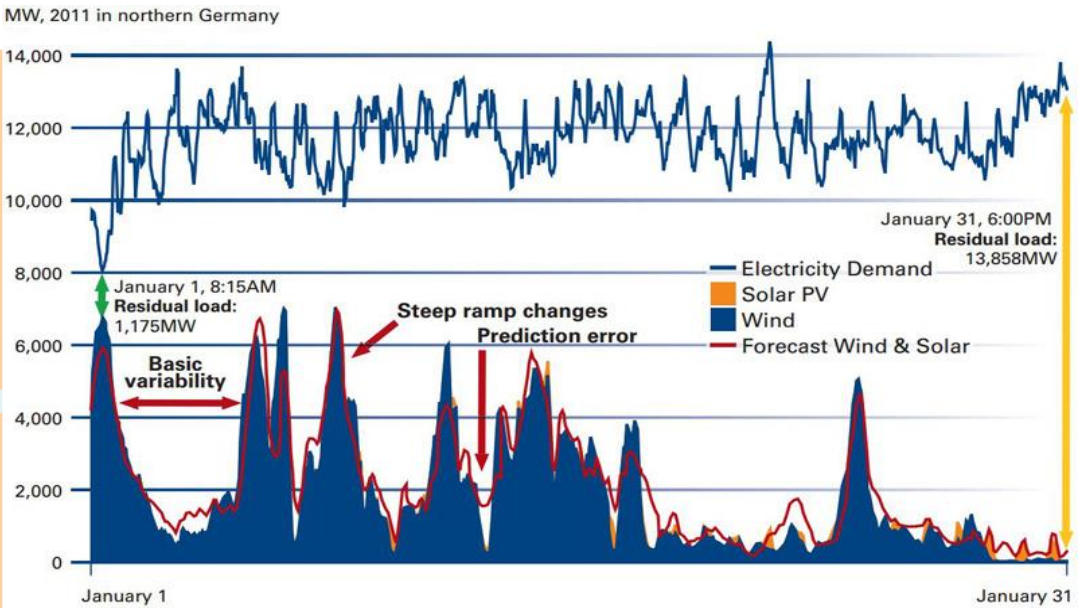
- Variable nature
  - Ramping Flexibility
- Wind-driven displacement of conventional synchronous power plant
  - low synchronous inertia
  - diminishing sources of frequency operating reserve
  - diminishing short circuit power and reactive power reserve
- Post-fault delayed active power recovery from wind turbine/plant

# Variability-need for flexibility






All India daily load curve (source: POSOCO)

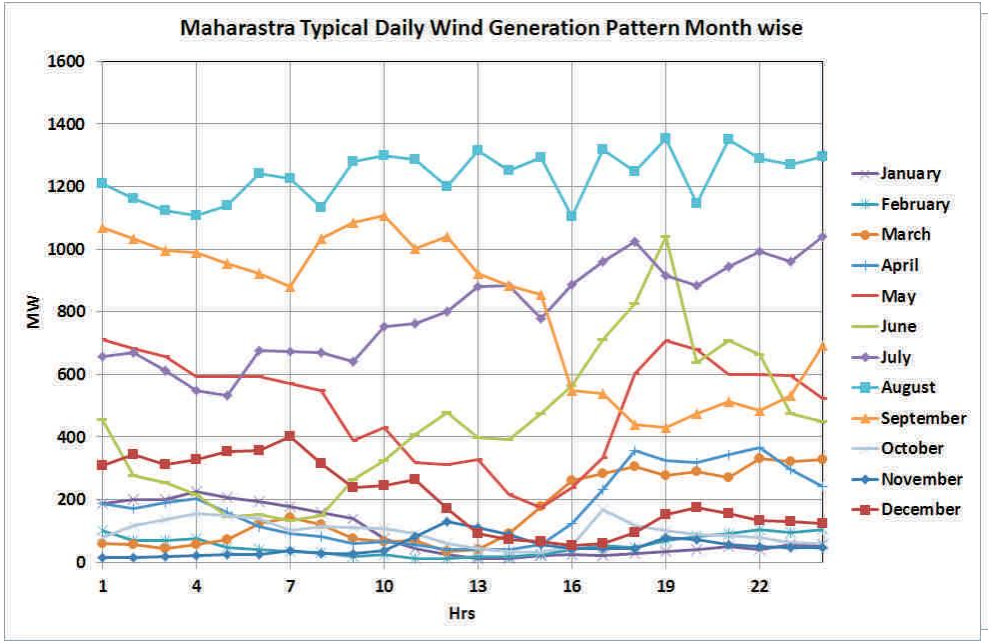


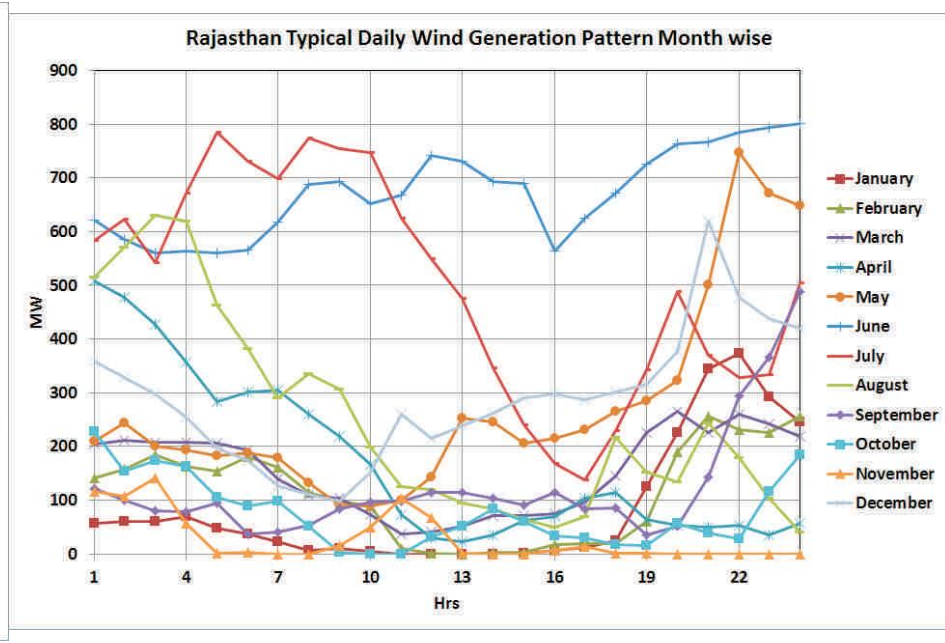

(SOURCES: SBC ENERGY INSTITUTE ANALYSIS BASED ON 50 HERTZ DATASET)

**2022 All India grid is expected to have significant downward ramp of Solar power generation, exacerbating the ramp requirement near evening peak**

# Variability-need for flexibility



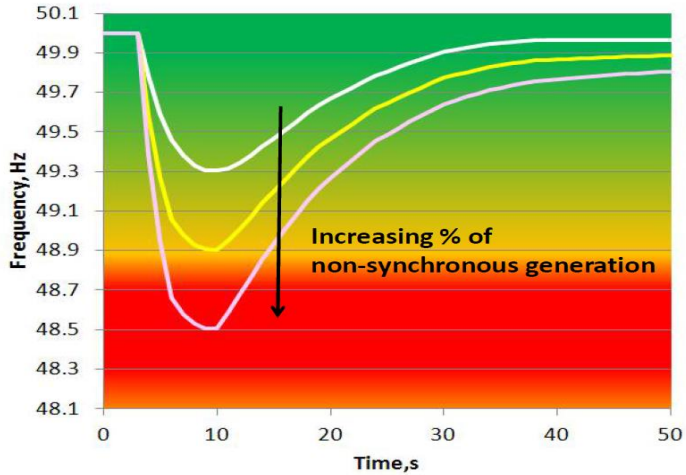


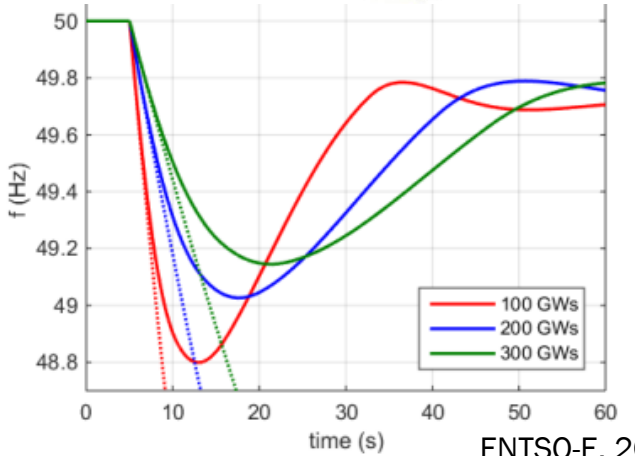




PGCIL, 2012

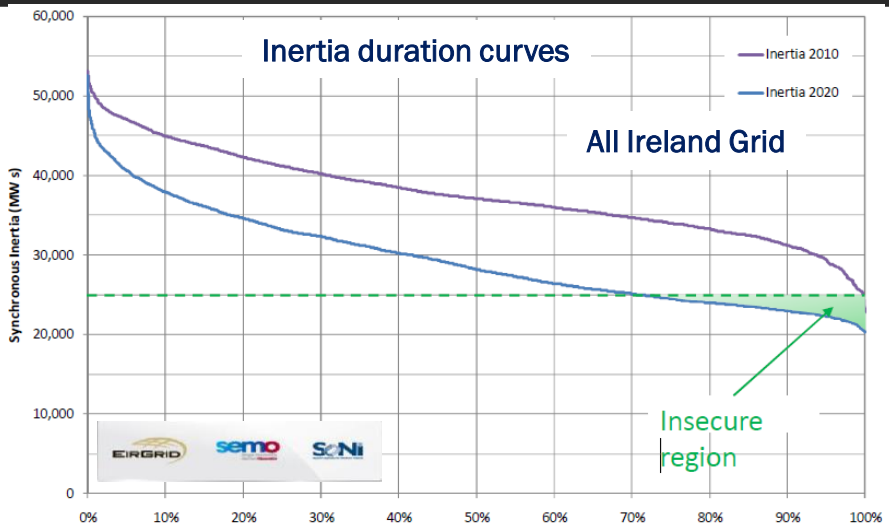
# System inertia under high wind penetration level

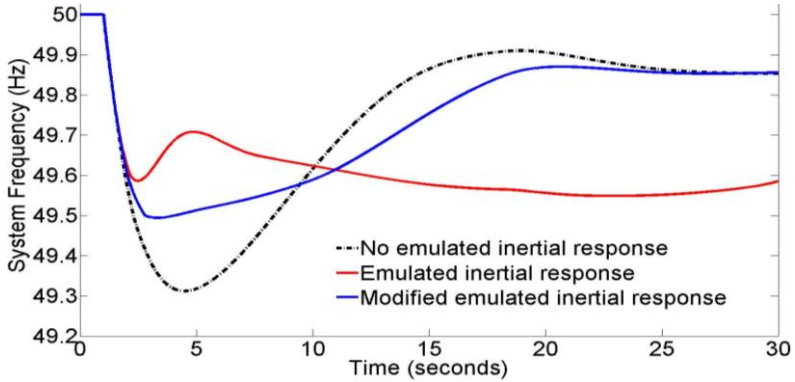





ENTSO-E. 2015

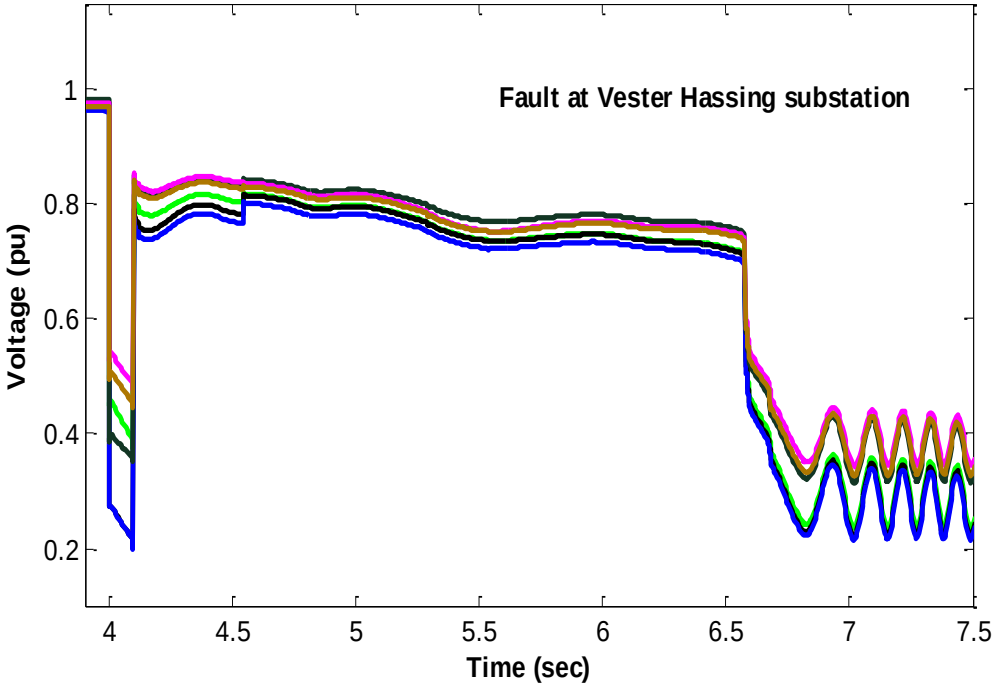


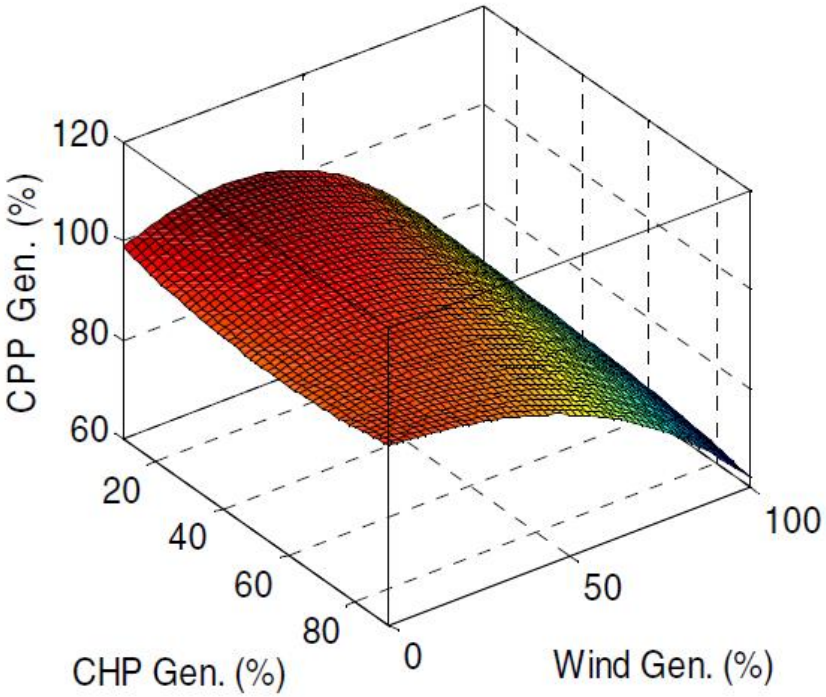

L. Ruttledge et. al., 2012

# Impact on grid security: Danish case study






Rather et al., 2015




Chengxi liu et al., 2014

# Reactive power support from must run conventional power plants in Danish grid



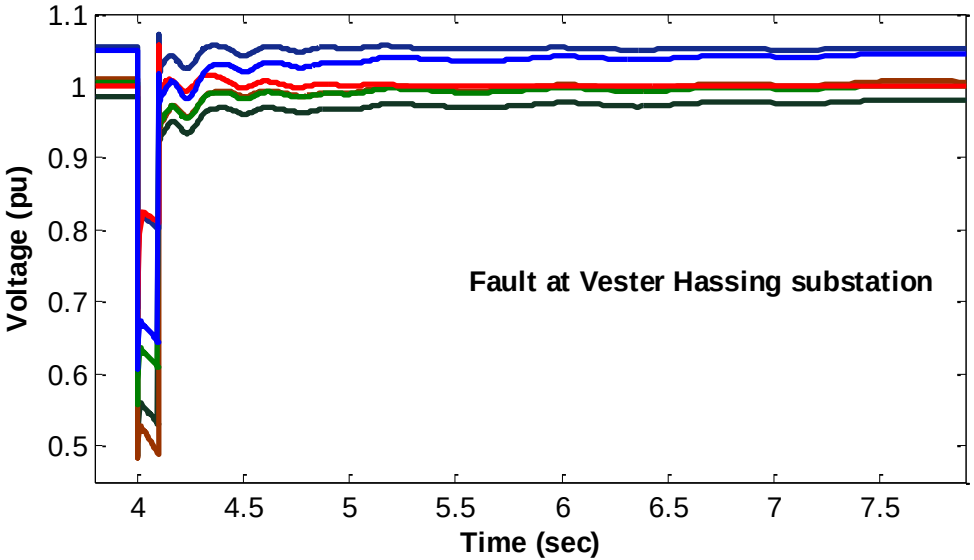
- Short circuit power
- Dynamic voltage control
  - Reactive power consumption from old wind turbines and commutation of HVDC LCC
- Continuous voltage control

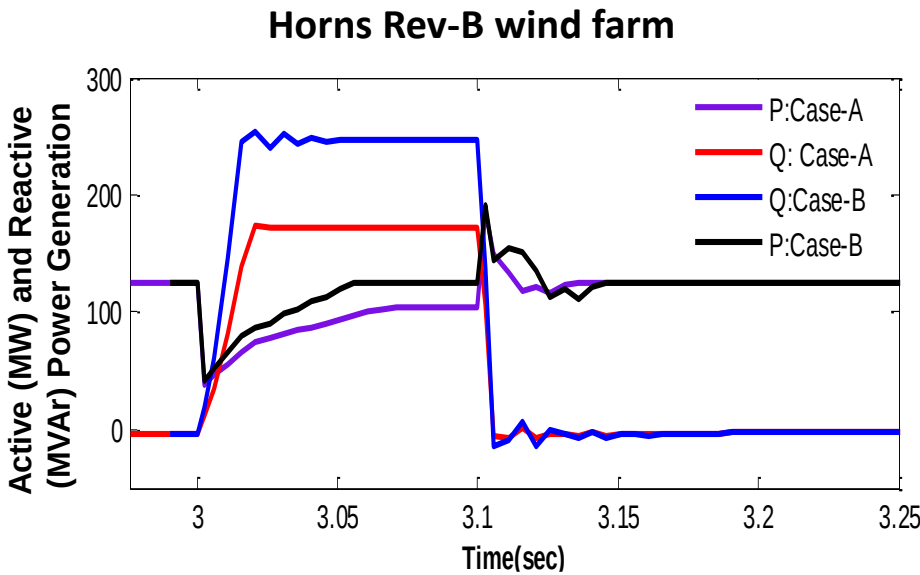
(Active power reserves are bought in separate markets and do not give rise to must-run)

**Must-run was costly**


Source: Energinet.dk (Danish TSO)

# Dynamic voltage stability considering dynamic reactive power compensation

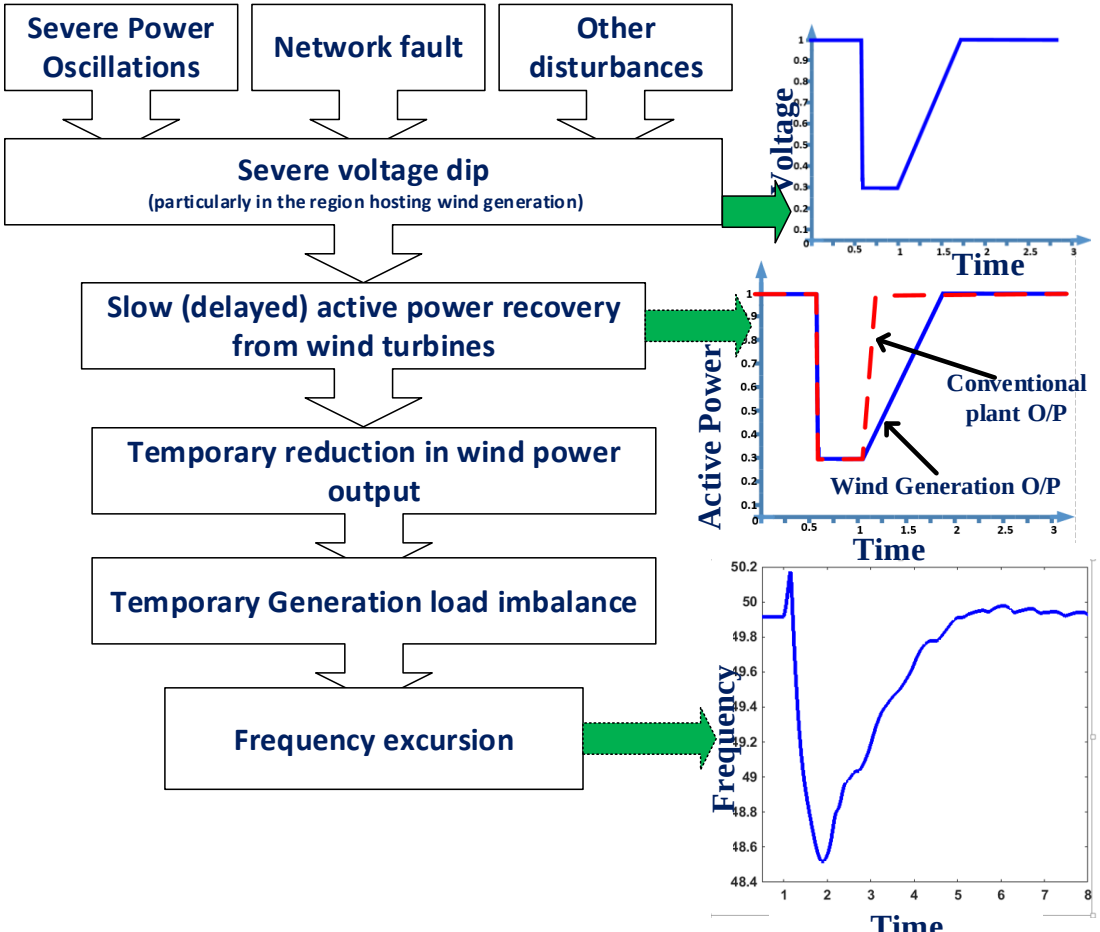



Rather et al., 2015

# Post-fault delayed active power recovery





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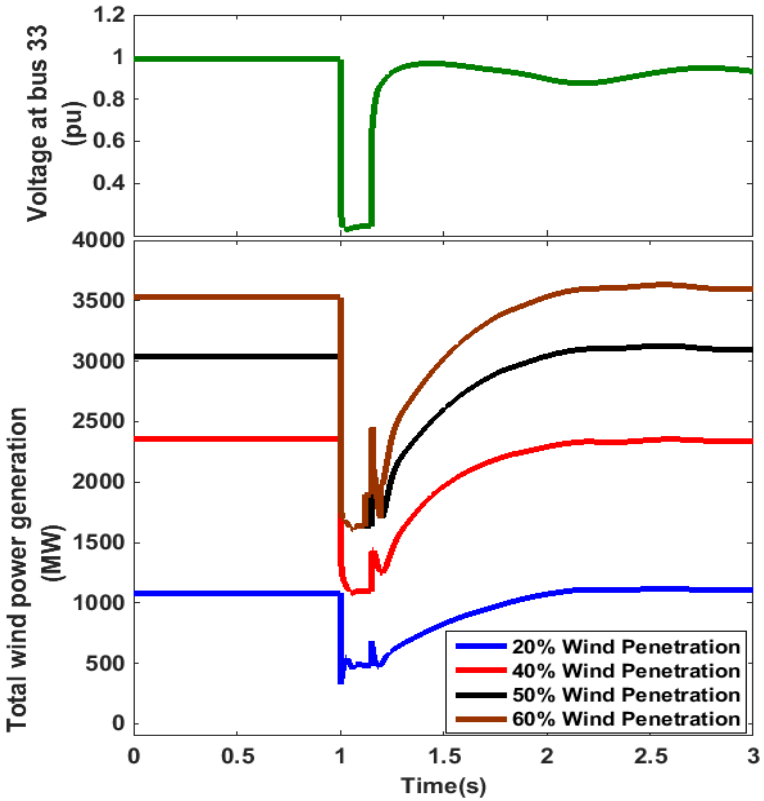


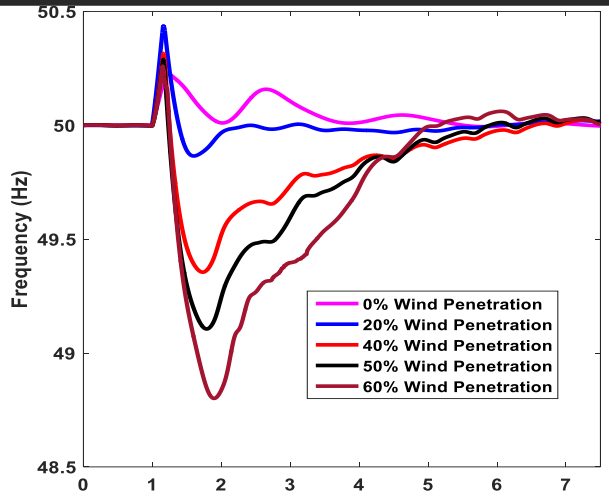


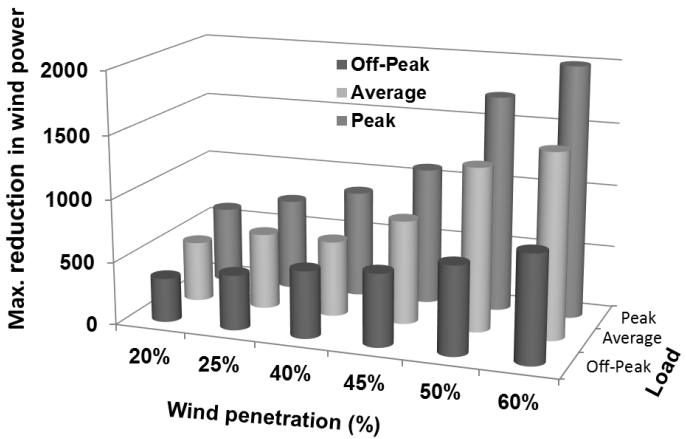


Rather et. al, 2017

# Conclusion



- High wind penetration-need for new and emerging ancillary service products for secure grid operation
  - Ramping margin/flexibility
  - Synchronous/non-synchronous inertial response
  - Fast frequency reserve
  - Dynamic reactive power reserve
  - Post-fault active power recovery reserve


THANK YOU
FOR YOUR
KIND ATTENTION