# Influence of Renewable Energy Sources on the European Transmission System

## *Impact of Increasing Volatility of Generation and Demand on the Security Level Supply*

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# Overview

**European power system**

**VGB research project**

**Stationary aspects**

**Dynamic aspects**

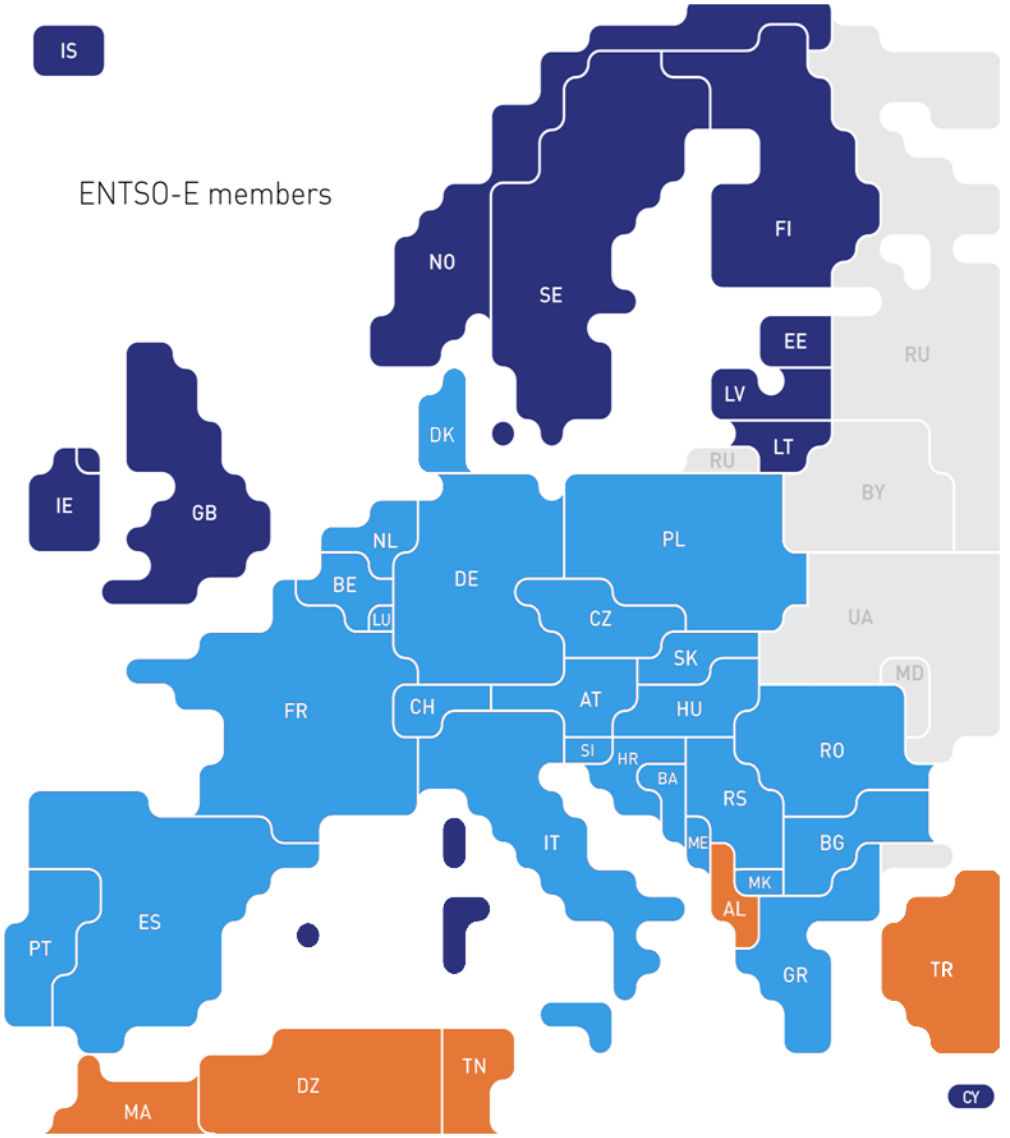
**Outlook**

**Conclusions**

# Synchronous grid of Europe

**Basic data on the European electrical power system:**

- Peak load: approx. 400 GW
- Off-peak load: approx. 150 GW
- Area of supply:  approx. 500 Mio. customers
- One of the largest synchronous systems of the world
- Special characteristics:
  - Geographic extent over three continents
  - Highly interconnected grid
  - 27 different TSOs

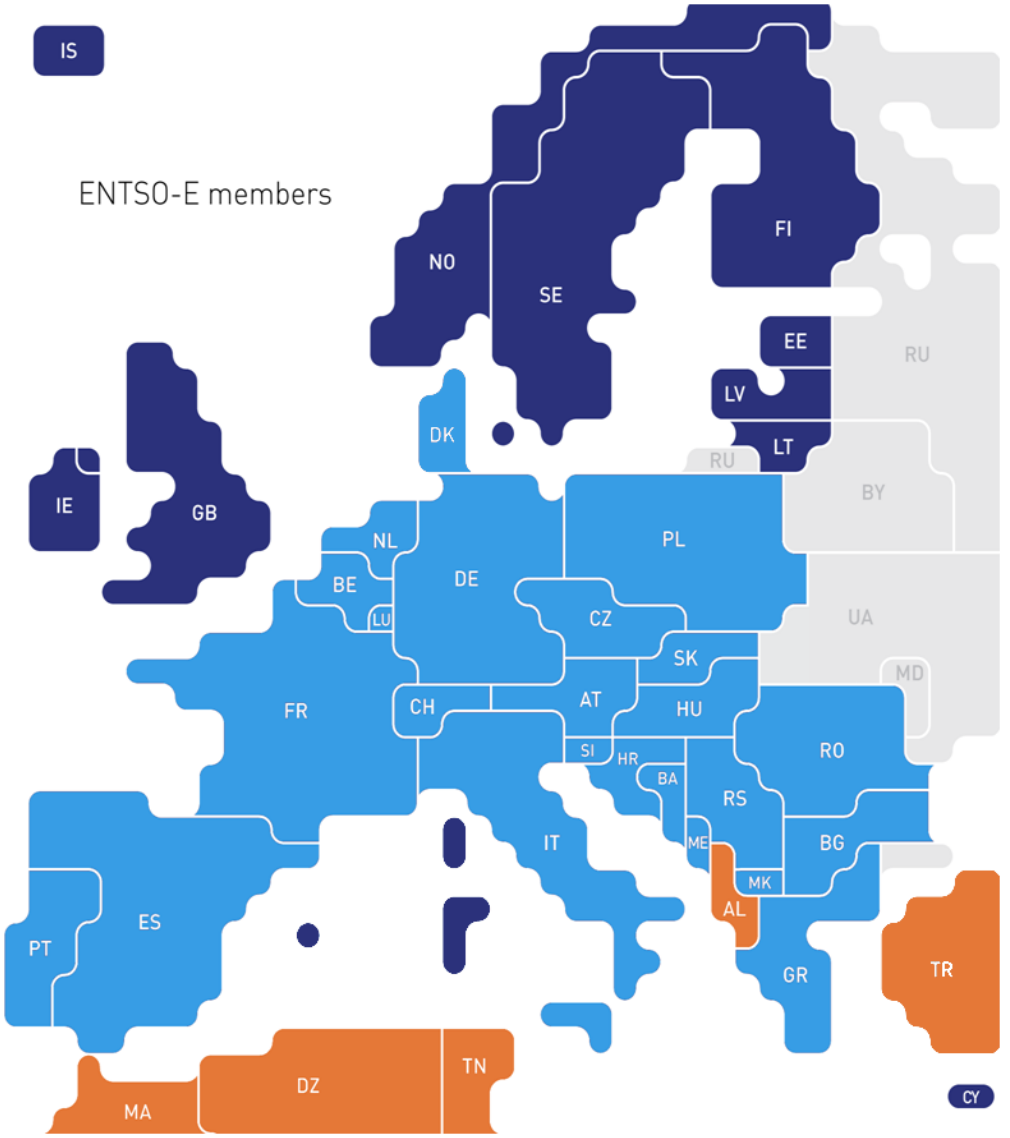


# Synchronous grid of Europe

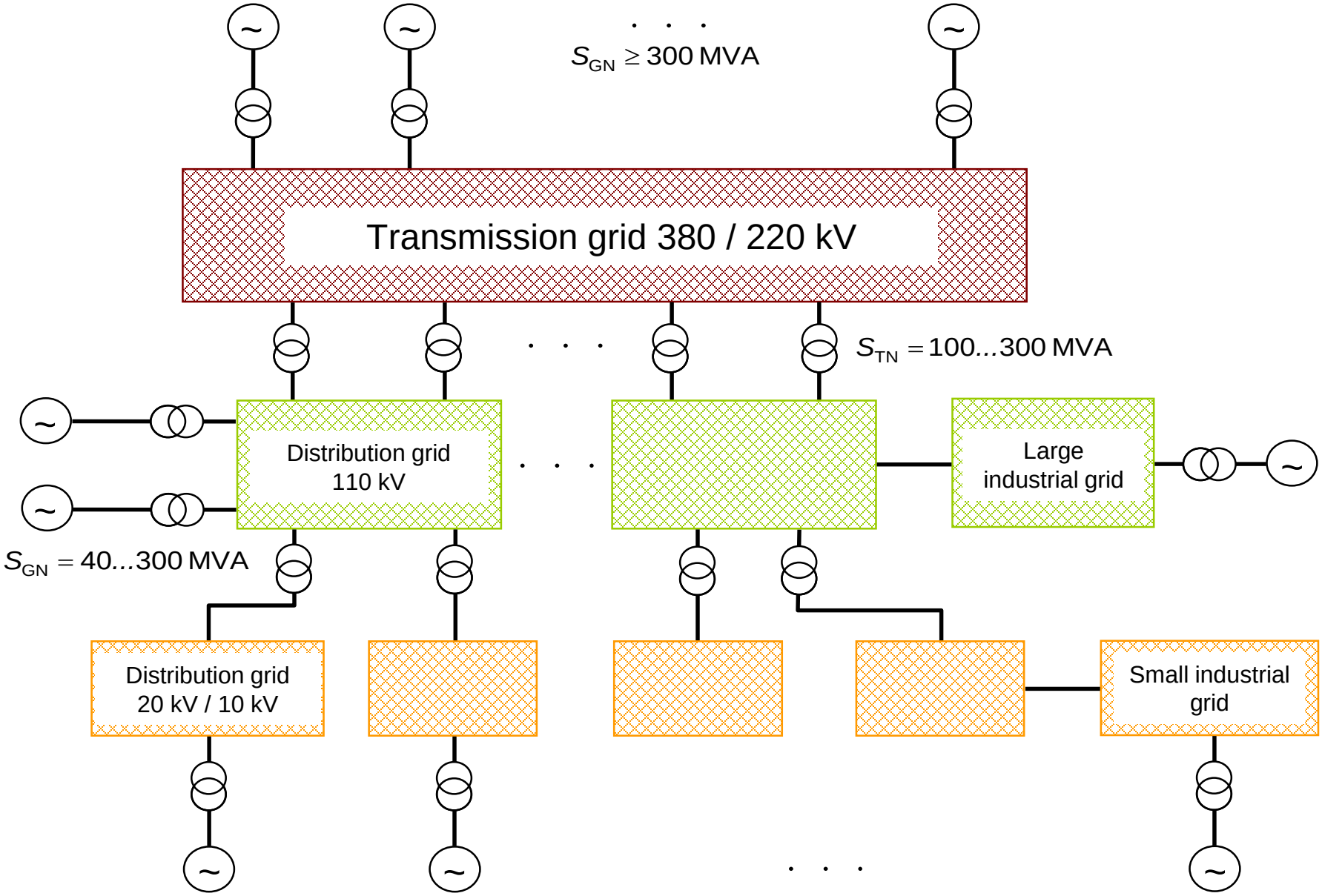
www.entsoe.eu

ENTSO-E RG CE

Synchronous connected areas



# Structure of power grid



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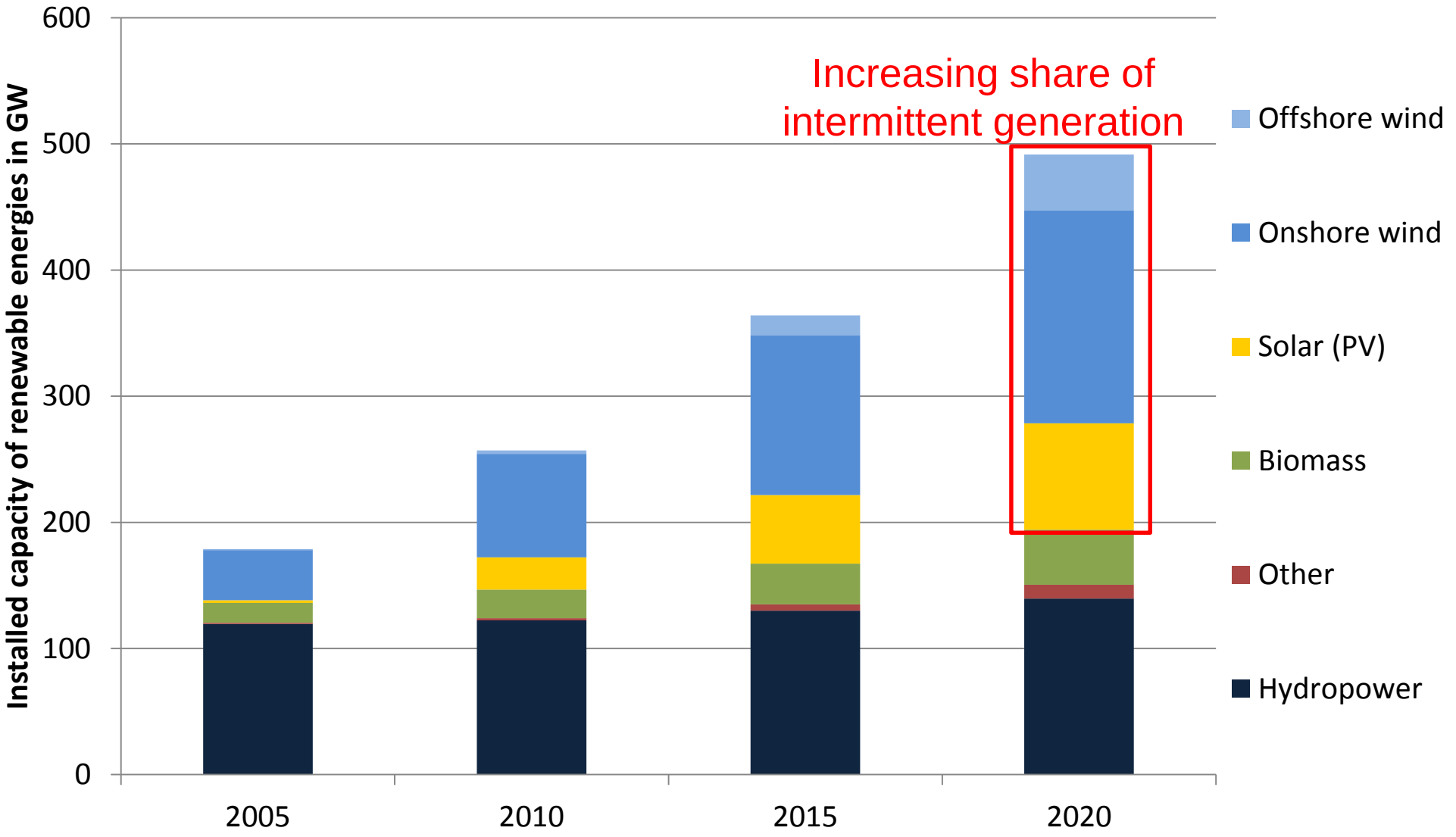
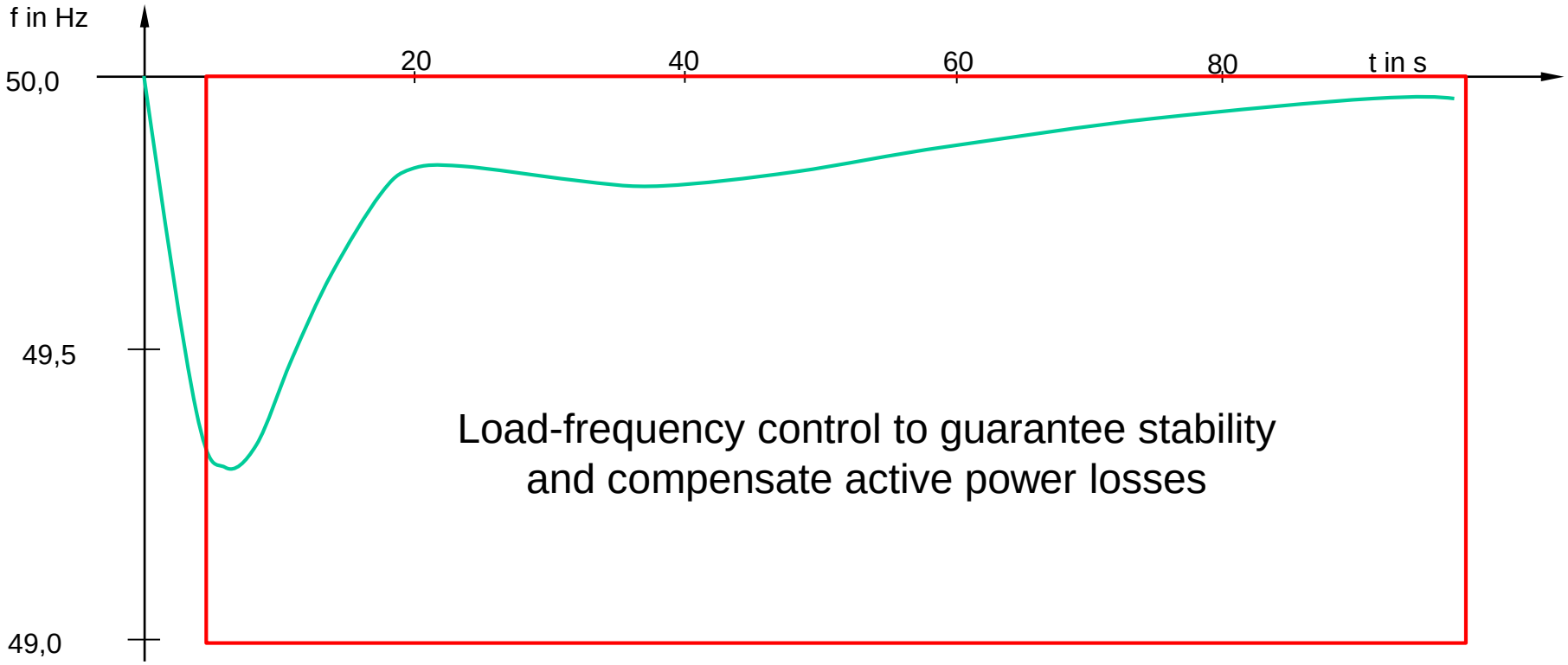
# Renewable energies in the European Union




Source: National Renewable Energy Action Plans (NREAP) collected by ECN

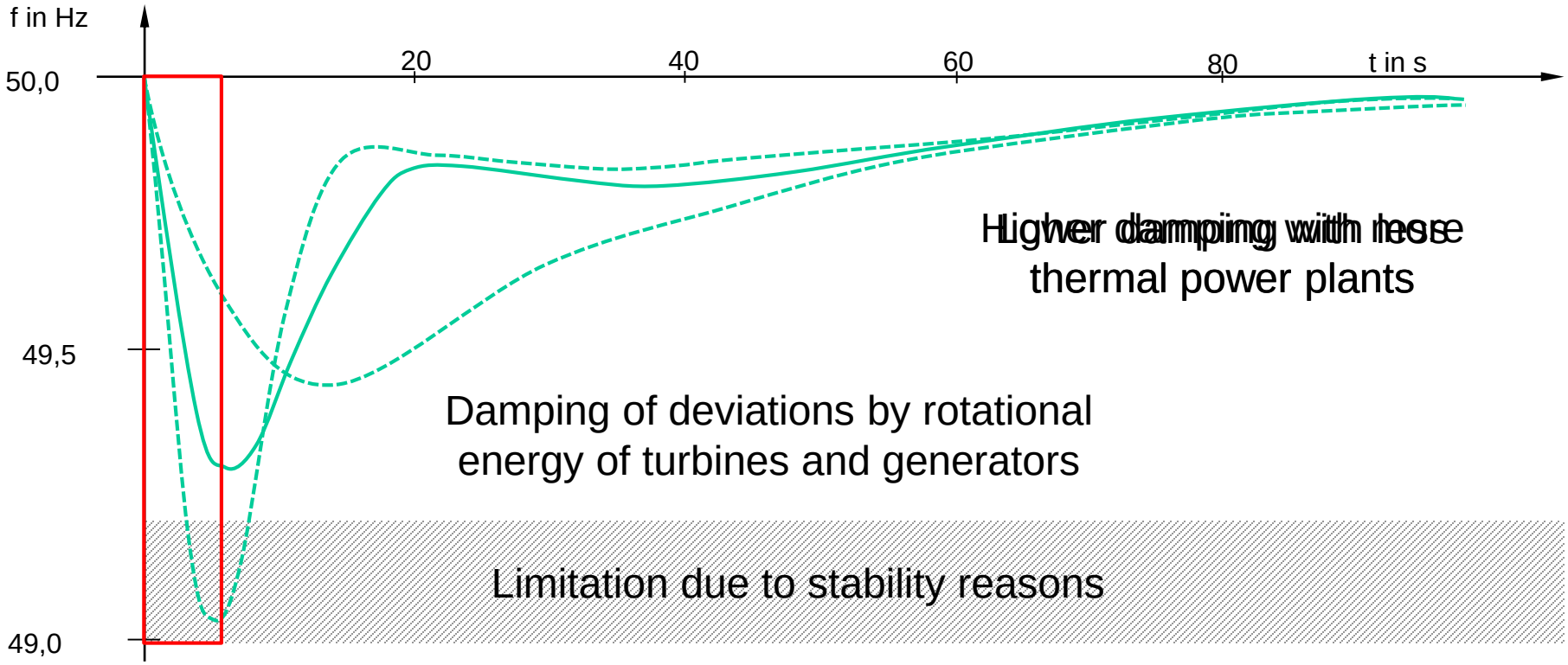
# Secure system operation

- Load-frequency control (primary, secondary and tertiary control)



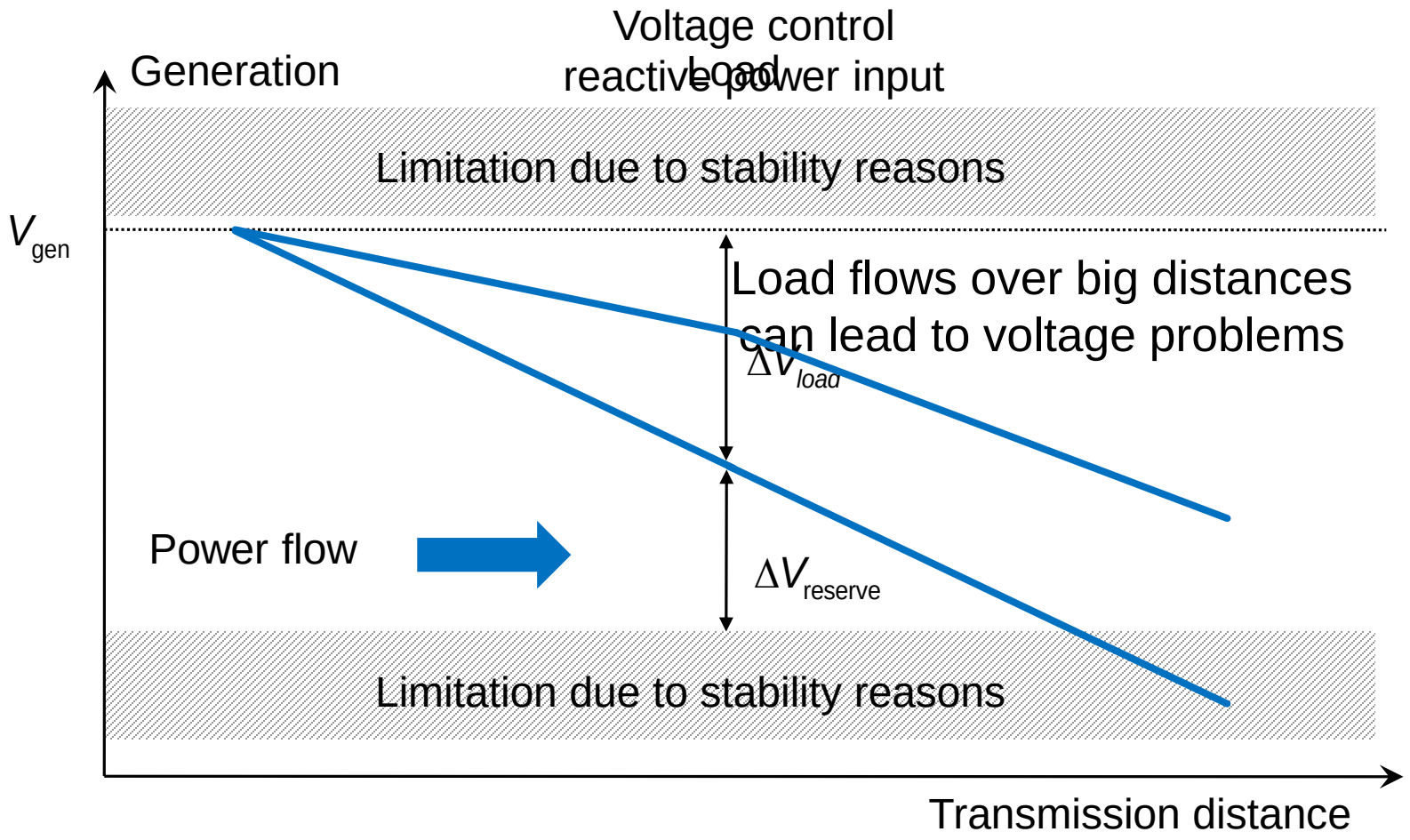
# Inertial response - grid inertia

- **R**ate **o**f **C**hange **o**f **F**requency (ROCOF) becomes problematic for systems with high feed-in from wind power like Ireland



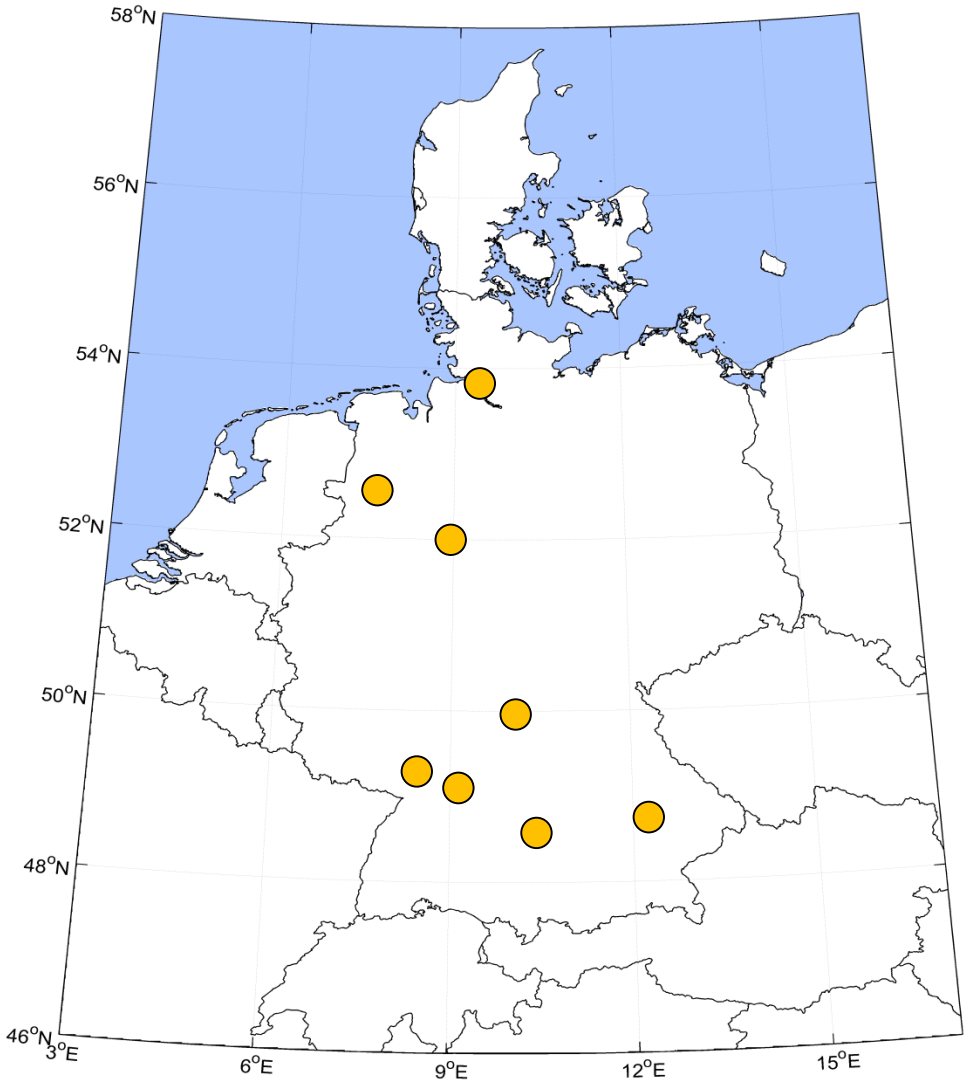
# Voltage control

- Voltage drop due to power flow



# Challenges within the European power grid

- Integration of renewable energy sources
- Increasing power flows over long distances
- German “Energiewende” with nuclear power phase out



# Joint research project

***„Influence of Increasing Generation and Consumption Volatility on Reliability of Supply “***

1. Worst case simulations (University of Rostock)
   - Time-frame up to 2020 and beyond
   - Copperplate model

2. Detailed simulation of power system (University of Stuttgart)
   - Current development up to 2020
   - Detailed model of European power system

➢ Different levels of detail and assumptions

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# Simulation procedure

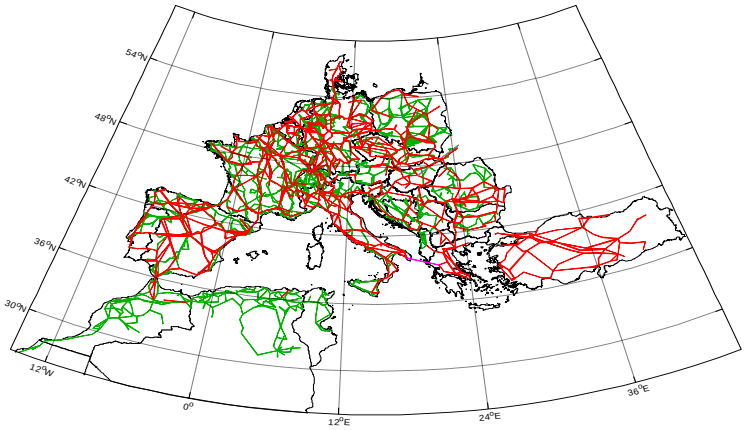
***Input*** ***Model*** ***Output***

Renewable Generation

Conventional Generation

Power Consumption

Detailed Model




Power Grid Development

Geographical Distribution

Voltage Distribution

Power Flows

Transient Dynamics

# Power flows and transmission limits – scenario 1

### *Scenario 1.a (2011):*

- Power flows from North to South
- Line utilization within limits

### *Scenario 1.b (2015):*

- Increasing power flows into western and southern region
- High load on few lines, already identified in NEP

### *Scenario 1.c (2020):*

- Overload on several lines
- NEP actions will improve utilization