Regeneratives Kombikraftwerk Deutschland: System Services with 100 % Renewable Energies

Dr. Kurt Rohrig
Fraunhofer IWES
Paris
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Kombikraftwerk 2

Review „Kombikraftwerk1“

- **Finished:** October 2007
- **Objective:** Demonstration of feasibility of 100% RES Energy Supply
- **Method:** ICT linkage of wind, solar and biogas power plants to a RES VPP

  Energy mix and capacity of plants correspondent to 100% scenario

German Award for Climate Protection 2009

- **Open Question**: Is a 100% RES scenario technical reliable and robust?

➢ **Quality of supply?** (voltage, frequency and grid stability)

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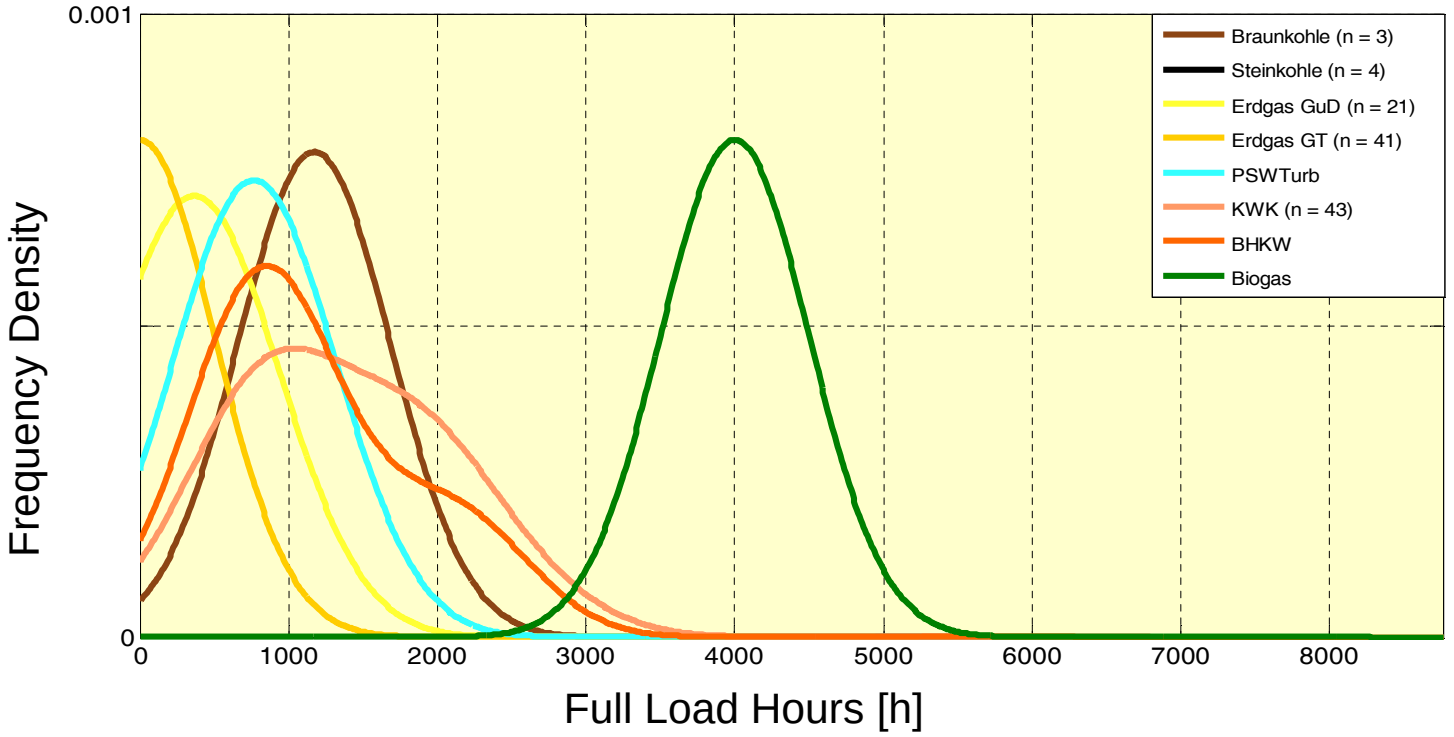
Development of Generation System in Germany



Source: BMU-Leitstudie 2011 (2020/2050)

„Kombikraftwerk 2“

Gefördert durch:

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit

aufgrund eines Beschlusses des Deutschen Bundestages

- **Objective:** Analysis of stability of 100% RES electricity supply in Germany

  (not considered: heat and mobile sector and economical aspects)
- **Supported:** Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit
- **Total Budget:** 3,053 Mio Euro
- **Support:** 1,810 Mio Euro
- **Duration:** 3 years
- **Finished:** December 2013
- **Team:** 10 partners from science, industry and service provider
- **www.kombikraftwerk.de**

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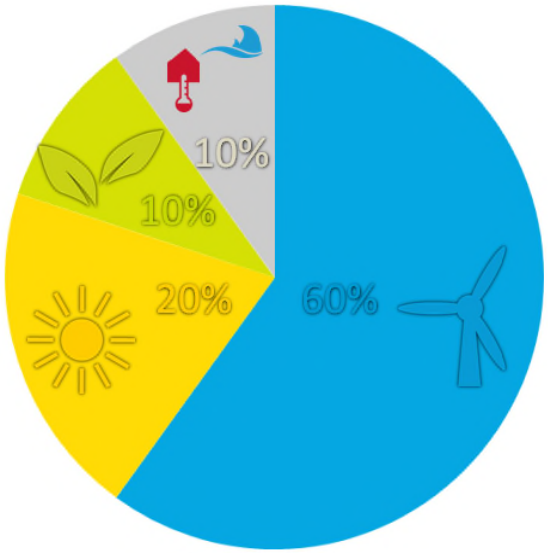
Part I: Simulation of a Future Electricity Generation with RE

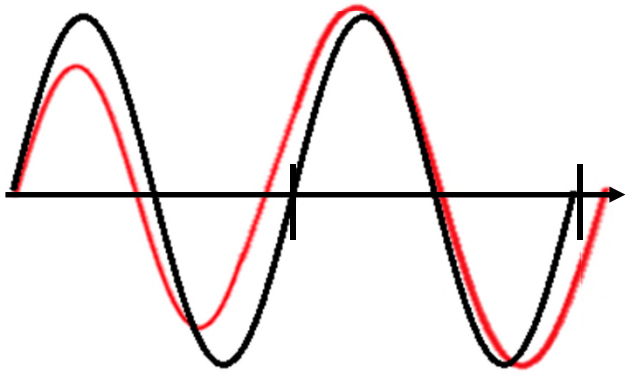
<u>Development of a consistent, spatial high-resolution scenario</u>

- energy mix
- detailed modelling of future generation park
- determination of storage capacity
- determination of generation peaks, surpluses and lacks
- where and when appear extreme situations in terms of frequency and voltage in future?

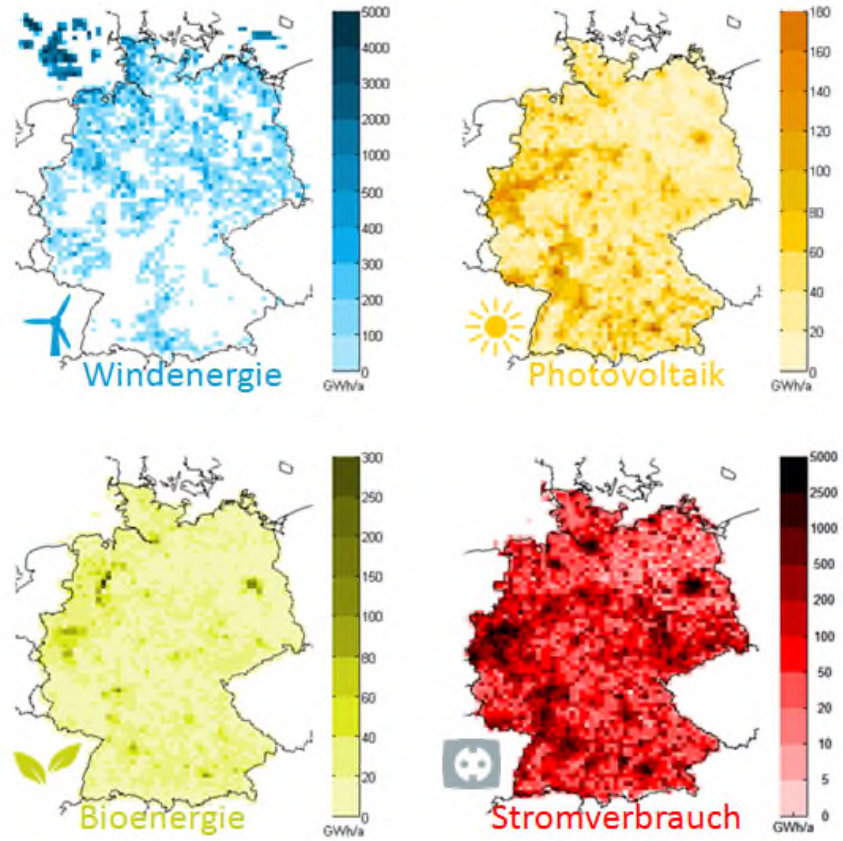


<u>Analysis of the system concerning its stability</u>

- amount of demand on control power and reactive power in the system
- can RES deliver all needed system services?



Modelling of spatial distribution



- High diversity of technology
  - ✓ 5 WPP-types
  - ✓ 5 PV-plant types
  - ✓ 10 bio energy types
  - ✓ Geo thermal
  - ✓ Hydro power
  - ✓ Methane power plants
  - ✓ 4 Energy storage types
  - ✓ 7 Demand scopes
  - ✓ Import and export
- considering potential areas, todays distribution and weather conditions
- unique high spatial resolution (exact location or 100m x 100m)

➢ interactive scenario map

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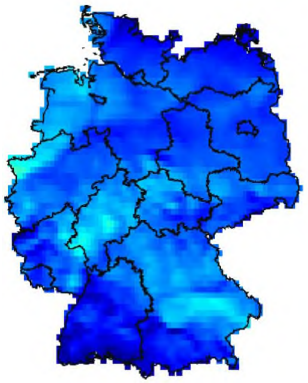
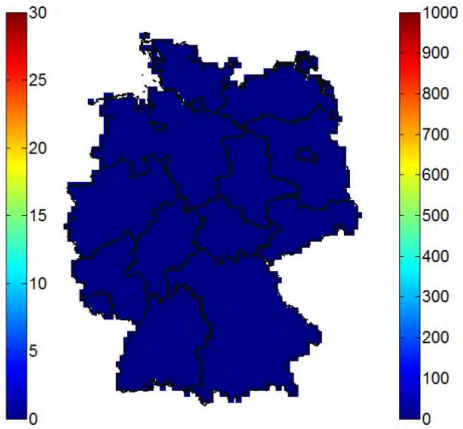
Temporal Characteristics of Energy Supply System

Wind speed [m/s]



Solar radiation [W/m²]



Transmision system model

Today‘s Grid

+ Offshore connection

+ dena1 + NEP2012

+ Own extension

- Weather dependent generators
  - high resolution historic weather data from Deutscher Wetterdienst (DWD)
  - physical plant models i.e. turbine characteristics, wake effects (wind), orientation, inclination (PV)
- Demand
  - historical load series
  - standard load profiles
  - load management strategies
- Balancing system (bio energy, storage systems, methane power plants)
  - determination of capcity and site selction by cost optimizing commitment and dimensioning

➢ Load flow animation

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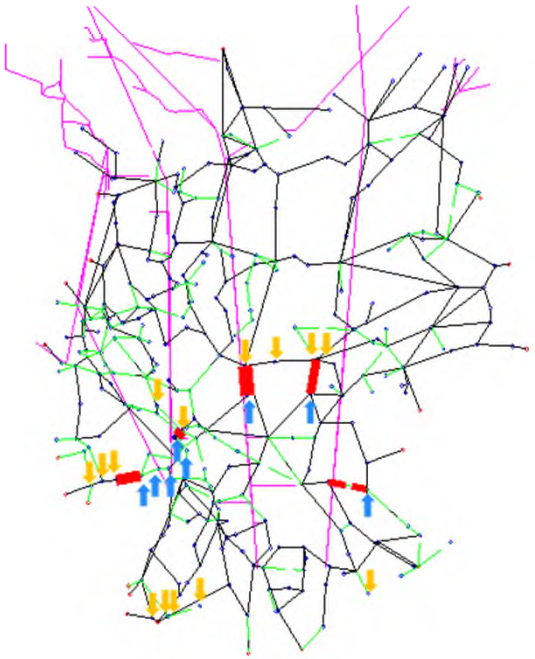
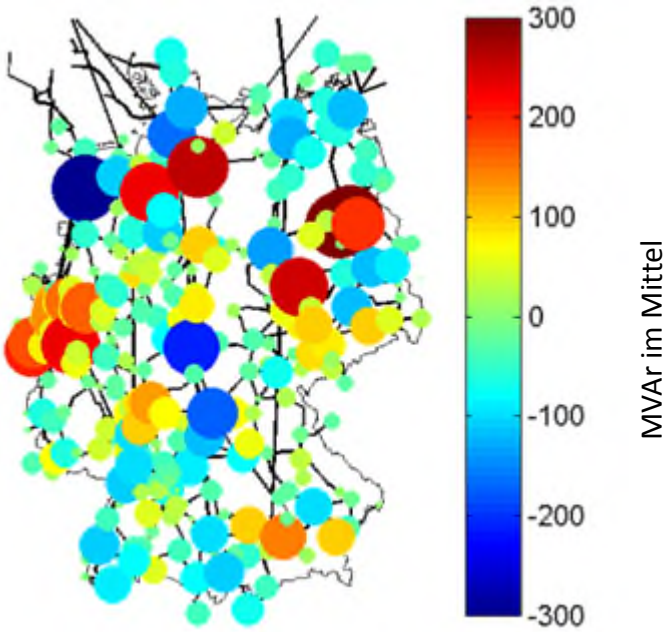
Stability Analysis and Calculation



- **Congestion detection** by n-1-reliability analysis
- **Congestion management** by multitude of decentralized plants



- **Reactive power demand** by AC-load flow calculation
- **Reactive power provision** by estimation of impact of connected plants

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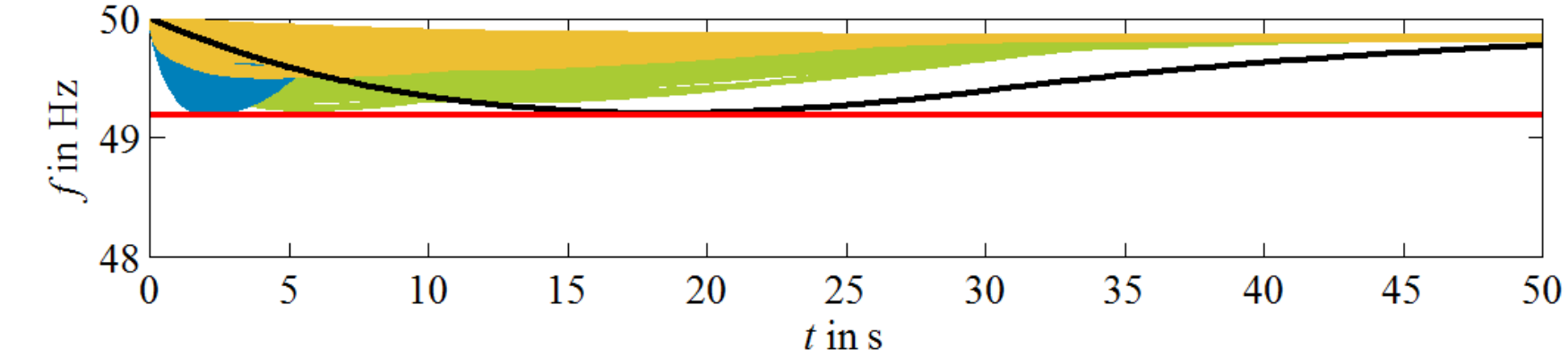
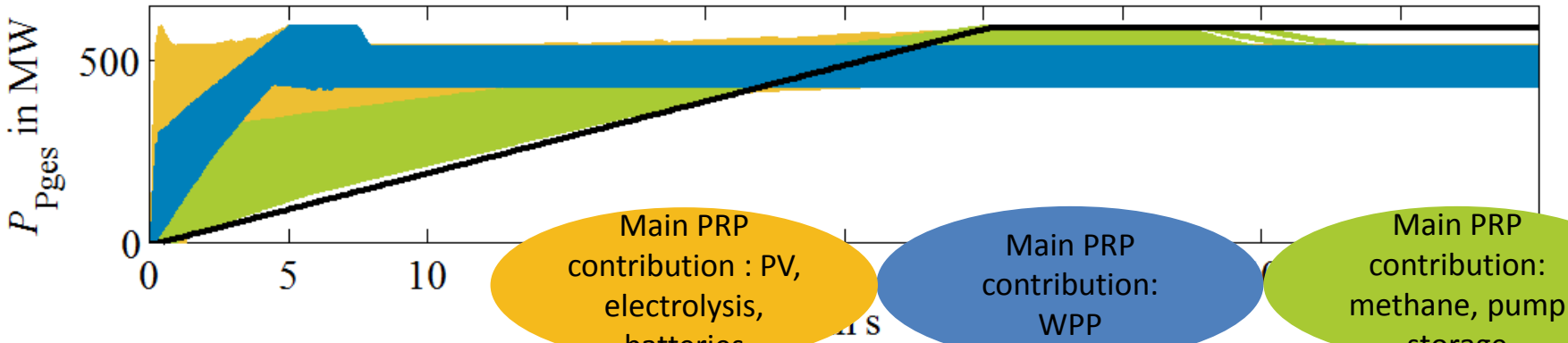
Improvement of Frequency Characteristics





Main PRP contribution : PV, electrolysis, batteries

Main PRP contribution: WPP

Main PRP contribution: methane, pump storage

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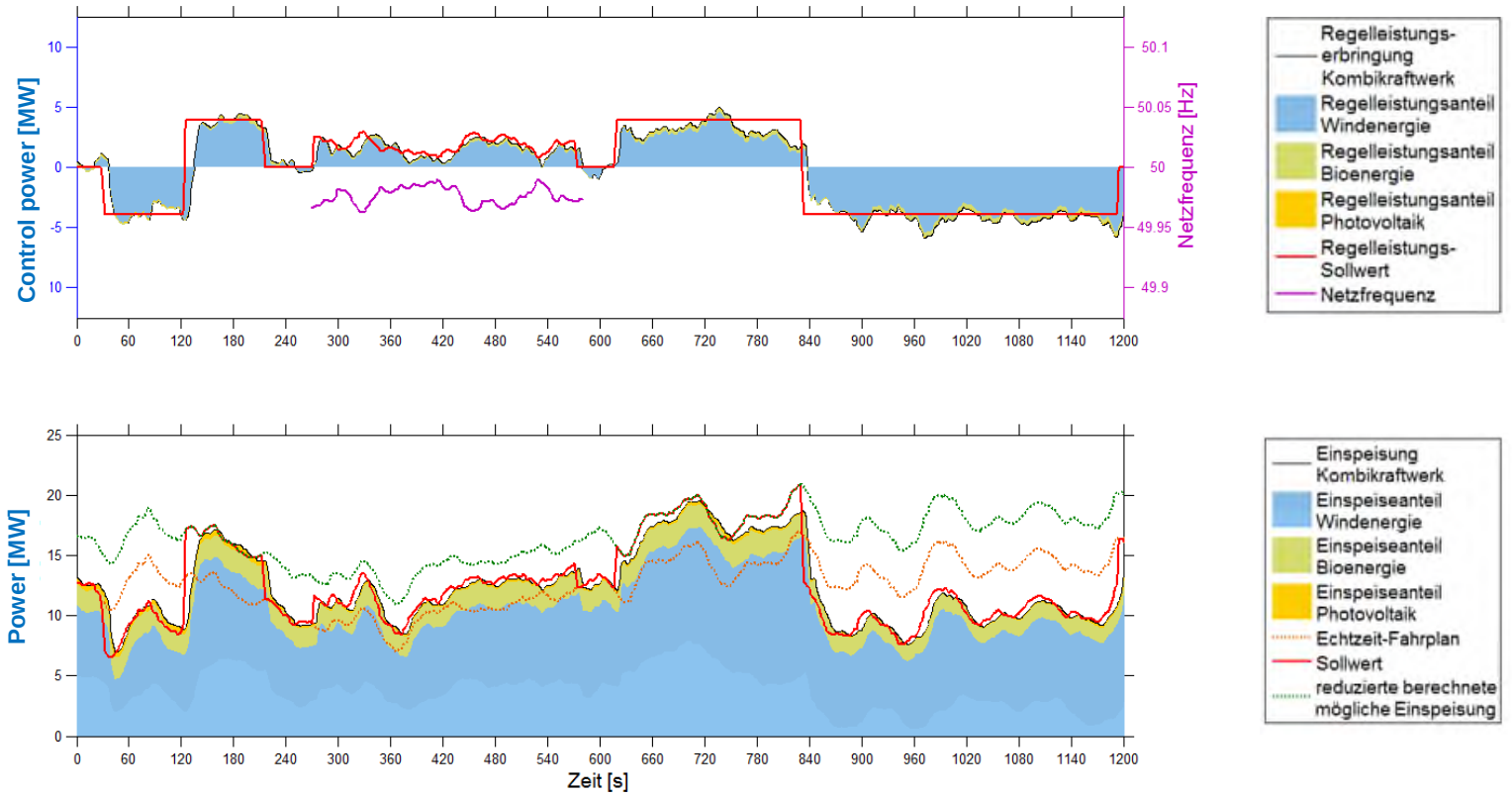
Control Power Provision: Field Test - Record



Conclusion

A safe and stable 100% RES power supply is technically feasible if renewable energy generation, storage and backup power plants with renewable gas interact intelligent

1. **System design**
   - 100 % RES are only feasible by the massive use of new storage technologies (eg electrolyzer, methanation , batteries).
   - Weather independent producers (mainly methane , biomass and hydro) must be available for safety's sake , with a total power of the order of the maximum load.
   - The DC lines of the NEP have a positive effect on network congestion and voltage stability .

2. **Frequency stability**
   - The rise of average control power demand is not expected due a new type of dynamic dimensioning and can always be covered easily in the 100 % RE system.
   - The reduction of rotating mass by increasing use of converter systems can be compensated by the rapid deployment of PRP due RE facilities and storage .

3. **Voltage control**
   - Reactive power demand will always be covered , possibly with additional compensation systems in consumption centers .
   - Distributed generation systems can be used to compensate the inductive reactive power demand of the loads.

4. **Congestion management**
   - The flexible generators and storage devices were positioned and adapted to minimize grid loads. This limits the re-dispatch and grid expansion efforts.
     Multiple (n-1) - bottlenecks can be overcome by optimized re-dispatch with distributed , small plants.

Thank You for Your Attention

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