Electrification of energy supply - sector coupling and digitization as drivers of the transformation

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Power to Change – governments, climate & mobility
Fraunhofer-Gesellschaft conducts applied research and comprises 66 institutes across Germany

- Europe’s largest applied research organisation
- Undertakes research for direct use by private and public enterprises, providing a wide range of benefits to society
- 80 research units, including 66 Fraunhofer Institutes
- Staff of around 24,500
- Annual research budget of around 2.1 bnEUR
Our service portfolio deals with **current and future challenges** faced by the **energy industry** and **energy system technology** issues.

We explore and develop **solutions for** sustainably **transforming renewable based energy systems**.

- Personal: approx. 310
- Annual budget: approx. 22 Mio EUR
- Director: Prof. Dr. Clemens Hoffmann

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Progress of Renewable Energy Use

In 2017, the total renewable energy supplied the largest share of the gross power consumption (33%) and thus more than nuclear and lignite power plants!!!
The German energy transition process is now in phase II

- The RES power has reached a system-determining magnitude (> 100GW)
- The general transformation of the entire energy supply system (electricity, heat, traffic) started
- Further installation, digitization and sector coupling will determine this phase

Required measures for the further (successful) transformation are

- Technological development
- Economics
- Political stability
- Acceptance and participation
Climate Protection Goals 2050 – 80% and 95%

Complying with COP21 Paris agreement requires emission reductions in the range of 80-95% vs. 1990 levels, implying consequences for the energy sector:

- **Challenge**: Coupling of energy sectors with key technologies to use renewable power generation (i.e. wind and solar) as the main primary energy source in the future.

- **Solution**:
  - **Power**
  - **Heat**
  - **Transport**

COP21: European Targets

A consistent implementation of the objectives of Paris leads to more extensive installation targets for renewable energies ......
95%-Scenario Electricity Generation and Demand in Germany 2050

Quelle: Fraunhofer IWES (2017): „Analyse eines europäischen -95%-Klimazielszenarios über mehrere Wetterjahre“
Electricity Generation and Demand in Germany 2050

Source: Fraunhofer IWES (2017): „Analyse eines europäischen -95%-Klimazielszenarios über mehrere Wetterjahre“
Digitization: Challenges and Opportunities

**Trends in the energy industry**
- Decarbonisation
- Liberalisation
- Internationalization
- Renewable Energy
- Decentralization
- Flexibility
- Sector Coupling

**IT-Trends**
- Big-Data
- IoT
- Digital Twins
- KI/machine.learning
- Blockchain
- Cloud Technology
- Industry 4.0
- IDS, EDS

Raise synergies and efficiency, anticipate IT innovation and adapt IT trends to energy industry issues.
Digitization in the Energy System
German Energy Supply – Today and Tomorrow

Current situation renewable energies
- >100 GW for 1.6 million power generators
- Most facilities without management
- Few power generators with remote meter access
- Separate consideration of different sectors (Power, Gas, Heat, Transport, Water)
- Limits of stability will be reached

Renewable energies in “2050“
- More than 250 GW and 5 million power units
- Complete supply from renewables – economically and secure
- All power generators with active management
- Smart-Grid / -Market fully applied
- Consideration of different sectors together

Installed capacity
Number of Units

Solar
Wind
Biomasse

>100 GW
1.6 million devices

Installed capacity
Number of Units

> 250 GW
> 5 Million

“2050“

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Key Elements of Energy Transition

- Power Forecasts
- Virtual Power Plants
- System Services by RES
- Sector Coupling - Smart Demand, Smart Cities, Smart Home
- Grid Planning and Operation
Forecast-Tools: From R&D to application – EWELine/GridCast

- observations
- assimilation
- weather forecast
- post processing
- power forecasts
- post processing

assimilation of power data
- PV and wind turbine

ensemble data assimilation

Improved model physics
- turbulence model
- aerosol optical thickness

MOS MiX
- A-priori estimation
  - Low stratus
  - Low pressure areas

Shortest term forecast

Day-ahead forecast

Grid-node forecast

Regional forecast

Probabilistic forecasts
Big Data, ML: Concept mobile sensors

Mobile Data → Weather Map → Plant-Model → Solar-Power

Vehicle Data
- solar radiation
- temperatur
- position
- direction

Aggregated meteorological information
- radiation
- temperatur

Simulated solar power production from weather map for single reference plants

Production now-cast from simulated solar power of single plants
VPP: Central Tool for the Energy System Transition

Support of:

- **Energy generation by demand**: using intelligent management
- **Compliance with the Schedule**: internal automatic Redispatch
- **Reduce the risk**: smoothing effects by aggregation of renewable energies
- **Market access**: for every type of facility (bridge between Smart-Grid / Market)
- **Scalability and Aggregation**: Any kind of facility, installed capacity, number of plants
- **Standardized protocols**: efficient communication architecture
- **Sector transcending management**:

  » **power plant type of the future**«

Secure system integration renewable energies as substitution of the large scale power plants
VPP: Manage Renewable Energy and Power

- Plant Operator
- VPP Operator
- Marketers
- Direct-Marketers VPP

Interfaces:
- Prices and Prediction data
- Portfolio-Commitment-Optimisation
- Optimal Schedule

Central Controller
- DV Port
- Communication Box

Plant Communication

VPP

Communication and Control Power Request
System Service: Voltage Support by Wind Farms

Online Grid information

Online power forecast

Set point to the local wind farm controller

Input WCMS

Wind-leistungs-prognose

Netzleitsystem

Ist-Werte Netz

Soll-Werte Parameter

Wetterdaten

Online power forecast

Set point to the local wind farm controller
System Service: Frequency Support – Control Power Provision

Demonstration: Primary and Secondary Reserve by Wind Farms
Sector Coupling: Sustainable Urban Energy Concepts with RES

Structure of the Energy System Frankfurt/M 2050

Based on 95% renewable energy sources regionally generated

Efficiency: Reduction of the energy demand from 2012 to 2050
From fossil fuels + electr. to electric vehicles only

- 79%
- 64%
- 72%
- 53%
- 78%
- 11%
- 10%

Total generation: 9759 GWh
Sector Coupling: Strategic Levels

Region/City

City Quarter

Local/Building
Sector Coupling: Approach on District Level

- Power-Heat System
  - Load management and renewable energies
- Innovative heat supply
  - Low temperature district heating
  - Integration of renewable and waste energies
Sector Coupling: Smart Home / Prosumer

Local Energy Management – Regulation and Incentives
European energy scenarios consider large-scale energy exchange and transport.
North Sea Offshore Network Initiative - NSON

Initial pre-project and feasibility phase

- Regulators and authorities

- NSON project(s) on national level with international cooperation and exchange

- Manufacturers, TSOs, renewable operators, ...

Pending phase

- NSON Initiative Framework

- Berlin Model type projects?

- Eranet Plus type project?

- H2020 type project?

Next phase

- Large-scale RD&D NSON project leading to full-scale commercial operation

NSON project opportunities need to be discussed to go ahead with industry involvement
Initial grid configuration shows realised and planned interconnector projects in Northern Europe – “Meshed Grid” shows investments in both interconnector and integrated offshore wind connections.
Conclusion and Outlook

- A safe and stable 100% RES power supply is technically feasible if renewable energy generation, storage and flexible demand interact intelligent.

- Precise wind and solar power prediction will reduce efforts for risk management and balancing.

- Wind power plants and PV-plants are able to provide control power.

- Renewable Energy VPP will support power plant operators, market players, and grid operators.

- Digitization will be the driver for advanced solutions and the link between technical and business requirements.

- Sector-coupling and urban energy management are crucial for the transition of the energy supply system.

- Grid planning and operation on European level is crucial for the energy supply with high shares of RES.
Thank you for your attention

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