74 applied research institutes with ca. 28,000 employees (incl. student researchers)

Annual research volume: 2,800 mio. Euros

With 2,000 mio. Euros financed by contracts with industry and publicly funded research projects.

Fraunhofer Society

Matthias Jarke, RWTH Aachen University and Fraunhofer FIT

Aachen, 5/9/2020

"Digital Energy"
Summary

Research Challenge Business Models -- Pebbles

Research Challenge IT Security -- MEDIT

Research Challenge Energy Systems -- PlaMES

Research Challenge Digitization -- Seams

Motivation and Concept of the Digital Energy Center

Talk Outline

- Motivation and Concept of the Digital Energy Center
- Research Challenge Digitization – Seam4Us
- Research Challenge Energy Systems -- PlaMES
- Research Challenge IT Security -- MEDIT
- Research Challenge Business Models -- Pebbles
- Summary
Motivation – Changes in Electricity Supply

*The simulations are based on scenario B of the German grid development plan.

\[ (PV) + (Wind) - (Consumption) = \text{Residual Load} \]

Most likely scenario for 2024: 40% renewables*

High Share of Renewables

Most likely scenario for 2035: 80% renewables*

Increasing Demand of Digitization, Networking and Automation


Today Energy System: Unbalanced Production and Consumption


Greenhouse Gas Emissions from Electricity Production in Germany (2014), installed capacity: 40% renewables.


Motivation – Future Action Lines of the Energy System Transformation

1. Ensuring Reliability of Supply:
   - Management of Renewables, Storages, Industry and Historical Grid Equipment

2. Digitization & Automation:
   - e.g. Integration of Information Technologies for Operation

3. Cyber Security:
   - Key Technology for a successful Digitization of critical Infrastructures / Equipment

4. Planning & Operation of Energy Supply Systems:
   - Key Technologies for a successful Digitization of critical Infrastructures / Equipment

5. New Business Models:
   - Forward-looking development with Digital Twins

6. Establishment of domain-spanning expertise of leading research institutions with their own laboratory infrastructure in the Rhine-Neckar area:
   - “Deep knowledge of the energy sector combined with deep knowledge of Cyber Security, Digitization and Financial Management”
Establishing an interdisciplinary, directly operational, trustworthy and independent cooperation under the Fraunhofer umbrella to promote IT security, digitization and financing of energy supply:

**Energy Systems**: EE @ RWTH Aachen University

**Digitization**: Fraunhofer FIT

**IT-Security**: Fraunhofer FKIE

**Business Models**: Fraunhofer FIT

Supporting services, organized close to the application:

- **Research & Development**: New Technologies and Methods
- **Education & Training**: Young Talents, Specialists and Managers
- **Test and Validation**: Integration in real systems

**Talk Outline**

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Central challenge in IoT research and application for the coming decades is the comprehensive linking of data, algorithms, devices and people via networks and software in all areas of business and life. Key challenges focus on controlability of the resulting systems and structures:

- Central challenges in ICT research and application for the coming decades is the comprehensive linking of data, algorithms, devices and people via networks and software in all areas of business and life.
- Integration of innovative information technologies (e.g. Blockchain, HPC, ...)
- Dealing with complex and heterogeneous systems.
- Dealing with large, heterogeneous masses of data
- Big data analytics, visualization, machine learning, ...
- In different industries and fields of application

SUSTAINABLE ENERGY MANAGEMENT

FOR UNDERGROUND STATION

Energy consumption of Metro Station Passeig de Gracia in Barcelona reduced by 5% (= 700 households) at ventilation shafts, lighting, escalators and lifts.

Foto: Martin Braun

Research Area „Digitization – Digital Technology Integration“
SEAM4US MODELLING

predictive-adaptive models development of embeddable methodology for the
Seam4Us developed a unique
accordingly
control history and adapt
Seam4Us models can learn from
occupancy predictions
of the weather forecasts, of the
on the basis of the past history,
estimate the future thermal and
Predictive-adaptive Models

Models
Based on several local Sensor
numerical model
Links Sensor network data with the
and Sensor-fusion.
Provides data for the post processing

Environmental Monitoring
Dynamic Control of lights

Lower lighting levels during higher occupancy

SEAM4US – CONTROL POLICIES

Reduction Potential

Baseline (Energy Audit)
CP0: Normal
CP1: Max Saving
CP2: Max Comfort

Load categories
Yearly consumption (MWh)
Role
Percentage
Yearly consumption (MWh)
Saving
Percentage
Yearly consumption (MWh)
Saving
Percentage
Yearly consumption (MWh)
Saving
Percentage

**Lighting**

<table>
<thead>
<tr>
<th>37.93</th>
<th>6%</th>
<th>25.17</th>
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</thead>
<tbody>
<tr>
<td>239.91</td>
<td>40%</td>
<td>187.61</td>
</tr>
<tr>
<td>39%</td>
<td>145.39</td>
<td></td>
</tr>
<tr>
<td>39%</td>
<td>127.6</td>
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</tr>
<tr>
<td>15%</td>
<td>203.93</td>
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**Ventilation**

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<th>20.72</th>
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<tr>
<td>75.81</td>
<td>13%</td>
<td>50.72</td>
</tr>
<tr>
<td>33%</td>
<td>46.93</td>
<td></td>
</tr>
<tr>
<td>38%</td>
<td>48.67</td>
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</table>

**Escalators**

<table>
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<tr>
<th>36.15</th>
<th>6%</th>
<th>25.17</th>
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</thead>
<tbody>
<tr>
<td>37.34</td>
<td>6%</td>
<td>25.17</td>
</tr>
<tr>
<td>39%</td>
<td>25.17</td>
<td></td>
</tr>
<tr>
<td>33%</td>
<td>25.17</td>
<td></td>
</tr>
<tr>
<td>33%</td>
<td>25.17</td>
<td></td>
</tr>
</tbody>
</table>

**Controlled Energy**

<table>
<thead>
<tr>
<th>353.07</th>
<th>59%</th>
<th>263.50</th>
</tr>
</thead>
<tbody>
<tr>
<td>33%</td>
<td>217.48</td>
<td></td>
</tr>
<tr>
<td>38%</td>
<td>277.77</td>
<td></td>
</tr>
</tbody>
</table>

**Demand Driven controllable equipment**

<table>
<thead>
<tr>
<th>128.72</th>
<th>21%</th>
<th>128.72</th>
</tr>
</thead>
<tbody>
<tr>
<td>21%</td>
<td>128.72</td>
<td></td>
</tr>
<tr>
<td>21%</td>
<td>128.72</td>
<td></td>
</tr>
<tr>
<td>21%</td>
<td>128.72</td>
<td></td>
</tr>
</tbody>
</table>

**Out of Scope Equipment**

<table>
<thead>
<tr>
<th>118.25</th>
<th>20%</th>
<th>118.25</th>
</tr>
</thead>
<tbody>
<tr>
<td>20%</td>
<td>118.25</td>
<td></td>
</tr>
<tr>
<td>20%</td>
<td>118.25</td>
<td></td>
</tr>
<tr>
<td>20%</td>
<td>118.25</td>
<td></td>
</tr>
</tbody>
</table>

**Total consumption**

<table>
<thead>
<tr>
<th>600.04</th>
<th>51%</th>
<th>470.47</th>
</tr>
</thead>
<tbody>
<tr>
<td>15%</td>
<td>464.45</td>
<td></td>
</tr>
<tr>
<td>23%</td>
<td>524.73</td>
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</tr>
</tbody>
</table>

SEAM4US – CONTROL POLICIES

- Dynamic control of lights
- Lower lighting levels during higher occupancy

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PlaMES Tool

- Expansion planning of distributed systems
- Expansion planning of central systems
- Transmission grid and energy supply structures

- GHG Emission Limits
- Political Restrictions
- Known/Planned Gen. Expansion
- Known/Planned Grid Expansion
- Fuel Prices
- Energy Demands per Sector
- Future Tech. Parameters
- Meteorological Conditions
- Uncertain Parameters
- Fixed Parameters
- Fixed Parameters
- Fixed Parameters

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- Research Challenge Digitalization -- SeamUs
- Motivation and Concept of the Digital Synergie Center

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Motivation and Concept of the Digital Synergie Center

Talk Outline
Methods for energy networks across to prevent, detect, react to IT attacks or failures.
Motivation and Concept of the Digital Synergie Center

Summary

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Talk Outline
Pebbles: Grid Services (I)

**Situation**
- DSO faces voltage problems, mainly in the low voltage grid.
- Voltage problems lead to a grid-friendly energy market.
- Objective: Motivate local energy market to be grid-friendly.
- Idea: React to voltage problems with grid-oriented price incentives.
- The grid price incentive is considered in the market-matching mechanism.
- Pebbles: Blockchain-Based Local Energy Markets (LEM)

**Conceptualization and development**
- Pebbles: Blockchain-Based Local Energy Markets (LEM)
- Conceptualization and development of LEM
- Conceptualization and development of grid services
- Development of software and hardware
- Identification and evaluation of new business models
- Analysis of the legal-regulatory framework
- Field tests
Voltage-dependent grid services

- Voltage in LV grids subject to lower and upper boundaries
- Every phase's voltage measured at the connection point of each market participant
- By using historical data, EMS predicts voltage levels
- DSO defines grid fees for voltage ranges considering grid operation factors
- The customer's software agent is able to optimize its residual load profile considering the grid fees
- The customer's software agent is able to optimize its residual load profile considering the grid fees
- Efficient energy allocation at local level

Pebbles: Grid Services (II)

- Pebbles Simulation Framework
  - Objectives & premises
    - Efficient energy allocation at local level
    - Market Design & Participants
      - Optimize against the market on the basis of their electrical behavior and flexibility
      - Place bids
      - Price-Quantity-Bids
      - Price settlements by coordinator
      - Volume optimization by participants
      - Evaluation of residuum
      - Determination of \( \gamma \)-coefficients
      - Winner determination
        - Problem (MILP)
  - Transaction objects: Discrete
  - Transaction objects: Discrete
  - Transaction objects: Discrete
Talk Outline

Motivation and Concept of the Digital Synergie Center

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SynErgie – National 10-Year Strategic Project with over 60% of German Industrial Energy Usage

SynErgie: Synchronization the Demand of Energy-Intensive Industrial Processes with the Volatile Character of Renewable Energies

- Make energy-intensive processes more flexible
- Synchronize the demand of energy-intensive industrial processes with the volatile character of renewable energies

Networking diverse actors such as network operators and user companies

Real-world test in model region

Co-evolution of the model region under participation of all stakeholders

Identify needed regulation changes

Analyze and design new rules for the market design 2030-2050 for the emerging solutions

Evolutionary migration path and decision support systems for user industries

Industry testing of the developed solutions

Build platforms for flexibility-relevant industrial data

Develop optimization services for using and selling flexibility

Platform for energy synchronization

Platform for energy flexibility

Platform for market evolution

Platform for energy system evolution