Energy Efficiency in Manufacturing

Prof. Dr.-Ing. Georg Frey
09.05.2017
Vienna
Saarland University | Chair of Automation and Energy Systems

- Saarbrücken, located in the heart of Europe
  - Two hours by train to Paris and Frankfurt
  - 200,000 inhabitants

- Saarland University
  - 18,000 students (17% international)
  - 279 professors, 1,300 academic staff

- Chair of Automation and Energy Systems
  - Head: Prof. Dr.-Ing. Georg Frey
  - Staff: 1 postdoc, 15 PhD candidates, 1 technician, 1 secretary
The focus of our research is on the development of methods to provide reliable automation and energy systems.

Conceptual design and analysis of networked automation systems, the so-called C³ systems (Communication, Computation, Control), whose complex time behavior imposes special requirements on their design and specification as well as on modeling and simulation.

Model-based design and automation of energy systems. In particular, the integration of renewable generators and the associated challenges for efficient operation.
### AES Research Topics (Selection)

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERACS</td>
<td>modeling and verification of reconfigurable discrete event control systems</td>
</tr>
<tr>
<td>Functional Safety</td>
<td>verification and validation of safety controllers</td>
</tr>
<tr>
<td>Compressed Air</td>
<td>simulation based design and operation of compressed air stations</td>
</tr>
<tr>
<td>BROS</td>
<td>browser-based reconfigurable orthopedic surgery</td>
</tr>
<tr>
<td>AutoIBN &amp; AutoIBN2</td>
<td>energy-efficiency in automated installations</td>
</tr>
<tr>
<td>EULE</td>
<td>energy efficiency and multiobjective optimization of public properties by building automation</td>
</tr>
<tr>
<td>EHSTEG</td>
<td>model-based analysis and design of waste heat recovery processes</td>
</tr>
<tr>
<td>DES</td>
<td>distributed energy systems</td>
</tr>
<tr>
<td>MOC²IES</td>
<td>model-based configuration and control of isolated energy systems</td>
</tr>
<tr>
<td>MOCES</td>
<td>modeling of complex energy systems</td>
</tr>
</tbody>
</table>
Motivation

- Energy consumption gets more attention because of rising energy prices and awareness of our environment

- Industry sector accounts for approximately one third of the final energy consumption in Germany

- Energy becomes to a more and more important cost factor

Source:
www.daikin.de, Arbeitsgemeinschaft Energiebilanzen: Auswertungstabellen zur Energiebilanz 1990 bis 2013, Stand 09/2015
Industry 4.0

Industry 1.0
The mechanical weaving loom, water and steam power.
1784

Industry 2.0
First production line.
Mass production using electrical energy.
1870

Industry 3.0
First programmable logic controller (PLC).
Use of electronics and IT for further automation.
1969

Industry 4.0
Based on cyber-physical systems linking real objects with information-processing/virtual objects and processes via information networks (e.g. the Internet).
Today

Source:
The vision Industrie 4.0 will change the German manufacturing systems. Smart Factories provide Cyber Physical Systems (CPS) that combine the virtual and physical world.

Completely new manufacturing processes and energy management systems will lead to an efficient production in terms of energy and resources in the future.

Energiewende demands for intelligent distribution networks of Energy that leads to Cyber Physical Systems again.

Energiewende can only be successful if energy production and demand can be balanced. Either by storage (expensive) or intelligent Demand Side Management → Industrie 4.0
Automated Wheel Adaption System
Automated wheel adaption to determine the rear axle geometry in the assembly line.

Assembly Worker Assistance Systems
Innovative Human Robot Concepts for the automation of production and testing processes in the continuous assembly line.

Virtual Plant Engineering
Advanced plant design and virtual commissioning along with efficient plant planning and production design.

Energy Efficient Production Facilities
Energy efficient operations for production facilities with variable operating modes.

Research & Test Environment
Research scenarios are set up and integrated in a model factory for validation.
Motivation

- Energy optimization takes advantages of switching components into energy efficient modes

Approach

- Material flow simulation combined with energy flow in order to improve the interaction between different components of a factory
- Use of extended Petri nets for the discrete-event modeling of the system according to specific energy states and evaluate switching strategies for energy-efficiency operations in a factory model
AutoIBN: Energy Efficiency

Motivation
- High degree of automation in the automotive industry. Especially the body in white production uses a huge number of robots. The aim is to increase the energy efficiency of industrial robots.

Approach
- Optimized path planning with respect to path and velocity
- Using software tools to show path planning concepts in the virtual plant simulation
Optimal Control of Compressed Air Supply

Source:
www.kaeser.de/Images/P-651-23-D-tcm6-12414.pdf
www.kaeser.de/Images/P-791-D-tcm6-16946.pdf
Questions?

Prof. Dr.-Ing. Georg Frey
Chair of Automation and Energy Systems
Saarland University
66123 Saarbrücken
Germany

georg.frey@aut.uni-saarland.de
www.aut.uni-saarland.de