INFO – Interdisciplinary Research on energy efficiency in manufacturing enterprises

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Course of talk

• Project – INFO Overview
• Optimization Fields
  • Buildings
  • Energy System
  • Machines
• Integrated Simulation
  • Approach and Model
  • Implementation
• Expected Results
Increasing importance of ENERGY EFFICIENCY in industrial sector

Main reasons:

• Rising energy costs
• Tightening of EU-Regulations
• Increasing ecological awareness

• Energy consumption of production industry: 29% of total energy consumption (in Austria)
• Potential of reduction: 30 – 65% depending on the sector

Possible approaches to reduction of energy consumption:

• Optimization of production process
• Optimization of the infrastructure of the facility

HOLISTIC, LIFE-CYCLE ORIENTED APPROACH
**Project INFO - Overview**

„Interdisziplinäre Forschung zur Energie-optimierung in Fertigungsbetrieben“
*Interdisciplinary research on energy efficiency in manufacturing enterprises*

**Funding:**
Project-based support grant by Austrian Federal Government
Project duration: 3 years

**Project Partners:**
7 TU Vienna institutes, 10 companies
Interdisciplinary approach:
building sciences, physical modelling,
energy systems architecture, manufacturing and computer science
Holistic approach to optimize energy efficiency of industrial facilities:
- Production processes
- Machinery
- HVAC-Systems
- Building

Objectives:
- Minimisation of waste heat production
- Re-use of waste heat
- Optimisation of production process
- Optimisation of stand-by load

Final Aim:
Integrated Simulation for energy optimization of production facilities for achievement of economic and ecologic sustainability aims in industrial sector
Optimization Fields

Analysis

Modelling

Process Machine Production System Building Energy System

Integrated simulation, optimization of options

Case study for an optimized production facility for Hörbiger Ventilwerke
Building site: Vienna 2015
Building - Concept

Planning targets:
Evaluation of the client’s requirements on the building performance and functionality

- Communication between R&D and production
- Flexibility of the production areas (adaptability to different building functions)
- Expandability of the R&D and production areas with minimal re-fitting effort
- Energy saving building hull and minimization of energy consumption for HVAC and lightning
Simulation components considered:

- Geometry and building hull (transparent and translucent elements)
- Internal gains: heat sources (people, machines, lighting)
- Weather data (hourly)
- Systems: HVAC (heating, ventilation, cooling)

Building simulation (E-plus) in the design process allows:

- Evaluation of visual and thermal comfort criteria (overheating, glare, etc.)
- Reduction of energy demand (heating, cooling, ventilation, lighting, etc.)
Energy System – Energy Flow Analysis

Energy Flows in the Building, present status

Electric Energy
146 931 kWh (~54%)

Thermal Energy
130 096 kWh (~46%)

Total Energy
277 027 kWh

Emissions:
107t CO₂

Machine Tools 51 355 kWh (~19%)
Pressurized Air 27 331 kWh (~10%)
Office 5 607 kWh (~2%)
Kitchen 8 371 kWh (~3%)
Water Heating 4 958 kWh (~2%)
IT-Infrastructure 8 574 kWh (~3%)
Auxiliary Devices 5 388 kWh (~2%)
Lighting 35 347 kWh (~13%)

Heating 130 096 kWh (~46%)
Energy System – Energy Flow Optimization

Energy Flows in the Building, optimized status

Electric Energy from grid
111 606 kWh (≈47%)
Electric Energy from PV
38 931 kWh (≈17%)
Thermal Energy from Solar
2 093 kWh (≈0.9%)
Thermal Energy from Oil
81 620 kWh (≈34%)

Total Energy
234 250 kWh

Emissions:
75.7t CO₂
30% reduction

Electric Energy to Grid
3 610 kWh
Machine Tools
51 355 kWh
Pressurized Air
27 331 kWh
Office
5 607 kWh
Kitchen
8 371 kWh
IT-Infrastr.
8 574 kWh
Auxiliary Dev.
5 388 kWh
Lighting
35 347 kWh
Water Heating
2576 kWh
Heating
81 620 kWh

Electric Energy from PV
38 931 kWh (≈17%)
Thermal Energy from Solar
2 093 kWh (≈0.9%)
Thermal Energy from Oil
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Total Energy
234 250 kWh

Emissions:
75.7t CO₂
30% reduction
Machine tool measurements to define and improve the machine tool’s energetic performance. Significant saving potential by optimizing machine tool layout and control.

Energy input

Machining energy 5%

Heat in the chip

Losses, Heat 95%

Internal energy gain

Heat in workpiece, tool
Main influencing factors on energy consumption of machine tools:

- Process
- Machine
- Production System

Energy optimization approaches for machine tools and the overall system:

- Optimization on process, machine, production system layer
  → Reduction of energy consumption/ process and machine efficiency
- Integration of thermal behavior of machine tool into building technology/
  Integration of machine tool into overall system
  → Use of waste heat by intelligent building technology
Conception of a **SYSTEMICALLY INTEGRATED MODEL** that considers all components of a production facility

From the machine tool (micro level)
To the facility (macro level)
Modeling objectives

Basis for simulations of the entire facility

- Focused on *energy flows* – *black-box* approach
- Allowing the involvement of multiple simulation tools
- Independent of used simulation tools
- Documentation of all relevant aspects of the system (communication instrument – multi-disciplinary project!)
- Aspects to be included in simulation can be adapted to individual needs

Optimization based on simulation:

- Task: Increase energy efficiency, better implement renewables
- Manual comparison of pre-selected scenarios
- No automatic design optimization
Model structure

Input/output variables

Information Components

Physical Components
Model Structure

Plan elements
(coordinating parameters)
Co-simulation

Goal: Integrated dynamic simulation
- Currently not available "out of the box"
- Consider dynamic dependencies
- Feedback between components during runtime

Coupling of established tools
- Preferred tool for each domain
- Re-use of existing models and expert knowledge
- Convenient parallelization
Building Controls Virtual Test Bed

Developed by:
M. Wetter @ LBNL
Based on Ptolemy II
Open source

Co-simulation with controlled time step

Connects well-known simulation tools
(EnergyPlus, Dymola, Radiance, Matlab/Simulink)
Expected Results

The integrated simulation ...

- is a tool to support the planning process of production plants (newly built or significant infrastructural changes)
- connects energy saving measures to financial benefits and costs
- illustrates the mutual influence of energy efficiency strategies and on operating results of a company
Thank you for your attention!

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