Demand-side Energy Management Systems for Manufacturing
Informatik 2010, Leipzig

SAP Research Center Dresden
Dr. Michael Ameling
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Agenda

1. Introduction
2. Scenario
3. Concept
4. Prototype
5. Conclusion
Section One

Introduction
Sustainability

- Economic View
- Ecologic View
- Social View
Introduction
Energy Monitoring & Management

Energy
- Water
- Air
- Gas
- Electricity
- Steam

Goals
- Benchmarking of energy consumption
- Reducing energy consumption
- Reducing energy loss (distribution)
- Avoiding energy peaks (in demand)
- Energy availability (resource) planning
- Increasing efficiency

key challenge: intermittency of RES [8]

Utilities
Supported by AMI, Smart Grid

Energy Production
Energy Storage
Energy Distribution
Energy Consumption

private & industrial consumer

“You can’t manage what you don’t measure”
Production
Paradigm Change & Role of ICT

Efficiency Nowadays
- Maximum gain from minimum capital
- Maximum gain from minimal resources

Savings
- Industrial production savings potential: 25 - 30% [1]
- Energy savings potential (by 2020): 25% (95 Mtoe) [2]
- Industry ≈ 30% of Europe’s primary energy consumption
  - Savings of up to 65% reasonably expected [2]

ICT Role
- ICT reducing carbon emission (by 2010) potential: up to 970 million tons (global)
  - Improved motor systems, industrial process optimization [3]
- ICT-optimized logistics (e.g.: optimized transport routes, networks, inventory reduction) [3]
  - Reduction in transport emission: up to 16%
  - Reduction in storage emissions globally: 27%
Energy Consumption and Savings Potential
Examples in Manufacturing

Electricity Consumption & Production
- Europe’s share of global primary energy consumption: 18% (10,900 Mtoe4) in 2006
  - equals annual increase of 2.4 %.

Electricity Usage
- Electricity in Germany: 15% (528 TWh) of primary energy [5]
  - Industry share: 47% (2/3 electrical drives, 1/3 heating and lighting

Compressed Air
- Compressed air: 10% of industrial energy consumption (> 80 TWh/year) [6]
  - 321,000 compressors (10 -300 kW) installed in Europe [5]

Strategies and Potential for Manufacturing:

<table>
<thead>
<tr>
<th>Optimization Strategy</th>
<th>Saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Optimization</td>
<td>25 - 30%</td>
</tr>
<tr>
<td>Optimized Logistic</td>
<td>16%</td>
</tr>
<tr>
<td>Integrated Process Chains</td>
<td>30%</td>
</tr>
<tr>
<td>Development of New Products</td>
<td>10 - 40%</td>
</tr>
<tr>
<td>Intelligent Motor Drives</td>
<td>20 - 40%</td>
</tr>
<tr>
<td>Alignment with Best Performers</td>
<td>15%</td>
</tr>
</tbody>
</table>
Section Two

Scenario
ADiWa - Work Package A4
Objective and Application Scenario

Overall Objective ADiWa
- From Internet of Things towards intelligent business processes
  - Usage of all IoT information relevant to a process
  - Flexible formation and dynamic adjustment of processes in companies

Overall Objective ADiWa WP A4
- Lean and green production and logistics
  - Provide a concept for reaching sustainability
  - Transparency in production and logistics
  - Efficient energy management

Application Scenarios
- Manufacturing in the SAP Research Future Factory
  - Demand-side energy management
  - Dynamic routing
Production of different kind of fridge magnets
- Several logos
- Several insertions (thermometer, sharpener)
- Any combination with different production plan

Resources
- Workers
- CNC Mills
- Drills
- Assembly workplaces
- Quality check workplaces

Energy Resource
- Units in hour
SAP Future Factory
Energy Consumption at Process Level

Provisioning ➔ Drilling ➔ Milling ➔ Assembling ➔ Packaging

0.327 kW/h
ADiWa - Work Package A4
Use Case Demand-Side Energy Management

Stock Market (e.g.: EEX¹)

- Fossil Power
- Green Power

Weather Data
- Day related
- Year related

Prozesse
- Drilling
- Milling
- Assembling

Management
- Order B

¹EEX – European Energy Exchange
Section Three

Concept
Section Four

Prototypes
Future Factory
Energy Meter Distribution in Production Line
Prototype
Energy Monitoring Dashboard

Presentation Layer

Logic & Analytic Layer

Persistency Layer

Device Abstraction Layer

Hardware

Xcelsius

Silverlight

BOBJ Explorer

ABAP/ Java + TREX Analytics

SAP TREX

MDI

PLOGGS

NZR SEM

easyMeter

E+H

Mitsubishi

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# Prototype - Energy Monitoring Dashboard

## Cumulated View of Assets

### Energy Information

#### Historical vs. Current

<table>
<thead>
<tr>
<th>Component</th>
<th>EM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulated View All</td>
<td></td>
</tr>
<tr>
<td>3D Printer</td>
<td>Mitsu.</td>
</tr>
<tr>
<td>Milling Machine</td>
<td>Mitsu.</td>
</tr>
<tr>
<td>Milling Machine 2</td>
<td>Mitsu.</td>
</tr>
<tr>
<td>Drill</td>
<td>Mitsu.</td>
</tr>
<tr>
<td>Terminal</td>
<td>Mitsu.</td>
</tr>
<tr>
<td>Laptop</td>
<td>Plogg</td>
</tr>
<tr>
<td>Touch Panel</td>
<td>Plogg</td>
</tr>
<tr>
<td>Pump</td>
<td>Plogg</td>
</tr>
<tr>
<td>NanoServer</td>
<td>Plogg</td>
</tr>
</tbody>
</table>

### Total Power Consumption

<table>
<thead>
<tr>
<th>Component</th>
<th>Total Consumption</th>
<th>Current Consumption</th>
<th>Energy Meter Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D Printer</td>
<td>4557 kWh</td>
<td>880 Watt</td>
<td>Mitsubishi</td>
</tr>
<tr>
<td>Milling Machine</td>
<td>2295 kWh</td>
<td>281 Watt</td>
<td>Mitsubishi</td>
</tr>
<tr>
<td>Milling Machine 2</td>
<td>20 kWh</td>
<td>0 Watt</td>
<td>Mitsubishi</td>
</tr>
<tr>
<td>Drill</td>
<td>6435 kWh</td>
<td>2 Watt</td>
<td>Mitsubishi</td>
</tr>
<tr>
<td>Terminal</td>
<td>425 kWh</td>
<td>36 Watt</td>
<td>Mitsubishi</td>
</tr>
<tr>
<td>Laptop</td>
<td>213 kWh</td>
<td>18.63 Watt</td>
<td>plogg</td>
</tr>
<tr>
<td>Touch Panel</td>
<td>215 kWh</td>
<td>41.42 Watt</td>
<td>plogg</td>
</tr>
<tr>
<td>Pump</td>
<td>1658 kWh</td>
<td>154.76 Watt</td>
<td>plogg</td>
</tr>
<tr>
<td>NanoServer</td>
<td>213 kWh</td>
<td>18.63 Watt</td>
<td>plogg</td>
</tr>
</tbody>
</table>

**Consumer: 3D Printer**  ///  **Total Power Consumption: 880**  ///  **Number of Devices Online: 4**  ///  **Heavy**
Literature (selection)


[2] Twenty Solutions for Growth and Investment to 2020 and Beyond, 2008


Thank you!
<table>
<thead>
<tr>
<th>Grid</th>
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</thead>
</table>

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## Definition and Halftone Values of Colors

<table>
<thead>
<tr>
<th>Color</th>
<th>RGB Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAP Blue</td>
<td>RGB 4/53/123</td>
</tr>
<tr>
<td>SAP Gold</td>
<td>RGB 240/171/0</td>
</tr>
<tr>
<td>SAP Light Gray</td>
<td>RGB 204/204/204</td>
</tr>
<tr>
<td>SAP Gray</td>
<td>RGB 153/153/153</td>
</tr>
<tr>
<td>SAP Dark Gray</td>
<td>RGB 102/102/102</td>
</tr>
</tbody>
</table>

### Primary Color Palette

- **100%**
  - SAP Blue: RGB 4/53/123
  - SAP Gold: RGB 240/171/0
  - SAP Light Gray: RGB 204/204/204
  - SAP Gray: RGB 153/153/153
  - SAP Dark Gray: RGB 102/102/102

### Secondary Color Palette

- **85%**
  - SAP Blue: RGB 68/105/125
  - SAP Gold: RGB 96/127/143
  - SAP Light Gray: RGB 125/150/164
  - SAP Gray: RGB 152/173/183
  - SAP Dark Gray: RGB 180/195/203

- **70%**
  - SAP Blue: RGB 96/127/143
  - SAP Gold: RGB 125/150/164
  - SAP Light Gray: RGB 152/173/183
  - SAP Gray: RGB 180/195/203
  - SAP Dark Gray: RGB 21/101/112

- **55%**
  - SAP Blue: RGB 125/150/164
  - SAP Gold: RGB 152/173/183
  - SAP Light Gray: RGB 180/195/203
  - SAP Gray: RGB 21/101/112
  - SAP Dark Gray: RGB 98/146/147

- **40%**
  - SAP Blue: RGB 152/173/183
  - SAP Gold: RGB 180/195/203
  - SAP Light Gray: RGB 21/101/112
  - SAP Gray: RGB 98/146/147
  - SAP Dark Gray: RGB 85/118/48

### Tertiary Color Palette

- **100%**
  - Cool Green: RGB 73/108/96
  - Ocher: RGB 129/110/44
  - Cool Red: RGB 132/76/84
  - Warning Red: RGB 158/48/57

- **85%**
  - Cool Green: RGB 101/129/120
  - Ocher: RGB 148/132/75
  - Cool Red: RGB 150/103/110
  - Warning Red: RGB 158/48/57

- **70%**
  - Cool Green: RGB 129/152/144
  - Ocher: RGB 167/154/108
  - Cool Red: RGB 169/130/136
  - Warning Red: RGB 158/48/57

- **55%**
  - Cool Green: RGB 156/174/168
  - Ocher: RGB 186/176/139
  - Cool Red: RGB 188/157/162
  - Warning Red: RGB 158/48/57

- **40%**
  - Cool Green: RGB 183/196/191
  - Ocher: RGB 205/197/171
  - Cool Red: RGB 206/183/187
  - Warning Red: RGB 158/48/57