Energy Assessment Strategy and Energy Concepts for Industrial Facilities

Industrial Process and Energy Optimization
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# Energy Assessment Strategy and Energy Concepts for Industrial Facilities

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## Supplementary Notes


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Energy system of an Enterprise

Energy flow

Energy system of enterprise

Procurement
e.g. electricity purchasing

Conversion
e.g. transformer, boiler, chp-unit

Distribution
e.g. compressed-air network

Utilization
e.g. motor, furnace, lighting

Development of energy demand

Energy Consultation Procedure

Establishing Contact

Quotation and contract

Ascertaining the current situation

Sufficient data?

yes

no

Additional measurements

Presenting and assessing the current situation

Proposals for efficient energy use

Development of overall concepts

Assessment and selection of measures

Presentation and consulting report

Implementation and efficiency review

According to VDI 3922
First Assessment of the Energy Efficiency

Similar products resp. similar services, similar processes and similar boundary conditions

Energy characteristic (measured)

Benchmark or reference

Comparison of energy characteristic

Quality of the system and room for improvement

Layer et al. 1999

Example: Compressed-Air System

- Thermodynamic minimum
- Reference point: max. 45 % above adiabatic compression

Specific Energy Consumption [kW/(m³/min)]

Pressure ratio \( p_1/p_2 \)

Thermodynamically not possible

Poor efficiency

Good efficiency

Ideal adiabatic compression

www.druckluft-effizient.de
Example: Assembly Plant for Passenger Cars

Energy consumption per passanger car [MWh/car]

On-site power production: W 5, W 7, W 13 and W 17

- Oil
- Coal
- District heat
- Gas
- Electricity

Example: Paint Shop

Specific Energy Consumption [kWh/car]

- Gas
- Heat
- Electricity

Leven 2004
Example: Cure Ovens

- Top coat oven
- Primer surfacer oven
- Anti-corrosion and sealer oven
- ELPO oven

Specific Gas Consumption [kWh/car]

Sankey Diagram for a Metal Processing Enterprise

- Natural Gas Distribution
- Workshop heating
- Useful heat
- Tempering furnace
- Heat losses
- Continuous furnace
- Office heating
- Water heating

Benefits:
- Identification of main energy consumers
- Cost accounting
- Areas with significant energy losses
- Starting points for detailed analyses
Electric Load Curve of a Data Processing Center

- **Peak load:** Which system operation can be temporarily shifted?
  - => Reduction of energy costs

- **Base load:** Which systems can be temporarily switched off?
  - => Reduction of energy consumption

**Proposals for Improved Energy Use**

1. **Avoidance**
   - of unnecessary consumption
     - (stand-by and idling, process parameters)

2. **Reduction**
   - of specific energy consumption
     - (processes, techniques)

3. **Improvement**
   - of efficiency and utilization ratios
     - (maintenance, controlling, cogeneration)

4. **Recovery**
   - of energy
     - (heat recovery, production residues)

5. **Supply**
   - using regenerative energy sources
     - (biomass, solar radiation)

According to VDI 3922
Development of Overall Concepts – Example (1)

Kind of company: Production of electronic components
Initial situation: Heat supply by oil boiler
Reason for action: Extension of work shop

Leven, Schaefer 2004

Development of Overall Concepts – Example (2)

Measures
1. Supply of increased heat demand by additional
   a. Boiler with the same fuel
   b. Boiler with different fuel (e.g. gas or biomass)
   c. Heat pump
   d. Cogeneration unit (CHP)
2. Reduction of heat demand by
   a. Insulation
   b. Heat recovery from exhaust air
   c. Heat recovery from processes or compressed-air system
   etc.

Concepts
- Concept 1:
  - Substitution of roof lights, modernization of the roof insulation (existing building)
  - Installation of a CHP unit
- Concept 2:
  - Integration of a CHP unit (No reductions of heat load)
- Concept 3:
  - Heat recovery from exhaust gases
  - Integration of a gas boiler (No reductions of heat load)
  etc.
Assessment and Selection of Measures

- Example:
  Heat recovery from exhaust gases

- Possible heat consumers
  - Hot water supply
  - Heating system
  - Air supply of building (outside air)

- Conventional approach vs. IER software tool

Assessment of Heat Recovery Measures

- Identification of a waste heat source
- Collection of information
- Site survey
- Measurements (e.g. load curve)
- Calculations
- Technical concept (i.e., feasibility)
- Profitability analysis
- Decision about realization

- Disadvantage:
  Highly time-consuming
  - Assessment of several combinations of the waste heat source and possible heat sinks (consumers or networks)
  - Collection of information and analysis for every combination

- Standardized procedure for the approximate estimation of economical and technical aspects by applying a software tool

Weber, Leven, Schaefer 2003
Assessment and Selection of Heat Recovery Measures

**Waste heat source**
- **Medium**
  - Flue gas from gas firing
  - Flue gas from oil firing
  - Flue gas from coal firing
  - Exhaust air
  - Compressed air
  - Oil
  - Water
- **Flow rate, inlet temperature, minimum outlet temperature**
- **Time characteristic**
  - Seasonal (yes or no)
  - Production (shifts per day)
  - Plant

**Heat sinks**
- **Standardized**
  - Air supply for buildings
  - Drinking water supply
  - Washers
  - Process heat network
  - Space heat network
- **Time characteristic**
  - Seasonal
  - Production
- **Energy source**
  - Natural gas
  - Hot water
  - Electricity
- **Distance to waste heat source**

Output Data (Selection) - Output for Suitable Heat Sinks

**Technical**
- Transferable heat capacity [MW]
- Useful operating time [h/a]
- Transferable heat [MWh/a]
- Demand of auxiliary energy [MWh/a]

**Economical**
- Annual cost savings [€/a]
- Capital cost for heat exchangers, pipes, pumps etc. [€]
- Payback period [a]
- Internal rate of return [%]
- Sensitivity analysis concerning energy prices

**Ecological**
- Reduction of CO₂ emissions [tons/a]
- Reduction of primary energy demand [MJ/a]
### Result Sheet of a Consulting Report

<table>
<thead>
<tr>
<th>Assessment criteria</th>
<th>Current situation</th>
<th>Measure 1</th>
<th>...</th>
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<td><strong>Energy</strong></td>
<td>Electricity consumption [kWh/a]</td>
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<td>Fuel consumption [TJ/a]</td>
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<td>Peak load [kW]</td>
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<td></td>
<td>Specific electricity consumption [kWh/m²a]</td>
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<td><strong>Economic efficiency</strong></td>
<td>Energy supply costs [$/a]</td>
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<td>Energy cost savings [$/a]</td>
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<td>Investment [$]</td>
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<td>Specific energy costs [$/m²a]</td>
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<td><strong>Environment</strong></td>
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<td>Specific GHG emissions [kg/m²a]</td>
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<td><strong>Qualitative criteria</strong></td>
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<td>Internal acceptance</td>
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According to VDI 3922

### Energy Concepts – Content of a Consulting Report

- Aims and Tasks
- Initial Situation
- Planned Modifications
- Comparison of Options
  - Economic assessment
  - Energy and CO₂ inventories
- Summary and Recommendations
- Appendices with essential Data and Assumptions
  - Energy prices
  - Economic life of equipment, interests

According to VDI 3922
Summary

- **Energy Concepts for Enterprises**
  - cover the procurement, conversion, distribution and utilization of energy
  - are based on a detailed analysis of the initial situation and planned modifications
  - should compare different options of measures and concepts

- **Applicable Methodologies are**
  - Energy characteristic (on different operational level)
  - Sankey diagrams and load curves

- **Standardized Procedures and Software Tools**
  - can significantly reduce time and costs

References


- VDI guideline 3807: *Characteristic values of energy consumption in buildings*. Düsseldorf: VDI - The Association of Engineers, 1994
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