
Energy Assessment Strategy and Energy Concepts for Industrial Facilities

**Industrial Process and Energy Optimization
Industry Workshop
Feb. 25-27, 2004 in Gettysburg, PA**

**Bernd Leven and Christoph Weber,
University of Stuttgart, Germany**

Contents

- **Energy System of an Enterprise**
- **Energy Consultation Procedure**
 - **Steps**
 - **Results**
 - **Examples**
- **Summary**
- **References**
- **Appendices**
 - **Energy Indicators in the Automobile Industry**
 - **Cost Effective Assessment of Heat Recovery Potentials**

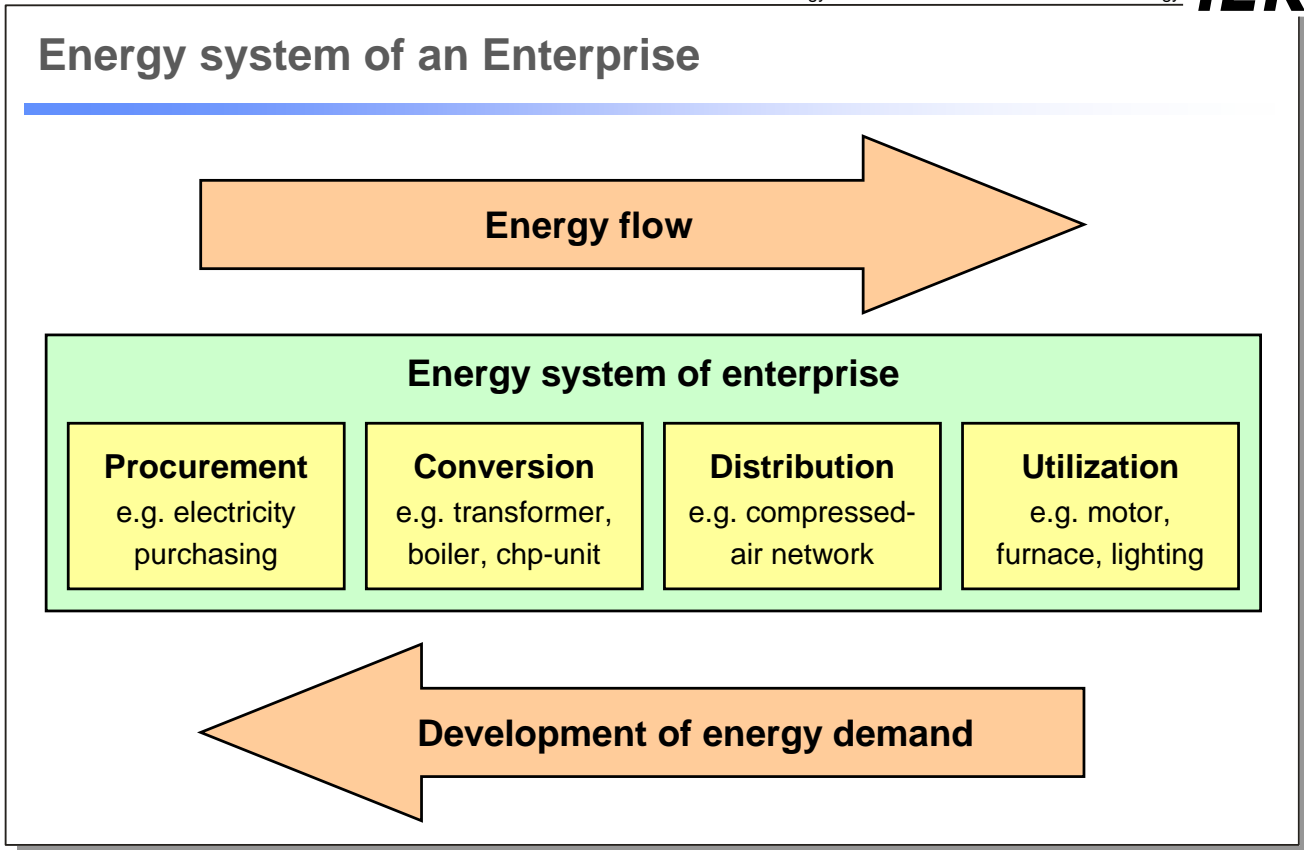
Report Documentation Page

Form Approved
OMB No. 0704-0188

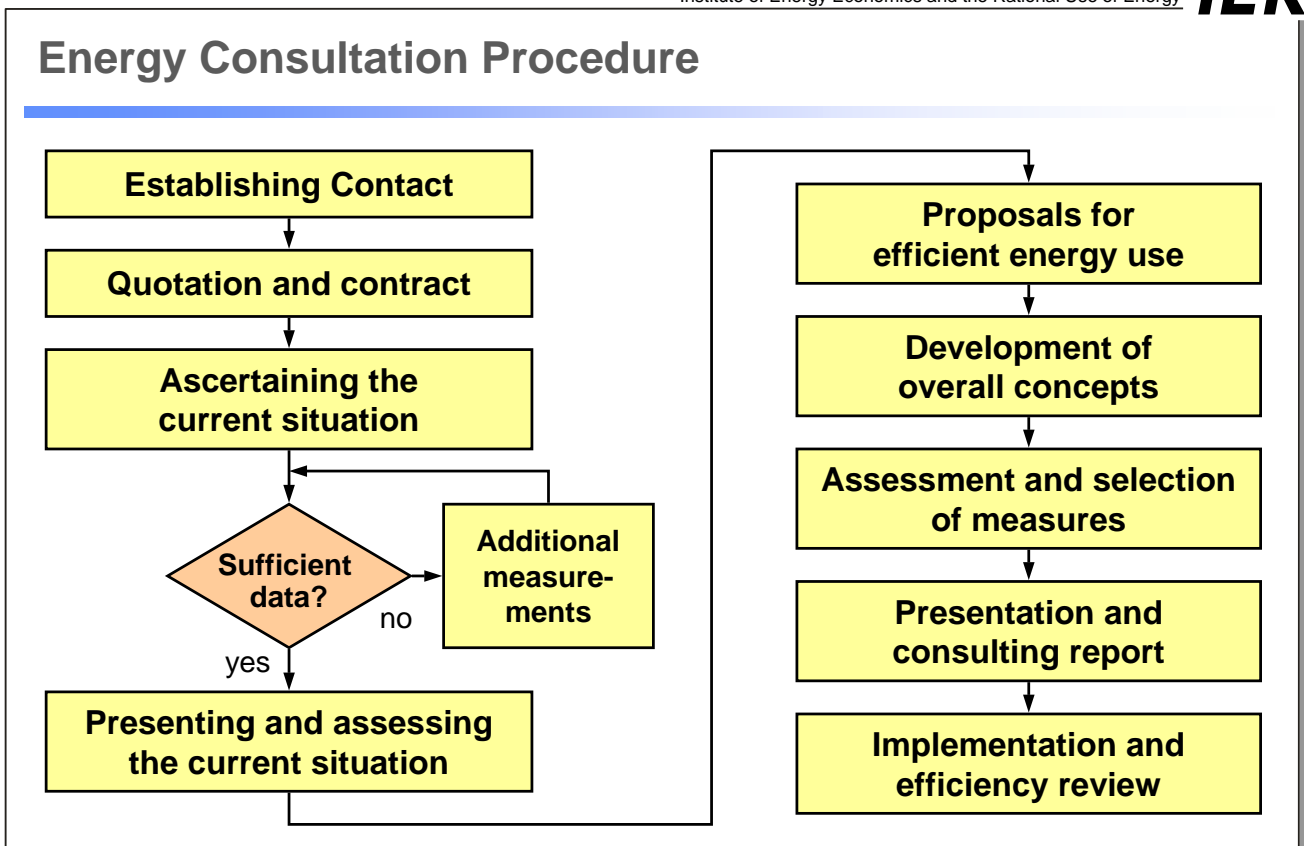
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE 25 FEB 2004		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE Energy Assessment Strategy and Energy Concepts for Industrial Facilities				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) University of Stuttgart, Germany				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES See also ADM001865, Industrial Process and Energy Optimization. Proceedings of the Industry Workshop Held in Gettysburg, PA, 25-27 February 2004., The original document contains color images.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

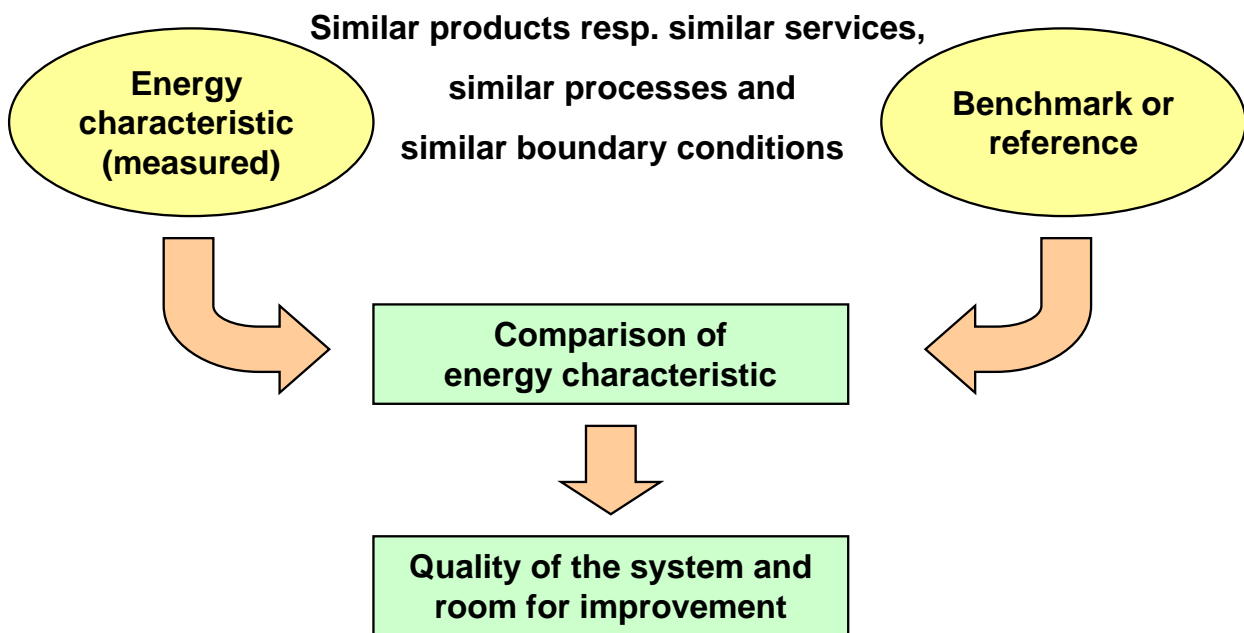
Energy system of an Enterprise



Energy Consultation Procedure



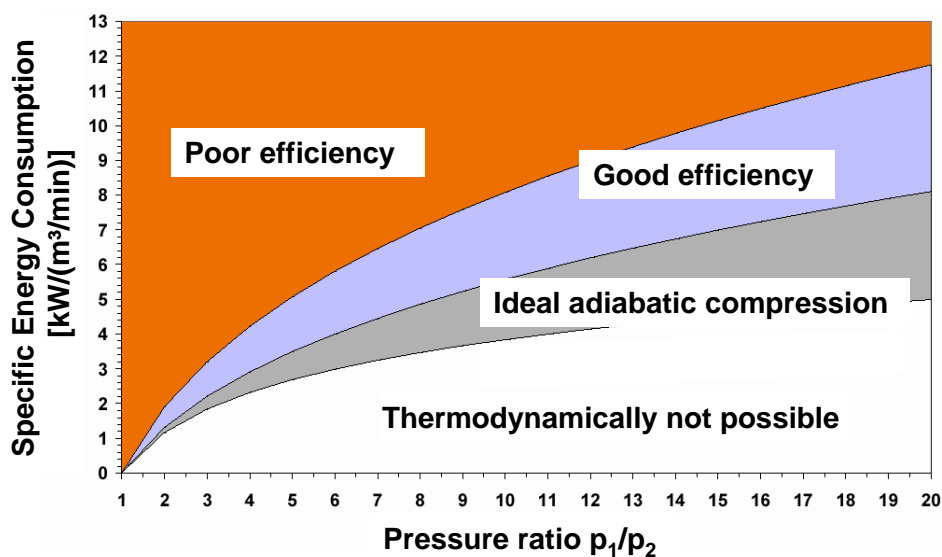
First Assessment of the Energy Efficiency



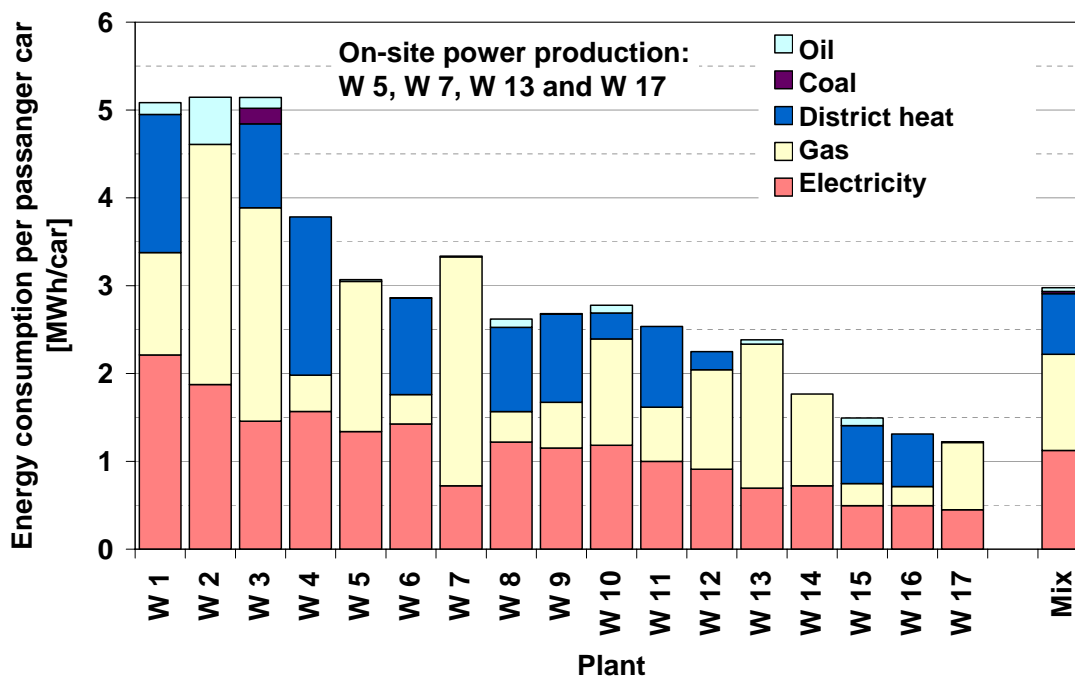
Layer et al. 1999

Example: Compressed-Air System

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

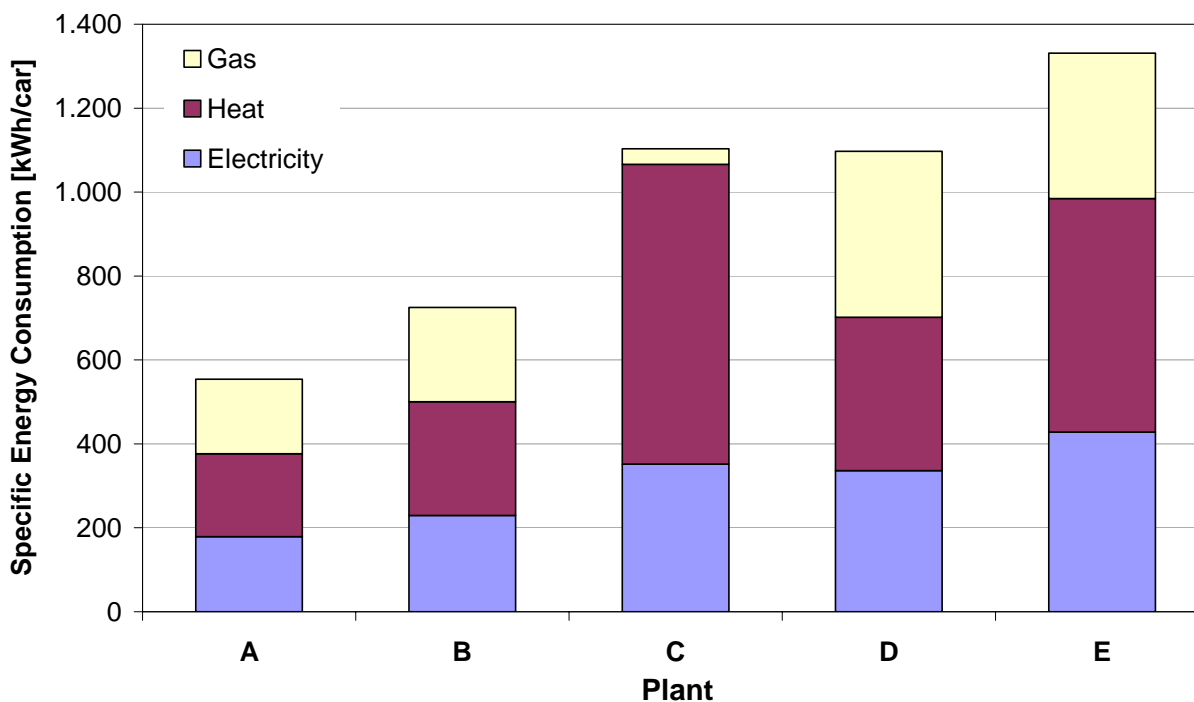


Example: Assembly Plant for Passenger Cars



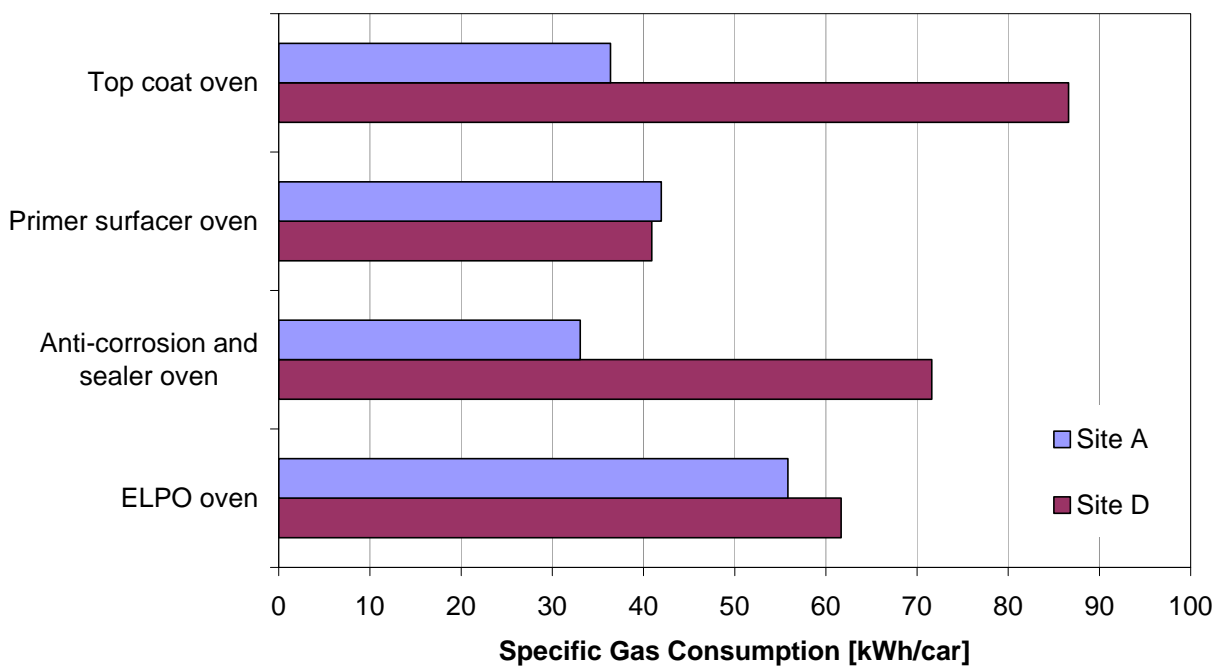
Leven 2004

Example: Paint Shop



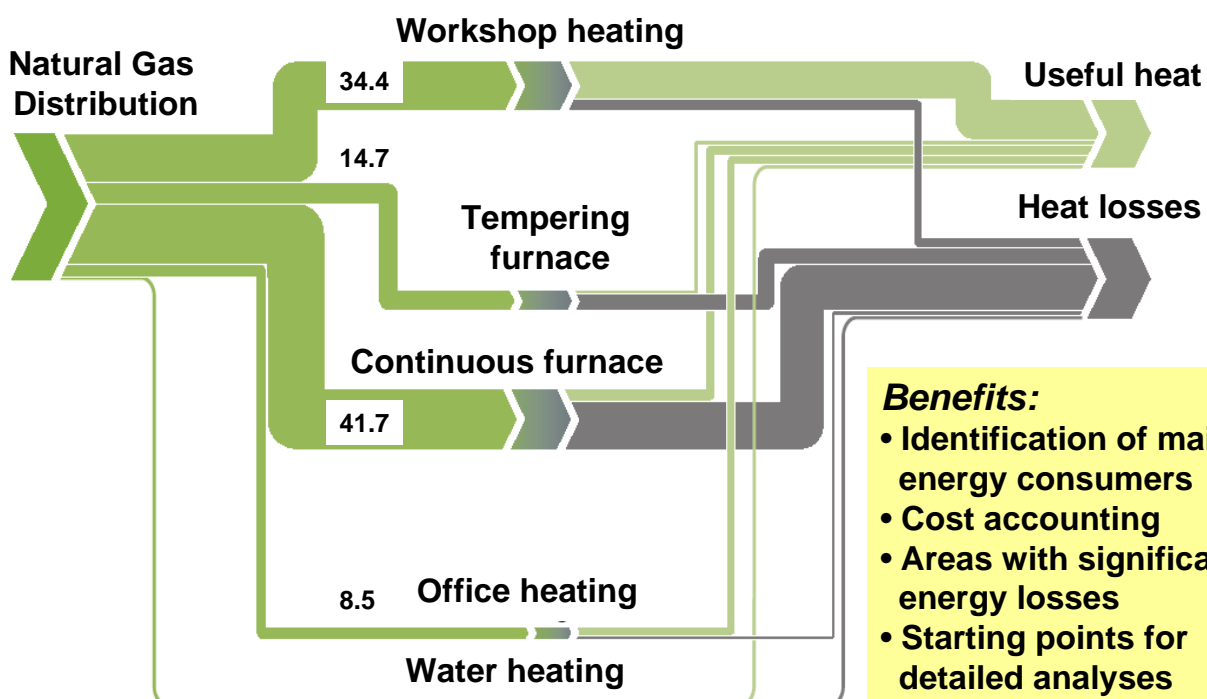
Leven 2004

Example: Cure Ovens

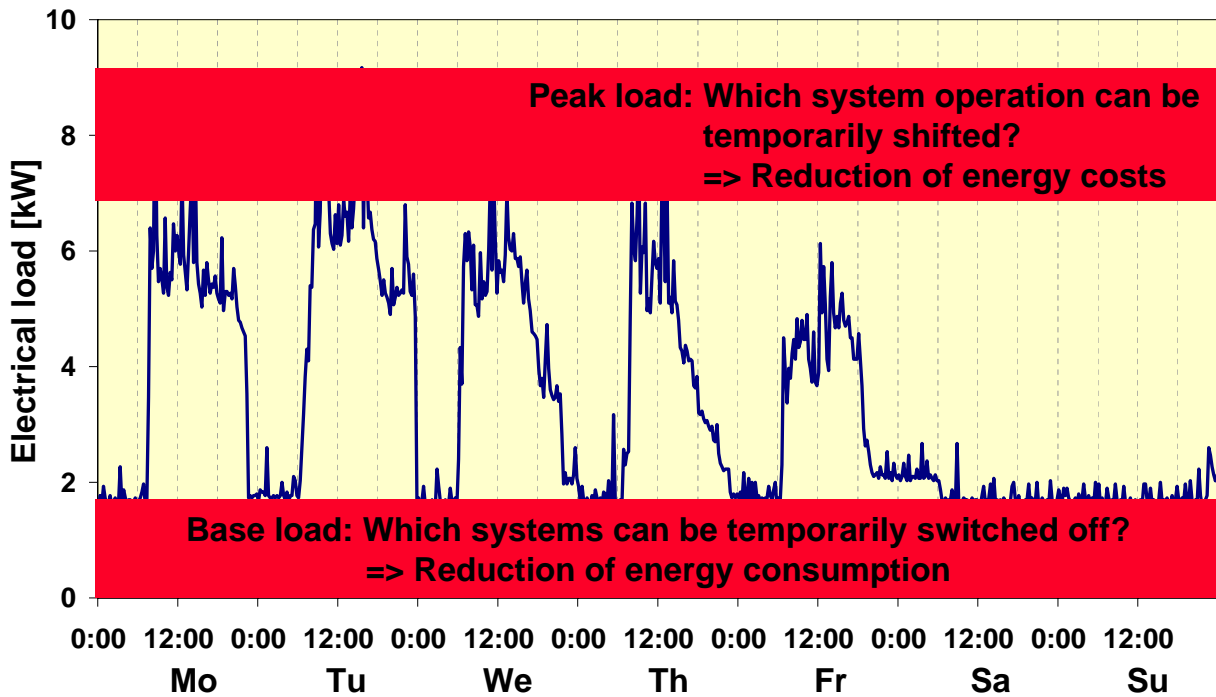


Leven 2004

Sankey Diagram for a Metal Processing Enterprise

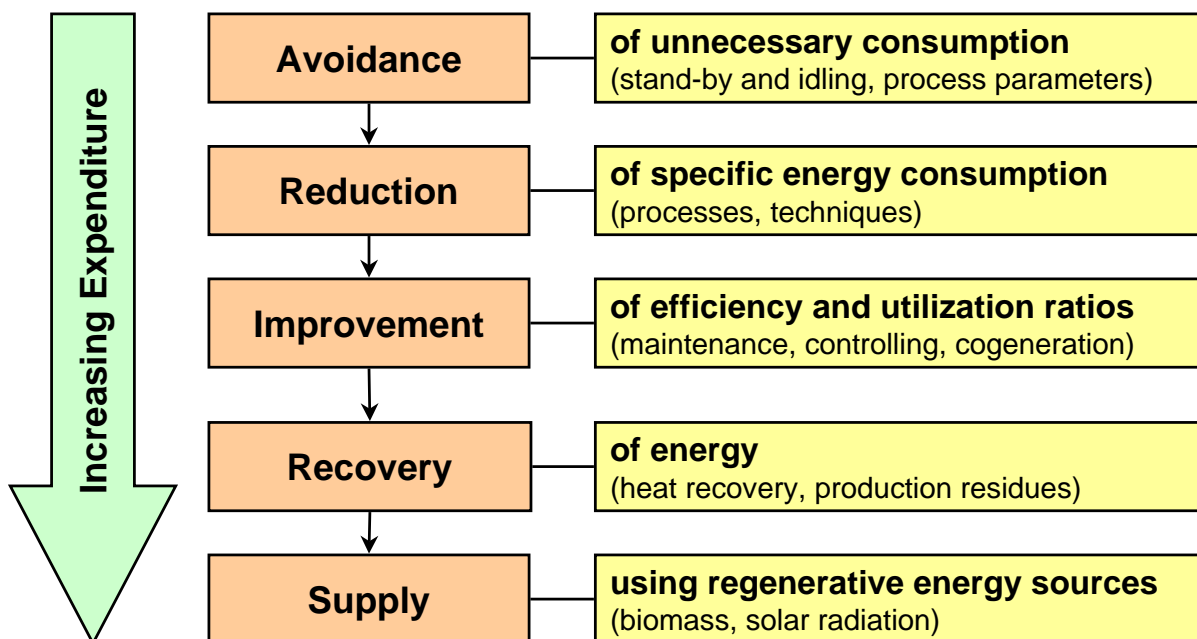


Electric Load Curve of a Data Processing Center



Leven, Schaefer 2004

Proposals for Improved Energy Use



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)

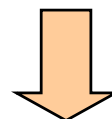
Calculations

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**

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**

Weber, Leven, Schaefer 2003

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]

Weber, Leven, Schaefer 2003

Result Sheet of a Consulting Report

Assessment criteria		Current situation	Measure 1	...
Energy	Electricity consumption [kWh/a]
	Fuel consumption [TJ/a]			
	Peak load [kW]			
	... Specific electricity consumption [kWh _{el} /m ² a]			
Economic efficiency	Energy supply costs [\$ /a]
	Energy cost savings [\$ /a]			
	Investment [\$]			
	... Specific energy costs [\$ /m ² a]			
Environment	Air pollutants [kg/a]
	GHG emissions [kg/a]			
	... Specific GHG emissions [kg/m ² a]			
	...			
Qualitative criteria	Reliability of supply
	Internal acceptance			
	...			

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

- Leven, B.; Schaefer, C.: **Energy Concepts for Small and Medium-Sized Enterprises**. Stuttgart: Ministry of Economics, 2004
- Leven, B.; Weber, C.: **Energy Efficiency in Innovative Industries – Application and Benefits of Energy Indicators in the Automobile Industry**. In: American Council for an Energy Efficient Economy: ACEEE-Summer Study on Energy Efficiency in Industry (Proceedings). Tarrytown, NY (USA) 24. - 27.07.2001
- Weber, C.; Leven, B.; Schaefer, C.: **Methodology for cost effective assessment of heat recovery potentials**. In: Proceedings of the Industry Workshop on Building Energy Performance Improvement through Advanced Technologies, Smart Organization and Financing. Chicago (USA): 7. – 8. 10. 2003
- Leven, B.: **Energy Management in the Investment Goods Industry**. Dissertation, to be published in 2004
- VDI guideline 3922: **Energy Consulting for Industry and Business**. Düsseldorf: VDI - The Association of Engineers, 1998
- VDI guideline 4661: **Energetic characteristics - Definitions, terms, methodology**. Düsseldorf: VDI - The Association of Engineers, 2003
- VDI guideline 3807: **Characteristic values of energy consumption in buildings**. Düsseldorf: VDI - The Association of Engineers, 1994

Contact Information

Name:	Bernd Leven	Christoph Weber
E-Mail:	bl@ier.uni-stuttgart.de	cw@ier.uni-stuttgart.de
Phone:	+49 711 780 61 45	+49 711 780 61 51
Fax:	+49 711 780 39 53	
Address:	University of Stuttgart, Institute of Energy Economics and the Rational Use of Energy Hessbruehlstr. 49 a D-70565 Stuttgart Germany	
Web:	http://www.ier.uni-stuttgart.de/public/en/indexe.html	