4 – BACKGROUND MATERIAL

4 Textbook

4.1 Purpose of the Textbook "Energy analysis"

Purpose of the textbook

The textbook describes the work entailed by a corporate energy analysis that will serve as a basis for a company's energy management system. The participants learn how to create and maintain an energy database for a company, based on which a corporate energy management system can be implemented to optimize the overall energy consumption.

Since the oil crisis, it has become a necessity for large companies with high energy consumption to establish an energy management system. Small and medium-sized enterprises, however, rarely worry about these matters. The following table summarizes the key aspects of a company's energy management system.

It comprises five areas:

1. Organization

2. Analysis and planning

3. Monitoring

4. Consulting

5. Implementation

Measures for achieving an efficient corporate energy system

Area	Contents
Organization	• Installation of an organizational unit focused on energy-related matters; • Clear guidelines concerning responsibilities (organizational chart) and funds; • Integration of this unit into investment-related decisions.
Analysis and planning	• Collection and documentation of data concerning energy supply and utilization in the company; • Description of the energy situation (annual update); • Survey of weak points and saving potentials; • Drawing-up or commissioning of energy analyses (measurement of equipment or machines); • Elaboration and planning of energy saving measures.

Area	Contents
Monitoring	• Monitoring of energy conversion equipment and energy consumers; • Creation of energy benchmarks (development); • Creation of company comparisons concerning energy efficiency (e.g. benchmarks).
Consulting	• Description of the energy situation (energy report to management); • Evaluation of different supply contracts; • Market analysis.
Implementation	• Implementation of energy saving measures; • Maintenance of energy facilities.

Major issues of an energy management system

The establishment of an energy management system involves the following activities:

- Collection and documentation of data on energy supply and utilization in the company;
- Description of the energy situation (annual update);
- Elaboration of energy benchmarks as a monitoring and decision-making tool;
- Identification of options to save energy and reduce costs.

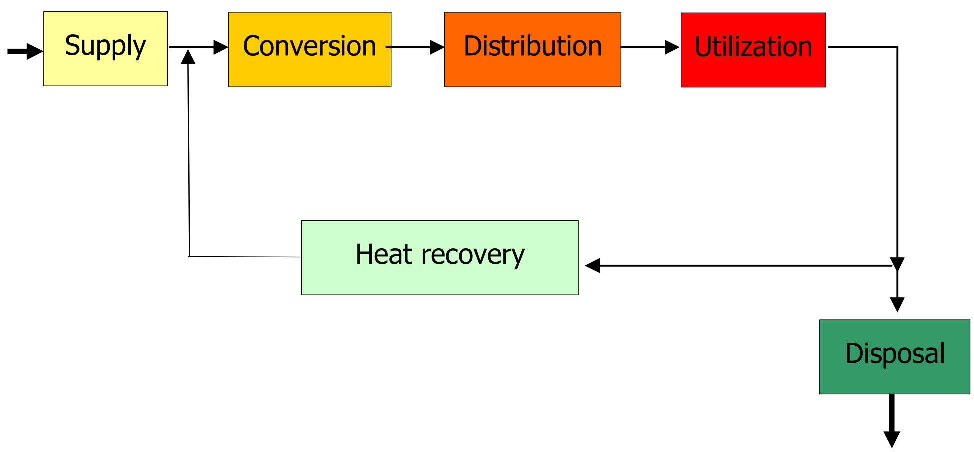
As mentioned above, setting up working groups which focus on energy is an important precondition for an efficient energy management system. The textbook of Volume 2 "Team, policy, motivation" of the Toolkit already dealt with the questions of staff motivation and responsibility. Please read this textbook while bearing in mind the involvement of the company's personnel in the implementation of an energy management system.

4.2 What are the main components of a corporate energy system? What is the basic approach?

Objectives of the corporate energy analysis

Basically, a company's energy system covers six areas. The aim of CP is not to consider energy purchase (input) as an unchanging constant. The idea is rather to elaborate measures designed to increase efficiency in terms of conversion, distribution and utilization of energy, also by means of heat recovery. The prime objective is to create the company's product or service with the minimum energy input. Therefore, this background information focuses on the energy service and not on the use of energy.

Structure of the corporate energy system



In all six areas, the following data are collected:

- Type, number and characteristics of equipment/machines;
- Types of energy consumed and energy consumption.

For energy purchase:

- Analysis of energy consumption along time.

For all areas:

- Interpretation of the data (comparison with benchmarks); and
- Suggestion of possible solutions for the efficient use of energy.

Energy units

Energy consumption is measured in joules (J, kJ, MJ, GJ). A further common unit is kWh: 1 kWh equals 3 600 kJ. Energy sources, such as fuels, are also stated in kilograms (kg), standard cubic metres (scm) or litres (l). These units can be converted into kJ or kWh (see conversion table at the end of the textbook).

Besides the energy consumption, the energy power is also an important factor. It indicates how much work is performed within a specific time and is usually measured in watts (W, kW, MW, GW).

4.3 Data collection and energy saving potential

Before you start collecting and analysing data, check if the following documentation is available in the company:

Profit from staff knowledge

- Records on energy consumption and consumer structure (e.g. machinery list);
- Plans, programme, measurements, etc.

Moreover it is very useful to talk to the company's personnel, because they can often provide important information on realistic energy-saving potential. The technical energy data, from purchase (input) to utilization and finally to disposal (output) are analysed in the following chapters. For each case, the analysis will proceed from general to specific, indicating possible ways of analysing and interpreting the collected data.

4.3.1 Energy data

Data on the annual consumption as well as costs have to be collected separately for each type of energy. These data are available in the invoices of the energy suppliers (electricity, district heating, gas) or suppliers of heating oil or diesel as well as in records of the in-company petrol station or electricity plant, etc.

Specific energy consumption – benchmarks

Benchmarks tell you more

For the evaluation of a company's energy consumption, reference values, the so-called indicators are essential (see also Volume 7 – Indicators and environmental controlling). For instance, in the case of a brewery, an indicator can be the heating oil consumption per hectolitre of beer. These reference values can differ substantially depending on the type of energy or the characteristics of the company. Typical reference values are production volume, turnover, number of staff, heated surface, transported volume, mileage, etc. to reduce its specific energy consumption.

For expanding companies, benchmark trends are the only reliable indicator of energy efficiency, whereas overall energy consumption is not really significant.

Based on the specific energy consumption, the energy situation in a company can be analysed and controlled. In this case, the following points have to be considered.

Identifying indicators

Interpreting indicators

- Has the specific energy consumption changed?
- Are the calculations of the specific energy consumption based on correct figures and assumptions?
- If the specific energy consumption has increased:
  - What could be the reason? Which areas have expanded? Has this expansion caused the higher specific energy consumption? Have energy sources been substituted?
- If the specific energy consumption has decreased:
  - Is the decrease due to specific energy saving measures? Have the targets been met? Or has the consumption decreased because energy sources were substituted?
- Where can I find appropriate benchmarks?
  - Ask colleagues for data from a particular sector.
  - Ask plant manufacturers for data.
  - Search in literature (research, magazines);
  - Carry out own calculations.

Data collection

Tracing energy carriers

Data should be collected separately for the following types of energy: electricity (energy supplier), in-plant electricity generation (hydropower, photovoltaics); natural gas, heating oil (heavy, light, extra light), fuels (diesel, petrol), biomass, solar power and district heating.

Transport is a major energy consumer

In particular, be aware of the fact that important areas such as purchased fuels are often not directly allocated to energy consumption but to different cost centres. These values have to be added up as they are generally a very important source of energy consumption, especially in service companies.

Annual profiles

If the monthly consumptions are lined up, they form an annual profile, from which the following conclusions can be drawn:

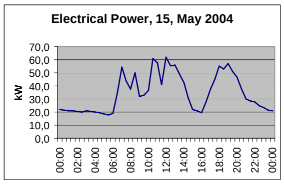
Interpretation of annual developments

- Determination of the winter-summer ratio to estimate the percentage of energy required for heating, cooling and process heat;
- Results achieved by the substitution of energy carriers, for instance if heating oil was substituted by electricity, etc. (in this case, several years need to be taken into account);
- Possibility of analysing energy carriers, e.g. for combined heat and power generation;

Power is a substantial cost factor

- Determination of months with significant consumption peaks and measures to avoid them (e.g. press, drier, bath, air conditioning, etc.).

The respective data can be taken from energy supplier bills and the company's own records.



Specific analysis of the annual electricity profile

Electricity is billed on the basis of two distinct quantities:

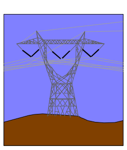
- **Power (kW)**
- **Consumption = work (kWh)**

Large companies usually have a so-called power management system ensuring that a certain maximum power is not exceeded. If the required power is higher, consumers are shut down temporarily in order of priority. Companies with a power management system should constantly check if the system works properly.

If there is a big difference between the monthly peak load and the calculated average power, a different production plan can be introduced to level out the consumption (cheapest solution). In addition, demand management, i.e. requesting offers from different companies in the sector can help to reduce the energy consumption. If reactive current costs are high (see electricity bill for details), they can be avoided by installing a compensation device. Specialized firms offer various designs and calculations of efficiency.

Weekly/daily statistics

Record the daily figures for at least one week and draw up statistics. Consider the day with the highest daily consumption or the day with the highest daily peak. The day with the highest daily consumption does not necessarily correspond to the day with the highest daily peak. Peaks may be entirely independent of the usual energy consumption, for instance, if repairs or test runs require large amounts of power.

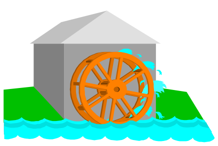


In order to collect data on electricity, companies with an electronic meter can call their energy supplier who will provide the data on peak consumption days in most cases free of charge. In addition, some energy suppliers offer their customers (free) measurements in order to draw up power consumption statistics for one or two weeks.

How to interpret weekly/daily statistics

- Do peaks cause bottle-necks in supply?
- Particularly with regard to electricity: can these peaks (= power price) be avoided?
- Is it really necessary to consume energy outside production hours or can it be saved?
- Is the energy consumption high at weekends? Can this be avoided, e.g. by switching off compressors, boilers, heating baths, by extending the night-time reduction also to weekends? In this case, however, observe the development of the outdoor temperature.
- Is consumption exceptionally high on any particular weekday? Can this be avoided? By implementing CP measures to reduce this peak consumption investments in additional equipment for the provision of supplementary energy can be avoided.

4.3.2 Conversion



So far we have only analysed the energy input. Now we will document and analyse the next stage of the company's energy system, conversion.

Conversion equipment includes heating boilers, steam boilers, district heating interconnecting stations, cooling equipment, combined heat and power generators (e.g. block-type power plants) and direct fuel consumers (e.g. gas driers).

Practically every company has energy converters in the form of heating or steam boilers. Therefore, this area is particularly important in terms of efficient use of energy.

Basic information on heat generation in boilers and its interpretation

The following table lists basic information on heat generation in boilers and provides possible interpretations and measures.

Basic information	Interpretation, measures
Rated power	Is the boiler used to capacity?
Fuel type and consumption	Is it possible to switch to a more environmentally friendly fuel?
Flow temperature (or pressure in steam boilers)	Are flow temperature/pressure correctly adjusted to the consumers or could they be reduced? (The higher the flow temperature, the greater the losses.)
Operating hours	See rated power.
Firing efficiency	Is the efficiency of the boiler regularly measured? Does it correspond to the manufacturer's specifications? Is the boiler regularly cleaned?

Basic information on central refrigeration equipment and its interpretation

The following table lists basic information on central refrigeration equipment and provides possible interpretations and measures.

Basic information	Interpretation, measures
Rated power Annual electricity consumption Operating hours	Operating hours should be between 4 000 and 6 000 h for well-designed equipment. Is the rated power adequate? Is the target refrigeration temperature maintained on hot summer days?
Outdoor/condensation temperature difference	At an outdoor temperature of more than 10 – 15 °C, the condensation temperature should not exceed the outdoor temperature by more than 10 – 15 °C. If the condensation temperature is too high, check the heat exchangers (control, design, etc.).
Refrigerator/evaporation temperature difference	The temperature difference between the refrigerator and evaporation should be less than 10 °C, for specific applications even less than 4 °C.

4.3.3 Distribution

As a next step, the company's energy distribution has to be analysed. Particularly heat distribution (hot water, steam) can involve major losses.

Importance of insulation

Therefore, check whether pipes are insulated (flow and return). The following example illustrates the importance of insulation. In 200 metres of uninsulated piping, a heating system with a flow temperature of 80 °C and a return temperature of 20 °C loses 31.2 kW of heat or almost 20% of the effective heat output. Covered with a 50 mm insulation, only 3.6 kW or 2% of heat are lost in 200 metres of piping.

Check steam traps

Steam traps in steam consumers must be regularly checked and renewed, if necessary (better utilization of steam). Furthermore, pay special attention to fittings as they have a large surface and can, therefore, cause major losses.

In general, the idea that radiant heat is not really lost is deceptive because:

- In most cases, pipes are located at the top and, as a result, heat is really lost;
- The generated heat is not used where and when it is needed;
- Individual areas can be overheated causing an additional burden on air-conditioning and unpleasant working conditions.

4.3.4 Consumers

Recording consumers

In Worksheet 4-4 the most important consumers, their rated power, operating hours and consumption are listed. All in all, a total of at least 80% of the purchased power should be recorded. It is important to distinguish consumers according to their applications.

For heat, according to:

- process heat, heating, hot water, air-conditioning.

For electricity, according to:

- refrigerating equipment, other cooling equipment, electric heating, hot water, lighting, process heat, drives (mechanical work).

For central refrigeration, according to:

- the individual cooling points.

Identifying potential savings

In addition, monitor the rated power and full-load hours. If necessary, estimate them for small machines, large machines usually have operating time meters. Then calculate the total consumption and allocate this value to consumer groups and specific applications. Use the column "Notes" to record details on energy saving measures and any necessary renewal or maintenance work identified during the data collection.

Interpretation of the collected data

Objective of the survey

As mentioned before, it is important to record and document equipment and machinery. Based on the collected data, the respective costs are calculated and allocated to the individual consumers. In this way, the concerned departments can determine the saving potential.

Suppliers often provide reference values of energy consumption for plants and equipment (e.g. efficiency of boilers, energy consumption of refrigerating equipment, etc.). By comparing these data to the data you have collected, you can determine whether it makes sense to investigate their saving potential in greater detail. With machines, for instance, which are more than five or ten years old considerable amounts of energy can be saved by installing new microelectronics and sensor technology (e.g.: frequency converters for speed control).

Based on the consumer structure, energy-saving measures can be prioritized and purchasing guidelines can be established. Potential measures can be derived from the following lists.

Heating/air-conditioning:

Energy saving measures

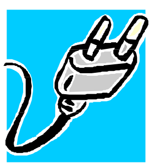
- Are heating controls regulated according to demand (thermostatic valves) and should individual areas of the company be regulated separately?
- Is room temperature adjusted to demand? (cooler in winter, warmer in summer, lowered at night and at weekends, allow greater variation of parameters, e.g. a range of minimum +/- 10%)
- Are inside sources of heat and humidity avoided in air-conditioned areas?
- Do the air-conditioned areas have sunshading facilities?
- Do fans have variable speed drives in order to adjust the volume of air to the demand?

- Are gates closed automatically? Is it ensured that windows and doors stay shut?
- Is there adequate vertical distribution of heat so as to avoid heat accumulation near the ceiling?
- Does the company take specific measures to ensure minimum consumption in process heat equipment? This includes minimum volumes of air in driers, minimum volumes of water in washing machines, bath covers, vat insulation, etc.
- Is the technology of cascaded heat utilization applied to process heat equipment?

Power consumers:

Energy saving measures

- Are machines and equipment adjusted to the demand? Avoid partial load operation of machines and equipment as reduced losses occur at the rated operating point. Adjusted drives, star-delta control, V-belt pulleys and frequency converters can help to reduce the energy consumption.
- Is consumption based on the demand, e.g. for fans (half speed equals a 75% reduction of power)?
- Is the compressor located in a cool room? Is the pressure level kept as low as possible? If possible, is compressed air avoided (most expensive form of energy!)?



- Are intake grids and nozzles regularly cleaned in order to reduce pressure loss?
- Are lights adjusted to the demand in terms of times and sites? Are light casings and reflectors regularly serviced and cleaned?
- If lights are old (older than 5 to 10 years), it generally pays off to install a more efficient lighting system. Evaluations are offered free of charge by firms operating in this sector.

4.3.4.1 Differentiation of consumption according to applications

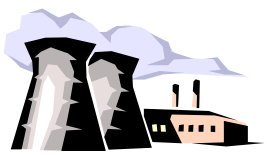
Based on the annual energy data and the consumer data, energy consumption is allocated to the following categories:

- Process heat;
- Heating;
- Hot water;
- Refrigeration;
- Lights;
- Other power consumers;
- Transport.

In this way, an overview of the company's energy system can be established. Once you have identified the energy consumption for the individual categories, set priorities for further analysis. In addition, these records are essential for an environmental audit.

Disposal of energy

Waste heat needs to be disposed of



The term disposal used in the context of energy does not match the usual meaning of the word, but is intended to illustrate the fact that additional equipment is required for the evacuation of waste heat. This equipment is not only a source of heat loss but causes supplementary costs and is time-consuming. Consequently, it should be analysed separately. Investing in energy-saving technologies can reduce the amount of time and costs required for disposal (from the symptom to the cause: for example, waste heat from computers has to be removed by the air-conditioning system, therefore, low-loss computers can pay off as a result of lower costs of air-conditioning).

For the documentation of waste heat, Worksheet 4-5 can be used. Briefly describe how used energy leaves the company paying particular attention to the utilizable temperature level.

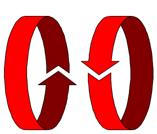
Essentially, the following areas have to be included:

- Exhaust gases (e.g. boiler, drier);
- Wastewater (before mixing, i.e. straight from each system);
- Refrigerating equipment (e.g. waste heat from condensers, product cooling);
- Other losses (e.g. outgoing factory air).

By analysing these data, it is possible to determine where to reduce or avoid energy consumption and to plan the reuse of this energy in a heat recovery system.

4.3.5 Heat recovery

Worksheet 4-5 indicates:



- Possibilities of cascaded utilization of heat;
- Connecting flows by means of heat exchangers;
- Current waste heat utilization;
- Possibilities of improving waste heat utilization.

Energy efficiency can be increased, if the waste heat generated by equipment is reused, especially in the aggregates themselves (e.g. preheating of air, preheating of water by counter-flow). By the so-called pinch technology, heat flows in process aggregates are linked and the effective deployment of heat pumps can be planned. More detailed information on this procedure can be obtained from specialized consulting firms.

Wastewater and exhaust air contain heat

Wastewater often contains heat. Recovering this heat, even at low temperatures, pays off in most cases. For example, if 1 m^3 of wastewater is cooled down by 10 °C and if this heat is simultaneously used for preheating fresh water, approximately 1.5 l of heating oil can be saved. For strongly polluted wastewater or wastewater containing solids, a special heat exchanger is recommended.

Air compressors are a frequent source of waste heat. In this case, cooling by oil or water is preferable to air cooling, because the warmed-up oil or water can be used for preheating fresh water.

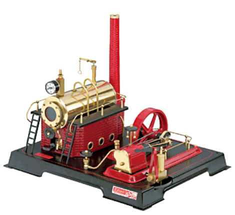
4.4 Typical areas with high potential for optimization

This chapter comprises typical questions for the following four areas with a particularly high potential for optimization:

- Boiler/steam system;
- Cooling/freezing system;
- Air pressure system;
- Lighting system.

In the following, however, only a small selection of possibilities is included, as a detailed description would go beyond the scope of this volume.

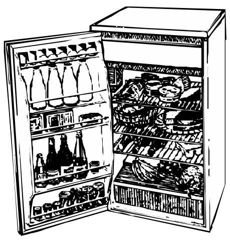
4.4.1 Boiler, steam system



- Is the condensate returned (contains up to 12% of the energy)?
- Is the combustion air preheated?
- Is fresh water preheated by heat recovery?
- Is the proportion of air correctly set? (no air surplus, no leaks, but still complete combustion)? Does the air flow controller work?
- Are the heating surfaces serviced and sufficiently cleaned (1 mm of accumulated dirt increases the exhaust air loss and consequently the energy consumption by approx. 5%)?
- Are steam losses avoided? Does the condensate discharge work properly?
- Is the vapour pressure in the system adjusted to the required temperature (higher pressure requires higher temperature causing unnecessary consumption)?
- Is the boiler sufficiently insulated (especially the front)?
- Is the boiler properly dimensioned (too high power causes unnecessary consumption during start-up, shut-down and operation)?
- Is the condensate container insulated?
- Are the steam/warm water pipes as well as shifter, valves, flange and distributor insulated?

- Would it make sense to install modern boilers with higher energy efficiency?
- ...

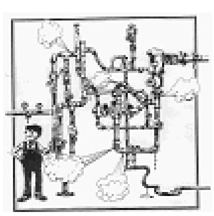
4.4.2 Cooling system



Cooling energy is cost-intensive

- Is the light reduced or switched off automatically in the cooling rooms?
- Are no warm products stored (they should be cooled down to room temperature if possible)?
- Does the defrosting cycle operate regularly but not too often (check the setting)? Is the vaporizer free of ice?
- Are plastic curtains or rapidly closing doors used to reduce losses?
- Is the required temperature in the cooling room recorded and adjusted to the needs (1 °C can save up to 4% of electricity)?
- Are open cooling units covered?
- Are the door seals undamaged?
- Are the opening times minimized?
- Are the cooling units regularly serviced and cleaned?
- Is the temperature in the condenser as low as possible?
- Can the discharged air in the condenser be reused?
- ...

4.4.3 Compressed-air system

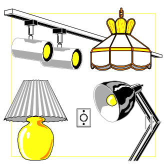


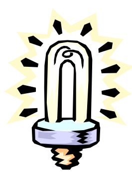
Compressed air is one of the most expensive forms of energy

- Are the compressors and driers switched off after operating time?
- Can the pressure be maintained after closing the valves?
- Are the pipes and plants checked for leaks (regular check after operating time or at the weekends)?
- Have the delivered air volume and the pressure of the compressor been measured (many compressor manufacturers offer this service)?
- Is the pressure reduced to the required minimum?
- Is a high level of pressure maintained for one single consumer although the others require lower pressure? (Install two separate grids using two pressure levels for this consumer.)
- Is the temperature of the intake air kept as low as possible (the colder the higher the efficiency)?
- Do you avoid using compressed air for cleaning?
- Are the air-intake filters regularly cleaned (avoiding pressure loss)?
- Is it possible to separate areas in the compressed-air system?
- Is it possible to cool the compressor with oil or water and to reuse the heat?

- Is the waste heat generated by the air-cooled compressors reused in winter (e.g. for heating the production area)?
- Is it possible to use electronic instead of pneumatic tools?
- ...

4.4.4 Lighting system





- Are only the required lights switched on?
- Is the light for outdoor areas and display-windows controlled (motion detector, timer)? Is daylight used as much as possible?
- Are lamps, lights and windows regularly serviced and cleaned?
- Are the rooms arranged in view of an efficient use of light?
- Do you use energy saving lamps (normal bulbs have an efficiency of just 1 – 2%, halogen lamps 1.3 – 3%, fluorescent or energy saving lamps 10 – 15%)?
- Are electronic power starter units used for fluorescent lamps?
- Are lights sufficiently equipped with reflectors?
- Has the lightning intensity of the workplaces been measured?
- Are there enough switches?
- Are there separate switches for the different workplaces?
- ...

4.5 Using renewable energy sources

Renewable energy sources and climate policy

In order to achieve the stabilization of greenhouse gases and increase efficiency, many countries are promoting the switch to renewable energy sources. Individual cities and regions have even committed themselves to reaching a specific reduction in CO_2 emissions within the next few years. In order to comply with the national targets, companies are requested to strengthen their own activities in this area.

For this reason, the analysis should document which renewable energy sources are used for which purpose and what percentage they account for in total energy consumption. Examples include: electricity generated by the company from hydropower or photovoltaics, heat obtained from biomass or solar collectors. Other renewable energy sources are wind power or the use of biogas and biofuels. Heat pumps also use renewable energy, if they extract heat from the ground or ambient air.

4.6 Traffic

In many countries traffic is already a major energy consumer. In future, this sector is expected to display even higher growth rates, which makes traffic the most significant impact in terms of energy consumption. For service companies, traffic is already the largest energy consumer in the company. It includes four areas:

Types of traffic

- Goods and services supplied by the company (outgoing delivery and business trips);
- Internal company traffic at the particular location and between plants;
- Goods and services purchased by the company (ingoing delivery);
- Staff traffic to and from work.

Reduction of traffic volume

Particularly staff traffic to and from work are difficult to survey in the initial stages. Knowledge of staff traffic to work allows us to create incentives for using bicycles, public transport (rail, combined means of transport) or car pools. Information concerning staff travel to and from work should be collected in advance. A minimization of costs and the duration of travel to and from work is of great interest to the company in order to increase staff satisfaction.

Generally, it is more difficult to collect data on deliveries to the company than on deliveries made by the company. However, the analysis of the available data should at least encourage the company to employ local carrier services or bicycle courier services and to transport larger amounts of goods by rail.

4.7 Contracting

Use energy as a potential area of saving

Many companies neglect energy aspects. Investments and planning are often not carried out until they have become unavoidable. However, as a result many potential savings and system renewals are not realized. A new instrument to solve this problem is contracting.

4.7.1 What is contracting?

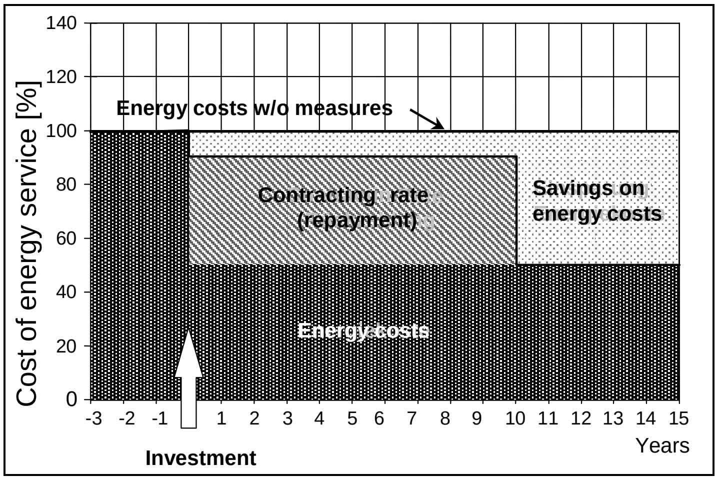
Contracting – or outside financing – means outsourcing energy supply or efficient energy utilization measures to external firms (contractors).

The user (= company) does not incur any investment costs. Investments are funded by the difference between previous energy costs and new reduced energy costs. The contractor provides funding and takes care of handling it.

We distinguish between two types of contracting:

New plants or energy reduction measures

1. **Plant contracting**: the contractor pre-funds the plant and calculates his remuneration on the basis of the amounts of energy supplied to the user.
2. **Energy-saving contracting**: the external firm (= contractor) implements measures aimed at reducing energy consumption. His remuneration is geared to the level of energy savings. (See diagram; source: Grazer Energieagentur)



Financing, support and service on the basis of contracting

Contracting allows a company to renew a piece of equipment (e.g. a heating system) and to implement energy-saving measures (e.g. installing insulation or thermostatic valves) without the company having to invest the necessary funds itself. In addition, the company receives professional support and service during the full duration of the contract.

4.7.2 When does contracting make sense?

Technical, organizational and financial reasons

- The existing energy supply system (e.g. heating system) is not state of the art.
- The company does not want to operate the machinery itself but rather wishes to outsource energy supply to an expert.
- The company does not have a budget for the new heating system and other energy-saving measures.
- The company wants to cut energy costs and reduce pollution.
- There is a mutual willingness to collaborate as partners for a longer period.

4.8 Drawing up an energy concept

Energy concept

Based on the analysis and evaluation of previously collected data, an energy concept is drawn up. During the recording of the energy situation, however, it often turns out that some essential data are missing. In this case, the company can either carry out detailed measurements or commission a service provider to draw up an energy concept. Nevertheless it is advantageous for a company to be able to assess its current energy situation and to estimate its basic potential for energy saving measures before recurring to external services.

The German Engineering Association VDI has published a guideline (VDI 3922) for energy consulting in trade and industry including detailed instructions for drawing up an energy concept.

The following items must be observed:

Steps of drawing up an energy concept (external consultants)

1. Initial contact with the consultant
2. Quotation and commission (clarification of scope of services)
3. Identification of the current situation
4. Additional measurements (if data are inadequate)
5. Description and evaluation of the current situation
6. Suggestions for a more rational use of energy
7. Development of an overall concept
8. Assessment and selection of measures
9. Presentation of the results and consultation report
10. Implementation and efficiency review

Current situation

The description and evaluation of the current situation has been described in the previous chapters. Once you have filled in all worksheets carefully, you have a sound basis and good view of the overall energy situation in a company. For the energy concept, it makes sense to sum up the key items.

Additional measurements

An investment decision often requires further detailed data and usually further measurements. With regard to electricity, for instance, such data are provided by the energy provider in the form of load development measurements. For questions of heat and refrigeration loss, thermography can be a very helpful instrument of analysis. If such measurements need to be performed, it is usually advisable to consult professionals.

Making suggestions

Suitable suggestions should be made on the basis of existing data and detailed measurements. Possible measures should consider the following items:

- Development of strategies for improvement;
- Identification of unnecessary energy consumption (distribution, consumers: e.g. buildings, idle times, steam consumers, etc.);
- Reduction of specific energy consumption (benchmarks);
- Optimization of efficiency and utilization rates (boiler optimization, frequency converters, etc.);
- Energy recovery;
- Use of renewable energy sources.

When outsourcing measurements, ensure that effective suggestions are presented which can be included in the energy concept. For the establishment of an overall energy concept, the following points have to be considered.

Criteria for a successful energy concept

- The preventive idea of CP has to be observed. The concept must include production-integrated solutions with long-term benefits, and not investments in end-of-pipe solutions.
- Special attention has to be paid to the impact of measures on production.
- Measures can be combined (e.g. water and energy consumption combined for process water, heat and electricity consumption of the air-conditioning system).
- Payback periods of the above-listed measures should be examined and listed in great detail. (Energy-saving investments often do not pay off, if energy is the only factor which is considered. Energy, however, does have a great influence on other areas. In addition, energy-saving measures often influence infrastructural changes and therefore can have long-term payback periods.)

Efficiency review

In addition to establishing an overview of the global energy situation of a company, the worksheets can also be used for a permanent review of energy efficiency. By establishing benchmarks and collecting data throughout several years, the success of an energy concept is monitored because the collected data can be compared to previous measurements.

Moreover the continuous upgrading of information provides a useful tool when dealing with suppliers. If a supplier is aware that you have detailed records and evaluations of energy-related data, he will be more careful and clearer in his quotations.

4.8.1 Thermography as an instrument of analysis

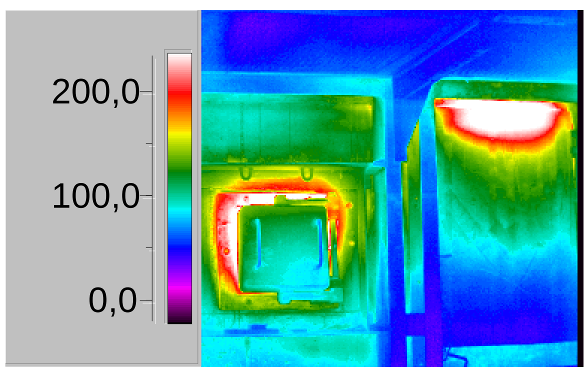
Measuring heat and cooling losses

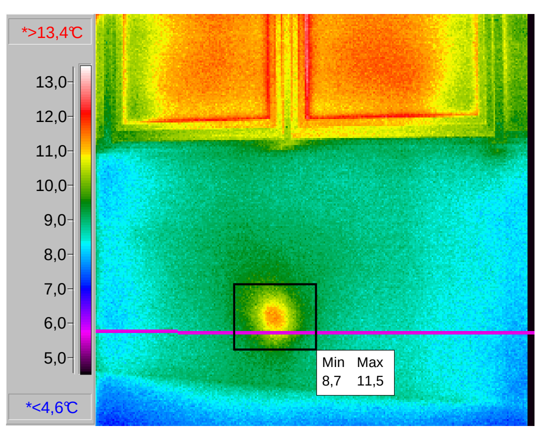
Thermography is an instrument for evaluating heat and refrigeration losses. Depending on the design of the measuring equipment you can measure surface temperatures at specific points (with so-called infrared thermometers) or visualize these temperatures with the aid of a thermal video camera.

Strictly speaking, thermography does not measure temperatures but rather object radiation. However, due to reflections and different emission behaviours, non-experts should be very careful when interpreting absolute temperatures.

Thermal cameras visualize the energy situation

The two following examples illustrate how information can be derived from thermographic measurements. The first picture shows a faulty pusher furnace. The temperature scale is indicated on the left of the picture. The colours/shades on this scale correspond to the colours/shades in the picture. The picture shows insulation faults (yellow and green on the tank top on the right) and areas of poor door sealing (white and red around the door in the left part of the picture). It is not possible to perceive the faults in the insulation (white and red, on the tank top on the right) just by observation – i.e. on site - without the aid of thermography.





The second picture also shows a thermal fault, this time in a prefab concrete element for a building facade. Of course, this fault cannot be detected by observation either.

By comparing the colours to the temperature scale included in both images, the losses involved can be roughly calculated.

Infrared thermometers are also particularly useful for detecting temperature problems. Although temperatures can only be measured at specific points and no images are saved for later use, this method is very inexpensive and easy to apply.

A major advantage of the analysis by camera is, however, that the colourful visualization of the company's energy leaks motivates staff to implement changes. Particularly when seen from this viewpoint, thermographic analysis is an ideal means of conveying the CP idea and convincing staff that energy saving measures can provide great benefits.

TIPS

Tips for energy saving measures

	Current situation	Measure/strategy
Management	Functions and competences are not clearly defined, energy relevant issues are not efficiently controlled (e.g. energy consumption of a new machine).	Set up an organizational unit "Energy".
	No energy saving measures are implemented in the company.	Provide specific training.
	High power is coupled with low efficiency, heat sources and cooling units are standing too close to each other.	Introduce production planning with regard to energy efficiency.
	Energy consumption and costs are not continuously recorded and controlled.	Implement energy accounting.
	High specific energy consumption of the plants, old technologies.	Determine energy indicators.
Energy supply	High SO_2, dust or NO_x emissions, no renewable energy sources.	Change to environmentally friendly fuel.
	High demand for warm and hot water also in summer.	Introduce solar energy.
	High power price, low continuous power.	Implement load management.
	High costs of reactive power.	Implement reactive power compensation.
	High electricity costs compared to other companies in the sector.	Negotiate prices with energy providers.
Conversion	High demand of thermal and electric energy at the same time.	Implement combined power-heat plants.
	Low efficiency, high temperature of exhaust air, no flue gas evacuation, badly adjusted burner.	Check the boiler.
	The heat demand has significantly changed in recent years.	Adjust the burner (change the nozzles).
	The heat exchangers of cooling units are not cleaned, the cooling temperatures are not checked, the location is badly ventilated.	Check and service the cooling units.
	Losses in the air-pressure system due to leaks, location close to a heat source, no filter maintenance.	Check the air-pressure system.
Distribution	High energy consumption in spite of low production (e.g. at night or weekends).	Insulate the steam pipes, maintain/renew the condensate discharge.
	See chapter 4.3.2.	Boiler/steam
Room temperature / warm water	High energy consumption at weekends, no zoned control possible, no thermostat valves, no seasonal adjustment of the room temperature, temperature is not lowered during the night, heaters are covered and hidden.	Improve the heat control.
	No automatic gates, windows and doors are in bad condition.	Diminish the transmission loss.
	High temperatures, no water saving fittings, no insulation of pipes.	Improve the warm/hot water system.

Tips for energy saving measures

	Current situation	Measures/strategy
	Air conditioning: too much air penetrates from outside, there are sources of heat and humidity in the air-conditioned area, no sun-protection equipment, no adjustment to demand.	Optimize the air conditioning control and avoid sources of heat and humidity in the air-conditioned area.
Process heat	Volume of air flow is not controlled, insufficient insulation, old processes (convection instead of infrared drying).	Optimize the process heat plants.
	Waste heat and wastewater streams at different temperature levels are not used, waste heat generated by cooling units is not used.	Check the use of waste heat.
Consumer coldness	The space in cooling units is badly utilized, the temperature is lower than necessary, no cooling curtains, interruption of the cold chain, heat source close to the cooling spots.	Optimize the use of the cooling units.
Consumer-electricity	The intake fence and nozzles of electric drives are not regularly cleaned, the engines mostly run at partial load.	Check the electric drives.
	Ventilators and pumps consume a high volume of electricity and are not adjusted to demand.	Build in a frequency converter.
	The plant is older than 10 years, no adequate lighting system, no zoned control.	Optimize the lighting system.
Consumer-transport	No transport concept, no control of the existing motor pool and routes, no transport by ship or railway, public transport is not used.	Optimize transports.

Conversion table: common energy units for energy sources in [kWh]

1 m^3 natural gas	9.4 kWh	1 kg wood air-dried	4.3 kWh
1 l heating oil	10.0 kWh	1 m^3 wood chips (softwood)	870 kWh
1 kg heating oil	11.9 kWh	1 m^3 wood chips (hardwood)	1 250 kWh
1 kg black coal	8.1 kWh	1 GJ district heating	277.8 kWh

1 Watt = 1 Joule/s		1 kWh = 3 600 kJ
1 000 J = 1 kJ	1 000 W = 1 kW	1 000 Wh = 1 kWh
1 000 kJ = 1 MJ	1 000 kW = 1 MW	1 000 kWh = 1 MWh
1 000 MJ = 1 GJ	1 000 MW = 1 GW	1 000 MWh = 1 GWh

Indicator of energy consumption for different buildings

Energy indicators in kWh/m² a (without warm water use)	**Administration building**	**Administration building (air-conditioned)**	**Storage, garage**
Old building	150	175	140
Old building after renovation	100	110	100
New building – minimum values	95	95	85
Reference values – new building	65	65	60

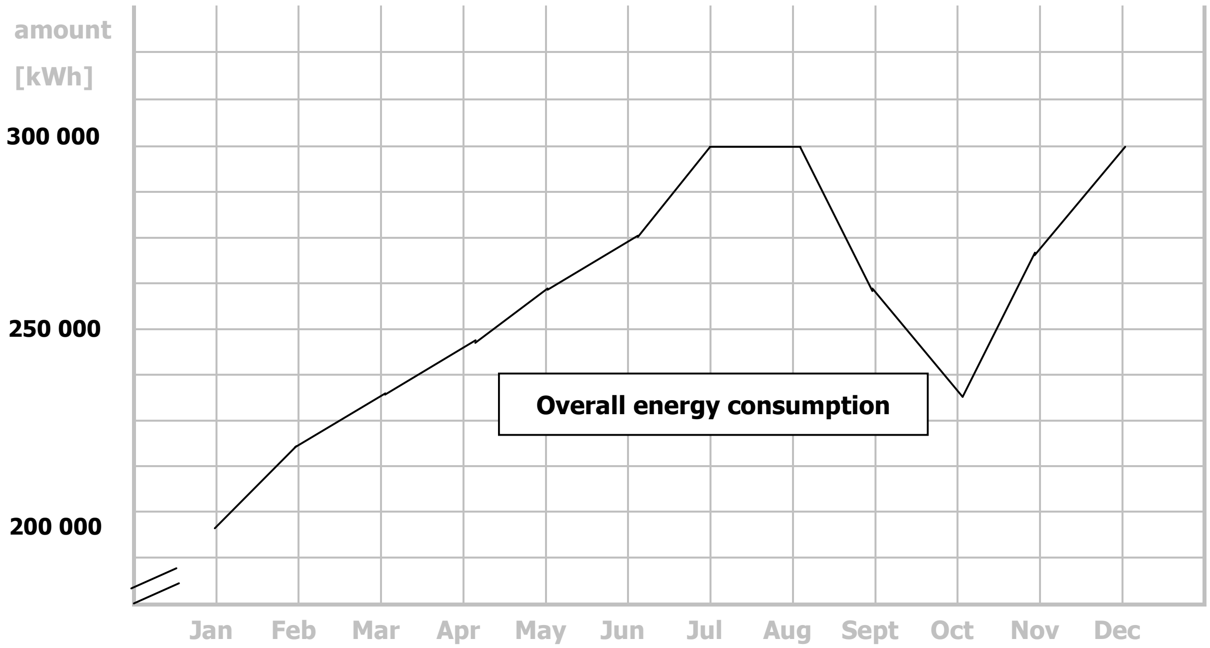
Source of reference values: Swiss handbook of energy (Schweizer Energiehandbuch)

Efficiency and burning life of different lamps

Type	**Efficiency (lumen/watt)**	**Burning life (hours, approx.)**
Light bulbs:		
Standard	up to 18	1 000
Halogen	up to 30	2 000
Discharge lamp: mercury steam-high pressure lamp	up to 60	10 000
fluorescent lamp	up to 80	6 000
fluorescent tube	up to 100	10 000
Halogen-metal steam lamp	up to 100	7 000
Sodium-high pressure lamps	up to 130	10 000

Source: Swiss handbook of energy (Schweizer Energiehandbuch)

Example of a monthly analysis for one year



Example of a daily load management analysis