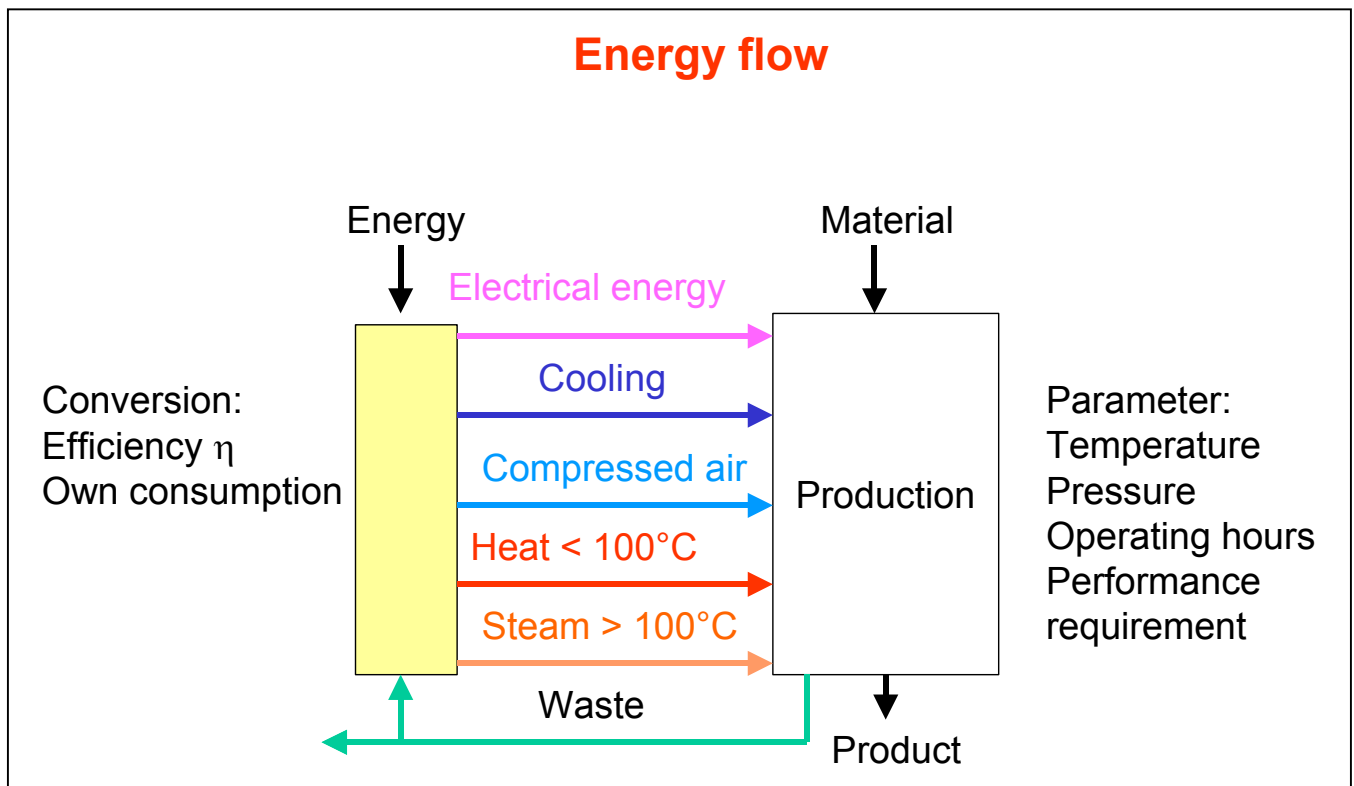


Introduction

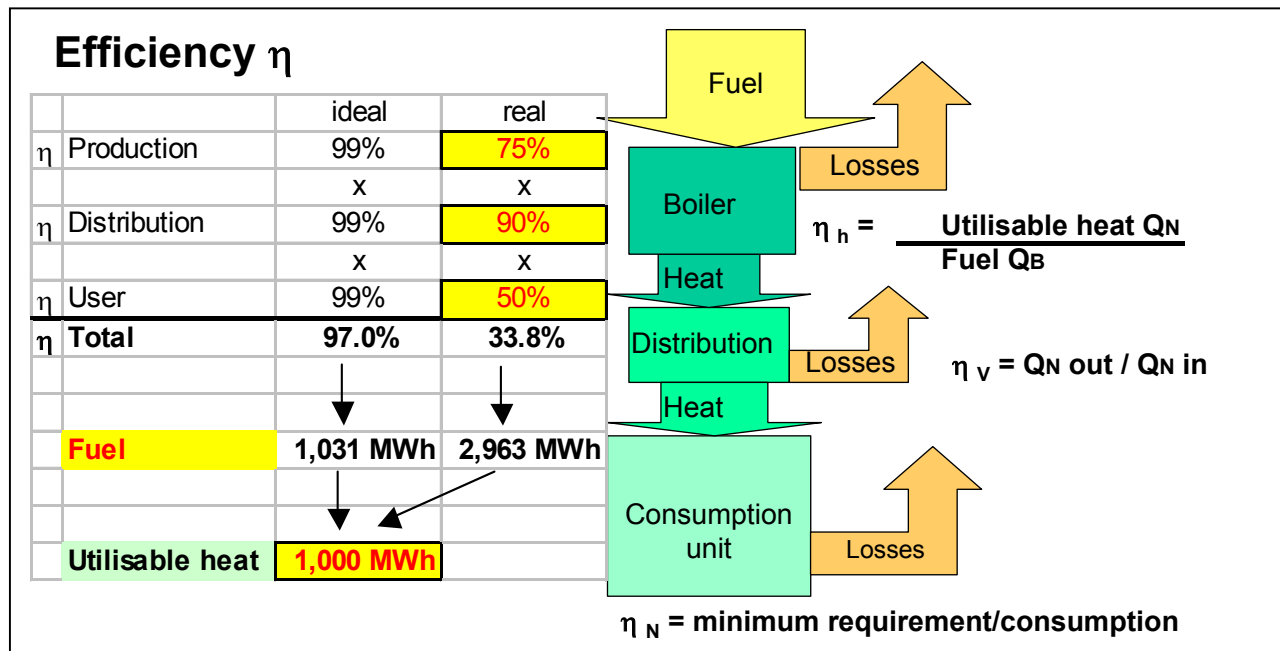
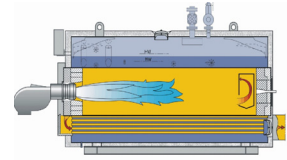


If one observes a production process many energy flows which influence each other to some extent are visible. Even though the following lesson mainly relates to process heat, the systematics can also be applied to other energy sources.

Parameters that influence the energy requirement

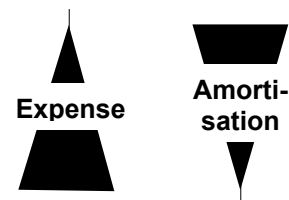
The energy requirement for process heat depends on:

- The temperature selected as well as, if applicable, the pressure selected
- The optimal degree of efficiency with regard to heat production
- The minimisation of losses (radiation, standby, exhaust gas and distribution losses)
- Regulation (running time and temperature)
- System optimisation
- Electricity consumption by support systems

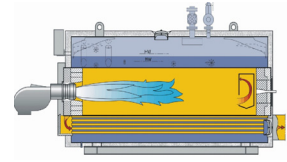


Hot air, warm or hot water and steam (as vapourised water) or thermal oil, as well as many other materials, are used as heat carriers for the transfer of energy in operational processes. For the implementation of optimisation measures, the following steps should be followed:

1. **Avoidance** of unnecessary energy consumption
2. **Efficient energy utilisation** in existing units
3. Introduce **new technologies / units**



In this regard, particular potential exists in the optimisation and automation of processes along with an appropriate training programme for the plant personnel. In this way losses caused by a careless approach to heat can be avoided (e.g. switching off the heat flow during idle time or production breaks). Large savings potentials can be achieved with minimal financial inputs through purely organisational measures (e.g. bringing plant into service on a phased time bases - in the case where several heat consuming units exist). Opportunities for recovering heat should always be watched out for. This is especially relevant with regard to planned investment into new heat producing or consuming units where the costs of heat recovery can often be amortised over a short period of time.



Fuel Characteristics

In the case of conventional heat production, one uses chemically bound energy from the energy source being used (oil, gas, coal, wood) that generally exists in the form of carbohydrates (C_nH_m). Combustion converts these into carbon dioxide - CO_2 - and water - H_2O .

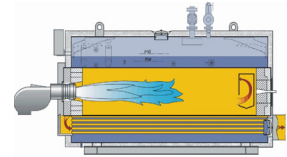
If water escapes in the form of steam, one talks in terms of the lower calorific value H_u . If, however, heat is accounted for in terms of release due to the condensation of existing water vapour, one obtains the upper calorific or combustion value.

The efficiency of energy production units is normally related to the lower calorific value - which does not take into account the heat of condensation. Because of this, lower calorific value measuring devices often show efficiency levels of over 100%. When related to the upper calorific value, the efficiency level naturally lies below 100%.

The upper calorific value generally depends on the amount of hydrogen bound within the fuel being considered. The higher the proportion of hydrogen, the greater the relationship between the upper to the lower calorific value and the greater the additional energy yield achieved by the calorific value technology.

Fuel	Heating value H_u	Calorific value H_o	max. CO_2 emission (kg/kWh) as related to	
			Heating value	Calorific value
Coal	8.14 kWh/kg	8.41 kWh/kg	0.350	0.339
Coke	7.50 kWh/kg	7.53 kWh/kg	0.420	0.418
Brown coal (raw) ¹	2.68 kWh/kg	3.20 kWh/kg	0.410	0.343
Brown coal- briquettes ¹	5.35 kWh/kg	5.75 kWh/kg	0.380	0.354
Heating oil EL	10.08 kWh/l	10.57 kWh/l	0.312	0.298
Heating oil S	10.61 kWh/l	11.27 kWh/l	0.290	0.273
Natural gas L	8.87 kWh/mn ³	9.76 kWh/mn ³	0.200	0.182
Natural gas H	10.42 kWh/mn ³	11.42 kWh/mn ³	0.200	0.182
City gas	4.48 kWh/mn ³	5.00 kWh/mn ³	0.200	0.179

In the case of fuels that are not classified as standard fuels (waste and residues), the calorific value depends upon the material characteristics and the water content. The requirements for combustion are standardised by means of the BImSchV.



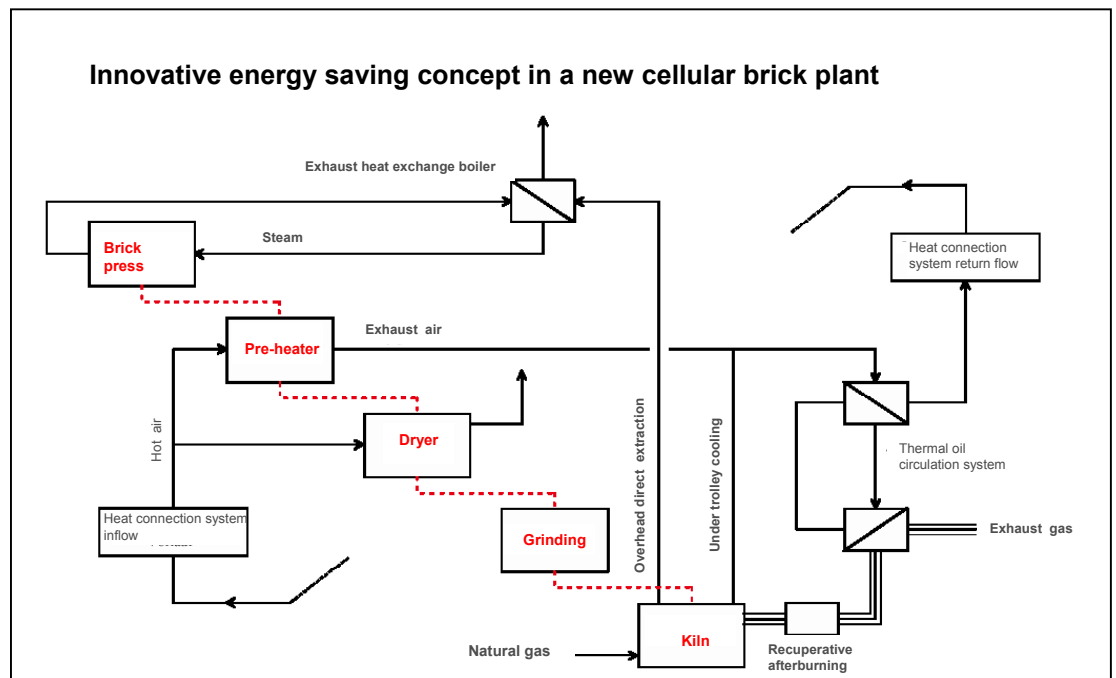
Heat recovery from process waste heat

In order to be able to implement heat recovery, the level of the waste heat must be useful, i.e. higher than the intended use temperature, otherwise heat pumps (vapour condensers) must be used.

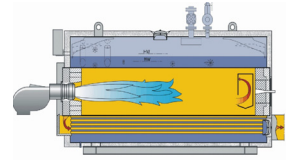
			Use area	Temperature	Medium
High Temperature	HT	>200°C	Ceramics/steel	>1000°C	Exhaust gas
			Roasting	200°C	Exhaust gas
Medium Temperature	MT	>100°C	Food processing	<120°C	Steam/heating water/thermal oil
			Extraction (e.g. soya oil)	<160°C	Steam/heating water/thermal oil
Low Temperature	LT	<100°C	Washing	<90°C	Steam/hot water
			Galvanic baths	<60°C	Hot water
			Photo film development	<40°C	Hot water
			Drying		Hot air

Heat recovery, waste heat utilisation and the use of heat pumps are highly recommended from the overall energy use perspective. Up to ten times more heat can be recovered with these technologies compared to using electricity. In this regard, the matching of the quality and the (timeliness of) availability with the needs of heat consuming units is a prerequisite.

Different ways exist for providing solutions, each one according to the production specific constraints and the quality of the heat source as well as the needs of the



consumption unit. As a rule, heat exchangers have the least electricity requirements. For example, the heat from the exhaust air arising from ventilation and air conditioning units can be recovered in the most economic way using these. Therefore this technology should be used in most units today.



The integration of combined cycle systems and heat pumps is possible without directly interfering in the process area.

Utilisable waste heat accumulates in association with a diverse range of industrial machines and processes:

- Motors und machines
- Compression for cooling and refrigeration processes
- Ventilation
- Waste water
- Drying processes
- Production units and finishing processes
- Exhaust gas from combustion processes
- Vapourisation from steam supply systems

In addition to directly feeding back into the process, other use areas include:

- Water heating
- Room heating
- Pre-warming
- Cold recovery
- Drying
- Feeding into the heating network.