Example 1:

The operating power plant consumes 130 wagons of coal per day. The coal has the heating value q_V = 14.5 MJ/kg and the power plant efficiency is η = 37 %. Each wagon transports 50 t of coal. Calculate, whether these parameters are sufficient enough to produce minimal constant power of 400 MW.

Solution:

Daily supply of coal: $m = 130 \cdot 50 = 6\,500\ t$

Gained energy: $\sum Q = m \cdot q_V = 6\,500 \cdot 1\,000 \cdot 14{,}5 = 94\,250\ GJ/day$

Supplied power: $P_S = \frac{\sum Q}{t(24h)} = \frac{94\,250}{24 \cdot 3\,600} = 1\,091\ MW$

Produced power: $P_P = 37\% \cdot P_S = 0{,}37 \cdot 1\,091 = \mathbf{404\ MW}$

The power 404 MW. → requirements are met.

Example 2:

A thermal power plant produces the daily power 120 MW in a combined operation (heat and electricity) during 18 h. In the remaining time 6 h, the power plant operates in the pure heating regime and produces 5 480 GJ of heat. The coal consumption of the power plant is 3 200 t and the coal heating value is 12 MJ/kg. Is it possible to use such a fuel, when the economically permissible limit of efficiency is η = 33 %?

Solution:

Produced energy: $Q = P \cdot t$

a) **Power station**

$$Q_E = P * t = 120 \cdot 10^6 \cdot 18 \cdot 3\,600 = 7\,776\ GJ$$

b) **Heating plant**

$$Q_H = 5\,480\ GJ$$

Total produced heat:

$$Q = Q_E + Q_H = 7776 + 5480 = 13256\ GJ$$

Supplied heat:

$$Q_S = m \cdot q_V = 3\,200 \cdot 10^3 \cdot 12 \cdot 10^6 = 38\,400\ GJ$$

Efficiency of the power plant:

$$\eta = \frac{Q}{Q_S} = \frac{13\,256 \cdot 100}{38\,400} = \mathbf{34,5}\ \%$$

The power plant efficiency is 34.5 % and used fuel is acceptable.

Example 3:

Compare the amount of required fuel for the permanent operating power plant of generated power 100 MW with efficiency η = 35 %. Considered fuels are the brown coal with heating value 12 MJ/kg and the uranium with heating value $82.5 \cdot 10^6$ MJ/kg.

Solution:

Produced energy:

$$Q = P \cdot t = 100 \cdot 10^6 \cdot 24h = 2\,400\ MWh \rightarrow 8\,640\ GJ\ (1\ MWh = 3\,600\ MJ)$$

Supplied energy:

$$Q_S = \frac{Q}{\eta} = \frac{8\,640}{0{,}35} = 24\,685\ GJ$$

Amount of used fuel:

$$m = \frac{Q_S}{q_V}$$

a. **Brown coal**

$$m_{hu} = \frac{Q_S}{q_{V\,co}} = \frac{24\,685 \cdot 10^3}{12} = \mathbf{2057\ t/day}$$

b. **Uranium**

$$m_{ur} = \frac{Q_S}{q_{V\,ur}} = \frac{24\,685 \cdot 10^3}{82{,}5 \cdot 10^6} = \mathbf{0{,}299\ kg/day}$$

Example 4:

Calculate the amount of needed fuel to produce energy 1 kWh. The average efficiency of the power plant is $\eta_e \approx 25\%$.

Solution:

Required energy to produce 1 kWh:

$$Q_c = \frac{3\,600\ kJ}{\eta_e} = \frac{3\,600}{0{,}25} = 14{,}4\ MJ$$

Heating value is $q_c = (8 \div 25)\ MJ/kg$

For 1 kWh is needed: $\frac{Q_c}{q_c}\ kg\ coal$

Summary of the fuel consumption according to type of coal:

Type of coal	Heating value (MJ/kg)	Consumption (kg/kWh)
Anthracite	30	0,48
Black coal	25	0,58
Brown coal	17,8	0,81
Lignite	10	1,44

Example 5:

Calculate the steam consumption to produce 1 kWh. The average efficiency of a thermal cycle is $\eta_t \approx 27\%$**.** Assume, the heat content of steam $Q_p \approx 3.3\ MJ/kg$.

Solution:

The heat content of steam corresponds to the enthalpy at admission steam parameters (8 MPa, 450 °C).

The consumption of steam for 1 kWh:

$$\dot{q} = Q_p \cdot \eta_t = 3.3 \cdot 0{,}27 = 0{,}891\ MJ/kg$$

$$\dot{w} = \frac{Q_p \cdot \eta_t}{3.6} = \frac{3.3 \cdot 0.27}{3.6} = 0{,}2475\ kWh/kg$$

$$m_{p1} = \frac{3{,}6}{Q_p \cdot \eta_t} = \frac{3{,}6}{3.3 \cdot 0{,}27} = 4\ kg/kWh$$