ESF II project of the University of West Bohemia in Pilsen, reg. number: CZ.02.2.69/0.0/0.0/18_056/0013239

Example 1:

Electricity production costs [CZK/kWh]

(Price of produced 1 kWh)

Instructions:

Calculate the price of 1 kWh produced in a power plant with installed capacity of 4x200 MW if:

Annual Maximum Utilization [h]	T_m =	6500
MAT (Attainable Capacity) [MW]	P_d =	750
Lifetime Period [years]	$T_ž$ =	25
CAPEX (Investment Costs) [CZK]	N_i =	8 000 000 000
Efficiency of the Power Station [%]	η_{el} =	30
Calorific Value of the Used Fuel [kJ/kg]	q_{pal} =	12 000
Price of Fuel [CZK/t]	c_{pal} =	400
Consumption of Mazut [t/year]	M_{mz} =	18 000
Price of Mazut [CZK/t]	c_{mz} =	1200
Consumption of Technological Water [m^3/year]	M_v =	11 000 000
Price of Technological Water [CZK/m^3]	c_v =	3
Number of Employees [-]		300
Average Annual Wage of 1 Employee [CZK/year]		300 000
Repair and Maintenance Costs [CZK/year]	N_{ou} =	50% of Depreciations

(MAT = Maximum Attainable Throughput, CAPEX = Capital Expenditures)

Moreover, calculate the individual unit costs:

a) The purchase price of installed kW [CZK/kW]

b) The specific work (labour) costs [CZK/kW]

c) The specific operating costs [CZK/kWh]

d) The specific repair and maintenance costs [CZK/kWh]

Solution:

The total costs of the produced electric energy [CZK/year]:

$$N_c = N_{st} + N_{pr}$$

N_{st} – fixed cost depend on the size of the installed capacity

N_{pr} – variable cost depend on the quantity of the produced electric energy

Fixed costs:

$$N_{st} = N_o + N_{pc} = N_i / T_z^{\check{}} + N_{pc} = \quad \textbf{CZK/year}$$

N_o – depreciations [CZK/year] $N_o = N_i / T_z^{\check{}} =$ **CZK/year**

N_{pc} – work (labour) costs (mainly wages) [CZK/year]

N_i – investment costs (CAPEX) [CZK]

$T_z^{\check{}}$ – lifetime period [years]

Specific fixed costs [CZK/kW] (fixed costs related to the installed capacity P_i)

$$n_{st} = N_{st} / P_i = N_o / P_i + N_{pc} / P_i = n_o + n_{pc} =$$

Variable costs:

$$N_{pr} = N_{pz} + N_{ou} = \quad \textbf{CZK/year}$$

N_{pz} – operation costs of the power station (fuel, other operating substances) [CZK/year]

$$N_{pz} = N_{pal} + N_{mz} + N_v =$$

N_{ou} – repair and maintenance costs [CZK/year]

Specific variable costs [CZK/kWh] (variable costs related to the quantity of produced electric energy W_c)

$$n_{pr} = N_{pr} / W_c = N_{pz} / W_c + N_{ou} / W_c = n_{pz} + n_{ou} =$$

The total costs are as follows [CZK/years]:

$$N_c = N_{st} + N_{pr} = N_o + N_{pc} + N_{pz} + N_{ou} =$$

The specific (unit) total costs [CZK/kWh]:

$$n_c = N_c / W_c = N_{st} / W_c + N_{pr} / W_c = N_i / T_{\check{z}} * W_c + N_{pc} / W_c + n_{pz} + n_{ou} =$$

ad a) The purchase price of installed kW

$$n_i = N_i / P_i =$$ **CZK/kW**

ad b) The specific work (labour) costs

$$n_{pc} = N_{pc} / P_i =$$ **CZK/kW**

ad c) The specific operating costs

$$n_{pz} = N_{pz} / W_c =$$ **CZK/kWh**

ad d) The specific repair and maintenance costs

$$n_{ou} = N_{ou} / W_c =$$ **CZK/kWh**

Fuel costs

- **Fuel costs N_{pal} [CZK/year]**

$$N_{pal} = M_{pal} \cdot c_{pal}$$

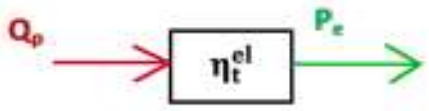
$$[CZK/year] = [kg/year] \cdot [CZK/kg]$$

- **Amount of fuel M_{pal} [kg/year]**

The amount of heat that we deliver for obtaiming P_e

$$M_{pal} = \frac{Q_p}{q_{pal}} \quad \frac{[kJ/year]}{[kJ/year]} = [kg/year]$$

q_{pal} – thermal calorific value



$$\eta_t^{el} = \frac{P_e}{Q_p}$$

- Q_p recalculation from [J/sec] on [J/year] :

$$Q_p = \frac{P_e}{\eta_t^{el}} \ [J/sec] \rightarrow Q_p = \frac{3600.P_e}{\eta_t^{el}} \ [J/hour]$$

P_e ... variable power output
Its value changes, but when converting Q_p per year we produce W_c, which can be determined from P_{max} a T_m

$$W_c = \int_0^{t_0} P_e \, dt = P_{max} \cdot T_m \rightarrow Q_p = \frac{3600.P_{max}.T_m}{\eta_t^{el}} \ [J/year]$$