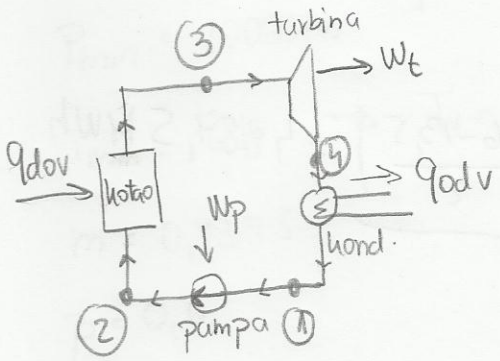
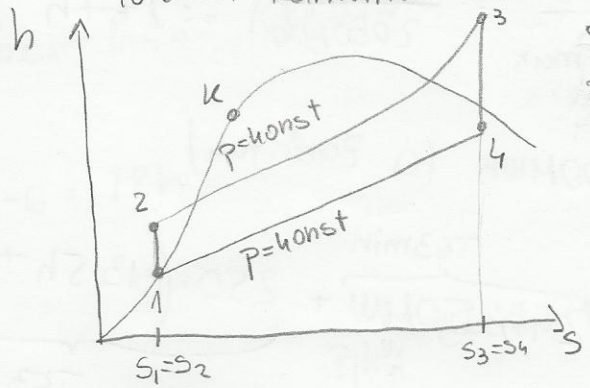
1. TE

$P_T = 400 MW$



Idealni Rankineov u.p.



$p_2 = p_3$

$p_1 = p_4 = p_{kond}$

$p_3 = 9 MPa$

$T_3 = 873 K$

$p_{kond} = 10 kPa$

$p_1 = p_4 = p_{kond}$

$p_3 = p_2$

KONDENZATOR: $h' = 191,8 kJ/kg$ $s' = 0,649 kJ/kgK$

$h'' = 2585 kJ/kg$ $s'' = 8,151 kJ/kgK$

$v' = 0,001 m^3/kg$

PRED TURBINOM: $h_3 = 3631 kJ/kg$

$s_3 = 6,957 kJ/kgK$

I voda

II para

$h_1 = h'$

a) $\eta_t = ?$

$$\eta_t = \frac{W_t - |W_p|}{q_{dov}}$$

$W_t = h_3 - h_4$?

$h_4 = h' + x \cdot (h'' - h')$

$s_3 = s_4 = s' + x(s'' - s')$

$$x = \frac{s_3 - s'}{s'' - s'} = \frac{6,957 - 0,649}{8,151 - 0,649} = 0,84 //$$

$h_4 = 191,8 + 0,84 \cdot (2585 - 191,8) = 2202 kJ/kg$

$W_t = 3631 - 2202 = 1429 kJ/kg$

$W_p = h_2 - h_1 = v' \cdot (p_2 - p_1) = 0,001 \cdot (9 \cdot 10^6 - 10 \cdot 10^3) = 8,99 kJ/kg$

$q_{dov} = h_3 - h_2 = 3631 - 200,79 = 3430,21 kJ/kg$

$h_2 = W_p + h_1 = 8,99 + h' = 8,99 + 191,8 = 200,79 kJ/kg$

$$\eta_t = \frac{W_t - W_p}{q_{dov}}$$

$$\eta_t = \frac{1429 - 8,99}{3430,21} = 0,413 //$$

b) $P_T = \dot{m} \cdot W_t \rightarrow \dot{m} = \frac{P_T}{W_t} = \frac{400 MW \cdot 10^3}{1429 kJ/kg} = 279,92 kg/s //$

c) $\dot{m}_{RV} = 20000 kg/s$

$c = 4,18 kJ/kg K$

$P_{uond} = \dot{m}_{RV} \cdot c \cdot \Delta T$

$P_{uond} = P_{odv} = \dot{m}(h_4 - h_1) = (2202 - 191,8) \cdot 279,92 = 562,7 MW //$

$$\Delta T = \frac{P_{uond}}{\dot{m}_{RV} \cdot c} = \frac{562,7 MW \cdot 10^3 \frac{kJ}{s}}{20000 \frac{kg}{s} \cdot 4,18 kJ/kg K} = 6,73 K //$$

TR

(2.) $c_p = 1005\ J/kgK$

$\kappa = 1,4$

$p_1 = 1,2\ bar$

$T_1 = 273K = konst$

$p_2 = 0,8\ bar$

$T_{okl} = 293K$

$c_v = \frac{c_p}{\kappa} = \frac{1005}{1,4} = 717,86\ J/kgK$

$R = c_p - c_v = 1005 - 717,86 = 287,14\ \frac{J}{kgK}$

$\Delta s_{pl}, \Delta s_{okl}, \Delta s_{skl} = ?$

$\Delta s_{skl} = \Delta s_{pl} + \Delta s_{okl}$

$\Delta s_{pl} = c_p \cancel{\ln \frac{T_2}{T_1}}^{0} - R \ln \frac{p_2}{p_1} = -287,14 \frac{J}{kgK} \cdot \ln \frac{0,8}{1,2}$

$\Delta s_{pl} = +116,43\ \frac{J}{kgK}$ //

$\Delta s_{okl} = \frac{q_{12}}{T_{okl}} = \frac{-31\,784,1\ J/kg}{293K} = -108,48\ J/kgK$

$q_{12} = pv \ln \frac{p_1}{p_2} = RT \ln \frac{p_1}{p_2} = 287,14 \frac{J}{kgK} \cdot 273K \ln \frac{1,2}{0,8} =$

$pv = RT$

$q_{12} = 31\,784,1\ J/kg$

$q_{izplina} = -q_{izohorice}$ PAZI

$\Delta s_{skl} = \Delta s_{pl} + \Delta s_{okl} = 116,43 - 108,48 = 7,95\ \frac{J}{kgK}$

(3.) PWR

241 g.el.

$l = 3{,}75\,m$

$18 \times 18 - 36$

$Q' = 18{,}64\,W/m$

$\Delta T = 33K$

$c = 5{,}544\,J/kgK$ } jezgra

3 rashl. petlje u I krugu

$P_p = 8\,MW$

$P_{hond} = 3300\,MW$

$\phi = 3 \cdot 10^{17}\,\frac{n}{m^2 s}$

---

a) $P_j' = (18 \cdot 18 - 36) \cdot 241 \cdot 3{,}75\,m \cdot 18{,}64\,W/m$

$P_j' = 4841{,}208\,MW$ //

b) $P_j' = \dot{m}_{I,uk} \cdot c \cdot \Delta T$

$\dot{m}_{I,uk} = \frac{P_j'}{c \Delta T} = \frac{4841{,}208\,MW \cdot 1000}{5{,}544\,kJ/kgK \cdot 33K} = 26480\,\frac{kg}{s}$

$\dot{m}_{1petlja} = \frac{\dot{m}_{I,uk}}{3} = \frac{26480\,kg/s}{3} = 8826\,\frac{kg}{s}$

c) $\eta = ?$

$P_T = P_j' + 3 \cdot P_p = 4841{,}208 + 3 \cdot 8 = 4865{,}208\,MW$

$P_{odv} = P_{hond}$; $P_T = P_{dov}$ $\quad \eta = 1 - \frac{P_{odv}}{P_{dov}} = 1 - \frac{3300}{4865{,}208}$

$\eta = 0{,}322$

d) $e = 0{,}03$

$m(UO_2)$

$\sigma_f = 580 \cdot 10^{-28}\ m^2$

$E_f = 200\,MeV$

$$P_j = E_f \cdot N_{U-235} \cdot \sigma_f \cdot \phi$$

$$N_{U-235} = \frac{4841{,}208\,MW}{200M \cdot 1{,}6 \cdot 10^{-13} \cdot 580 \cdot 10^{-28} \cdot 3 \cdot 10^{17}} = 8{,}695 \cdot 10^{27} \text{ //}$$

$$m(UO_2) = N_{U-235} \cdot \frac{1}{e} \cdot \frac{270}{238} \cdot \frac{235}{N_A}$$

$$m(UO_2) = 128\,310\,kg = 128{,}31\,t \text{ //}$$

e) 3d nakon obustave $\{ t = 12.30 + 3 \; ; \; t_0 = 12.30 \}$ ▽ 0

$12 m_j \cdot 30\,d$

$$P(t) = 0{,}0061 \cdot P_j \cdot \left[(t - t_0)^{-0{,}2} - t^{-0{,}2} \right]$$

$$= 0{,}0061 \cdot 4841{,}208\,MW \cdot \left[(3)^{-0{,}2} - (12.30+3)^{-0{,}2} \right]$$

$$P(12.30+3) = 14{,}62\,MW \text{ //}$$

(4.) DER. HE

$H_{zah} = 200m$ n.V.

$H_t = 50m$ n.V.

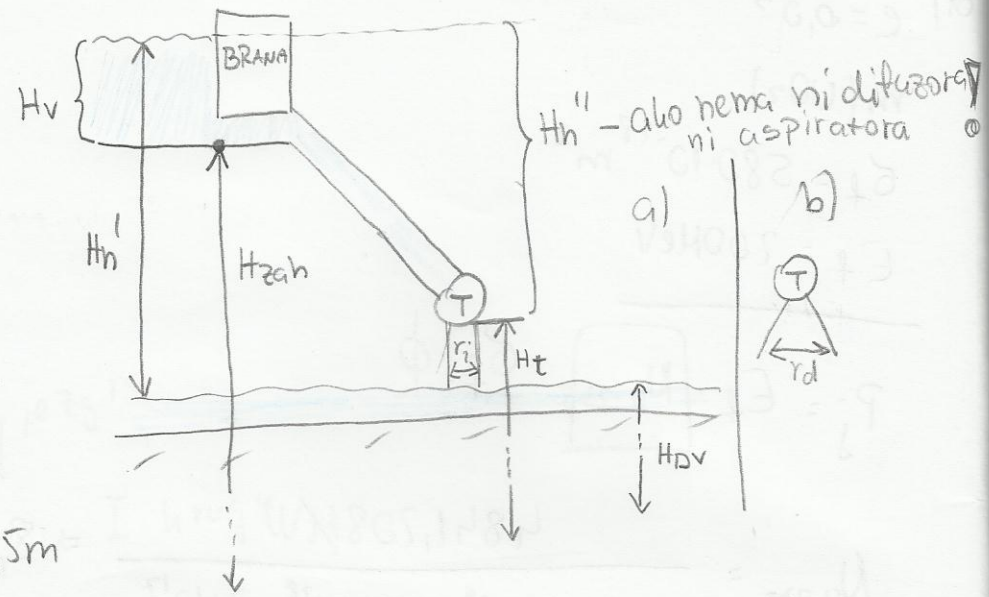
$H_V = 40m$

$H_{DV} = 45m$ n.V.

$Q_i = 150 m^3/s$

$\eta = 0,85$

$2 \cdot r_i = 3m \rightarrow r_i = 1,5m$



a) ASPIRATOR ; $r_A = r_i$

$Q_i = A \cdot C \rightarrow C_A = \frac{Q_i}{A_A} = \frac{150 m^3/s}{1,5^2 \cdot \pi\, m^2} = 21,22 m/s$

$A_A = r_i^2 \pi$

$H_{nA} = \overbrace{H_V + (H_{zah} - H_{DV})}^{H_n' \text{ na sliči}} - \frac{C_A^2}{2g} = 40m + (200 - 45) - \frac{(21,22)^2}{2 \cdot 9,81}$

$H_{nA} = 172m$

$P_{iA} = 9,81 \cdot 10^3 \cdot Q_i \cdot H_{nA} \cdot \eta = 9,81 \cdot 10^3 \cdot 150 \cdot 172 \cdot 0,85 =$

$P_{iA} = 215,13 MW$ //

b) DIFUZOR ; $r_d = r_i + 1m = 2,5m$

$Q_i = A_d \cdot C_d \rightarrow C_d = \frac{Q_i}{A_d} = \frac{150 m^3/s}{(2,5)^2 \cdot \pi\, m^2} = 7,64 m/s$

$H_{nD} = \overbrace{H_V + (H_{zah} - H_{DV})}^{H_n'} - \frac{C_D^2}{2g} = 40 + (200 - 45) - \frac{7,64^2}{2 \cdot 9,81}$

$H_{nD} = 192m$

$P_{iD} = 9,81 \cdot 10^3 \cdot 150 \cdot 192 \cdot 0,85 = 249,15 MW$ //

c) $m = 0,7 = \frac{W_{god}}{8760 \cdot P_i}$

$W_{god,A} = 0,7 \cdot 8760 \cdot P_{iA} = 0,7 \cdot 8760 \cdot 215,13MW = 1319,2\,GWh$

$W_{god,D} = 0,7 \cdot 8760 \cdot 240,15MW = 1472,6\,GWh$

5.) $P = 200MWe$

$\eta = 0,4$

$m = 0,75$

$H = 25\,MJ/kg$

$w(S,g) = 0,02 = \frac{m(S)}{mg}$

$m(SO_2) = ?$

$A_r(S) = 32\,g/mol$

$A_r(O_2) = 32\,g/mol$

$\eta = \frac{Wel}{W_t} \rightarrow W_{t,god} = \frac{Wel,god}{\eta} = \frac{1314\,GWh}{0,4} = 3285\,GWh$

$m = \frac{Wel,god}{8760 \cdot P} \rightarrow Wel,god = 8760 \cdot 200MW \cdot 0,75 = 1314\,GWh$

$m_g = \frac{W_{t,god}}{H} = \frac{3285\,GWh}{25\,MJ/kg} = \frac{3285 \cdot 10^{8} \cdot 3600}{25 \cdot 10^{6}} = 4,73 \cdot 10^{8}\,kg$ (1000)

$m(S) = w(S,g) \cdot mg = 0,02 \cdot 4,73 \cdot 10^{8}\,kg = 9,46 \cdot 10^{6}\,kg$

$S + O_2 \rightarrow SO_2 \Rightarrow n(S) = n(SO_2)$ (potpuno izgaranje)

$\frac{m(S)}{M(S)} = \frac{m(SO_2)}{M(SO_2)} \rightarrow m(SO_2) = m(S) \cdot \frac{M(SO_2)}{A_r(S)}$

$m(SO_2) = 9,46 \cdot 10^{6}\,kg \cdot \frac{32+32}{32} = 1,892 \cdot 10^{7}\,kg = 18920\,t$

(6.)

$A_{zemlje} = 5\,km^2$

$P_{max}, W_{max} = ?$

a) BM

$A_{elektrane} = 15\% A_{zemlje}$

$\Rightarrow A_{BM} = 0{,}85 \cdot A_{zemlje}$ $\quad A_{BM} = A_z - A_{ele} = A_z(1-0{,}15) = 0{,}85 A_z$

$\eta = 0{,}32$

$H = 14\,MJ/kg$

$M = 7\,t/ha$ $\quad * \frac{t}{ha} = \frac{10^3 kg}{ha \cdot 10^4 \frac{m^2}{ha}} = 0{,}1\,kg/m^2$ *

$m = 0{,}8$

$W_t = M \cdot H \cdot A_{BM} = \frac{W_{el}}{\eta}$

$W_{el,god} = M \cdot H \cdot \eta \cdot A_{BM} = 7 \frac{10^3 kg}{ha \cdot 10^4 \frac{m^2}{ha}} \cdot 14\,MJ/kg \cdot 0{,}32 \cdot 5 \cdot 10^6 m^2 \cdot 0{,}85 \cdot \frac{1}{3600}$

$W_{el,god} = 3702\,MWh$

$m = \frac{W_{el,god}}{8760 \cdot P_{max}} \rightarrow P_{max} = \frac{W_{el,god}}{8760 \cdot 0{,}8} = 0{,}528\,MW$

b)

	$v_{poč}$	v_{max}
VA1: $v_{in} = 11\,m/s$	6,6	17,6
VA2: $v_{in} = 15\,m/s$	9	24

$2r = 50m \rightarrow r = 25m$

$\eta = \frac{W_{el}}{W_{men}} = 99$

$A_{elektrane} = 40 \cdot A_L = 40 \cdot 25^2 \cdot \pi = 0{,}078544\,km^2$

$c_{pe} = 0{,}593$ $\quad$ broj elektrana: $\frac{A_{zemlje}}{A_{elektrane}} = \frac{5\,km^2}{0{,}078544\,km^2} = 63{,}66 \approx 63$

tolko VA stan na zemlju

VA1 $v = 8 m/s \rightarrow P_8 = \boxed{\eta_{cp} \cdot 0{,}5 \cdot \rho \cdot A} \cdot v^3$

$= 0{,}9 \cdot 0{,}593 \cdot 0{,}5 \cdot 1{,}225 \cdot 25^2\pi = 641{,}85 = K$

$P_8 = K \cdot 8^3 = 328{,}64 kW$

$P_n = K \cdot 11^3 = 854{,}34 kW$

$W_{god} = (0{,}2 \cdot P_8 + 0{,}14 \cdot P_n) \cdot 8760 = 1623 MWh$

63 elektrane:

$P_{max} = 63 \cdot P_n = 53{,}82 MW$

$W_{god,uk} = 63 \cdot W_{god} = 102 GWh$ } VA1

1/3600

VA2 $v = 10 m/s \rightarrow P_{10} = K \cdot 10^3 = 641{,}85 kW$

$v = v_n \rightarrow P_n = K \cdot 15^3 = 2166{,}24 kW$

$W_{god} = (0{,}1 \cdot P_{10} + 0{,}07 \cdot P_n) \cdot 8760h = 1890 MWh$

63 elektrane:

$P_{max} = 63 \cdot P_n = 136 MW$

$W_{god,uk} = 63 \cdot W_{god} = 119 GWh$?? } VA2

---

c) $P_{opt} = 1000 W/m^2$

$H_h = 1600 kWh/m^2$ godišnje

$\frac{H_{opt}}{H_h} = 1{,}22$

$\eta_{FN} = 0{,}12$ $\eta_R = 0{,}32$ $A_{FN} = 2 \cdot A_a$

$\eta_{ST} = 0{,}45$ $\eta_{DK} = 0{,}85$ $A_{ST} = 2{,}2 \cdot A_z$

= 63

stan

eju

ST

$P_{el} = P_{opt} \cdot \eta_{ST} \cdot \eta_R = 1000 \frac{W}{m^2} \cdot 0{,}45 \cdot 0{,}32 = 144 \frac{W}{m^2}$

$W_{usmj,god} = u_{Du} \cdot H_{Bopt} = u_{Du} \cdot 1{,}22 \cdot H_h$

$= 0{,}85 \cdot 1{,}22 \cdot 1600 kWh/m^2$

$= 1659{,}24 kWh/m^2$

$W_{el,god} = \eta_{ST} \cdot \eta_R \cdot W_{usmj,god}$

$= 0{,}45 \cdot 0{,}32 \cdot 1659{,}24 kWh/m^2$

$= 238{,}924 kWh/m^2$

$A_{ST} = 2{,}2 \cdot A_z = 5 km^2$

$A_z = \frac{5 \cdot 10^6 m^2}{2{,}2} = 2{,}27 \cdot 10^6 m^2$ //

$W_{el} = A_z \cdot W_{el,god} = \underline{542 GWh}$ // $\left(\frac{5}{2{,}2} \cdot 238{,}92 = 543 GWh \right)$

$\frac{P_n}{P_{el}} = A_z \cdot \eta$

$P_n = A_z \cdot P_{el} = 326 MW$ //

FN

$$P_{el} = P_{opt} \cdot \eta_{FN}^{0,12} = 1000 \frac{W}{m^2} \cdot 0,12 = 120 \frac{W}{m^2}$$

$$W_{usm,god} = H_{Bopt} = 1,22 \cdot H_h = 1952 \text{ kWh/m}^2$$

$$W_{el,god} = \eta_{FN} \cdot W_{usm,god} = 0,12 \cdot 1952 \frac{kWh}{m^2} = 234,24 \text{ kWh/m}^2$$

$$A_{FN} = 2 \cdot A_a = 5 km^2$$

$$A_a = 2,5 \cdot 10^6 m^2$$

$$W_{el} = W_{el,god} \cdot A_a = 234,24 \frac{kWh}{m^2} \cdot 2,5 \cdot 10^6 m^2 = \underline{585,6 \text{ GWh}}$$

$$P_h = P_{el} \cdot A_a = 120 \frac{W}{m} \cdot 2,5 \cdot 10^6 m^2 = \underline{300 \text{ MW}}$$

Najviše el. energije godišnje na $5 km^2$ proizvode FOTONAPONSKE ĆELIJE.

7.

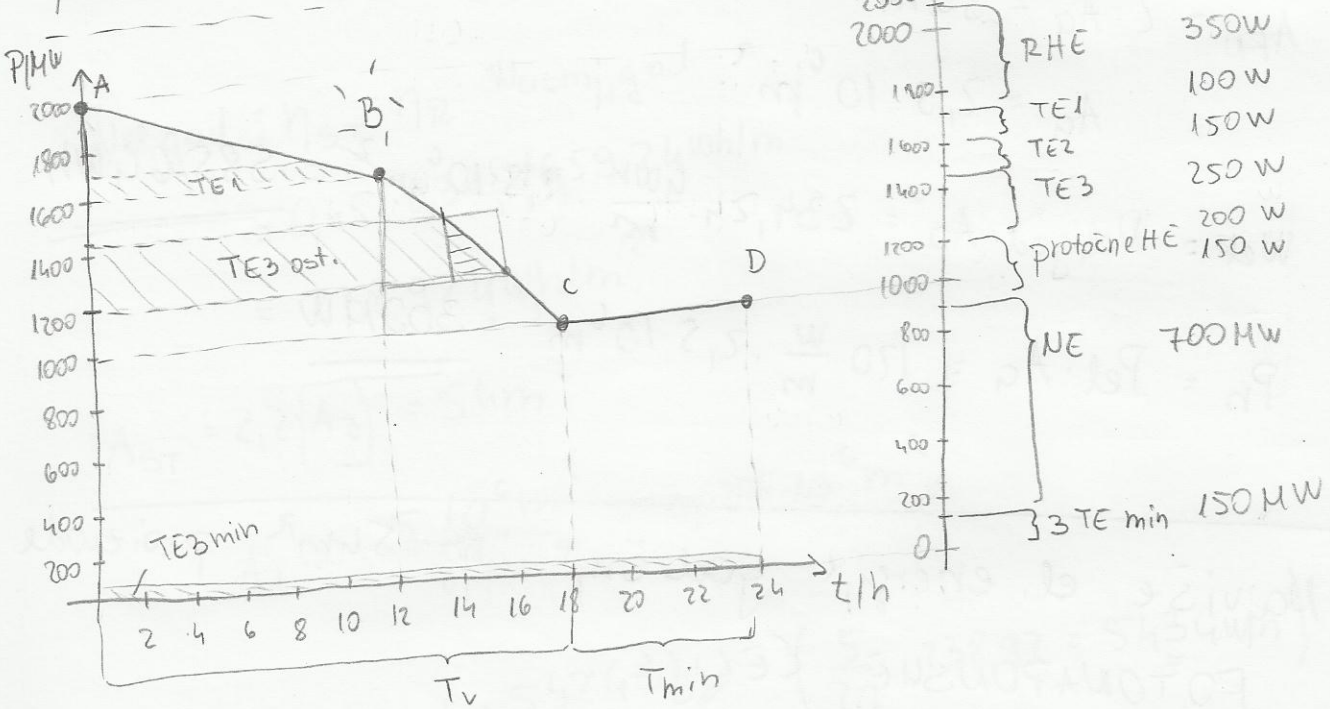
$P_{max} = 2000MW$ } $P_v = P_{max} - P_{min} = 1000MW$

$P_{min} = 1000MW$

$T_{min} = 6h \rightarrow T_v = 24 - 6 = 18h$

$m = 0{,}7375$

$\beta = 0{,}6$



TOČKA B (prijelomna) → (α) T_v, $P_H + \beta \cdot P_v$

$\alpha + \beta = 2 \cdot \frac{W_v}{T_v \cdot P_v}$

$x_B = \alpha \cdot T_v = \frac{2}{3} \cdot 18 = 12h$

$y_B = 1000 + 0{,}6 \cdot 1000 = 1600MW$

$W_v = W_d - W_{uonst}$

$W_{uonst} = 24h \cdot P_{min} = 24h \cdot 1000MW = 24000MWh$

$m = \frac{W_d}{24 \cdot P_{max}} \rightarrow W_d = 24 \cdot P_{max} \cdot m = 24 \cdot 0{,}7375 \cdot 2000MW$

$W_d = 35400MWh$

$W_v = 35400 - 24000 = 11400MWh$

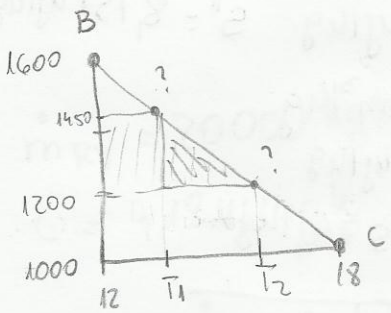
$\alpha = 2 \cdot \frac{W_v}{T_v P_v} - \beta = 2 \cdot \frac{11400MWh}{18h \cdot 1000MW} - 0{,}6 = \frac{2}{3}$ (0,667)

b) $T_{pmax} = \frac{W_d}{P_{max}} = \frac{35400\,MWh}{2000\,MW} = 17,7\,h$

c) $W_V = 11400\,MWh$ (iz zadatka)

d) $W_{TE3} = \overbrace{24h \cdot 50MW}^{TE3min} + \underbrace{250 \cdot \left(13,5h + \frac{16-13,5}{2}\right)}_{TE3\,ost.} = 4887,5\,MWh$

karakteristični trokuti



$$\frac{1600-1000}{18-12} = \frac{1600-1450}{T_1-12}$$

$$T-12 = \frac{150}{600} \cdot 6$$

$$T_1 = 13,5\,h$$

$$\frac{1600-1000}{18-12} = \frac{1600-1200}{T_2-12}$$

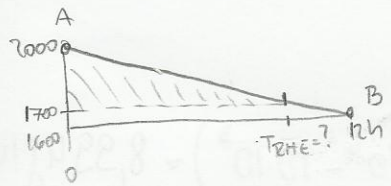
$$T_2 - 12 = \frac{400}{600} \cdot 6$$

$$T_2 = 16h$$

e) $T_{TEIost} = ?$ iz grafa: $T_{EIOST} = 12h$ (do točke B)

f) $W_{RHE} = ?$

$$W_{RHE} = \frac{T_{RHE} \cdot 300MWh}{2} = \frac{9h \cdot 300MWh}{2} = 1350MWh$$



$$\frac{2000-1600}{12-0} = \frac{2000-1700}{T_{RHE}-0}$$

$$T_{RHE} = \frac{300}{400} \cdot 12 = 9h$$