$$
\begin{array}{rccccccccc}
 & \mathbf{Bid} & P_H & P_G & P_P & E & d & T & P_{DL} & \\
variables = & [\ x0 & x1 & x2 & x3 & x4 & x5 & x6 & x7 &]
\end{array}
$$

Bid_i	0		x_0
P_{Hs}	1	s	x_1
P_{Gs}	s+1	2s	x_2
P_{Ps}	2s+1	3s	x_3
E_s	3s+1	4s	x_4
d_s	4s+1	5s	x_5
T_s	5s+1	6s	x_6
P_{DLs}	6s+1	7s	x_7

Equations:

 # Eq. 0: Regulation costs for period i $\Rightarrow [0:0]$

$$T_i = \sum_{s=1}^{S} T_{s,i} \cdot \rho_s$$

$$Eq.\,0 = \begin{matrix} P_{Hi} & P_{Ps,i} & E_{s,i} & P_{G_i} & T_i & T_{s,i} & d_{s,i} \end{matrix}$$
$$\begin{bmatrix} 0 & 0 & 0 & 0 & 1 & -1 \cdot \rho & 0 \end{bmatrix}$$

$$b = \begin{bmatrix} 0 \end{bmatrix}$$

 # Eq. 1: Hydro Pumped Storage (1) $\Rightarrow [1:s]$

$\hookrightarrow$ 1st hour

$$E_{s,1} = e\_begin$$

$$Eq.\,1 = \begin{matrix} P_{Hi} & P_{Ps,i} & E_{s,i} & P_{G_i} & T_i & T_{s,i} & d_{s,i} \end{matrix}$$
$$\begin{bmatrix} 0 & 0 & 1 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$b = \begin{bmatrix} e\_begin \end{bmatrix}$$

 # Eq. 2: Hydro Pumped Storage (2) $\Rightarrow [s+1:s+1]$

$\hookrightarrow$ 1st hour

$$P_{H,i} = e\_begin \cdot \frac{\eta_{hydro}}{t}$$

$$Eq.\,2 = \begin{matrix} P_{Hi} & P_{Ps,i} & E_{s,i} & P_{G_i} & T_i & T_{s,i} & d_{s,i} \end{matrix}$$
$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$b = \begin{bmatrix} e\_begin \cdot \frac{\eta_{hydro}}{t} \end{bmatrix}$$

 # Eq. 3: Hydro Pumped Storage (3) $\Rightarrow [s+2:2s+1]$

$\hookrightarrow$ remaining hours

$$E_{s,i} = E_{s,i-1} + t \cdot \left[\eta_P \cdot P_{Ps,i} - \frac{P_{Hi}}{\eta_H} \right]$$

$$Eq.\,3 = \begin{matrix} P_{Hi} & P_{Ps,i} & E_{s,i} & P_{G_i} & T_i & T_{s,i} & d_{s,i} \end{matrix}$$
$$\begin{bmatrix} 1_{t-1} \cdot \frac{t}{\eta_H} & -1_{t-1} \cdot \eta_P \cdot t & 1\& - 1_{t-1} & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$b = \begin{bmatrix} 0 \end{bmatrix}$$

 # Eq. 4: Imbalance for every scenario $\Rightarrow [2s+2:3s+1]$

$d_{s,i} = P_{WGi} - P_{Ws,i} + P_{Ps,i} + P_{Sp_{s,i}}$

$$Eq.\,4 = \begin{matrix} P_{Hi} & P_{Ps,i} & E_{s,i} & P_{G_i} & T_i & T_{s,i} & d_{s,i} & P_{Spi} & P_{Sps,i} \end{matrix}$$
$$\begin{bmatrix} 0 & 1 & 0 & 1 & 0 & 0 & 1 & 0 & 1 \end{bmatrix}$$

$$b = \begin{bmatrix} P_{Ws,i} \end{bmatrix}$$

 # Eq. 5: Spill for period i $\Rightarrow [3s+2:3s+2]$

$$P_{Sp_i} = \sum_{s=1}^{S} P_{Sp_{s,i}}$$

$$Eq.\,5 = \begin{matrix} P_{Hi} & P_{Ps,i} & E_{s,i} & P_{G_i} & T_i & T_{s,i} & d_{s,i} & P_{Spi} & P_{Sps,i} \end{matrix}$$
$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 \end{bmatrix}$$

$$b = \begin{bmatrix} 0 \end{bmatrix}$$

 # Eq. 6: Pump Power for period i $\Rightarrow [3s+3:3s+3]$

$$P_{P_i} = \sum_{s=1}^{S} P_{P_{s,i}}$$

$$Eq.\,6 = \begin{matrix} P_{Hi} & P_{Ps,i} & E_{s,i} & P_{G_i} & T_i & T_{s,i} & d_{s,i} & P_{Spi} & P_{Sps,i} & P_{P_i} \end{matrix}$$
$$\begin{bmatrix} 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$b = \begin{bmatrix} 0 \end{bmatrix}$$

 # Eq. 7: Pump Power for period 24 $\Rightarrow [3s+4:4s+3]$

$$P_{P_{s,i_{24}}} = 0$$

$$Eq.\,6 = \begin{matrix} P_{Hi} & P_{Ps,i} & E_{s,i} & P_{G_i} & T_i & T_{s,i} & d_{s,i} & P_{Spi} & P_{Sps,i} & P_{P_i} \end{matrix}$$
$$\begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$b = \begin{bmatrix} 0 \end{bmatrix}$$

 # Eq. 8: Energy for period 24 $\Rightarrow [4s+4 : 5s+3]$

$E_{s,i_{24}} - \frac{P_{H_{24}}}{\eta_H} = 0$

$$Eq.\ 6 = \begin{array}{c} \begin{matrix} P_{Hi} & P_{Ps,i} & E_{s,i} & P_{G_i} & T_i & T_{s,i} & d_{s,i} & P_{Spi} & P_{Sps,i} & P_{P_i} \end{matrix} \\ \left[\begin{matrix} -\frac{1}{\eta_H} & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{matrix} \right] \end{array}$$

$$b = \begin{bmatrix} 0 \end{bmatrix}$$

Inequalities:

 # Ine. 0: Hydro Generation $\Rightarrow [0 : s-1]$

$$P_{Hi} \leq \eta_H \cdot \left[\frac{E_{s,i}}{t} + \eta_P \cdot P_{Ps,i} \right]$$

$$Ad.\ 0 = \begin{matrix} P_{Hi} & P_{Ps,i} & E_{s,i} & P_{G_i} & T_i & T_{s,i} & d_{s,i} & P_{Spi} & P_{Sps,i} & P_{P_i} \end{matrix}$$
$$\begin{bmatrix} 1 & -t \cdot \eta_H \cdot \eta_P & -\frac{\eta_H}{t} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$bd = \begin{bmatrix} 0 \end{bmatrix}$$

 # Ine. 1: Epigraph Form (1) $\Rightarrow [s : 2s-1]$

$$d_{s,i} \cdot p_i^+ \leqslant T_{s,i}$$

$$Ad.\ 1 = \begin{matrix} P_{Hi} & P_{Ps,i} & E_{s,i} & P_{G_i} & T_i & T_{s,i} & d_{s,i} & P_{Spi} & P_{Sps,i} & P_{P_i} \end{matrix}$$
$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & -1 & p\_plus & 0 & 0 & 0 \end{bmatrix}$$

$$bd = \begin{bmatrix} 0 \end{bmatrix}$$

 # Ine. 2: Epigraph Form (2) $\Rightarrow [2s : 3s-1]$

$$-d_{s,i} \cdot p_i^- \leqslant T_{s,i}$$

$$Ad.\ 2 = \begin{matrix} P_{Hi} & P_{Ps,i} & E_{s,i} & P_{G_i} & T_i & T_{s,i} & d_{s,i} & P_{Spi} & P_{Sps,i} & P_{P_i} \end{matrix}$$
$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & -1 & -p\_minus & 0 & 0 & 0 \end{bmatrix}$$

$$bd = \begin{bmatrix} 0 \end{bmatrix}$$

 # Ine. 3: Hydro + Pump Constraint $\Rightarrow [3s : 4s-1]$

$$P_H + P_{Ps,i} \leq P_H^M$$

$$Ad.\ 3 = \begin{matrix} P_{Hi} & P_{Ps,i} & E_{s,i} & P_{G_i} & T_i & T_{s,i} & d_{s,i} & P_{Spi} & P_{Sps,i} & P_{P_i} \end{matrix}$$
$$\begin{bmatrix} 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$bd = \begin{bmatrix} P_H^M \end{bmatrix}$$

 # Ine. 4: Wind Power Constraint $\Rightarrow [4s : 5s-1]$

$$P_{Ws,i} \leq P_{WGi} + P_{Ps,i} + P_{Sp_{s,i}}$$

$$Ad.\ 4 = \begin{matrix} P_{Hi} & P_{Ps,i} & E_{s,i} & P_{G_i} & T_i & T_{s,i} & d_{s,i} & P_{Spi} & P_{Sps,i} & P_{P_i} \end{matrix}$$
$$\begin{bmatrix} 0 & -1 & 0 & -1 & 0 & 0 & 0 & 0 & -1 & 0 \end{bmatrix}$$

$$bd = \begin{bmatrix} -P_{Ws,i} \end{bmatrix}$$

 # Ine. 5: Pump + Spill Constraint $\Rightarrow [5s : 6s - 1]$

$P_{Ps,i} + P_{Sp_{s,i}} \leq P_{Ws,i}$

$$Ad.\,4 = \begin{array}{c} \begin{matrix} P_{Hi} & P_{Ps,i} & E_{s,i} & P_{G_i} & T_i & T_{s,i} & d_{s,i} & P_{Spi} & P_{Sps,i} & P_{P_i} \end{matrix} \\ \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix} \end{array}$$

$$bd = \begin{bmatrix} P_{Ws,i} \end{bmatrix}$$