Model Description

Mathematical model

The model is a linear (mixed-integer) optimisation model for the Jordanian electricity and water system.

Definitions

Sets

Symbol	Index	Description
T	t	Timesteps
R	r	Renewable units
C	c	Conventional units
S	S	Storage units
U	u	All supply units ($R \cup C$)

Variables

Symbol	Description
$p_{u,t}$	Power output unit u at timestep t
$h_{c,t}$	Fuel consumption of unit c at timestep t
$s_{s,t}^{in}$	Storage charge of storage s at timestep t
$s_{s,t}^{out}$	Storage discharge of storage s at timestep t
$e_{s,t}$	Storage level of storage s at timestep t
$y_{c,t}$	Status if unit c is committet (binary) at timestep t
$shortage_t$	Shortage variable
$excess_t$	Excess variable

Parameter

Symbol	Description
$p_u^{max/min}$	Normalised maximum production level
$p_u^{max/min}$	Normalised maximum production level
$P_u^{nom,el}$	Nominal power capacity of unit u
E_s^{nom}	Nominal storage energy capacity
d_t^{el}	Electricity demand
η_s^{loss}	Standing loss of storage
η_s^{in}	Charge efficiency of storage
η_s^{out}	Discharge efficiency of storage

Symbol	Description
c_u^{opex}	Operational expenditure

Objective function

The model minimises total operational cost of the system.

$$\min: \sum_{u \in U} p_u \cdot c_u^{opex} + shortage_t \cdot 3000$$

Demand constraint

Demand must equal the sum of supply of all producing units and storage output.

$$\sum_u p_{u,t} + \sum_s s_{s,t}^{out} - \sum_s s_{s,t}^{in} + shortage_t - excess_t = d_t^{el} \qquad \forall t$$

Supply constraints and fuel consumption

$$\cdot P_u^{nom} \cdot \underline{p}_u \leq p_{u,t} \leq \cdot P_u^{nom} \cdot \overline{p}_u \qquad \forall u, t$$

$$h_{c,t} = \frac{p_{c,t}}{\eta_c} \qquad \forall c, t$$

Optional

If P-min constraint is set, operation will be restricted by binary variables:

$$y_{c,t} \cdot P_c^{nom} \cdot \underline{p}_c \leq p_{c,t} \leq y_{c,t} \cdot P_c^{nom} \cdot \overline{p}_c \qquad \forall c, t$$

For modelling part-load efficiency the following equation applies:

$$h_{c,t} = y_{c,t} \cdot a_{c,t} + b_{c,t} \cdot p_{c,t} \qquad \forall c, t$$

Storage equations

$$e_{s,t} = e_{s,t-1} \cdot \eta_s^{loss} - \frac{s_{s,t}^{out}}{\eta_s^{out}} + s_{s,t}^{in} \cdot \eta_s^{in} \qquad \forall s, t$$

$$0 \leq e_{s,t} \leq E_{s,t}^{nom} \qquad \forall s, t$$