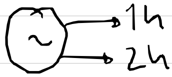
Example: Capacity limit

as power constraints

$F = 10\,MW$



generator with 2 outputs

$f^{2}_{1:2} \cdot D$

Capacity constraints:

$$f^{1}_{1:1} + f^{2}_{1:2} \leq \overline{F} \qquad \forall t=1$$

$$f^{1}_{2:2} + f^{2}_{1:2} \leq \overline{F} \qquad \forall t=1$$

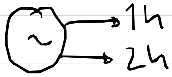
where $f_{i,j}$ is the flow from period i to period j
↳ in power (MW, no MWh)

Constraint written in the highest resolution

Example: Capacity limit

as Energy constraints

$F = 10\,MW$



generator with 2 outputs

Energy constraints:

$$\underbrace{f^1_{1:1}}_{f^e}\cdot\Delta^1 + f^1_{2:2}\cdot\Delta^1 + \boxed{f^2_{1:2}\,\Delta^2} \le \boxed{F\times\Delta^{(2)}} \rightarrow ? \qquad \forall t = 1:2$$

Constraint written in the lowest resolution

Of course you can create a new variable representing the energy $f^e = f\cdot\Delta$, resulting in an exactly equivalent reformulation wit different variables.

$$\boxed{f^1_{11}} = \boxed{20 \le 10\times\boxed{2}}$$

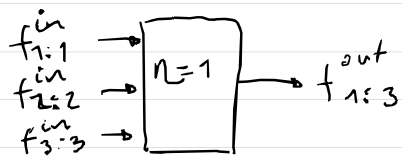
$$f^p\cdot\Delta = f^e$$

So can it be in the highest resolution?

$$\begin{aligned} f^1_{1:1}\,\Delta^1 + \overset{20}{\boxed{f^2_{1:2}\,\Delta^?}} &\le F\cdot\Delta^1 \qquad \forall t = 1:1 \\ f^1_{2:2}\,\Delta^1 + f^2_{1:2}\,\Delta^? &\le F\cdot\Delta^1 \qquad \forall t = 2:2 \end{aligned}$$

what if the constraints are written in energy? i.e. $f^e = f\cdot\Delta$ what to do with the $\Delta^?$ of the eqs. above?

Conversion as Energy Constraints



Eq. written in the lowest resolution:

$$\eta \cdot \left(f^{in}_{1:1} + f^{in}_{2:2} + f^{in}_{3:3}\right) \cdot \Delta^{in} = f^{out}_{1:3} \cdot \Delta^{out} \qquad \forall t = 1:3$$

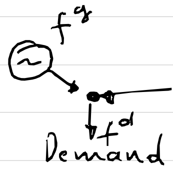
What if we write it at the highest resolution?

$$f^{in}_{1:1}\, \Delta^{in} = f^{out}_{1:3} \cdot \Delta^{?} \qquad \forall t=1$$
$$f^{in}_{2:2}\, \Delta^{in} = f^{out}_{1:3} \cdot \Delta^{?} \qquad \forall t=2$$
$$f^{in}_{3:3}\, \Delta^{in} = f^{out}_{1:3} \cdot \Delta^{?} \qquad \forall t=3$$

which impose:

$$\boxed{f^{in}_{1:1} = f^{in}_{2:2} = f^{in}_{3:3}}$$ is this correct?

Nodal balance as power



f^i = net import from another region.

f^g and f^d in hourly resolution.
f^i in 4 hours resolution.

$$f^g_{1:1} - f^d_{1:1} = f^i_{1:4} \quad \forall t=1$$
$$\vdots$$
$$f^g_{4:4} - f^d_{4:4} = f^i_{1:4} \quad \forall t=4$$

written in the highest resolution

what if net import is zero $f^i_{1:4} = 0$?

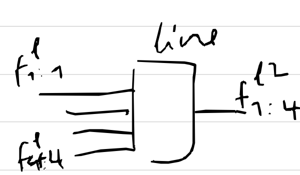
Now nodal balance as energy:

written in the lowest resolution:

$$(f^g_{1:1} + f^g_{1:2} + f^g_{3:3} + f^g_{4:4})\Delta^g - (f^d_{1:1} + f^d_{2:2} + f^d_{3:3} + f^d_{4:4})\Delta^d = f^i_{1:4} \cdot \Delta^i$$

what if the net import is zero $f^i_{1:4} = 0$?

$$f^g_{1:1} - f^d_{1:1} = f^l_{1:1}$$
$$\vdots$$
$$f^g_{4:4} - f^d_{4:4} = f^l_{4:4}$$



$$f^l_{1:1} + f^l_{4:4} = \cancel{f^{l2}_{1:4}}$$

I think in highest resolution for the connections will work

$$f^l_{1:1} = \cancel{f^{l2}_{1:4}} \quad 6$$
$$\vdots$$
$$f^l_{4:4} = \cancel{f^{l2}_{1:4}} \quad 0$$

What about storage balance

An energy constraint by definition:

$$e_{1:2} = e_0 + n\left(f^{in}_{1:1} + f^{in}_{2:2}\right)\Delta^{in} - \left(f^{out}_{1:1} + f^{out}_{2:2}\right)\Delta^{out}$$ In the lowest resolution

what if we write it in the highest resolution?

$$e_{1:2} = e_0 + n f^{in}_{1:1} \cdot \Delta^{in} - f^{out}_{1:1} \cdot \Delta^{out}$$
$$e_{1:2} = e_0 + n f^{in}_{2:2}\, \Delta^{in} - f^{out}_{2:2} \cdot \Delta^{out}$$

Assuming we avoid simultaneous charge/discharge, these eqs. impose:

$$f^{in}_{1:1} = f^{in}_{2:2}$$
$$f^{out}_{1:1} = f^{out}_{2:2}$$

Can the storage variable have a higher resolution than the highest of the inputs?