

# Long Term Modelling

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## Capacity Expansion and NPV

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Capacity expansion considers the:

- cost of retirements
- cost of new builds
- fixed operating costs and,
- variable operating costs

to:

- Maximise the NPV (Net Present Value) of the total costs of the system over a long-term planning horizon.

$$NPV = \frac{R_t}{(1+i)^t}$$

where:

- $R_t$  = net cash flow
- $i$  = discount rate
- $t$  = time of cash flow

NPV is used to determine the profitability of a certain project.

Capacity Expansion allows us to find out:

- How much to invest?
- What technologies to build?
- How many units to build?
- Where to build?
- When to build?

Within the LT object there are 2 components:

- Capital Costs  $C(x)$  and,
  - One off fees i.e. new generators, transmission expansion, generator retirements
- Production costs  $P(x)$ 
  - Operational costs i.e. operating existing and new builds of transmission network, notional cost of unserved energy.

The goal is to minimise NPV by formulating it as a Mixed-Integer Problem:

$$C(x) + P(x) = \text{Total Cost}$$

To formulate this you usually have an objective function: in this case to minimise costs and constraints that the equation is subject to. i.e.

objective function

minimize cost:

$$\begin{aligned} & \sum (y) \sum (g) DF_y \times (BuildCost_g \times GenBuild(g,y)) \\ & + \sum (y) DF_y \times [FOMCharge_g \times 1000 \times PMAx_g (Units_g + \sum_{i \leq y} GenBuild(Units_g, i))] \\ & + \sum (t) DF_t \times \epsilon_y \times Lt \times [VolL \times USE_t + \sum g (SRMC_g \times GenLoad(g,t))] \end{aligned}$$

constraints

subject to:

- › Equation 1: Energy Balance  

$$\sum (g) GenLoad(g,y) + USE_t = Demand_t \quad \forall t$$
- › Equation 2: Feasible Energy Dispatch  

$$GenLoad(g,t) \leq PMAx_g (Units_g + \sum_{i \leq y} GenBuild(Units_g, i))$$
- › Equation 3: Feasible Builds  

$$\sum_{i \leq y} GenBuild(g,i) \leq MaxUnitsBuilt_{g,y}$$
- › Equation 4: Integrality  

$$GenBuild(g,y) \text{ integer}$$

## Application in PLEXOS

In PLEXOS, there is an LT Plan Object where you can consider:

- Step Size: in years, can also consider overlap
- Chronology: Partial, Fitted Sampled
- Discount Rate: %, End Effects Method (Perpetuity, None), Discount/Expansion Period (Month, Quarter, Year)
- Transmission: Regional, Zonal, Nodal
- Expansion Algorithm: Linear Programming, Mixed Integer Programming