Unit Commitment

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Algorithms for Decision Support, 2019-2020

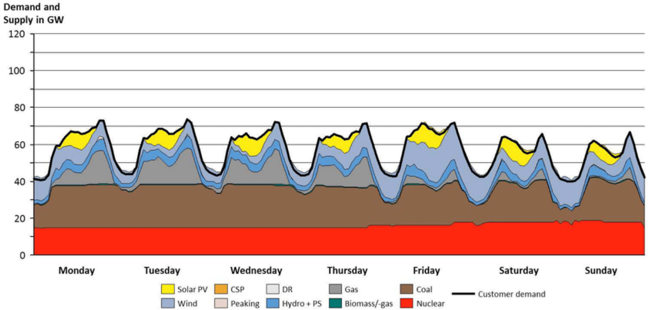
Unit Commitment

Tijd:	17:00	18:00	19:00	20:00	..
Demand:	1200 MW	1300 MW	1350 MW	1150 MW	..

???

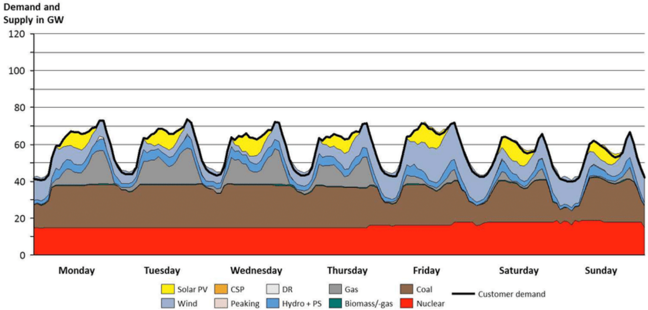
Solution to the Unit Commitment problem

- Which unit is on at what time



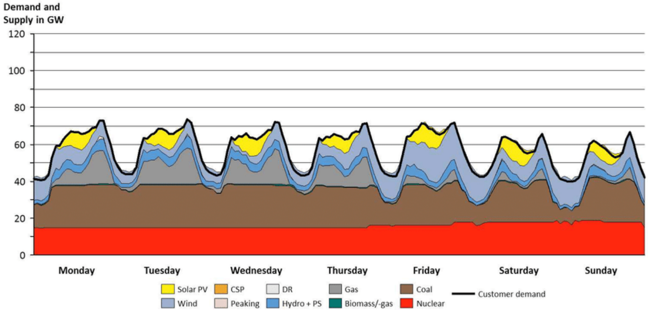
Solution to the Unit Commitment problem

- Which unit is on at what time
- How much energy is produced per a unit produce at what time

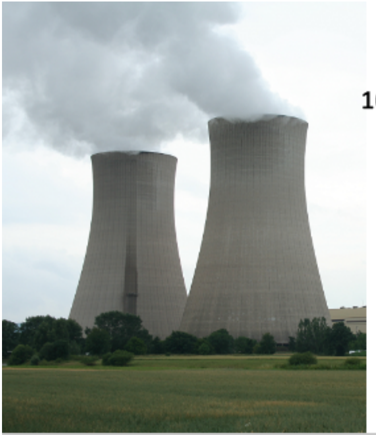


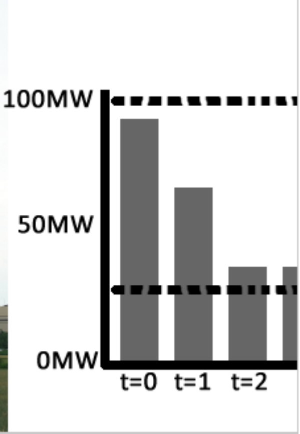
Solution to the Unit Commitment problem

- Which unit is on at what time
- How much energy is produced per a unit produce at what time
- (Energy flow in the network, RES-curtailment, energy storage, demand response etc.)

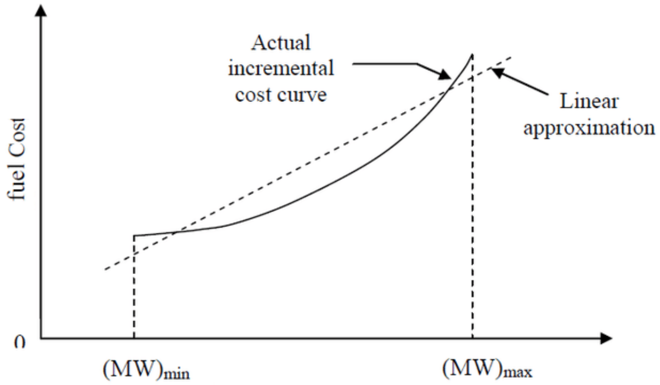


Generation limits





Production Cost



Unit Commitment, Decision Variables, Objective

- p_{jt} power output variable of generator j at time t
- $x_{jt} = 1$ when generator j is on at time t
- $a_j + b_j * p_j$, linear generation cost for power provided

$$\min \sum_{j=1}^{n} \sum_{t=1}^{T} a_j x_{jt} + b_j p_{jt}$$

Unit Commitment, Demand Constraint

- At every timestep t the total power output must be equal to the demand, D_t.

$$\sum_{j=1}^{n} p_{jt} = D_t \qquad \forall t = 1 \ldots T$$

Unit Commitment, Generation Limits

- If generator j is on at time t, i.e. $x_{jt} = 1$, it must produce between his minimal $\underline{P}_j$ and maximal $\overline{P}_j$ generation.

Unit Commitment, Generation Limits

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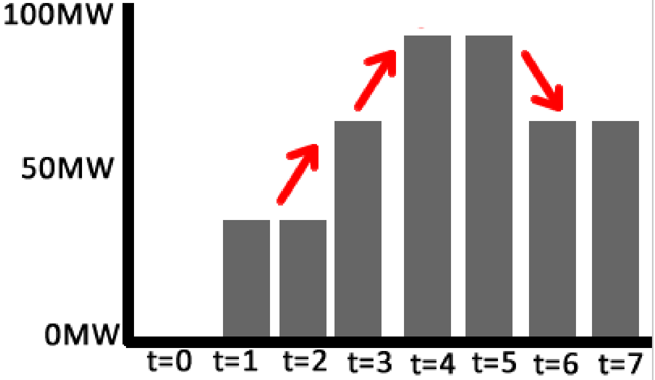
- $$\underline{P}_j x_{jt} \leq p_{jt} \leq \overline{P}_j x_{jt} \qquad \forall j = 1 \dots n, \forall t = 1 \dots T$$

Ramping Limits



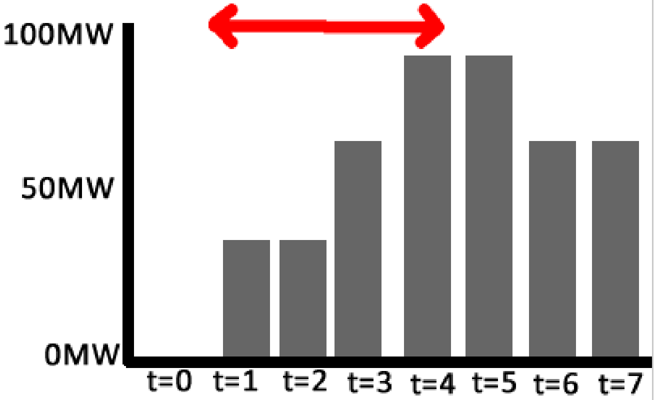
Unit Commitment, Ramping Limits

- Ramping constraint limits the power output between two consecutive periods.
- Δ_j^+ is the ramp-up limit of generator j
- Δ_j^- is the ramp-down limit of generator j

Unit Commitment, Ramping Limits

- Ramping constraint limits the power output between two consecutive periods.
- Δ_j^+ is the ramp-up limit of generator j
- Δ_j^- is the ramp-down limit of generator j
- $$p_{jt} - p_{jt-1} \leq \Delta_j^+ \qquad \forall j = 1 \ldots n, \forall t = 2 \ldots T$$
  $$p_{jt-1} - p_{jt} \leq \Delta_j^- \qquad \forall j = 1 \ldots n, \forall t = 2 \ldots T$$

Minimum up and down time



Unit Commitment, Mininum up and down time

- If a generator is turned on(off), it must stay on(off) for $UT(DT)$ timesteps.
- UT_j is the minimum uptime of generator j
- DT_j is the minimum downtime of generator j

$$\sum_{s=t}^{t+UT_j-1} x_{js} \geq UT_j(x_{jt} - x_{jt-1}) \qquad \forall j, \forall t = 2 \ldots T - UT_j + 1$$

$$\sum_{s=t}^{t+DT_j-1} (1 - x_{js}) \geq DT_j(x_{jt-1} - x_{jt}) \quad \forall j, \forall t = 2 \ldots T - DT_j + 1$$

Unit Commitment, a Full Model

$$\min \sum_{j=1}^{n} \sum_{t=1}^{T} a_j x_{jt} + b_j p_{jt} \text{ subject to}$$

$$\sum_{j=1}^{n} p_{jt} = D_t \qquad \forall t = 1 \dots T$$

$$\underline{P} x_{jt} \leq p_{jt} \leq \overline{P} x_{jt} \qquad \forall j, \forall t = 1 \dots T$$

$$p_{jt} - p_{jt-1} \leq \Delta_j^+ \qquad \forall j, \forall t = 2 \dots T$$

$$p_{jt-1} - p_{jt} \leq \Delta_j^- \qquad \forall j, \forall t = 2 \dots T$$

$$\sum_{s=t}^{t+UT_j-1} x_{js} \geq UT_j (x_{jt} - x_{jt-1}) \qquad \forall j, \forall t = 2 \dots T - UT_j + 1$$

$$\sum_{s=t}^{t+DT_j-1} (1 - x_{js}) \geq DT_j (x_{jt-1} - x_{jt}) \qquad \forall j, \forall t = 2 \dots T - DT_j + 1$$

$$x_{jt} \in \{0, 1\}, p_{jt} \geq 0 \qquad \forall j, \forall t \in T$$

Why Unit Commitment?

- Analysis of future electricity networks, e.g with more renewables (wind and solar) and reduced amount of fossile fuels.
- MIP models for Unit Commitment are included in analysis tools for power networks: PLEXOS, DispaSET.

Algorithmic Computing and Data mining for Climate integrated Energy System Models (ACDC-ESM)

- Research project of Computer Science, Geo Sciences, Tennet and Dutch national weather service (KNMI)
- Rogier Wuijts (PhD student supervised by MvdA and Geo)
  - Solving UC may require a lot of computation time. Can we find faster algorithms?
  - Improved dynamic programming algorithm for UC with single unit.
  - Include in MIP-based (decomposition) algorithms for UC
  - Models for UC with transmission
- Laurens Stoop (PhD student supervised by Ad Feelders and Geo) :
  - Analyzing weather data
  - Find the most adverse scenarios for UC