Capacity Expansion of the Energy Grid: Coupled Scenario Generation and Time Aggregation

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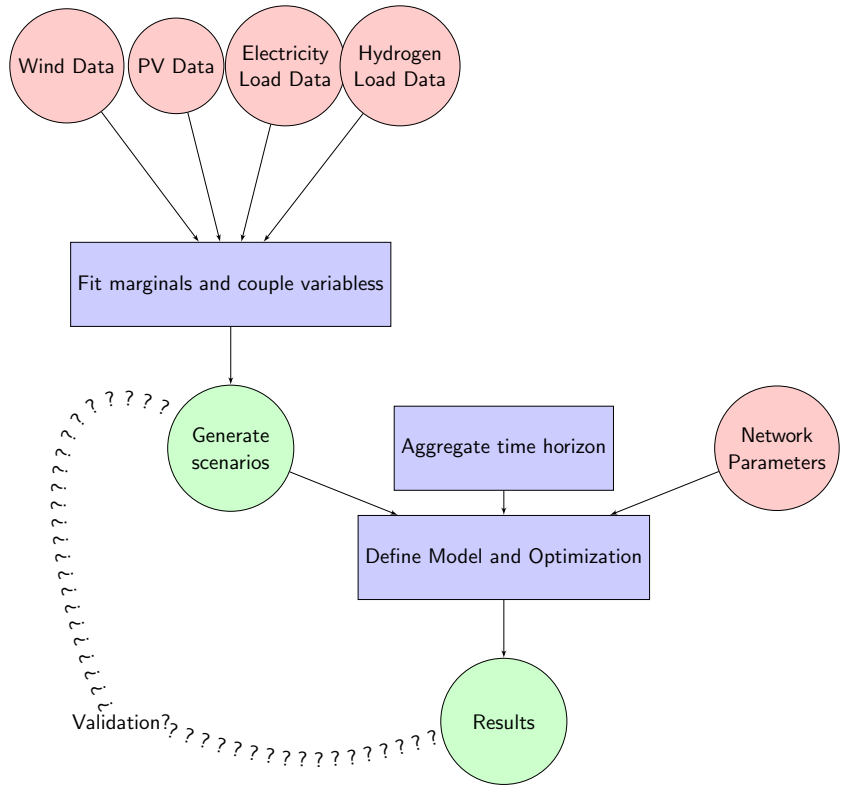
Introduction

Workflow


Wind Data
PV Data
Electricity Load Data
Hydrogen Load Data
Fit marginals and couple variabless
Generate scenarios
Aggregate time horizon
Network Parameters
Define Model and Optimization
Results
Validation?

Model 1

We consider a two stage stochastic program consisting of a Capacity Expansion Problem (CEP) and an Economic Dispatch (ED) problem:

$$\min_{x} \; c'x + \mathbb{E}_{\omega}\left[\mathcal{V}(x,\omega)\right]$$

$$s.t. \quad 0 \leq x_{n,g} \leq X_{n,g} \qquad \text{(CEP)}$$

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- The first stage determines the capacity expansion (x) for each generator $g \in \mathcal{G}$ and network component.
- The second stage solves the Economic Dispatch (ED) in function of the expanded capacities x and the scenario ω, yielding $\mathcal{V}(x,\omega)$ as solution.

Economic Dispatch (ED) model

Economic Dispatch (ED) model Scary Slide

Economic Dispatch (ED) model

$$\min y \; q' y_\omega$$

$$\text{s.t.} \quad \mathrm{ns} \cdot \mathcal{PV}_{j,t,n} + \mathrm{nw} \cdot \mathcal{W}_{j,t,n} + fhte_k \cdot \mathrm{HtE}_{j,t,n} + \tag{1}$$
$$- \mathrm{EtH}_{j,t,n} - \sum_{l \in Out(n)} \mathrm{P}_{j,t,l} + \sum_{l \in In(n)} \mathrm{P}_{j,t,l} \geq \mathcal{P}^L_{j,t,n};$$

$$\mathrm{H}^S_{j,t+1,n} = \mathrm{H}^S_{j,t,n} + feth_k \cdot \mathrm{EtH}_{j,t,n} - \mathrm{HtE}_{j,t,n} - \mathcal{H}^L_{j,t,n} + \tag{2}$$
$$- \sum_{l \in Out(n)} \mathrm{H\_edge}_{j,t,l} + \sum_{l \in In(n)} \mathrm{H\_edge}_{j,t,l}$$

$$\mathrm{H}_{j,t,n} \leq \mathrm{nh}_n; \tag{3}$$

$$\mathrm{EtH}_{j,t,n} \leq \mathrm{meth}_n; \tag{4}$$

$$\mathrm{HtE}_{j,t,n} \leq \mathrm{mhte}_n; \tag{5}$$

$$|\mathrm{P}_{j,t,l}| \leq p_l^{\max} + \mathrm{P}_l^{\max_0}; \tag{6}$$

$$|\mathrm{H}_{j,t,l}| \leq h_l^{\max} + \mathrm{H}_l^{\max_0}. \tag{7}$$

Literature Review

- Computational costs increase rapidly with the number of nodes and scenarios (CEP on large grids it tipically solved on only a couple of scenarios)
- To adress this, in [PJ24] Pecci et al. propose a regularized decomposition method.
- In Pypsa [Hör+18], Brown et Al use a node clustering method.
- In our work we introduced (a possibly iterated) time horizon clustering technique to further reduce the model.
- An other problem is to obtain realistic scenarios for powere production. ... scenario generation...