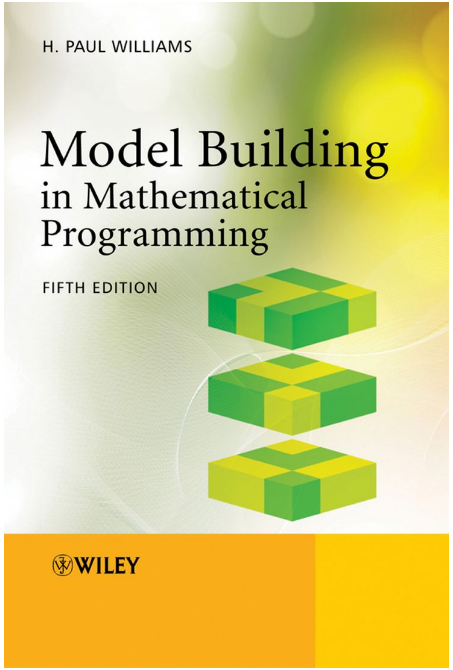
Stochastic Tariff Rates Optimization Model

Aalto University
School of Science - Mathematics
Stochastic Programming and Robust Optimization

Presented by Jules Roques

Inaccurate Deterministic Problem



	Minimum level	Maximum level	Cost per hour at minimum	Cost per hour per megawatt above minimum	Cost
Type 1	850 MW	2000 MW	1000	2	2000
Type 2	1250 MW	1750 MW	2600	1.30	1000
Type 3	1500 MW	4000 MW	3000	3	500

12 p.m. to 6 a.m.	15 000 MW
6 a.m. to 9 a.m.	30 000 MW
9 a.m. to 3 p.m.	25 000 MW
3 p.m. to 6 p.m.	40 000 MW
6 p.m. to 12 p.m.	27 000 MW

Outline of the presentation

Stochastic Optimization Model

Dataset Generation

Scenarios Reduction

Results

Limits

Stochastic Optimization Model

Decision Variables

- $n_{i,t}$: Number of generating units of type i working in period t (integer, non-negative).
- $s_{i,t}$: Number of generators of type i started up in period t (integer, non-negative).
- $x^{\xi}_{i,t}$: Total output rate from generators of type i in period t under scenario ξ (non-negative).

Objective Function

Minimize the total cost:

$$\min \quad \text{First-stage cost} + \text{Expected second-stage cost}$$

$$\min \quad \sum_{i\in\mathcal{I}}\sum_{t\in\mathcal{T}}(E_{i,t}n_{i,t} + F_i s_{i,t}) + \sum_{\xi\in\Xi}\pi^{\xi}\sum_{i\in\mathcal{I}}\sum_{t\in\mathcal{T}} C_{i,t}\left(x^{\xi}_{i,t} - m_i n_{i,t}\right)$$

Stochastic Optimization Model

Constraints

$$s_{i,t} \geq n_{i,t} - n_{i,t-1}, \quad \forall i \in \mathcal{I}, t \in \mathcal{T}$$

$$n_{i,0} = n_{i,T}, \quad \text{(periodic boundary condition)}$$

Turn on reactors

$$n_{i,t} \leq N_i, \quad \forall i \in \mathcal{I}, t \in \mathcal{T}$$

Number of reactors upper bound

$$\sum_{i \in \mathcal{I}} x_{i,t}^{\xi} \geq D_t^{\xi}, \quad \forall t \in \mathcal{T}, \xi \in \Xi$$

Flow meets the demand

$$\sum_{i \in \mathcal{I}} M_i n_{i,t} \geq 1.15\, D_t^{\xi}, \quad \forall t \in \mathcal{T}, \xi \in \Xi$$

Secure possibly higher demand

$$m_i n_{i,t} \leq x_{i,t}^{\xi} \leq M_i n_{i,t}, \quad \forall i \in \mathcal{I}, t \in \mathcal{T}, \xi \in \Xi$$

Flow can be produced

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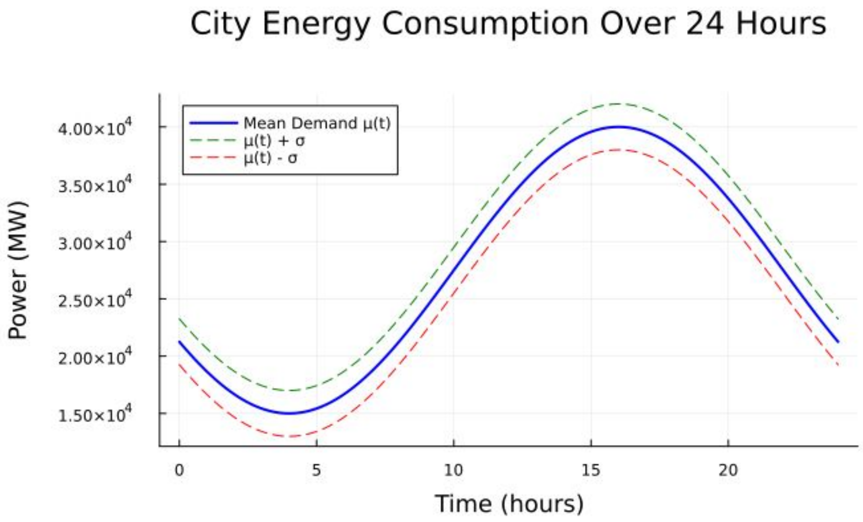
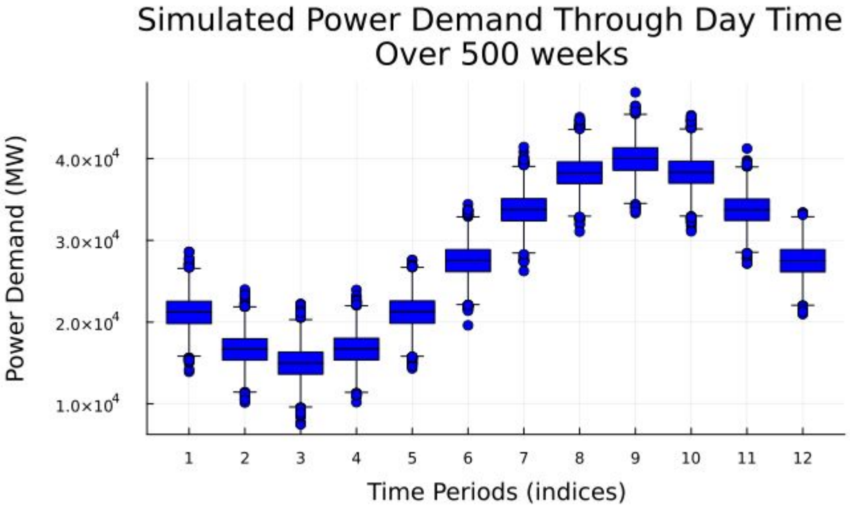
$$D_t \sim \mathcal{N}(\mu(t), \sigma^2)$$

$$\mu(t) = B + A\sin(\omega t + \varphi)$$



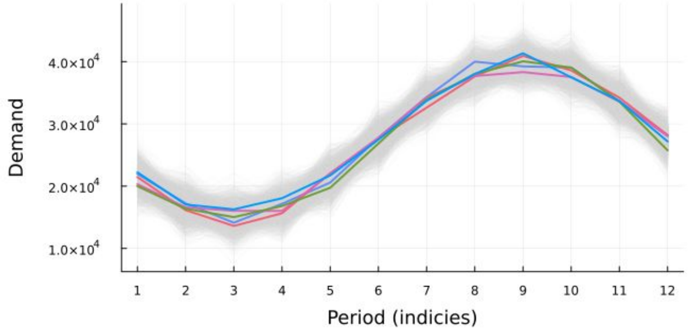


Outline of the presentation

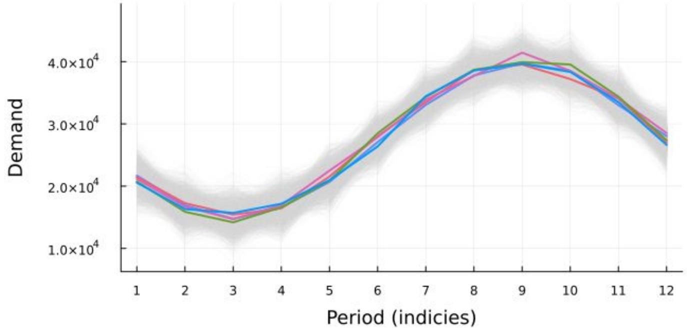
Scenarios Reduction

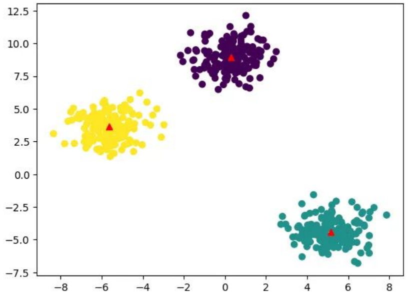
Centroids of Clusters (k=5)

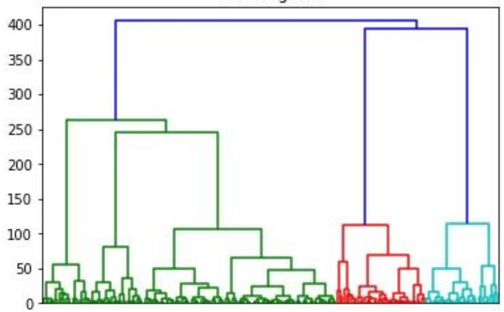
K-Means



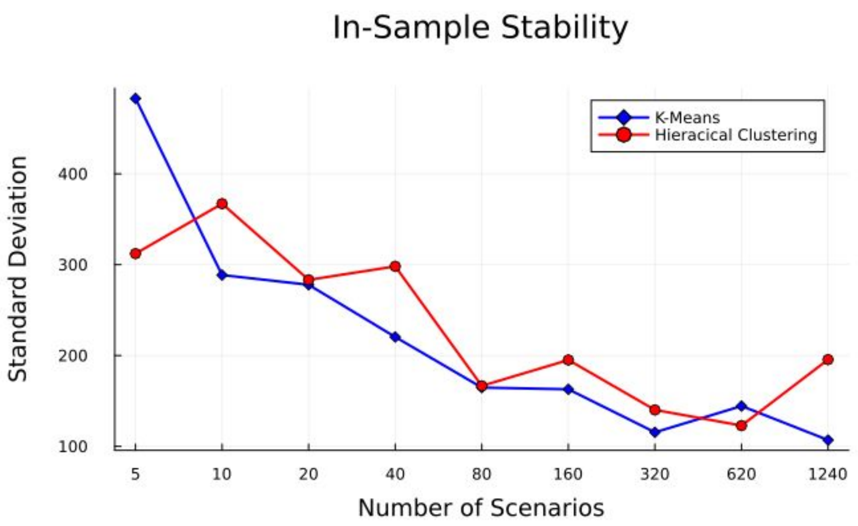
Hierarchical Clustering with Ward's distance

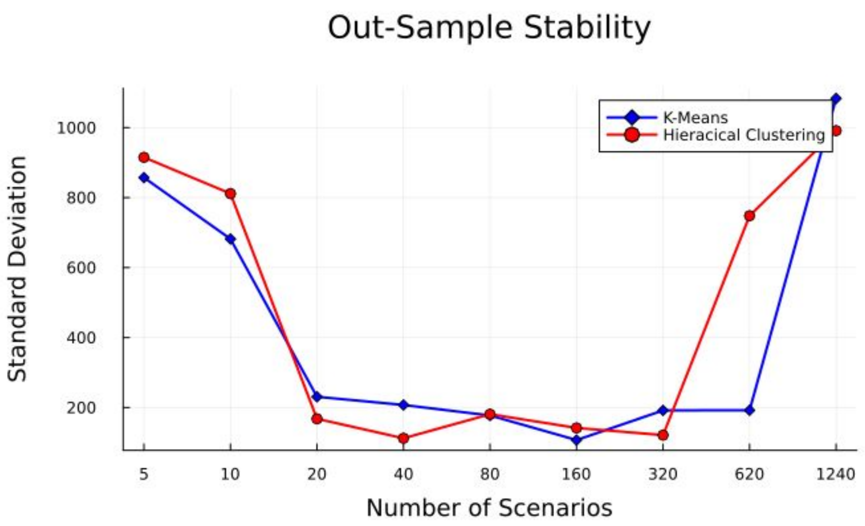






Scenarios Reduction





Elbow Criterion

=> k = 20 scenarios

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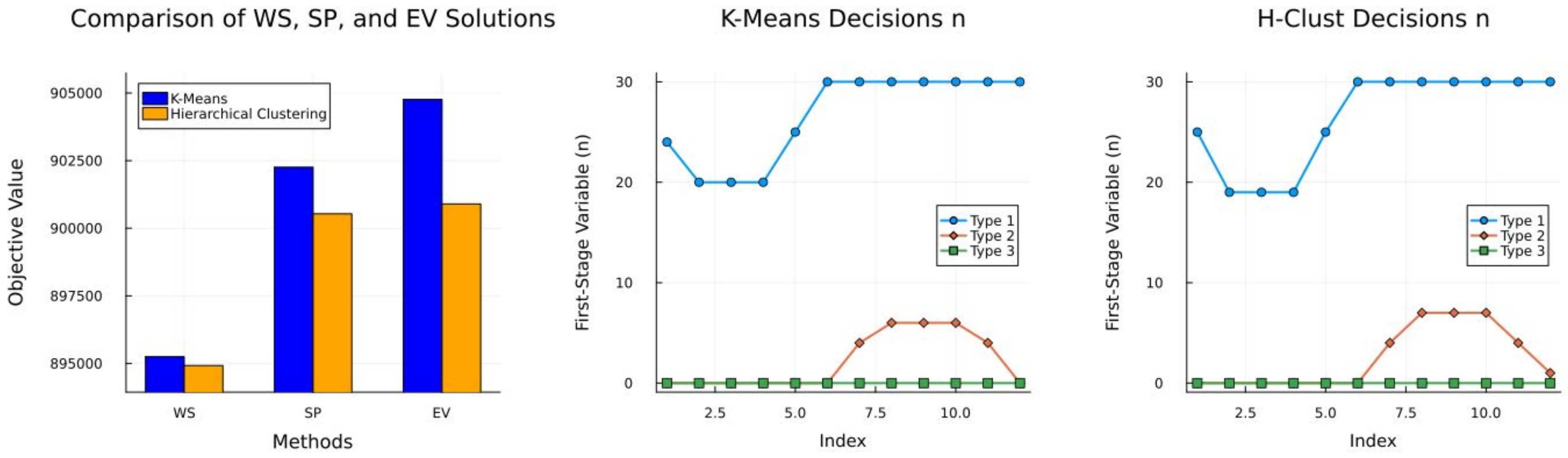


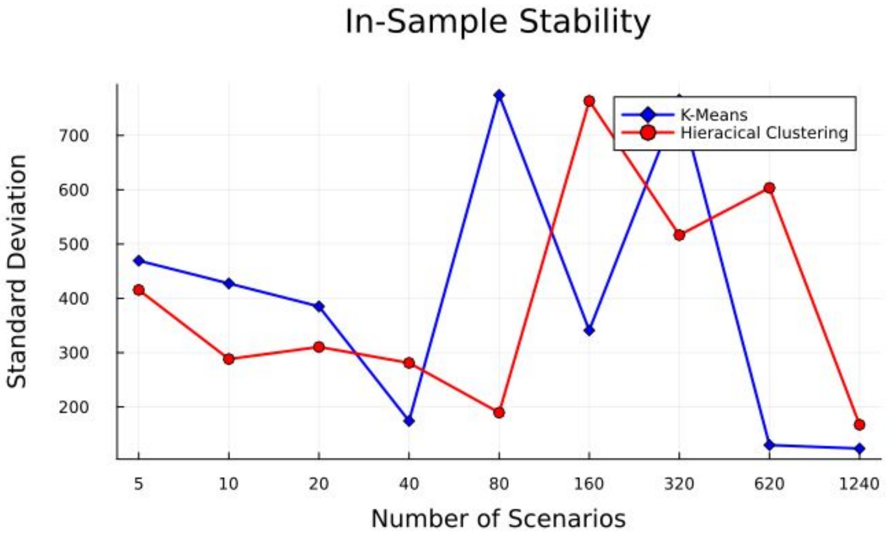
SP instead of EV

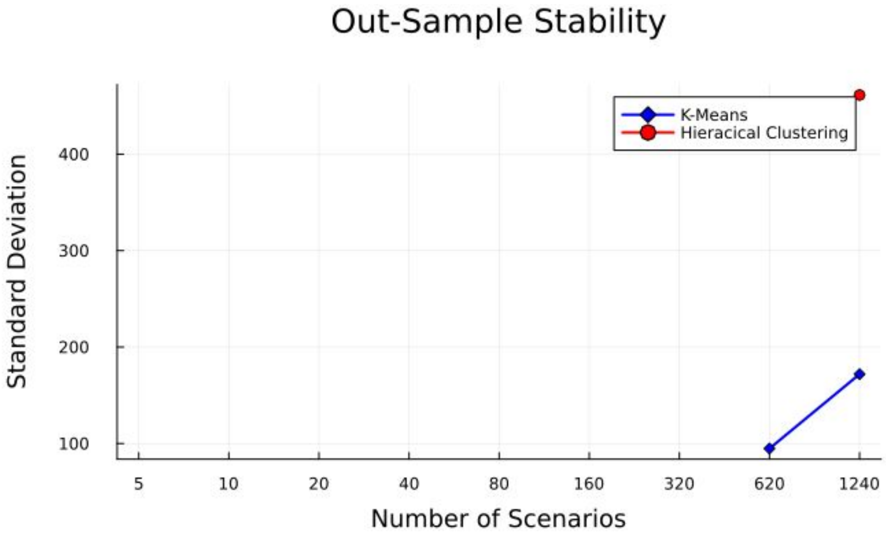
=> Between 500€ and 2500€ per day

Outline of the presentation

Limits

When we change a bit the
numbers of available reactors…





Conclusion

- **Objective**: Incorporate stochasticity in a deterministic model

- **Key Features**: K-means & Hierarchical clustering

- **Improvements**:
  - More tolerant with infeasible solutions
  - Explore Sample Average Approximation
  - Study real datasets