Paper No: 20PESGM1277

A Data-Driven Two-Stage Distributionally Robust Planning Tool for Sustainable Microgrids

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Motivation and Background

Input → **Microgrid Planning Tool** → **Output**

Input:
- Network Topology
- Forecast demand
- Forecast production
- Investment candidates

Microgrid Planning Tool:
- Minimise Total Costs
- Adequacy | Security | Resilience

Output:

Uncertain! - - - - - - - - → Infeasible!

Uncertainty Management
- Stochastic Optimisation
- Distributionally Robust Optimisation
- Robust Optimisation

Problem Formulation

Deterministic Model

$$\min_{x} \; c^T \cdot x + \sum_{t \in \Omega^T} S(x, \tilde{\eta}_t)$$

Investment Cost

Operation Cost

Uncertainty Vector

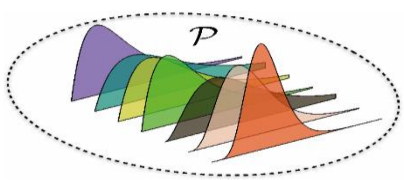
$$S(x, \tilde{\eta}_t) = \min_{y_t} \{ d^T \cdot y_t | E(x) + F \cdot y_t \geq G(x) \cdot \tilde{\eta}_t \}$$

Distributionally Robust Model

Ambiguity Set

$$\Theta_W = \{ \mathbb{P} \in \Xi(\Omega) : dist_W\left(\mathbb{P}, \widehat{\mathbb{P}}_{N_s}\right) \leq \rho \}$$

Wasserstain Metric



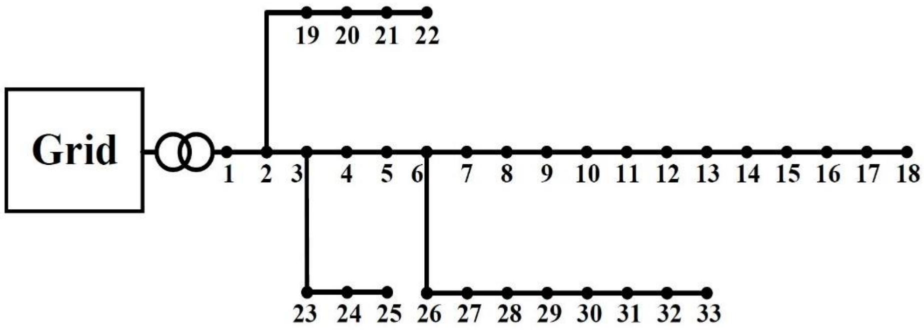
source: https://web.mit.edu/vanparys

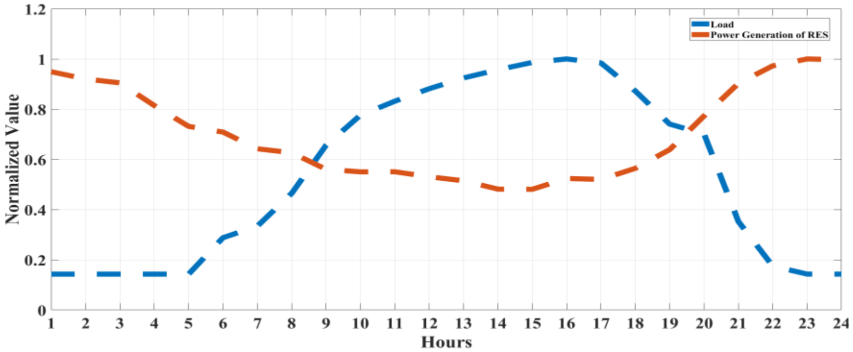
$$\min_{x} \; c^T \cdot x + \max_{\mathbb{P} \in \Theta_W} \mathbb{E}\left[\sum_{t \in \Omega^T} S(x, \tilde{\eta}_t) \right]$$

A tractable MILP counterpart can be obtained by using the duality theory *.

* G. A. Hanasusanto and D. Kuhn, Oper. Res., vol. 66, no. 3, pp. 849–869, 2018.

Case Study





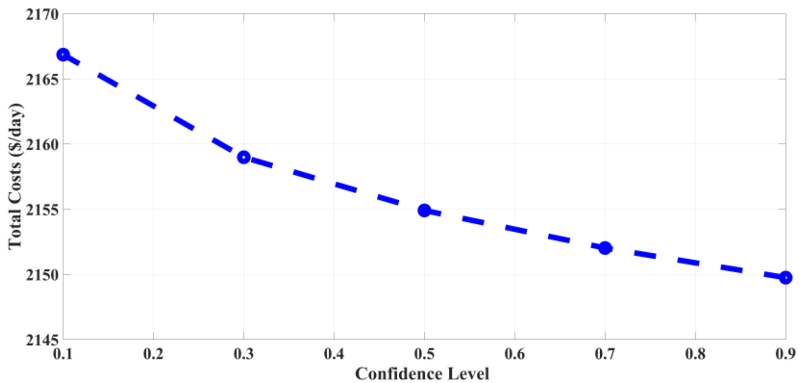
Daily Patterns of Loads and RES Power Generations

Total Costs of Different Planning Models

Model	Total Costs ($/Day)	Computation Time (s)
Deterministic	1667	34
Distributionally robust	2155	128
Robust	2333	184

Total Costs in DR-MIRP vs. Number of Training Samples

Training Sample (#)	Total Costs ($/Day)	Computation Time (s)
5	2155	128
10	2141	295



Total Costs vs. Values of Confidence Level

Conclusions

- Bridge between SO and RO
  - Present a DRO-based microgrid planning tool
- Introduce a tractable MILP counterpart
- Control conservatism-level by
  - Increasing/decreasing the number of training samples
  - Increasing/decreasing the confidence level

SCAN ME

Future works

- Implement the proposed model in **PyEPLAN**
- Increase the accuracy of network modeling
- Include static/dynamic security constraints under islanding