Optimisation of multi-year planning strategies to better integrate renewable energies and new electricity uses in the distribution grid

Bruno Barracosa, Héloïse Baraffe, Julien Bect, Gilles Malarange, Juliette Morin, Emmanuel Vazquez

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OPTIMISATION OF MULTI-YEAR PLANNING STRATEGIES TO BETTER INTEGRATE RENEWABLE ENERGIES AND NEW ELECTRICITY USAGES ON THE DISTRIBUTION GRID

1. CONTEXT

- Future of electricity distribution: new usages in the distribution grid, e.g., electric vehicles, distributed energy generation, local storage units...
- How to adapt the grid to these new usages at lowest cost?

2. DECISION TOOL

- PARADIS (EDF R&D and CentraleSupélecL2S, (DUT15)) is a tool to simulate planning strategies for different scenarios

- Scenario generator: creates realistic random scenarios of RE's arrivals and the consumption and production profiles
- Strategy planning: defines the decision tree used by the Distribution System Operator (DSO)
- Simulator: simulates the evolution of the grid
- Balance: computes the final costs of the planning strategy

- For a prescribed planning strategy:

- In PARADIS, planning strategies are defined using parameters (up to about 10 parameters)

3. PLANNING STRATEGIES

Main characteristics of the problem

- Expensive simulations (e.g., 5 minutes for one simulation)
- Continuous parameters
- Stochastic simulator (scenario-based)
- Conflicting objectives
- Impact of extreme values

Different formulations of the problem

- Mono-objective optimisation: \( \min q_a(x) \), with \( q_a(x) \) an a-quantile (or superquantile) of the cost \( Z(x) \).
- Multi-objective and/or constrained optimisation with more than one cost function \( Z_1(x), Z_2(x), \ldots \)
- Robust optimisation: e.g., \( \min \max q_a(x + \epsilon) \), with \( \epsilon \) a random perturbation of the parameters
- Quasi-optimal regions:
  \[
  \Gamma = \{ x \in \mathbb{X}, q_a(x) \leq q^- + \Delta \cdot q^+ = \min q_a(x) \}
  \]
  with \( \Delta \) a constant that defines the accepted level of quasi-optimality, or
  \[
  \Gamma = \{ x \in \mathbb{X}, q_a(x) \leq q^-; q^+ = \inf \{ e \in \mathbb{R}, P_q(x' \in \mathbb{X}, q_a(x') \leq e) \geq \frac{1}{\Gamma} \} \}
  \]

4. RESEARCH IDEAS

- Bayesian Optimization!
- And other ideas:
  - Scenario min-max optimisation [CAR15]
  - Quantile estimation [LAB16]
  - Reliability-based design optimisation [DUB11]
  - Bayesian algorithms for best arm identification [RUS16]
  - Informational approach to global optimisation [VIL09]

SOME REFERENCES