Optimisation of multi-year planning strategies to better integrate renewable energies and new electricity uses in the distribution grid
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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 CentraleSupélec/L2S, [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: \( \min \, q_\alpha(x) \), with \( q_\alpha(x) \) an \( \alpha \)-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., \( \min_{x, \epsilon} q_\alpha(x + \epsilon) \), with \( \epsilon \) a random perturbation of the parameters
- Quasi-optimal regions:
  \[ \Gamma = \left\{ x \in \mathbb{X}, q_\alpha(x) \leq q^* + \Delta; q^* = \min_{x, \epsilon} q_\alpha(x) \right\} \]
  with \( \Delta \) a constant that defines the accepted level of quasi-optimality, or
  \[ \Gamma = \left\{ x \in \mathbb{X}, q_\alpha(x) \leq q^*; q^* = \inf \{ x \in \mathbb{R}, q_\alpha(x') \leq x \} \right\} \]

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