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 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)

   ![Grid evolution simulator](image)

   ![Two-parameter strategy (tan φ and curtailment)](image)

   ![Possible impact of extreme values!](image)

   Two-parameter strategy (\(\tan \phi\) and curtailment)

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 \(Z_\alpha(x), Z_\beta(x), \ldots\)
• Robust optimisation: e.g., \(\min \max q_\alpha(x + \epsilon)\), with \(\epsilon\) a random perturbation of the parameters
• Quasi-optimal regions:

\[
\Gamma = \{x \in \mathbb{X} : q_\alpha(x) \leq q^* + \Delta \} = \min \{q_\alpha(x)\}
\]

with \(\Delta\) a constant that defines the accepted level of quasi-optimality, or

\[
\Gamma = \{x \in \mathbb{X} : q_\alpha(x) \leq q^*\} \cap \{x \in \mathbb{X} : q_\alpha(x) \leq x \}
\]

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

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