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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:

   - One-parameter strategy ($\tan \phi$)
   - 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 $Z_j(x)$, $Z_k(x)$, ...
• Robust optimisation: e.g., $\min_x q_\alpha(x + \epsilon)$, with $\epsilon$ a random perturbation of the parameters
• Quasi-optimal regions:
  $\Gamma = \{x \in \mathbb{R}^n | q_\alpha(x) \leq q^* + \Delta \alpha; q^*$ = $\min_x q_\alpha(x)\}$
  with $\Delta \alpha$ a constant that defines the accepted level of quasi-optimality, or
  $\Gamma = \{x \in \mathbb{R}^n | q_\alpha(x) \leq q^*; q^*$ = $\inf_{x \in \mathbb{R}^n} \{x' \in \mathbb{R}^n | q_\alpha(x') \leq s \geq \beta\}\}$

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

SOME REFERENCES

