



HAL
open science

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

Bruno Barracosa, H elo ise Baraffe, Julien Bect, Gilles Malarange, Juliette Morin,
Emmanuel Vazquez

► To cite this version:

Bruno Barracosa, H elo ise Baraffe, Julien Bect, Gilles Malarange, Juliette Morin, et al.. Optimisation of multi-year planning strategies to better integrate renewable energies and new electricity uses in the distribution grid. Journ ees annuelles du GdR MASCOT NUM (MASCOT NUM 2019), Mar 2019, Rueil-Malmaison, France. . <hal-02481410>

HAL Id: hal-02481410

<https://centralesupelec.hal.science/hal-02481410v1>

Submitted on 21 Feb 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire HAL, est destin e au d p t et   la diffusion de documents scientifiques de niveau recherche, publi s ou non,  manant des  tablissements d'enseignement et de recherche fran ais ou  trangers, des laboratoires publics ou priv s.



Distributed under a Creative Commons CC BY-NC-SA 4.0 - Attribution - Non-commercial use - ShareAlike - International License



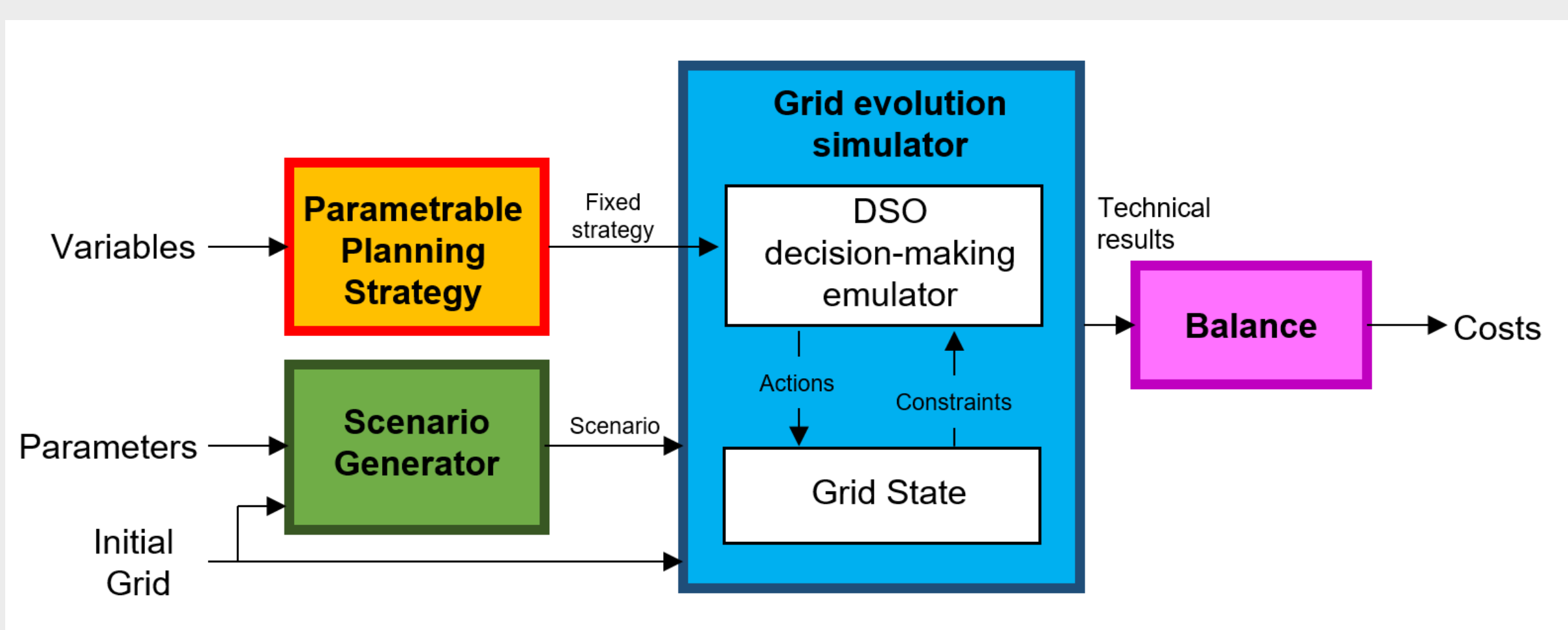
OPTIMISATION OF MULTI-YEAR PLANNING STRATEGIES TO BETTER INTEGRATE RENEWABLE ENERGIES AND NEW ELECTRICITY USAGES ON THE DISTRIBUTION GRID

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**?

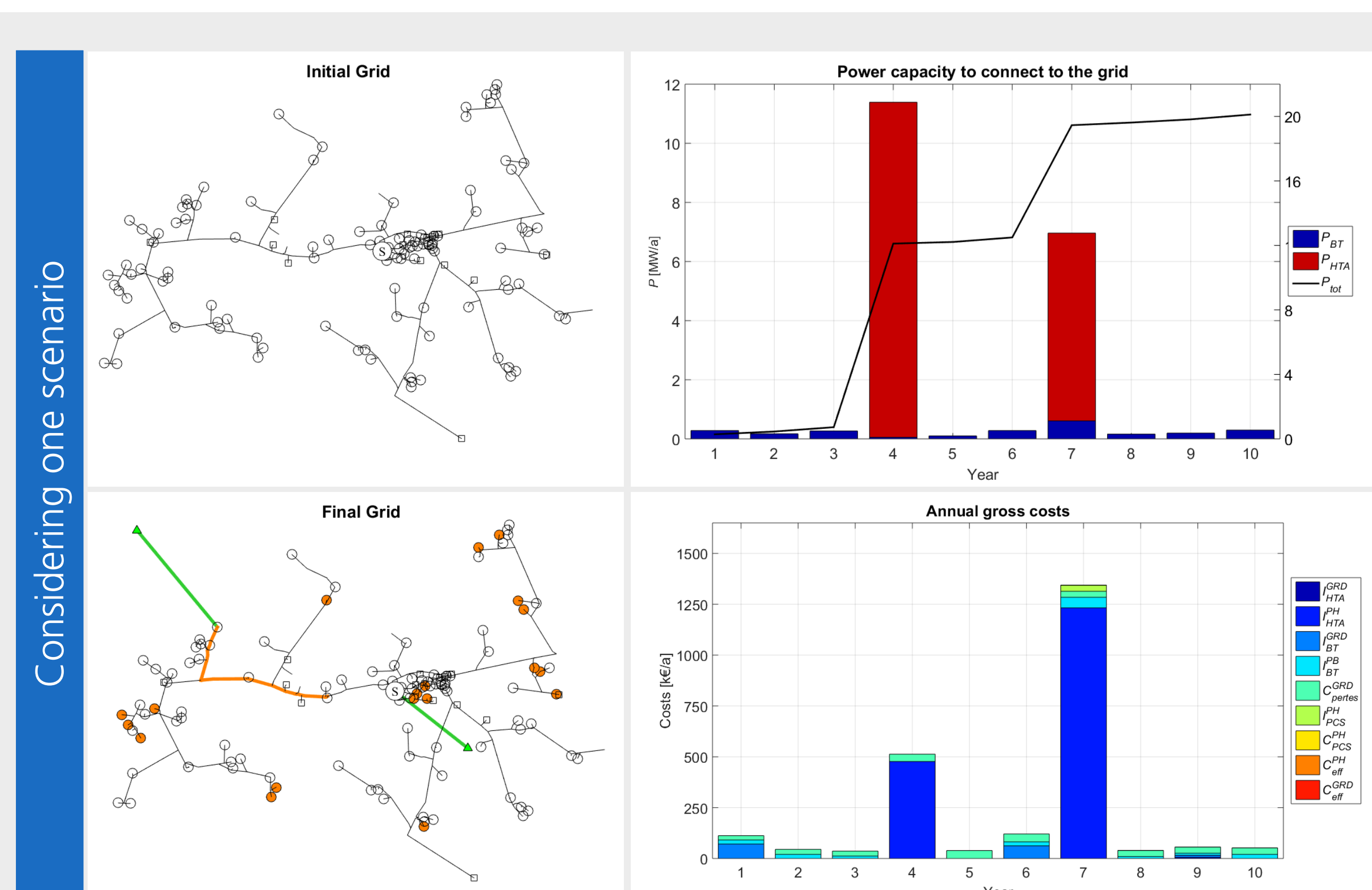
2. DECISION TOOL

- PARADIS (EDF R&D and CentraleSupélec/L2S, [DUT15]) is a tool to simulate planning strategies for different scenarios

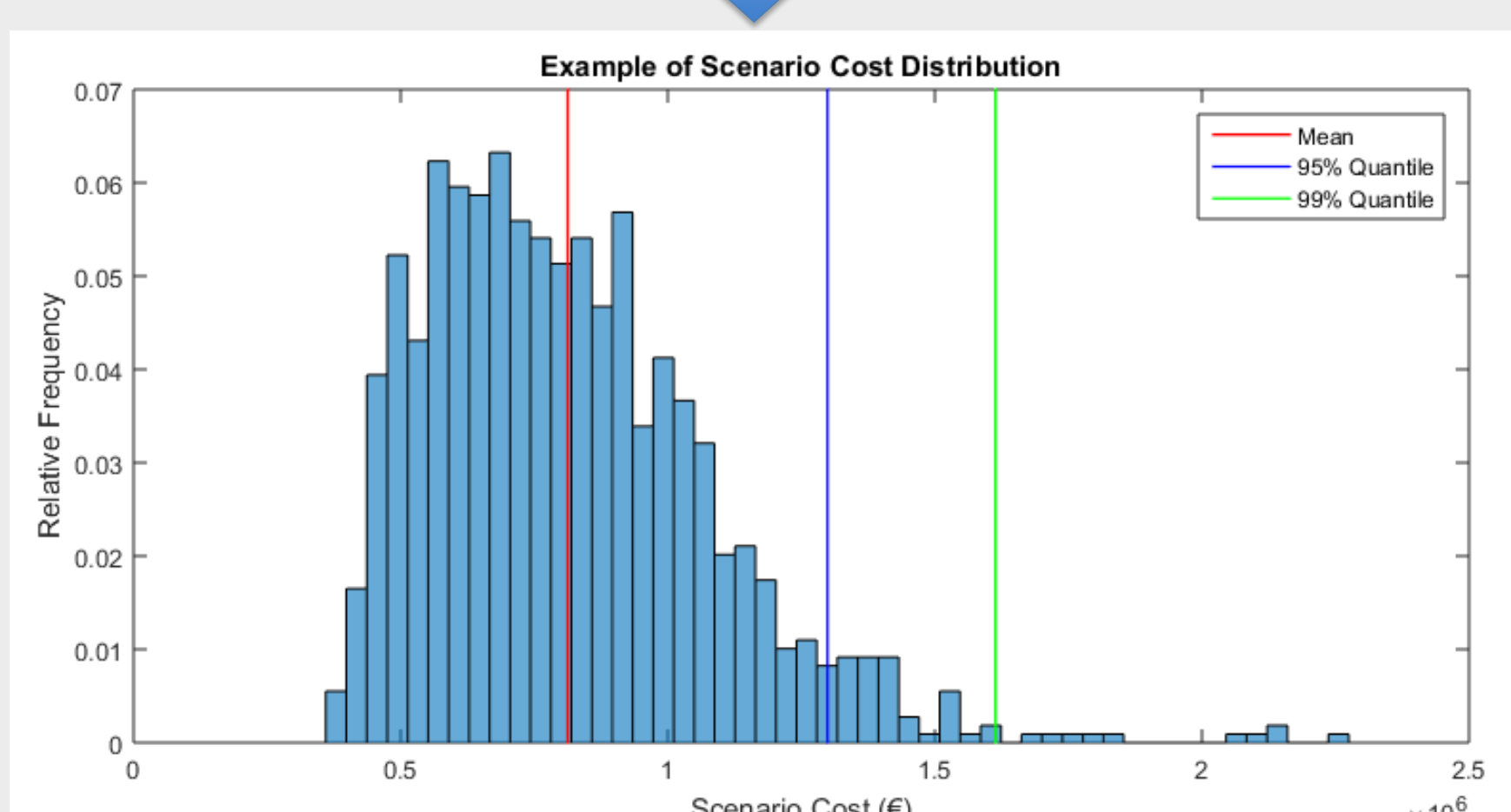


- **Scenario generator**: creates realistic random scenarios of RE's arrivals and the consumption and production profiles
- **Strategy planning**: defines the decision tree used by the Distribution System Operator (DSO)
- **Simulator**: simulates the evolution of the grid
- **Balance**: computes the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

- For a prescribed planning strategy:



Considering different realistic scenarios

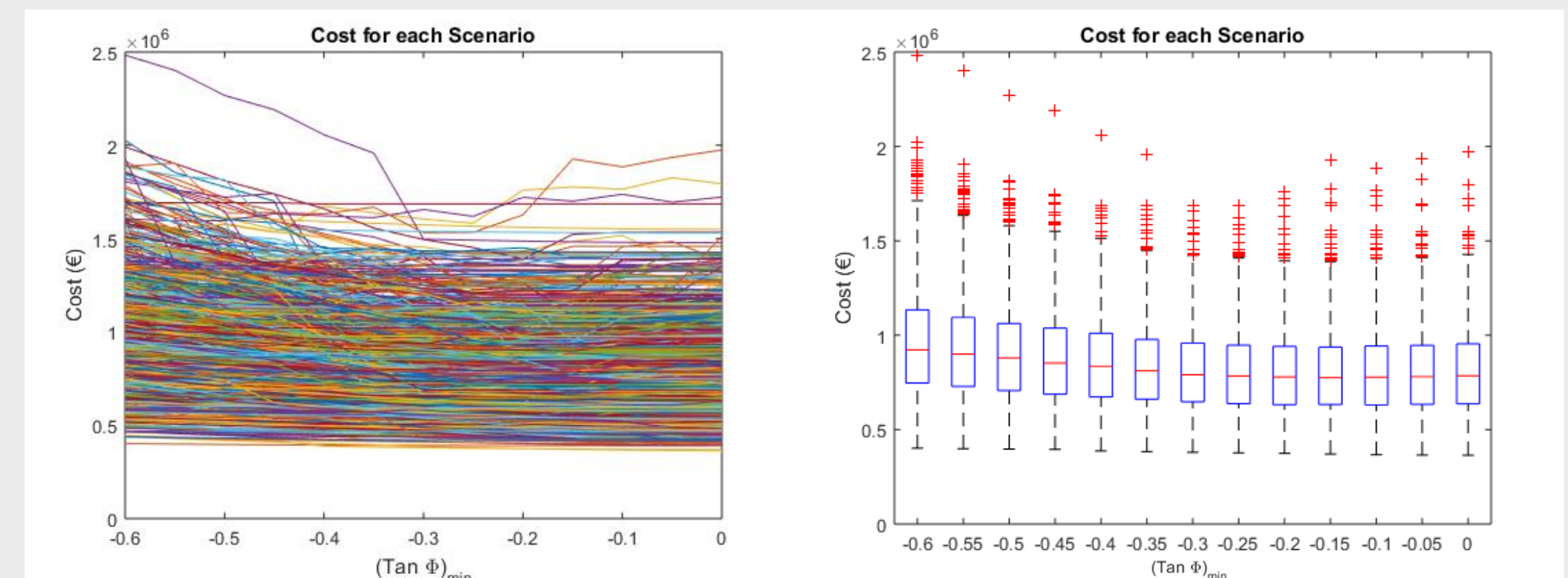


Significant variation in cost!

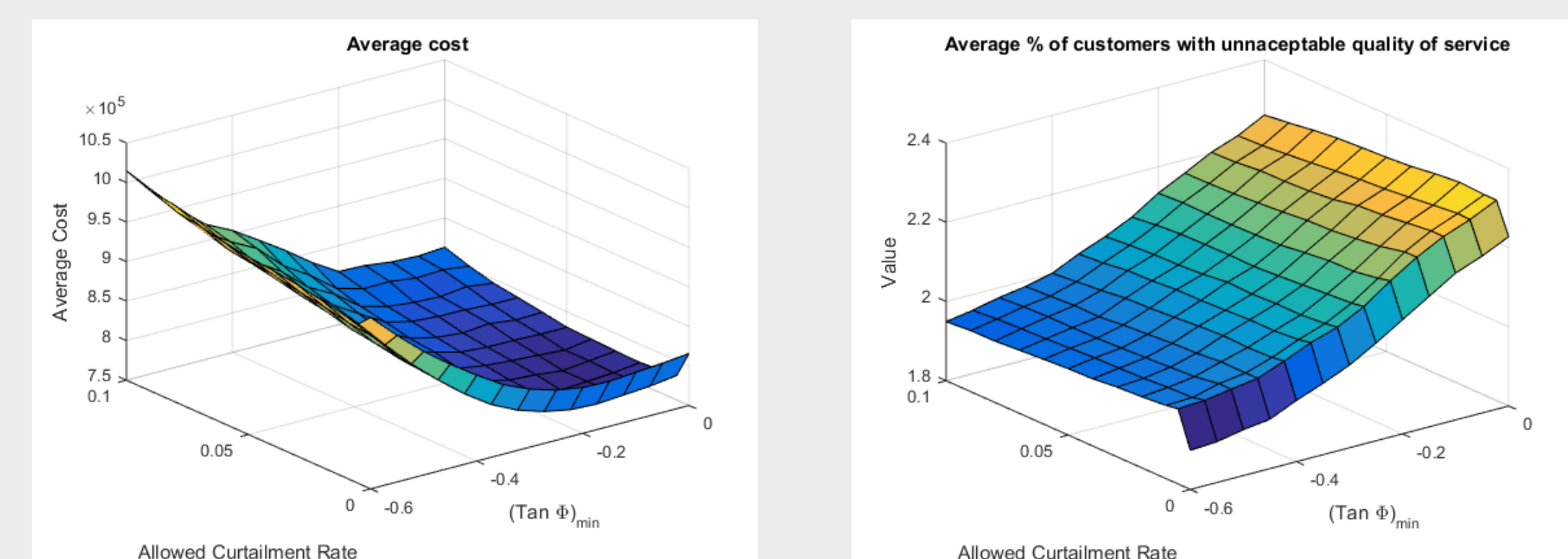
- In PARADIS, **planning strategies** are defined using **parameters** (up to about 10 parameters)

One-parameter strategy ($\tan \phi$)

Possible impact of extreme values!



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



Conflicting Objectives!

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: $\min_x q_\alpha(x)$, with $q_\alpha(x)$ an α -quantile (or superquantile) of the cost $Z(x)$.
- Multi-objective and/or constrained optimisation with more than one cost function $Z_1(x), Z_2(x), \dots$
- Robust optimisation: e.g., $\min_{x \in \mathbb{X}} q_\alpha(x + \varepsilon)$, with ε a random perturbation of the parameters
- Quasi-optimal regions:

$$\Gamma = \{x \in \mathbb{X}, q_\alpha(x) \leq q^* + \Delta; q^* = \min_{x'} q_\alpha(x')\}$$

with Δ a constant that defines the accepted level of quasi-optimality, or

$$\Gamma = \{x \in \mathbb{X}, q_\alpha(x) \leq q^*; q^* = \inf\{z \in \mathbb{R}, P_{\mathbb{X}}(x' \in \mathbb{X}, q_\alpha(x') \leq z) \geq \beta\}\}$$

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

[DUT15] H. Dutrieux, "Méthodes pour la planification pluriannuelle des réseaux de distribution. Application à l'analyse technico-économique des solutions d'intégration des énergies renouvelables intermittentes", thèse de doctorat en génie électrique, Ecole Centrale de Lille, novembre 2015.
[CAR15] A. Caré, S. Garatti and M.C. Campi, "Scenario min-max optimization and the risk of empirical costs", SIAM Journal on Optimization, 25, n° 4, pp. 2061-2080, 2015.
[LAB16] T. Labopin-Richard and V. Picheny, "Sequential design of experiments for estimating percentiles of black-box functions", arXiv preprint, 2016.
[DUB11] V. Dubourg, B. Sudret and J. Bourinet, "Reliability-based design optimization using kriging surrogates and subset simulation", Structural and Multidisciplinary Optimization, 44(5), pp. 673-690, 2011.
[RUS16] D. Russo, "Simple Bayesian Algorithms for Best Arm Identification", JMLR: Workshop and Conference Proceedings, vol. 49, pp. 1-2, march 2016.
[VIL09] J. Villemonteix, E. Vazquez and E. Walter, "An informational approach to the global optimization of expensive-to-evaluate functions", Journal of Global Optimization, vol. 44, n° 4, pp. 509-534, 2009.

Contacts:

Bruno BARRACOSA* (EDF R&D, L2S, CentraleSupélec), Héloïse BARAFFE (EDF R&D), Julien BECT (L2S, CentraleSupélec), Gilles MALARANGE (EDF R&D), Juliette MORIN (EDF R&D), Emmanuel VAZQUEZ (L2S, CentraleSupélec), *bruno.tebbal-barracosa@edf.fr