



**HAL**  
open science

# Comparing models for generating scenarios in the design of multi-energy microgrids under uncertainty

Gianmarco Lorenti, Maurizio Repetto, Bruno Sareni

► **To cite this version:**

Gianmarco Lorenti, Maurizio Repetto, Bruno Sareni. Comparing models for generating scenarios in the design of multi-energy microgrids under uncertainty. OIPE 2023 (17th International Workshop on Optimization and Inverse Problems in Electromagnetism), Sep 2023, Graz, Austria. hal-04369777

**HAL Id: hal-04369777**

**<https://hal.science/hal-04369777>**

Submitted on 2 Jan 2024

**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 destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# Comparing models for generating scenarios in the design of multi-energy microgrids under uncertainty

Gianmarco LORENTI\*, Maurizio REPETTO\*, Bruno SARENI\*\*

*\*Dipartimento Energia “Galileo Ferraris”, Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129 Torino, Italia*

*gianmarco.lorenti@polito.it (G.L.), maurizio.repetto@polito.it (M.R.)*

*\*\*LAPLACE, UMR CNRS-INPT-UPS, Université de Toulouse, 2 rue Camichel, 31071 Toulouse, France*

*sareni@laplace.univ-tlse.fr*

**Abstract.** This study is in the context of the design of multi-energy microgrids under uncertainty, where the objective is to determine optimal sizes for renewable generators and flexibility assets considering stochastic parameters, such as energy demand and renewable energy sources availability. In particular, we compare existing models to generate synthetic scenarios of these parameters leveraging historical data, e.g. using Markov Chains, probability distributions, and time series analysis. The assessment focuses on their ability to generate diverse scenarios that capture key characteristics of the original data. Additionally, we conduct an application-specific assessment to examine the impact of different scenario generation methods on design optimization. This evaluation utilizes a two-stage stochastic programming approach and a three-year dataset to evaluate performance on unseen scenarios.

**Keywords:** Design under uncertainty, multi-energy microgrid, scenarios generation, stochastic programming.

## INTRODUCTION

The design of multi-energy microgrids aims to determine optimal sizes for renewable generators and flexibility assets, for instance, to minimise costs while ensuring a desired share of local, renewable supply, considering the availability of renewable energy sources (RES) and the energy demand. Given the stochastic nature of these parameters, design optimisation under uncertainty seeks “robust” system sizes that perform well across various scenarios. These represent different trajectories of the stochastic parameters, such as photovoltaic (PV) production, electricity and heating loads, over a given time horizon (e.g., one year) [1]. However, gathering a sufficient amount of historical time series data is challenging and often impossible, thus necessitating the generation of synthetic ones. Among the existing models [2], we focus on those generating stochastic time series by leveraging the available historical data. Numerous models are available, e.g. [1, 3, 4], but they are seldom cross-validated [5], making it difficult to select the appropriate one for design optimisation. In this work, our objective is to compare existing models based on their ability to generate diversified scenarios that capture the main characteristics of the original data. Additionally, acknowledging the necessity of coupling “mathematical” validity assessment with application-specific evaluation emphasized by Kang et al. [5], we assess the potential impact of different scenario generation models on the output of design optimisation under uncertainty.

## METHODOLOGY

### Design under uncertainty

The design optimisation of the multi-energy microgrid in Figure 1 is approached as a two-stage stochastic programming problem [1]. The first stage involves determining the sizes of the RES and flexibility assets, while the second stage focuses on scenario-specific energy management. At the first stage, only scenarios with an associated probability of the uncertain parameters (PV production, electricity and heating demand) are known, which are revealed after fixing the first-stage variables, allowing for optimal operation within sizing constraints (see Figure 2). Determining the sizing that performs best across all scenarios is framed as a single mixed integer linear programming (MILP) optimisation problem, as in [1].

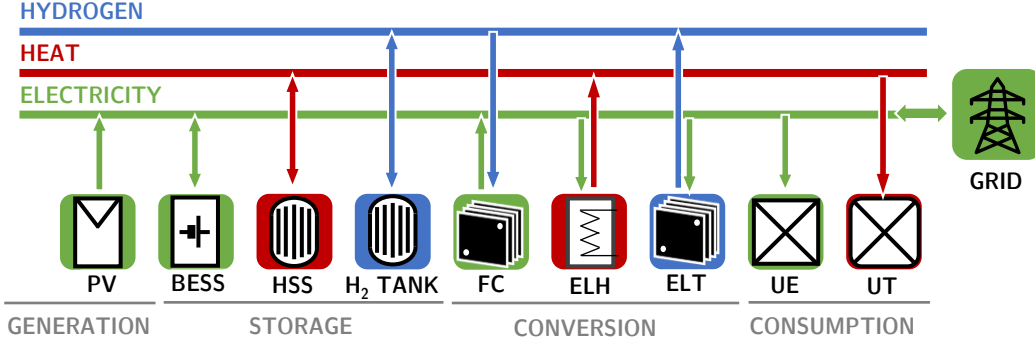


Figure 1: Layout of the multi-energy microgrid.

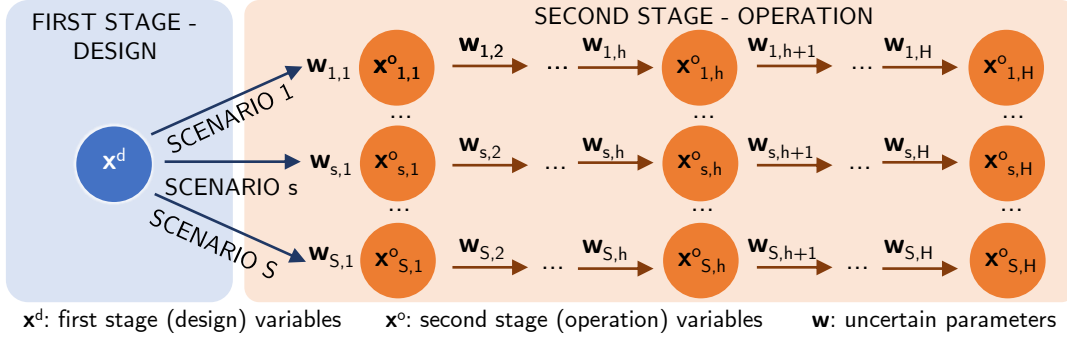


Figure 2: Two-stage design optimisation under uncertainty.

### Scenarios generation

Existing models in the literature can generate synthetic time series of the uncertain parameters from historical data, e.g. using Markov Chains [1], multivariate probability distributions [3], and time series analysis [4]. Our work focuses on comparing these models rather than proposing a new one. Particularly, we evaluate the models' ability to generate diverse scenarios that capture the statistical characteristics of the original data and align with similarity measures reported in [2]. Eventually, we analyse the variation of these measures with the amount of data used for model fitting. Finally, we perform an application-specific assessment to examine if and how scenarios generated with different models impact the output of the MILP design optimisation. To ensure robustness, we use three years of measured data (Ausgrid dataset [1, 5]), split into training and testing sets to evaluate design performance on unseen scenarios.

### REFERENCES

- [1] H. Radet. Integrated design methods for distributed multi-energy systems under uncertainties. Ph.D. dissertation, INP Toulouse, France, 2023.
- [2] S. Köhler R. Rongstock, M. Hein and U. Eicker. Similarity measures and comparison methods for residential electricity load profiles. *Energy and Buildings*, vol. 271, 2022, p. 112327. [Crossref].
- [3] E. M. S Duque. P. P. Vergara, P. H. Nguyen, A. van der Molen and J. G. Slootweg. Conditional multivariate elliptical copulas to model residential load profiles from smart meter data. *IEEE Transactions on Smart Grid*, vol. 12, no. 5, 2021, pp. 4280–4294. [Crossref].
- [4] S. Patidar, D. P. Jenkins and S. A. Simpson. Stochastic modelling techniques for generating synthetic energy demand profiles. *International Journal of Energy and Statistics*, vol. 4, num. 3, 2016, p. 1650014. [Crossref].
- [5] X. Kang, J. An and D. Yan. A systematic review of building electricity use profile models. *Energy and Buildings*, vol. 281, 2023, p. 112753. [Crossref].