Co-Design of Microgrids with Renewable Integration: A Modular Julia-based Tool and Applications

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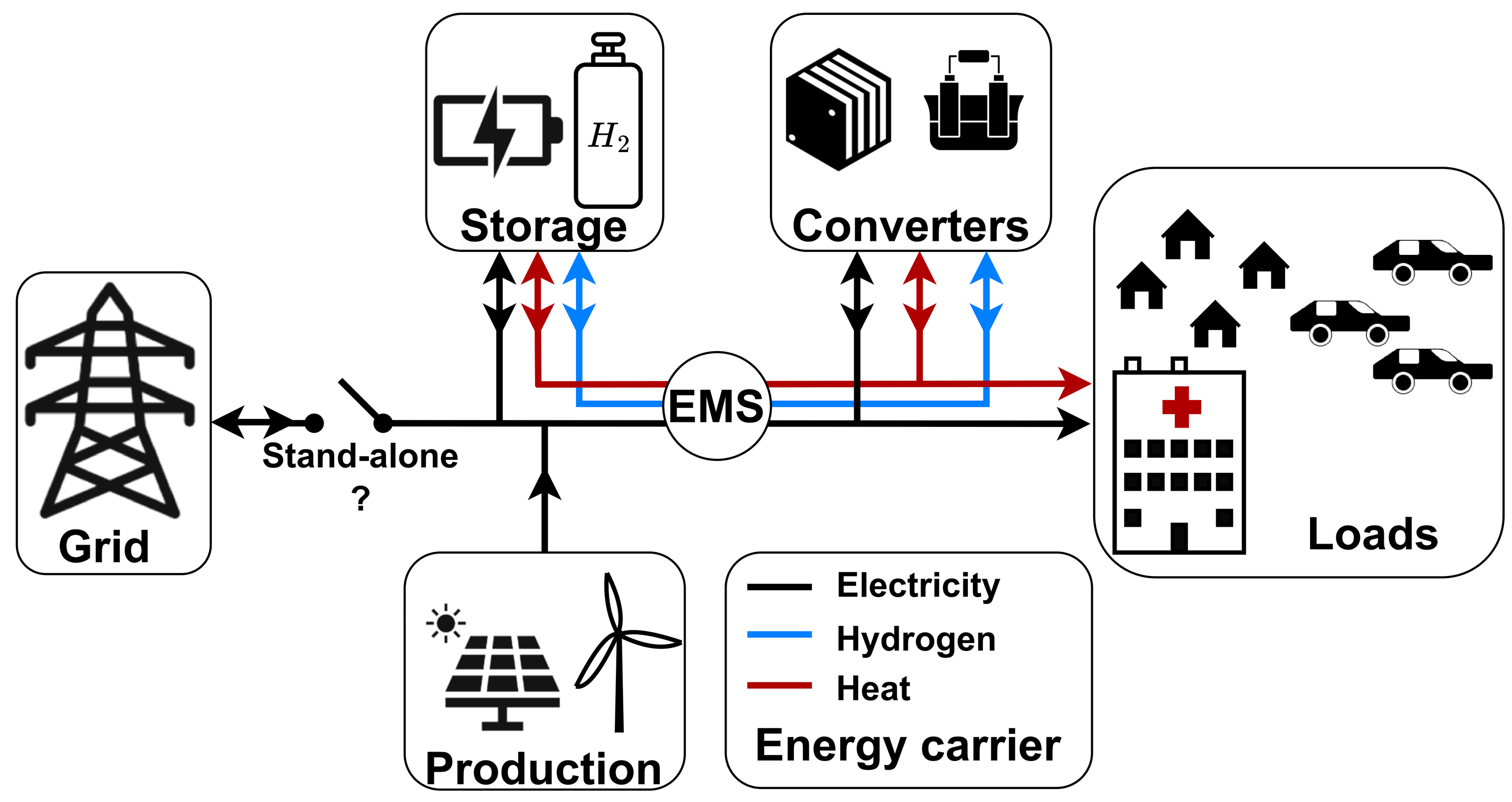
LABORATOIRE PLASMA ET CONVERSION D'ÉNERGIE

General Multi-Energy Microgrid Architecture



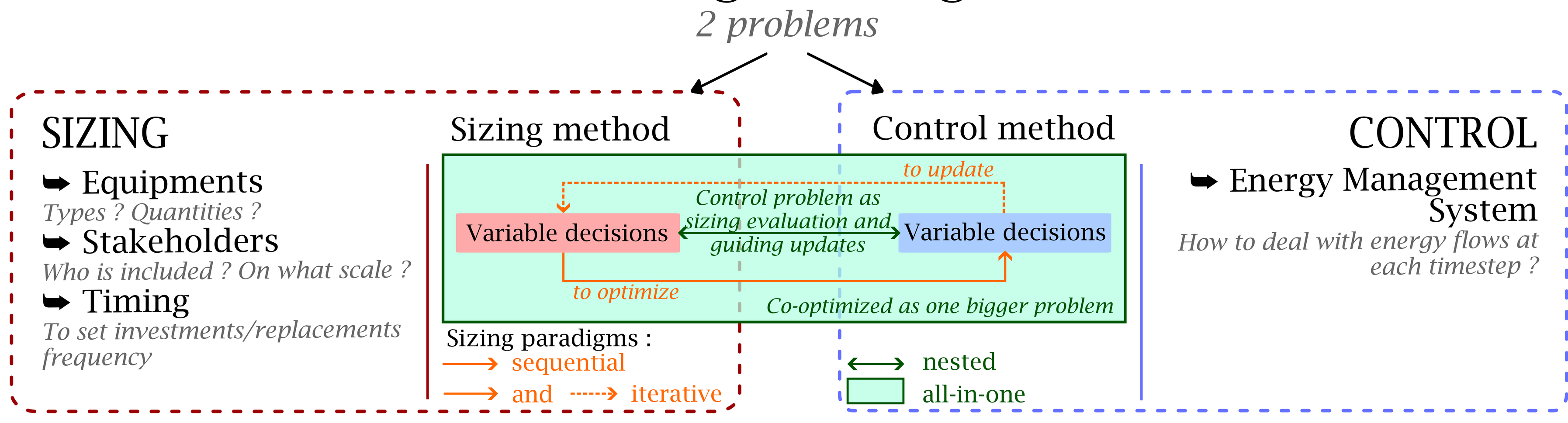
Co-design of Microgrids: 2 Types of Questions

Sizing

What types of units should be installed, when, where and in what quantities to optimize the chosen criteria?

Control

At any given moment, which production, conversion, and storage units should be deployed and at what levels to meet demand and technical constraints while optimizing the chosen criteria?



Functionalities and Modularity

Every study case come with research questions implying different modeling focus, the tool offer the necessary modularity for addressing a large variety of cases.

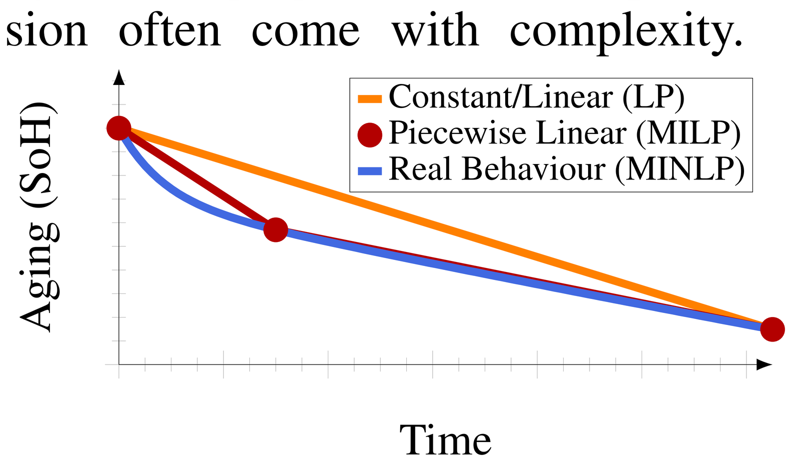
Modularity Axes

Modularity and Functionalities List

- Different architecture as displayed on the above microgrid;
- Flexibility on time modeling (horizon, step);
- Component models with various precision levels;
- Several algorithms for both sizing and control;
- Uncertainty management with scenarios;
- Metrics and plots.

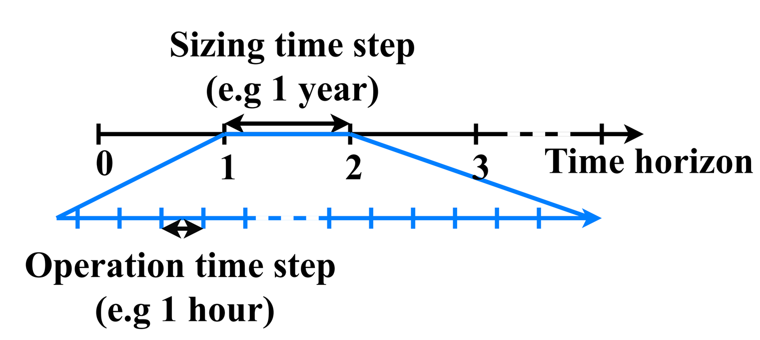
Component Models

Several levels of precision are available for most storage and conversion units. Including models for their efficiency, capacity and aging. However precision often come with complexity.



Time Models

Time horizon and decision (sizing and control) time step are adjustable to the case study. They are highly correlated to the amount of variables and constraints.



Optimization Algorithms

Depending on the modeling choices some algorithms are unavailable.

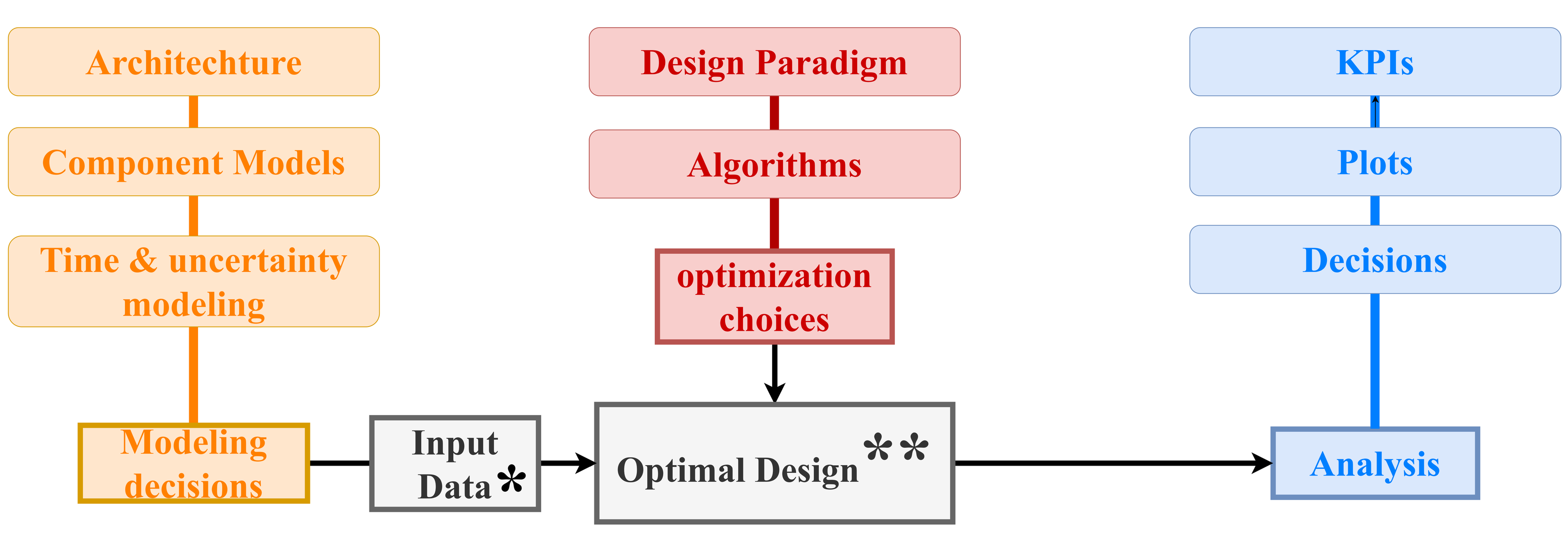
Algorithms for Sizing

- Mathematical Solvers (imply compatible control)
- Clearing
- NSGA-II

Algorithms for Control

- Mathematical Solvers
- Rule Based

Design pipeline



Optimization Result

*: Input data dimensions—length, frequency and multiplicity—of time series (TS) depend on horizon, time-step and number of scenarios

**: Solutions and KPIs are optimal under the modeling assumption.

Main Interactions Between Modeling Features

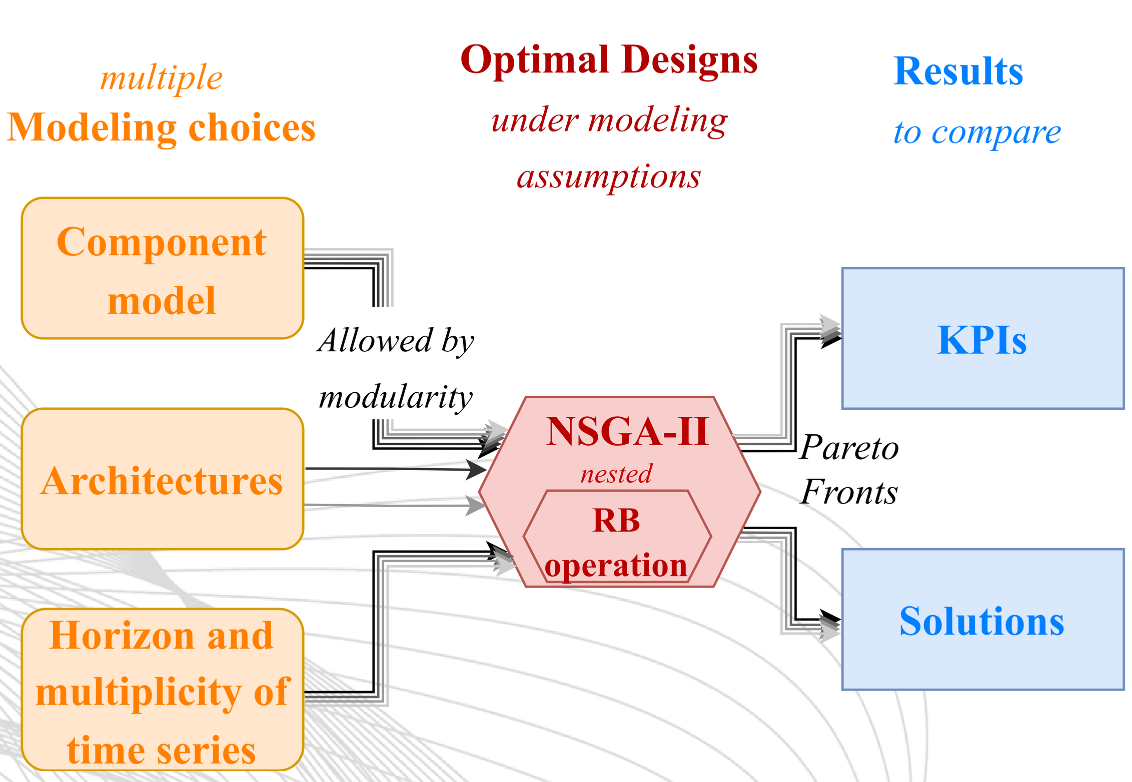
- Some non-linear model equation might imply high exact solving time;
- Time horizon associated to time-step determines the number of decision step;
- Design paradigm drives the choice of optimization methods.

Example Study Cases

Corentin Boennec's Thesis

Research Questions

What impact the modeling assumptions have on optimization processes ? From problem tractability to objectives and decisions.



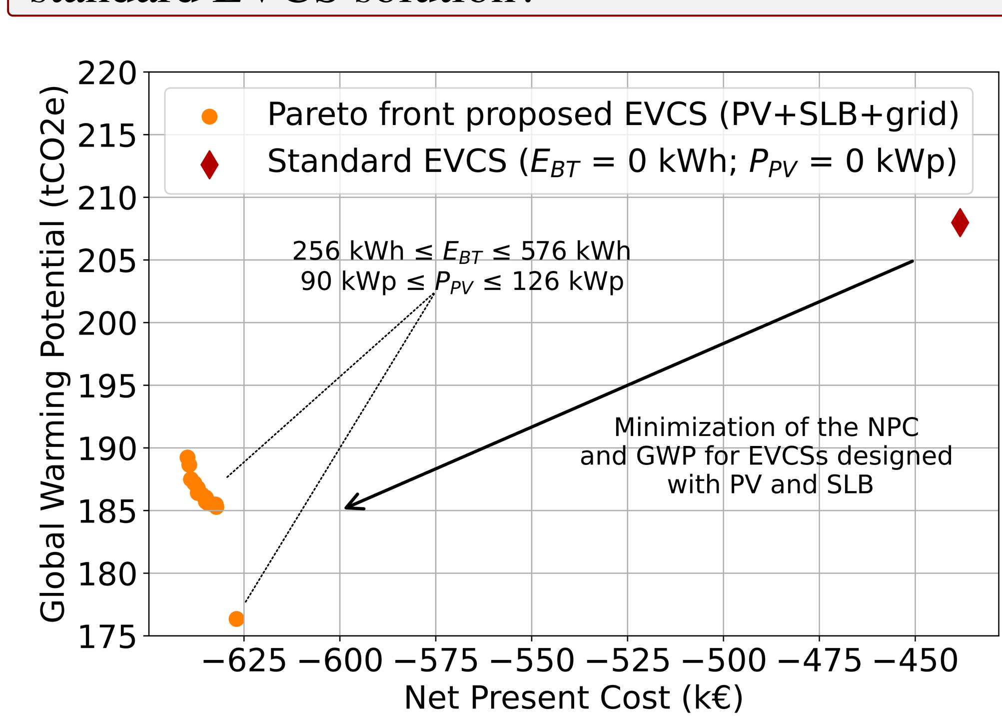
Main Results

- Long term dynamics and especially battery aging should not be overlooked;
- Long horizon are required to precisely assess long term dynamics;
- First order of magnitude is the horizon, second order we have component model while multiplicity of series is of third order.

Evelise Antunes's Thesis

Research Questions

How to co-design an Electric Vehicle Charging Station (EVCS) composed of photovoltaic panels (PV) and second life stationary batteries (SLB)? It is possible to minimize the economic costs and the Global Warming Potential in relation to an standard EVCS solution?



Tool Improvement

- The tool is still limited regarding the study of vehicle-to-grid (V2G) applications, in which EVs charging demand needs to be modeled as an decision variable of the optimal control;
- The addition of controllable loads in the tool could allow the study of other microgrids configurations, not only EVCS.

Camille Bergougnoux's Thesis

Research Questions

To what extent can Toulouse-Blagnac airport be made 100% self-sufficient and 100% renewable energy? From airport microgrid modeling to multi-stream and tricriteria co-optimization.

Project background

- Toulouse airport is a complex microgrid, using three energy vectors on its platform: electricity, heat and hydrogen.
- Uses are highly varied: some are linked to tertiary sector (services), others are related to aeronautic activities.