

#### How to enforce non-anticipativity in microgrid sizing optimization?

Pierre Haessig, Jean Fructhieu Nikiema, Nabil Sadou, Elsy El Sayegh

#### ► To cite this version:

Pierre Haessig, Jean Fructhieu Nikiema, Nabil Sadou, Elsy El Sayegh. How to enforce nonanticipativity in microgrid sizing optimization?. Openmod Grenoble workshop 2024, Mar 2024, Grenoble, France. . hal-04543567

#### HAL Id: hal-04543567 https://hal.science/hal-04543567

Submitted on 12 Apr 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.



Distributed under a Creative Commons Attribution 4.0 International License



# How to enforce + non-anticipativity + in microgrid sizing optimization?



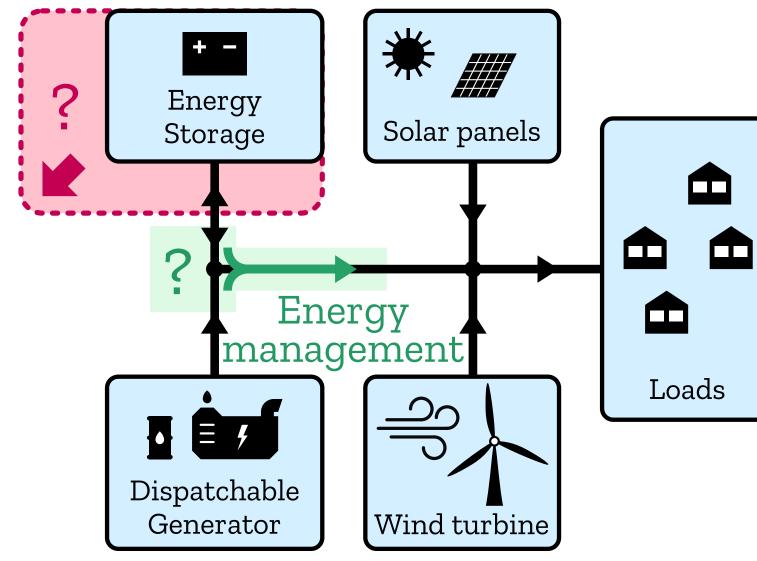
Pierre Haessig<sup>1</sup>, Jean Fructhieu Nikiema<sup>1</sup>, Nabil Sadou<sup>1</sup>, Elsy El Sayegh<sup>2</sup> <sup>1</sup> CentraleSupélec, IETR | <sup>2</sup> EDF R&D Saclay

## Microgrid optimal design: definition & challenges

Microgrids

Definition: standalone energy systems, e.g. needed for rural electrification

#### Sizing



Microgrid **design objectives**: (min) Lifecycle cost = Investment + Operation + Replace (max) Quality of Service ( $\rightarrow$  min load shedding) and also: environmental impact...

Two *intertwined* optimization problems:

- Microgrid **sizing**: find the optimal components' size
- Energy management (EM): choose, at each instant, the optimal power flows

### Microgrid sizing tool

Since each project is a specific design  $\rightarrow$  need for reliable microgrid sizing tool



Fact: due to uncertainty of project data, **anticipative** Energy Management may not be applicable on field.

Q: Which microgrid model formulation yield: o reliable & fast convergence? (~ in seconds) o non anticipative operation?

design tool

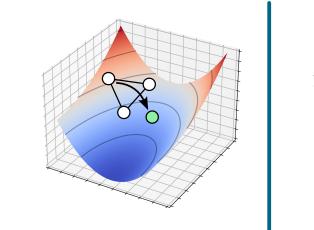
- weather &
- load time series
- prices of components
- technical bounds

- size of each component
- Key Performance Indicators (KPIs)

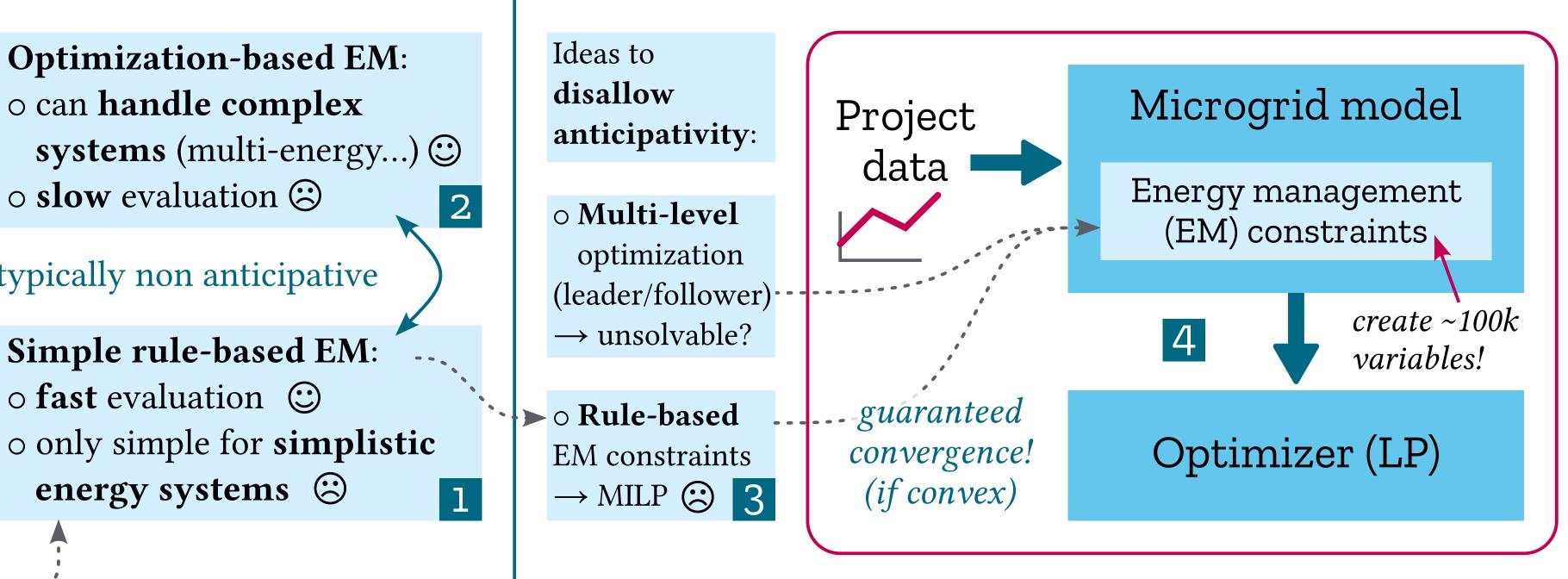
**Different formulations for sizing & operation optimization** Operation Algebraic Other optim. Heuristic (energy management) (Mixed Integer) Linear Program ex: MPC, SDP, Metaheuristics... Rule-based control (ex: load following) Pointless? Classical 1 (ex.: HOMER, iHOGA...) Too computationally intensive? Blackbox A microgrid performance **simulator** A microgrid performance **simulator** If inner level energy management ex: Metaheuristics embeds a simple **rule-based** energy embeds optimization-based energyoptimization is algebraic, why not go all the way up to sizing? management. management. 1 2 Sizing The worst of both worlds? Classical 2 (ex. DER-CAM, PyPSA...) Impossible Algebraic Rule-based energy management "All-in-one" joint optimization of A toplevel algebraic sizing cannot (Mixed Integer) **enforced** (nonconvex constraints) sizing and energy flows in one embed an inner non algebraic energy within algebraic sizing optimization. 3 Linear Program algebraic problem. management. Δ



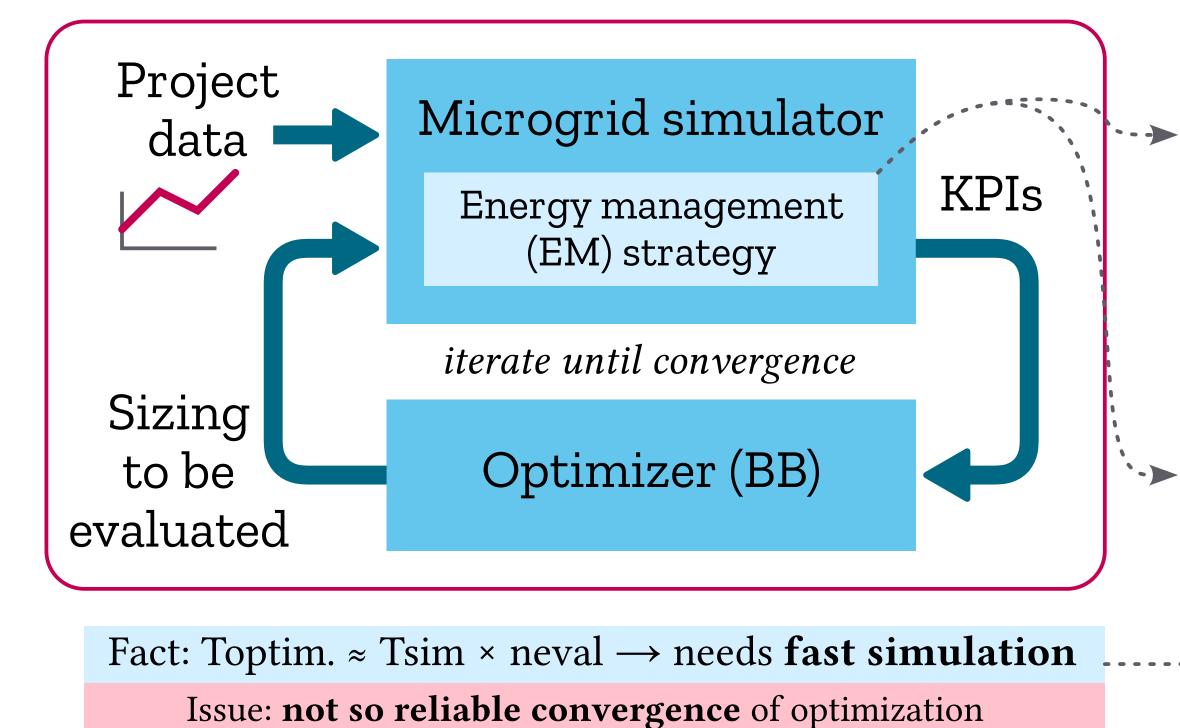
### Blackbox sizing with 1&2 embedded energy management

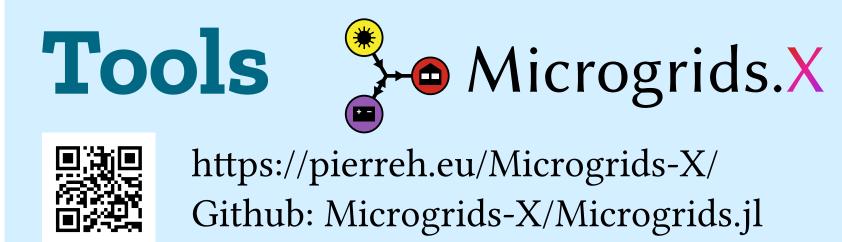


## Algebraic all-in-one sizing & energy management 3&4



#### Issue: anticipative ("perfect foresight") energy management by default





Operational & economic simulation of Microgrids - with simple rule-based energy management - with sizing optimization example

Three implementations		NEW
Julia	Matlab	Algebraic variant:
the factor one	Python	JuMP based
0.15 ms/sim	with in-browser demo version	in progress

## Conclusions

### No clear winning approach

o can **handle complex** 

typically non anticipative

**Simple rule-based EM**:

energy systems 🔅

 $\circ$  **fast** evaluation  $\bigcirc$ 

 $\circ$  **slow** evaluation  $\bigcirc$ 

**Non anticipative** energy management typically implies **blackbox** sizing optimization with *either*: o simplistic energy system (rule-based control) or o prohibitively slow evaluation time (optimization-based--energy management)

Algebraic sizing optimization models typically assumes anticipative ("perfect foresight") energy management

### Perspectives

For blackbox optimization: - Use Bayesian optimization to circumvent the increased simulation time due to optimizationbased energy management (Model Predictive control, Stochastic Dynamic Programming)

#### For algebraic optimization:

- Is there an efficient way to enforce **non anticipative** Energy Management?

Open Energy Modelling initiative (openmod) – Grenoble workshop 2024

