



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

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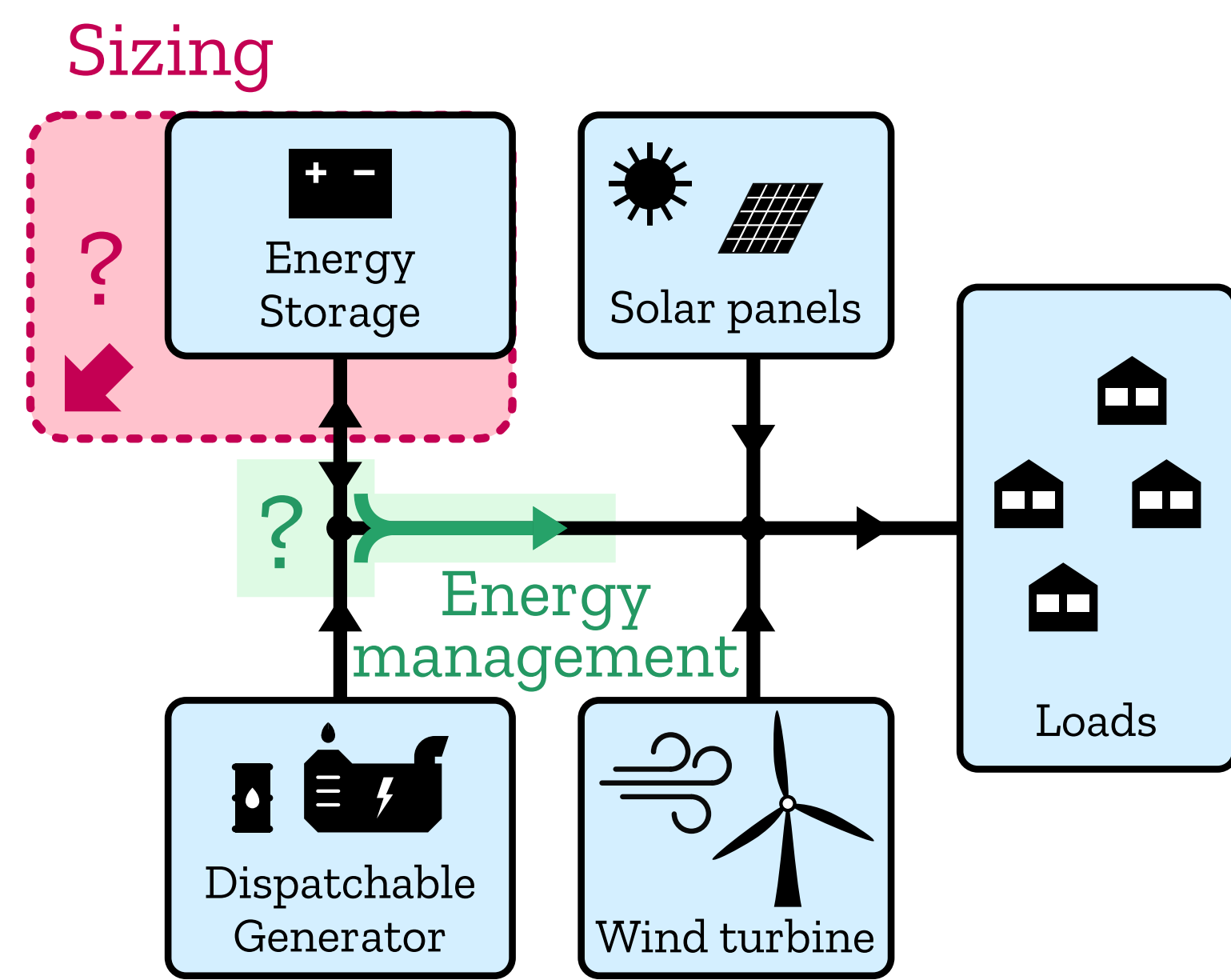
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## Microgrid optimal design: definition & challenges

### Microgrids

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



Microgrid **design objectives**:

(min) Lifecycle cost = Investment + Operation + Replace  
(max) Quality of Service (→ 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

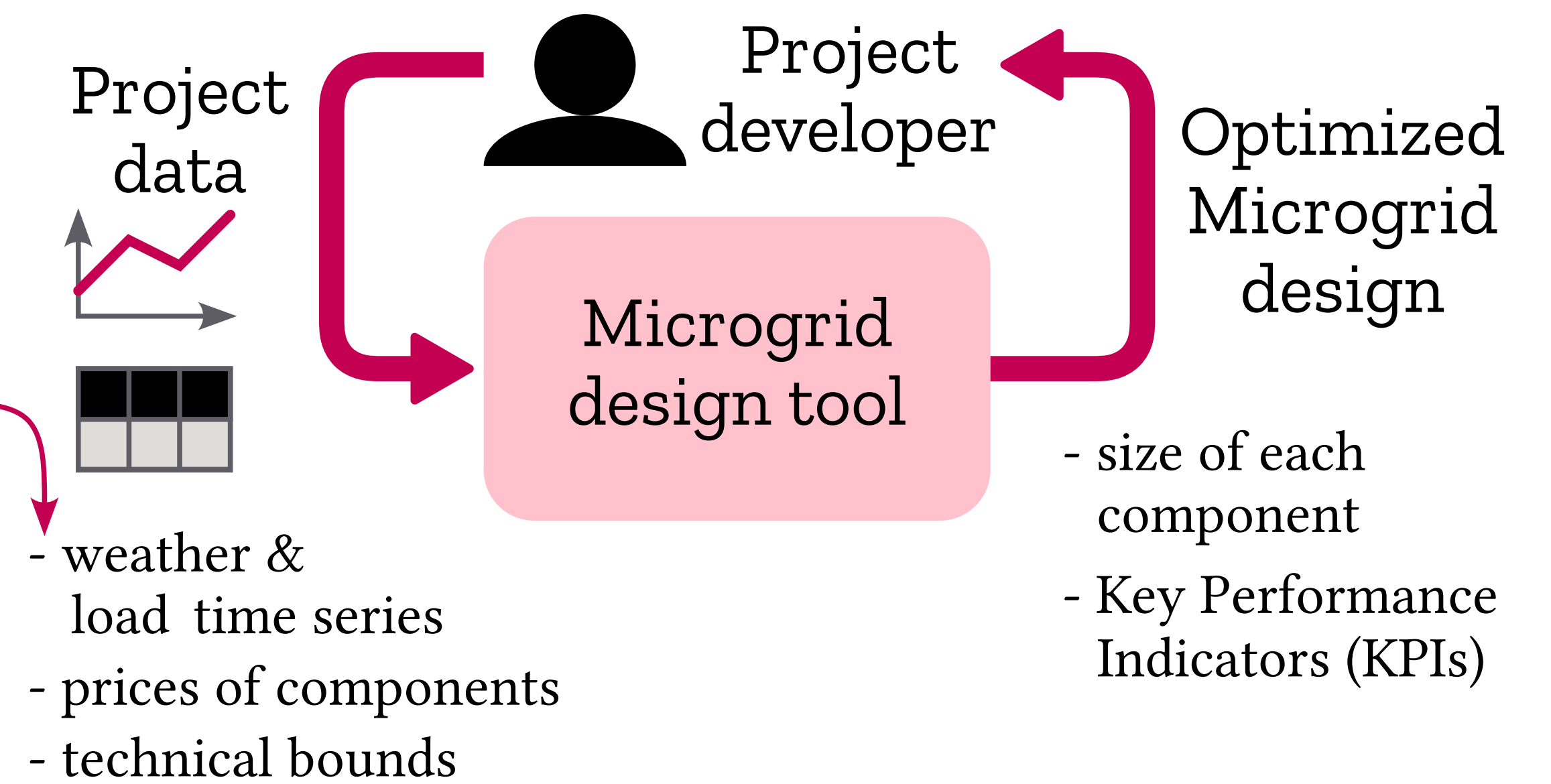
Fact: due to uncertainty of project data, **anticipative** Energy Management may not be applicable on field.

Q: Which **microgrid model formulation** yield:

- reliable & **fast** convergence? (~ in seconds)
- **non anticipative operation**?

### Microgrid sizing tool

Since each project is a specific design  
→ need for reliable microgrid sizing tool



## Different formulations for sizing & operation optimization

### Operation (energy management)

#### Heuristic

Rule-based control (ex.: load following)

*Classical 1 (ex.: HOMER, iHOGA...)*  
A microgrid performance **simulator** embeds a simple **rule-based** energy management. **1**

*The worst of both worlds?*  
Rule-based energy management **enforced** (nonconvex constraints) within algebraic sizing optimization. **3**

#### Algebraic

(Mixed Integer) Linear Program

*Pointless?*  
If inner level energy management optimization is algebraic, why not go all the way up to sizing? **2**

*Classical 2 (ex. DER-CAM, PyPSA...)*  
“**All-in-one**” joint optimization of sizing and energy flows in one algebraic problem. **4**

#### Other optim.

ex: MPC, SDP, Metaheuristics...

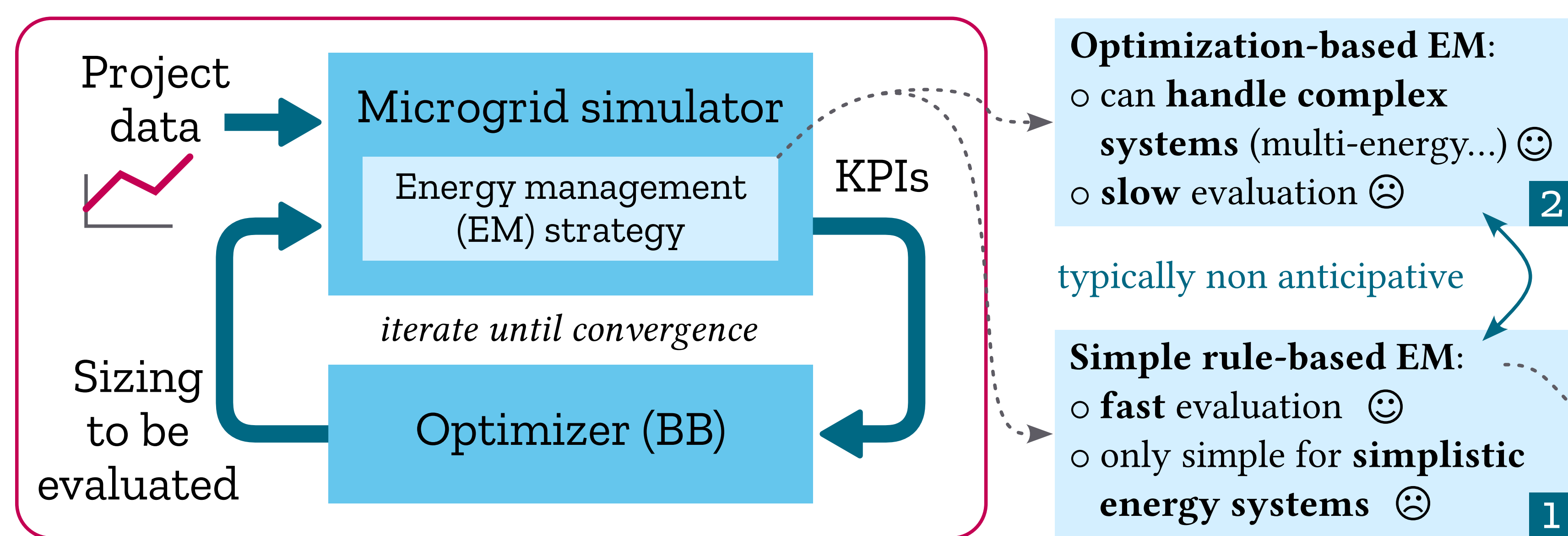
*Too computationally intensive?*  
A microgrid performance **simulator** embeds **optimization-based** energy-management. **2**

*Impossible*  
A toplevel algebraic sizing cannot embed an inner non algebraic energy management.

**Blackbox**  
ex: Metaheuristics

**Algebraic**  
(Mixed Integer) Linear Program

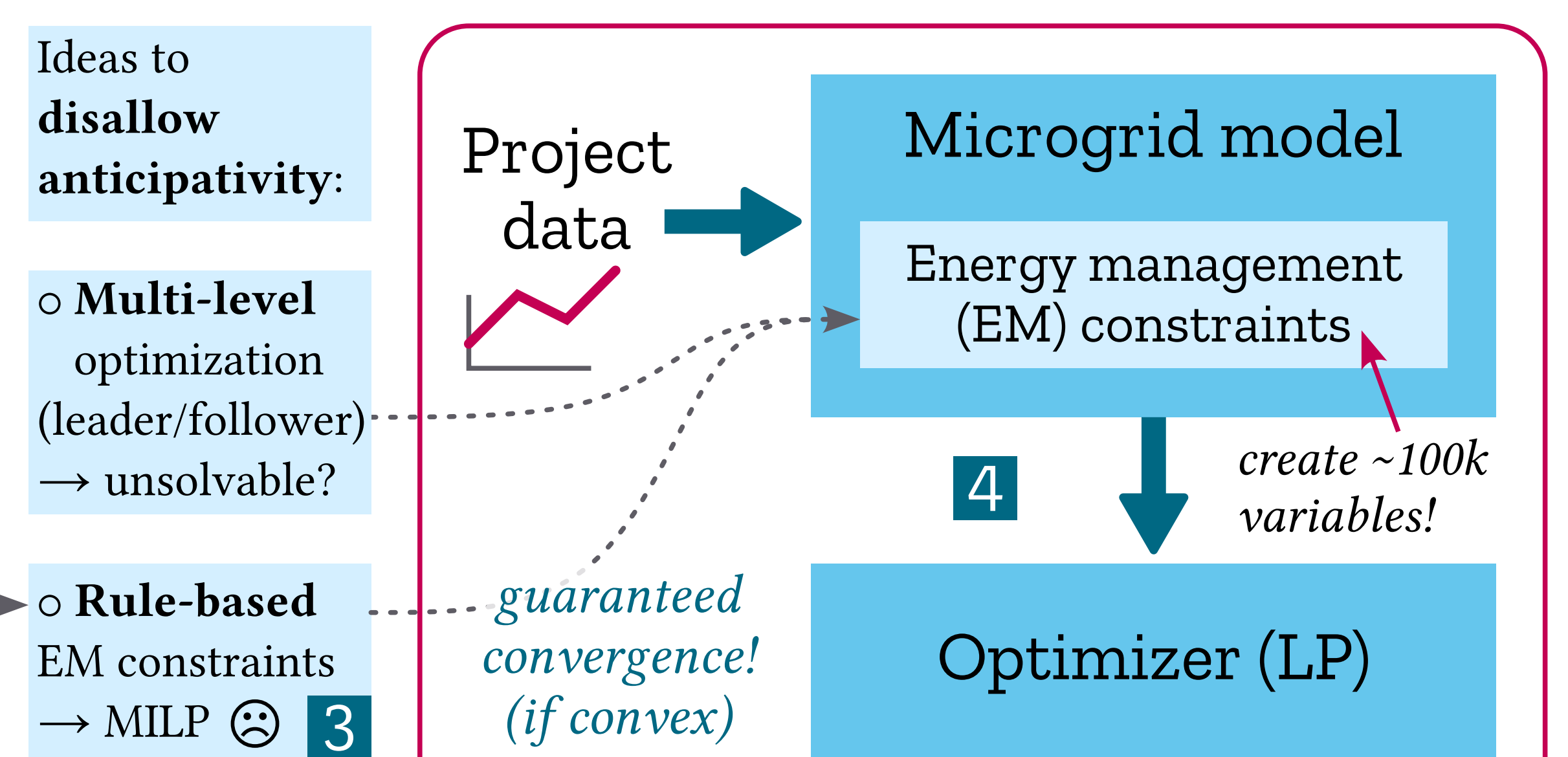
### Blackbox sizing with embedded energy management **1 & 2**



Fact: Toptim. ≈ Tsim × neval → needs **fast simulation**

Issue: **not so reliable convergence** of optimization

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



Issue: **anticipative** (“perfect foresight”) energy management by default

## Tools

Microgrids.X



<https://pierreh.eu/Microgrids-X/>  
Github: Microgrids-X/Microgrids.jl

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

Three implementations

**Julia**

the fastest one:  
0.15 ms/sim

**Matlab**

**Python**  
with in-browser  
demo version

**NEW**

Algebraic variant:  
**JuMP** based  
in progress...

## Conclusions

### No clear winning approach

**Non anticipative** energy management typically implies **blackbox** sizing optimization with *either*:

- simplistic energy system (rule-based control)  
or
- 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 optimization-based energy management (Model Predictive control, Stochastic Dynamic Programming)

For algebraic optimization:

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