



HAL
open science

Sizing optimization for Islanded Microgrid with long-term Hydrogen Storage: A comparison of 2 rules-based operation strategy

Jean Fruchthieu Nikiema, Pierre Haessig, Nabil Sadou, Hervé Gueguen

► To cite this version:

Jean Fruchthieu Nikiema, Pierre Haessig, Nabil Sadou, Hervé Gueguen. Sizing optimization for Islanded Microgrid with long-term Hydrogen Storage: A comparison of 2 rules-based operation strategy. Openmod Grenoble workshop 2024, Mar 2024, Grenoble, France. . hal-04622780

HAL Id: hal-04622780

<https://hal.science/hal-04622780v1>

Submitted on 24 Jun 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.

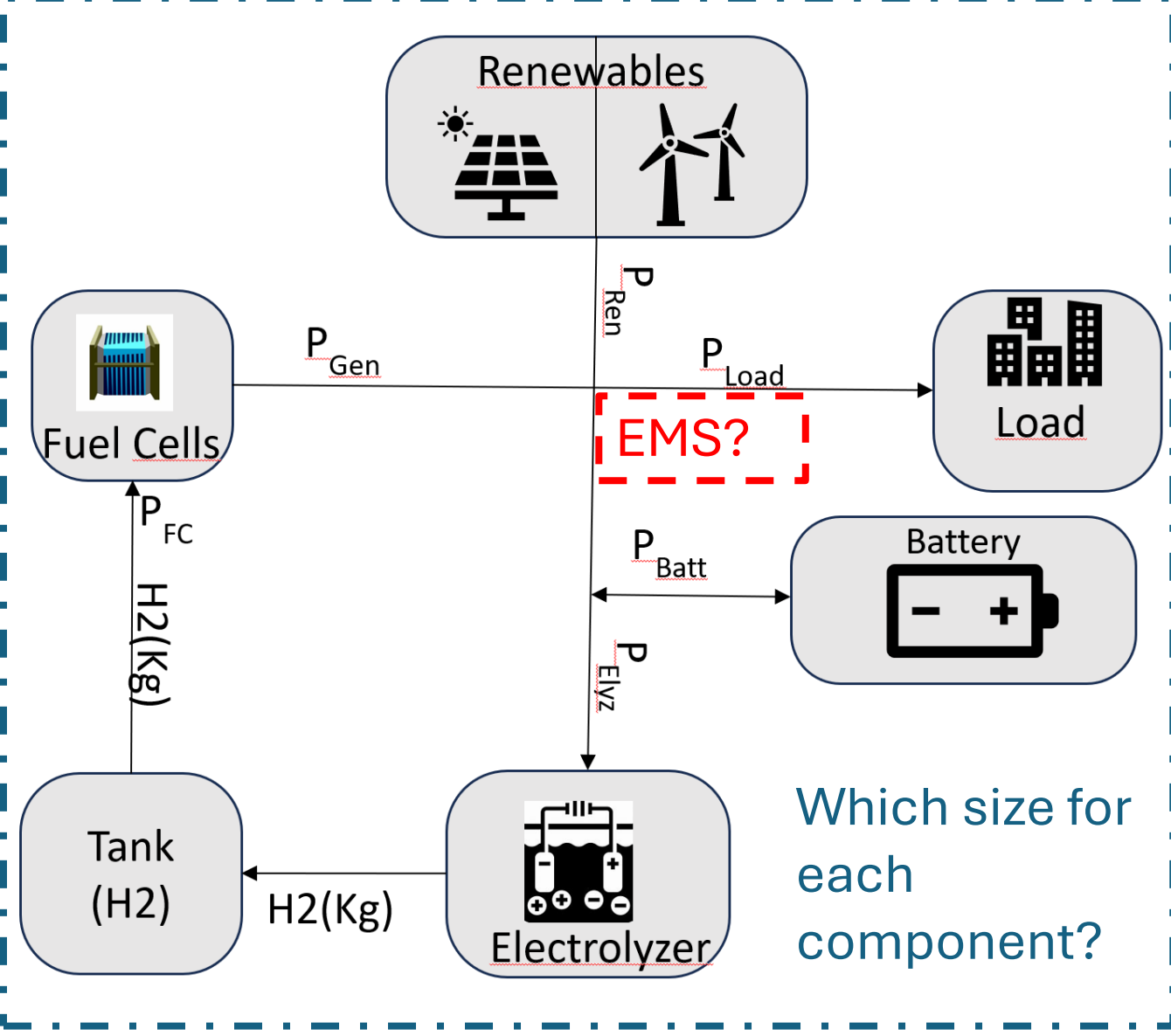


Distributed under a Creative Commons Attribution 4.0 International License

Sizing optimization for Islanded Microgrid with long-term Hydrogen Storage: A comparison of 2 rules-based operation strategy

Jean Fruchthieu NIKIEMA, Pierre HAESSIG, Nabil SADOU, Hervé GUEGUEN
Centrale Supélec - IETR, France

Microgrid & problem description



Our **islanded** Microgrid (100 REN) is composed of:

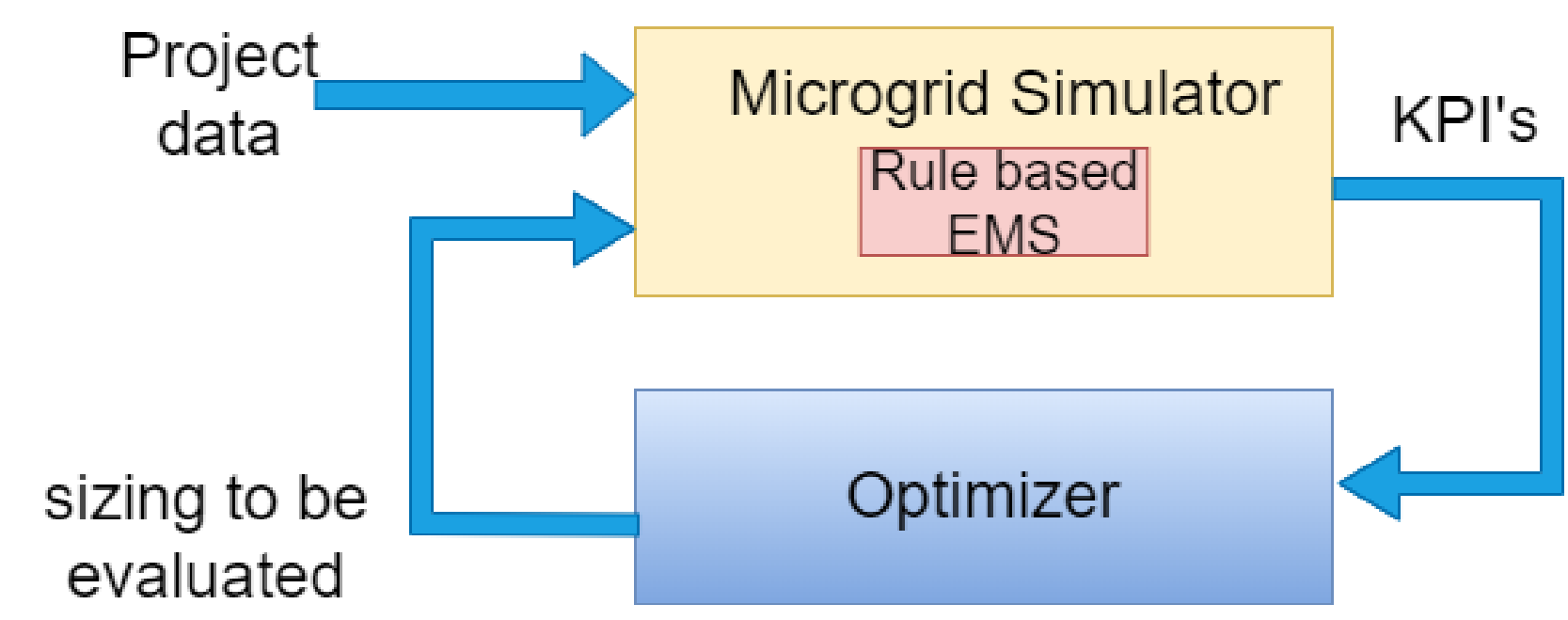
- Renewable sources - Photovoltaic modules and wind turbines
- Short-term storage**: Li-ion batteries
- Seasonnal storage**: PEM electrolyser, compressed Hydrogen tank and PEM fuel cell

Problem : Optimal components **sizing** intertwined with the choice of the the **energy management system**

Contribution :

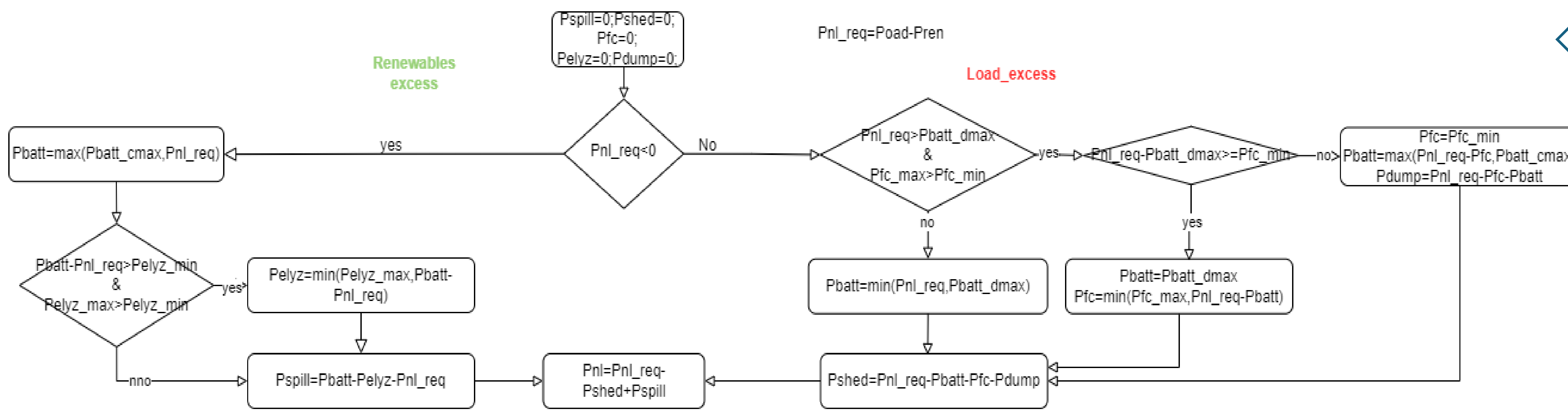
- 2 **rules based** energy management strategies proposed
- Techno-economic comparison of these 2 strategies and their impact on the optimal sizing

Optimization Setup



- Black Box optimization
- Tool link Github: Microgrids-X/Microgrids.jl
- Gradient-free algorithm used : GN_CRS2_LM from Nlopt.jl
- Maximal evaluation number : 100 000

- Optimization variables : component sizes
- 2 criteria have been considered ; one economic: Levelized Cost of Energy (LCOE) ; and one for the Quality of Service : the shedding rate.
- Objective function : $f(X) = LCOE(X) + 10^5 \cdot \max((T_{shed}(X) - T_{shed,max}), 0)$

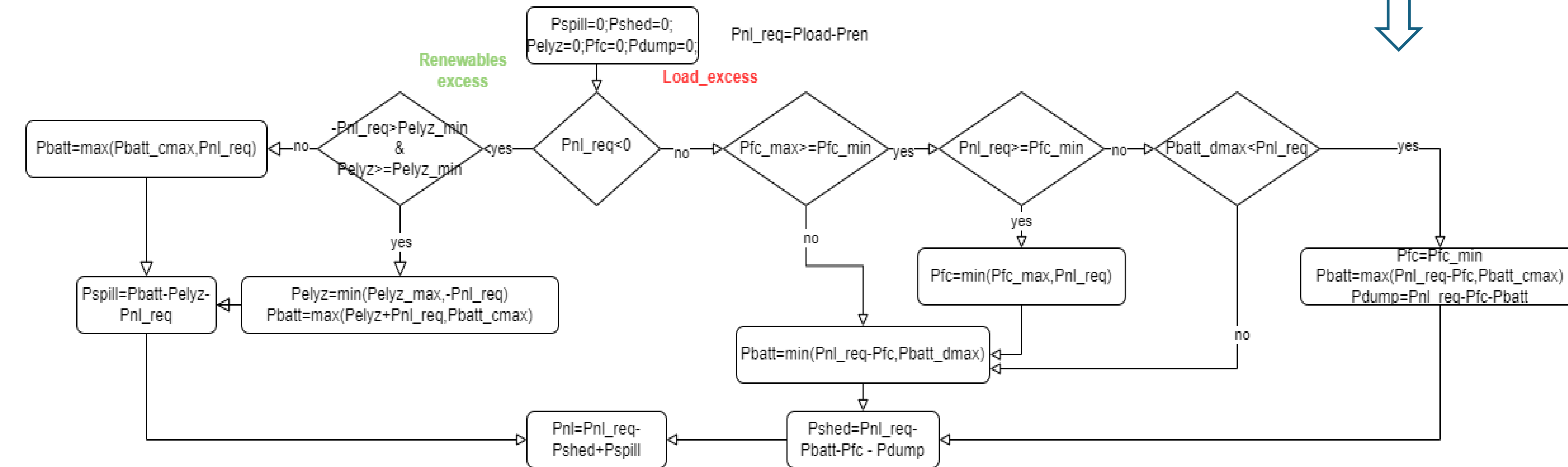


Strategy 1: battery priority

Strategy 1 will use the battery before the hydrogen chain to store excess energy or power the load in the event of a lack of renewable generation. Strategy 2 do the opposite by using primarily the power-H2-power chain.

Strategy 2: Hydrogen priority

- Note:**
- Batteries round-trip efficiency is 95%
 - Power-H2-Power efficiency has been modelled to be equal to 30%
 - PEM fuel and PEM electrolyser have a minimal running power equal to 5% of their nominal capacity.
 - Simulations are made on 1 year with a time step of 1 hour. The results are then extrapolated over 25 years.

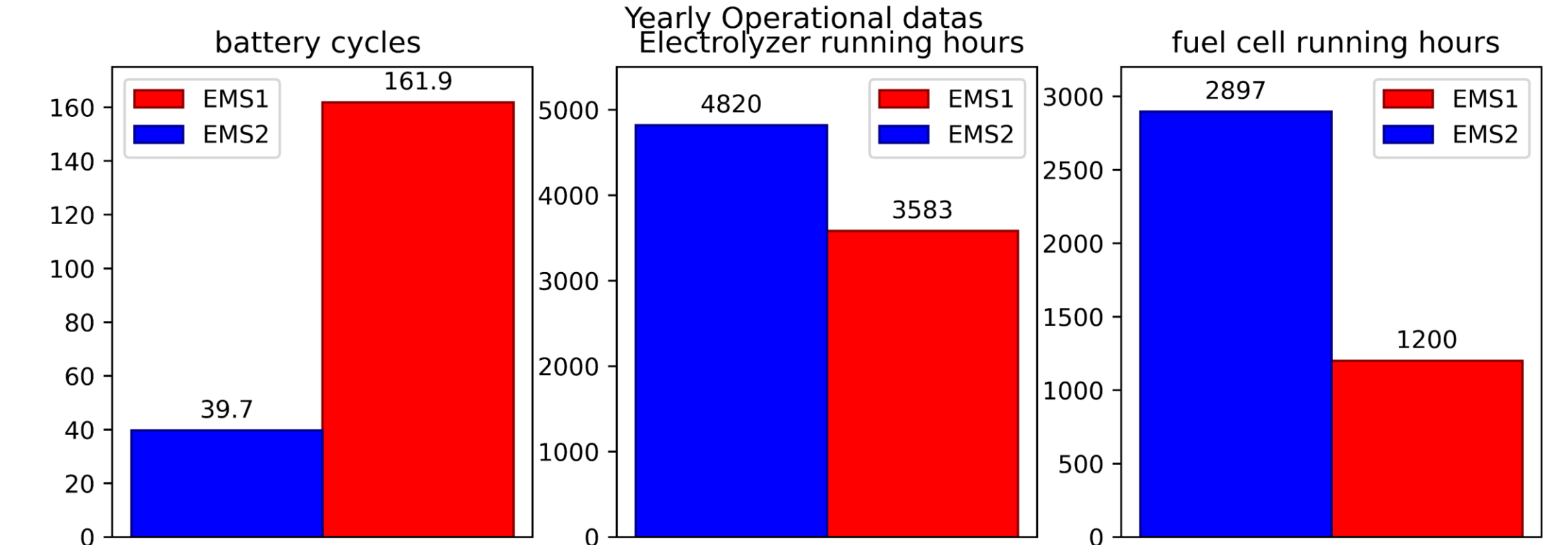


Results

Optimization stats

- Wind capacity is limited to 1800 kWc in our case of study
- Average simulation time (~5ms)
- Average optimization time (~24s)
- Average evaluation number (~21000)

EMS	T _{shed}	C _{pv} (kWp)	C _{wind} (kW)	C _{batt} (kWh)	C _{el} (kW)	C _{fc} (kW)	C _{h2tank} (kg)	LCOE (\$/kWh)
1	0%	4 001	1 800	5 489	866	1 537	16 270	0,3592
2	0%	6 681	1 800	262	1 901	1 423	17 000	0,4136
1	0,01%	4 001	1 800	5 492	864	1 435	16 238	0,3559
2	0,01%	6 649	1 800	198	1 911	1 389	16 990	0,4121
1	0,10%	4 033	1 800	5 406	863	1 240	15 923	0,3485
2	0,10%	6 546	1 800	132	1 935	1 241	16 805	0,4057



Observations & Conclusion

As might be expected for the 2 strategies, the higher the permissible load shedding rate, the lower the LCOE.

More renewable capacity with the EMS 2 due to the low efficiency of the Power-H2-Power chain.

More intensive use of the electrolyser and the fuel cell with the strategy 2. Which imply :

- Higher maintenance costs
- More frequent replacements

Strategy 2, is more sensible to fuel cell and electrolyser price variation.

In case of event of a significant fall in the manufacturing costs of these components, the competitiveness of the 2 strategies should be reassessed.

Perspectives

Try more advanced EMS strategies based on predictive control or stochastic dynamic programming.

Study effect of these strategies on the optimization tool . If needed :

- Try Gradient-based algorithms
- Reduce the simulation time by performing it on representative days or weeks?
- Multistart with local optimization algorithms?

Sensibility analysis

A sensibility analysis have also been conducted on the electrolyser and fuel cell investment prices.

- Case 1** : Respectively 500\$/kW and 1000\$/kW for PEMel and PEMfc in accordance with « Fuel Cell and Hydrogen Joint Undertaking (FCH 2 JU) » goals for 2030.
- Case 2** : Respectively 2200\$/kW and 2500\$/kW for PEMel and PEMfc in case of slower industrialization than expected, and high raw materials prices
- For the **base case** prices were taken equal to 1600\$/kW for both

