Finding the optimal design of Microgrid energy systems using a genetic algorithm

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Context & Motivations

For the sake of TwInSolar project, conducted by the laboratory PIMENT, DTU and the Fraunhofer ISE, a microgrid has to be created on the campus of Terre Sainte, in the south of the island of La Réunion (Indian Ocean). The microgrid needs to be carefully designed, according to specific constraints and objectives.

What solutions exist to find the optimal design of a microgrid ?

Some algorithms/softwares do exist but are often commercials, with implementation difficulties or with strong assumptions (HOMER, iHOGA, HyDesign, DER-CAM)

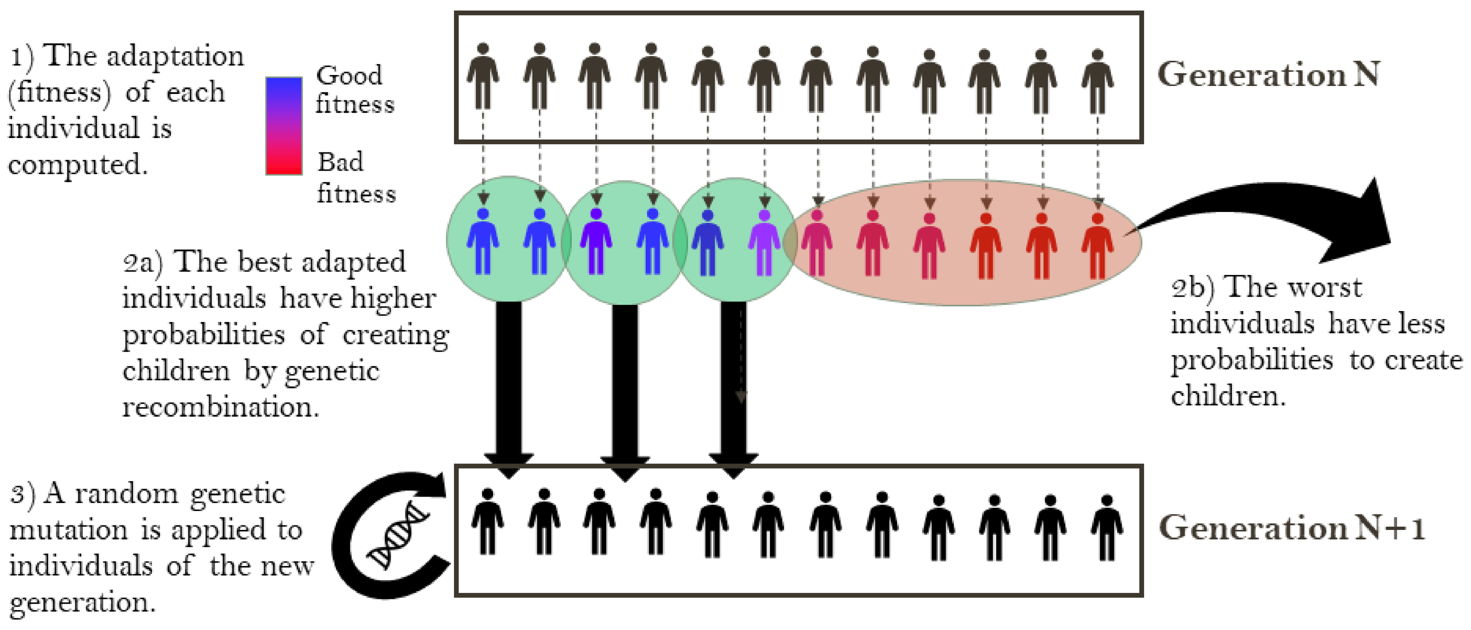
Motivation for the creation of a new optimization tool, open and flexible (i.e. non linear)

Method

ERMESS is a new algorithm using a genetic algorithm approach to find the optimal design of a microgrid.

What is a genetic algorithm ?

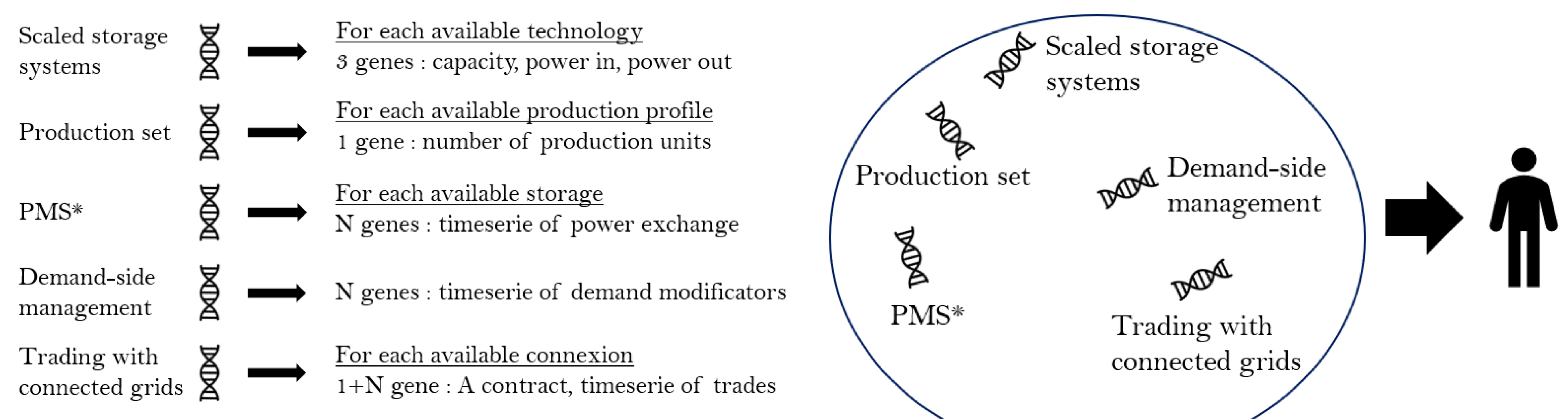
It is an algorithm that simulates the biological genetic selection process to solve an optimization problem. A population of individuals (each representing a potential solution) is created and its evolution over several generations is simulated.



Implementation

How is constituted an individual in the evolution process proposed by ERMESS ?

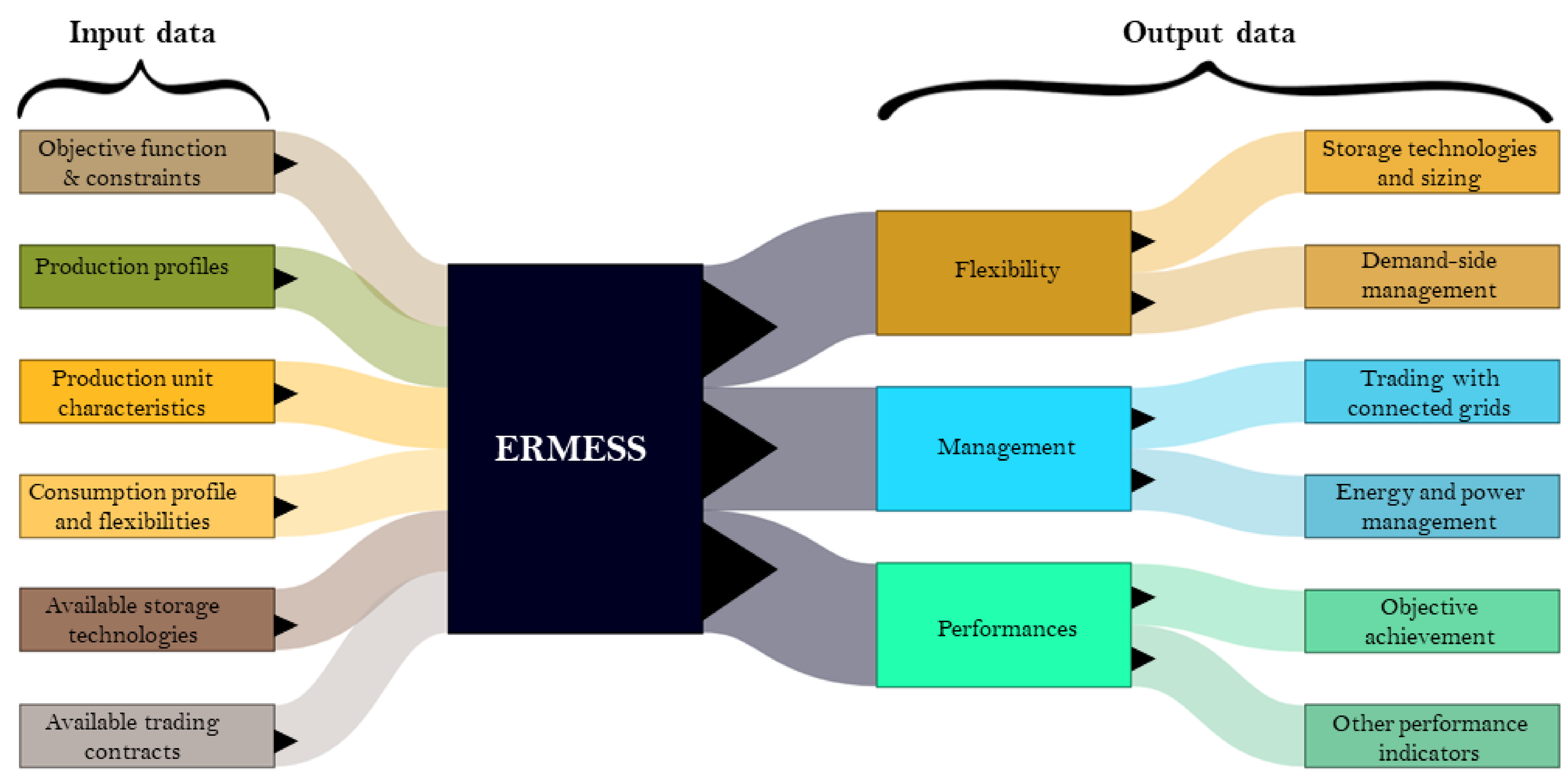
An individual is formed of 5 chromosomes, each representing one key feature of a microgrid. Each one mutates following specific rules.



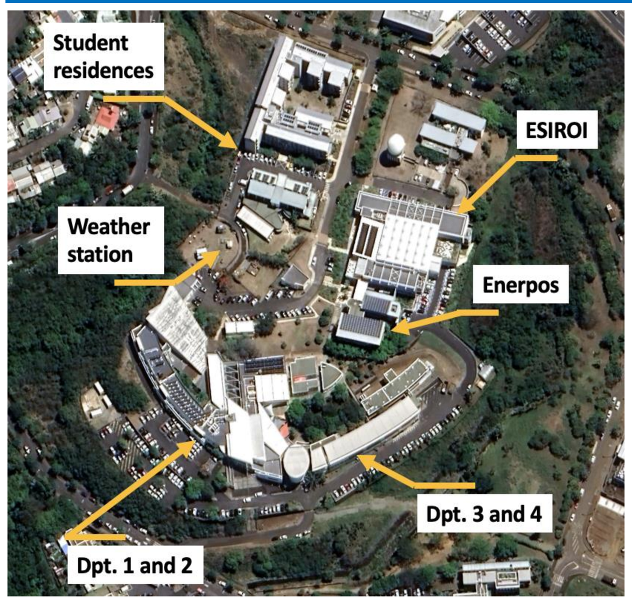
*PMS : Power Management System

What are the input data needed to run ERMESS and which results and recommandations are given by the optimizer ?

Input and output data are presented below :

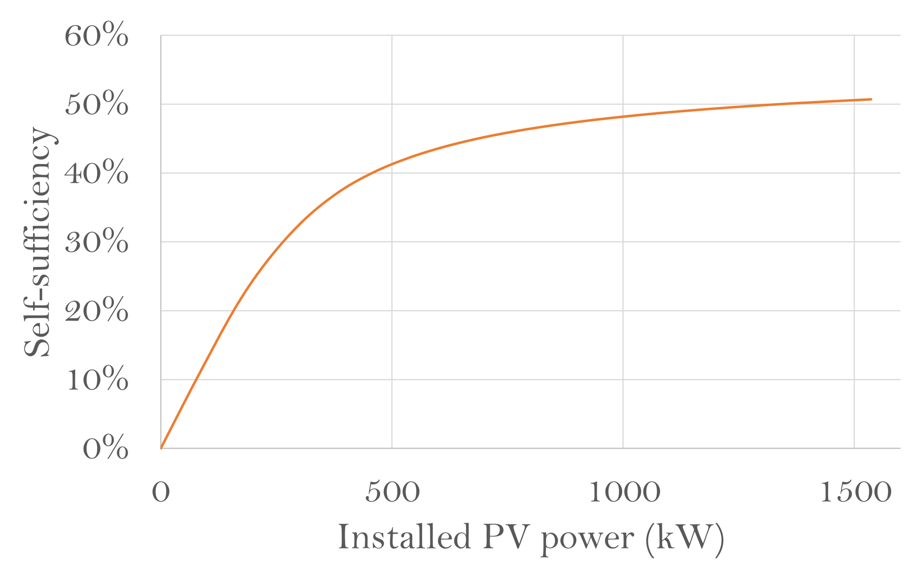


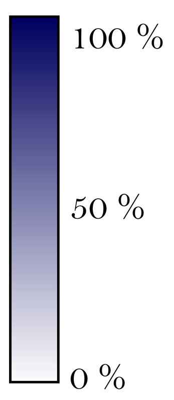
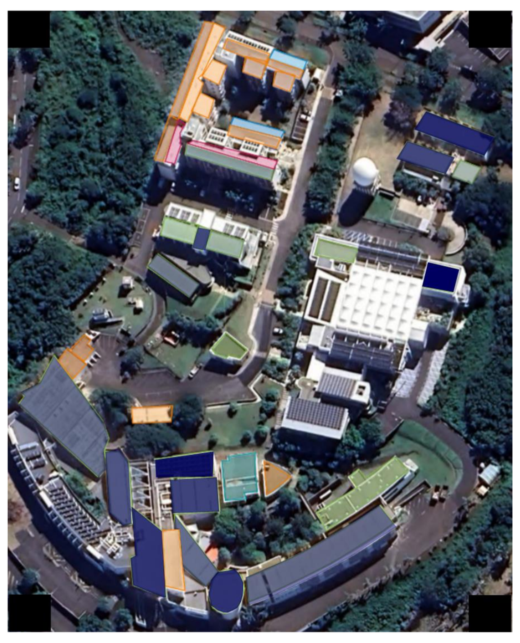
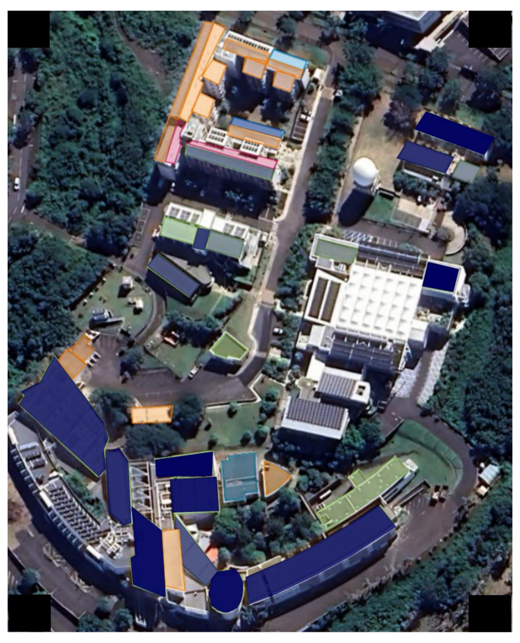
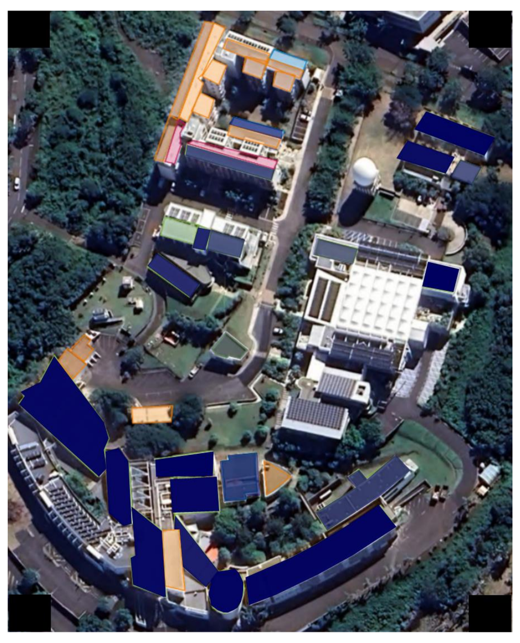
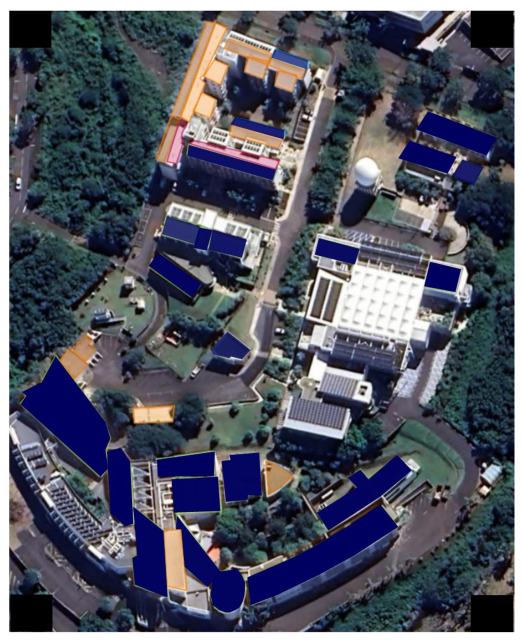
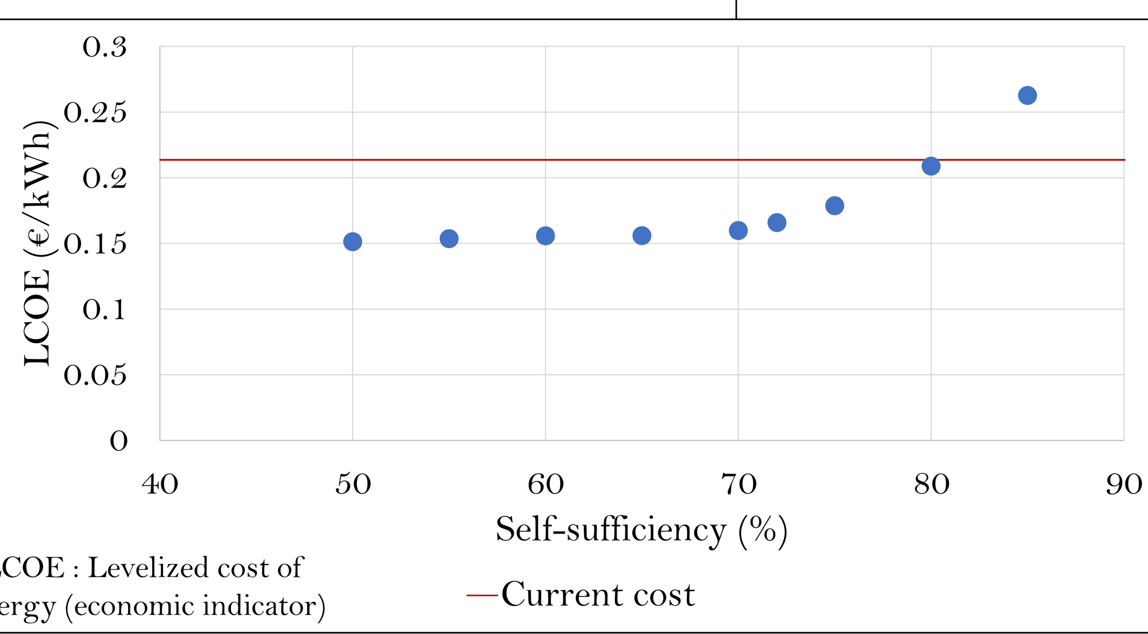
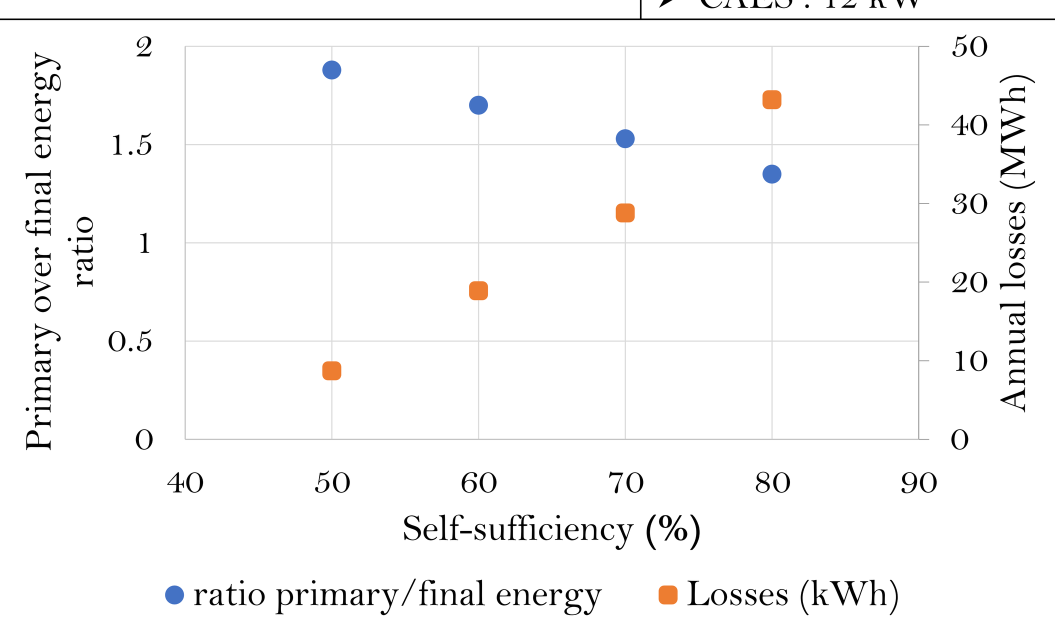
Case study & results



- The university campus of Terre Sainte is home of the ESIROI, the only french school of engineering of the Indian Ocean, 7 departments of the university technology institute, a university restaurant and student residences. The average electric load is 1273 MWh per year., with a strong seasonal variability.
- Photovoltaic is the only technology of electric production that can be easily installed in the campus.
- As the night consumption is quite significant, a high level of self-sufficiency is not reachable without storage systems (see figure on the right).

Evolution of the self-sufficiency of the campus without flexibility



Objective & Constraints		Minimize LCOE* & Self-sufficiency > 50 %	Minimize LCOE & Self-sufficiency > 60 %	Minimize LCOE & Self-sufficiency > 70 %	Minimize LCOE & Self-sufficiency > 80 %
Production set	Roof PV coverage ratio 				
Storage	Capacity	Lithium-ion : 0.4 MWh	Lithium-ion : 0.9 MWh	Lithium-ion : 1.5 MWh	Lithium-ion : 2.8 MWh CAES : 1 MWh
	Power	Lithium-ion : 33 kW	Lithium-ion : 121 kW	Lithium-ion : 196 kW	Lithium-ion : 251 kW CAES : 12 kW
Performances					

*LCOE : Levelized cost of energy (economic indicator)

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