

Multivariate metaheuristics in nonlinear energy systems modelling: application to the optimal hydrogen supply chain design

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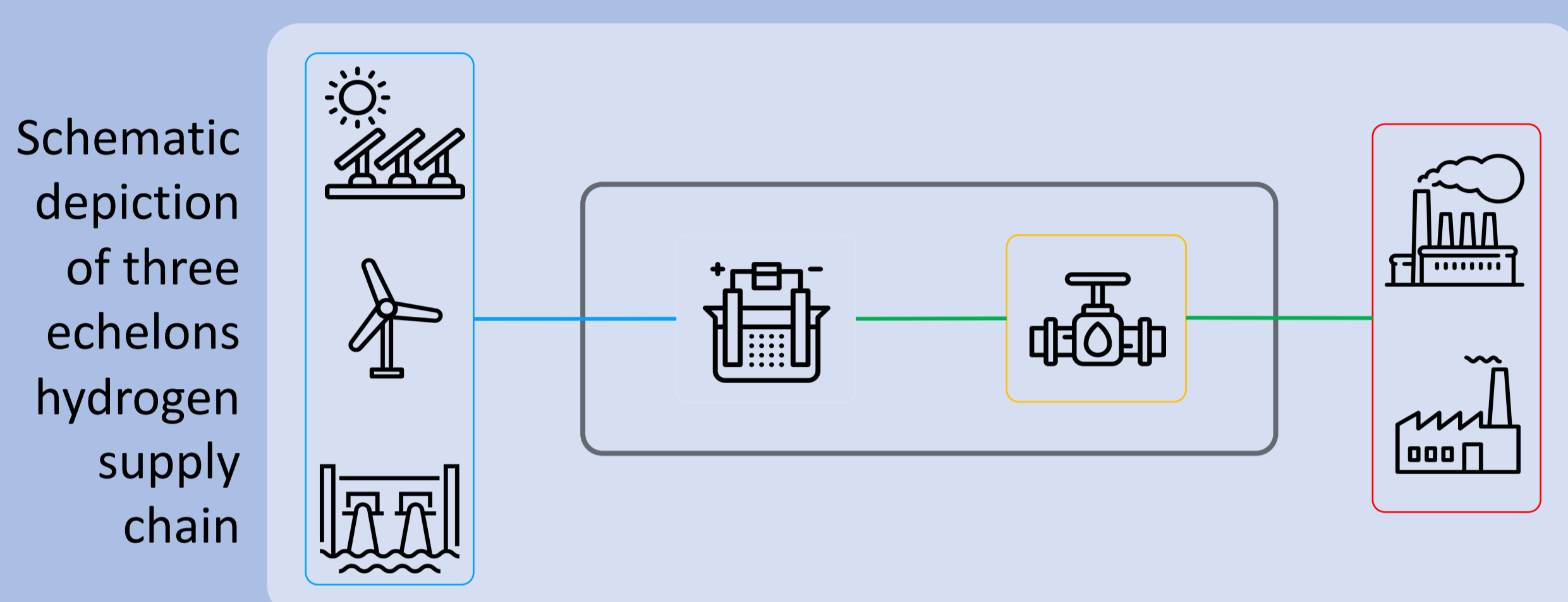
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Objective

Benchmarking state-of-the-art population-based meta-heuristic algorithms for mixed-integer nonlinear programming against mixed-integer linear programming solvers.

Hydrogen Supply Chain Design Optimization

The optimization problem aims at identifying the optimal design of the greenfield infrastructure of the supply chain for hydrogen delivery. In a three echelons supply chain, the optimization identifies the optimal size of the production and transport technologies.



Candidate Multi-Variate metaheuristics

Ant Colony Optimization

Adaptive Estimation Distribution

Particle Swarm Optimization

Differential Evolution

Genetic Algorithm

Population-based metaheuristics

Stochastic gradient-free optimization algorithms based on a trial-and-error procedure. Nature-inspired are derived from biological systems, like genes modification or interactions among insects. Compared to mathematical programming, they have potential advantages in handling nonlinearities and solving large-scale instances.

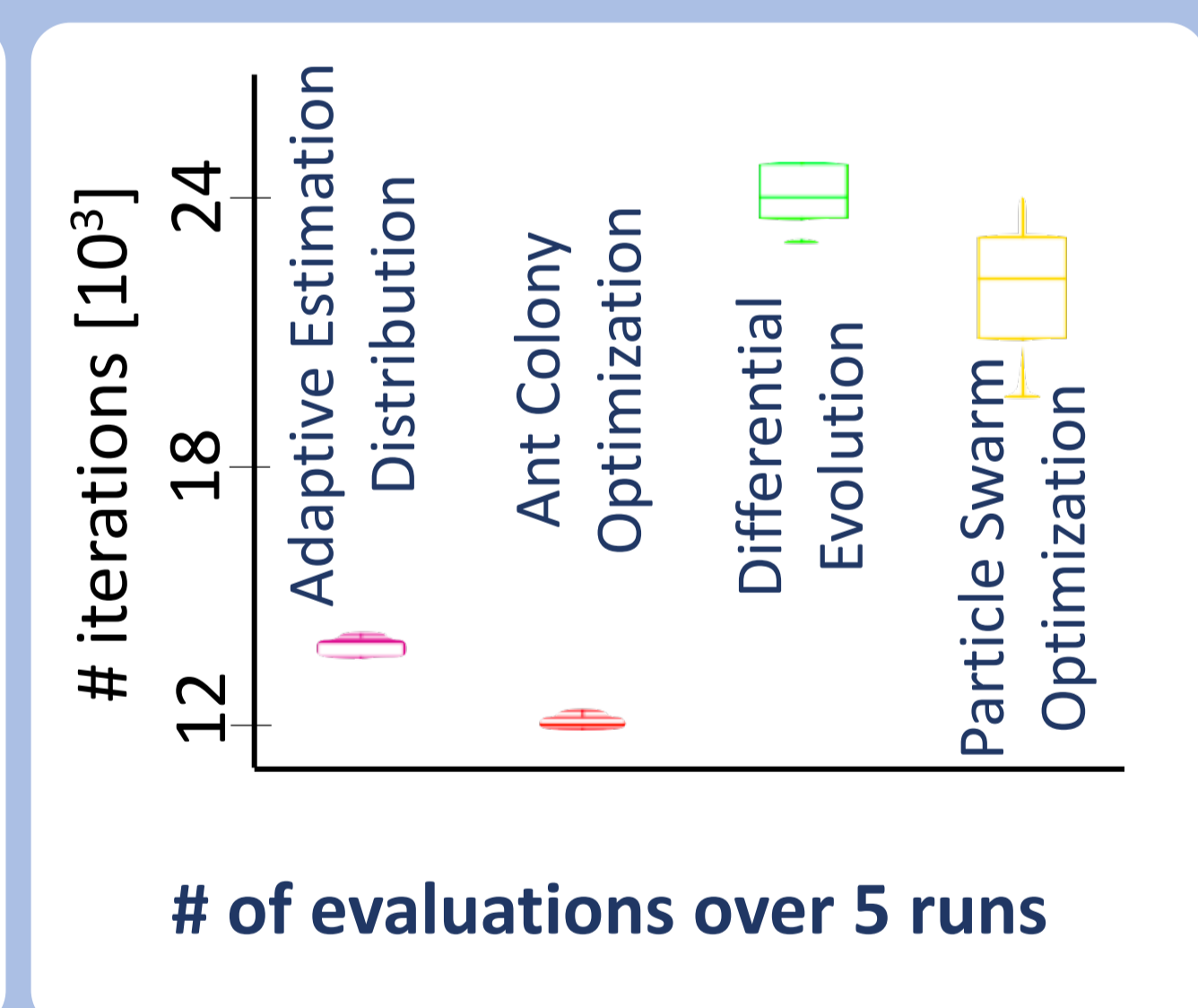
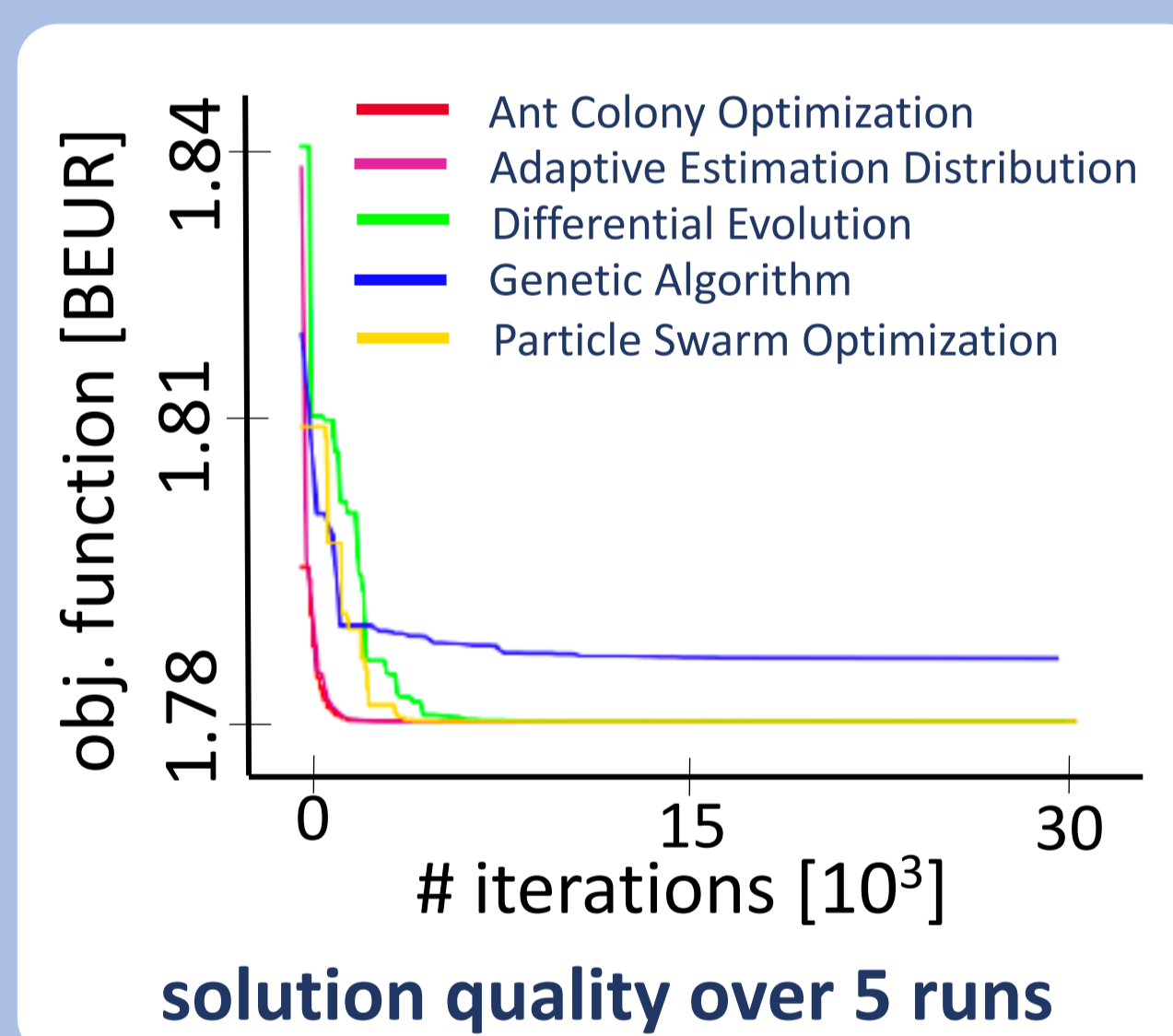
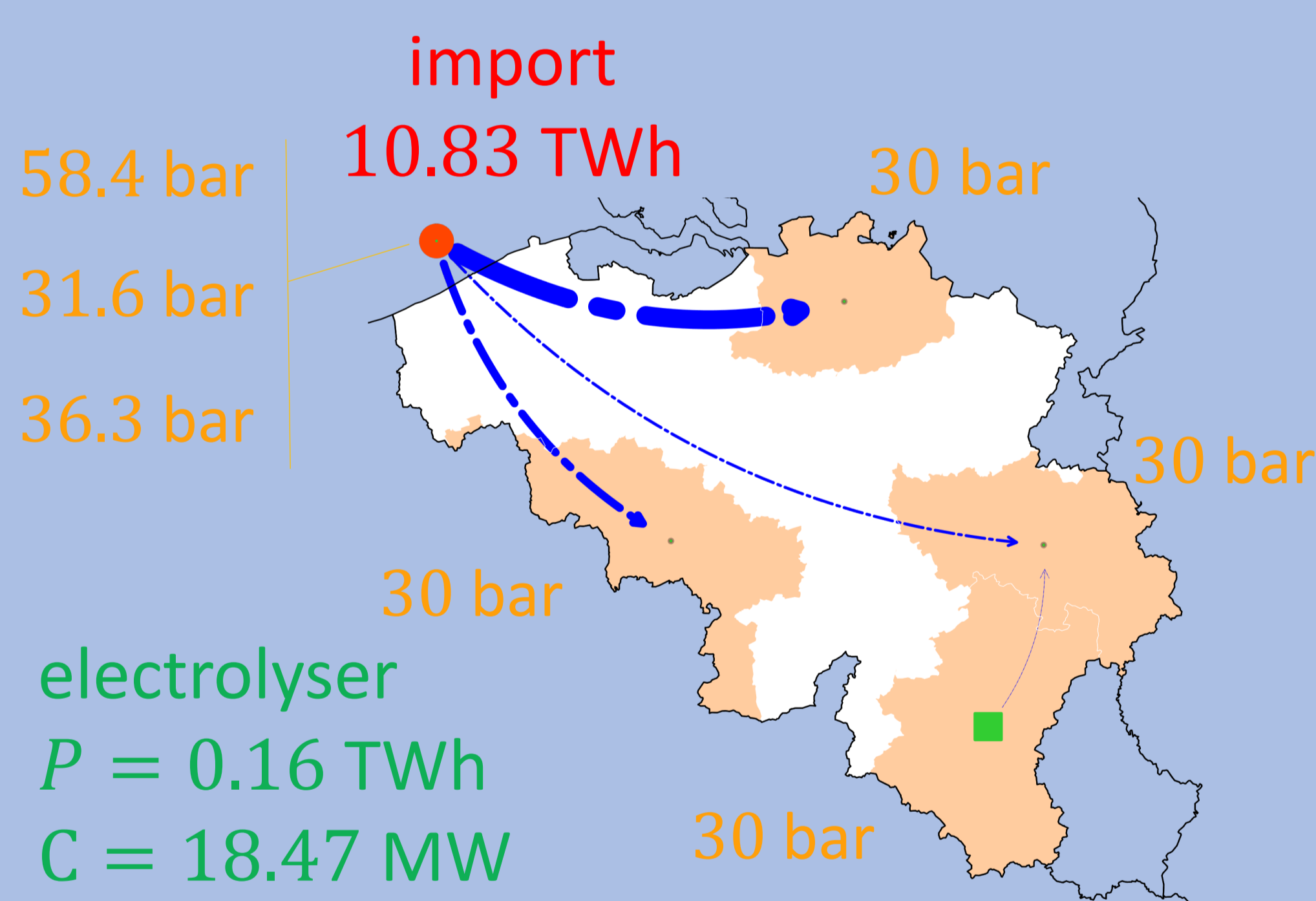
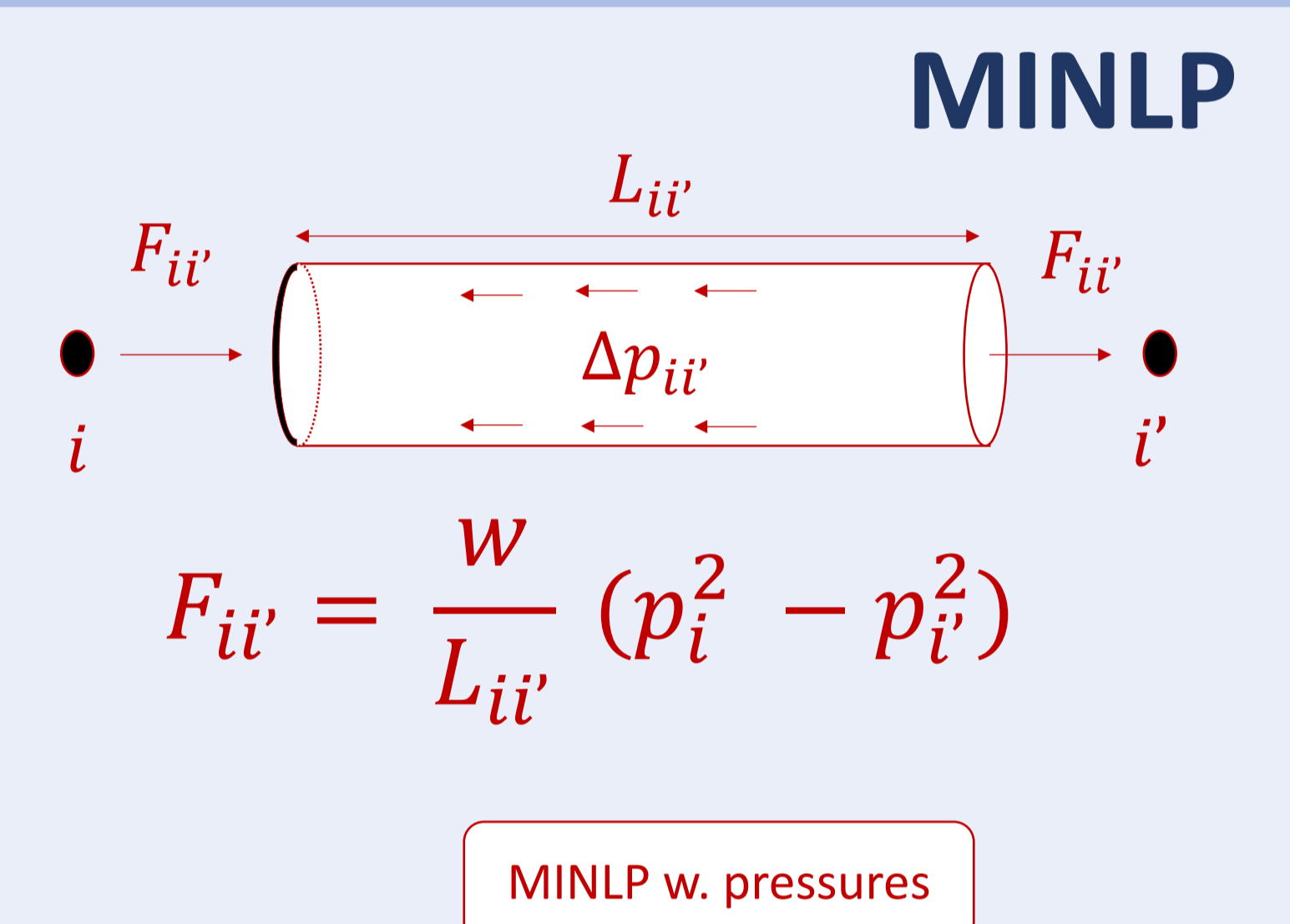
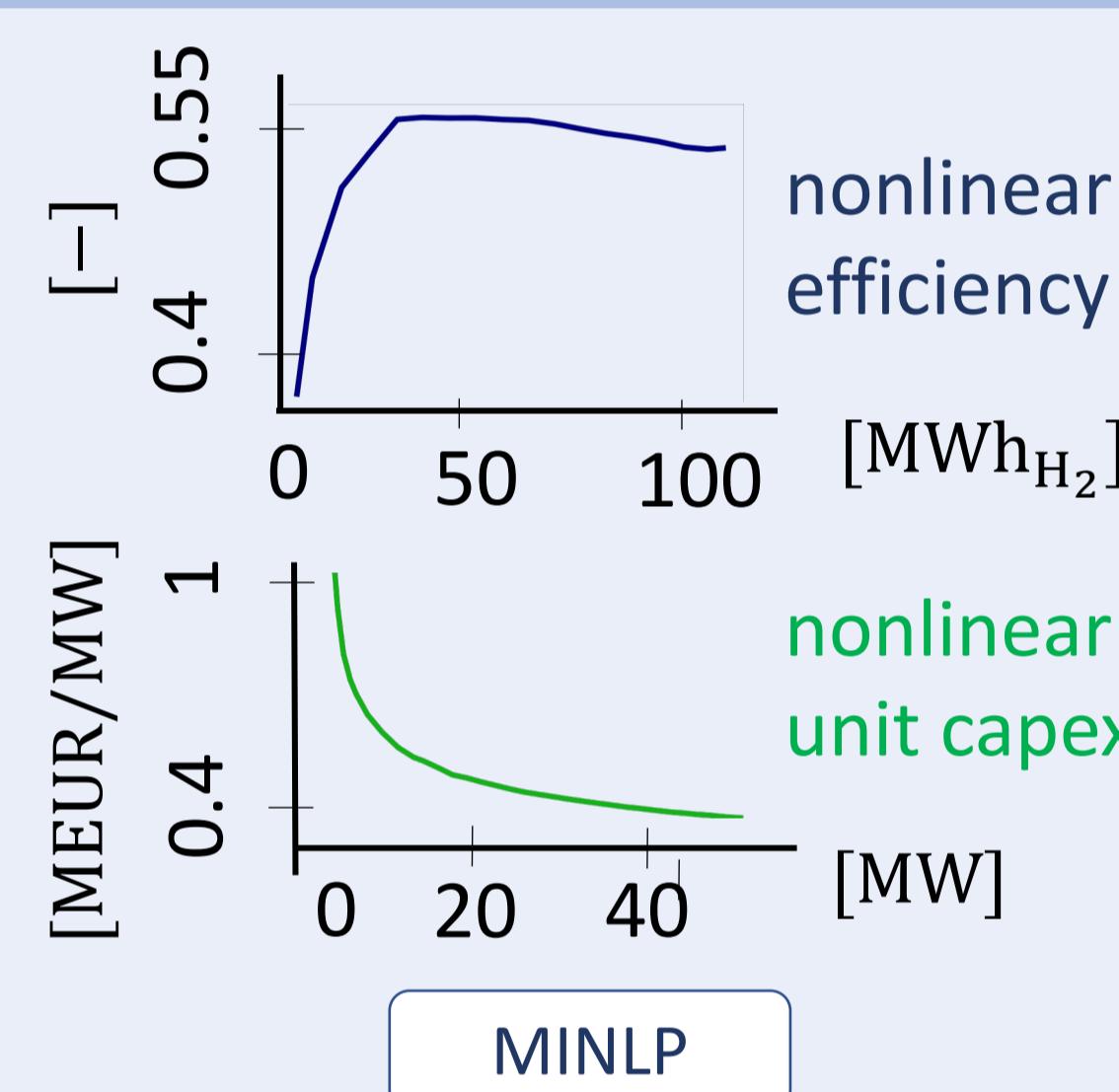
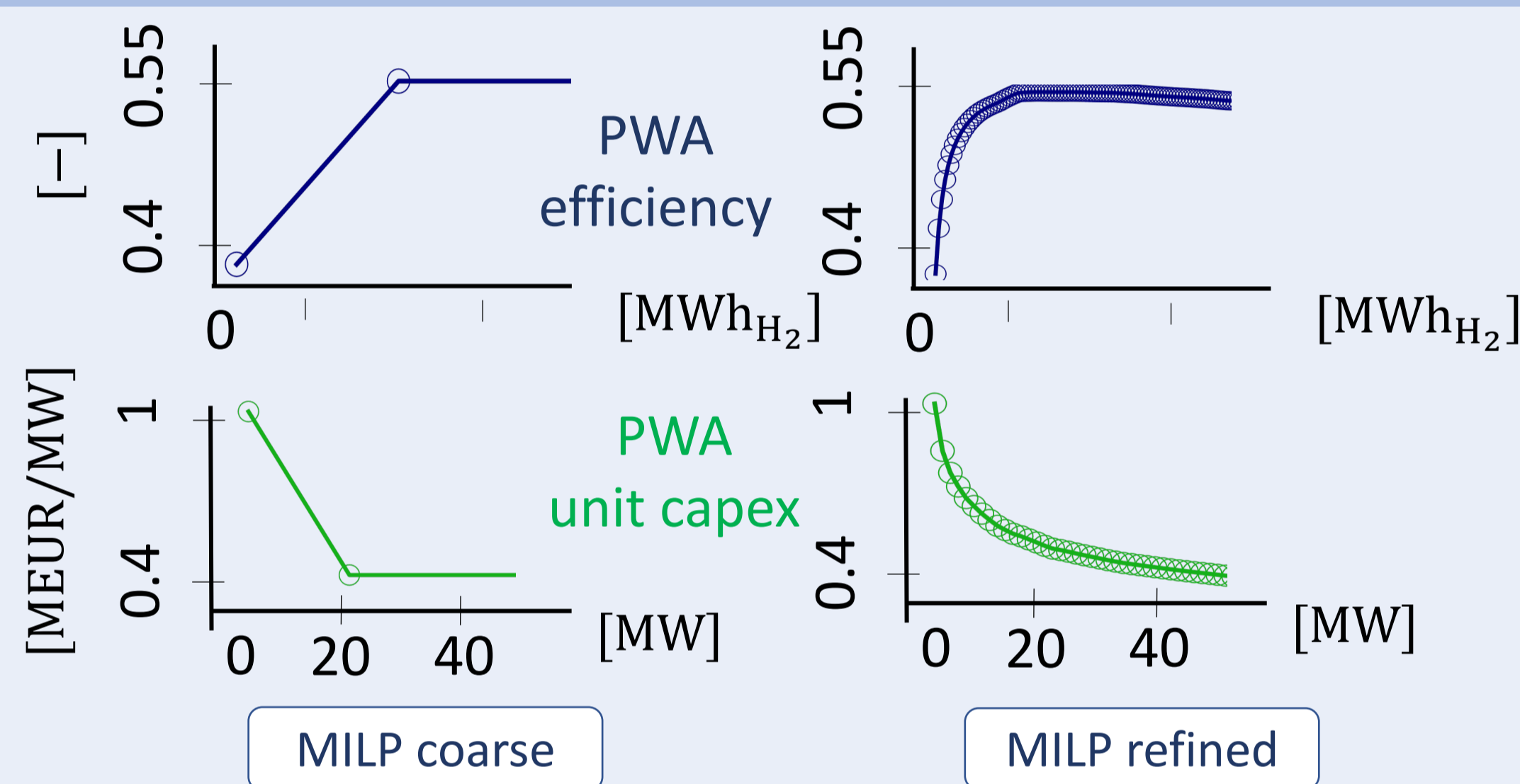
Multi-Variate metaheuristics

Subclass of metaheuristic algorithms which allow an abstract representation of continuous, integer and boolean decision variables through a solution archive.

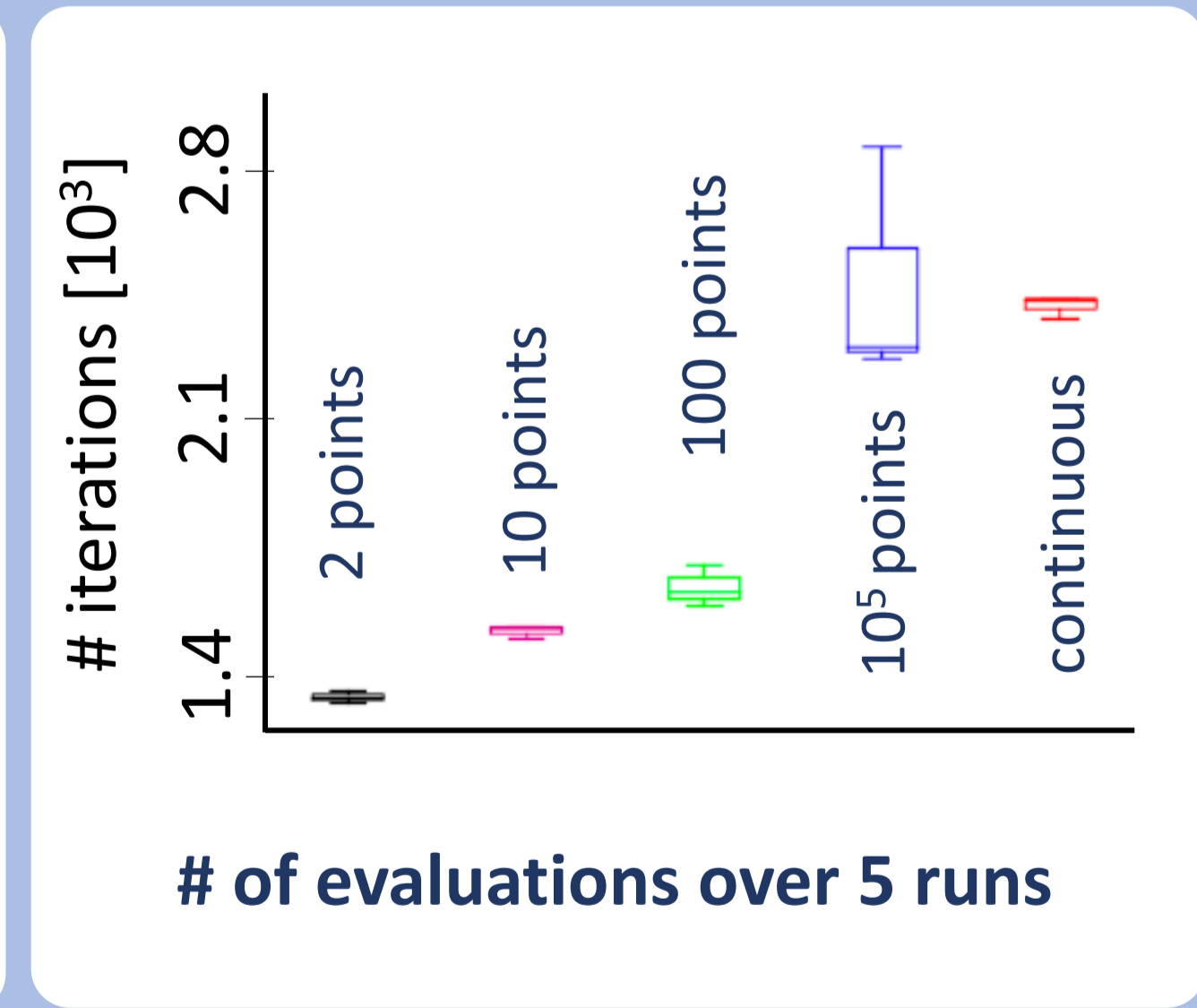
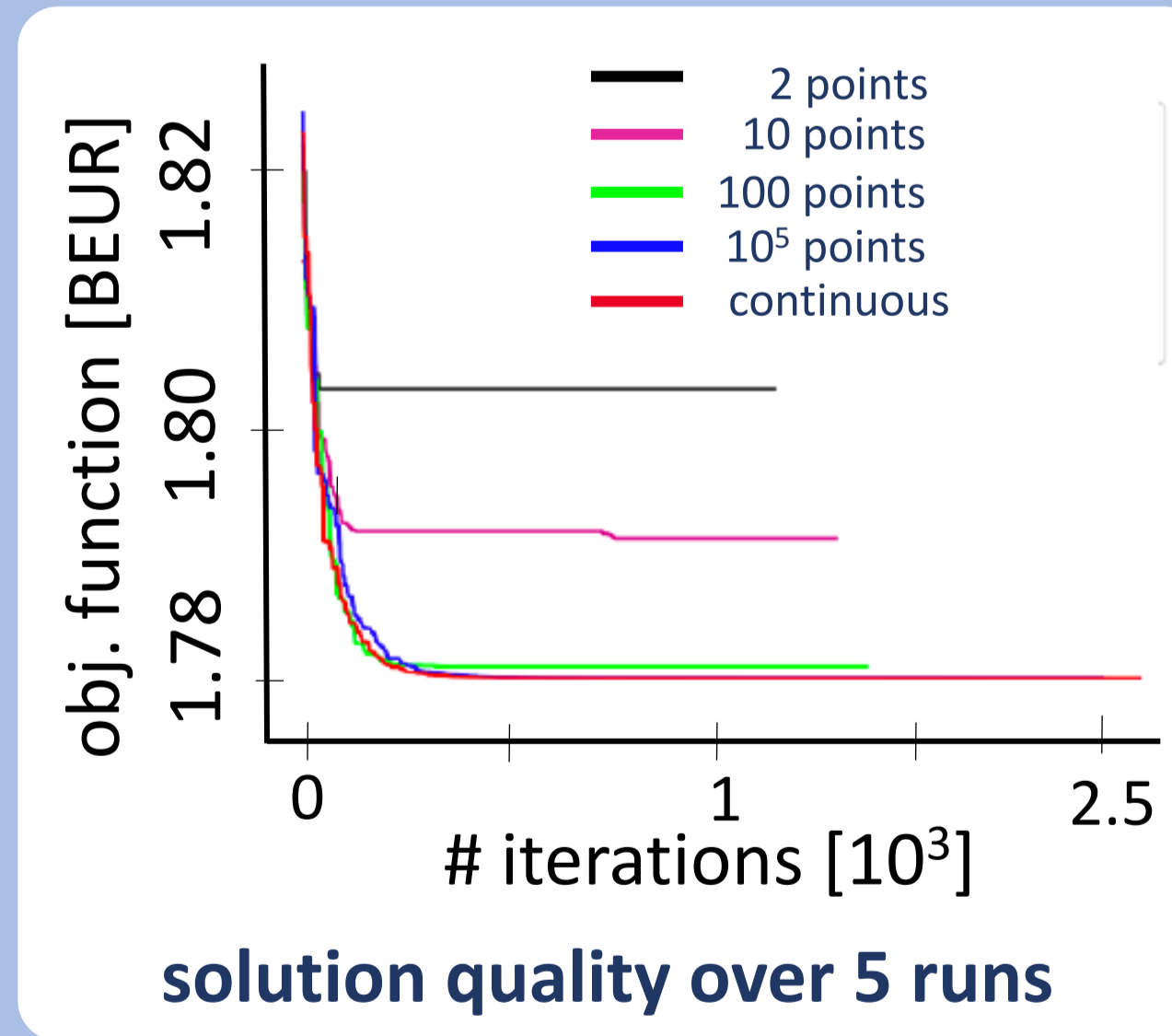
MILP

MILP based on piece-wise affine approximation (PWA) with two refinements:

- 2 segments
- 100 segments

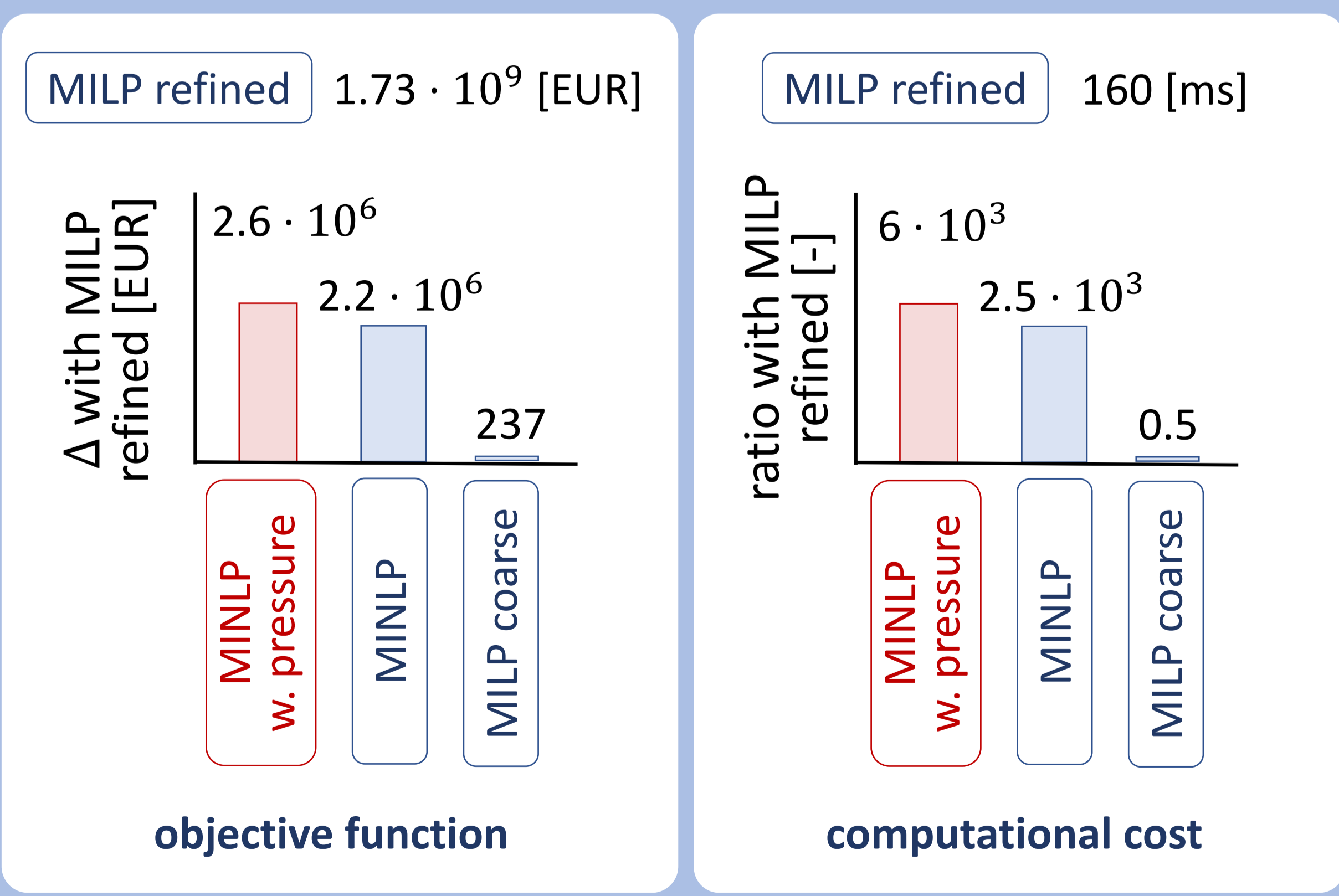


Comparison metaheuristics performance on the 5 nodes case study of hydrogen supply chain design in Belgium



Impact of decision variables discretization on solution quality and iterations of best performing metaheuristic

Comparison of best performing metaheuristic for MINLP with MILP coarse and MILP refined models



Conclusions

- ant colony optimization results the best metaheuristic
- mathematical programming overperforms the best metaheuristic in computational time independently of PWA refinement
- computational time of metaheuristic can be mostly halved by using a low granularity and discrete decision variables
- the impact of the discretization on the objective function is more than 10 times larger than the impact of the nonlinearities
- use of metaheuristics is justified only for unlinearizable nonlinearities