7th International conference on Smart Energy Systems

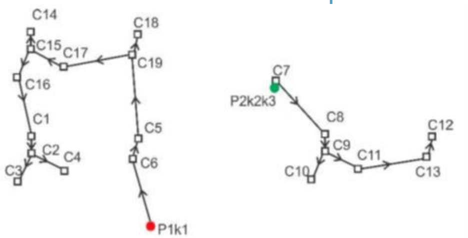
Formulation and assessment of multi-objective sizing: application to low temperature DH networks

21-22/09/2021

Yannis MERLET

In the literature

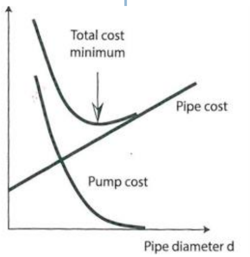
Optimal design of DH Networks



From Mertz et al, 2017

Layout (topology)

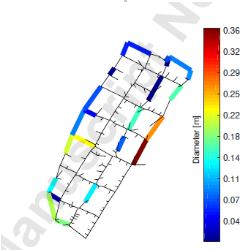
Sizing (fixed layout)



From Frederiksen and Werner, 2013

Local design rules

Global system sizing



From Pizzolato et al, 2018

Mono-objective optimization

From Vesterlund and Toffolo, 2017

Multi-objective optimization → **Almost only Genetic Algorithms**

Outlook of the presentation

I. Introduction

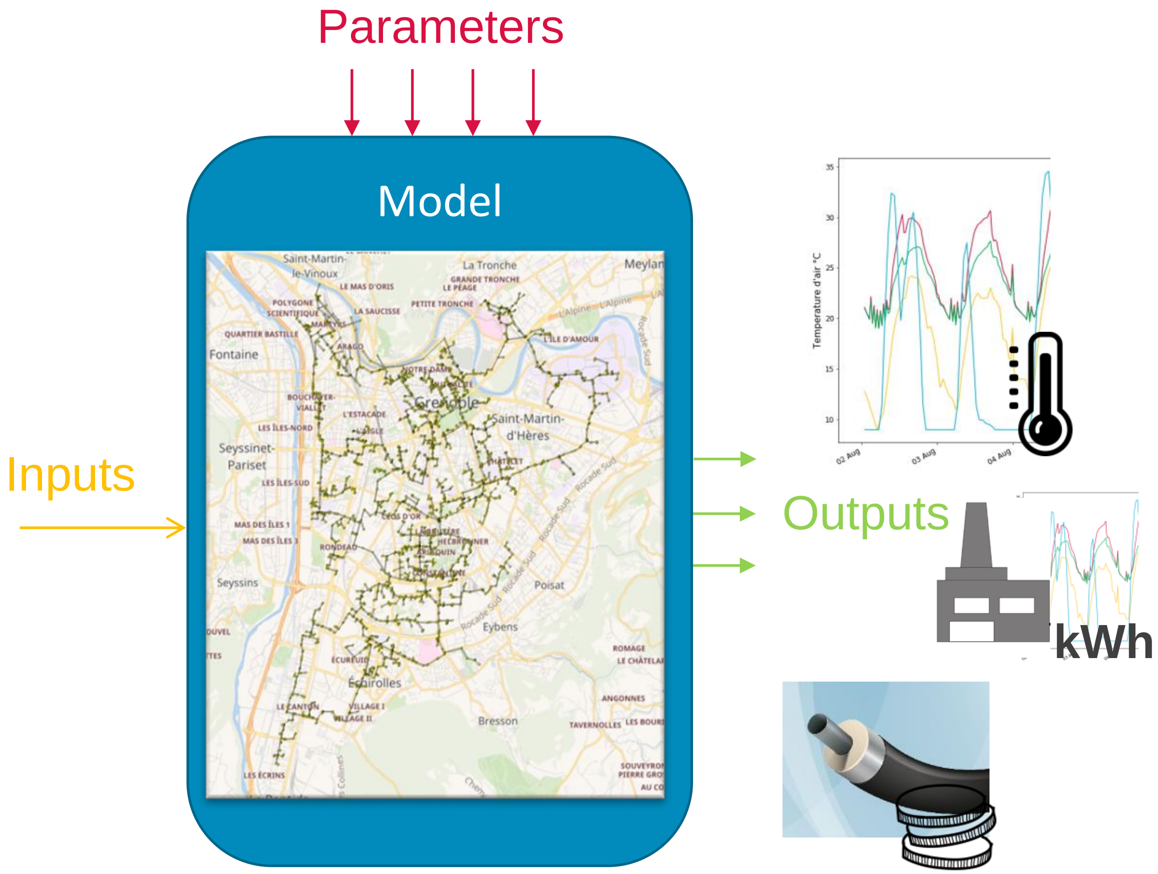
II. Methodolodgy for the optimal sizing

III. Validation method for the framework

IV. Validation results

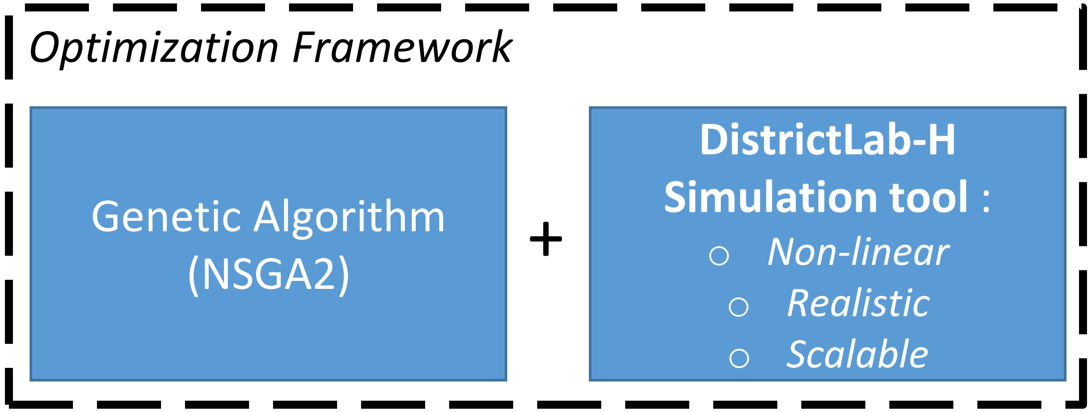
V. Conclusion

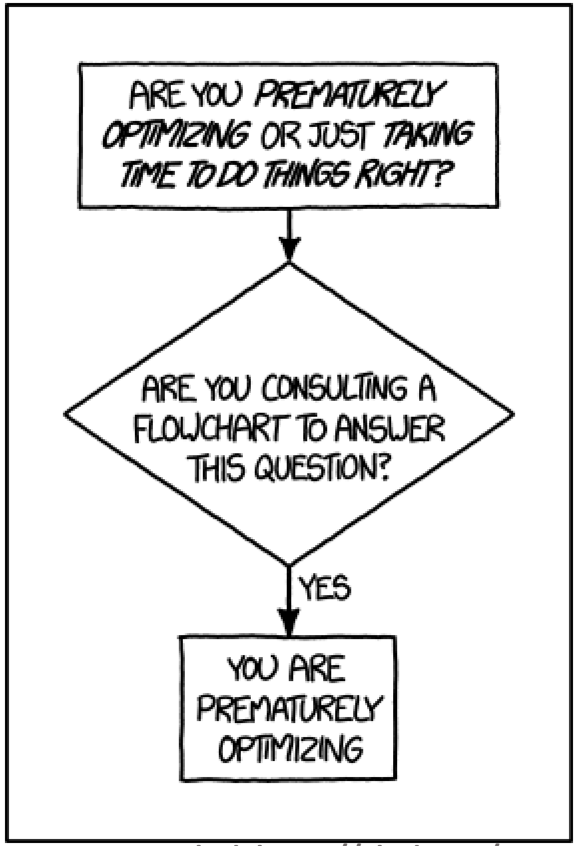
Optimization problem



- **Decision parameters:**
  - diameters of the pipes
  - *(insulation thickness)*
- **Objectives :**
  - CAPEX
  - Pumping cost
  - *(thermal power)*
- **Constraints :**
  - Satisfaction of the consumers
  - Fluid velocity
  - Absolute pressure

Multi-objective optimization for sizing





From xkcd, https://xkcd.com/1691

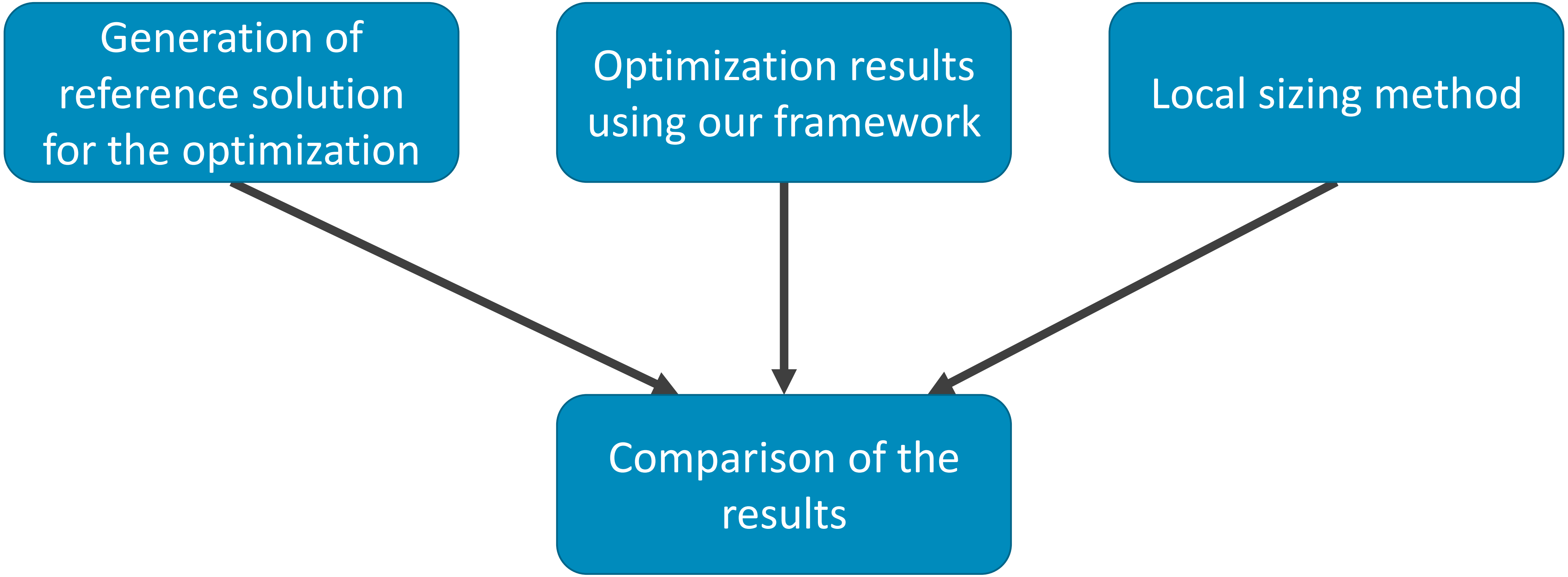
Meta-heuristics known issues :

- **Interpretability**
- **Parametrization**

Quality of the results of our implementation considering those issues ?

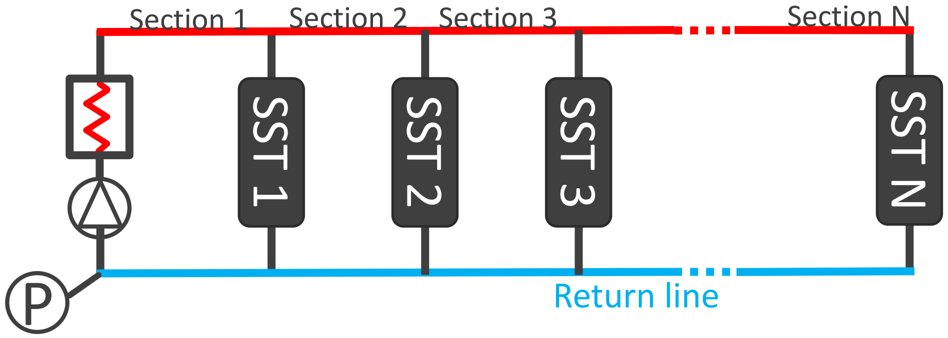
Outlook of the presentation

Validation method

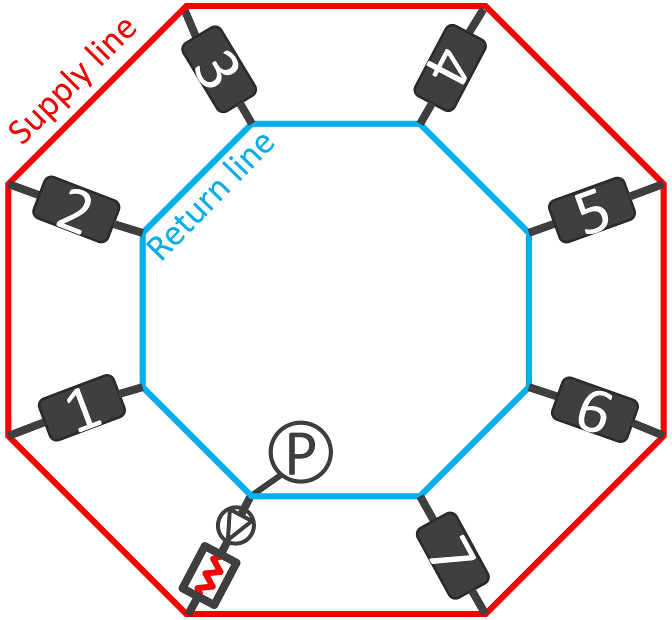


3 Validation Test cases

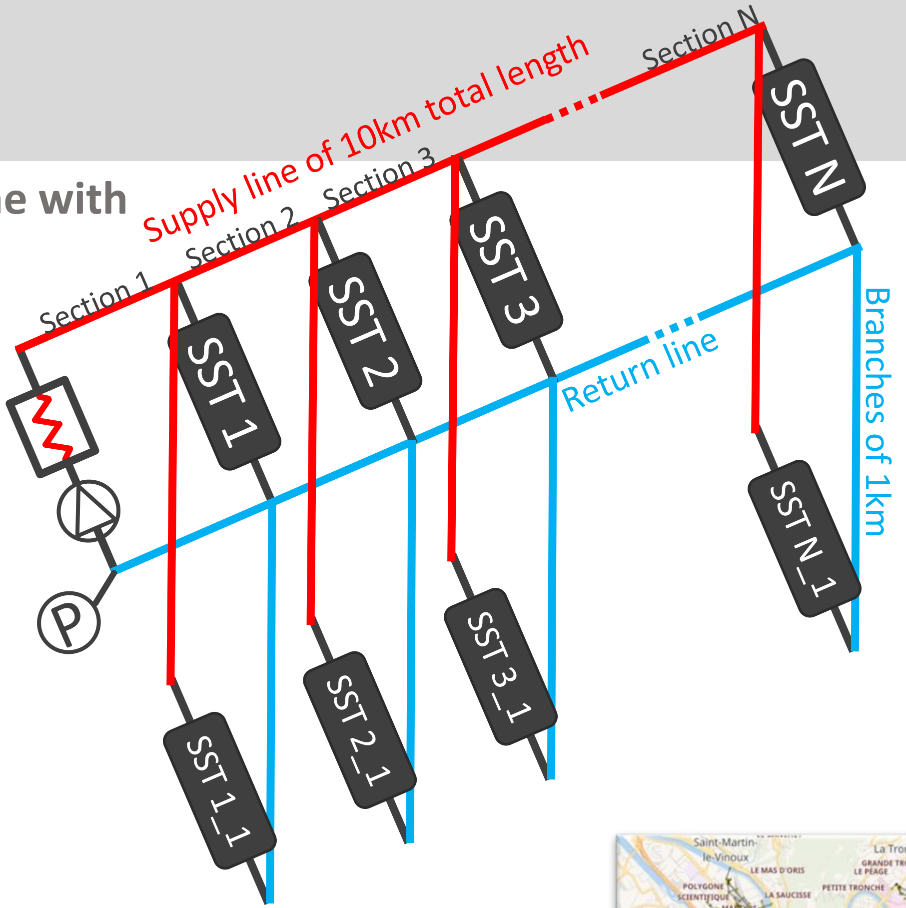
- **Simple line:**



- **Loop**



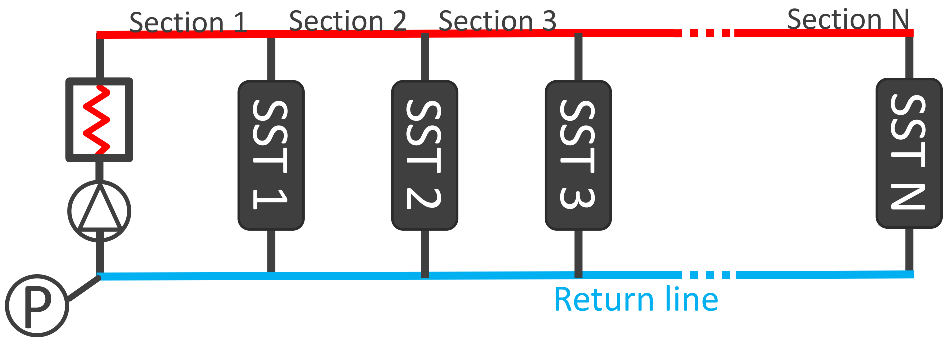
- **Simple line with branches**



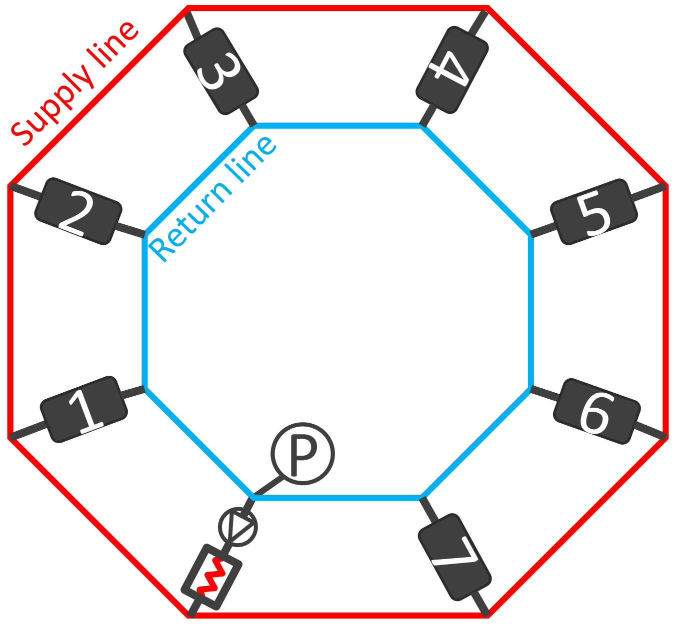
Application to real-size DH network

3 Validation Test cases

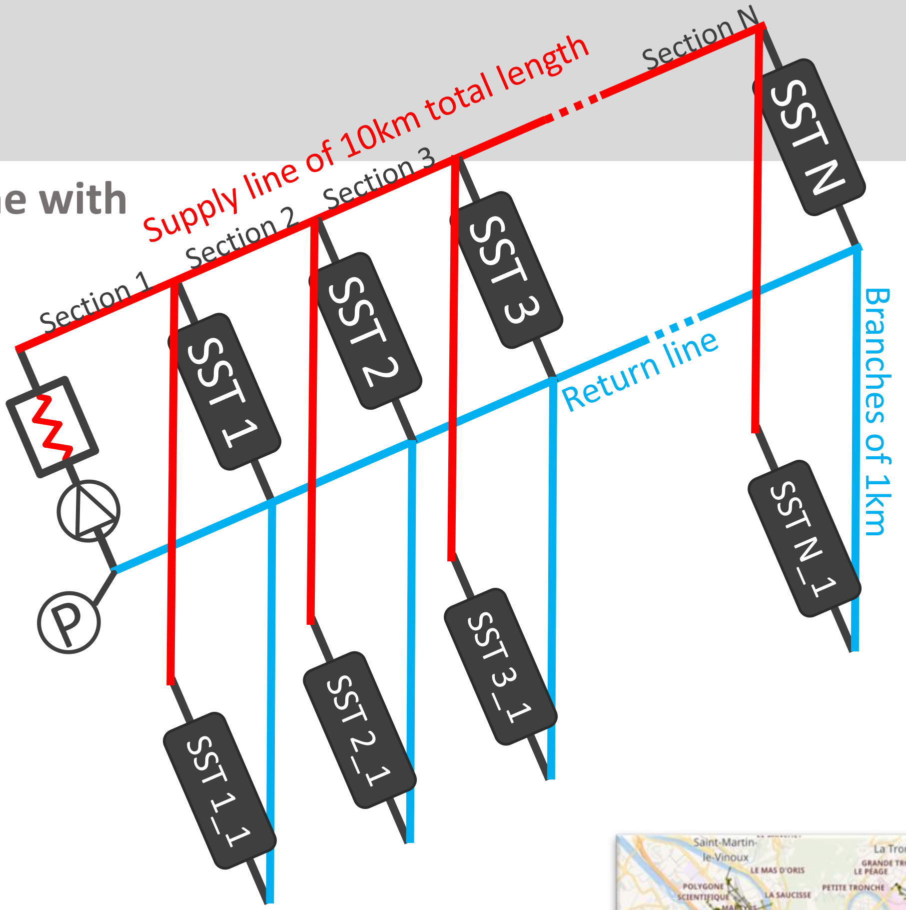
- **Simple line:**



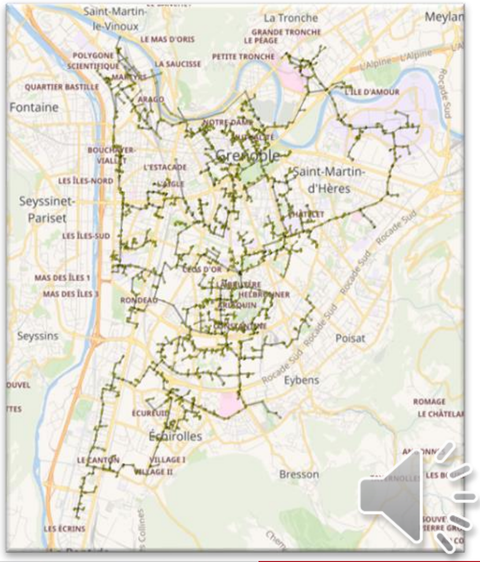
- **Loop**



- **Simple line with branches**

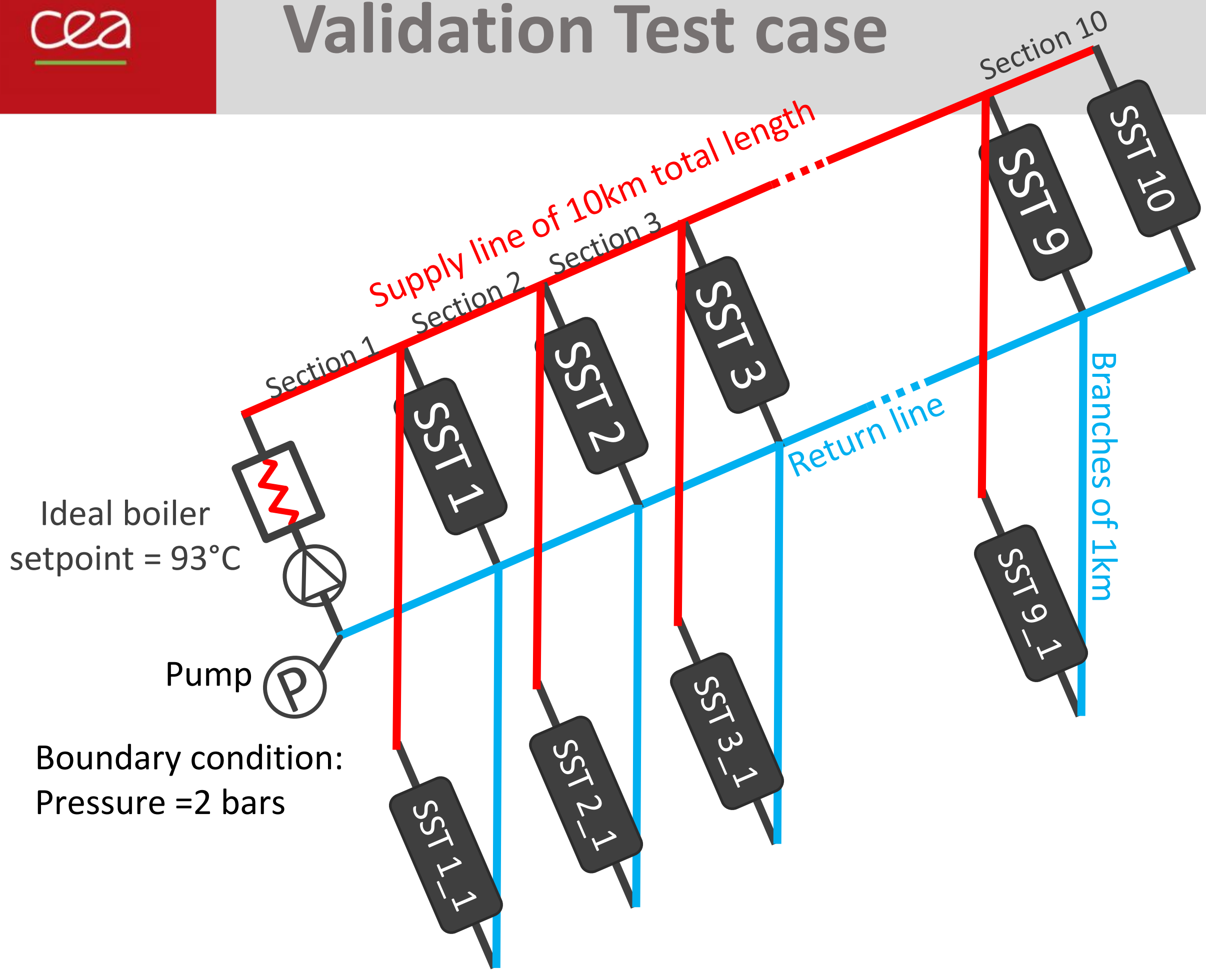


Application to real-size DH network



Outlook of the presentation

Validation Test case



Total power demand	50 MW : 2,5MW for each SST except SST10 : 5MW
Total length	10km main supply line + 10 km main return line 1km branch supply line + 10 km branch return line
Boundary condition	P=2 bars on return line at boiler
Temperature primary circuit	90°C/40°C
Temperature secondary circuit	70°C/50°C

Constraints :

Absolute pressure < 25 bar

Fluid velocity < 5 m/s

Consumer heat demand satisfaction > 98%

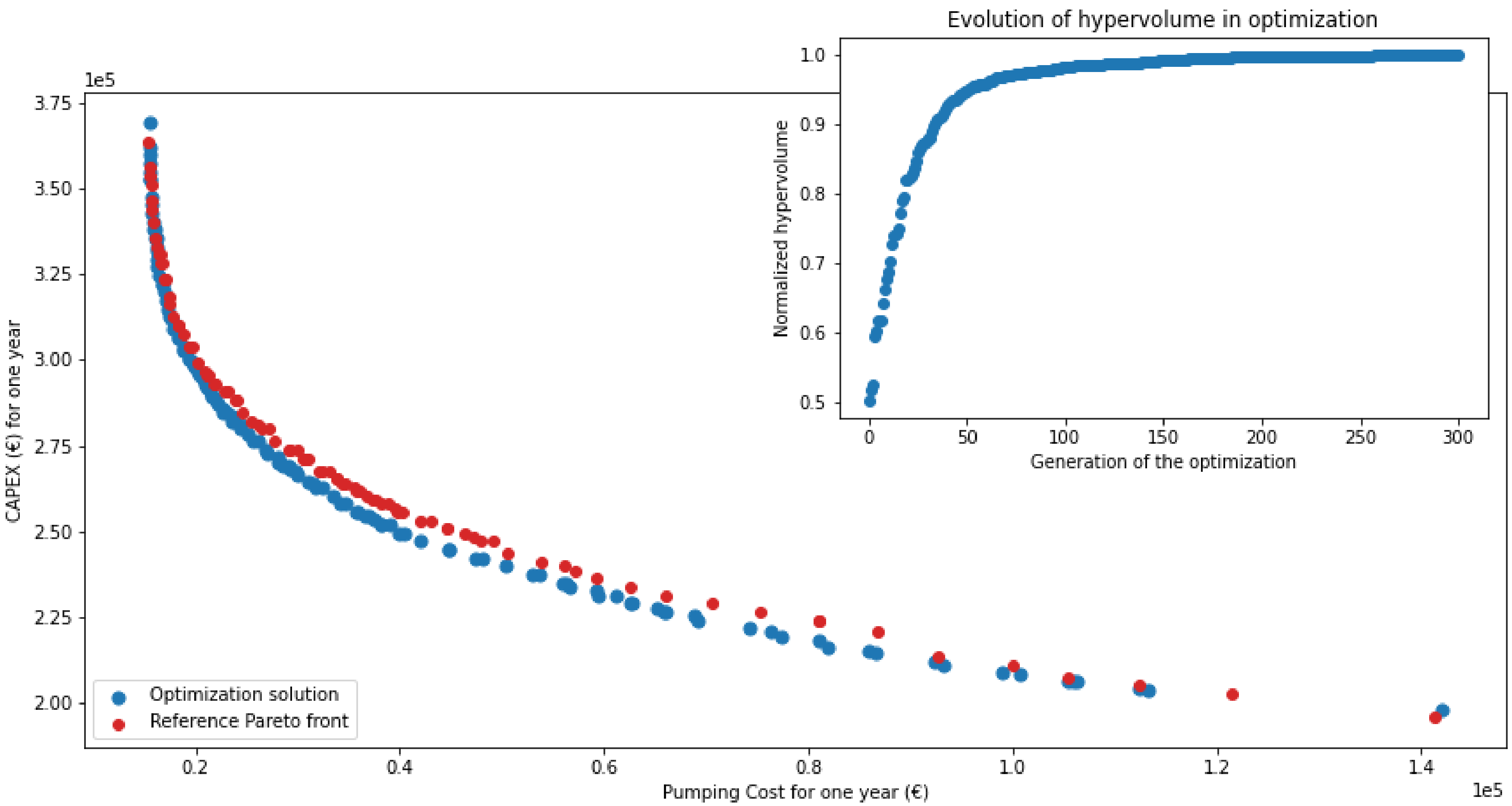
Optimization :

Individuals : 300

Generations : 300

Mutation probability : 0,2

10 Substations + 9 branches : convergence

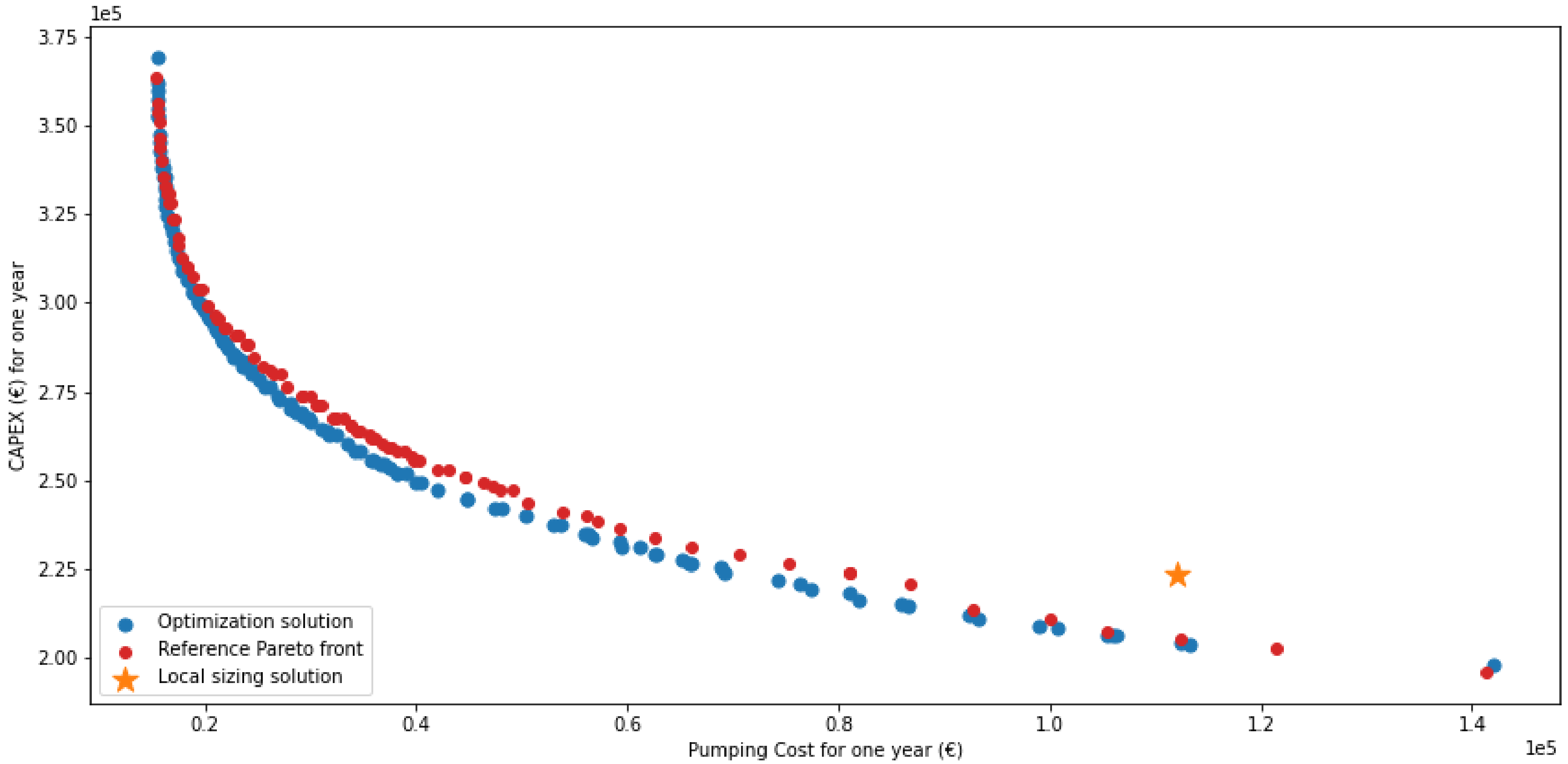


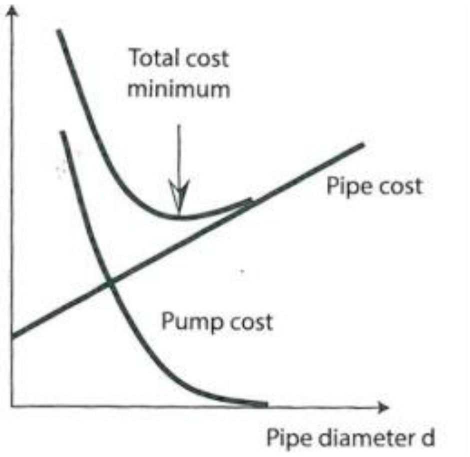
Reference solution and optimization solution are close

Solutions with higher pumping cost may have a critical substation in the branches

Validation Test case

10 Substations + 9 branches





From Frederiksen and Werner, 2013

Difference local sizing/optimization:

- 100k€ of savings per year compared to closest solution

→ 7% of savings for a 40 years lifetime of the system

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Conclusion

- **Presentation of an optimal sizing method for pipe diameters in DH networks**

- **Validation methodolodgy for optimal sizing in DH network approaches**

- **Validation of the framework with branched networks**
    - Elaboration of a reference solution for a branched test case
    - Comparison to optimization results

    → Great quality of the Pareto front and good convergence

- **Comparison to a local sizing method**
    - Optimal solution are at least 7% less costly in tested cases
    - Qualitative difference in the solutions

Thank you for your attention !

Any questions ? Yannis.merlet@cea.fr