Planning and Operation Model for Multi-Energy Systems (POMMES)

Thibaut Knibiehly[a], Anaëlle Jodry[a], Pedro Affonso Nobrega[a], Thomas Heggarty[b], Robin Girard[a]

[a]Mines Paris - PSL, Centre PERSEE, Campus Pierre Laffitte, Sophia-Antipolis
[b]RTE R&D, Window, La Défense

Framework description

The POMMES framework enables to **minimise the cost** of **investment pathways** in **multi-energy systems** with a **deterministic** approach. The problem written optimises simultaneously the planning (**conversion** capacities, **storage** volumes, **import** capacities) of the system at each planning step (*e.g.* 10 years) and the operation of a multi-energy system (*e.g.* hourly production of conversion plants, storage levels and imports) as shown in figure 1. The vector coupling is modelled as an **energy supply-chain model** (figure 2).

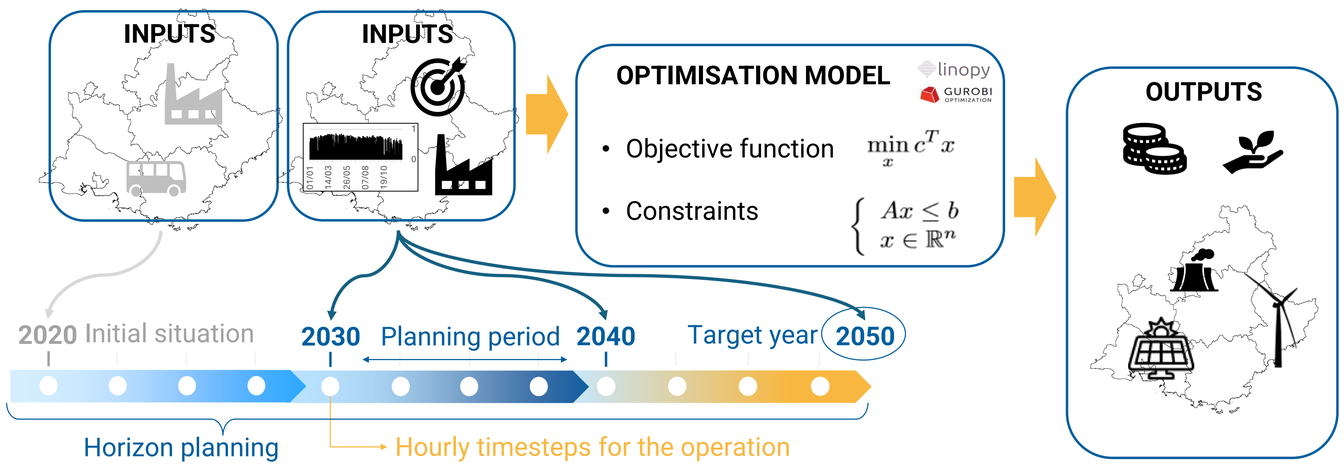


Figure 1 – Principle of a planning and operation model [1]

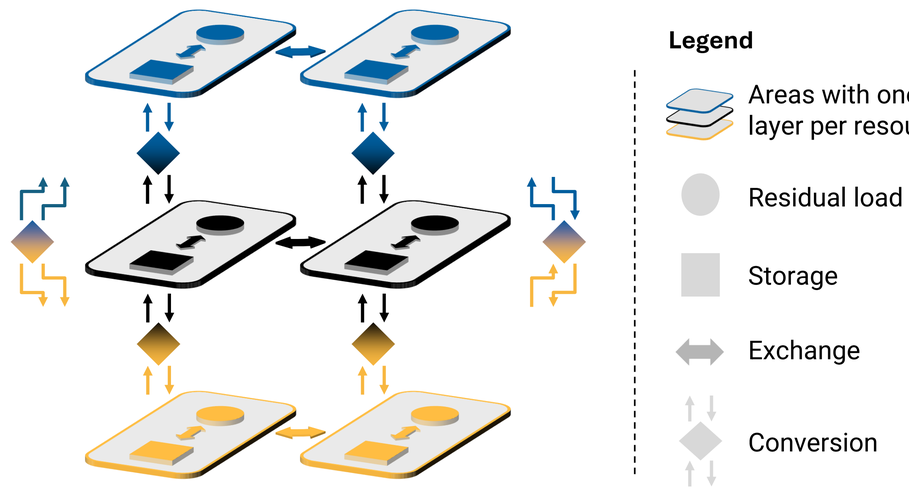


Figure 2 – Principle of an energy supply-chain model [2]

Highlights of POMMES

- **The investment index is kept in the operation variables**

  In equation (1), $\mathbf{P}^{c}_{y,t,c,i}$, is the dispatch power of the conversion technology c invested for year i at operation year y and operation time t bound by the installed conversion capacity $\bar{P}^{c}_{y,c,i}$.

- **Investment variables are indexed by the investment year and the decommissioning year**

  Equation (2) defines $\bar{P}^{c}_{y,c,i}$ as the sum of the invested capacities $\mathbf{P}^{c,inv}_{c,i,d}$ of c made for year i not yet decommissioned ($d > y$).

$$\forall \boldsymbol{i}, y \geq i, t, c, \qquad \mathbf{P}^{c}_{y,t,c,\boldsymbol{i}} \leq a_{y,t,c,\boldsymbol{i}}\, \bar{P}^{c}_{y,c,\boldsymbol{i}} \qquad (1)$$

$$\forall i, y \geq i, c, \qquad \bar{P}^{c}_{y,c,i} = \sum_{\boldsymbol{d}>y} \mathbf{P}^{c,inv}_{c,i,\boldsymbol{d}} \qquad (2)$$

Why another framework?

- Inherited from in-house models
- Used for teaching purpose
- Will to benchmark with other tools in the community

Index nomenclature

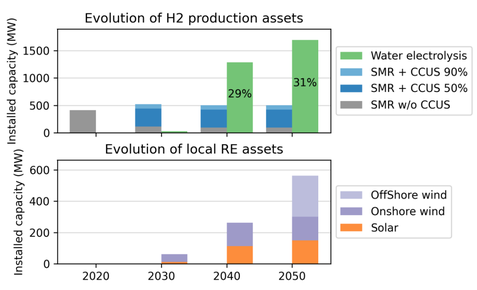
i	investment year
d	decommissioning year
y	operation year
t	operation time
c	conversion technology

Link to GitLab repository

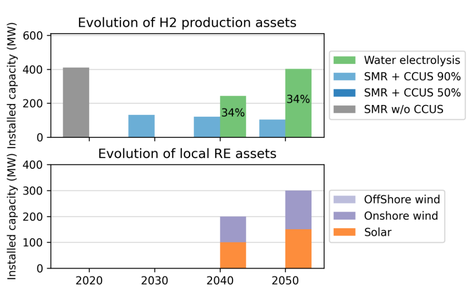
Application cases

Previous works conducted with the framework SPHYDERS on the deployment of decarbonised hydrogen production in the industrial hub of Fos-sur-Mer in South of France [1] were reused to test POMMES. Two main evolutions were implemented. First, the invested capacities - modelled in SPHYDERS as a stock with inflow and outflow without history - were modelled with variables indexed on the investment and decommissioning year. We call this intermediate step “Intermediate model”. Second, the investment year indexed was added to the operation variables to make the POMMES model.

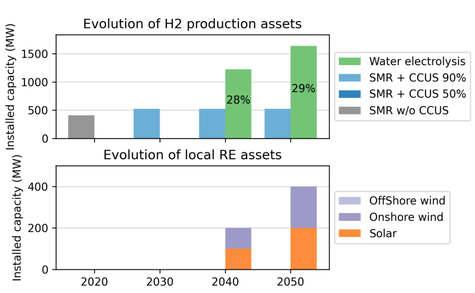
Results on the industrial hub of Fos-sur-Mer



SPHYDERS

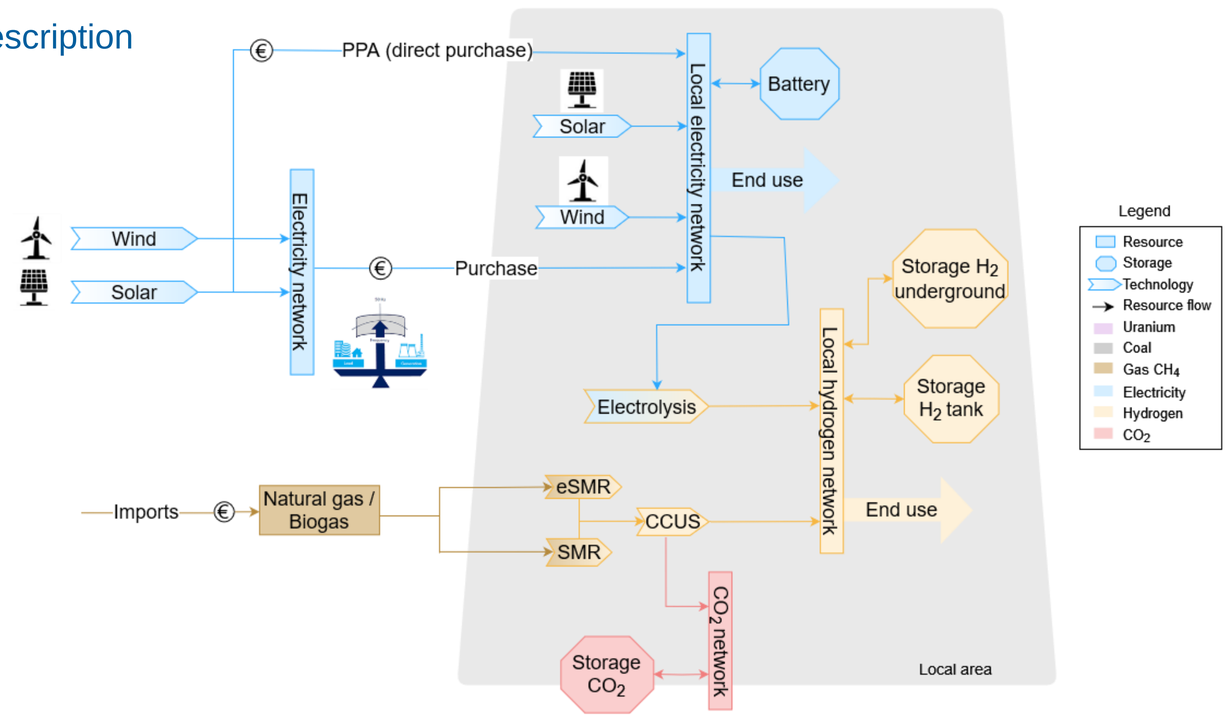


Intermediate model



POMMES

Input description



Case	Computation time
SPHYDERS	78s
Intermediate model	45s
POMMES	60s

Table 1 – Comparison of computation time depending on the framework

Hardware platform

- Window 11 Professional version 22h2
- 13th Gen Intel(R) Core(TM) i7-13800H 2.50 GHz
- RAM 16,0 Go

Software

Gurobi 10.0.2 was used as solver. As Gurobi updates its hyper-parameters, the computation time of the third iteration is taken. The results still vary, the above table is thus rather to be taken as order of magnitude.

Assumptions

- Geographical and meteorological local constraints.
- Electricity price and emission factor time series are exogenously simulated based on RTE scenario N1 from [3].
- Existing hydrogen production assets (steam methane reformers) are considered in the optimisation.

Bibliography

[1] Jodry, R. Girard, P. H. Affonso Nobrega, R. Molinier, M. D. Elalaouifaris, *Industrial hydrogen hub planning and operation with multi-scale optimisation*, Journal of Cleaner Production, 2023

[2] Sheila Samsatli, Nouri J. Samsatli, *A multi-objective MILP model for the design and operation of future integrated multi-vector energy networks capturing detailed spatio-temporal dependencies*, Applied Energy, Volume 220, 2018

[3] Réseau de Transport d’Électricité (RTE), *Futurs Énergétiques 2050*, 2021

Acknowledgment

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Link to PlaneTerr website

Contact: thibaut.knibiehly@minesparis.psl.eu