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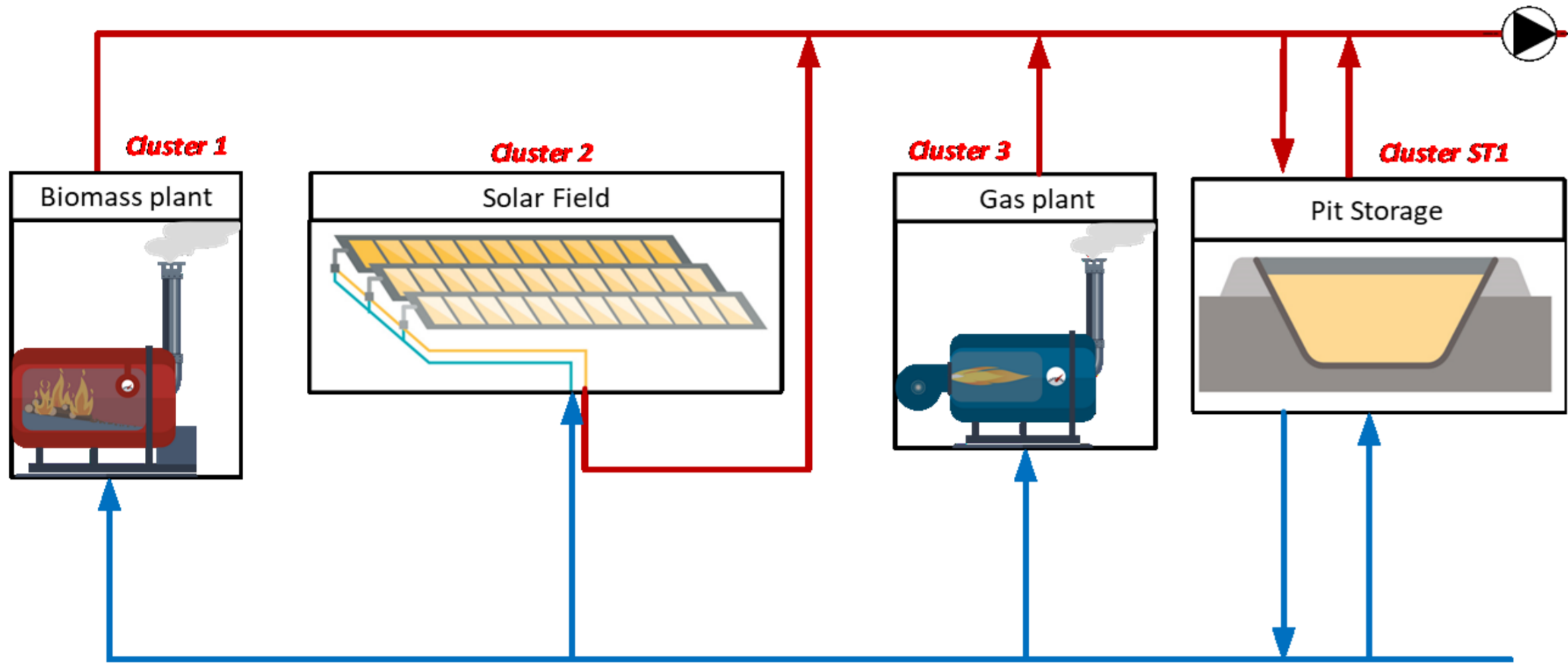
Improved pre-calculation of solar thermal production for MILP-based optimization problems

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Solar District Heating Network

- Solar District Heating (SDH) networks are a promising solution for reducing the carbon emissions of the heat supply sector.
- Enhanced with 3rd and 4th DH generation.



SDH network composed of a biomass plant, a solar field, a gas plant associated with a Pit Thermal Energy Storage (PTES)

Problematics

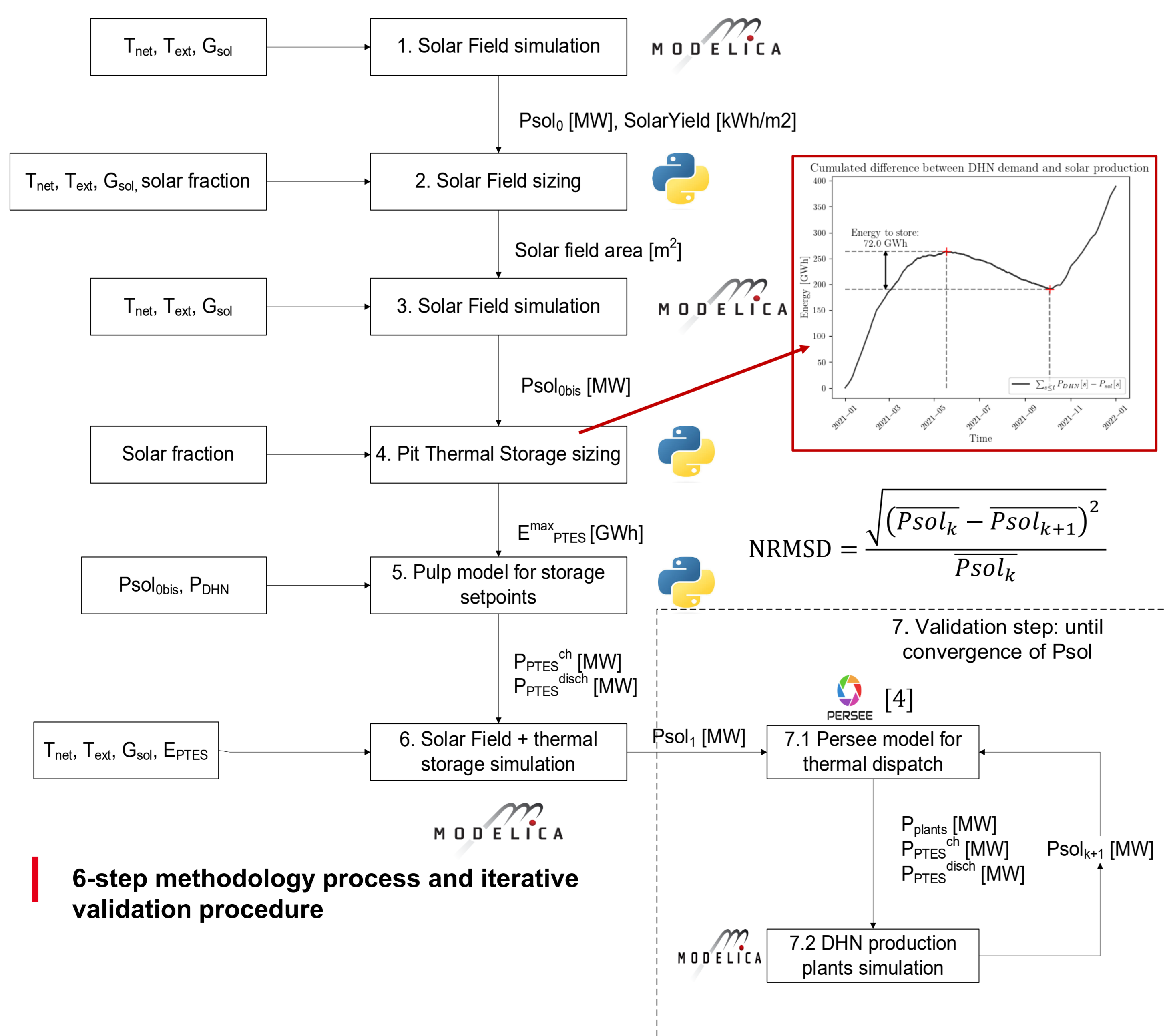
- Modeling SDH systems is **challenging** due to **complex thermal storage dynamics** (non linear thermo-hydraulic behaviour)
- MILP models** often oversimplify solar input, leading to inaccurate predictions. [1]
- MINLP models** are prone to numerical issues (convergence, initialization) [2]

Objective

Improve the pre-computation of solar thermal production for MILP-based optimization problems

Methodology

- Relies on **Modelica models** of increasing complexity [3]
- Linear **Pulp** optimization model to **anticipate PTES behavior**
- A new solar production profile is obtained, **with PTES influence**
- Iterative validation procedure** with MILP optimization problem and SDH plants simulation
- Convergence criteria is **Normal Root Mean Square Deviation**



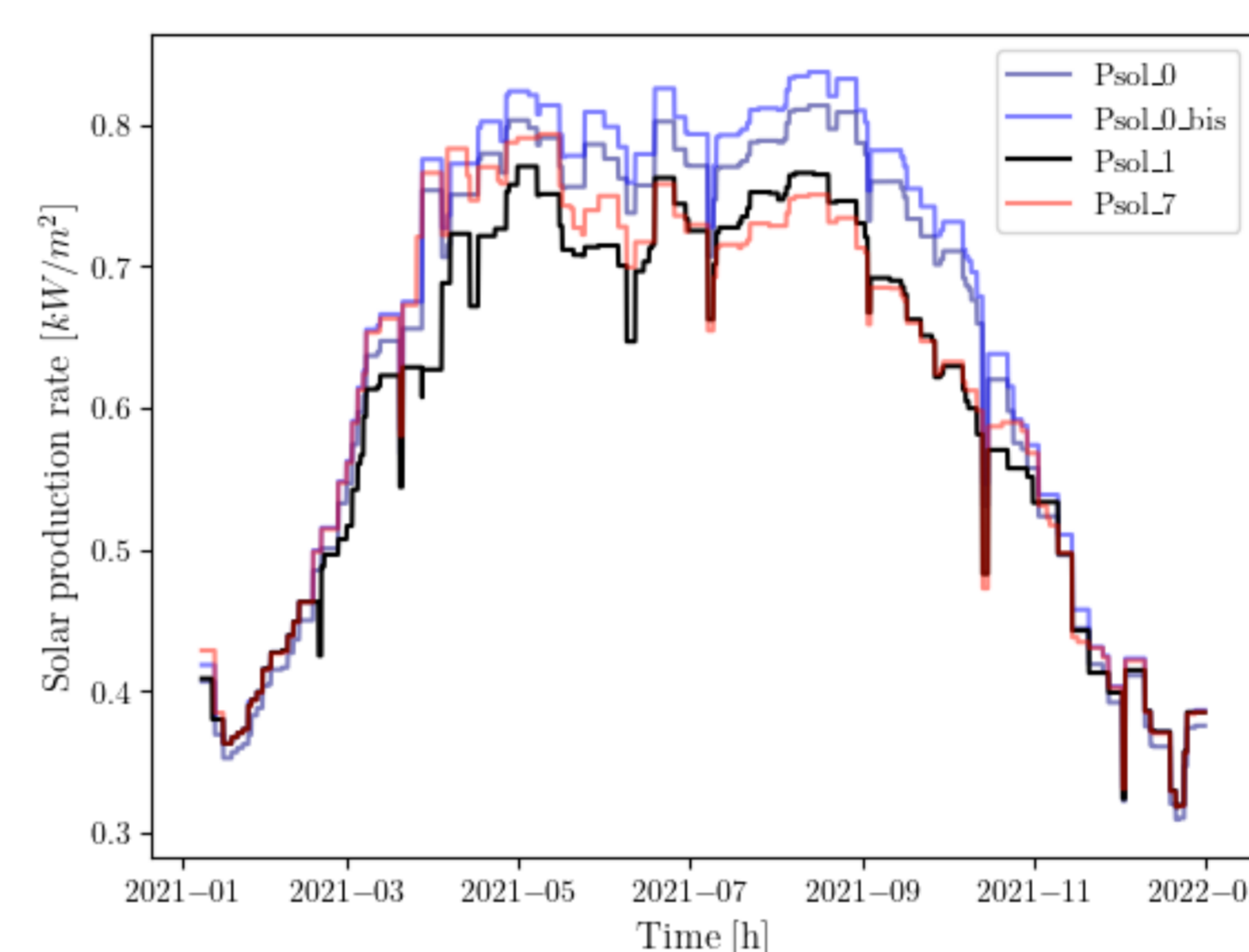
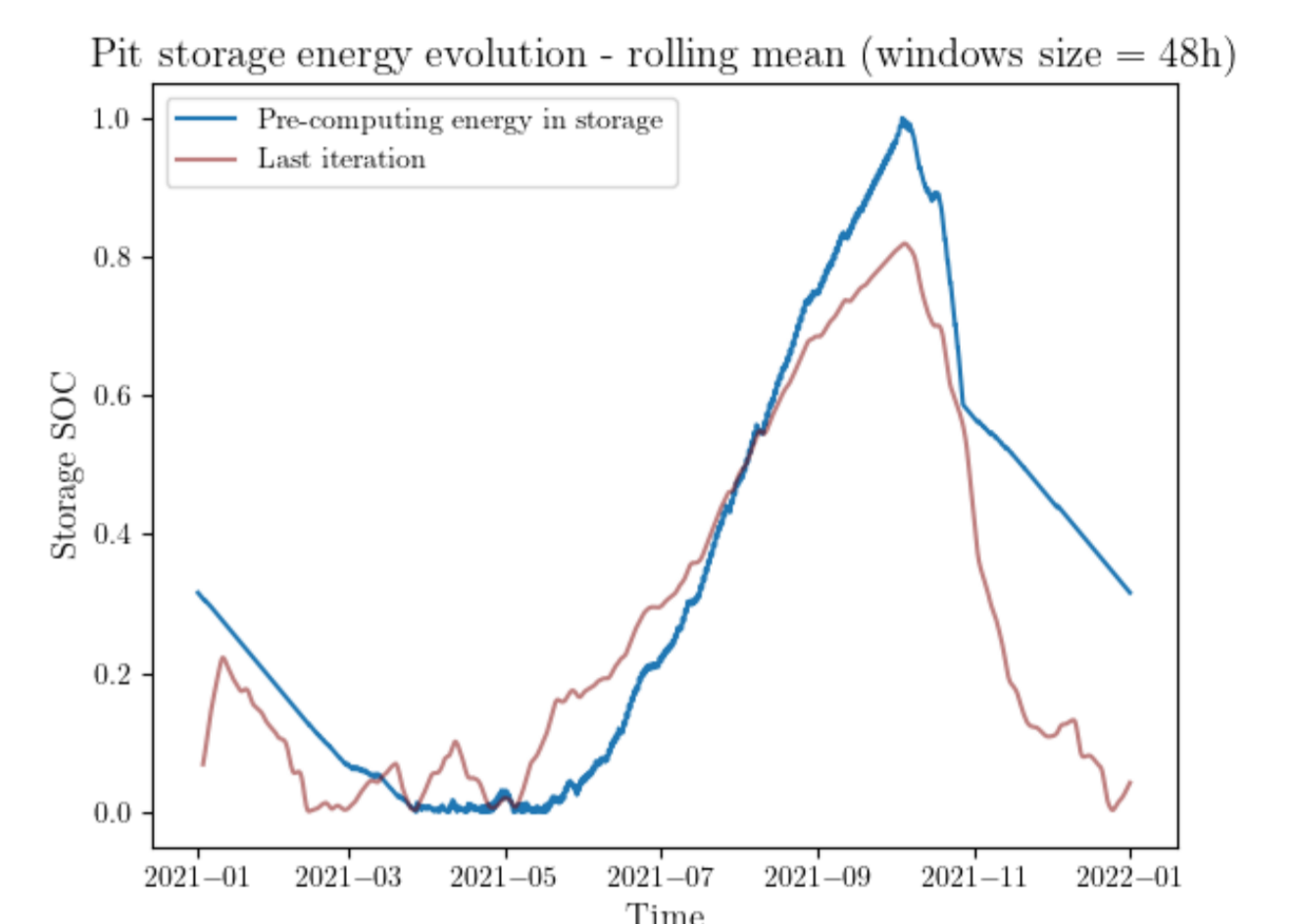
Results

Case studies

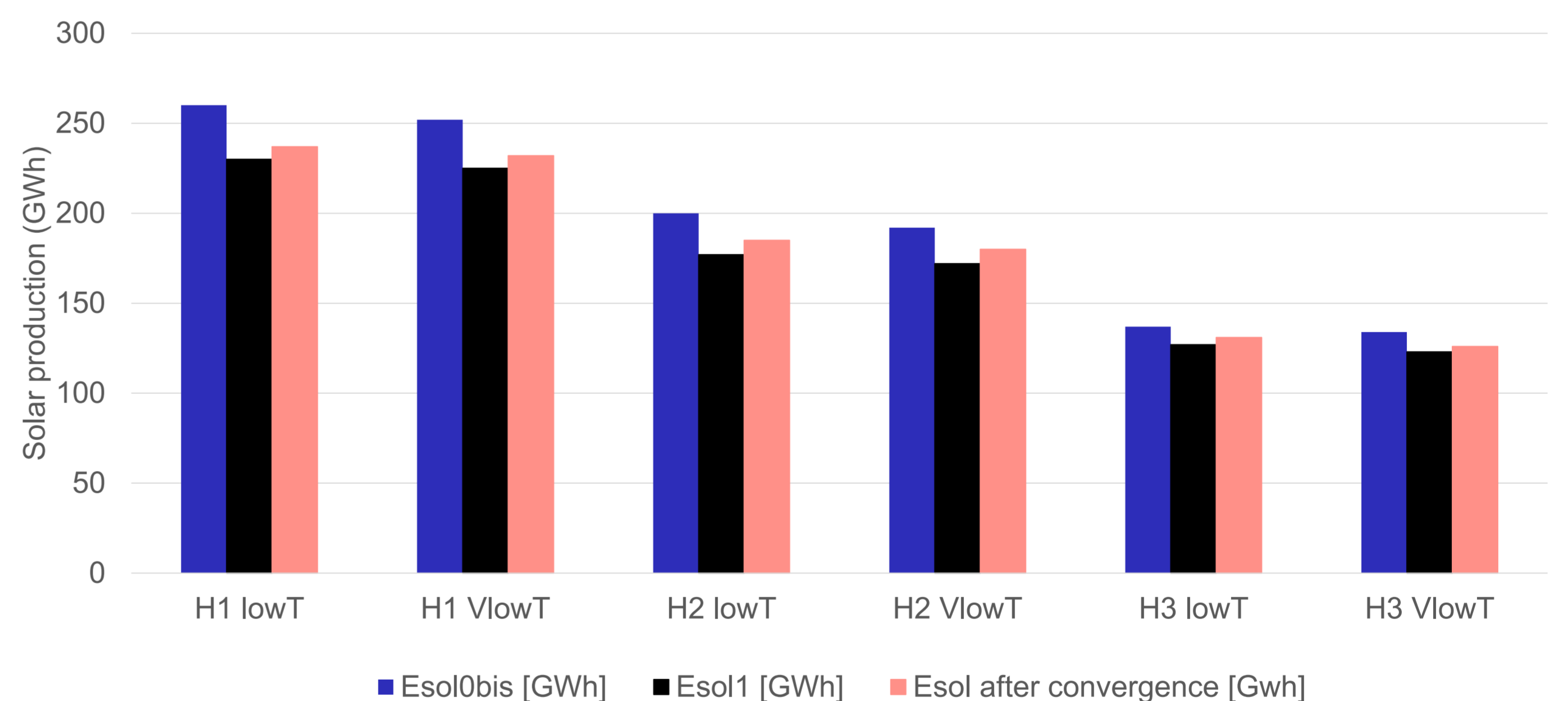
- Tests on **3 meteorological areas in France** (H1, H2, H3) for **3rd and 4th generation of DH** (low temperature – Very low temperature)
- District heating data generated by **HeatPro app** [6]
- Desired **solar fraction of 40%**

Convergence obtained after 5 iterations

Storage behavior is rather well predicted comparing last iteration result (7.1) and precomputing step (5). Minor differences explained by :
 > **Thermal losses** : faster discharge (autumn)
 > **Influence of biomass plant** and prices (spring)



Naive computation of solar production (P_sol0 & P_sol0bis) overestimates annual solar production, **The influence of storage behavior is attested** :
 > Mass flow limited availability when discharging limits solar production
 > PTES temperature influences solar production when charging
 Differences between P_sol1 & P_sol7 are explained by storage trajectories



The error on Esol0bis compared to Esol1 is around -10%, **indicating an overestimation of solar production in precomputation**. The methodological step corrects this by reducing the estimated solar output. Validation shows that the error on Esol1 is approximately +3%. Notably, **Esol1 is conservative compared to the actual solar output after convergence** (step 7), which is preferable. It's important to highlight that **steps 1-5 are fast (~5 minutes)**, while **convergence step 7 is slower (~hours)** for only a modest gain in accuracy.

Conclusion

- Comprehensive approach** for SDH optimization: Combines solar field and thermal storage models with LP optimization for **accurate pre-calculation**.
- Error reduction achieved**: Validated solar production levels showed a **final error rate of 3.4%**, with conservative Esol1 estimates proving reliable.
- Rapid initial computations**: Quick execution for precomputation for estimated solar production levels (**~5 minutes**) contrasts with slower validation (**~hours**).
- Future improvements**: Consider rolling horizon in the validation loop to address model mismatches and enhance precision.