Innovative Concepts and Appliation for Large Scale and Multimode Systems: Use Case Study of Heat Networks

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In a global effort to replace fossil fuels in the building sector, many communities in Europe are exploring sustainable alternatives. Thus, the progressive insertion of new energy production systems with high penetration of renewables is leading to more and more decentralization with a large diversity of technologies, actors and consumers, with sometimes divergent points of interests. Since this global setup is expected to play a major role in the future energy mix, there is a strong need for new modeling and simulation means to design and combine such systems for a better definition, control and operation of their targeted performance. Related to ENGIE there are initiatives promoting electrification of space heating and cooling in homes and buildings primarily using heat pumps; on the other hand, there are national and local programs encouraging utility thermal energy networks.

Within this context, ENGIE joined the French consortia industry project ModeliScale supported by the French State, in [2018 , 2021] to create and simulate digital twins, with innovative technological bricks to better analyze larger, more diverse and more complex scenarios for large scale decentralized multi physics energy systems.

The ambition of the project was to develop new scientific concepts for the analysis and resolution of these systems, to prototype technological solutions based on the Modelica and FMI open standards, and to validate them on industrial demonstrators. Thus, the ModeliScale collaborative project addressed several scientific challenges such as: modeling large scale systems (compiling and execution of models with more than 106 equations), multimode modeling (generation of correct simulation code in all modes) and correct and efficient initialization of large Modelica models.

While several case studies dealing with large scale energy grid and heat networks (example in Figure 1) provided by the industrial partners requested the development of Modelica libraries by integrating operational specifications and 'from the field' requirements; ENGIE particularly focused on the modeling and simulation of thermal energy networks, which activity is crucial to develop performing and cost-efficient solutions for customers. To answer to the ENGIE challenges, partners could benefit from enhancements in Dymola prototypes, as well as Modelica library prototypes developed by project partners.

This industrial user presentation will illustrate the ENGIE use case study and the results obtained. The authors will describe the main set of hypothesis (location, characteristics of the existing heat network and its substations, segmentation and architecture, data used for model parameterization, etc.). We will review the different Modelica blocks and physical components that enabled to build the whole model. Consideration about the network tuning, integration and validation will be explained as well. Then an illustration of the Entreprise MBSE engineering scenario example will be given through combination of multiple apps in 3DEXPERIENCE platform, from project management to validation. Finally, the presentation will conclude with summary of benefits and outlook on future work in the domain.

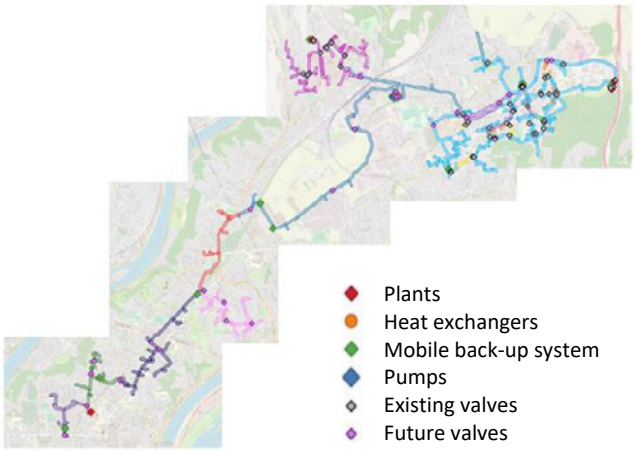

Figure 1. ENGIE Heat network layout in the northern plateau of Lyon, France

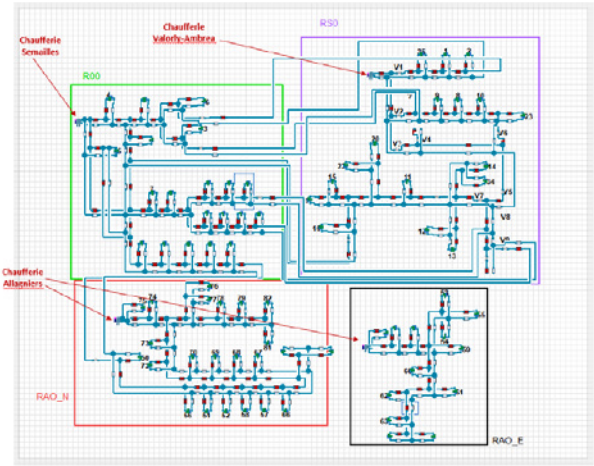

Figure 2. ENGIE global Modelica architecture of the Heat Network