Politecnico di Torino
Dipartimento di Automatica e Informatica
PhD in Computer and Control Engineering
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Distributed Software Methods and Platforms for Modelling and Co-simulation of Multi-Energy System

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1. Research Context

Multi-Energy Systems (MES) are complex systems where heterogenous energy vectors (e.g., electricity, heat exchanging fluids, natural gas) interact together in such a multi-faceted way that they are very difficult to be analyzed comprehensively [1]. Their complexity reflects on the difficult effort needed to simulate MES to assess their efficiency from an operational and planning aspect.

2. Methodological Approach

The proposed methodology led to the development of the Energy Center Distributed Co-simulation Infrastructure to simulate MES [2]. The platform will allow to run energy-related simulations of specific elements of a MES, or to combine them in a homogenous simulation environment. The co-simulation platform will offer different functionalities to manage MES simulation, connecting in a plug-and-play fashion different software models, hardware and real-world devices. The functionalities take into account:

i) The scenario generation to simplify the design of MES, automating the interconnection of different ready-to-use models;

ii) The simulation step and time management to manage the simulation of each model in a distributed simulation environment, including real-time simulation and HIL testing;

iii) The exchange of information among different software, models, simulators, respecting their scenario dependencies.

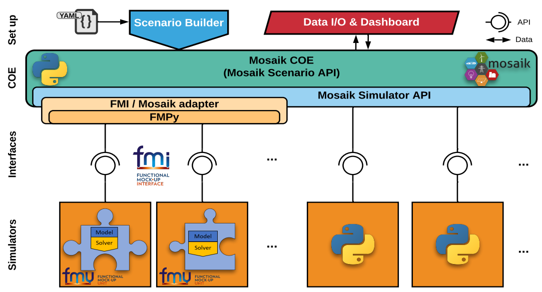

Figure 1 Scheme of the Energy Center Distributed Co-simulation Infrastructure

The infrastructure is presented in Figure 1 and it reports the enabling technologies and main elements of the platform: Scenario Builder, Data I/O & Dashboard interface, Mosaik Co-simulation Orchestrator Engine including Scenario and Simulator APIs, FMI/Mosaik adapter, simulation blocks and their interfaces.

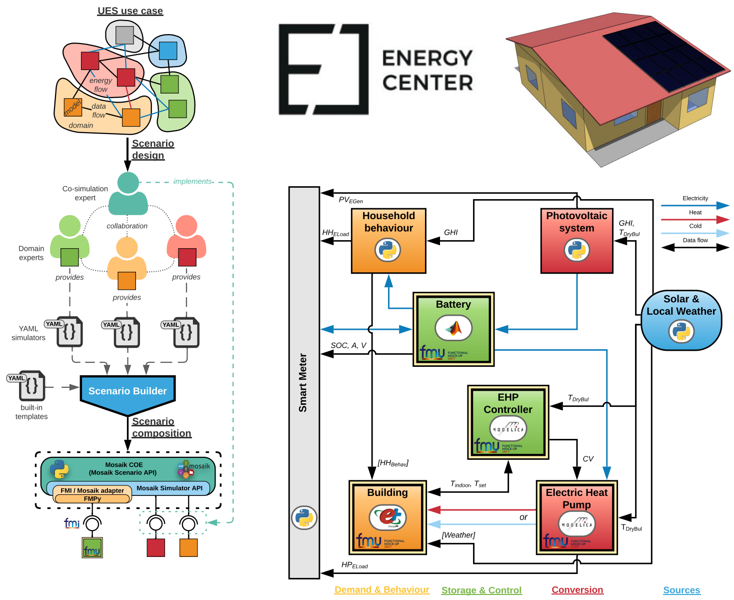

Figure 2 The Energy Center Collaborative Platform and its first use case: a MES residential building including i) the Building Thermal Behaviour, ii) the Household Behaviour, iii) a Photovoltaic Panel, iv) an Electric Heat Pump, v) an Electric Storage, vi) the Electric Heat Pump PID Controller, vii) the Global Horizontal Irradiance, and viii) the Local Weather Forecast

3. Results

The Energy Center Collaborative Platform [3] is presented in Figure 2. The first MES use case described in the Figure 2 is the smallest unity of a Smart City MES, a residential building. In Figure 3, different model results are presented that represent the operational behavior of the MES residential building [4].

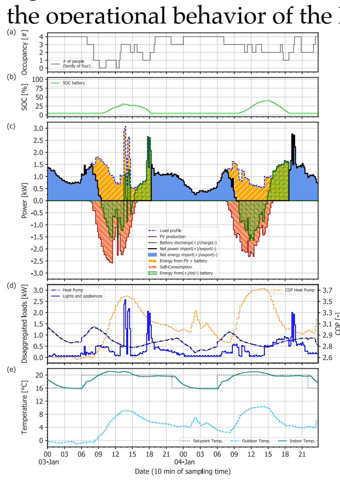

Figure 3 The figure presents the scenario simulation results showing a general time window of two consecutive days in a months of the winter season (i.e., a weekend of January). The time-series plots depict: a) the number of people in the house, b) the State Of Charge (SOC) of the battery, c) the profiles of the net power, total load, PV production, and battery, highlighting the self-consumption and the energy covered by the combined PV-battery system, d) the view of load profile in terms of its disaggregated elements, i.e., lights, appliances, and heat pump, the latter linked to its Coefficient Of Performance (COP), and e) the outdoor, indoor, and scheduled set-point temperatures

4. References

[1] P. Mancarella, "MES (Multi-Energy Systems): An overview of concepts and evaluation models," Energy, vol. 65, p. 1–17, 02 2014
[2] D. S. Schiera, L. Barbierato , A. Lanzini, R. Borchiellini, E. Pons, E.F. Bompard, E. Patti, E. Macii, and L. Bottaccioli, "A Distributed Platform for Multi-modelling Co-simulations of Smart Building Energy Behaviour," in 2020 IEEE International Conference on Environment and Electrical Engineering (EEEIC), 2020, pp. 1-6
[3] L. Barbierato, D. S. Schiera, E. Patti, E. Macii, E. Pons, E.F. Bompard, A. Lanzini, R. Borchiellini, and L. Bottaccioli, "GAMES: A General-purpose Architectural Model for Multi-Energy System engineering applications," in 2020 IEEE 44th Annual Computers, Software, and Applications Conference (COMPSAC), 2020, pp. 1405–1410.
[4] D.S. Schiera, L. Barbierato , A. Lanzini, R. Borchiellini, E. Pons, E.F. Bompard, E. Patti, E. Macii, and L. Bottaccioli, "A Distributed Multi-Model Platform to Co-Simulate Multi-Energy Systems in Smart Buildings," IEEE Transactions on Industry Applications, pp. 4428-4440