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COMPUTER AND CONTROL ENGINEERING

PNRR/HPC - Automatic composability of Large Co-simulation Scenarios for smart energy communities

Funded By	Dipartimento DAUIN MINISTERO DELL'UNIVERSITA' E DELLA RICERCA [P.iva/CF:97429780584] Politecnico di TORINO [P.iva/CF:00518460019]

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Context of the research activity	The emerging concept of multi-energy systems is linked to heterogeneous competencies spanning from energy systems to cyber-physical systems and active prosumers. Studying such complex systems needs the usage of co-simulation techniques. However, the setup of co-simulation scenarios requires a deep knowledge of the framework and a time-consuming setup of the distributed infrastructure. The research program aims to develop automatic composability of multi-energy system co-simulations to ease usage. Progetto finanziato nell'ambito del PNRR M4C2, Investimento 1.4 - Avviso n. 3138 del 16/12/2021 - CN00000013 National Centre for HPC, Big Data and Quantum Computing (HPC) - CUP E13C22000990001

	A complex system such as a multi-energy system requires the accurate modelling of the heterogeneous aspects that constitute the overall phenomena under study. To achieve this goal researchers in different fields have started using co-simulation and model coupling to build new models capable of describing the interactions and the overall complexity. Such approaches give the possibility of coupling different models, running on different simulators and/or simulation engines, by exchanging data via some standard protocols over the internet. Indeed, such models have been developed and validated following a methodology that can be compared to service-oriented architecture, thus, reducing the time and complexity of building new models from scratch. Moreover, such an approach disease the interconnection of the vertical knowledge coming from each discipline/domain that is involved in the complex system, eg. ICT or Energy experts. Examples of models can be software entities that replicate the realistic behaviour of a photovoltaic (PV) system, energy storage, heating

Objectives	distribution networks or, even, human beans. Nowadays, researchers have invested in the usage of co-simulation orchestrators to achieve the goal of interconnection and synchronization of different models and simulators, including real-time simulators. However, the setup of the co-simulation is not an easy and trivial task as it is time-consuming and it requires the involvement of domain and co-simulation experts. This research topic aims to develop a framework, that exploits existing co-simulation orchestrators, for the automatic composability of co-simulation scenarios in a distributed infrastructure to assess different aspects of Multi-Energy-Systems. The framework will integrate models in a plug-and-play fashion reducing as much as possible the coding phase and the presence of a co-simulation expert easing the work of multi-energy systems engineers. Moreover, the framework will ease the setup in terms of computational resources for the modelling of complex and large scenarios. The final purpose consists of simulating the impact and management of future energy systems to foster the energy transition. Thus, the resulting infrastructure will integrate with a semantic approach in a distributed environment heterogeneous i) data sources, ii) cyber-physical-systems, i.e. Internet-of-Things devices iii) models of energy systems and iv) real-time simulators. The starting point of this activity will be the already existing EC-L co-simulation platform, which will be enhanced by embedding all the aforementioned features. Hence the research will focus on developing: - a methodology based on semantic web technologies for linking and interconnecting simulators automatically in a co-simulation approach - a domain-specific ontology for describing the components and interconnection of multi-energy system models - a methodology for the automatic composability and setup of the distributed infrastructures of the energetic scenario to assess (e.g., the impact of PV systems and EVs in a city) In a nutshell, the final result will provide a tool that exploits visual programming, semantic representation and cloud technologies to offer co-simulation as a service to describe multi-energy systems simulation scenarios in a plug-and-play fashion opening the usage of co-simulation to a wider audience. The outcomes of this research will be a distributed co-simulation platform for: - planning the evolution of the future smart multi-energy system by taking into account the operational phase - evaluating the effect of different policies and related customer satisfaction - evaluating the performances of hardware components in a realistic test bench During the first year, the candidate will study the literature solutions of existing co-simulation platforms to identify the best available solution for i) large-scale smart energy system simulation in distributed environments and ii) semantic web solutions to describe complex systems with a focus on the multi-energy system domain. Finally, the student will design the overall framework starting from the requirements identification and definition. During the second year, the candidate will face the implementation of the visual and semantic framework for model coupling and scenario creation. Furthermore, the candidate will start developing software solutions for automatic composability and setup of the co-simulation environments in terms of simulator deployment in a cloud system. During the third year, the candidate will complete the overall framework development and test it in different case study scenarios to assess the

	capabilities of the platform in terms of automatic scenario composition and setup. Possible international scientific journals and conferences: - IEEE Transaction Smart Grid - IEEE Transaction on Industrial Informatics, - IEEE Transaction on sustainable computing, - IEEE EEEIC conf. - IEEE SEST conf. - IEEE Compsac conf.

Skills and competencies for the development of the activity	- Programming and Object-Oriented Programming (preferably in Python), - Frameworks for orchestration and setup of containerized applications, - Knowledge of semantic technologies, - Computer Networks