PhD in Computer and Control Engineering

Research Title: Distributed software infrastructure to model and co-simulate different multi-energy systems

Funded by	Energy Center Lab (EC_lab) – Centro Interdipartimentale sull'Energia

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Context of the research activity	The emerging concept of smart energy societies and cities is strictly connected to heterogeneous and interlinked aspects, from energy systems, to cyber-infrastructures and active prosumers. One of the key objectives of the Energy Center Lab is to develop instruments for planning current and future energy systems, accounting for the complexity of the various interplaying layers (physical devices for energy generation and distribution, communication infrastructures, ICT tools, market and economics, social). The EC tackles this issue by aiming at building a virtual model made of interactive, interoperable blocks. These blocks must be designed and developed in the form of multi-layer distributed infrastructure that exploits the modern design patterns (e.g., the microservice approach). Examples of systems realizing partial aspects of this infrastructure have been recently developed in the context of European research projects, such as energy management of district heating systems [1], smart-grid simulation [2], thermal building simulation [3] systems, renewable energy source planning such as [4-5]. However, a comprehensive and flexible solution for planning and simulate future smart energy cities and societies, is still missing. The research program aims at developing the backbone software infrastructure allowing to interface and interoperate real/virtual models of energy production systems, energy networks (e.g. electricity, heat, gas), communication network and prosumer models.

Objectives	This research aims at developing a novel distributed software infrastructure to model and co-simulate different Multi-Energy-Systems and general-purpose scenarios by combining different

	technologies (both Hardware and Software) in a plug-and-play fashion and analysing heterogeneous information, often in (near-) real-time. The final purpose consists of simulating the impact of future energy systems. Thus, the resulting infrastructure will integrate in a distributed environment heterogeneous i) data-sources, ii) cyber-physical-systems, i.e. Internet-of-Things devices, to retrieve/send information in (near-) real-time, iii) models of energy systems, iv) real-time simulators, v) third-party services to retrieve information in (near-) real-time data, such as meteorological information. This infrastructure will follow the modern software design patterns (e.g. microservice) and each single component will adopt the novel communication paradigms, such as publish/subscribe. This will ease the integration of "modules" and the link between them to create holistic simulation scenarios. The infrastructure will enable also both Hardware-in-the-Loop and Software-in-the-Loop again to perform real-time simulations. Furthermore, the solution should be able to scale the simulation from micro-scale (e.g. dwelling, buildings) up to macro-scale (e.g. urban or regional scale) and span different time scales from micro-seconds up to years. In a nutshell, the platform will offer simulations as a service that can be used by different stakeholders to build and analyse new energy scenarios for short- and long-term planning activities and for testing and managing the operational status of smart energy systems

Skills and competencies for the development of the activity	The candidate should know basic concept of Internet-of-Things communication technologies and good programming skills. Knowledge of multi-energy-systems is encouraged. Furthermore, the candidate should be able to work in a multi-disciplinary context.

References	[1] Brundu et al. IoT software infrastructure for Energy Management and Simulation in Smart Cities. In: IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS vol. 13 n. 2, pp. 832-840. - ISSN 1551-3203 [2] Bottaccioli et al. A Flexible Distributed Infrastructure for Real-Time Co-Simulations in Smart Grids. In: IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS - ISSN 1551-3203 (In Press) [3] Bottaccioli et al. Building energy modelling and monitoring by integration of IoT devices and Building Information Models. In: 41st IEEE Annual Computer Software and Applications Conference (COMPSAC 2017), Torino, Italy, 4-8 July 2017. pp. 914-922 [4] Bottaccioli et al. GIS-based Software Infrastructure to Model PV Generation in Fine-grained Spatio-temporal Domain. In: IEEE SYSTEMS JOURNAL (In press)

[5] Bottaccioli et al. PVInGrid: A Distributed Infrastructure for evaluating the integration of Photovoltaic systems in Smart Grid. In: 8th Advanced Doctoral Conference on Computing, Electrical and Industrial Systems (DoCEIS 2017), Caprica (Lisbon), Portugal, 03-05 May 2017. pp. 316-324