Organization and Control of Electrical Energy Infrastructure

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Decarbonization policies in Europe and the Netherlands are triggering a profound revolution in the way we produce and consume electricity. If the electricity supply system is to become (almost) 100% renewable over the next 20-30 years, taking into account also the increase in demand coming from the electrification of the heat and transportation sectors, many challenges must be dealt with, starting right now. These challenges concern the following system-level aspects: maintaining the generation-demand balance over various time scales, respecting network capacity constraints, ensuring adequate generation capacity, and establishing a well-functioning electricity market.

We are already witnessing the so-called vertical-to-horizontal transformation of the electricity system, where large-scale fossil-fueled plants are replaced with many distributed wind and solar power plants. The evolution of power systems into smart grids is being facilitated by the advent of ICT. Smart grids are cyber-physical systems, based on distributed (as opposed to centralized) control architectures. Such systems consist of many interacting smart devices, installed either directly at the network level, or at the producer and end-user premises, each capable of sensing, two-way communication and (semi)-autonomous decision-making. Hence, a multi-agent system is the appropriate design and operational paradigm for the smart grid, due to its scalability, robustness and ability to handle uncertainty and complexity.

In this talk we explore the main solutions to the challenges of decarbonizing the electricity system, which can be summarized under the heading of “flexibility” in 3 distinct domains: flexibility at the demand side, including storage and smart charging of electric vehicles, flexibility in energy trading, and flexibility in the electricity network itself.