Title: **Smart Grid In A Room: A Hybrid Test-Bed Facility For Cyber- Physical Systems (Cps)-Based Standards In Microgrids And Their Interactions With Utility Systems**

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Sponsor: The National Institute of Standards and Technology (NIST)

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Description:
This project funded by the National Institute of Standards and Technology (NIST) targets modeling, sensing, communications, and control design principles for the evolving smart grid by viewing it as a Cyber-Physical System (CPS). We wish to ultimately answer two key open questions:
Is it possible to design sufficiently general CPS standards and protocols to support a mass plug-and-play deployment of smart grid (SG) technologies without reliability or privacy/security problems?
What standards/protocols are required to transform today's electric power grids into end-to-end enablers of sustainable electric energy services?

We aim to answer these questions by developing a hybrid software-hardware facility capable of taking input data from today's electric power grids and any available microgrid physical test beds and demonstrating what could be done to transform them into smart grids with well-defined functionalities.

Based on the findings so far from the Dynamic Monitoring and Decision Systems (DyMonDS) framework introduced by our group, we are proposing to design and build an end-to-end, system-level hybrid test facility named Smart Grid In a Room Simulator (SGRS) to be housed in the recently founded Scott Institute for Energy Innovation at CMU. The simulator will use

- the real world NIST microgrid to collect measurements and practice the controls generated by the high-performance computing (HPC) simulator, and
- the HPC simulator to amplify the NIST lab grid to a "large-scale" grid.

We plan to demonstrate solutions to the following representative emerging problems through this project:

- Balancing electricity from intermittent resources by means of adaptive load management;
- Self-reconfiguration in response to sudden changes in supply and/or physical outages;
- Assurance of secure retail power supply;
- Secure control against cyber-attacks;
- DyMonDS-based control architecture to ensure system stability; and,
- Demonstrating end-to-end DyMonDS-based control architecture using real-world data given in [11].

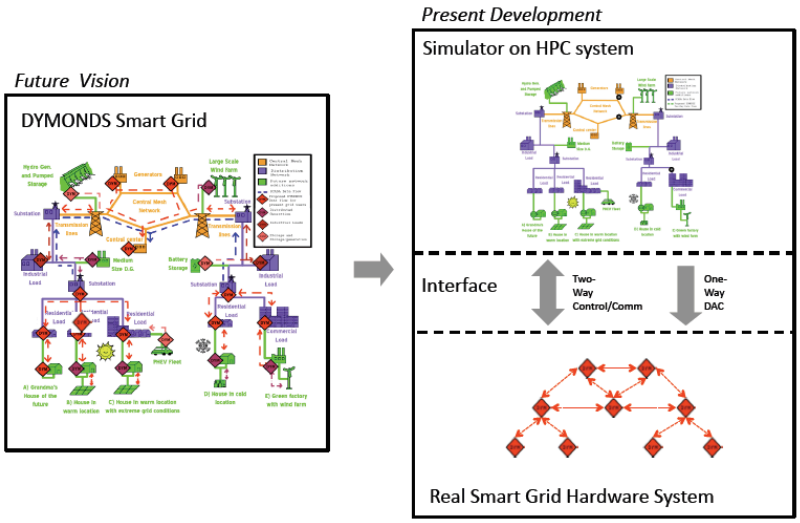

Figure 1. DyMonDS-Enabled Smart Grid as the Basis for the Smart Grid in a Room Facility

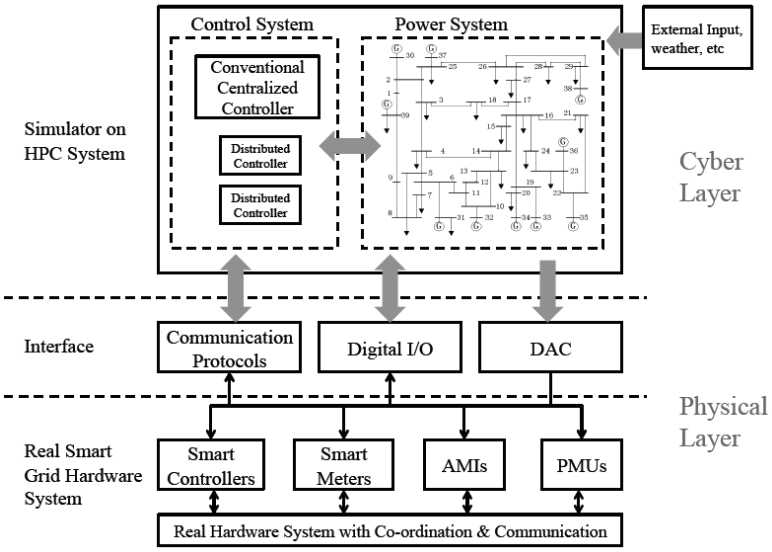

Figure 2. High-performance computing (HPC) Hybrid Smart Grid in a Room Facility: Physical Layers at NIST and Elsewhere

Related publications:

1. Ilic, Marija; Xie, Le; Joo, Jhi-Young, "Efficient Coordination of Wind Power and Price-Responsive Demand Part I: Theoretical Foundations," *IEEE Transactions on Power Systems*, v.26, no. 4, Nov. 2011, pp. 1875-1884.
2. Ilic, Marija; Xie, Le; Joo, Jhi-Young, "Efficient Coordination of Wind Power and Price-Responsive Demand Part II: Case Studies," *IEEE Transactions on Power Systems*, v.26, no. 4, Nov. 2011, pp. 1885-1893.

3. Rotering, Niklas; Ilic, Marija, “Optimal Charge Control of Plug-In Hybrid Electric Vehicles In Deregulated Electricity Markets,” *IEEE Transactions on Power Systems*, vol. 26, No. 3, 2011, pp. 1021-1029.
4. Xie, Le; Carvalho, Pedro Ferreira; Luis, F.M.; Liu, Juhua; Krogh, Bruce; Popli, Nipun; Ilic, Marija, “Wind Integration in Power Systems: Challenges and Possible Solutions,” *Proceedings of the IEEE*, Special Issue on Network Systems Engineering for Meeting Energy and Environment Future, vol. 99, no.1, January 2011, pp. 214-230.
5. Zhang, Yi; Ilic, Marija; Tonguz, Ozan, “Mitigating Blackouts via Smart Relays: Machine Learning Approach,” Special Issue on Network Systems Engineering for Meeting Energy and Environment Future, ibid, pp. 94-118.
6. Kulakarn, Siripha; Ilic, Marija, Chapter 18, in Reference [11].
7. Thoma, C; Cui, Tao; Franchetti, Franz, “Privacy Preserving Smart Metering System Based Retail Level Electricity Market,” *Power and Energy Society General Meeting (PES)*, *2013 IEEE*, vol., no., pp.1,5, 21-25 July 2013.
8. Cui, Tao; Franchetti, Franz, "A multi-core high performance computing framework for probabilistic solutions of distribution systems," *Power and Energy Society General Meeting, 2012 IEEE*, vol., no., pp.1,6, 22-26 July 2012.
9. Ilic, M., “Dynamic Monitoring and Decision Systems for Enabling Sustainable Energy Services,” *Proceedings of the IEEE*, Special Issue on Network Systems Engineering for Meeting Energy and Environment Future, vol. 99, no.1, January 2011, pp. 58-79.
10. Ilic, M.; Joo, J.-Y.; Xie, L.; Prica, M.; Rotering, N., “A Decision-Making Framework and Simulator for Sustainable Energy Services,” *IEEE Transactions on Sustainable Energy*, vol. 2, No. 1, January 2011, pp. 37-49.
11. Ilic, Marija; Xie, Le; Liu, Qixing, *Engineering IT-Enabled Sustainable Electricity Services: The Tale of Two Low-Cost Green Azores Islands*. Vol. 30. Springer Science & Business, 2013.
12. Ilic, M.D.; Zaborszky, J., *Dynamics and Control of Large Electric Power Systems*, Wiley Interscience, May 2000.