VII.14 Dynamic Modeling and Validation of Electrolyzers in Real Time Grid Simulation

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Overall Objectives

- Validation of the benefits of hydrogen electrolyzers through grid services and hydrogen sale to fuel cell vehicles for full-scale deployment
- Characterization of the potential and highest economic value based on the needs of multiple stakeholders for specific grid regions
- Demonstration of the reliable, fast-reacting performance of hydrogen-producing electrolyzers for at-scale energy storage devices
- Verification of the communications and controls needed for successful participation in electricity markets and demand response programs

Fiscal Year (FY) 2015 Objective

- Develop a geographically distributed testbed for real-time simulation of electrolyzer hardware with models of industry-standard transmission and distribution systems

Technical Barriers

This project addresses the following technical barriers from the Technology Validation section of the Fuel Cell Technologies Office (FCTO) Multi-Year Research, Development, and Demonstration (MYRDD) Plan:

(B) Lack of Data on Stationary Fuel Cells in Real-World Operation

(G) Hydrogen from Renewable Resources

(H) Hydrogen and Electricity Co-Production

Contribution to Achievement of DOE Technology Validation Milestones

This project will contribute to achievement of the following DOE milestones from the Technology Validation section of the FCTO MYRDD Plan:

- Milestone 3.9: Validate large-scale system for grid energy storage that integrates renewable hydrogen generation and storage with fuel cell power generation by operating for more than 10,000 hours with a round-trip efficiency of 40%. (4Q, 2020)

APPROACH

In order to meet project objectives, a 120-kW electrolyzer is being used, located at the National Renewable Energy Laboratory's (NREL's) Energy Systems Integration Facility. A simulation model of the distribution system is hosted in a computer located at NREL connected to a Real-Time Digital Simulator (RTDS®), and a simulation model of the transmission system is hosted in a computer located at INL, also connected to an RTDS®. RTDS®-to-RTDS® communication is established for simulation of both the transmission and distribution system in real time. A schematic for the distributed co-simulation is shown in Figure 1. In FY 2016, the electrolyzer will be connected to the distribution system. Using this power hardware-in-the-loop (PHIL) strategy, it will be possible to quantify the value of fuel cells and electrolyzers from specific grids and hydrogen refueling stations, and meet other objectives of the project.

FY 2015 ACCOMPLISHMENTS

- Completed the RTDS® model of Institute of Electrical and Electronics Engineers (IEEE) 13 node feeder system with electrolyzer [1,2]
- The model was sent to NREL and was utilized during the RTDS®-to-RTDS® demonstration to Dr. Danielson (Assistant Secretary, U.S. Department of Energy)

FUTURE DIRECTIONS

- Develop and test the 120-kW electrolyzer interface with RTDS® at NREL; develop final details of the locations that will be simulated and tested within the San Francisco Bay area served by Pacific Gas and Electric (PG&E)

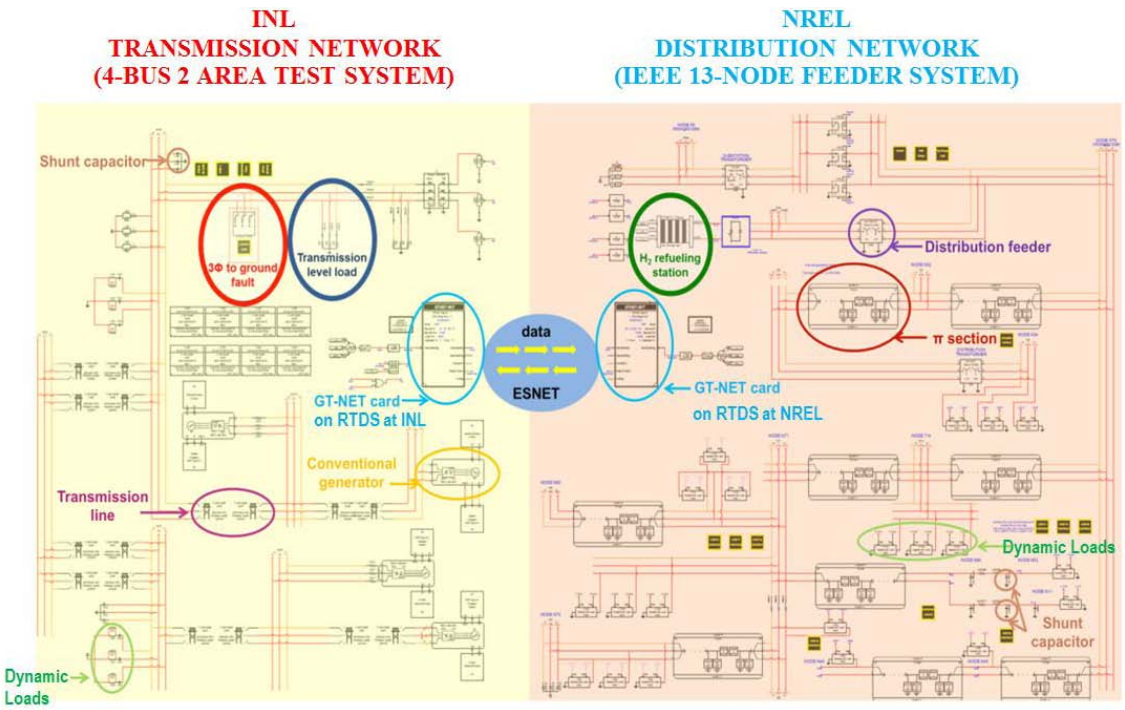

FIGURE 1. Representation of the simulation model spread across INL and NREL

- Perform distributed real-time PHIL simulations with the electrolyzer connected to the IEEE 13 node-based microgrid that is modeled as part of FY 2015 work
- Develop suitable PG&E distribution network model in RTDS® and dynamically test scenarios under existing demand response programs
- Modify the PG&E distribution network model (expand) in RTDS® in order to accommodate future refueling stations as planned in the San Francisco Bay area served by PG&E
- Perform distributed real-time simulation for the expanded distribution networks with future refueling stations under novel demand programs

SPECIAL RECOGNITIONS & AWARDS/ PATENTS ISSUED

1. Geographically distributed co-simulation using RTDS was covered in *SmartGrid News* (May 6, 2015).

REFERENCES

1. Kersting, W.H. "Radial distribution test feeders." *Power Engineering Society Winter Meeting, 2001. IEEE*. Vol. 2. IEEE, 2001.

2. Kuffel, R., et al. "RTDS-a fully digital power system simulator operating in real time." *WESCANEX 95. Communications, Power, and Computing. Conference Proceedings, IEEE*. Vol. 2. IEEE, 1995.