

Development of Integrated Transmission, Distribution, and Communications Models

CHALLENGE

Industry must better understand the interdependencies among grid subsystems—the transmission, distribution, and communication, or TDC, domains—which will give them the confidence to deploy new systems. To illuminate these interdependencies, integrated modeling and simulation capabilities, which currently do not exist, need to be developed.

For example, as distributed energy resources, such as smart loads, distributed energy, and storage, proliferate and integrate with the power grid, the electricity industry has become increasingly concerned about impacts on the nation's power system. To maintain—even improve—the power system's reliability, resiliency, and cost efficiency, new control and protection systems combined with communications networks must be developed and deployed so that all the domains can “talk” with each other.

APPROACH

National laboratory partners are collaborating to develop a flexible and scalable open-source simulation framework. The framework comprises a set of software modules and coupling methods that readily link simulation tools for each separate TDC domain. The tools are being integrated to simulate regional and interconnection-scale power system behaviors at unprecedented levels of detail and speed.

This team effort aims to link a 50,000-node transmission system with millions of distribution nodes, coupled with 100,000 communications points. The simulation framework will help utilities, planners, researchers, and additional stakeholders more quickly and completely understand the implications of integrated power system planning or coordination of power and communication systems. And integration, rather than building a simulator from the ground up, will allow for reuse of tools that typically come with years' worth of validation and experience.

Leveraging best-in-class simulation and high-performance computing capabilities available at the national laboratories, project activities include:

- Engaging industry stakeholders to design the framework, develop guiding documentation, and provide feedback from using the framework.

At-A-Glance

PROJECT LEADS

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BUDGET

\$4 million

DURATION

April 2016 – October 2018

TECHNICAL AREA

Design and Planning

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Developing and deploying an initial prototype framework as well as two versions with improved algorithm and computing capabilities (based on

feedback from use on the prototype and version 1 capabilities).

EXPECTED OUTCOMES

The results of this modeling and simulation effort will:

- Enable better informed decisions about the investments necessary to support data and communication needs relative to modernizing grid subsystems.
- Allow exploration of future scenarios in a variety of applications, such as integration of clean energy and distributed control.
- Allow power system planners to understand the bottlenecks and pitfalls among the TDC domains.
- Provide decision makers with quantified impacts on system reliability and costs to increase confidence in designing the future grid, minimize outages and associated costs, operate with a leaner power reserve margin, and increase penetration of renewable energy.

Example use cases include:

- Wide-area control and protection relies on high-speed, robust communications. Network-induced delays, data packet dropouts, and packet disordering can affect the behavior of these systems in adverse ways. Co-simulation allows researchers to explore the implications of communication issues for power system

- performance and adapt the control systems prior to deployment or field demonstrations.
- Retail markets and Distribution System Operators (DSOs) have been proposed in multiple states to manage the deployment and operations of DERs, while also increasing customer engagement. Interactions between wholesale markets and retail markets can lead to market instability, if the systems are not properly coordinated across the Independent System Operator-to-DSO boundary. Co-simulation allows planners to evaluate the performance of connected markets to ensure proper operations.
- Smart inverters, both at sub-transmission and distribution levels, offer a new and valuable resource for managing voltage constraints throughout the power system. Without proper coordination of these devices, voltage instability or oscillations between controllers can occur. Co-simulation allows researchers to explore the interaction of these control systems across transmission and distribution boundaries while also assessing the impact of decentralized versus centralized control, and the communication requirements needed to support them.

LAB TEAM



Launched in November 2014 under the U.S. Department of Energy's Grid Modernization Initiative, the GMLC is a strategic partnership between DOE Headquarters and the national laboratories, bringing together leading experts and resources to collaborate on national grid modernization goals. The GMLC's work is focused in **six technical areas** viewed as essential to modernization efforts:

Devices and Testing | Sensing and Measurements | Systems Operations and Control
Design and Planning | Security and Resilience | Institutional Support