System Operations, Power Flow, and Control—Overview

As the nation’s electric grid transitions from one that is centrally controlled, with one-way delivery of power from central-station power plants, into one that features both distributed generation and distributed control systems based on advanced communications, new approaches are needed to enhance reliability and efficiency. The opportunity exists to harvest advanced technologies to optimize the operation of the system and react to off-normal conditions in a way that preserves system reliability and improves resilience.

The “System Operations, Power Flow, and Control” focus area has three main activities designed to support innovation and advancements in these technologies. Each activity has specific goals and target achievements to be completed by 2020.

Activity 1: Develop a New System Architecture and Control Theory

Goal: The existing grid architecture has developed organically and has grown so complex that it is impossible to make any significant change with a full understanding of the consequences. To address this issue, this activity will develop a modern grid system architecture and an associated control theory.

Target achievements:

- Develop an architectural model that encompasses all major elements of the grid and allows people from various industry segments and geographic regions to view the grid in the most appropriate way for them.
- Develop advanced control theories and algorithms—including wide-area control strategies—to improve grid flexibility, adaptability, and resilience, while not compromising reliability or security.

Activity 2: Develop Coordinated System Controls

Goal: Create a next-generation grid operating system that functions like an autopilot system. Through grid-level integration of Energy Management Systems (EMS), Distribution Management Systems (DMS), and Building Management Systems (BMS), this system will operate with less reserve margin, dramatically enhancing the energy and economic efficiency of the system.

Target achievements:

- Develop a prototype, next-generation EMS that has fast and automated control mechanisms to allow the grid to be operated reliably, even without full backup capacity for all the power being transmitted (the so-called N-1 criterion).
Incorporate probabilistic risk-based approaches into the next-generation EMS, DMS, and BMS platforms and develop a framework for integrating the platforms.

**Activity 3: Improve the Analytics and Computations for Grid Operations and Control**

**Goal:** Power systems are operated today using the same conservative approaches that have been used for decades, resulting in an underutilized grid infrastructure, higher energy costs to consumers, and expensive or difficult deployment of new grid technologies. This activity will develop a new suite of power grid analytics for grid control and system modeling and will draw on parallel and distributed computing algorithms run on advanced computational platforms.

**Target achievements:**

- Evaluate current and future grid operating conditions to make decisions in short time frames, despite a high degree of uncertainty in system inputs.
- Automate grid protection and control with predictive capabilities, advanced computations, and parallel processing, including the non-linear optimization of highly stochastic processes.
- Provide decision support to control room operators through advanced, much faster computations and pinpoint visualizations for situational awareness.

**Activity 4: Develop Enhanced Devices for Power Flow Control**

**Goal:** Develop low cost, efficient, and reliable power electronic devices for power flow control, potentially eliminating wasteful loop flows and helping to decrease grid congestion.

**Target achievements:**

- Draw on wide-bandgap devices and inverter-coupled technologies for power flow control, enabling them with advanced controls, communication protocols, and computational methods.
- Following tests and simulations, publish a report detailing the potential operational and economic impact of employing advanced power electronics to control power flows on the grid.