**Visualization and Analysis of Grid-Cyber Systems Security**

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**National Renewable Energy Laboratory (NREL)**

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## Overview

Increasing penetration of renewable energy, energy storage, controllable loads and electrified transportation on the electric grid are causing a generational and operational change in how the grid is designed and operated. Smart electric inverters, critical to enabling this transformation, utilize a level of communication and control not previously required. While enabling grid control through communication networks, these changes are exponentially increasing the cyber vulnerability surface. NREL’s Secure Cyber-Energy Systems Group is developing environments that combine emulated communication and power systems with real-physical grid devices to construct virtual grids, utilities, cites or regions to study threats, vulnerabilities, mitigations, analyses and visualizations. An overview will be provided of how this environment, NREL’s Energy Systems Integration Facility and Flatirons Campus are being interconnected to develop these environments to support future grid cybersecurity research and development efforts.

## BIOS

**Dr. Md Touhiduzzaman** is an energy cyber-physical security researcher in the Secure Cyber-Energy Systems group at NREL. In NREL, he co-lead the research and development of the DERCF tools and NAERM communication effort. In developing the DERCF tool, Dr. Touhiduzzaman assisted with technical and physical security research for DER cybersecurity and leading the effort to combine the risk management framework in DERCF webtool. Touhiduzzaman received his PhD in electrical engineering from Washington State University (2019) and Tuskegee University (2015), respectively; and received his BSc degree in electrical engineering from Bangladesh University of Engineering and Technology, Bangladesh (2009).

**Dr. Dane Christensen** serves as Principal Engineer for Energy Security and Resilience at NREL. His research focuses on identifying and mitigating cross-infrastructure dependencies, which lead to unanticipated vulnerability to natural hazards and man-made threats. Since joining NREL in 2008, Dane primarily studied Internet of Things, data-driven controls and analytics, and grid-interactive residential building solutions. He led pioneering work in home energy management, resulting in a 2018 R&D100 award for the foresee™ technology. He has over 50 peer-reviewed publications, four issued patents, and other innovative ventures. Dane received a PhD in mechanical engineering from University of California, Berkeley, and his BS in mechanical engineering from Rice University.