Smart Reconfiguration and Protection in Advanced Electric Distribution Grids

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Fourth International Grid Simulator Testing Workshop,
National Renewable Energy Laboratory, Golden, CO, USA
April 25-26, 2017

Outline

- Smart Reconfiguration
- Protection Systems
- Demonstration Project in Idaho Falls Power Grid
  - Project Objectives & Partners
  - Distribution Grid Overview
  - Critical Loads
  - Micro-PMUs
  - Hardware-in-the-Loop Testing
  - Co-simulation with Communication
- Concluding Remarks

Smart Reconfiguration

- **Reconfiguration**
  - **Concept**
    - (Initiate) Change in topology → OPEN/CLOSE Breakers
  - **Criteria**
    - Can be multiple (Economic, Load served, Operation-based Criticality, Reliability, Resiliency)
    - Short-term (Instantaneous), Longer-term ('x' hour-ahead)
  - **Constraints**
    - Physical stability (Steady-state, Dynamic)

Smart Reconfiguration

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- **[+] *Smart* Reconfiguration for Advanced Electric Distribution Grids**
  - Advanced measurement (micro-PMUs)
  - (near) Real-time decision-making: Pre-programmed, On-line
  - Under the conditions: Local generation, Bi-directional power flow, Adaptive protection

Protection Systems

- Some special considerations
  - Local generation, bi-directional power flow
  - Micro-PMUs
  - Adaptive or setting-less schemes
- Practical Challenges
  - Including micro-PMUs for protection systems
  - Communication and control
    - Synchronization of high sample rate data
    - Communication channel
  - Protection scheme co-ordination

Demonstration Project in Idaho Falls Power Grid

- Develop methods for keeping as much of the system operating as possible during system events at transmission or distribution level by using functionalities such as **smart reconfiguration**, controlled and seamless **islanding**, intelligent demand response utilizing loads as a resource, **black start** for emergency, and **resynchronization** in presence of DERs
- Provide a **generalized roadmap**, including **best practices**, based on **regional case for IFP**, which utilities and system operators across the United States can apply to their respective distribution networks
- Show effectiveness of implemented **smart reconfiguration** by comparison with existing power system performance

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WASHINGTON STATE UNIVERSITY

Idaho Falls Power

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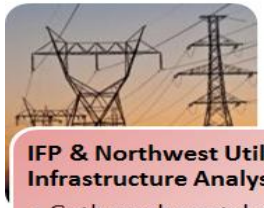
Demonstration Project in Idaho Falls Power Grid

Grid Modernization project 1.3.09

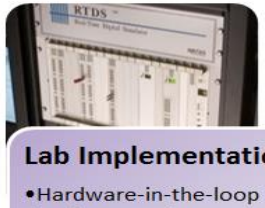


IFP & Northwest Utility Infrastructure Analysis

- Gather relevant data from IFP & other stakeholders
- Existing distribution model development

Develop Advanced Reconfiguration and Protection Algorithm

- Sensor placements, islanding for better quality of service
- Measurement based control



Lab Implementation

- Hardware-in-the-loop implementation
- Simulate Grid Events and Scenarios
- Embed the validated algorithms in hardware

Future Work

[IFP Lead, INL Support]

Future Idaho Falls Power hardware deployment

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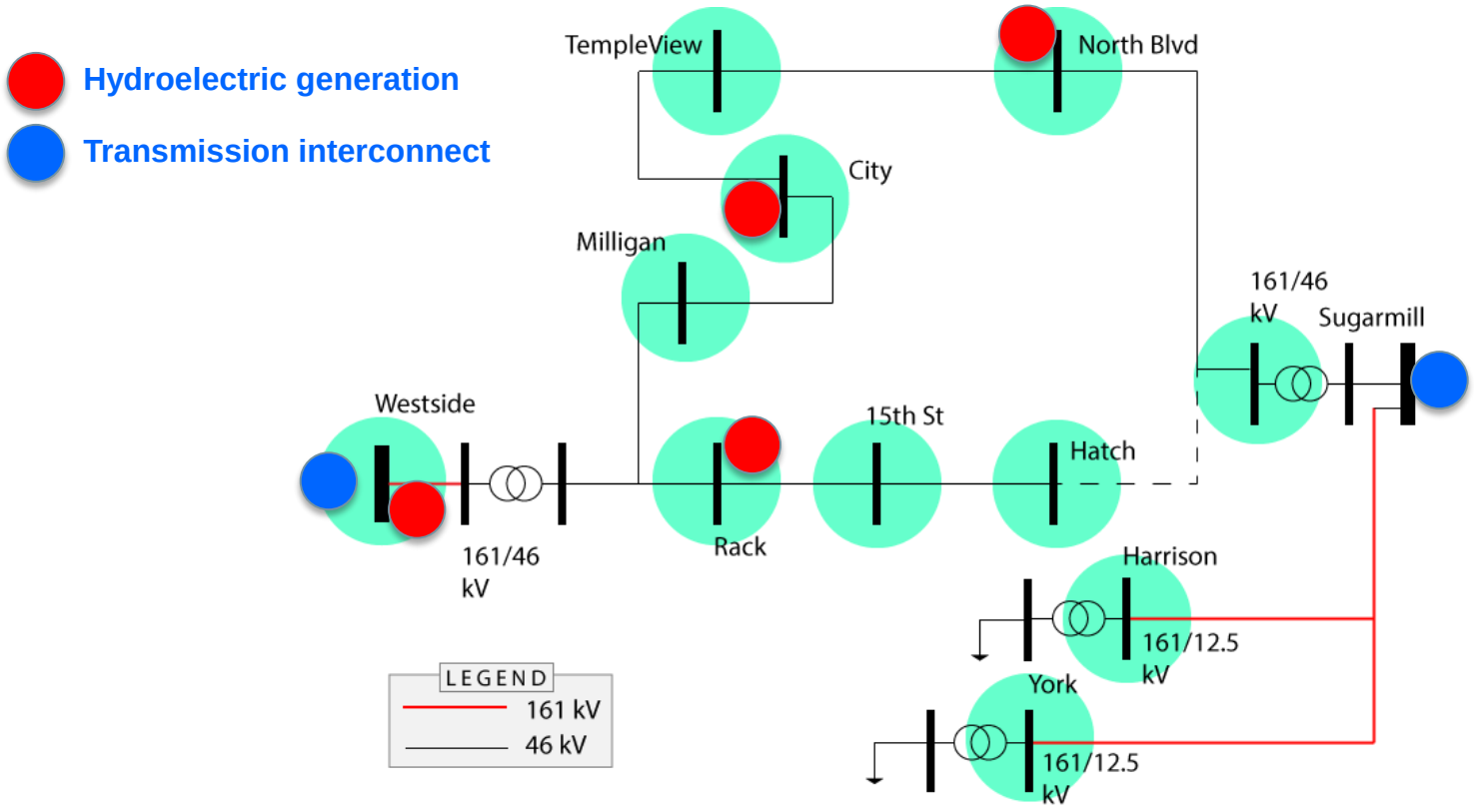
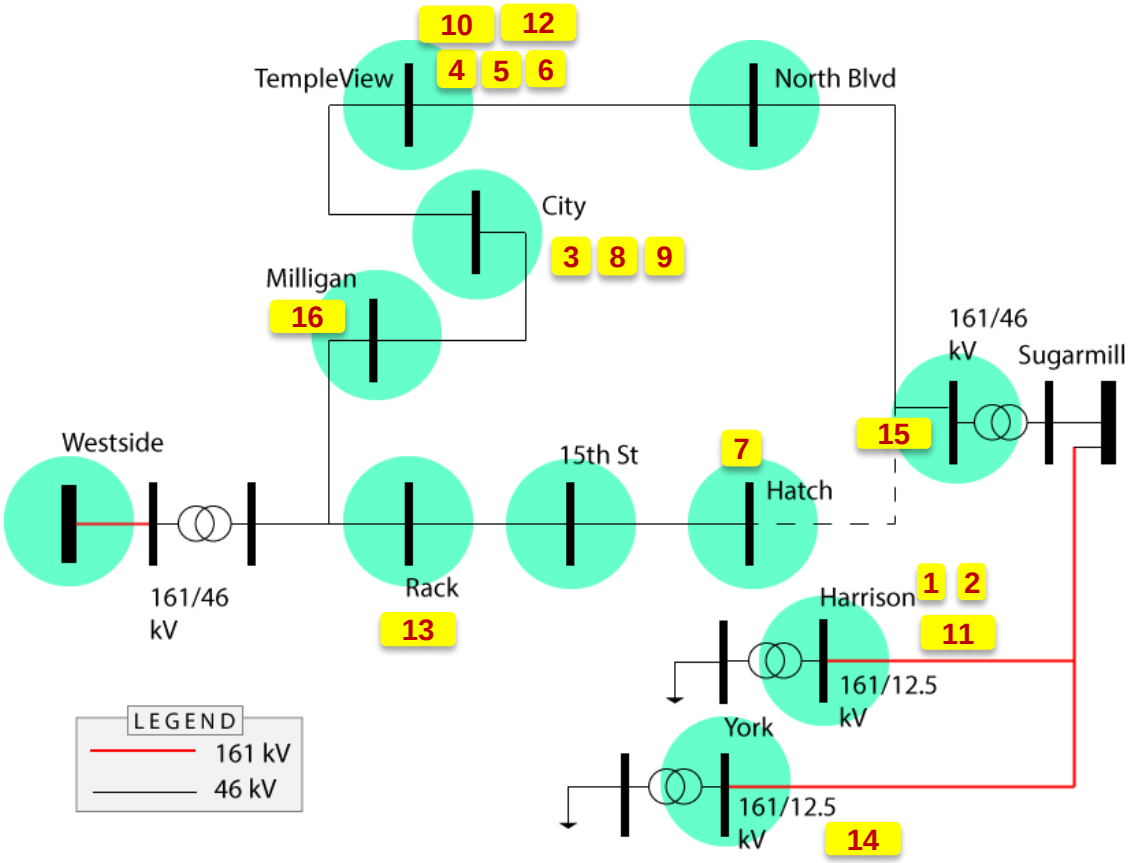
Idaho Falls Power Distribution Grid Overview

- 4 hydroelectric generators ~25% local load demand
- 2 transmission interconnects
- Currently not configured to operate in islanded mode



Critical Loads

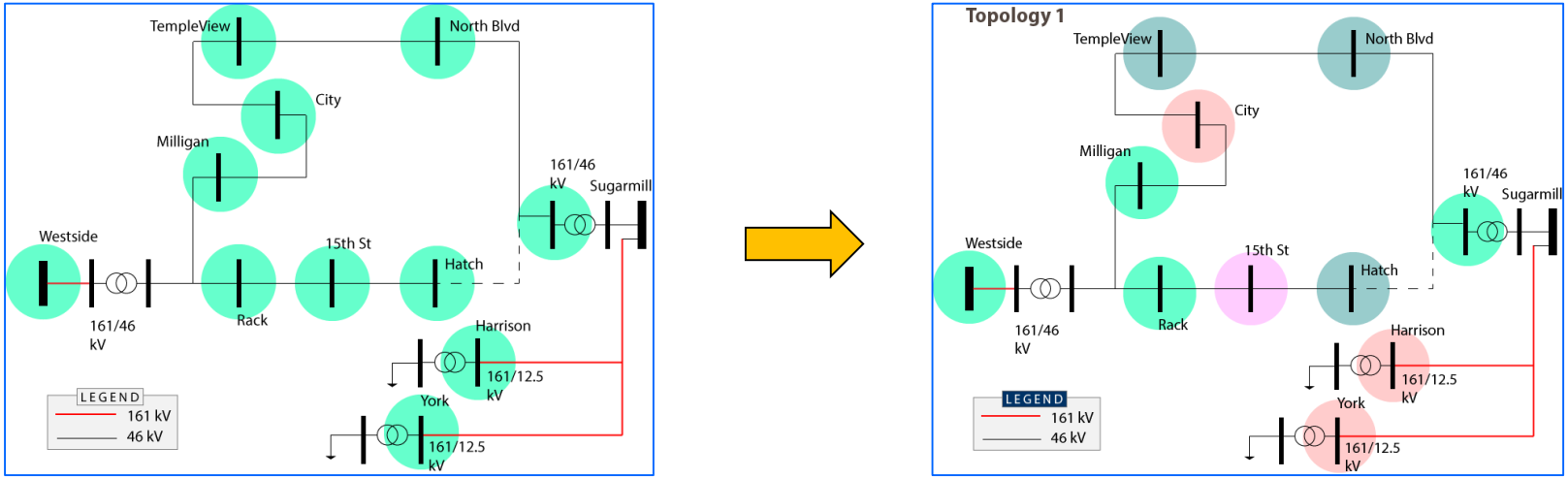
- Critical loads as identified by Idaho Falls Power



Priority	Description
1 – 4	**Very High Priority Loads** (*Examples*: Hospitals, Control/Command center, Emergency Response/Dispatch)
5 – 9	**High Priority Loads** (*Examples*: Airport, Correctional Facilities, Police Department, Fire Station)
10 – 12	**Medium Priority Loads** (*Examples*: Fire Station, State Services)
13 – 16	**Low Priority Loads** (*Examples*: Water Treatment, Community Care)

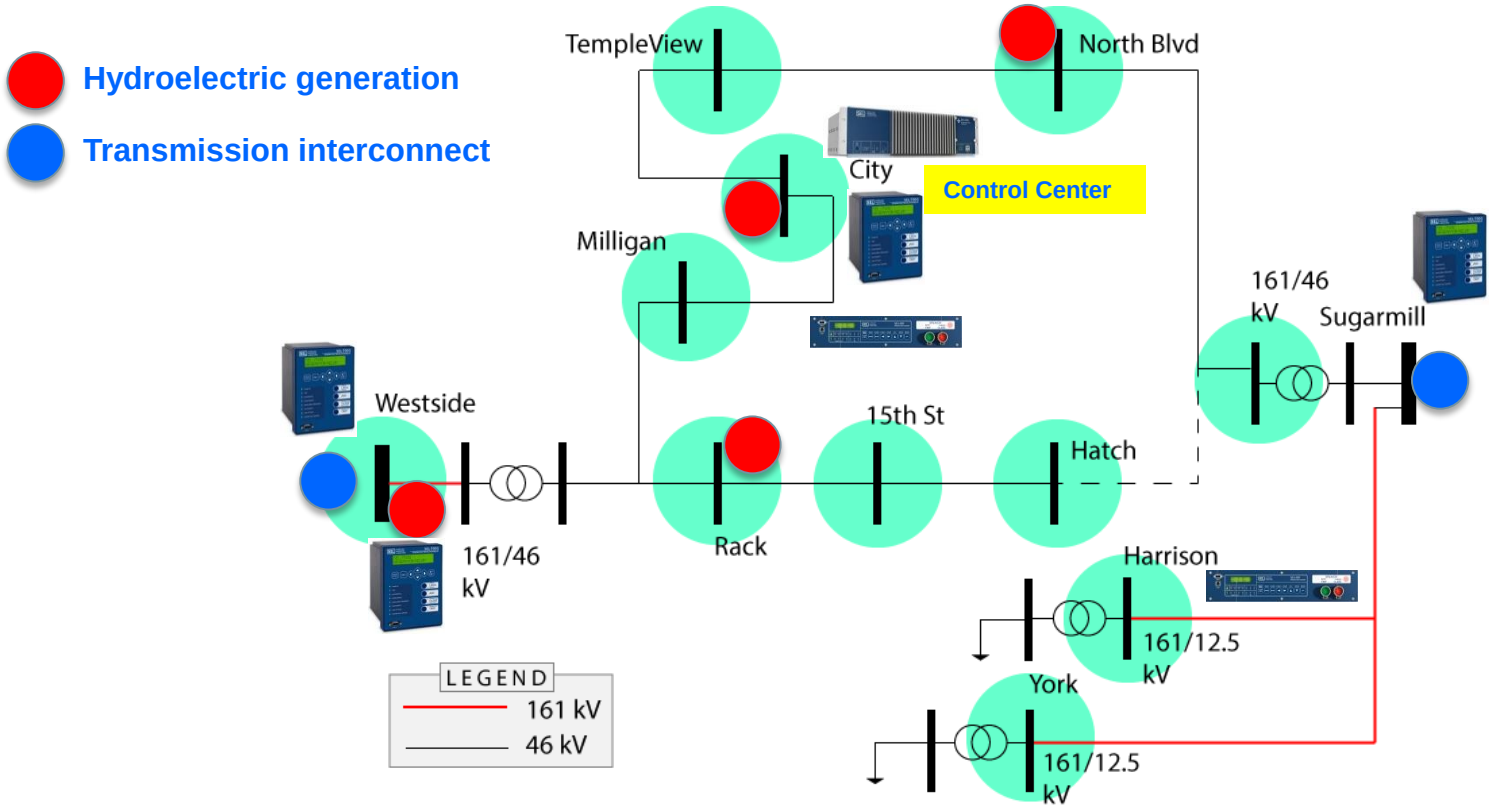
Distribution Level PMUs

- Placement and use of micro-PMUs
  - An approach: State-estimation under topology changes (steady-state)
  - *Criticality-based*
  - *Dynamics-based*



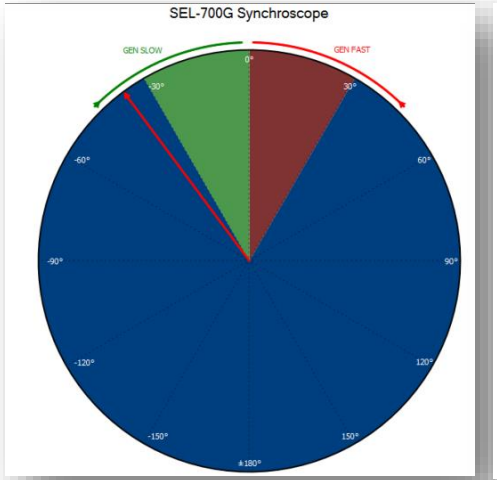
Hardware-in-the-Loop Testing

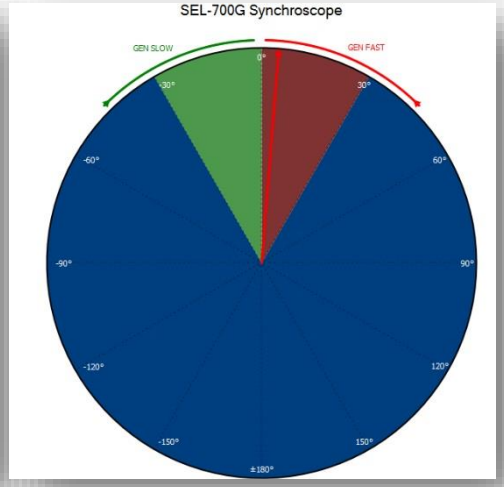
- Hardware provided by SEL
  - six relays and one controller are proposed to be tested as HIL

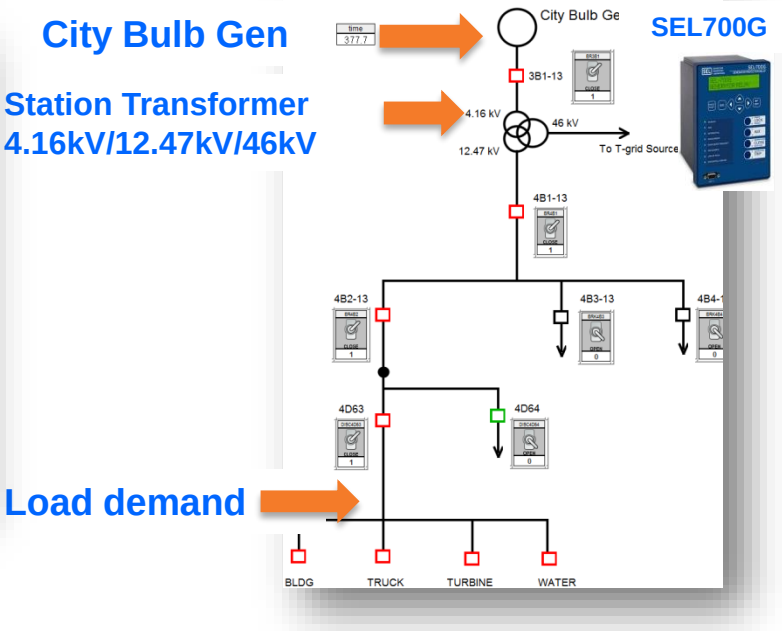


Hardware-in-the-Loop Testing

- Black Start scenario is investigated to test synchronization of City Bulb generator to grid while serving the local command center critical loads
- Synchronization controls are modeled in RTDS-RSCAD for seamless resynchronization
- SEL 700GT+ Relay is used as HIL interfaced with RTDS

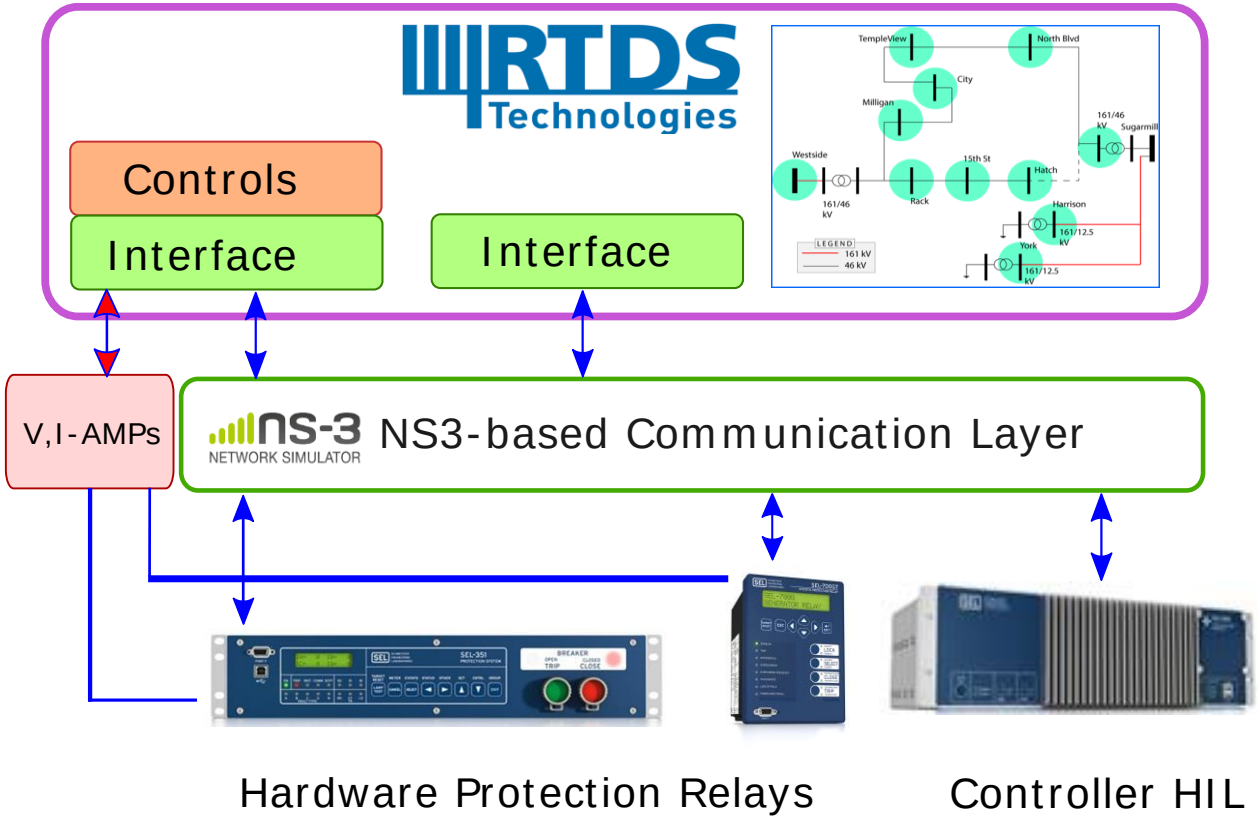






Co-simulation with Communication

- NS3-based communication layer is emulated for co-simulation of power systems and control/communication network between hardware devices



Concluding Remarks

- Advanced measurement-based approach for
  - Maintaining supply to critical loads during loss of generation due to faults/events
  - Improved reliability and resiliency in advanced electric distribution grids
- Integrated Real-time HIL testing for smart **reconfiguration** and **protection** system
- Hardware controller implementation/testing of **smart islanding**, **resynchronization**, and **black startup** algorithms
- Optimal co-ordination of schemes under real-time operation
- **Successful implementation:** Generalized approach for developing and deploying advanced distribution grid

THANK YOU & QUESTIONS

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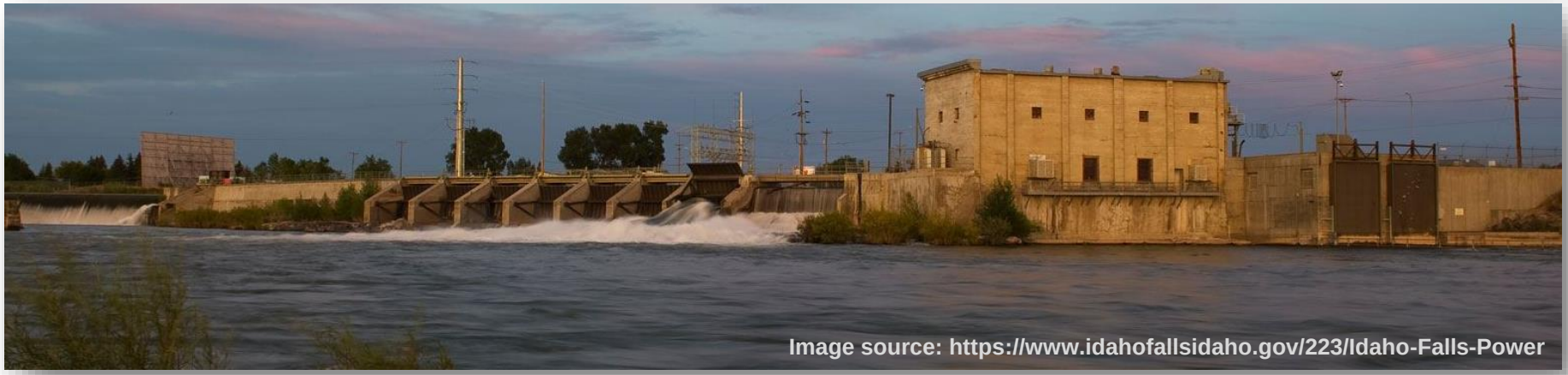

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