Power and Energy Research Lab

Our mission:

- To develop novel solutions and technologies in the area of smart grid and grid modernization for having a reliable, resilient, secure, affordable, and sustainable energy system.

Lab Assets (Hardware)

- Digital Real-Time Simulators
  - RTDS: 9 racks
    - EMT with 50 µs timesteps: practical capacity ~**3,500** nodes
    - Phasor domain (electromechanical) 10 ms timesteps: practical capacity ~**400,000** nodes
  - OPAL-RT HYPERSIM (16 cores)
    - EMT with 50 µs timesteps: practical capacity ~**2,500** nodes
    - Phasor domain (electromechanical) 10 ms timesteps: practical capacity ~**86,000** nodes
- Intelligent electronic devices
- Substation automation devices
- Amplifiers
- Bidirectional DC power supply
- Regenerative AC load
- Control room LED wall
- Protection and control devices by SEL, ABB, GE, Basler
- Communication network emulator
- Precise time and networking equipment
- Physical and virtual workstations

Lab Assets (Software)

- EMTP
- PSCAD
- RSCAD
- RT-LAB
- OpenDSS
- MATLAB

- eHSx128 - Power electronics simulation toolbox
- ARTEMiS - Includes VBR machine, protection relay and smart inverter libraries
- eMEGASIM
- ePHASORsim
- Optimization solvers (GAMS/Knitro, BARON, etc.)
- LCA database (Ecoinvent 3.11)

Cyber-Physical Power System Testbed

Physical	Monitoring & Communication	EMS & Decision Making
1. Power Systems Physical Layer (RTDS and Opal-RT) Layer 2. Power Amplifier Layer	1. Relays & Monitoring Devices Layer 2. Communication & Cyber Layer	1. Stead-state and Dynamic Tools, OPF, SE, DSA, etc. 2. Cyber-Physical Awareness

Lab Capabilities and Value Propositions for Users

❖ Almost all lab assets can be accessed **remotely** as well

1. Real-Time Simulation and Hardware-in-the-Loop (HIL) Capabilities

- Real-time HIL relay testing for protection and control applications.
- HIL studies with inverter-based resources (IBRs), distributed energy resources (DERs), battery energy storage systems (BESs), and electric vehicles (EVs).
- HIL testing for asset controller tuning, validation, and certification.
- Co-simulation of transmission–distribution–DER interactions under high renewable penetration.
- Validation of grid-forming inverter controls and adaptive protection schemes.

2. Cyber-Physical Security and Automation

- Power system cybersecurity studies, including malware detection, impact analysis, and mitigation strategies.
- Cyber-resilient control algorithm design and validation using physical and network emulation.
- End-to-end substation automation and protection coordination testing.
- Secure communication architecture evaluation and resilience testing under coordinated cyber–physical attacks.

Lab Capabilities and Value Propositions for Users Cont.

3. Renewable Integration, Microgrids, and Emerging Applications

- Microgrid research for off-grid communities, military bases, mining operations, and data centers.
- Integration and control of hybrid renewable systems and energy storage in grid and islanded modes.
- Dynamic performance evaluation of IBRs and hybrid plants during disturbances.
- Validation of grid-supportive inverter functions for voltage, frequency, and resilience enhancement.

4. Grid Planning, Resilience, and Climate Adaptation

- Resilience assessment and restoration strategy validation under extreme weather and contingency scenarios.
- Grid modernization and investment planning using stochastic and optimization-based scenario analysis.
- Climate impact modeling on grid operations by integrating weather, wildfire, and load data into simulations.
- Development of digital twins of the electricity grid for real-time monitoring and resilience assessment.

Lab Capabilities and Value Propositions for Users Cont

5. Data Analytics, AI, and Optimization

- AI-driven anomaly detection and predictive maintenance using real-time simulation data.
- Integration of optimization solvers (GAMS/Knitro, BARON, etc.) for operational decision support (dispatch, reconfiguration, storage management).
- Probabilistic and machine learning–based grid forecasting, diagnostics, and asset health assessment.

6. Education, Training, and Technology Demonstration

- Hands-on workforce training for utilities and industry partners in protection, automation, and cybersecurity.
- Live demonstrations of smart grid, HIL, and cyber-physical applications for education and outreach.
- Cross-disciplinary projects integrating engineering, data science, and sustainability principles.

Contact us

Hanif Livani
Associate Professor
hlivani@unr.edu

Mahdi Mehrtash
Assistant Professor
mahdim@unr.edu