America’s Electric Cooperatives

- Serve 42 million people in 47 states through 65 generation & transmission (G&T) co-ops and 840 distribution co-ops
- Own and maintain 42% of the nation’s distribution lines
- Average 7.4 consumers per mile of distribution line
Objective: Develop and demonstrate new technical capabilities that directly address challenges faced by electric cooperative utilities.

Funded by cooperative member dues, U.S. Department of Energy (OE, EERE, and ARPA-E), and U.S. Department of Defense (DARPA).

Strategic focus areas:
- Utility data analytics
- Grid cybersecurity

Research projects are usually collaborative partnerships with universities, national laboratories, utility vendors, and cooperative utilities.
Emerging Grid Requirements

- Enabling distributed & renewable generation
- Facilitating changing consumer demands (incl. vehicles)
- Mitigating aging infrastructure impacts
- Accommodating changing central generation mix (increasing natural gas generation)
- Managing rapidly evolving cybersecurity threats
- Increasing critical infrastructure resiliency
New Technologies for New Challenges

Distributed Energy Resources
MV & HV Solid State Power Electronics
Advanced Optimization Algorithms
Advanced Architectures & Agile Control
Advanced Analytics
Advanced Communications
Advanced Sensors
Sensors at Distribution Cooperatives

- AMI installed nearly everywhere*
- SCADA used by the majority of co-ops
- Communications support:
  - Existing deployments primarily use PLC (1-5 baud)
  - Wireless RF gaining more widespread use
  - Fiber deployments growing rapidly from demand for rural high-speed internet
- Falling DPMU costs suggest power quality monitoring opportunities.
- A lot more can be done with data from existing sensors!

*Source: 2013 Co-op Technology Survey, NRECA Market Research Services
Challenges:

- Backhaul and data storage.
- Security.
- G&T–D interfaces.
- System integration.
- Developing end-use applications:
  - Planning
  - Operations
• Sensor data key input to planning models

• Software results put in to free and open source electric utility modeling software, Open Modeling Framework (OMF, https://www.omf.coop)

• Built by the co-ops and the US Department of Energy

• Offers models to determine:
  • Cost-benefit and engineering analysis models for multiple DERs (solar, energy storage, etc.)
  • Full distribution and transmission dynamic powerflow simulation
  • Supporting tools in Python for data import, conversion, simulation and visualization

• Users from 176 organizations (utilities, vendors, universities, national labs) as of June 2017.
Planning Application: Volt-VAR Optimization

- Inputs:
  - AMI or SCADA data (used to calibrate load models)
  - CYMDIST or Windmil models (converted automatically to open format)
- Key results:
  - Quasi-static time series (QSTS) simulation run via GridLAB-D
  - VVO control scheme evaluated over multiple seasons
  - Control algorithm comparison to verify reasonable number of control actions of voltage regulators and capacitor banks
  - Peak demand and energy reductions converted to cost impacts
- More information:
Planning Application: Solar Integration

• Inputs:
  • Load and circuit model as before
  • Utility location (used to automatically import historical weather data from NOAA)

• Key outputs:
  • Overvoltage detection for centralized versus distributed solar deployment options
  • Reverse powerflow prediction based on climate and demand
  • Changes to voltage regulation and protective device operation calculated

• More information:
  • Research report: https://goo.gl/41hwXp
  • Try the model: https://www.omf.coop/newModel/solarEngineering/EAC
Planning Application: Energy Storage Valuation

• Inputs:
  • Load, circuit, location data as before
• Key outputs:
  • Calculation of realistic storage dispatch (via forecasting algorithms on top of scikit-learn)
  • Impact of net load on cash flow for the utility based on arbitrage, peak demand reduction or asset capacity deferral approaches
  • Integrated in to full QSTS circuit simulation to calculate interaction with solar, electric vehicles and load control
• More information:
  • Try the storage capacity deferral model: https://www.omf.coop/newModel/storageDeferral/EAC2
• Inputs:
  • Load, circuit, location data as before
  • Extreme weather event spatial impacts (wind speeds, water levels, etc. examples provided)

• Key outputs:
  • Estimated damage to the distribution system calculated via an asset fragility model
  • Given a fixed budget, calculates an optimal set of hardening upgrades (undergrounding, back-feeding, etc.) based on damage models
  • Calculates new switching and control actions for hardened system

• More information:
  • Model overview: https://goo.gl/VauxGd
• Meter reading efficiencies typically provide the cost savings needed to deploy new systems.
• “Long tail” of additional applications added over time.
• Integration costs largest barrier to additional applications.

Source: 2013 Co-op Technology Survey, NRECA Market Research Services
• A system for passively monitoring and analyzing a comprehensive range of data from and about utility electrical and control system operations

• Initial development funded by U.S. Department of Energy and DARPA for cybersecurity anomaly detection

• Objective is to provide utilities and other stakeholders total operational situational awareness

• Passively collects and organizes all communications traffic within utility industrial control system networks

• Distribution PMUs can provide more detailed and timely state awareness
Future Research: Unification of Grid Planning and Operations Software

Grid Configurations
Network Models
Future Scenarios
Utility ICS Topology

Grid Telemetry:
AMI/AMR
SCADA
Distribution PMUs

OMIF
Planning &
Engineering Analysis

Configuration
And Analysis

Calibration Data
Physics Problems

Distribution System
Operations

GridState
Conclusions

• Sensor networks widely deployed at rural electric cooperatives.
• Data integrated into multiple planning applications.
• As backhaul bandwidth increases, operational and control opportunities emerge.

Feedback?
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