Overview for Affiliate Universities

Tom Reddoch
Principal Technical Executive
Power Delivery and Utilization
treddoch@epri.com

2021

www.epri.com

Action Items for Affiliate Universities

- Send an email to Amy Feser at (afeser@epri.com) with the following information:
  - Contact information for primary point(s) of contact including name, email, and phone number
  - Confirmation of logo to use on the GridEd website
  - Questions, concerns, and comments about this initiative

- For more information about GridEd: http://grided.epri.com
- Contact Information:
  - Tom Reddoch –treddoch@epri.com, (865) 456-3708
  - Amy Feser –afeser@epri.com, (865) 218-8051

Electric Utility Workforce Development Drivers and Needs

Electric Power Educational Needs Amid Industry Transformation

Drivers

1. Aging utility workforce
2. Many new hires lack power systems education
3. Power system transformation:
   - Renewables and distributed energy resources
   - Digital communication, cyber security, and data analytics

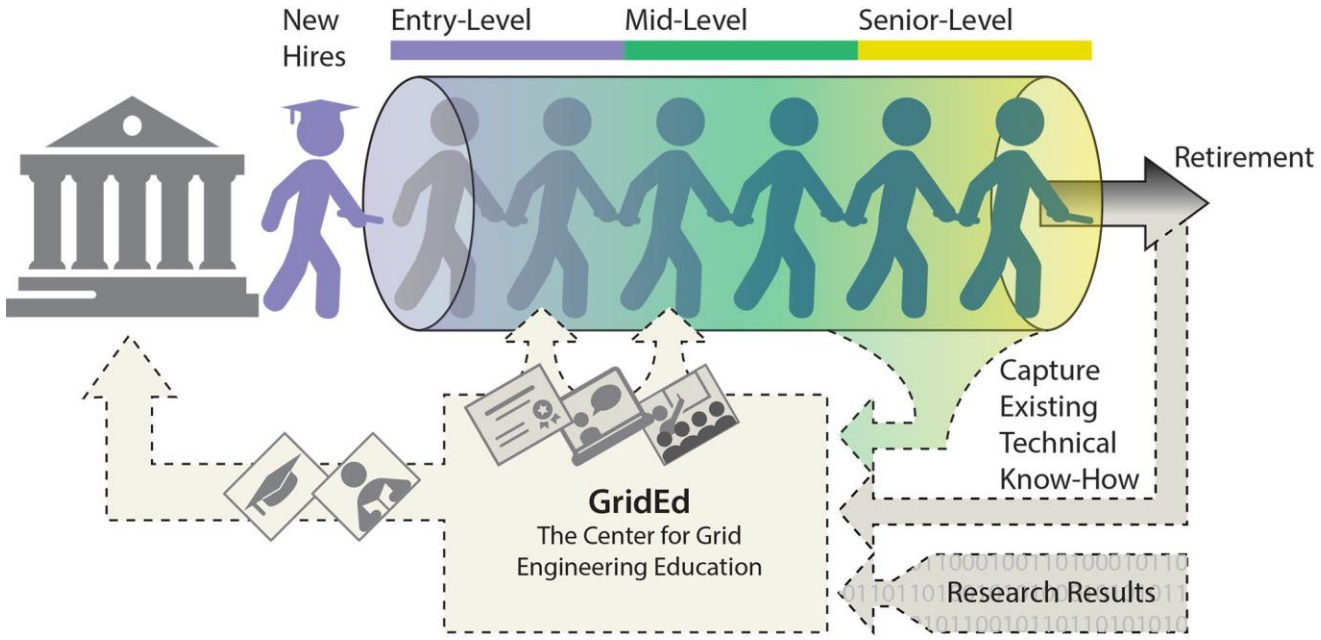
Needs

1. Attract, retain, and train the workforce of the future
2. Elevate fundamentals of power systems education in universities and through professional training
3. Update educational materials with new practices, devices, and paradigms
4. Dedicate resources to continuing education and training on new technologies

Mission & Objectives of GridEd

Educating Future Power Engineers & Data Scientists for the Power Industry

- Build strong relationships between electric utilities and local universities



- Advance workforce knowledge through a robust professional training program
- Engage students to expand the electric utility talent pool of the next generation
- Leverage research in power systems and the smart grid at partner institutions

History

Accomplishments through 2015
- 14 utility advisors, 4 Partner universities, 20 Affiliate universities
- 160 trainees receiving 1,700 professional development hours
- 7 new and revised university courses

Accomplishments through 2018
- 19 utility advisors, 7 Partner universities, 28 Affiliate universities
- 910 trainees receiving 10,000 professional development hours
- 18 new and revised university courses

2013 2014 2015 2016 2017 2018 2019

2013
The U.S. Department of Energy awarded to EPRI and its team a $4.2M project known as Grid Engineering for Accelerated Renewable Energy Deployment (GEARED) which consisted of four university partners in the eastern U.S. and Puerto Rico.

GEARED

2016
The U.S. Department of Energy award to EPRI and its team a $1.0M expansion of the GEARED project call Solar Training and Education for Professionals (STEP) and for GridEd collaborative expanded to the western U.S. to form GridEd-West, adding three more Partner universities.

SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

2019
EPRI was selected to receive a $6.5M award from the U.S Department of Energy to launch the Grid-Ready Energy Analytics Training (GREAT) with Data initiative.

The "GREAT with Data" Initiative

The GREAT with Data initiative will help merge grid Operations Technology (OT) and Information Technology (IT) to enable the integration of distributed energy resources (DER), especially solar, through enhanced industry coordination and workforce readiness initiatives by training, educating, and recruiting qualified personnel into the electric utility industry.

The "GREAT with Data" Initiative – Key Activities

Intersection of digital systems and power systems with focus on DER Integration

Core Elements

- Technical and Human Resource Advisory Committees
- Training Evaluation Pilot
- Regional Training Hubs
- Data Analytics Center of Excellence
- Workshops, Seminars, Conference Engagements

Industry Professionals

- Credentials & Certifications
- Professional Training Courses and Workshops
  - *Cyber Security*
  - *Data Science*
  - *DER Integration*
  - *Information & Communication Technologies*
- Distribution Operations Simulator Training Modules
- AR/VR Training Modules

University Curriculum & Students

- New and Revised University Courses
- Co-developed Course - *Introduction to Digital Power Systems*
- Undergraduate Design Projects
- GEARED Course Repository

GridEd Members

Utility Members *(2014-2019)*

1. Arizona Public Service
2. Arkansas Electric Cooperative
3. Bonneville Power Administration
4. CPS Energy
5. Central Hudson
6. ConEdison
7. DTC Energy
8. Duke Energy
9. EcoElectrica
10. Entergy
11. FirstEnergy
12. LG&K and KU
13. Lincoln Electric System
14. National Grid
15. New York Power Authority
16. Pacific Gas & Electric
17. Portland General Electric
18. Tennessee Valley Authority
19. Tri-State G&T
20. Salt River Project
21. Snohomish PUD
22. Southern California Edison
23. Southern Company
24. Western Area Power Administration
25. Xcel Energy

Utilities in Short Courses

1. Alliant Energy
2. American Electric Power
3. Avista Corp.
4. CenterPoint Energy
5. Dakota Electric
6. Energy United
7. Eversource
8. Exelon
9. Fortis Alberta
10. Four County EMC
11. Hawaiian Electric
12. Korea Electric Power Corp.
13. Missouri River Energy Services
14. North Carolina EMC
15. PowerSouth Energy Coop.
16. PSE&G
17. Public Service Co. of New Mexico
18. Puget Sound Energy
19. Sacramento Municipal Utility District
20. Seattle City Light
21. Tokyo Electric Power Company

Other Short Course Participants

1. ABB
2. Alstom
3. ARUP Laboratories
4. Birds Eye Energy
5. Boise State University
6. Chonbuk National University
7. Cisco Systems
8. Department of Energy
9. Energy SA
10. General Electric
11. George Washington University
12. Georgia Tech
13. Heriot Watt University
14. Honda R&D North America
15. Power Services
16. North Carolina PUC
17. North Carolina State University
18. Schneider Electric
19. Subnet Solutions
20. SunPower Corp.
21. U.S. EPA
22. University of California, Irvine
23. University of North Carolina
24. University of Washington
25. Washington State University
26. Western Washington University

University Engagement in GridEd

There are two categories of universities in the GridEd program:

Partners and Affiliates

- **Partner University**: Participated in the proposal preparation of the DOE proposals and are now the recipients of federal funds under the project. They are primarily responsible for developing new and revised curriculum in electric power systems as work product of the project.

- **Affiliate University**: They are nominated by GridEd utility project advisors. Each GridEd project advisor can nominate two universities for the GridEd project. Affiliates university receive work product created by the Partner universities and students from Affiliates are allowed into all GridEd student activities.

GridEd University Engagement

GEARED University Partners

1. Arizona State University
2. Clarkson University
3. Georgia Institute of Technology
4. Portland State University
5. University of California, Riverside
6. University of North Carolina, Charlotte
7. University of Puerto Rico, Mayaguez

GREAT with Data University Partners

1. Stony Brook University
2. University of California, Riverside
3. Virginia Polytechnic Institute and State University
4. Washington State University
5. University of Texas

EPRI Practices with Universities

- **EPRI changed it's charter in 2006 to reflect education:**
  - "To educate and instruct the public on electric power subjects useful to the individual and beneficial to the national as well as worldwide communities;"

- **University Pricing**
  - EPRI reports are available to universities for a nominal printing fee ($250 for print and $450 for software). Could be used as textbooks.
    - Email orders@epri.com with signed official university letterhead requesting specific report(s) and the intended use (classroom educational material, graduate research, etc.)
  - EPRI has an accepted practice of offering training / workshops at a discount to graduate students (no official policy yet)

Engaging Affiliate Universities: Fundamental Activities

Goal: Extend the GridEd experience to a wide university audience by linking with universities through a program with electric utility partners.

Extend University Participation	Each utility can sponsor two universities to participate
Access to EPRI R&D Portfolio	EPRI reports can be purchased by any university for $250.
Tech Transfer Workshops	Sharing of materials, ideas, and best practices created by GridEd
Core Curriculum Courses	Access to featured course material
GridEd Shared Materials	Featured course materials shared and reviewed by ALL
Student Engagement	Funding for undergraduate student design projects.
Short Courses	Attend GridEd short courses for free via waitlist pending availability

Benefits from Affiliate University Engagement

Benefits for Affiliate Universities

- Access to growing library of course material
- Invitation to attend Tech Transfer workshops
- Funding for undergraduate student design projects at the intersection of power systems and digital systems
- Free registration to GridEd short courses via waitlist
- Engagement with GridEd's network
- Industry recognition through affiliation with GridEd

Benefits for Utilities

- Engage local universities & create an everyday presence on university campuses
- Opportunity to develop direct involvement with faculty and students
- Guide and shape curriculum content at universities where future employees are educated
- Provide advanced education to professional staff

Benefits for EPRI/University Partners

- Broaden outreach of EPRI material within academia
- Enhance tech transfer of EPRI research results to members
- Create new university Curriculum

Roles and Responsibilities

EPRI and Partner Universities

- Lead the consortium by organizing and coordinating associated activities
- Create curriculum materials
- Create and deliver professional short courses
- Create tech transfer material
- Issue funding for undergraduate design projects

Utilities

- Designate and sponsor two Affiliate Universities to join the consortium
- Maintain primary relationship between GridEd and its Affiliate Universities
- Provide guidance and direction on project activities

Affiliate Universities

- Attend tech transfer events and seminars
- Provide feedback and input on activities including curriculum review and core course content & material
- Apply for GridEd funding for undergraduate student design projects
- Register faculty and students in GridEd short courses

GridEd Products – *10 New & 19 Revised Under/Graduate Courses*

Power Engineering Emphasis	Undergraduate Courses	Combined Undergraduate / Graduate Courses	Graduate Courses
Electric Power System Analysis	• Analytical Methods for Power Systems • Design of Transmission and Distribution Systems • Power System Analysis • Power System Engineering • Power Systems I • Senior Design Projects (x2)	• Electric Power Distribution Systems II • Energy Markets • Power Systems Protection	• Advanced Topics in Energy Power Systems • Deregulated Power Systems • Electric Power Distribution Systems • IoT for Grid Modernization • Market Operation of Power Systems • Power System Dynamics • Power System Planning • Power System Reliability • Power System Stability • Power System Steady State and Market Analysis • Power Quality
Machines & Drives	• Industry Design Processes		
Power Electronics	• Power Electronics • Power Electronics and Power Management	• Utility Applications of Power Electronics	• Advanced Power Electronics • Renewable Electric Energy Systems
New Energy Systems	• Electrical Energy Systems • Introduction to Energy Systems		• Distributed Energy Resources

REVISED courses in BLACK; NEW courses designated in BLUE

GridEd Products – Basic Power Systems Course

Free Open-Access eLearning Modules

- **Response to Utility Request**
- **Two Semester Course Series**
  - Fundamentals of Power System Analysis
- **Modular Video Lectures**
  - Split among four GridEd-East partner Universities
- **Problem Assignments & Homework**
- **Textbook:** Glover, J.D., Overbye T. and Sarma, M. (2016) Power System Analysis and Design. Sixth Edition. Cengage Learning, Stamford, CT, USA.

Part 1
Energy, apparent, real and reactive power, power factor, Review of phasors
Single-phase circuit analysis
Efficiency and regulation
Per unit
Balanced Three-phase circuit analysis, Single-phase equivalent circuits, efficiency and regulation; Per unit 3 phase analysis
One-line diagram representation of three-phase circuits
Transformer connections and Phase Shift. Per-Unit Equivalent Circuits of Balanced Three-Phase Two-Winding Transformers. Three-Winding Transformers. Autotransformers. Transformers with Off-Nominal Turns Ratios
Transmission lines classification; models and parameters

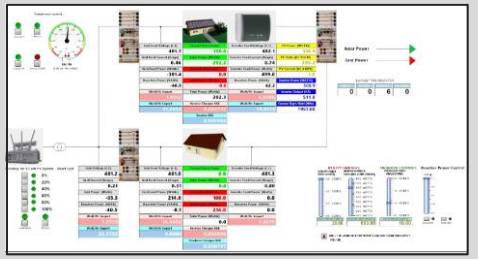
Part 2
Review of phasors, balanced three phase; per unit analysis and transformers
Admittance Matrix Formulation and Network Calculations
Power Flow Analysis; Iterative Solutions to nonlinear Algebraic Equations: Newton-Raphson. The Power-Flow Problem. Power-Flow Solution by Newton-Raphson. Control of Power Flow. Sparsity Techniques. Fast Decoupled Power Flow.
Intro to fault analysis: Impedance Matrix Formulation and Network Calculations
Symmetrical Components
Short circuit – unloaded synchronous machine. power system three-phase short circuit, circuit breaker and fuse selection; and unsymmetrical faults
Definition of stability, system dynamic performance and criteria for system dynamic performance; Types of stability studies Causes of major blackouts. Real-Time Dynamic Security Assessment: Fast Simulation and Modeling Applied to Emergency Outage Security of the Grid.
Synchronous Machine Classical Model
The swing equation; Synchronizing power and natural frequencies of oscillations
The Equal Area Criterion
Multi-machine dynamics and stability studies; Digital simulation of multi-machine systems

GridEd Products – Student Design Projects

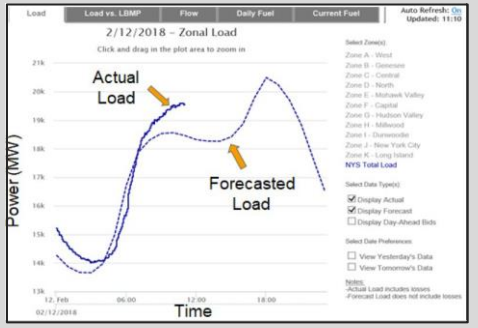
- Financial support ($5k per project)
- For **Affiliate universities**
- **Undergraduate** design projects
- Focused on **power engineering** related concepts
- Students submit a **summary report**
  - 5 page maximum through a **Creative Commons** license (https://creativecommons.org/)

Example Projects

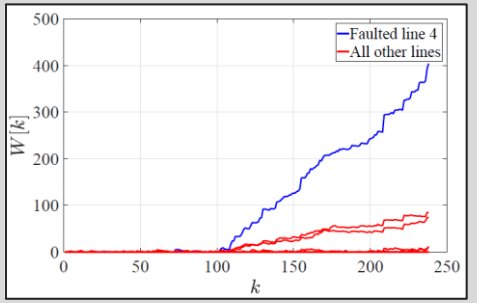
Buffalo State
Testbed for Transactive Energy and its Effects on the Distribution System and Protective Devices



Rensselaer Polytechnic Institute
Estimation of Behind-Meter Renewable Generation from Power Consumption Data



Western Washington University
A Statistical Framework for Real-Time Event Detection in Power Systems



GridEd Products – *Professional Training Program*

Designed to address fundamentals of electric power systems. Essential to all engineers who want to upgrade professional skills, supplement traditional college education, and/or obtain professional development hours.

Course Topics

Power System Fundamentals

- Business Case Analysis in the Electric Utility Industry
- Distribution System Reliability
- Electric Power Distribution Systems
- Electricity Markets
- IEEE Standard 762
- Power Quality
- Predictive Analytics and Optimization for Distribution Systems
- Unbalanced Distribution System Analysis

DER Technologies and Integration

- Applications of Smart Inverter Technology
- Bulk System Integration of Variable Generation
- DG Interconnection on Radial Distribution Systems
- Distributed Generation Technologies
- Electric Transportation
- Energy Storage Technologies, Applications and Integration
- Utility Applications of Power Electronics

What Students Have Said

- *"I liked the real example discussion, and the professional environment."*
- *"Overall the course was very good and the instructor was obviously very knowledgeable on the topics discussed."*
- *"Good balance of 'textbook' theory and practical application/ experience and case studies."*

Delivery Options

- Live In-Person
- Live Online
- Recorded Online

GridEd Reports

- *The Center for Grid Engineering Education (GridEd) 2014 Progress Report.* EPRI. Palo Alto, CA. 2017. 3002011182
- *The Center for Grid Engineering Education (GridEd) 2015 Progress Report.* EPRI. Palo Alto, CA. 2017. 3002011183
- *The Center for Grid Engineering Education (GridEd) 2016 Progress Report.* EPRI. Palo Alto, CA. 2017. 3002011184
- *The Center for Grid Engineering Education (GridEd) 2017 Progress Report.* EPRI. Palo Alto, CA. 2018. 3002012596
- *The Center for Grid Engineering Education (GridEd) 2018 Progress Report. EPRI. Palo Alto, CA. 2019.* 3002016652
- *The Center for Grid Engineering Education (GridEd) 2019 Progress Report. EPRI. Palo Alto, CA. 2020.* 3002017812
- *Identifying Training and Education Gaps in the Electric Industry: A GridEd Report*. EPRI. Palo Alto, CA. 2018. 3002014732
- University Gaps Assessment in Digital Power Systems Education. EPRI. Palo Alto, CA. 2020. 3002020016
- *Developing a Sustainable Business Model for Training and Education in the Electric Power: A GridEd Report.* EPRI. Palo Alto, CA. 2019. 3002014734
- *GridEd Human Resources Committee Report*. EPRI. Palo Alto, CA. 2019. 3002016750
- Final GridEd GEARED/STEP Report - *forthcoming*