

GRIDED

The Center for Grid Engineering Education

<http://grided.epri.com>

Overview for Affiliate Universities

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www.epri.com

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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](mailto:treddoch@epri.com), (865) 456-3708
 - Amy Feser [_afeser@epri.com](mailto:afeser@epri.com), (865) 218-5909
 - Lisa K. “LK” Browning – lbrowning@epri.com, (615) 968-9024

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

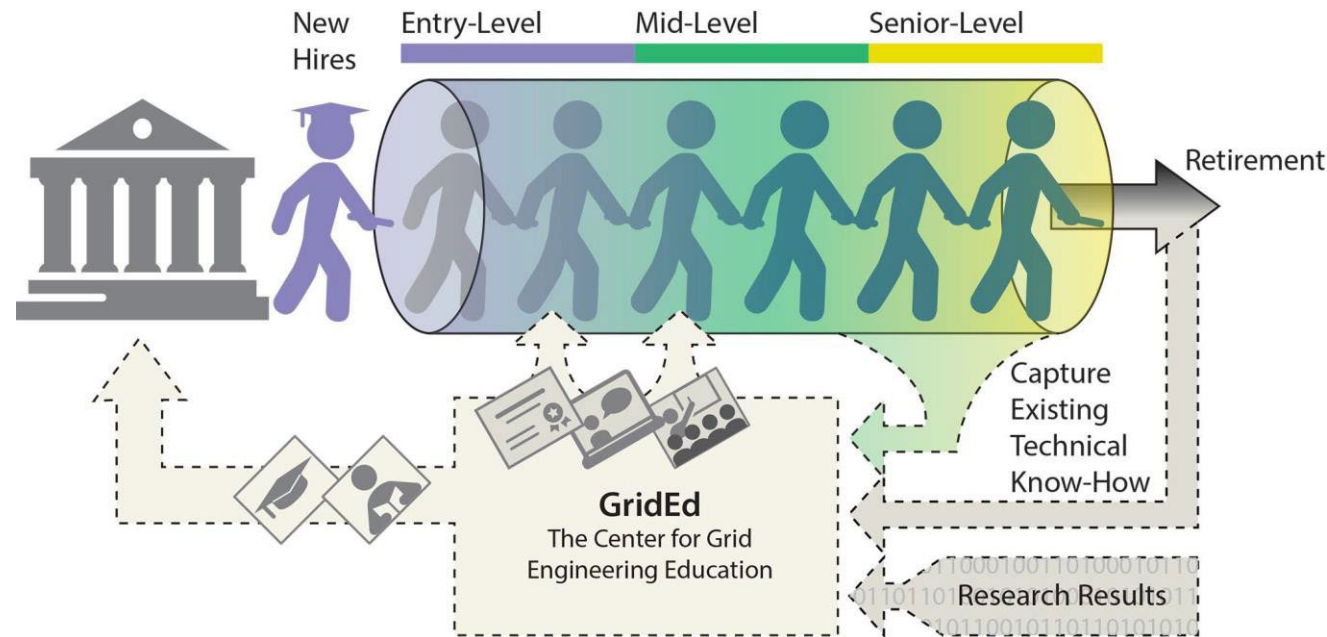
Needs

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

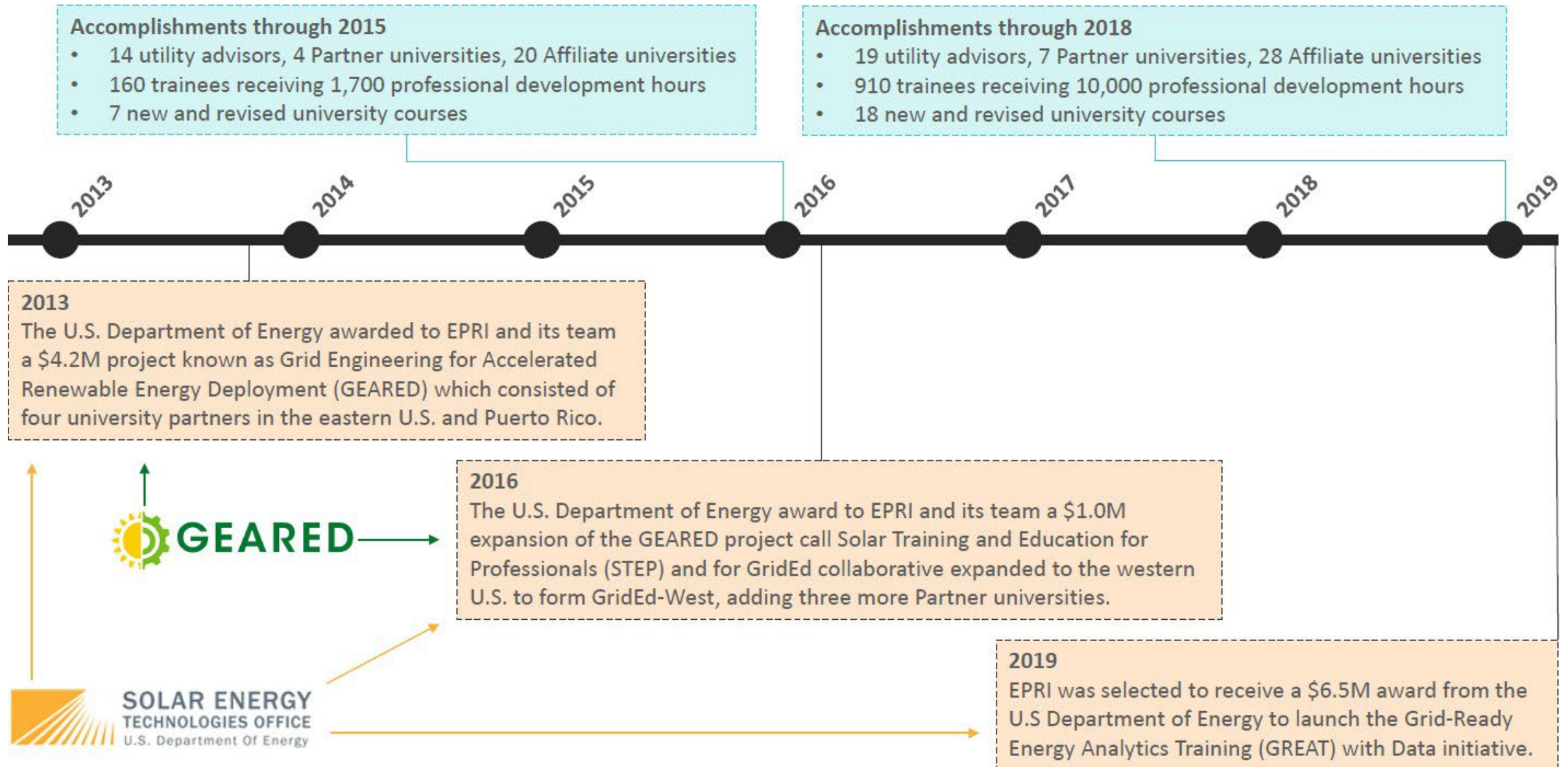


- Engage students to expand the electric utility talent pool of the next generation

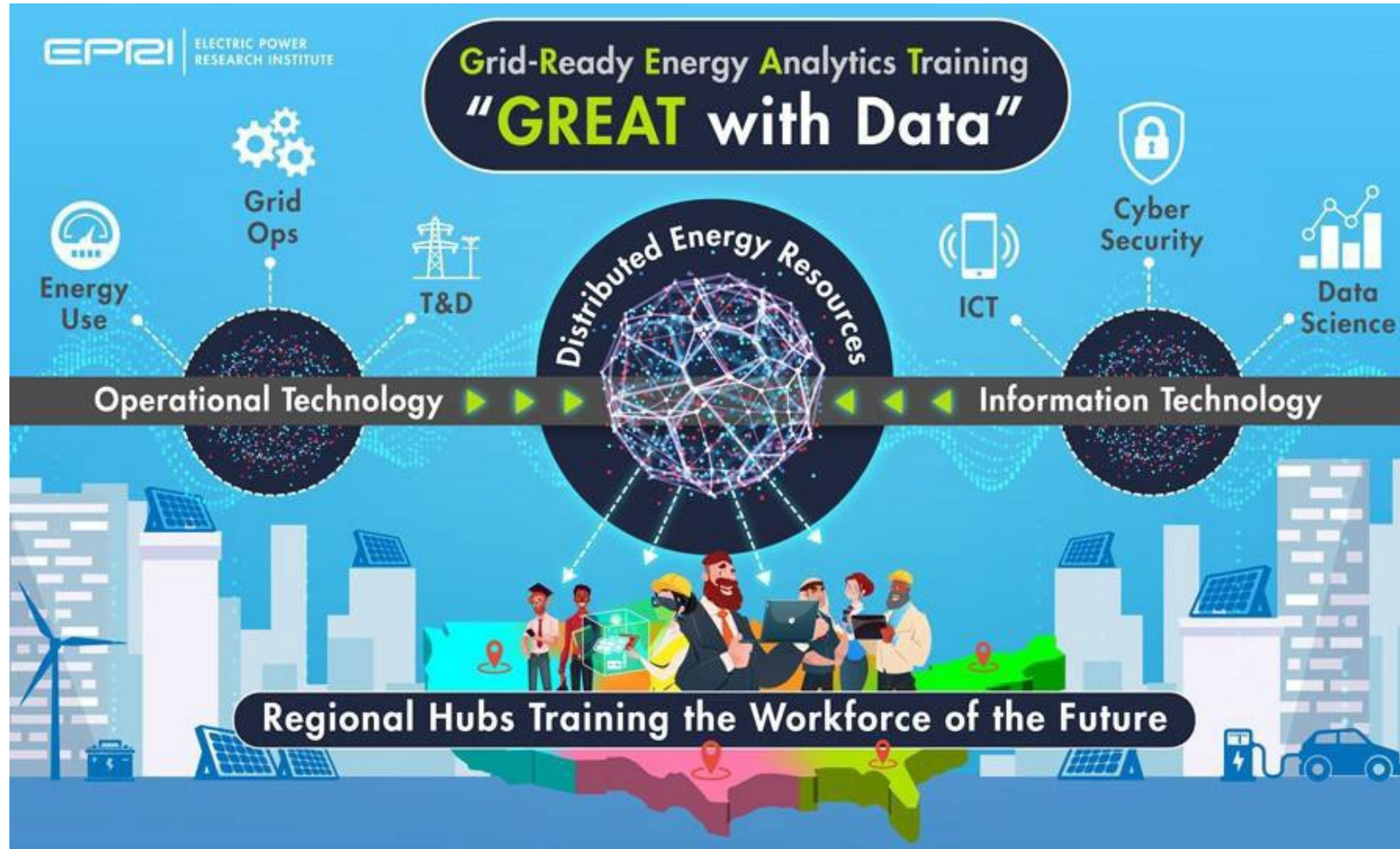
- Advance workforce knowledge through a robust professional training program

- Leverage research in power systems and the smart grid at partner institutions

History



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 (2014-2018)

Utility Members (2014-2018)

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

Non-Utility 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

GridEd Membership (2019-2024)

Utility Members (2019-2024)

American Electric Power
Austin Energy
Duke Energy
FirstEnergy
Lincoln Electric System
New York Power Authority
Portland General Electric
Salt River Project
Santee Cooper
Southern California Edison
Southern Company
Tennessee Valley Authority
Western Area Power Authority

Partner Universities

1. Stony Brook University
2. University of California - Riverside
3. University of Texas - Austin
4. Virginia Tech - Blacksburg
5. Washington State University

Affiliate Universities

California Polytechnic State University
California State University - Los Angeles
City University of New York - Grove School of Engineering
Colorado State University
Cleveland State University
Iowa State University
North Carolina A&T State University
Oregon State University
Portland State University
Prairie View A&M University
South Carolina State University
South Dakota State University
Tennessee State University
Texas State University
Tuskegee University
State University of New York - Buffalo
University of Memphis
University of Nebraska - Lincoln
University of North Carolina - Charlotte
University of Pittsburgh
University of Puerto Rico - Mayaguez
University of South Alabama
University of Tennessee - Chattanooga

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 its 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 |
|---------------------------------------|--|--|--|
| <i>Electric Power System Analysis</i> | <ul style="list-style-type: none"> Analytical Methods for Power Systems Design of Transmission and Distribution Systems Power System Analysis Power System Engineering Power Systems I Senior Design Projects (x2) | <ul style="list-style-type: none"> Electric Power Distribution Systems II Energy Markets Power Systems Protection | <ul style="list-style-type: none"> 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 |
| <i>Machines & Drives</i> | <ul style="list-style-type: none"> Industry Design Processes | | |
| <i>Power Electronics</i> | <ul style="list-style-type: none"> Power Electronics Power Electronics and Power Management | <ul style="list-style-type: none"> Utility Applications of Power Electronics | <ul style="list-style-type: none"> Advanced Power Electronics Renewable Electric Energy Systems |
| <i>New Energy Systems</i> | <ul style="list-style-type: none"> Electrical Energy Systems Introduction to Energy Systems | | <ul style="list-style-type: none"> 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 Solution 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 |

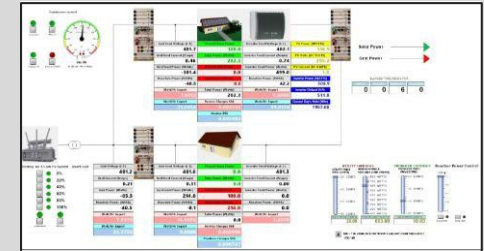
GridEd Products – Student Design Projects

- 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



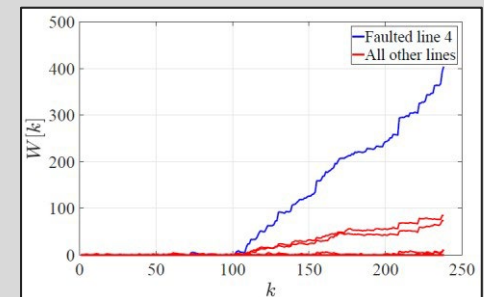
Rensselaer Polytechnic Institute

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) 2019-2020 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](#)
- *Leveraging Industry Research to Educate a Future Electric Grid Workforce.* EPRI. Palo Alto, CA 2020. [3002017113](#)

A blue-tinted photograph of four people, two men and two women, standing together. They are wearing white lab coats or dark polo shirts with the EPRRI logo. One woman is wearing a white hard hat. They appear to be in a professional setting, possibly a laboratory or office. The text "Together...Shaping the Future of Energy" is overlaid in white on the image.

Together...Shaping the Future of Energy