Grid-Ready Energy Analytics Training with Data (GREAT with Data)

Training Roadmap

Technical Update

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3002020585

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THE ELECTRIC POWER RESEARCH INSTITUTE (EPRI) PREPARED THIS REPORT.

This is an EPRI Technical Update report. A Technical Update report is intended as an informal report of continuing research, a meeting, or a topical study. It is not a final EPRI technical report.

NOTE

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Acknowledgments

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Abstract

The Electric Power Research Institute along with electric utility partners and universities are launching the Grid-Ready Energy Analytics Training (GREAT) with Data initiative to train and educate the next generation of electric utility workers to be GREAT with Data. This new effort is in-part funded by the U.S. Department of Energy. EPRI will leverage prior DOE investments with utility funding in workforce development through EPRI's Center for Grid Engineering Education (GridEd) project, several EPRI Board approved investments in EPRI|U (EPRI University) and EPRI's internal Data Analytics, Artificial Intelligence, and Cyber Security initiatives, along with relevant EPRI research & development and university shared funding and research. The GREAT with Data initiative will develop and deliver training and educational materials (both professional and university training) to address issues for merging Grid Operations Technology (OT) and Information Technology (IT). The central theme is to create necessary activities for the next generation power engineers and data scientists, so they can design and develop the grid architecture and infrastructure to enable the integration of distributed energy resources (DER).

Keywords

Training

Education

Workforce Development

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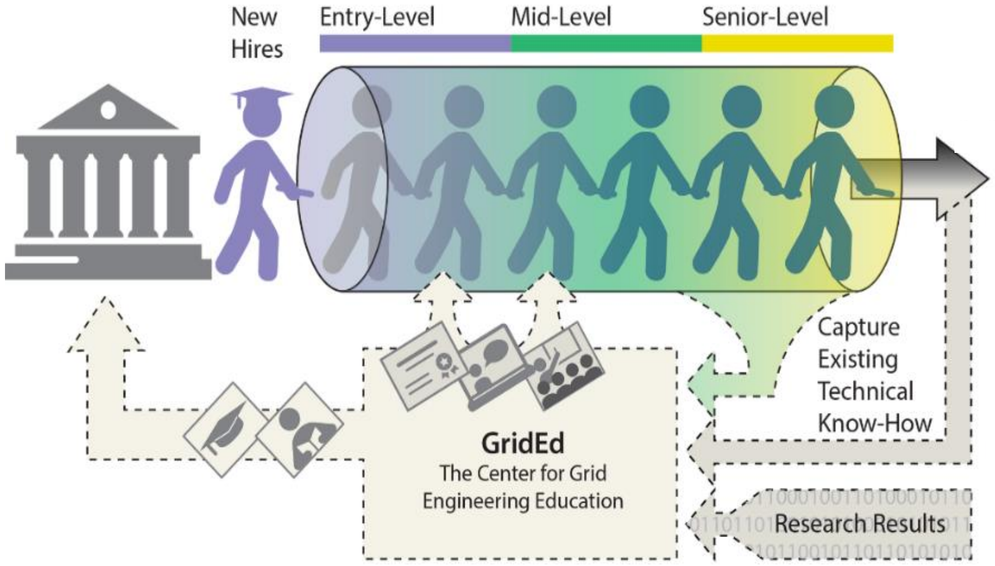
Executive Summary

GridEd's *GREAT with Data* Initiative

Train and educate an electric industry workforce at the intersection of the physical power system and digital systems to enable an Integrated Grid.

EPRI | U™ Infrastructure for Training Records and PDHs



Professional Training

University Curriculum

Student Engagement

Leverage Research

Supplemental Project: 3002015049

The "GREAT with Data" Initiative *– Key Activities*

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

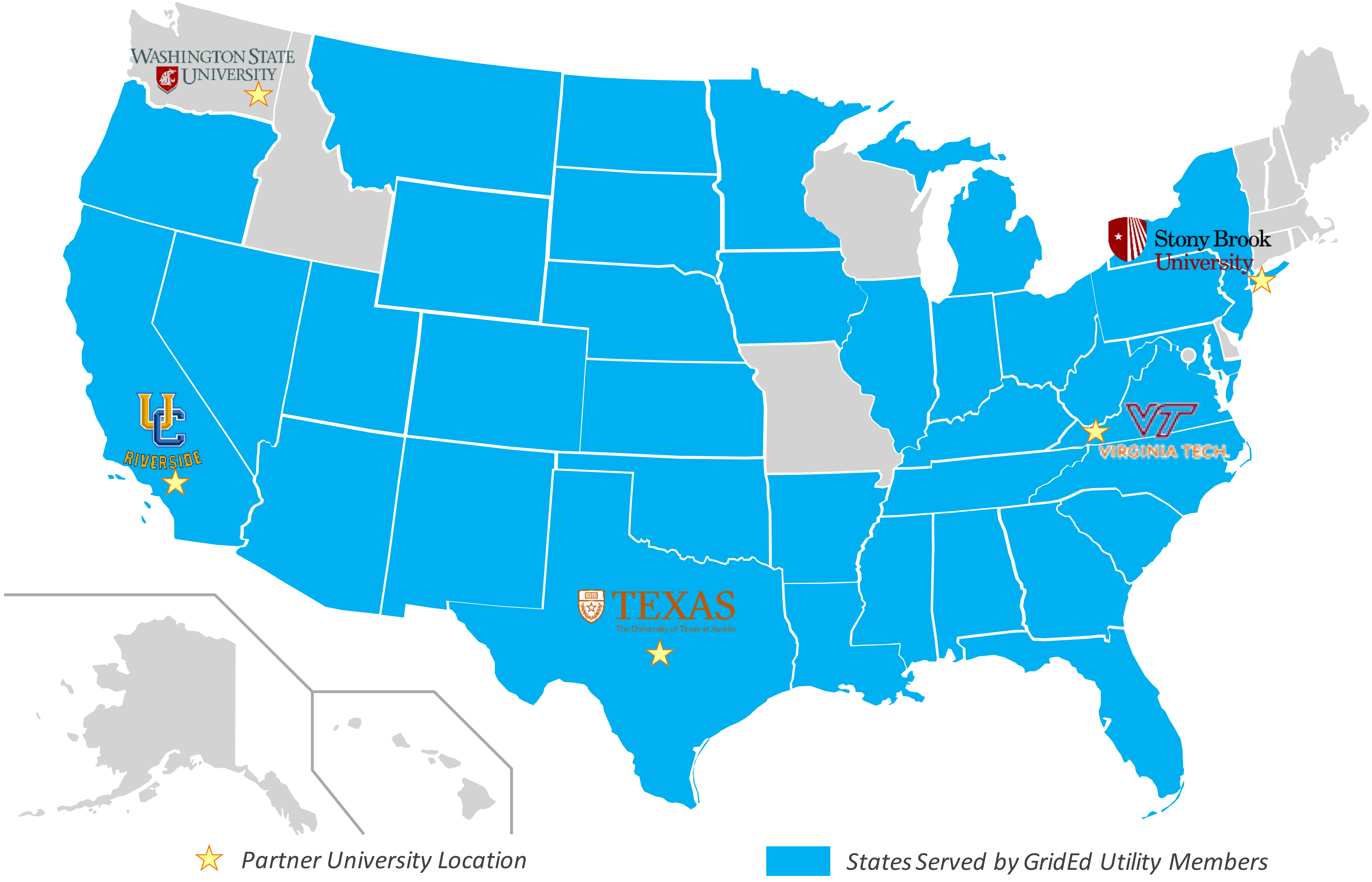
- New and Revised University Courses
- Co-developed Course - *Introduction to Digital Power Systems*
- Undergraduate Design Projects
- GEARED Course Repository

Participation in GridEd's GREAT with Data Initiative

(as of Dec. 2020)

Utility Members

- AEP ENERGY
- AUSTIN ENERGY
- DUKE ENERGY
- FirstEnergy
- LES Lincoln Electric System
- New York Power Authority
- PGE
- SRP SALT RIVER PROJECT
- SOUTHERN CALIFORNIA EDISON An EDISON INTERNATIONAL Company
- Southern Company
- TVA
- Western Area Power Administration

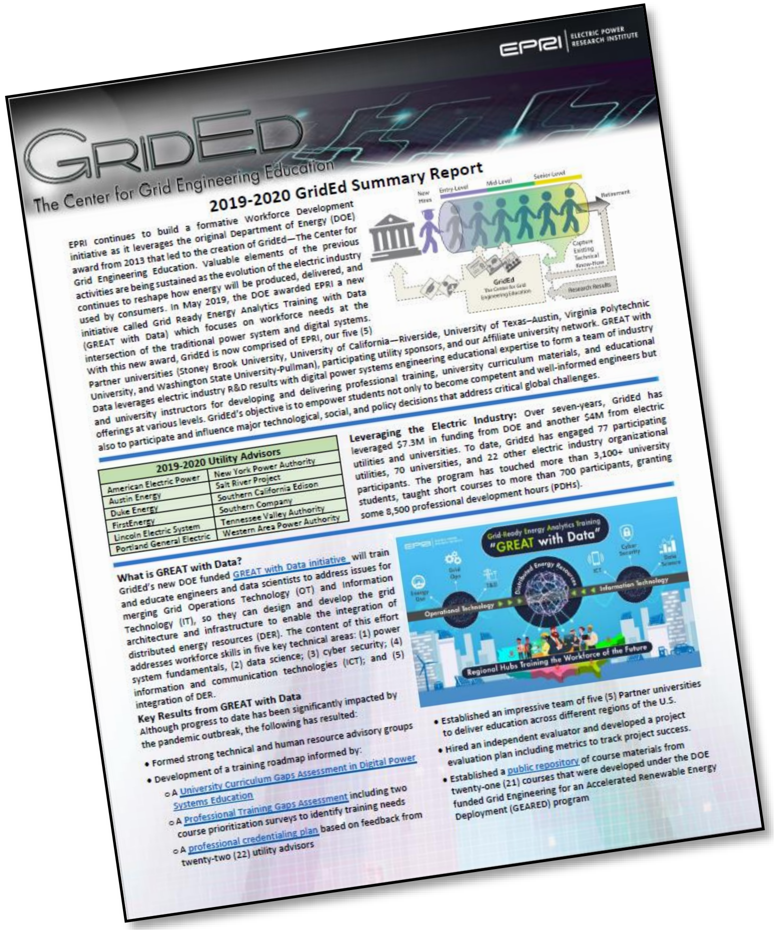


Affiliates

- ASU Arizona State University
- Cal Poly
- Colorado State University
- Iowa State
- NM State
- North Carolina Agricultural and Technical State University
- OSU Oregon State University
- Portland State University
- Prairie View A&M University
- South Dakota State University
- Texas State University
- Tuskegee University
- University at Buffalo The State University of New York
- The University of Memphis
- University of Nebraska Lincoln
- UNC Charlotte
- University of Pittsburgh
- University of Puerto Rico at Mayagüez
- University of South Alabama
- The University of Tennessee Chattanooga

2019-2020 GridEd Summary Report

https://grided.epri.com/tpl/docs/2019_2020_GridEd-GREATwithData_Annual_Report.pdf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GridEd The Center for Grid Engineering Education

2019-2020 GridEd Summary Report

EPRI continues to build a formative Workforce Development initiative as it leverages the original Department of Energy (DOE) award from 2013 that led to the creation of GridEd—The Center for Grid Engineering Education. Valuable elements of the previous activities are being sustained as the evolution of the electric industry continues to reshape how energy will be produced, delivered, and used by consumers. In May 2019, the DOE awarded EPRI a new initiative called Grid Ready Energy Analytics Training with Data (GREAT with Data) which focuses on workforce needs at the intersection of the traditional power system and digital systems. With this new award, GridEd is now comprised of EPRI, our five (5) Partner universities (Stoney Brook University, University of California—Riverside, University of Texas–Austin, Virginia Polytechnic University, and Washington State University-Pullman), participating utility sponsors, and our Affiliate university network. GREAT with Data leverages electric industry R&D results with digital power systems engineering educational expertise to form a team of industry and university instructors for developing and delivering professional training, university curriculum materials, and educational offerings at various levels. GridEd's objective is to empower students not only to become competent and well-informed engineers but also to participate and influence major technological, social, and policy decisions that address critical global challenges.

2019-2020 Utility Advisors	
American Electric Power	New York Power Authority
Austin Energy	Salt River Project
Duke Energy	Southern California Edison
FirstEnergy	Southern Company
Lincoln Electric System	Tennessee Valley Authority
Portland General Electric	Western Area Power Authority

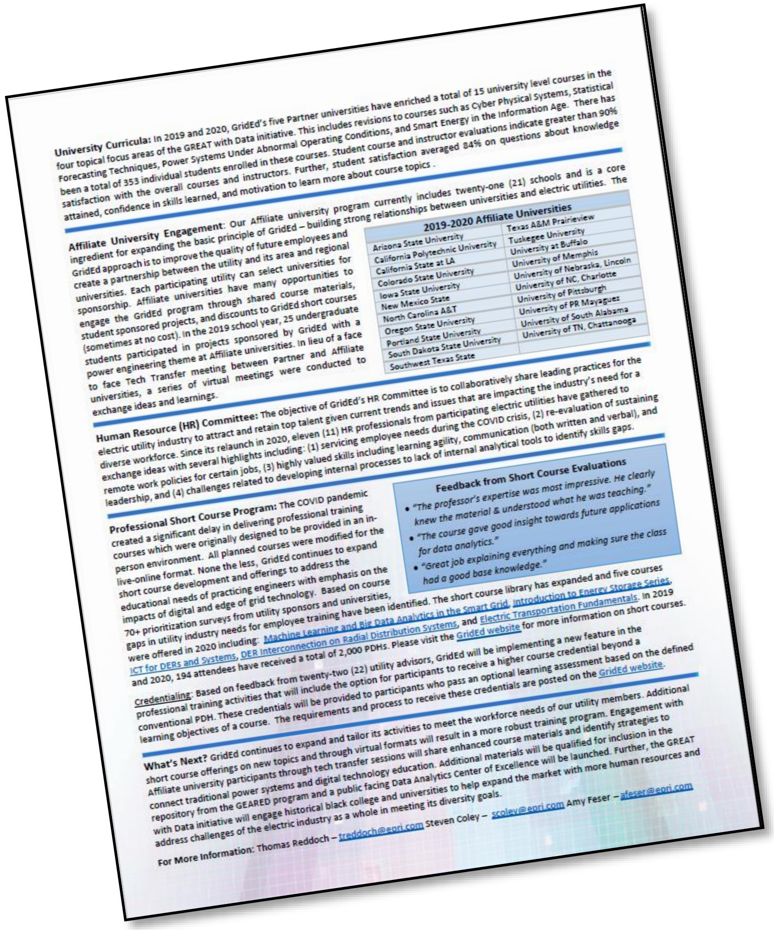
Leveraging the Electric Industry: Over seven-years, GridEd has leveraged $7.3M in funding from DOE and another $4M from electric utilities and universities. To date, GridEd has engaged 77 participating utilities, 70 universities, and 22 other electric industry organizational participants. The program has touched more than 3,100+ university students, taught short courses to more than 700 participants, granting some 8,500 professional development hours (PDHs).

What is GREAT with Data? GridEd's new DOE funded GREAT with Data initiative will train and educate engineers and data scientists to address issues for merging Grid Operations Technology (OT) and Information Technology (IT), so they can design and develop the grid architecture and infrastructure to enable the integration of distributed energy resources (DER). The content of this effort addresses workforce skills in five key technical areas: (1) power system fundamentals, (2) data science; (3) cyber security; (4) information and communication technologies (ICT); and (5) integration of DER.

Key Results from GREAT with Data

Although progress to date has been significantly impacted by the pandemic outbreak, the following has resulted:

- Formed strong technical and human resource advisory groups
- Development of a training roadmap informed by:
  - A University Curriculum Gaps Assessment in Digital Power Systems Education
  - A Professional Training Gaps Assessment including two course prioritization surveys to identify training needs
  - A professional credentialing plan based on feedback from twenty-two (22) utility advisors
- Established an impressive team of five (5) Partner universities to deliver education across different regions of the U.S.
- Hired an independent evaluator and developed a project evaluation plan including metrics to track project success.
- Established a public repository of course materials from twenty-one (21) courses that were developed under the DOE funded Grid Engineering for an Accelerated Renewable Energy Deployment (GEARED) program


University Curricula: In 2019 and 2020, GridEd's five Partner universities have enriched a total of 15 university level courses in the four topical focus areas of the GREAT with Data initiative. This includes revisions to courses such as Cyber Physical Systems, Statistical Forecasting Techniques, Power Systems Under Abnormal Operating Conditions, and Smart Energy in the Information Age. There has been a total of 353 individual students enrolled in these courses. Student course and instructor evaluations indicate greater than 90% satisfaction with the overall courses and instructors. Further, student satisfaction averaged 84% on questions about knowledge attained, confidence in skills learned, and motivation to learn more about course topics.

Affiliate University Engagement: Our Affiliate university program currently includes twenty-one (21) schools and is a core ingredient for expanding the basic principle of GridEd – building strong relationships between universities and electric utilities. The GridEd approach is to improve the quality of future employees and create a partnership between the utility and its area and regional universities. Each participating utility can select universities for sponsorship. Affiliate universities have many opportunities to engage the GridEd program through shared course materials, student sponsored projects, and discounts to GridEd short courses (sometimes at no cost). In the 2019 school year, 25 undergraduate students participated in projects sponsored by GridEd with a power engineering theme at Affiliate universities. In lieu of a face to face Tech Transfer meeting between Partner and Affiliate universities, a series of virtual meetings were conducted to exchange ideas and learnings.

2019-2020 Affiliate Universities	
Arizona State University	Texas A&M Prairieview
California Polytechnic University	Tuskegee University
California State at LA	University at Buffalo
Colorado State University	University of Memphis
Iowa State University	University of Nebraska, Lincoln
New Mexico State	University of NC, Charlotte
North Carolina A&T	University of Pittsburgh
Oregon State University	University of PR Mayaguez
Portland State University	University of South Alabama
South Dakota State University	University of TN, Chattanooga
Southwest Texas State	

Human Resource (HR) Committee: The objective of GridEd's HR Committee is to collaboratively share leading practices for the electric utility industry to attract and retain top talent given current trends and issues that are impacting the industry's need for a diverse workforce. Since its relaunch in 2020, eleven (11) HR professionals from participating electric utilities have gathered to exchange ideas with several highlights including: (1) servicing employee needs during the COVID crisis, (2) re-evaluation of sustaining remote work policies for certain jobs, (3) highly valued skills including learning agility, communication (both written and verbal), and leadership, and (4) challenges related to developing internal processes to lack of internal analytical tools to identify skills gaps.

Feedback from Short Course Evaluations

- *"The professor's expertise was most impressive. He clearly knew the material & understood what he was teaching."*
- *"The course gave good insight towards future applications for data analytics."*
- *"Great job explaining everything and making sure the class had a good base knowledge."*

Professional Short Course Program: The COVID pandemic created a significant delay in delivering professional training courses which were originally designed to be provided in an in-person environment. All planned courses were modified for the live-online format. None the less, GridEd continues to expand short course development and offerings to address the educational needs of practicing engineers with emphasis on the impacts of digital and edge of grid technology. Based on course 70+ prioritization surveys from utility sponsors and universities, gaps in utility industry needs for employee training have been identified. The short course library has expanded and five courses were offered in 2020 including: Machine Learning and Big Data Analytics in the Smart Grid, Introduction to Energy Storage Series, ICT for DERs and Systems, DER Interconnection on Radial Distribution Systems, and Electric Transportation Fundamentals. In 2019 and 2020, 194 attendees have received a total of 2,000 PDHs. Please visit the GridEd website for more information on short courses.

Credentialing: Based on feedback from twenty-two (22) utility advisors, GridEd will be implementing a new feature in the professional training activities that will include the option for participants to receive a higher course credential beyond a conventional PDH. These credentials will be provided to participants who pass an optional learning assessment based on the defined learning objectives of a course. The requirements and process to receive these credentials are posted on the GridEd website.

What's Next? GridEd continues to expand and tailor its activities to meet the workforce needs of our utility members. Additional short course offerings on new topics and through virtual formats will result in a more robust training program. Engagement with Affiliate university participants through tech transfer sessions will share enhanced course materials and identify strategies to connect traditional power systems and digital technology education. Additional materials will be qualified for inclusion in the repository from the GEARED program and a public facing Data Analytics Center of Excellence will be launched. Further, the GREAT with Data initiative will engage historical black college and universities to help expand the market with more human resources and address challenges of the electric industry as a whole in meeting its diversity goals.

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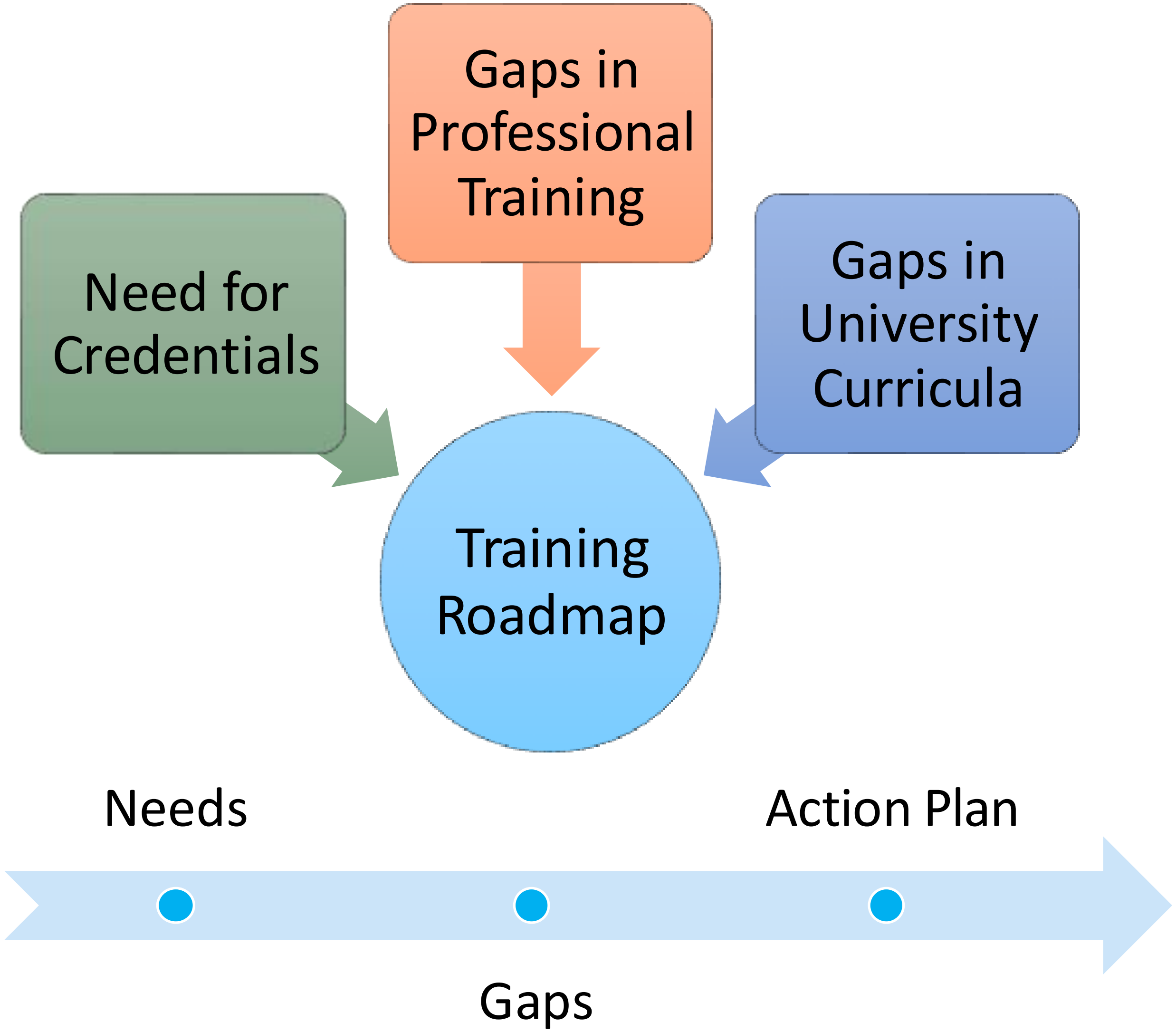
GREAT with Data Training Roadmap

What is it?

- Project action plan based on gaps assessments



GREAT with Data Training Roadmap

- The roadmap provided on the next two slides provides course titles being develop/offered in each of the four focus areas of the GREAT with Data as part of the projects core plan for the training & education
  - Additional information on course descriptions/content can be found at the end of this report.
- Slide 10 summarizes courses for universities (undergraduate and graduate courses)
- Slide 11 summarizes professional training courses
- It is the current plan as of the end of 2020

Great with Data University Curriculum Roadmap

Note course modules in the topic areas of interest are modified within the broader course topic

	Data Science	Cyber Security	Information and Communications Technology	Integration of Distributed Energy Resources
Available Now	✓ Smart Energy in the Information Age ✓ Big Data Analytics in Smart Grid ✓ Power Quality and Harmonics	✓ Power Systems Under Abnormal Operating Conditions ✓ Electric Energy Distribution Systems ✓ Smart Energy in the Information Age ✓ Cyber Power Systems	✓ Power Systems Under Abnormal Operating Conditions ✓ Electric Energy Distribution Systems ✓ Smart Energy in the Information Age ✓ Cyber Power Systems	✓ Smart Energy in the Information Age
Develop in 2021	✓ Big Data Systems, Algorithms and Networks ✓ Introduction to Reinforcement Learning ✓ Data Analytics in Power Systems	✓ Big Data Systems, Algorithms and Networks	✓ Big Data Systems, Algorithms and Networks	✓ Electric Power Distribution Systems
Future Courses	✓ Basics of Digital Power Systems	✓ Basics of Digital Power Systems	✓ Basics of Digital Power Systems	✓ Basics of Digital Power Systems

Great with Data Professional Training Roadmap

	Data Science	Cyber Security	Information and Communications Technology	Integration of Distributed Energy Resources
Available Now	✓ Machine Learning and Big Data Analytics in Smart Grid (live-online) ✓ Introduction to Data Analytics (3hr CBT)	✓ Cyber Security Culture (20min CBT)	✓ Information and Communication Technologies for Distributed Energy Resources and Systems (live-online)	✓ DER Interconnection on Radial Distribution Systems (live-online) ✓ Introduction to Energy Storage Short Course Series (live-online) ✓ IEEE Standard 1547 (CBT)
Develop in 2021	✓ Machine Vision for the Electric Utility (Professional Track) ✓ Interpreting & Assessing Results: Machine Vision (Leader Track)	✓ Cyber Security For Utility Employees (12hr) ✓ OT Familiarization for Cyber Security Professionals (20hr)	✓ Information and Communication Technologies for Distributed Energy Resources and Systems (live-online) ✓ Telecommunications Technologies for Data, Metering, and Analytics (live)	✓ Distributed Energy Resource Management Systems (live-online) ✓ Microgrid Concepts and Designs (TBD)
Future Courses	✓ Time Series in the Electric Utility (Professional Track) ✓ Interpreting & Assessing Results: Time-Series (Leader Track) ✓ NLP in the Electric Utility (Professional Track) ✓ Interpreting & Assessing Results: NLP (Leader Track) ✓ Customer Analytics (Professional Track) ✓ Fundamentals of Data Governance (Leader Track)	✓ Cyber Security for DER (live) ✓ Cyber Security in a Low Carbon Future (live) ✓ Technical Assessment Methodology (life) ✓ Cyber Security for Executives (CBT) ✓ Secure Remote Access: Introduction to a Functional Architecture for Grid Operations (CBT) ✓ How to Plan an Integrated Security Operations Center (CBT)	✓ ICT for Customer-Sited DER: Demand-Responsive Loads and Data Analytics (Live) ✓ Common Information Models (CIM) and IEC 61850 for Utility Enterprise Systems and Distribution Systems: Protocols and Information Models (Live) ✓ ICT for Inverter-based DER Interconnection: Solar Photovoltaic and Energy Storage Systems (Live)	✓ DER Interconnection Processes and Screening (TBD) ✓ Modeling and Simulation for DER Integration (12hrs)

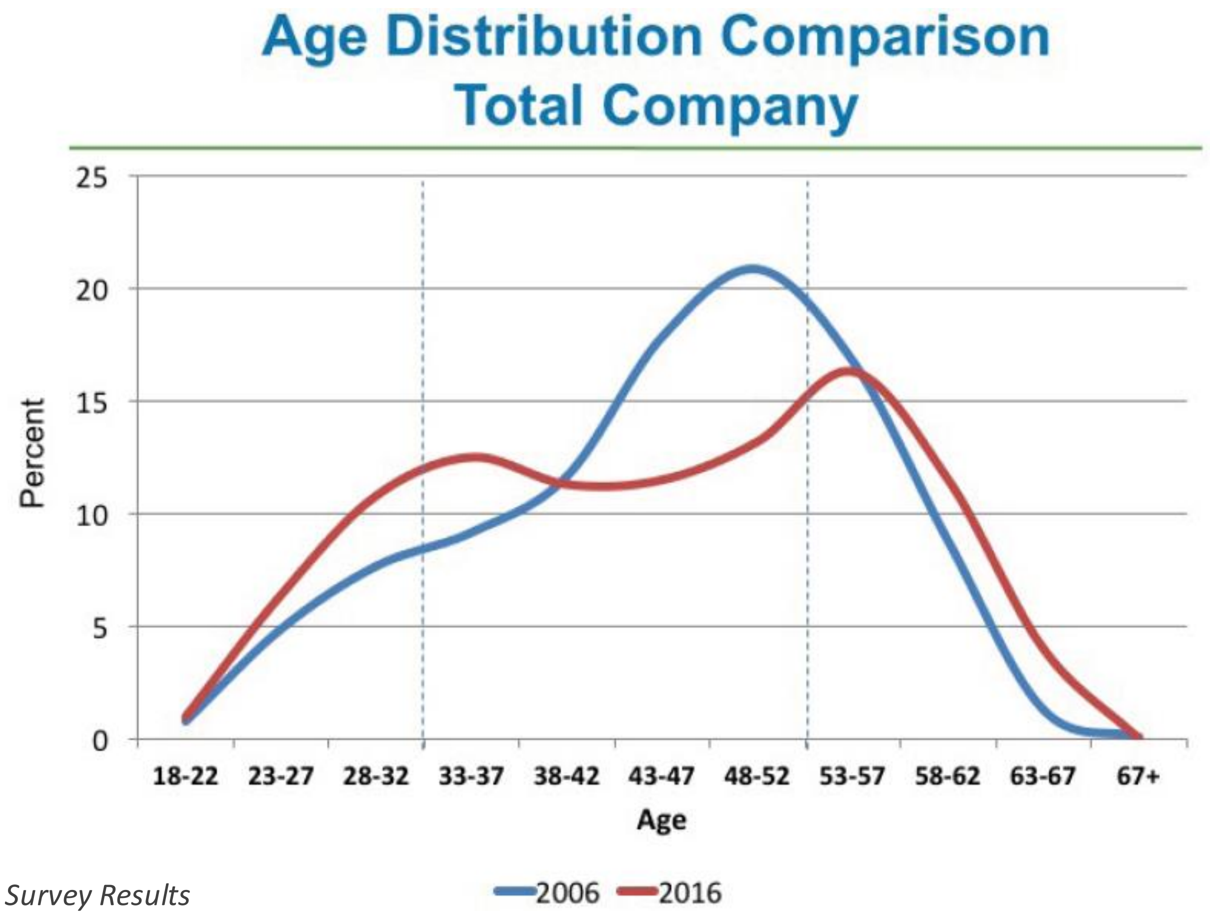
Electric Utility Workforce Development Challenges

Drivers Changing Electric Utility Workforce Needs

Where are we today?

Electric Power Educational Challenges Amid Industry Transformation

1. Early career workforce

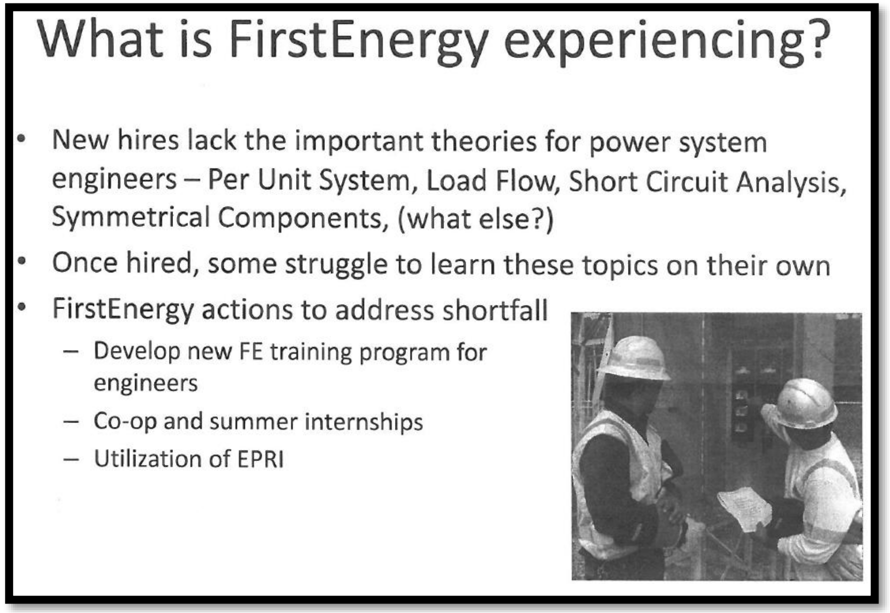


Source: Gaps in the Energy Workforce Pipeline,
2017 Center for Energy Workforce Development Survey Results

Where are we today?

Electric Power Educational Challenges Amid Industry Transformation

1. Early career workforce
2. Many new hires lack power systems education

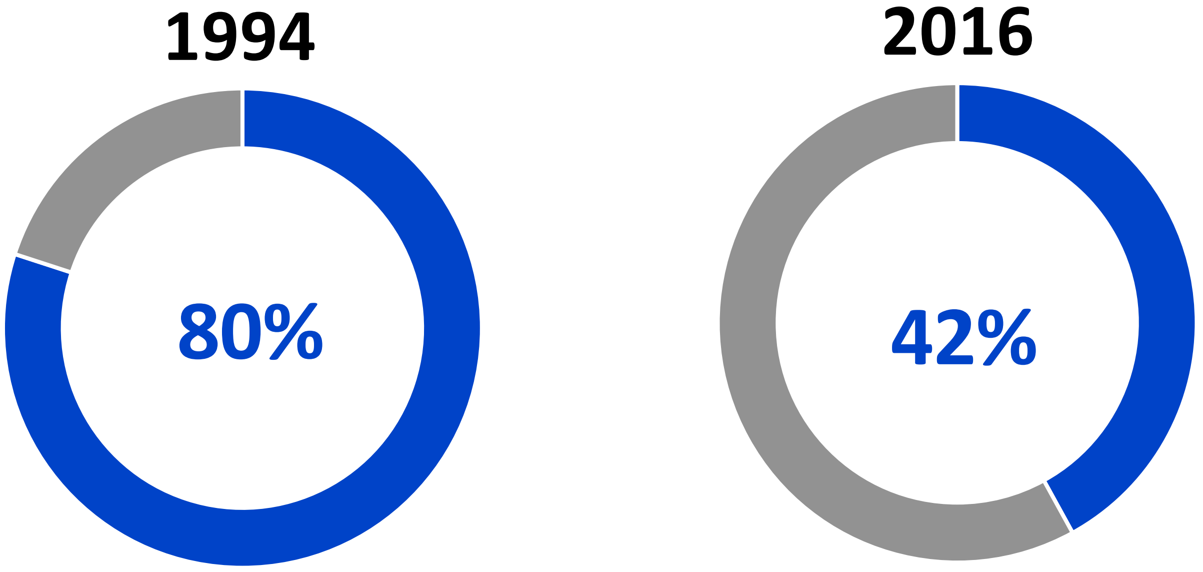


What is FirstEnergy experiencing?

- New hires lack the important theories for power system engineers – Per Unit System, Load Flow, Short Circuit Analysis, Symmetrical Components, (what else?)
- Once hired, some struggle to learn these topics on their own
- FirstEnergy actions to address shortfall
  - Develop new FE training program for engineers
  - Co-op and summer internships
  - Utilization of EPRI

Source: Rodney Philips, Director, Transmission Operations, FirstEnergy. IEEE PES General Meeting. July 19, 2017.

Percentage of U.S. Universities with a Required Undergraduate Power Systems Course



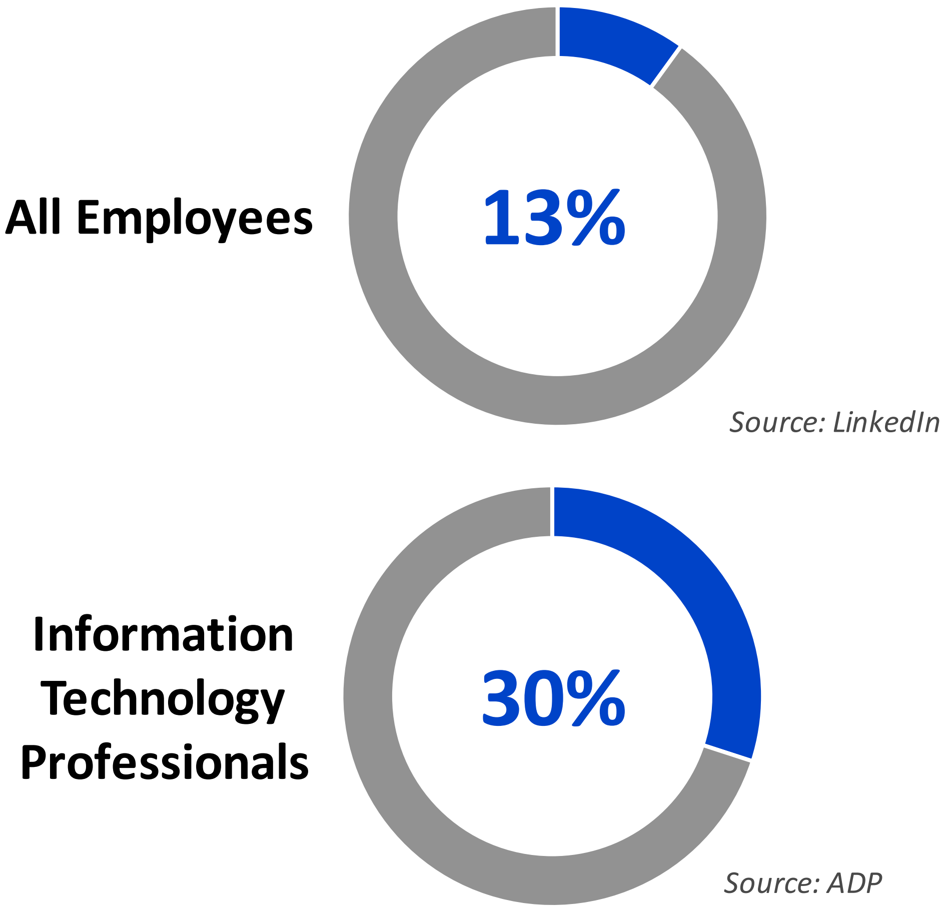
Source: Electric Power Engineering Education Resources: 2015-16 US and Canadian University Survey Results. Report from the Power and Energy Education Committee of the IEEE Power & Energy Society. November 2017.

Where are we today?

Electric Power Educational Challenges Amid Industry Transformation

1. Early career workforce
2. Many new hires lack power systems education
3. Difficult to hire and retain top data science professionals

Employee Turnover Rates



Where are we today?

Electric Power Educational Challenges Amid Industry Transformation

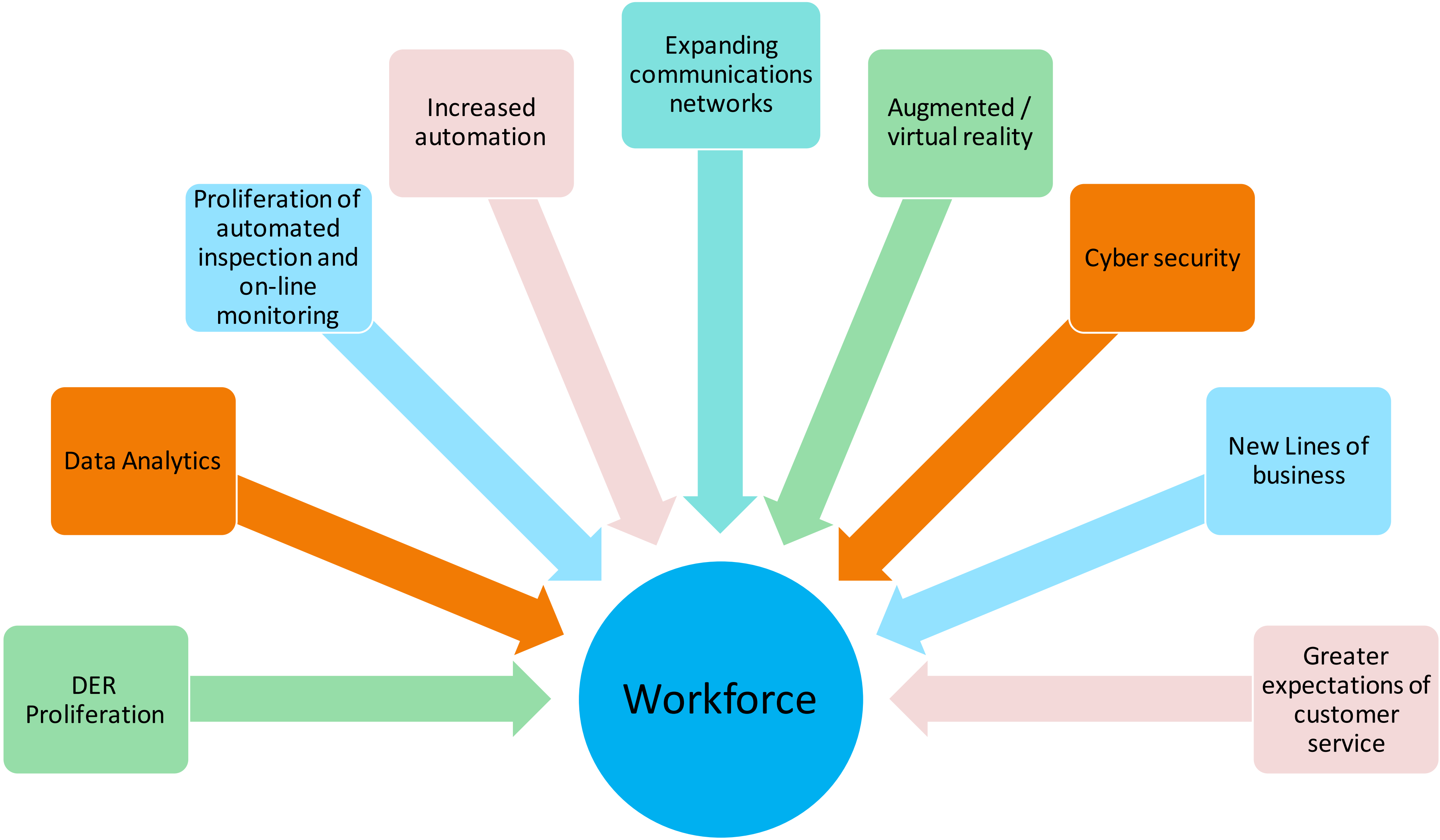
1. Early career workforce
2. Many new hires lack power systems education
3. Difficult to hire and retain top data science professionals
4. Power system transformation:
   - Renewables and distributed energy resources
   - Digital communication, cyber security, and data analytics

Overarching Issues

IT / OT Convergence – will require a better understanding of technologies and principles on both sides. Information Technology (IT) people will need to better understand the Operating Technology world and vice-versa.

Creating "cultures" for Cyber Security and Data – similar to the safety culture that is now common within the industry, utilities will need to create both cyber security and data cultures. All workers will need to have a heightened awareness of cyber security and how it can impact their jobs. Workers also need to understand the value that data will have for the company and what their role is in obtaining, maintaining and using high-quality data

Drivers That Will Impact the Workforce



Impact on Required Skillsets for Different Positions at Electric Utilities

Identifying Workforce Skillsets Required for a Modern Grid

- Background
  - In 2019, EPRI engaged over 120 subject matter experts from across Southern Company as part of a project to develop the vision of a modern distribution system ten years in the future and a roadmap for acquiring the capabilities required to realize this vision.

- Approach for Identifying New Workforce Skillsets
  - Through the Southern Company work, EPRI identified two overarching issues and nine drivers associated with grid modernization. By studying the impacts of these issues and drivers, a successful identification of new skills required for several job classifications were determined.
  - This information is captured in the following tables.

Workforce Categories

Distribution Operations

Distribution Planning

Asset Management

Engineering

Field Work

Information Technology

Customer Service

Distribution Operations

Drivers	Impacts
DER Proliferation	• Incorporation of distributed resources into the operation of the distribution system • Incorporation of third service providers into the operation of the distribution system • Greater integration between distribution, transmission, and fleet operations • Distributed energy resource management system (DERMS) integrated with other operating systems • Greater autonomy of operation at the grid edge
Data analytics	• Automation of detection and interpretation of events
On-line monitoring / automated inspection	• Higher resolution of information on grid state
Increased automation	• Greater autonomy of operation at the grid edge
Expanding communications networks	• Higher resolution of information on grid state • Greater coordination between distribution control centers and with the transmission control center and fleet operations center.
Augmented / virtual reality	• Control center could become a virtual control center
Cyber security	• Increased awareness of the possibility of cyber-attacks on the grid • Enhanced situational awareness to detect cyber events
New lines of business	
Greater customer expectations of services	

Distribution Operations

How the job will change	Skillsets
Distribution operations will become much more complex in the future due to higher penetrations of intermittent, renewable generation, distributed generation, customer programs that enable DER-provided grid services, third party service providers and grid modernization investments that provide greater visibility and controllability. To address this complexity in the near-term, there will be improvements in short-term load and generation forecasting. In the longer-term, there will be an increase in autonomous systems located at the grid edge. These system will take local actions, coordinate with neighboring systems and inform the operator of the actions taken. There will also be greater coordination between transmission, distribution and fleet operation. Advanced in virtual reality could mean that there will no longer be the need for a physical control center.	**Traditional:** ▪ Think and act quickly in emergencies ▪ Exercise sound judgment. ▪ Effectively communicate both verbally and in writing with other employees, agencies and the general public. ▪ Maintain control and remain professional and courteous in normal and emergency situations under adverse conditions ▪ Follow oral and written directions and procedures. ▪ Technical expertise of distribution system operations **New:** • Be able to adapt to new operating strategies, tools and technologies • Understanding of distribution operations with high penetrations of DER • Increased collaboration / coordination with transmission and fleet operations • Physical skills similar to an on-line gamer (hand / eye coordination)

Distribution Planning

Driver	Impacts
DER Proliferation	• Integration of DER into distribution planning • Partnership with third party service providers in distribution planning • Tighter integration of transmission, distribution and resource planning
Data analytics	• Greater understanding of customer technology adoption trends (what and where) • Higher quality forecasting tools • Higher quality models and more powerful simulation tools
On-line monitoring / automated inspection	• Models of loads and resources are based on actual performance
Increased automation	• Ability to produce better studies with more data.
Expanding communications networks	• Enhanced ability to bring back data that can be used in planning
Augmented / virtual reality	
Cyber security	
New lines of business	• Understanding requirements for new lines of business • Understanding impacts of new lines of business
Greater customer expectations of services	• Customers can choose to join to participate in programs the provide DER-enabled DER grid services

Distribution Planning

<table>
<tr><th>How the job will change</th><th>Skillsets</th></tr>
<tr><td rowspan="2">Similar to Distribution Operations, Distribution Planning will become much more complex in the future due to higher penetrations of intermittent, renewable generation, distributed generation, customer programs that enable DER-provided grid services, third party service providers and grid modernization investments that provide greater visibility and controllability.

Traditionally, distribution planners have needed to have tremendous technical depth. In the future they will also need to have breadth as transmission, distribution and resource planning becomes increasingly coordinated.

Planners in the future will also need to be good communicators, able to work in a team, and quickly be able to adapt as things change. This is also a reflection of the growing need for planners to act as coordination points interfacing with multiple groups across the organization and with third parties.</td><td>Traditional:
▪ Strong technical foundation:
– Power system modeling and simulation
– Load and DER forecasting
– Protection and power quality
– Control operations
– Field implementation issues</td></tr>
<tr><td>New:
• Excellent collaborator (strong interpersonal skills, works well in a team environment, adaptable)
• Data analytics and programming
• Focus on technical breadth rather than technical depth</td></tr>
</table>

Asset Management

Driver	Impacts
DER Proliferation	• Understand how higher penetrations of DER can impact grid assets • Understand O&M issues associated with new technologies (such as power electronics, smart inverters, energy storage systems, etc.)
Data analytics	• Better assets models (understanding aging and failure of assets) • Increased fleet management of assets • AI for detecting and diagnosing problems from imagery and on-line monitoring data • Optimizing vegetation management • Identifying incipient equipment failure
On-line monitoring / automated inspection	• Greater quantity and quality of asset health data
Increased automation	• Greater number of devices to maintain • New types of equipment to maintain
Expanding communications networks	• Expanded infrastructure to maintain
Augmented / virtual reality	• Use of new tools to visualize asset health and management.
Cyber security	• Convergence of asset health monitoring and cyber security monitoring
New lines of business	• Understanding impact that new lines of business may have on assets
Greater customer expectations of services	

Asset Management

How the job will change	Skillsets
Electric utilities are one of the most asset intensive of all industries. In North America, many of these assets have been in services for 30 years or longer. The challenges of a utility asset manager are to optimize the life cycle of a fleet of assets that are approaching their planned end of life, select new equipment and develop new designs that will optimize the balance between life cycle performance and cost. They do this while introducing new materials and technologies that have significantly different life-cycle issues the traditional equipment. The proliferation of asset monitoring and advanced data analytics will change how asset management is performed within electric utilities. Asset manager will have a better understanding of how equipment ages and fails. Equipment will increasingly have online and diagnostics built in by the manufacturer. Maintenance will transition to condition-based and predictive. An asset manager will know precisely where each piece of equipment is in its life cycle.	**Traditional:** ▪ Understanding of economics (be able to monetize benefits and risks) ▪ Understanding of utility equipment, materials and workforce issues ▪ Understand how small details can impact the big picture **New:** • Expertise with data analytic • Understanding of life cycle issues associated with the embedding microprocessors and communications into traditional equipment • Understanding of new technologies such as energy storage • Understand of life cycle issues associated with new materials

Distribution Engineering

Driver	Impacts
DER Proliferation	• Development of new designs that address issues associated with higher penetrations of DER • Migration towards greater use of looped and/or networked systems
Data analytics	• Designs are continually refined through analysis of equipment failures and modeling and simulation • Optimal sizing of equipment • Optimal placement of automation equipment • Continued progression towards standardized designs •
On-line monitoring / automated inspection	• The need to understand a growing number of complex devices and tools.
Increased automation	• Migration towards settingless protection
Expanding communications networks	• Access to data no matter the location.
Augmented / virtual reality	• Use of AR/VR tools to expedite work and to provide better situational awareness. • Adaption of products and service that incorporate these technologies.
Cyber security	•
New lines of business	• Adaptation of the workforce to support non-traditional job functions.
Greater customer expectations of services	• Greater engagement of engineers with the customer.

Distribution Engineering

<table>
<tr><th>How the job will change</th><th>Skillsets</th></tr>
<tr><td rowspan="2">Increased penetrations of distributed energy resources will change the way that the distribution system is designed and operated. Distribution Engineers will need to develop designs that can accommodate DER and new technologies such as energy storage and power electronic controllers.</td><td>Traditional:
Estimating costs and timelines for project delivery
Interpreting technical drawings and design specifications
Creating project prototypes and models using three-dimensional design software
Communicating with team members during project design and development
Designing and performing tests to determine whether new products and systems meet standards
Proposing electrical product and system modifications to improve quality and efficiency
Monitoring user comments to learn of areas where products and systems warrant improvements
Writing product documentation and reports
Problem solving
Critical thinking and problem solving
Expertise in electricity system theory and engineering
Communications skills</td></tr>
<tr><td>New:
Expertise with data analytic tools</td></tr>
</table>

Utility Field Worker

Driver	Impacts
DER Proliferation	• Understanding of O&M issues associated with new technologies
Data analytics	• Shift away from looking for problems to being told what and where problems • Sensors / analytics embedded into clothing and equipment for greater situational awareness and safety
On-line monitoring / automated inspection	
Increased automation	• Adapting to a work environment in which the worker is surrounded with complex technologies.
Expanding communications networks	• Connectivity at any location in the service territory • Office apps and data are readily available to the worker at any location.
Augmented / virtual reality	• Needs to be comfortable working with technology • Augmented reality headset will be standard equipment • Digital assistant • Access to relevant information • Access to virtual on-line job aids and to subject matter experts • Just in-time or refresher training for the daily tasks.
Cyber security	• Role-based access to data and facilitates
New lines of business	• Needs to be able to quickly pick up new skill sets required by new lines of business
Greater customer expectations of services	• Needs to be able to provide customers with timely and accurate information

Utility Field Worker

How the job will change	Skillsets
Utility field workers are the "boots on the ground" for electric utilities and this job function will change in response to new technologies and philosophies that are adopted within the company. Maintenance will transition from time-based to condition-based. Field equipment will increasingly have embedded monitoring, computing and telecommunications. New tools, such as drones, augmented reality, digital personal assistants, on-line access to remote subject matter experts, will be common. There will be increased use of distribution automation and microgrids.	**Traditional:** ▪ Understanding of electric utility equipment and procedures ▪ Able to follow written and verbal instructions ▪ Able to detect equipment issues and determine the appropriate response
	New: • Ability to learn about O&M issues associated with field equipment that is based on new technologies (solid-state equipment, energy storage, smart inverters, etc.) • Ability to learn about O&M issues relating to field equipment that has embedded computing and communications • Ability to perform with new technologies such as drones, augmented reality, personal digital assistant, on-line access to remote subject matter experts • Ability to expand their capability in response to new lines of business

Information Technology

Driver	Impacts
DER Proliferation	• Migration to a distributed computing architecture • Will have visibility of a customer's DER • Will need to have a connection with third party service providers • Analytics to detect new DER devices connected to the grid
Data analytics	• Develop the infrastructure and capabilities for data management • Increase in the number of data scientists • Integration of data from internal and external sources • Data governance • Data analytics center of excellence • Analytics that identify and fix errors in data • Data is accessible to those how need it
On-line monitoring / automated inspection	• Data automatically flows from the field into the system of record – updates are made to associated systems and to the network model • Remote management of networked intelligent field equipment • Transition from centralized to distributed command and control
Increased automation	• Expanded number of sensors and devices to maintain.
Expanding communications networks	• Development and adoption of telecommunication planning tools
Augmented / virtual reality	• An ever-expanding suite of technologies to have knowledge of and to integrate into the workforce
Cyber security	• Enhanced cyber security operations center • Intrusion detection
New lines of business	• Understanding impacts of and requirements for new lines of business
Greater customer expectations of services	• Availability of higher quality information to customers through a variety of media

Information Technology

How the job will change

The development of IT/OT architectures will become more important as the complexity of the distribution system increases as a result of the participation of DER devices, the emergence of third-party service providers and a transition to a more distributed command and control structure.

The role of data scientists will expand in the future with advances in data analytic tools and the availability of data.

Skillsets

Traditional:

- Application Development
- Architecture
- Cyber Security
- Information Management
- Digital Communications
- APIs
- Configuration Management
- Develop and Secure Network Structures
- Develop and Test Methods to Synchronize Data
- Interaction Designs and Flows
- Mobile Applications
- Open Source Technology Integration
- Artificial Intelligence

- Cloud Computing
- Cloud Systems Administration
- Maintain Database Access
- Install, Maintain, and Merge Databases
- Analyze and Recommend Database Improvements
- Analyze Impact of Database Changes to the Business
- Database Administration
- Continually Review Processes for Improvement
- Critical Thinking
- Emerging Technologies
- Logical Thinking
- Problem Solving
- Project Management

New:

- Greater understand on operational technology
- Increase in the number of data scientists

Customer Service

Driver	Impacts
DER Proliferation	• New utility programs that enable grid services from DER will be available to customers • New utility programs that assist customers in maintaining customer owned DER. • Will have visibility of a customer’s DER • Will need to have a connection with third party service providers • Analytics to detect new DER devices connected to the grid
Data analytics	• Analytics will identify the customers who are most likely to enroll in the different programs • Better forecasts of estimated time to restoration • Proactive sharing of relevant information to customers • Greater understanding of issues on the customer side of the meter
On-line monitoring / automated inspection	• Greater access to system and customer information
Increased automation	
Expanding communications networks	
Augmented / virtual reality	
Cyber security	• Greater awareness of data privacy and cyber security threats
New lines of business	• Understanding customer service requirements of new lines of business
Greater customer expectations of services	• Customer views the utility as a provider of many difference services not just an electricity service provider.

Customer Service

<table>
<tr><th>How the job will change</th><th>Skillsets</th></tr>
<tr><td rowspan="2">Customers expectations from service providers will increase in the future. To meet these expectations, utility customer service representatives will need to have greater levels of information and control available to them.

As customers adopt more DER, utilities will expand their offerings of customer programs that will enable grid services from these resources. Customer service representatives will need to be able to answer questions and provide customer support for these programs.

As utilities begin to branch out into new lines of business, customer service representatives will need to be able to be able to expand their capabilities, as necessary.</td><td>Traditional:
▪ Interpersonal skills
▪ Gather information / assess situation
▪ Logical thinking / problem solving
▪ Conflict resolution
▪ Utilizing resources and information
▪ Inform customer about services</td></tr>
<tr><td>New:
• Be able to expand their understanding of new customer service offerings and new lines of business and be able to provide the necessary support
• Be able to work with new systems that provide more information on both the customer and the system</td></tr>
</table>

Findings from GridEd's Human Resources Committee

GridEd's Human Resources Committee?

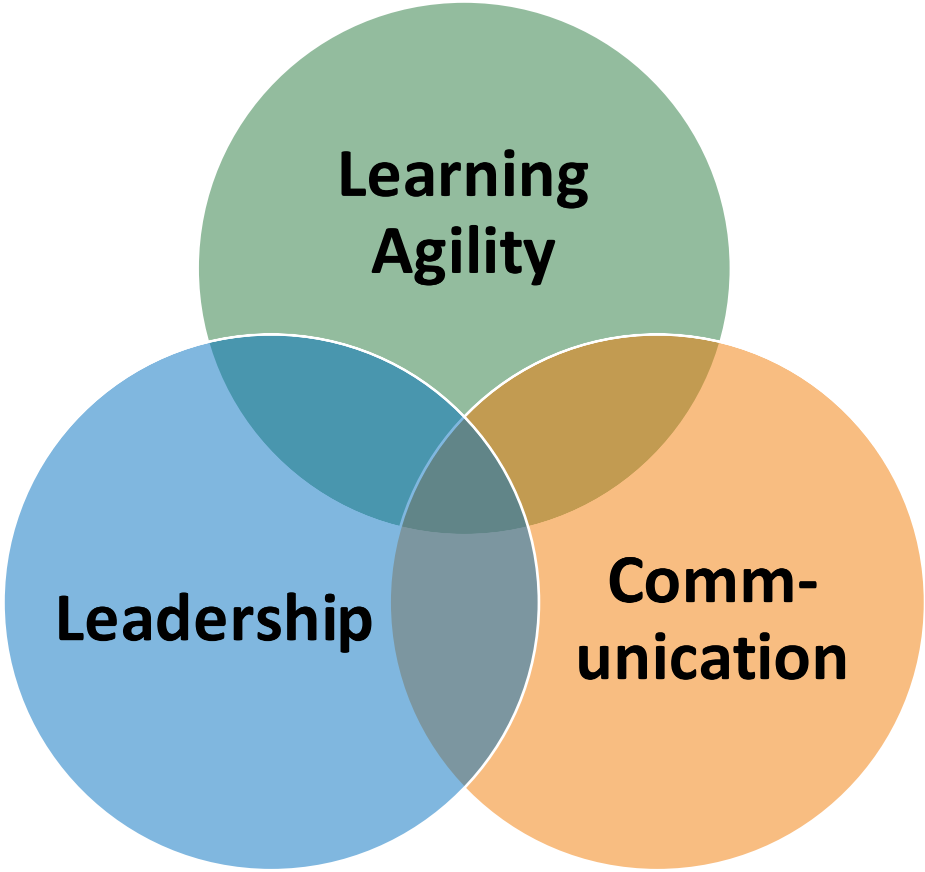
What is it?

A group of HR professionals that meets periodically to share leading practices for the electric utility industry to attract and retain top talent given current trends and issues that are impacting the industry's diverse workforce.

Example Discussion Topics:

- Organizational skills gaps
- Current processes being used to identify gaps

Skills identified as most valuable



Identifying Skills Gaps

Tools

- There are available tools that can provide valuable information on skills needed to fill future, or even current, roles.
- Most companies represented on the HR Committee do not currently have an internal tool to assist with identifying skills gaps.
- Tools requires input from the company on current skills, current roles/positions and future roles/positions.

Impact of COVID Pandemic

- Many HR professionals are having discussions with senior management to re-evaluate roles that were previously required to be in the office, recognizing they now may be able to work remotely.

Lessons Learned from the HR Committee

Trends in HR Organizations Across the Industry

Executive Buy-In

Getting Executive leadership buy in and investment to provide HR teams the needed resources (people/systems, etc.) to analyze their organizations current workforce; evolving roles as well as current roles.

Community Outreach

Developing strategies to do community outreach and to increase diversity and reach candidates they would not have attracted without outreach.

In-house Training

Creating inhouse training programs internally to upskill internal talent for new roles based on our evolving industry.

Recruiting Improvements

Improving their recruiting strategies to bring in early career and train for the future.

Cyber Security Engineers and Data Scientists

Over the past few years, there is an emergence of cyber security roles within the engineering career paths especially in the energy industry.

There are defined career paths for cyber security and data scientist in R&D as well as IT. (*see appendix for job descriptions*)

Source: *Job descriptions from a 2019/2020 AON Hewitt compensation survey*

Identifying Education and Training Gaps and Needs

University Gaps Assessment in Digital Power Systems Education

Download the Full Report

University Gaps Assessment in Digital Power Systems Education

https://www.epri.com/research/products/000000003002020016

University Gaps Report by Partner Universities

Course Inventory from University of California, Riverside; Washington State University; University of Texas, Austin; Virginia Tech; Stony Brook University

Data Science

School	UG	U/G	Grad	Total
SBU	1	–	4	5
UCR	2	1	1	3
UT	2	1	2	5
VT	2	–	4	6
WSU	–	–	1	1
Others	–	–	4	4
Total	**7**	**2**	**16**	**25**

ICT & Cyber Security

School	UG	U/G	Grad	Total
SBU	1	–	5	6
UCR	1	–	6	7
UT	4	–	–	4
VT	3	–	6	9
WSU	2	1	2	5
Others		1	4	5
Total	**11**	**2**	**23**	**36**

DER Integration

School	UG	U/G	Grad	Total
SBU	1	–	4	5
UCR	1	–	3	5
UT	3	1	1	5
VT	3	–	3	6
WSU	3	–	2	5
Others	2	5	9	16
Total	**14**	**6**	**22**	**42**

Graduate and undergraduate courses offered at the five Partner universities of the GREAT with Data program are used as the basis for the gaps analysis. The project team has also reviewed relevant courses from other universities that are participating as an Affiliate University or courses that were developed as part of the DOE GEARED Program. Further, courses were categorized into undergraduate, graduate, or cross-listed courses

Competency Framework

Data scientist/analyst/engineer in the electric power industry

Competency	Skill
Design Analysis	Discover the needs for data analytics in smart grid and power systems
	Explicitly plan the data analysis in the power system domain
	Anticipate and address competing explanations using data science and power engineering knowledge
	Determine the best way to evaluate the data analytics results in the context of power system
Conduct Analysis	Explore the data appropriately
	Build or apply appropriate algorithms with power engineering domain knowledge
	Clearly summarize results and document findings
Incorporate Analysis Into Power System Planning and Operations	Read/write data to/from power system applications
	Integrate data analytics work into power system planning and operation processes
	Package data analytics work for visualization and reporting

Data Analytics Gaps Assessment

Existing Courses Offered by Partner Universities

	Power Systems		Machine Learning and Data Mining		
	Classical Data Processing Techniques	Bridging Courses	Data Science	Machine Learning	Statistics
Undergrad	Power System Analysis		Data Science Laboratory Data Science Principles	ECE Machine Learning Artificial Intelligence and Engineering Applications CS Machine Learning	Nonparametric Technique
Under/Grad		Introduction to Power Distribution Systems Power Quality and Harmonics			
Graduate	Power System Operation and Control Computer Methods in Power Engineering	Big Data Analytics in Smart Grid Data Analytics in Power Systems Smart Energy in the Information Age Cyber-Power Systems	Big Data Analysis Big Data Systems, Algorithms, and Networks Big Data Analytics	Advanced Machine Learning Deep Learning Reinforcement Learning Theory and Practice	

Gap in *widely Bridging Courses* at the undergraduate level

Summary of Gaps and Conclusions

Data Science

- ***There is a lack of broad course offerings in data science for power systems applications at the undergraduate level*.**
  - An undergraduate student focusing on power/energy systems may have to take a course outside of one's own focus area to learn data science concepts, while taking additional effort to connect these concepts to power system applications.

- ***There is little coordination among new courses on data science for power systems in the academic community*.**
  - Considering courses focusing on this area are relatively new, the list of topics and concepts that should be covered has not been widely discussed and vetted by the power engineering education community.

Competency Framework

Cyber security and ICT analyst/engineer in the electric power industry

Competency	Skill
Information and communications technology, Data acquisition	Internet/proprietary networking in electricity markets/power system operation
	Communications for power system operation, control, substation and distribution automation, AMI
	Communication protocols and standards for power grids
	Advanced computing: GPU, cloud computing, edge computing
Cyber security and vulnerabilities	Cyber security concepts and technologies for the power grid
	Vulnerabilities of cyber attacks and intrusions in power grid components and systems
	Critical Infrastructure Protection (CIP) Standards
Cyber-power system security	Cyber security for inverters, SCADA, renewables, AMI, distribution automation, substation automation, and microgrids
	Independencies between cyber systems and power systems
	Cyber-physical system security of an integrated cyber-power system

Cyber Security and ICT Gaps Assessment

Existing Courses Offered by Partner Universities

	Power Systems			ICT & Cyber Security		
	Traditional Power	**Use Communications**	**Bridging Courses**	**Cyber Physical**	**Cyber Security**	**Computer Networking/ Science**
Undergrad	Power System Analysis Power System Analysis and Control	Smart Grids Power System Protection	Cyber-Infrastructure for the Smart Grid Electric Energy Distribution Systems		Computer Security Fundamentals Network Security and Privacy Information Security and Privacy	Cloud Computing Intro to Computer Networks
Under/Grad			Distributed Control and Optimization for Smart Grids		Computer Security	
Graduate		Power System Operation and Control Power System Dynamics Big Data Analytics in the Smart Grid Modern Grid with Renewables	Power Systems under Abnormal Operating Conditions Cyber-Power Systems Smart Energy in the Information Age Microgrids Introduction to Power Distribution Systems Power System Steady State and Market Analysis	Cyber Physical Systems	Cybersecurity and IoT Networks and Protocols Network Security Computer Security Computer System Security Information Security	Cloud Computing Cloud Computing and Cloud Networking Computer Communication Networks

Gap in *widely applicable* outlines of *bridging* courses

Summary of Gaps and Conclusions

ICT and Cyber Security

- ***There is a critical need for widely applicable outlines of bridging courses/modules*.**
- ***Modeling of the cyber (information and communication) systems is lacking for power system applications***. It is necessary to develop and modularize the cyber system models that can be interfaced with the large number of existing and future power system software tools.
- ***There is a great need to develop and incorporate an integrated cyber-power system security concept and methodology into curriculum***. Existing power system analysis largely ignores the cyber systems and the interdependencies between cyber and power systems.
- ***Modeling software tools used in curricula lack the necessary characteristics of communications in power grids***. Software tools such as NS-3 have been used for cyber network modeling; however, they are designed for computer networks and not customized for power grids.
- ***There is a critical need to closely integrate new technologies in power systems to enhance power system reliability, security and resiliency***. New information and communication technologies are emerging, such as AI, decentralized operation and control, 5G, Internet of Energy, data centers, cloud computing, and edge computing.

Competency Framework

DER integration engineer in the electric power industry

	Competencies Needed
Alternative Energy Resources	Alternative Energy resources and power conversion technology – wind, solar, etc.
	Energy economics and sustainability
	Modeling DERS and flexible loads – PV, wind, battery storage, electric vehicles, HVAC, home water heaters
	Impacts assessment of DERS in the power grid – power quality, voltage, stability, protection related issues
Grid Integration of DERs	Power electronics interface to integrate DERs – Inverter technology: Grid-forming, grid following, and grid supporting technologies (smart inverters)
	Modeling and simulation tools for microgrids with DERs
	DER interconnection standards
Active Electric Power Distribution Systems	Simulation tools and modeling of active power distribution systems
	Emerging systems to manage DERs and Microgrids – ADMS, DERMS, Microgrid EMS
	Prosumers and demand-side participation – demand response, real-time pricing, home area networks, advanced metering systems, smart loads and appliances (buildings)
	Electricity market mechanisms for DERS in a distribution system – centralized or decentralized market, transactive energy, ancillary services

DER Integration Gaps Assessment

Existing Courses Offered by Partner Universities

	Alternative Energy Resources	Grid Integration of DERs	Active Electric Power Distribution Systems
Undergrad	Alternate Energy Systems Analysis of Power Systems with Renewable Energy Sources Introduction to Photovoltaics Renewable Energy Resource	Power Electronics Microgrids Power Electronics Laboratory	Power Systems Analysis Smart Grids Protection of Power Systems I
Under/Grad	Power Quality and Harmonics		
Graduate	Advanced Alternate Energy Systems Analysis of Power Systems with Renewable Energy Sources Modern Energy Technologies Introduction to Photovoltaics	Power Converter Modeling and Control Microgrids Systems Applications of Power Electronics	Power Systems Under Abnormal Operating Conditions Introduction to Power Distribution Systems Power System Steady State and Market Analysis Big Data Analytics in Smart Grid Smart Energy in the Information Age Power Quality Analysis

Gap on courses related to ***active distribution systems and DER-interfaced microgrids with regard to integration of digital technologies***

Summary of Gaps and Conclusions

DER Integration

- There is a gap on courses related to ***active distribution systems and DER-interfaced microgrids with regard to the use of digital technologies***.
  - While a few relevant topics are covered in some courses, there lacks a consistent framework to address this topic.

- ***Generally, the curriculum is limited in the topics related to active power distribution systems***.
  - While certain elements of the relevant topics are included in the curriculum, it is not well structured.
  -

- ***There is little content describing how energy storage and flexible loads can be used to mitigate impacts of intermittency caused by renewable energy***.
  - This includes the technical requirements as well as emerging market and regulatory practices to address these future challenges.

- ***Existing content related to microgrids with DER technology needs revisions based on new research developments***.
  - This includes adding new course materials on topics including emerging grid-forming/grid-supporting/grid-following modes of operation, interaction between synchronous generators and inverter-based resources with widely different time scales, new control architectures to manage DER-interfaced microgrids, and the use of DERs for enhancing grid resilience.

Prioritization of Training Topics in Key Areas

Professional Training Course Prioritization Survey

What is it?

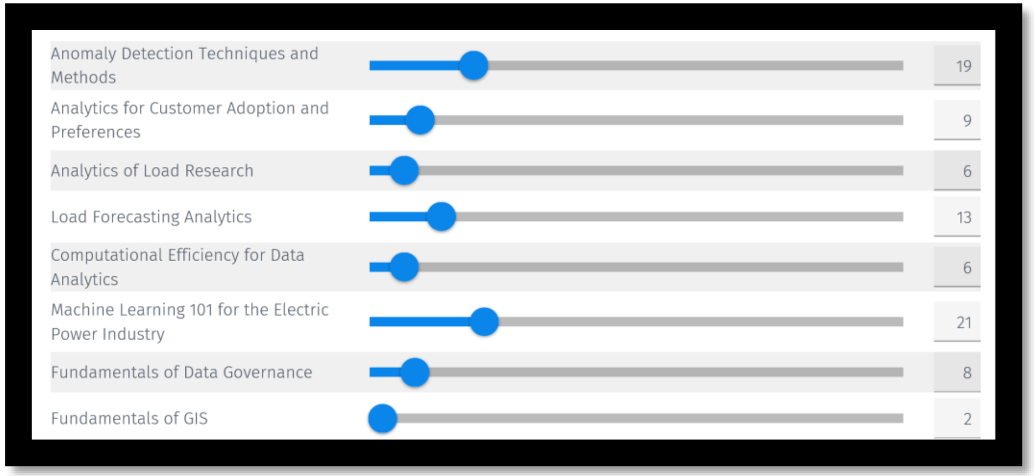
- Survey to prioritize a list of ~30 topics in the areas of data science, ICT, cyber security, and DER integration

Why do we need your help?

- Identify training needs for the industry
- Used to prioritize which professional training courses are developed/offered through the GREAT with Data program

Top 5 Topics from 2019 Survey

1. Big Data Analytics for Electric Power Distribution Systems
2. Energy Storage Technologies, Applications, and Integration
3. DG Interconnection on Distribution Systems
4. Machine Learning 101 for the Electric Power Industry
5. Cyber Security Fundamentals for Power Systems Professionals



2019 Course Prioritization Responses

17+ Utilities | **6 Universities** | **38 Completed Surveys**

Utilities:
1. AEP (x2)
2. Alliant Energy (x2)
3. BPA
4. CenterPoint
5. ConEd
6. DTE
7. Duke
8. First Energy
9. LES (x5)
10. National Grid
11. NYPA
12. TVA
13. Southern (x3)
14. SRP (x3)
15. TVA
16. WAPA (x2)
17. Xcel (x3)
18. Other

Universities:
1. Buffalo State
2. SDSU
3. UCR
4. U. of Memphis
5. U. of Nebraska
6. WWU (x2)

States	Responses
NE	12.50%
NY	10.94%
TN	9.38%
AZ	9.38%
WA	6.25%
CA	6.25%
CO	4.69%
AL	4.69%
OH	3.12%

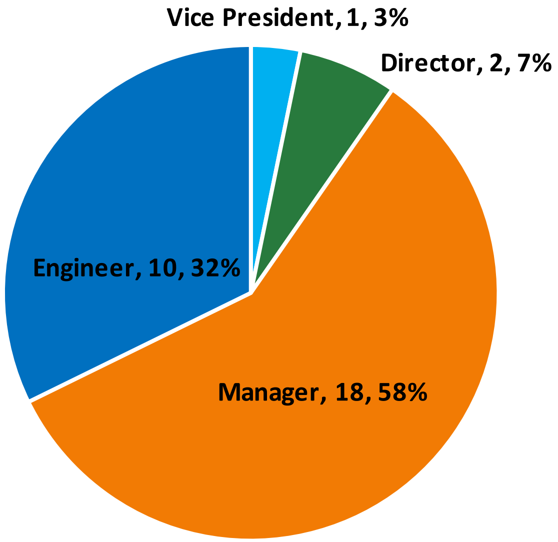
2019 Course Prioritization Responses

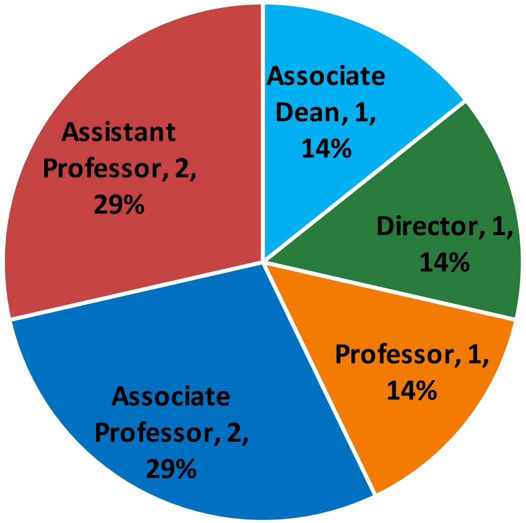
Utilities

Area	Role
Communications	Manager
Customer Programs	Manager
Cyber	Manager
Distribution	Director (2), Manager, Engineer(3)
Energy Services	Vice President, Manager
Enterprise Solutions	Manager
Engineering	Manager, Engineer
Operations	Engineer (2)
Planning	Manager (2)
R&D	Manager (4), Engineer (2)
Substation	Manager
T&D	Manager
Transmission	Manager (2), Engineer
Workforce/Training	Manager, Engineer

Universities

Area	Role
Engineering Technology	Professor
EE&CS	Assistant Professor (2)
E&C Engineering	Associate Professor (2), Associate Dean
Institute for Energy Studies	Director

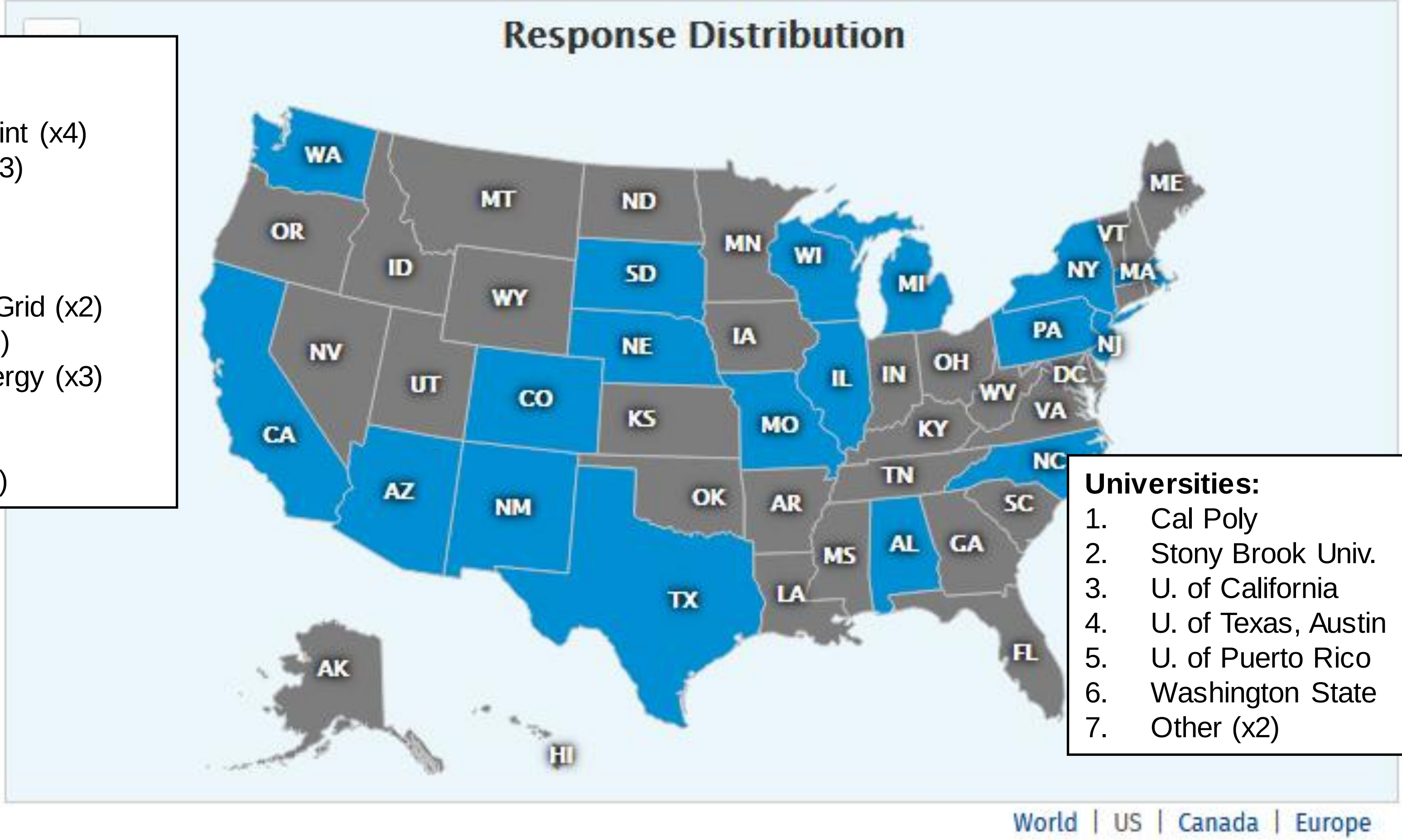




2020 Course Prioritization Responses

12+ Utilities | **7+ Universities** | **33 Completed Surveys**

Utilities:
1. BPA (x2)
2. CenterPoint (x4)
3. ConEd (x3)
4. DTE
5. Duke
6. Exelon
7. National Grid (x2)
8. NYPA (x3)
9. WEC Energy (x3)
10. WAPA
11. Xcel
12. Other (x3)



Universities:
1. Cal Poly
2. Stony Brook Univ.
3. U. of California
4. U. of Texas, Austin
5. U. of Puerto Rico
6. Washington State
7. Other (x2)

States	Responses
NY	17.81%
TX	13.70%
NE	9.59%
WA	8.22%
WI	6.85%
PA	4.11%
NC	4.11%
CO	4.11%
MA	4.11%
MO	4.11%

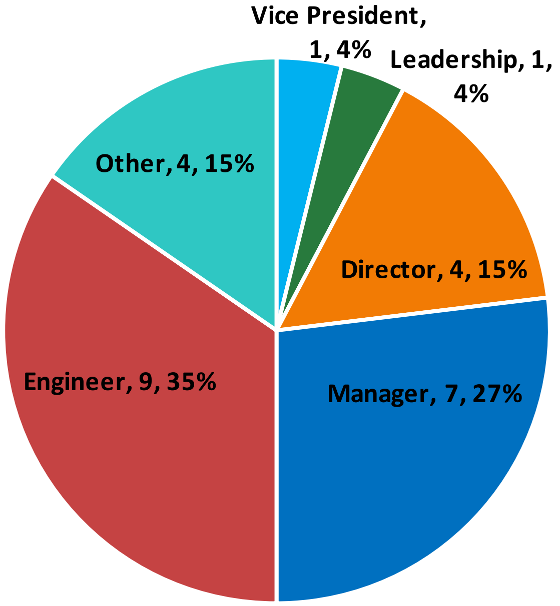
2020 Course Prioritization Responses

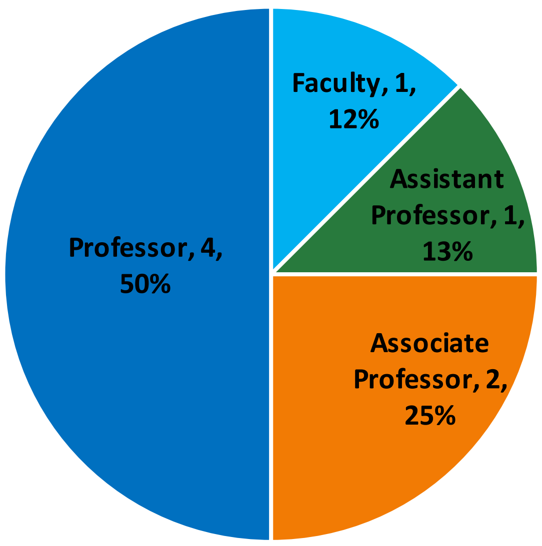
Utilities

Area	Role
Analytics	Program Strategist
Customer Programs	Manager
Distribution Automation	Manager
Distribution Engineering	Manager, Engineer
Environmental Health and Safety	N/A
Energy Efficiency/DSM	Engineer
Engineering	Director, Leadership, Engineer
Innovation	Director (x2)
IT Security	Director
Operations Planning	Engineer
OT	EMS/ADMS support
Planning	Manager
Research and Development	Engineer/Project Manager (x2), Specialist
System Operations	Engineer
Technical Services	Vice President
Training	Manager
T&D Design	Manager
Transmission	Program Manager, Engineer (x2)

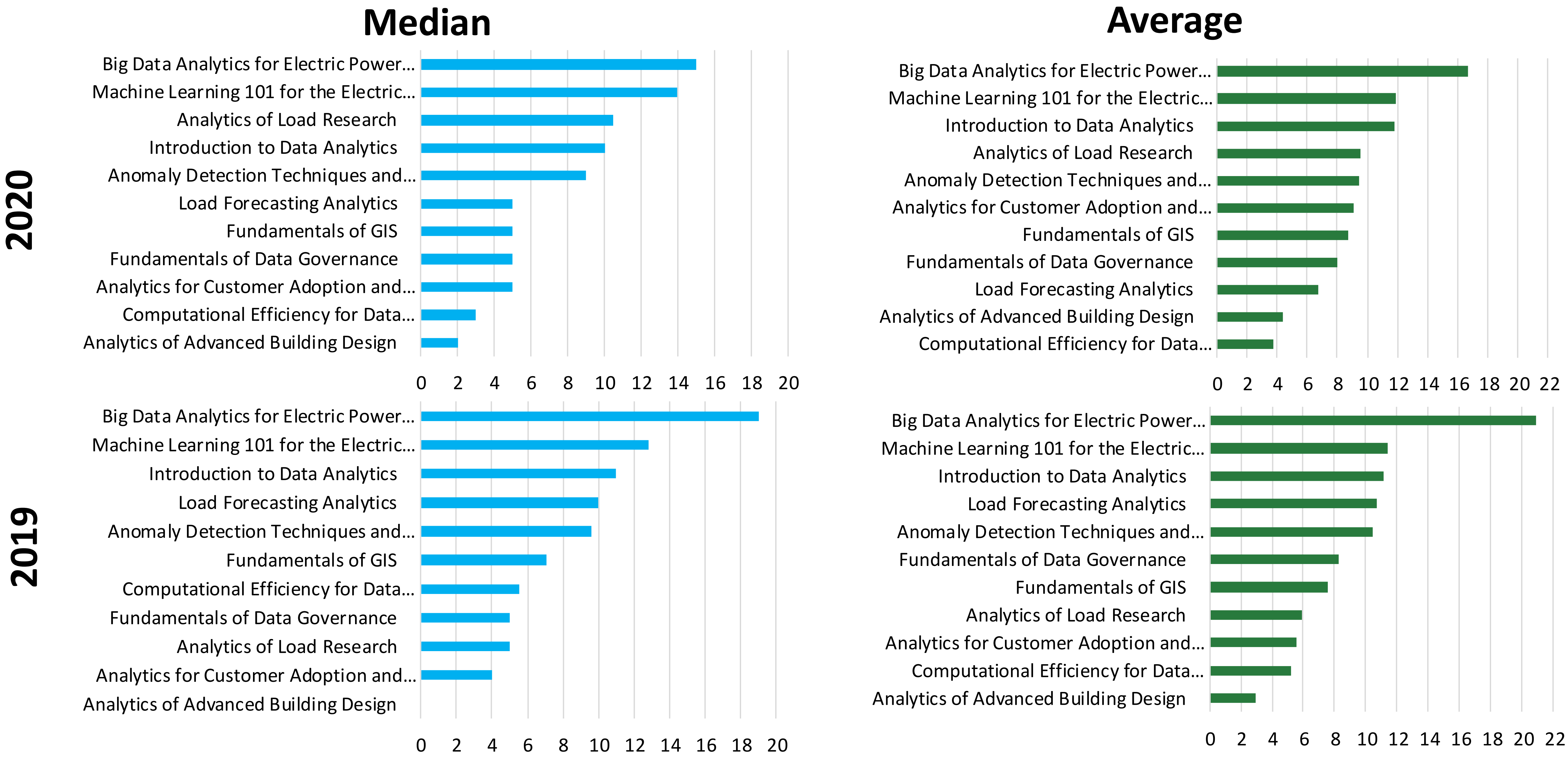
Universities

Area	Role
Applied Math	Faculty
Electrical & Computer Engineering	Associate Professor(x2), Professor(x2)
Electrical Engineering & Computer Science	Assistant Professor
Electrical Engineering	Professor (x2)





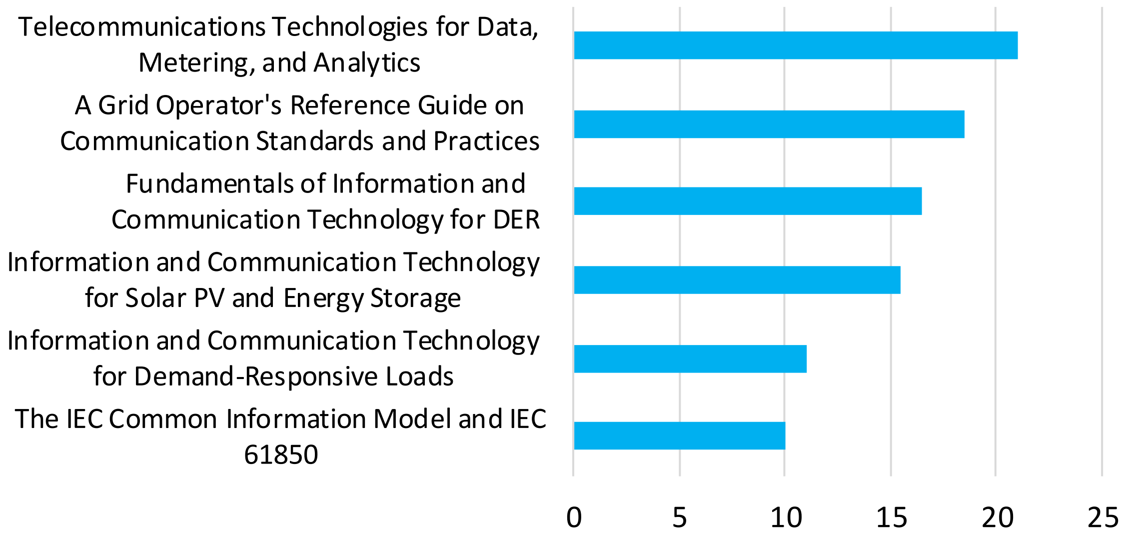
Data Science Course Prioritization Results

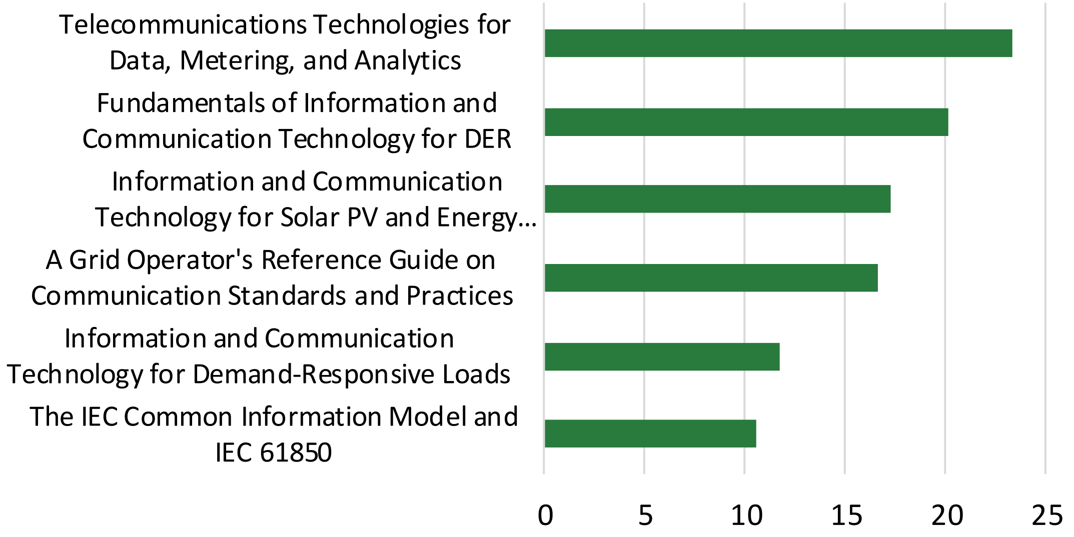


ICT Course Prioritization Results

Median | Average

2020





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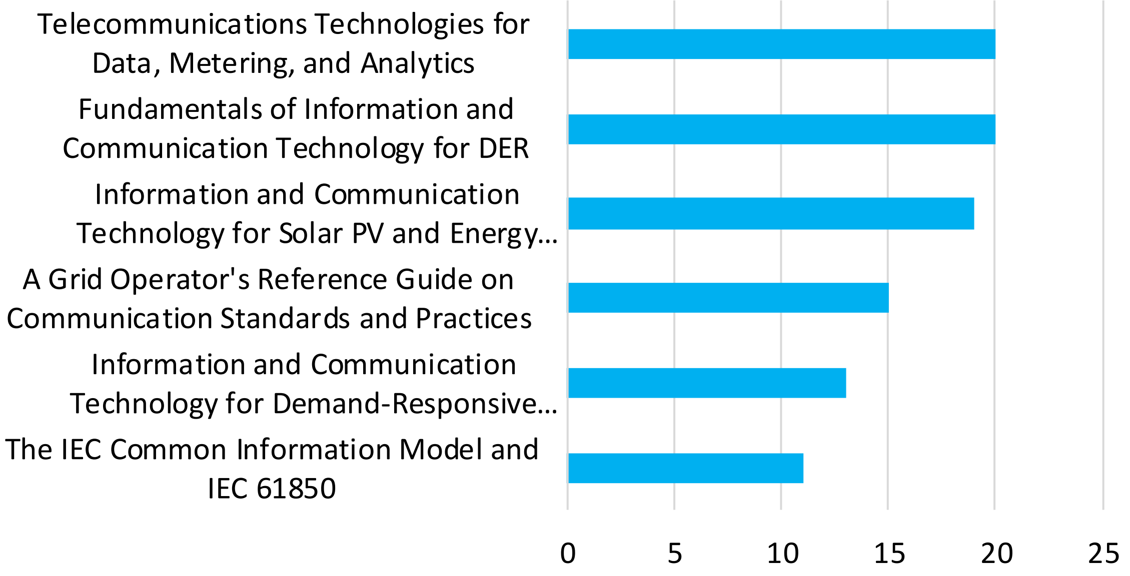
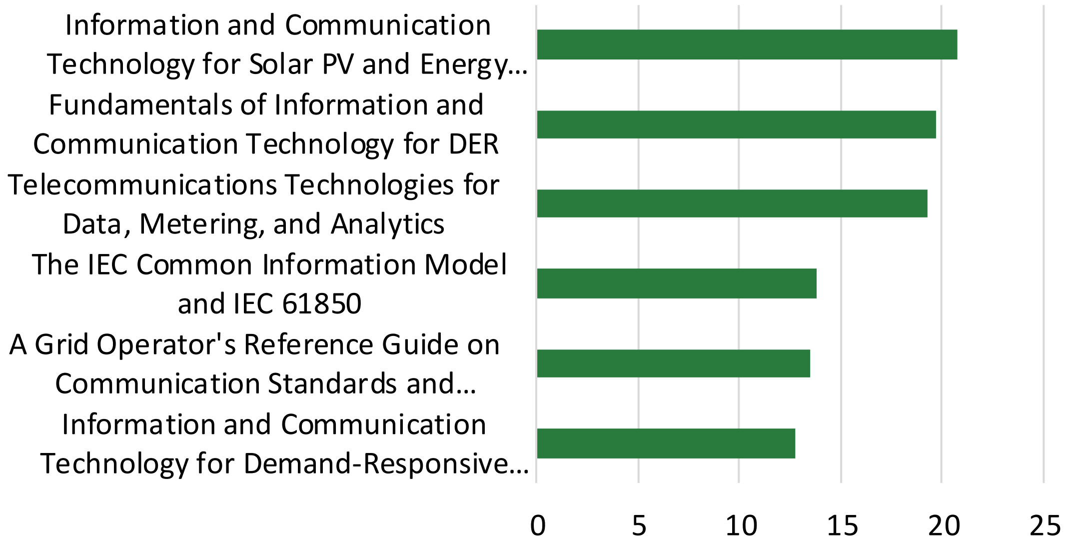


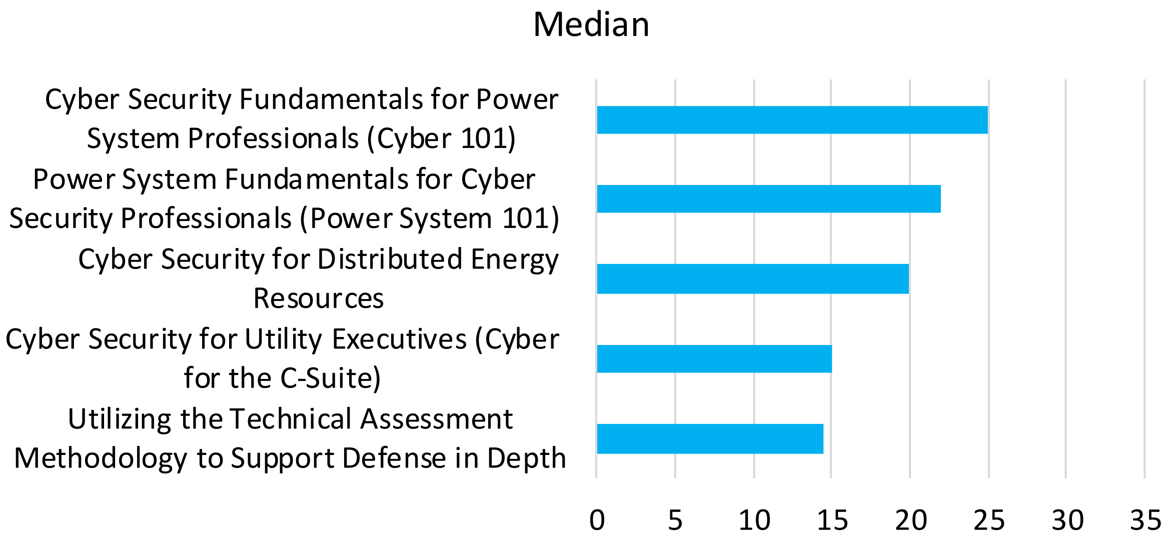


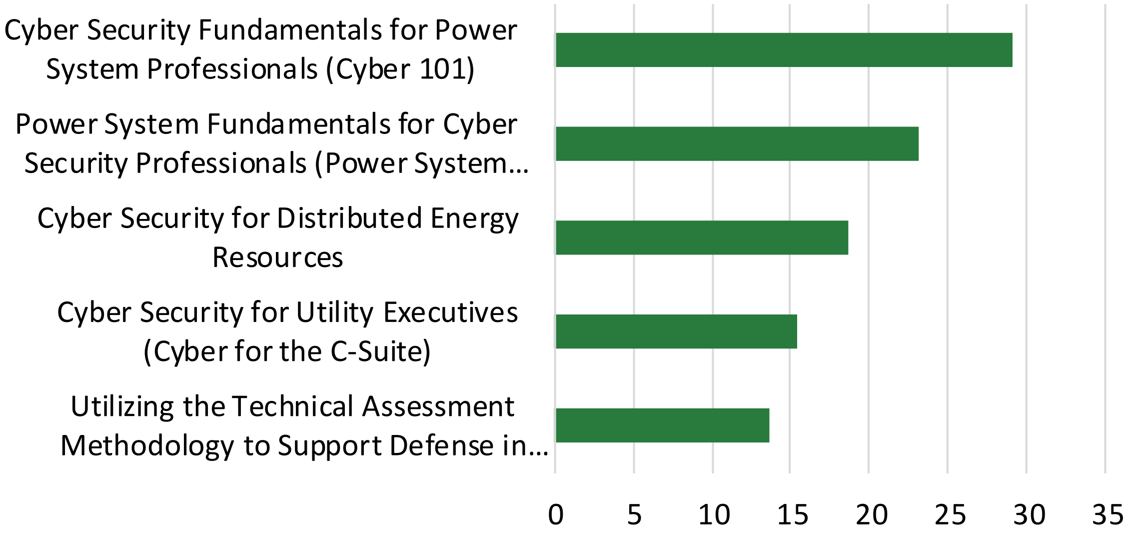
Cyber Security Course Prioritization Results

Median

Average

2020





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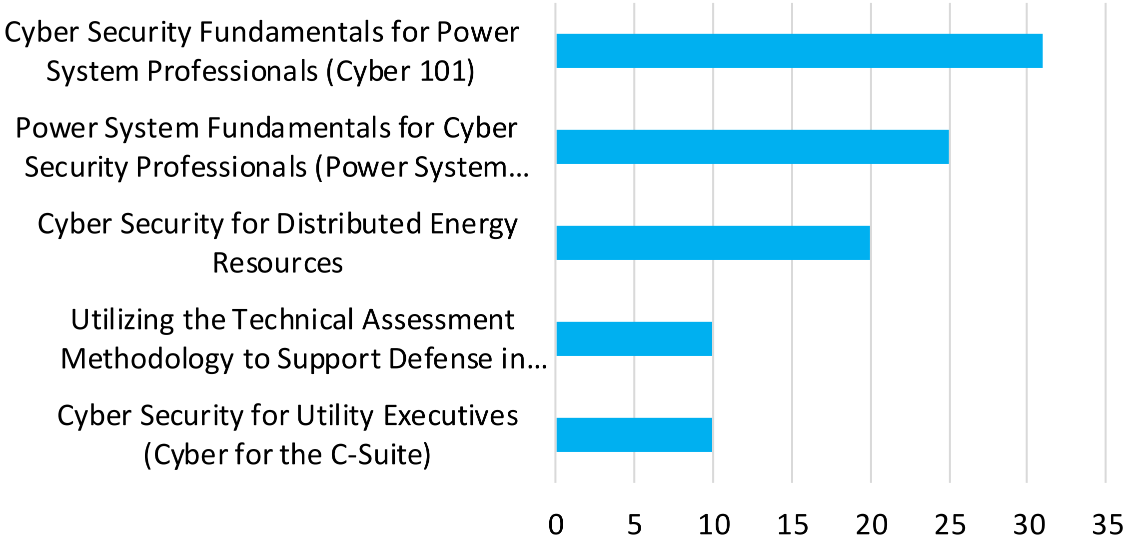
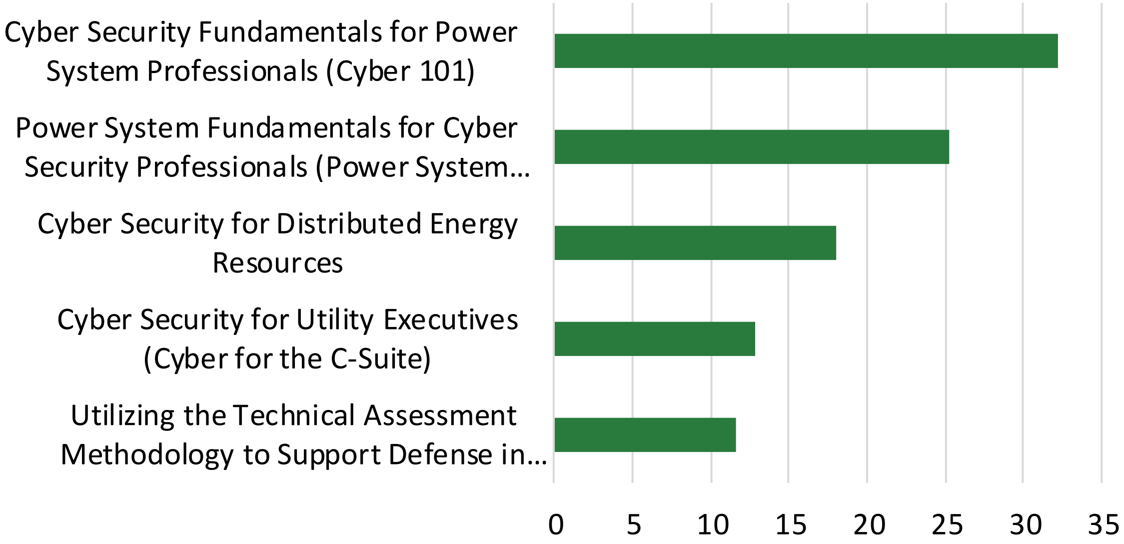
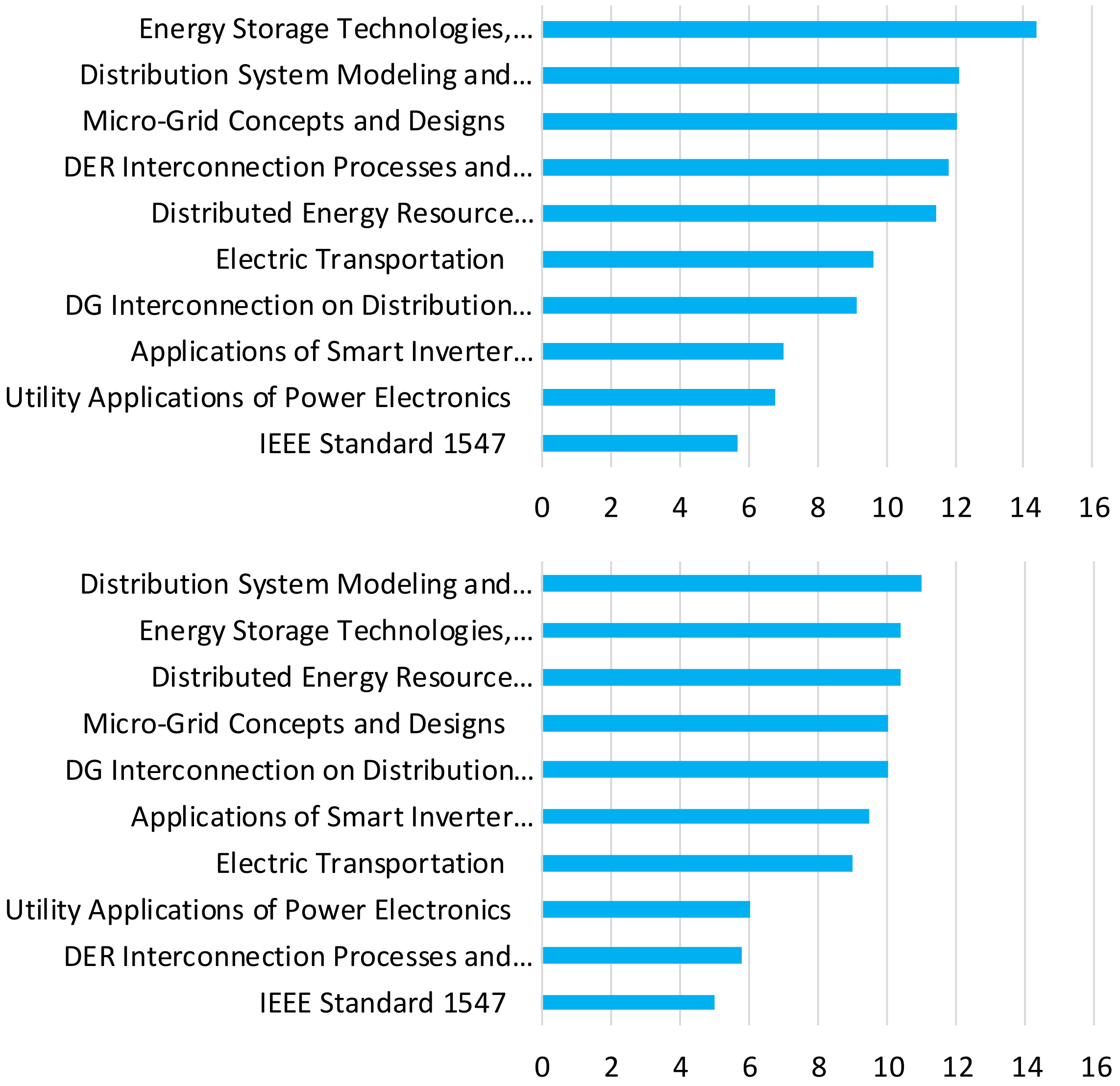




DER Integration Course Prioritization Results

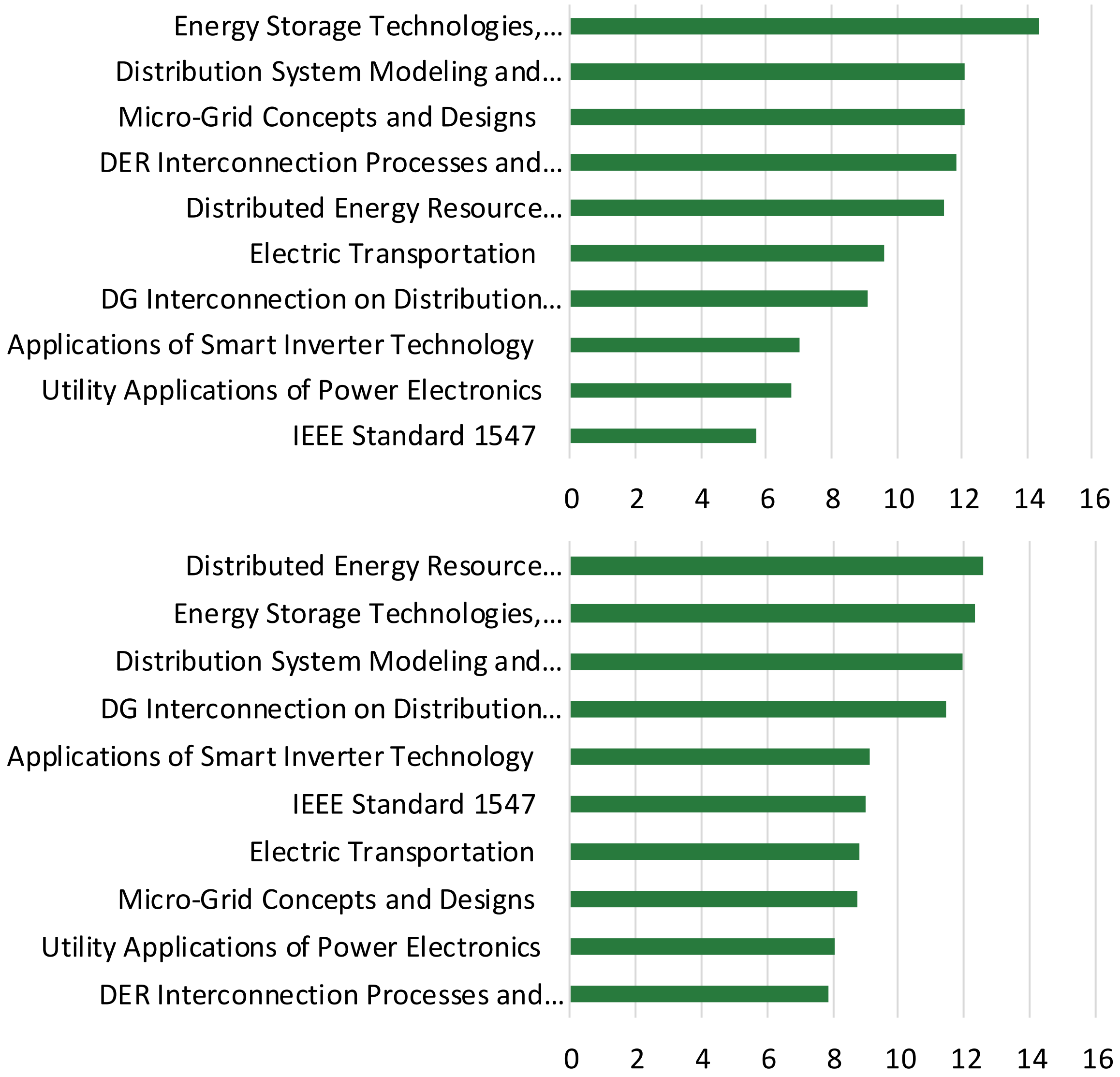
Median

2020



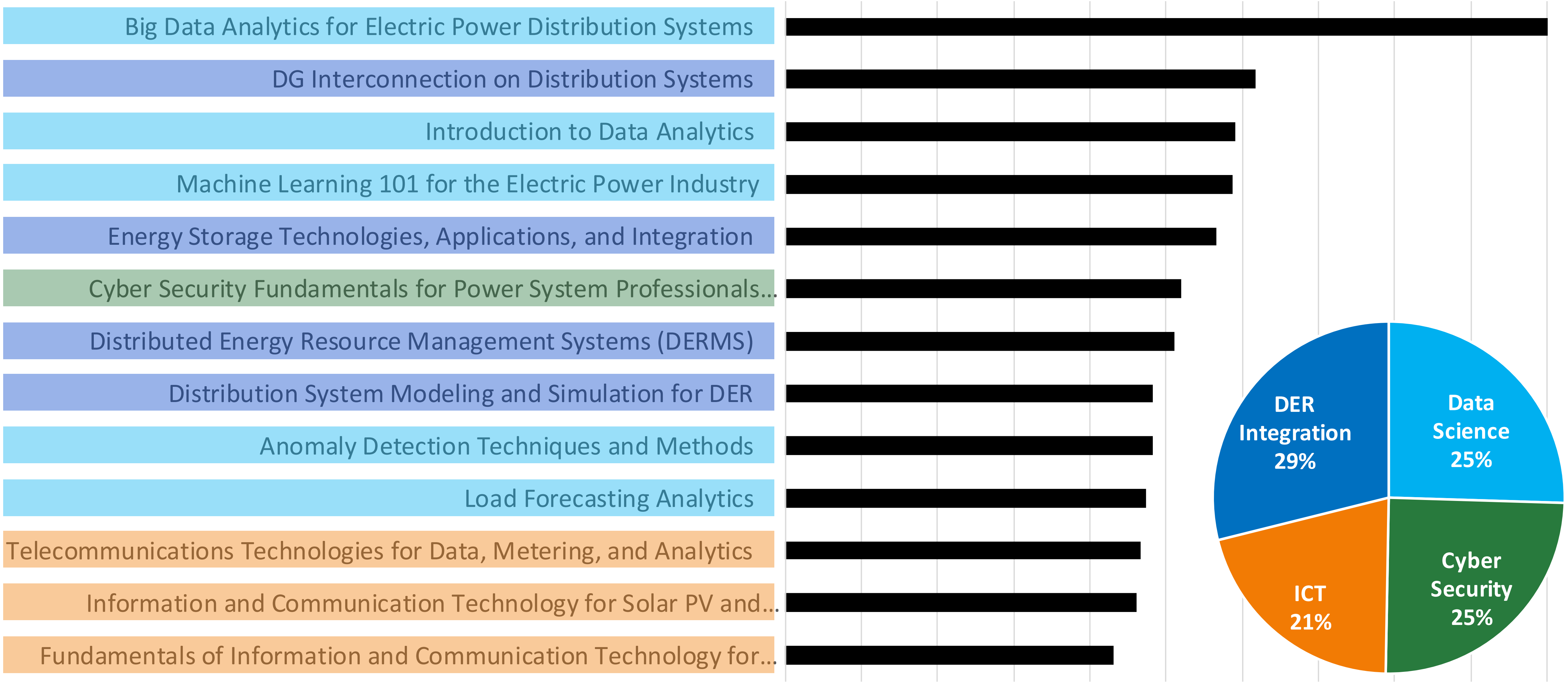
2019

Average



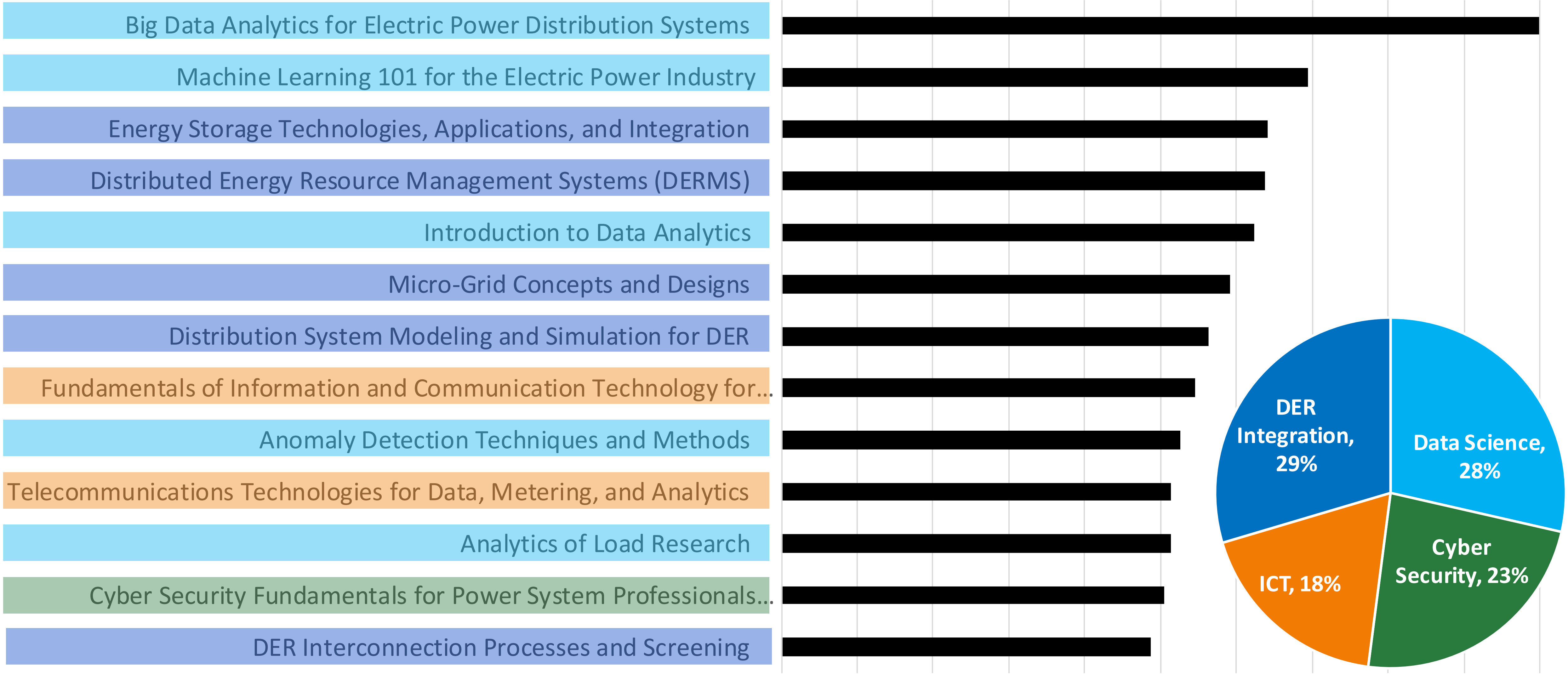
2019 Course Prioritization Results

Weighted Based on Topic Area and Mean/Median Combination



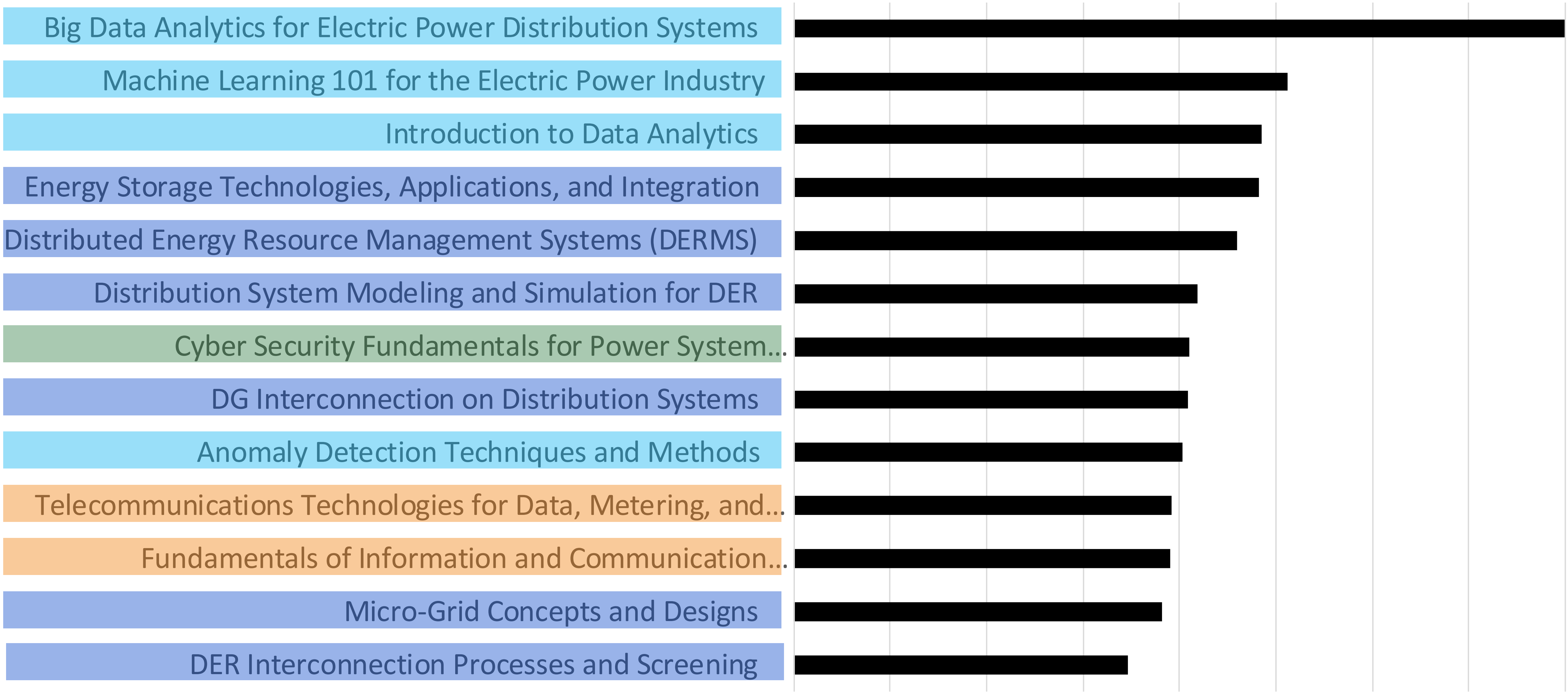
2020 Course Prioritization Results

Weighted Based on Topic Area and Mean/Median Combination



Combined 2019 & 2020 Course Prioritization Results

Weighted Based on Topic Area and Mean/Median Combination



Assessing the Need for Credentials

Terminology for GridEd's Credentialing Framework and Processes

A *credential* is a document that details a qualification, competence, or authority issued to an individual by a third party with a relevant or *de facto* authority or assumed competence to do so.

Examples of a credential include diplomas, degrees, certifications, IDs, badges, passwords, user-names, keys, powers of attorney, etc.

- A certificate is a piece of paper stating attendance in a class or passed an exam.
- **Learning objectives** are a specified set of knowledge content that is central to the content of an instructional course.
- A **professional development hour (PDH)** is recognition of attendance in a course with a defined agenda and technical content which is provided. There is no requirement for an assessment of knowledge gained through participation in the course and is the most elementary form of a credential.
- A **certificate of completion** is a document that carries a recognition that the recipient has attended a course and passed an exam or some other measuring instrument that demonstrates a prescriptive knowledge level tied to the learning objectives of that course.
- An **advanced credential** holds higher level requirements which could include holding certificates of completion for multiple courses in a related subject area, passing a standardized exam, or demonstrating sufficient work experience and on-the-job skill sets.

Credentials Questions for GridEd Advisors

- **What is the value of a credential in your company?**
- **Does your company value credentials that are awarded without some indication of knowledge acquired?** *(A simple PDH)*
- **Is there added value in your company for a credential that uses a measure of knowledge gained?** *(Are some employees required to have a credential before performing their job?)*
- **Has your company set standards for certain job qualifications that require credentials?** *(Grid Operators passing NERC courses?)*
- **EPRI is considering differentiating between a credential that has performance testing as opposed to one that does not – would your company support that principle?** *(PDH vs. optional test on knowledge gained from the short course)*

Comments from GridEd Advisors

- In some companies, employees objected to being tested to obtain a credential.
- One company said, if you don't test, I am not interested in participating in the program. Testing is required!
- Another company said providing enhanced credentials is important for some jobs.
- Some courses should require testing, but not all.
- Giving participants and/or company ***the option*** to receive a higher course "credential" by providing a "test" based on the principle of "learning objectives" for materials taught is a good practice!

Value of Credentials Survey (18 responses)

- AEP
- Austin Energy
- BGE
- Con Edison of NY
- Duke Energy
- Eversource Energy
- FirstEnergy (2)
- Hydro One
- KU
- LG&E
- National Grid
- SRP (2)
- TN Valley Public Power Assoc.
- WAPA (2)
- Washington State University

What is your PERSONAL opinion about the VALUE of these two options?

	Valuable	Meaningful	Worthwhile	Unimportant	Irrelevant	No Opinion/Not Sure
A credential awarded for attending a course AND scoring 80%+ on a test of course knowledge	5 31.3%	**6** **37.5%**	4 25%	1 6.3%	0 0%	0 0%
A credential awarded for participation - without a test of knowledge required (i.e., simple PDH).	2 11.8%	3 17.7%	**10** **58.8%**	1 5.9%	1 5.9%	0 0%

What is your COMPANY's opinion (not necessarily your personal opinion) about the VALUE of these SAME two options?

	Valuable	Meaningful	Worthwhile	Unimportant	Irrelevant	No Opinion/Not Sure
A credential awarded for attending a course AND scoring 80%+ on a test of course knowledge	3 25%	3 25%	**5** **41.7%**	1 8.3%	0 0%	0 0%
A credential awarded for participation - without a test of knowledge required (i.e., simple PDH).	1 8.3%	3 25%	**7** **58.3%**	1 8.3%	0 0%	0 0%

Please provide one example of credentials required by your company for certain job qualifications? (e.g., Grid Operators passing NERC course).

- NERC Certification (5)
- EE Exams for variety of entry level positions
- PE License
- Compliance courses have a knowledge check

EPRI is considering differentiating between credentials: those that require testing course knowledge vs. those that do not. Would your company support that principle?

Definitely YES	Probably YES	Probably NO	Definitely NO
4 25%	**11** **68.8%**	1 6.3%	0 0%

EPRI has received feedback from our Advisors that spans: from "testing must be required" to "we object to being tested to obtain a credential." Where do you fall on this scale? Should testing be OPTIONAL or MANDATORY to receive the credential?

Definitely OPTIONAL	1	6.3%
LEANING towards OPTIONAL	3	18.8%
LEANING towards MANDATORY	**10**	**62.5%**
Definitely MANDATORY	2	12.5%

GridEd's Credentialing Process for the GREAT with Data Initiative

GridEd is committed to providing participants of its professional training courses with the option of achieving two different levels of credentials as follows:

- **Professional Development Hours** (PDHs) will be provided to participants who satisfactorily attend a course. The number of PDHs eligible are provided based on the instructional time of delivery according to the course agenda. A participant must attend the full length of the course and submit an evaluation survey to receive the specified number of PDHs. No partial PDHs will be provided for attending part of a course.

- A **Certificate of Completion** will be provided to participants who satisfactorily attend a GridEd course and pass a learning assessment with a grade of 80% or greater. The learning assessment will be developed by the course instructor and will be tied to the stated learning objectives for each course offering. The certificate of completion will be an optional credential. Participants can qualify for a PDH without taking or passing the learning assessment.

Applying the Credential Process to a Job Specification

GridEd is committed to continue exploring the value of developing and issuing advanced credentials for various roles in the key focus areas of the GREAT with Data initiative. Initial feedback from utility advisors and other subject matter experts have indicated the potential value of advanced credentials in data science for the electric utility industry.

Based on an initial exploration with electric industry professionals, two categories of jobs have emerged as a priority for advanced credentials.

- **Electric Utility Data Science "Leader"**: This credential is for leaders, managers and decision makers who need to understand the potential value and risks in electric utility data analysis, artificial intelligence and machine learning projects for allocating resources and overseeing results from work in this area.

- **Electric Utility Data Science "Professional"**: This credential is for technical personnel, such as electric utility engineers, IT personnel, or data scientists entering the electric utility industry, who need to become data science professionals for an electric utility.

A deeper description of the potential approach is provided here. A similar approach will be explored in the other three focus areas of the GREAT with Data initiative.

GREAT with Data Course Descriptions

University Graduate and Undergraduate Courses

Big Data Analytics in Smart Grid

University of California, Riverside: Nanpeng Yu

- **Description**: Penetration of advanced sensor systems such as advanced metering infrastructure and phasor measurement units have been increasing significantly in smart grid. By 2022, the electric utility industry will be swamped by more than 2 petabytes of data annually from smart meters alone. However, machine learning and big data analytics algorithms and applications for unlocking the potential of big data in smart grid are at an early stage of development. This graduate level course introduces various big data analytics/machine learning applications in smart grid. The lectures will not only cover basics of machine learning and big data analytics methods and tools, but also their key applications in the smart grid.

Level	Frequency	Anticipated Class Size	Type
Graduate (EE260)	Every other year	10-15 students	Modified: Lectures, course assignments and project, and technical references.

Link to Gaps Assessment:

The problem identified in the gap analysis for the area of Data Analytics for Power System and the Smart Grid is partially addressed by this bridging courses.

- ***Linking power system and data science.*** This course covers the applications of machine learning and big data analytics in power systems and smart grids. It also leverages the domain knowledge of power systems and embeds them in tailored machine learning algorithms.

Timeline:

Syllabus ready by:	First offering of course:	Public Release of Materials
Spring 2020	Spring 2020	Summer 2021

Big Data Systems, Algorithms and Networks

Stony Brook University: Zhenhua Liu

Description: Recent progress on big data systems, algorithms and networks. Topics include the design of big data systems and their applications to real-world systems such as power systems.

Level	Frequency	Anticipated Class Size	Type
Graduate	Once per year	20-50 students	Modified: add a course project on data analysis for smart grid, add materials about big data systems for smart grid, add cyber security for power systems.

Link to Gaps Assessment:

This course bridges the gap in ICT, cyber security, and data analytics.

Timeline:

Modified syllabus ready by:	First offering of modified course:	Public Release of Materials
2021	Fall 2020	2023

Cyber-Power Systems

Washington State University: Anurag K Srivastava

Description:

This course is related to cyber infrastructure and system security of the integrated cyber and physical power system. The topics include the cyber-power system infrastructure, cyber-security concepts, vulnerabilities of the integrated system, intrusion detection, data analytics for anomaly detection/ classification and localization, mitigation and defense, cyber-power resiliency and case studies.

Level	Frequency	Anticipated Class Size	Type
Graduate core course	Once in two years	Example: 10-25 students	Modified: Adding updated modules for cyber-power data analytics for anomaly detection, classification, and localization as well as use-cases

Link to Gaps Assessment: Modified modules integrated with existing cyber-power systems addresses gap assessment in data science as well as in ICT & cyber-security.

Timeline:

Syllabus ready by:	First offering of course:	Public Release of Materials
Fall 2020	Fall 2020	Fall 2022 for modules

Data Analytics in Power Systems

University of Texas, Austin: Hao Zhu

Description: covers basics of machine learning and aims to introduce the tools for data-enabled modeling and inference in power systems. Discuss the applications of data-driven models and methods in real-time power system operations, and how to integrate data-driven and physics-based reasoning in modern power systems.

Level	Frequency	Anticipated Class Size	Type
UG/Grad	Every other year	20 students	Modified: Lectures and hands-on project assignment for undergraduate students.

Link to Gaps Assessment:

The gap analysis in the area of Data Analytics for Power Systems and Smart Grid describes the following needs for bridging courses:

- *Existing courses are at graduate level and thus may have missed the opportunity to prepare undergraduate students for this timely area.* Hence, training UG students on this important topic is very timely.
- *Coordination among all new courses on data science for power systems is slightly weak so far*. Presenting this course to the partner universities and broader education community would benefit the convergence of topic areas for this new course.

Timeline:

Syllabus ready by:	First offering of course:	Public Release of Materials
Spring 2021	Spring 2021	Spring 2021

Electric Energy Distribution Systems

Virginia Tech: Chen-Ching Liu, American Electric Power Professor

Description: In recent years, due to the Smart Grid development efforts, critical communication and control capabilities have been installed in distribution systems, leading to a cyber-physical system environment. On-line monitoring and control systems enable efficient fault location and fast recovery after major outages. The trend will continue as the reliability and resiliency requirements of distribution systems become higher to avoid catastrophic failures. This senior level course provides the fundamental principles for distribution system engineering, including cyber-physical system security. The theory will be supplemented by modern software tools for system planning and operation.

Level	Frequency	Anticipated Class Size	Type
Undergraduate (ECE4984)	Once per year	10-20 students	Modified: Lectures and computer demonstration of cyber-physical system security of distribution systems.

Link to Gaps Assessment:

The gap analysis in the area of Information and Communications Technology and Cyber Security results in the following needs for bridging courses:

- ***Modeling of the cyber (information and communication) systems is lacking for power system applications***. It is necessary to develop and modularize the cyber system models that can be interfaced with the large number of existing and future power system software tools.
- ***There is a great need to develop and incorporate an integrated cyber-power system security concept and methodology into curriculum*** . Existing power system analysis largely ignores the cyber systems and the interdependencies between cyber and power systems.
- ***Modeling software tools used in curricula lack the necessary characteristics of communications in power grids*** . Software tools such as NS-3 have been used for cyber network modeling; however, they are designed for computer networks and not customized for power grids.

Timeline:

Syllabus ready by:	First offering of course:	Public Release of Materials
Fall 2019	Fall 2019	Fall 2020

Electric Power Distribution Systems

Washington State University: Anamika Dubey

Description: This senior level course provides the fundamental principles for distribution system engineering. The course objective is to provide each student with the ability to analyze, design, and operate distribution systems. The theory is supplemented by modern software tools for system planning and operation.

Level	Frequency	Anticipated Class Size	Type
Undergraduate course	Once in year	Example: 25-35 students	Modified: Adding new modules on (1) Advanced Distribution Management Systems (ADMS), (2) ADMS Applications with focus on data-rich and control-rich environment – Volt-VAR optimization, Fault Location, Isolation and Service Restoration (FLISR), (3) Application demonstration using open-source ADMS environment (GridAPPS-D).

Link to Gaps Assessment: Addresses gaps related to the DER integration in active power distribution systems. Specific topics addressed are:

- Integration of digital sensing and control technologies
- Emergence of Data-driven application for distribution systems operation
- Evolution of distribution management systems and applications

Timeline:

Syllabus ready by:	First offering of course:	Public Release of Materials
Spring 2021	Spring 2021	Spring 2022 for modules

Introduction to Reinforcement Learning

University of California, Riverside: Nanpeng Yu

Description: This course provides an introduction to reinforcement learning. It covers finite Markov Decision Process, dynamic programming / Monte Carlo methods, temporal-difference learning, on-policy methods, off-policy methods, safe reinforcement learning, batch constrained reinforcement learning, and multi-agent reinforcement learning. This course also covers the development of applications of reinforcement learning in power systems.

Level	Frequency	Anticipated Class Size	Type
Graduate (EE260)	Once per year	15-20 students	New Course: Lectures, homework, and class project.

The problem identified in the gap analysis for the area of Data Analytics for Power System and the Smart Grid is partially addressed by this bridging courses.

- ***Linking power system and data science.*** This course covers the basics of reinforcement learning and its applications in power systems and smart grid, which establish strong connection between data science and power systems.

Timeline:

Syllabus ready by:	First offering of course:	Public Release of Materials
Winter 2021	Winter 2021	Summer 2022

Power Systems Under Abnormal Operating Conditions

Virginia Tech: Chen-Ching Liu, American Electric Power Professor

- **Description**: Cascading events can cause widespread catastrophic power outages. Vulnerabilities exist as the power grid increasingly depends on information and communications technology for its monitoring, operation, protection and control. This course will address issues concerning cascading events, vulnerabilities, defense strategy, cyber-physical system security, system restoration, and resiliency.

Level	Frequency	Anticipated Class Size	Type
Graduate (ECE5984)	Every other year	15 students	Modified: Lectures, course assignments and project, and technical paper on cyber-physical system security of the power grid

Link to Gaps Assessment:

The gap analysis in the area of Information and Communications Technology and Cyber Security results in the following needs for bridging courses:

- ***Modeling of the cyber (information and communication) systems is lacking for power system applications***. It is necessary to develop and modularize the cyber system models that can be interfaced with the large number of existing and future power system software tools.
- ***There is a great need to develop and incorporate an integrated cyber-power system security concept and methodology into curriculum*** . Existing power system analysis largely ignores the cyber systems and the interdependencies between cyber and power systems.
- ***Modeling software tools used in curricula lack the necessary characteristics of communications in power grids*** . Software tools such as NS-3 have been used for cyber network modeling; however, they are designed for computer networks and not customized for power grids.

Timeline:

Syllabus ready by:	First offering of course:	Public Release of Materials
Fall 2020	Fall 2020	Spring 2021

Power Quality and Harmonics

University of Texas, Austin: Surya Santoso

- **Description**: Introduction and analysis of power quality and harmonic phenomena in electric power systems: characteristics and definitions, voltage sags, electrical transients, harmonics, mitigation techniques, voltage regulation, impacts of distributed energy sources, and technical standards

Level	Frequency	Anticipated Class Size	Type
UG/Grad	Every other year	35 students	Updated: Lectures, course assignments and project, and technical paper on cyber-physical system security of the power grid

Link to Gaps Assessment:

The gap analysis in the area of Data Analytics for Power Systems and Smart Grid describes the following needs for bridging courses:

- *Existing courses are at graduate level and thus may have missed the opportunity to prepare undergraduate students for this timely area.* Hence, training UG students on this important topic is very timely.

Timeline:

Syllabus ready by:	First offering of course:	Public Release of Materials
Fall 2020	Fall 2020	Spring 2021

Smart Energy in the Information Age

Stony Brook University: Zhenhua Liu

Description: This course studies how to use Information Technology (IT) to improve sustainability in our energy-hungry society. In particular, topics include the applications of machine learning, algorithm design, optimization, game theory, and control theory in real systems. The goal of the course is to provide rigorous foundations for the study of smart energy management for sustainability.

Level	Frequency	Anticipated Class Size	Type
Graduate	Once per year	20-50 students	Modified: add, enhance or update ICT, cyber security, and data analytics components for power systems.

Link to Gaps Assessment:

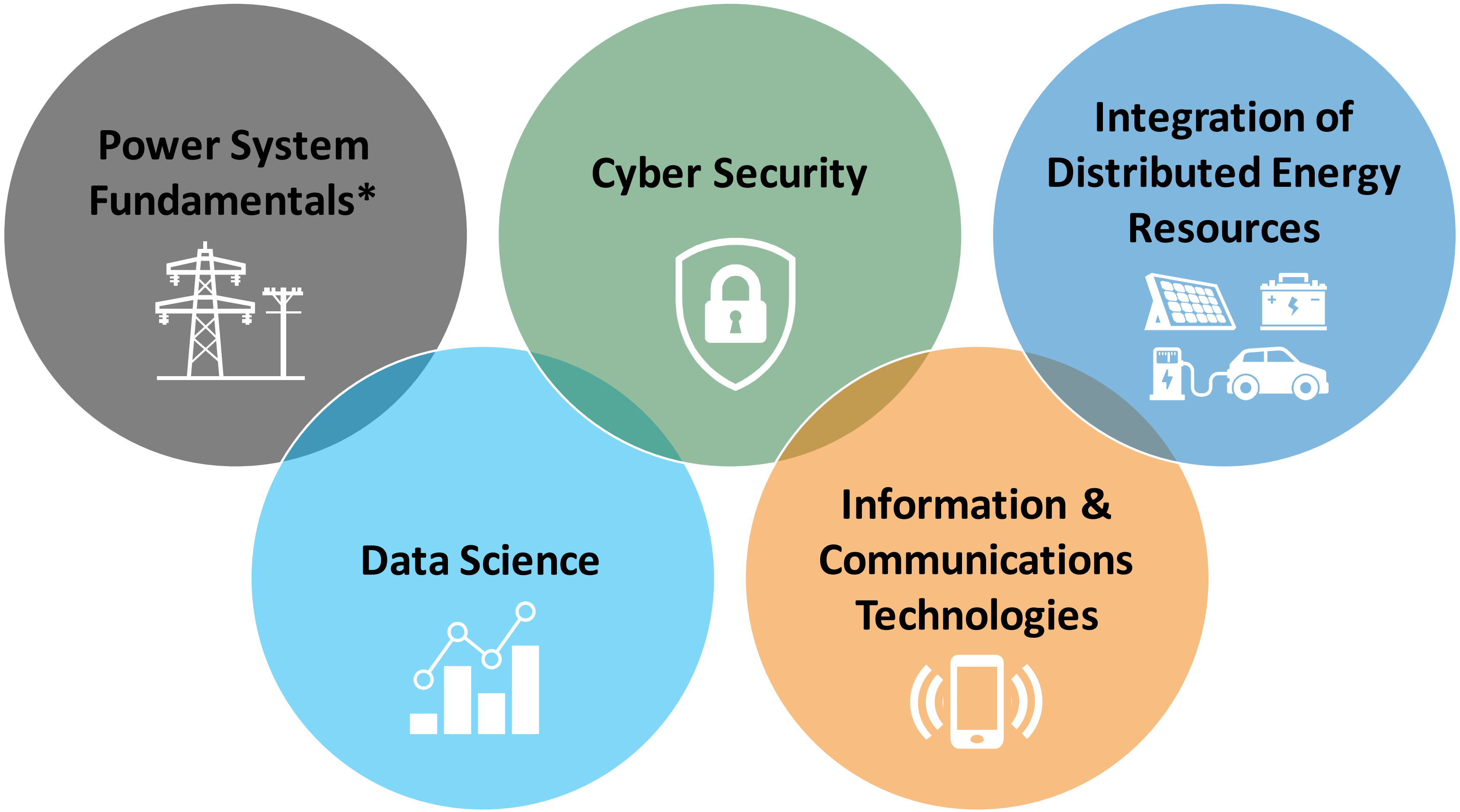
This course bridges the gap in ICT, DER, cyber security, and data analytics.

Timeline:

Modified syllabus ready by:	First offering of modified course:	Public Release of Materials
2020	Spring 2020	2022

Professional Training Courses

GridEd Professional Training Program



What Students Have Said

- *“I liked the real example discussion, and the professional environment.”*
- *“Good balance of ‘textbook’ theory and practical application/ experience and case studies.”*

Delivery Options

- Live In-Person
- Live Online
- Recorded Online

EPRI | U™ Infrastructure for Training Records and PDHs

**Power System Fundamentals is a focus area of GridEd but not the GREAT with Data Project*

GridEd Professional Training Program

Key Focus Areas

- **Power System Fundamentals**
- **Data Science**
- **Cyber Security**
- **Information and Communications Technology**
- **Integration of DER**

Power System Fundamentals

	Live In-Person	Live Online	Video/CBT
Available Now	• Business Case Analysis in the Electric Utility Industry (12hrs) • Electric Power Distribution Systems (12hrs)		• Basic Power systems I & II (75hrs – raw material)
Develop in 2021			• Basic Power Systems I & II (TBD hrs – PDHs)
Potential Future Courses			• Basic Power Systems I & II (TBD hrs – PDHs)

GridEd Professional Training Program – Data Science

- Two credentials:
  - *Electric Utility Data Science Leader*: for managers leading/overseeing data science teams or efforts. Focus on assessing metrics, interpretation of results, etc.
  - *Electric Utility Data Science Professional*: for staff directly developing the technical data science work. Focus on hands-on application of data science to electric utility applications.
- Focused on *domain application* of data science to the electric utility industry.
  - Core topics (basics related to data science in general) are available from a variety of sources, and therefore are outside the scope of this project. GREAT will only provide a list of typically covered topics for reference.

GridEd Professional Training Program

Key Focus Areas

- Power System Fundamentals
- Data Science
- Cyber Security
- Information and Communications Technology
- Integration of DER

Data Science

Live In-Person	Live Online	Video/CBT	
• Big Data Analytics for Electric Power Systems (12hrs)		• Introduction to Data Analytics (3hrs)	*Available Now*
• Machine Vision for the Electric Utility (Professional Track) • Interpreting & Assessing Results: Machine Vision (Leader Track)			*Develop in 2021*
• Time Series in the Electric Utility (Professional Track) • Interpreting & Assessing Results: Time-Series (Leader Track) • NLP in the Electric Utility (Professional Track) • Interpreting & Assessing Results: NLP (Leader Track) • Customer Analytics (Professional Track)		• Fundamentals of Data Governance (Leader Track)	*Potential Future Courses*

GridEd Professional Training Program

Key Focus Areas

- Power System Fundamentals
- Data Science
- Cyber Security
- Information and Communications Technology
- Integration of DER

Cyber Security

	Live In-Person	Live Online	Video/CBT
Available Now			• Cyber Security Culture (20min)
Develop in 2021		• Cyber Security For Utility Employees (12hr) • OT Familiarization for Cyber Security Professionals (20hr)	
Potential Future Courses	• Cyber Security for DER • Cyber Security in a Low Carbon Future • Technical Assessment Methodology		• Cyber Security for Executives • Secure Remote Access: Introduction to a Functional Architecture for Grid Operations • How to Plan an Integrated Security Operations Center

GridEd Professional Training Program

Key Focus Areas

- Power System Fundamentals
- Data Science
- Cyber Security
- Information and Communications Technology
- Integration of DER

Information and Communications Technology

	Live In-Person	Live Online	Video/CBT
Available Now		• Fundamentals of ICT for DER (8hr)	
Develop in 2021			
Potential Future Courses	• Communication Standards and Practices • Telecommunications Technologies for Data, Metering, and Analytics • IEC Common Information Model and IEC 61850 • ICT for Demand Responsive Loads • ICT for Solar PV and Energy Storage		

GridEd Professional Training Program

Key Focus Areas

- **Power System Fundamentals**
- **Data Science**
- **Cyber Security**
- **Information and Communications Technology**
- **Integration of DER**

DER Technology Integration

Live In-Person	Live Online	Video/CBT	
• Electric Transportation (12hrs) • Energy Storage Applications (12hrs)	• DG Interconnection on Distribution Systems (12hrs) • Utility Applications of Power Electronics (12hrs) • Energy Storage Short Course Series (12hrs)		*Available Now*
	• Distributed Energy Resource Management Systems (DERMS) (12hrs) • Microgrid Concepts and Designs (TBD hrs)	• IEEE Standard 1547 (TBD hrs)	*Develop in 2021*
• Modeling and Simulation for DER Integration	• DER Interconnection Processes and Screening		*Potential Future Courses*

GREAT with Data Professional Training Courses Offered in 2020

DER Interconnection on Radial Distribution Systems

This course includes discussion of key issues that arise when exporting inverter-interfaced DER are added to radial distribution systems and followed by exercises on specific issues.

- **Live-Online**
- **PDHs Available:** 16 Hours
- **Fully Subscribed!**

Instructors:


Devin Van Zandt


Thomas Ortmeyer


Tom Key


Brian Deaver

Dates: Oct. 6th – Oct. 29th
Tuesdays & Thursdays from 3:00-4:30pm ET

Sessions:

1. Radial distribution system basics
2. PV and inverter basics
3. Smart inverter functions and settings modeling for voltage regulation
4. Introduction to hosting capacity
5. Emerging DER management
6. Effective grounding and temporary overvoltage
7. Distribution automation
8. DER application special topics

Introduction to Energy Storage Short Course Series

Introduces energy storage technologies and applications. Students will learn about the technical challenges facing the wider use of energy storage and what can be done to address those challenges.

- **Live-Online**
- **PDHs Available:** 12 Hours

Instructors:

Ben Kaun

Erin Minear

Mike Simpson

Brittany Westlake

Miles Evans

Agenda

- **Introduction to Energy Storage** *(6 hours)*
  Economics, Technologies, Implementation
- **Deep Dive 1: Valuation Training** *(2 hours)*
  Modeling approaches, StorageVET, Case studies, sensitivity analysis
- **Deep Dive 2: Safety** *(2 hours)*
  Hazards; Codes, standards, and regulation; risk analysis and mitigation
- **Deep Dive 3: Battery Technology and Performance** *(2 hours)*
  Lithium ion; emerging technologies, integrated systems, testing and evaluation, performance guarantees

Information and Communications Technologies for Distributed Energy Resources and Systems

This course trains participant in understanding the fundamentals and applying the information and communication technologies (ICT) for distributed energy resources (DER) and systems such as demand response (DR), solar, energy storage, and electric vehicles.

- **Live-Online**
- **PDHs Available:** 8 Hours

Instructors:


Rish Ghatikar


Doni Nastasi


Chuck Thomas


Tim Godfrey

Agenda:

Day 1 – The Context for DER Technologies, Communications, and Systems

1. The Value of Grid-Connected DER
2. Information and Communication Technology Fundamentals for DER
3. Maturity – Present and Future States

Day 2 – A Deep Dive into Standards, Telecommunications, and Reference Implementations

1. Private Long-Term Evolution (LTE) Network Overview
2. Standards to Streamline Grid Interoperability
3. Standards and Architecture to Integrate DERs

Exercise: Develop Solution for an Energy Storage Use Case for DR Program

Machine Learning and Big Data Analytics in Smart Grid

The course will review the basics of unsupervised learning, supervised learning, reinforcement learning algorithms, and generative models. Important applications of big data analytics and machine learning in electric power distribution systems, transmission networks, and electricity markets will be presented with real-world data set.

- **Live-Online**
- **PDHs Available:** 12 Hours

Instructor:

Nanpeng (Eric) Yu is an Associate Professor in the Electrical and Computer Engineering department at the University of California, Riverside

Agenda:

1. Introduction to Data Driven Analytics and Machine Learning in Smart Grid
2. Introduction to Machine Learning Algorithms
   – Unsupervised, supervised, reinforcement algorithms & generative models
3. Applications in Power Distribution Systems
   – Topology identification, theft detection, predictive maintenance, estimation of BTM solar, controls
4. Applications in Transmission Network
   – Anomaly detection, motifs and signature discovery, event classification with PMU data
5. Application in Electricity Market
   – Algorithmic trading with virtual bids

Introduction to Data Analytics

This course is intended to provide foundational information and practical steps to increase someone's knowledge of data analytics. The course will provide sample data analytics use cases in the electric power industry, introduce data science techniques, and provide information on available resources for deeper learning. This course is intended to assist people with diverse backgrounds, interests and skills, from analysts to engineers to data scientists.

- **Computer Based Training**
- **PDHs Available:** 3 Hours

Instructor:

Michael O'Connor

Agenda:

1. Introduction to Data Analytics
2. Analytic Resources
3. Challenge Problem
4. Analytics Center of Excellence
5. Applying Data Science: Preprocessing
6. Anomaly Detection
7. Applying Data Science: Models and Algorithms
8. Applying Data Science: Miscellaneous

Together…Shaping the Future of Electricity

Job Descriptions for Cyber Security and Data Science Professionals in the Electric Power Industry

Job Descriptions

Benchmark Title	Summary
Cyber Security R&D Engineer - Entry	Responsible for creating new defensive cyber security technology components and systems to ensure that critical missions are resilient to cyber exploits and attacks. Develops hardware and software prototypes, and tests those prototypes in realistic environments. Where appropriate, transitions those prototypes either into operations directly or to a development organization for production and full-scale deployment. Assesses the utility of the resulting system and the mission it supports in operational environments, identifying gaps to seed the next round of research and development. Areas of focus include secure software design, secure hardware design, machine learning, reverse engineering, malicious software analysis, statistical modeling, formal methods and cryptographic protocols. Entry professional role, contributing in a support capacity. Work subject to frequent review by more experienced professionals. Responsible for output (documents, analyses, product) in specific work area to appropriate time and quality targets. Expected to work under own initiative, prioritize own work, and meet agreed timescales. Typically a graduate, although may have progressed into the role via equivalent business experience.
Cyber Security R&D Engineer - Intermediate	Responsible for creating new defensive cyber security technology components and systems to ensure that critical missions are resilient to cyber exploits and attacks. Develops hardware and software prototypes, and tests those prototypes in realistic environments. Where appropriate, transitions those prototypes either into operations directly or to a development organization for production and full-scale deployment. Assesses the utility of the resulting system and the mission it supports in operational environments, identifying gaps to seed the next round of research and development. Areas of focus include secure software design, secure hardware design, machine learning, reverse engineering, malicious software analysis, statistical modeling, formal methods and cryptographic protocols. Intermediate professional role, responsible for delivery of professional activities. Applies standard techniques and procedures to routine instructions, but requiring professional knowledge in specialist areas. Focuses on providing standard professional advice and creating initial reports/analyses for review by experienced team professionals. Prepares work for approval by senior colleagues.

Job Descriptions

Benchmark Title	Summary
Cyber Security R&D Engineer - Senior	Responsible for creating new defensive cyber security technology components and systems to ensure that critical missions are resilient to cyber exploits and attacks. Develops hardware and software prototypes, and tests those prototypes in realistic environments. Where appropriate, transitions those prototypes either into operations directly or to a development organization for production and full-scale deployment. Assesses the utility of the resulting system and the mission it supports in operational environments, identifying gaps to seed the next round of research and development. Areas of focus include secure software design, secure hardware design, machine learning, reverse engineering, malicious software analysis, statistical modeling, formal methods and cryptographic protocols. Career-level (fully competent) experienced professional able to carry out a full range of professional duties. Works independently with guidance on more complex issues. Provides professional know-how to enhance the knowledge and skill base of the organization. Uses advanced analytical, technical and problem solving skills to adapt policies and programs and develop models to support smaller projects. Focuses on providing analyses and applying results to improve business operations.
Cyber Security R&D Engineer - Advanced	Responsible for creating new defensive cyber security technology components and systems to ensure that critical missions are resilient to cyber exploits and attacks. Develops hardware and software prototypes, and tests those prototypes in realistic environments. Where appropriate, transitions those prototypes either into operations directly or to a development organization for production and full-scale deployment. Assesses the utility of the resulting system and the mission it supports in operational environments, identifying gaps to seed the next round of research and development. Areas of focus include secure software design, secure hardware design, machine learning, reverse engineering, malicious software analysis, statistical modeling, formal methods and cryptographic protocols. Advanced level professional providing professional input to complex assignments & providing direction to others Works autonomously, only requiring "expert" level technical support from others. Exercises judgment in the evaluation, selection, and adaptation of standard and complex techniques & procedures. Uses professional knowledge to develop models and procedures, and monitor trends, within own discipline area.

Job Descriptions

Benchmark Title	Summary
Cyber Security R&D Engineer - Expert	Responsible for creating new defensive cyber security technology components and systems to ensure that critical missions are resilient to cyber exploits and attacks. Develops hardware and software prototypes, and tests those prototypes in realistic environments. Where appropriate, transitions those prototypes either into operations directly or to a development organization for production and full-scale deployment. Assesses the utility of the resulting system and the mission it supports in operational environments, identifying gaps to seed the next round of research and development. Areas of focus include secure software design, secure hardware design, machine learning, reverse engineering, malicious software analysis, statistical modeling, formal methods and cryptographic protocols. Expert-level professional providing expert content/professional leadership on complex assignments/projects. Exercising considerable creativity, foresight, and judgment in conceiving, planning, and delivering initiatives. Uses deep professional knowledge and acumen to advise functional leaders. Focuses on providing thought leadership within own discipline but works on broader projects, which require understanding of wider business. Recognized internally as a subject matter expert.
Cyber Security R&D Engineer - Principal	Responsible for creating new defensive cyber security technology components and systems to ensure that critical missions are resilient to cyber exploits and attacks. Develops hardware and software prototypes, and tests those prototypes in realistic environments. Where appropriate, transitions those prototypes either into operations directly or to a development organization for production and full-scale deployment. Assesses the utility of the resulting system and the mission it supports in operational environments, identifying gaps to seed the next round of research and development. Areas of focus include secure software design, secure hardware design, machine learning, reverse engineering, malicious software analysis, statistical modeling, formal methods and cryptographic protocols. Principal advisor providing guidance to the company/board on strategic decisions. Advice has a significant impact on strategic planning. Industrywide authority. Represents organization externally. Widely recognized as expert and thought leader by both internal and external community. Responsible for the technical leadership of a major department/multiple departments across a function.

Job Descriptions

Benchmark Title	Summary
Data Scientist-Junior	Under close supervision, applies statistical data modeling techniques to large data sets. Uses statistical analysis software packages (SAS, SPSS, etc.) and business intelligence and analytics platforms (i.e., Tableau, Power BI, etc.) to create dashboards and reporting capabilities. Assists in interpreting the results and summarizes findings. Learning role with 1 to 2 years of experience.
Data Scientist - Intermediate	Under broad supervision, applies statistical data modeling techniques to large data sets. Uses statistical analysis software packages (SAS, SPSS, etc.) and business intelligence and analytics platforms (i.e., Tableau, Power BI, etc.) to create dashboards and reporting capabilities. Interprets results and summarizes findings. Typically has an advanced degree and 3 - 5 years of experience.
Data Scientist-Senior	Under general directions, applies advanced statistical data modeling techniques to large data sets to create actionable business insights- Uses statistical analysis software packages (SAS, SPSS, etc.-) and business intelligence and analytics platforms (i-e-, Tableau, Power BI, etc.-) to create dashboards and reporting capabilities- Typically has an advanced degree and more than 5 years of professional experience- Incumbent designs, develops and deploys algorithms through statistical programming that: support complex business decision making, manage large amounts of data and create visualization and insights- Incumbent will have overlapping skills with data analysts and database engineers and will utilize big data platforms such as Hadoop, Aster, Cloudera, MongoDB or equivalent- Additional programming language experience may include: C, C++, Java, Python, SQL, R or SAS analytic tools-

Job Descriptions

Benchmark Title	Summary
Data Scientist-Advanced Senior	Develops sophisticated statistical models to analyze and predict complex business outcomes. Applies broad business knowledge and advanced statistical modeling techniques when building data structures and tools. Regarded as an industry expert in the data science field and has published or presented industry papers on methods. Typically has a PhD and at least 5 years of professional experience. Incumbent designs, develops and deploys algorithms through statistical programming that: support complex business decision making, manage large amounts of data and create visualization and insights- Incumbent will have overlapping skills with data analysts and database engineers and will utilize big data platforms such as Hadoop, Aster, Cloudera, MongoDB or equivalent. Additional programming language experience may include: C, C++, Java, Python, SQL, R or SAS analytic tools.
Data Scientist - Expert	Develops sophisticated statistical models to analyze and predict complex business outcomes. Applies broad business knowledge and advanced statistical modeling techniques when building data structures and tools. Regarded as an industry expert in the data science field and has published or presented industry papers on methods. Typically has a PhD and at least 5 years of professional experience.

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