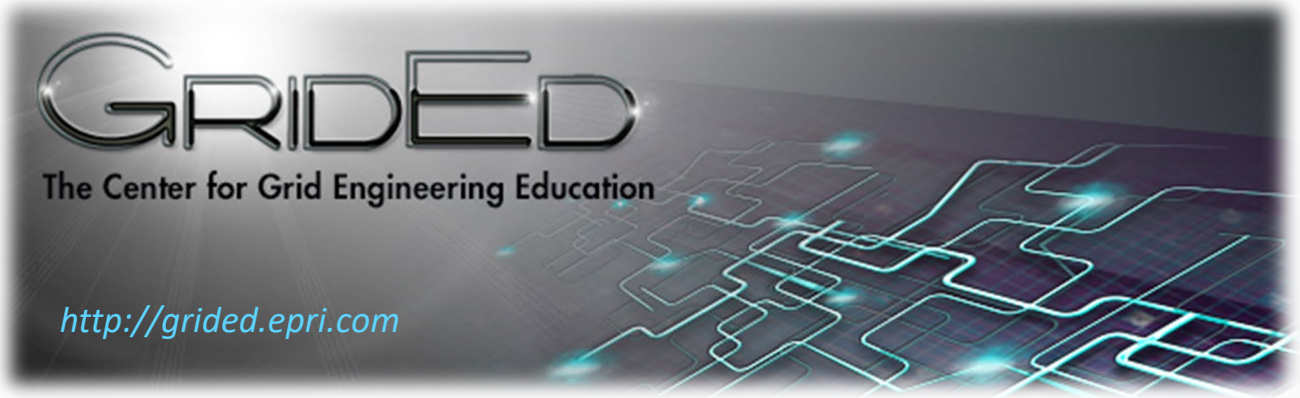


EPRI | ELECTRIC POWER RESEARCH INSTITUTE

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

Gaps Assessment in Professional Training

October, 2020

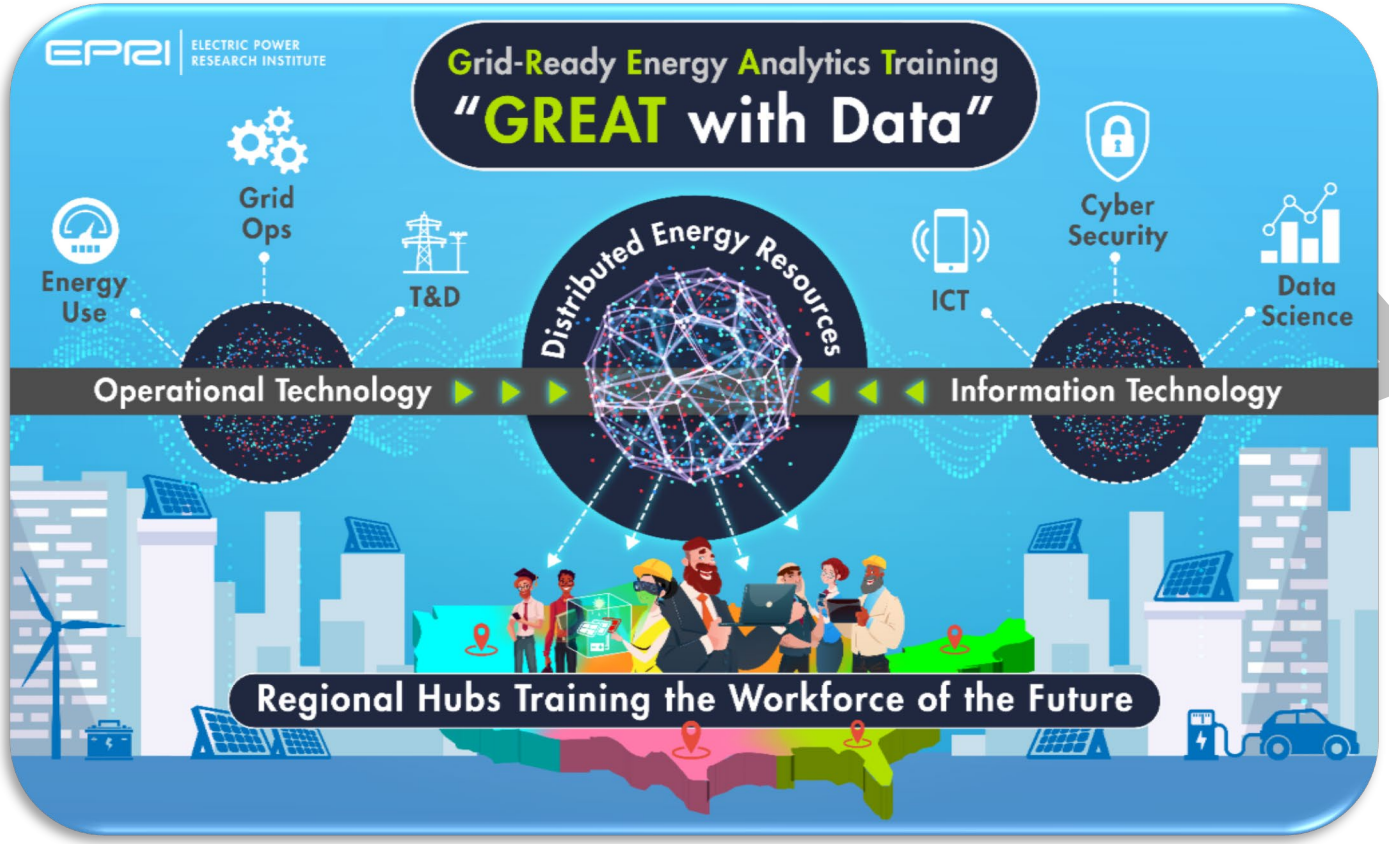
DRAFT

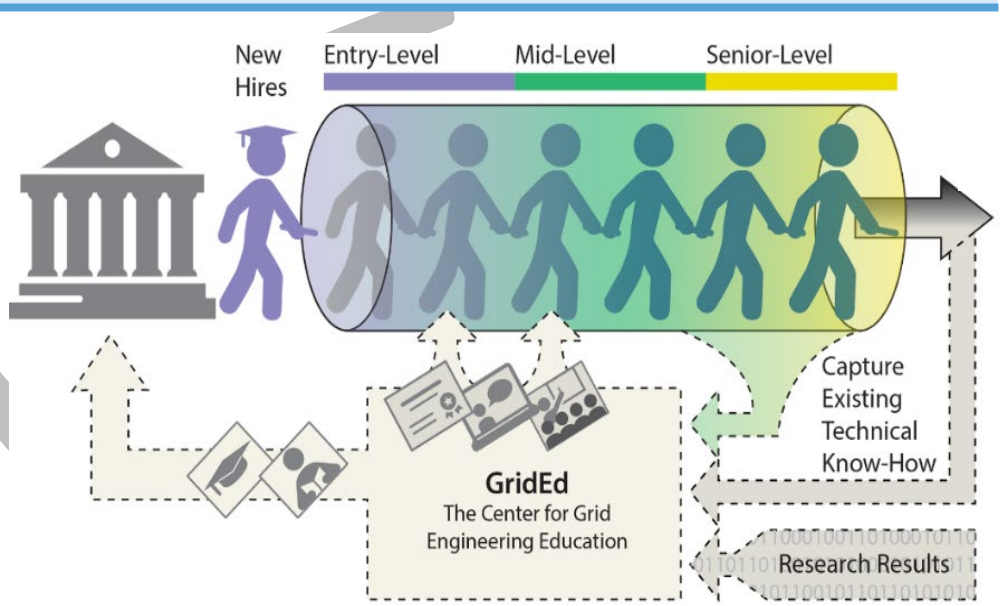
Outline

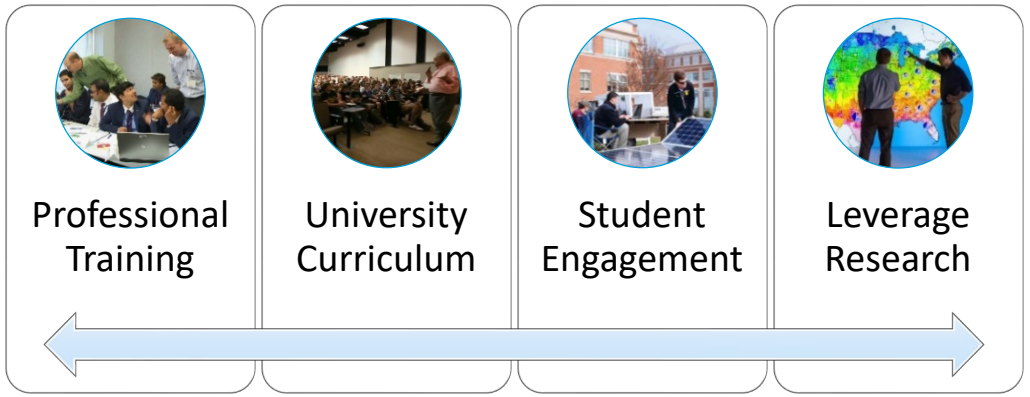
- Background on the GREAT with Data Initiative
- Drivers Changing Workforce Development Needs
- Impact on Required Skillsets for Different Positions at Electric Utilities
- Prioritization of Training Topics in Key Areas
- Summary and Conclusions

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

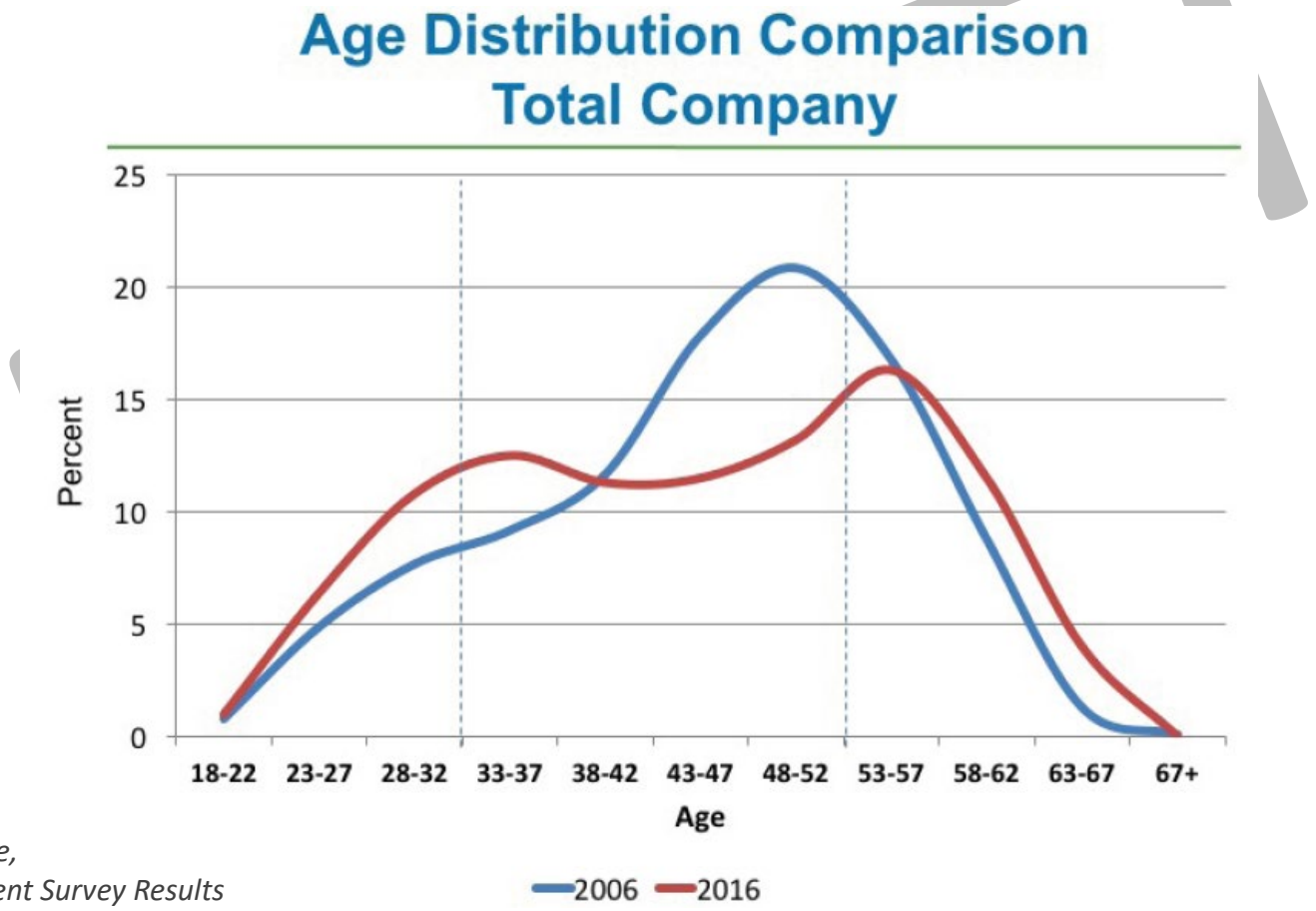
Supplemental Project: 3002015049

Drivers Changing Workforce Development 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

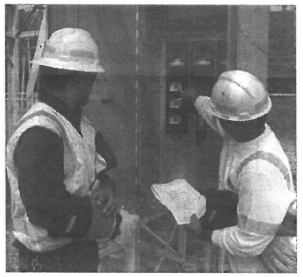
Where are we today?

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

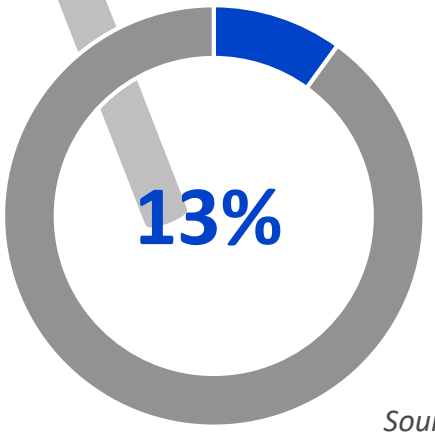
Source: Electric Power Engineering Education Resources: 2015-16 US and Canadian University Survey Results. Report from the Power and Energy Education Committee of the IEEE Power & Energy Society. November 2017.

Where are we today?

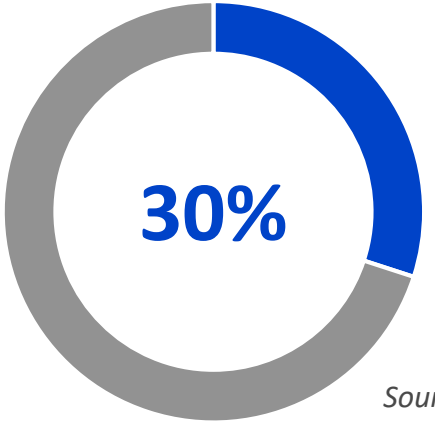
Electric Power Educational Challenges Amid Industry Transformation

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



Source: LinkedIn



Source: ADP

Where are we today?

Electric Power Educational Challenges Amid Industry Transformation

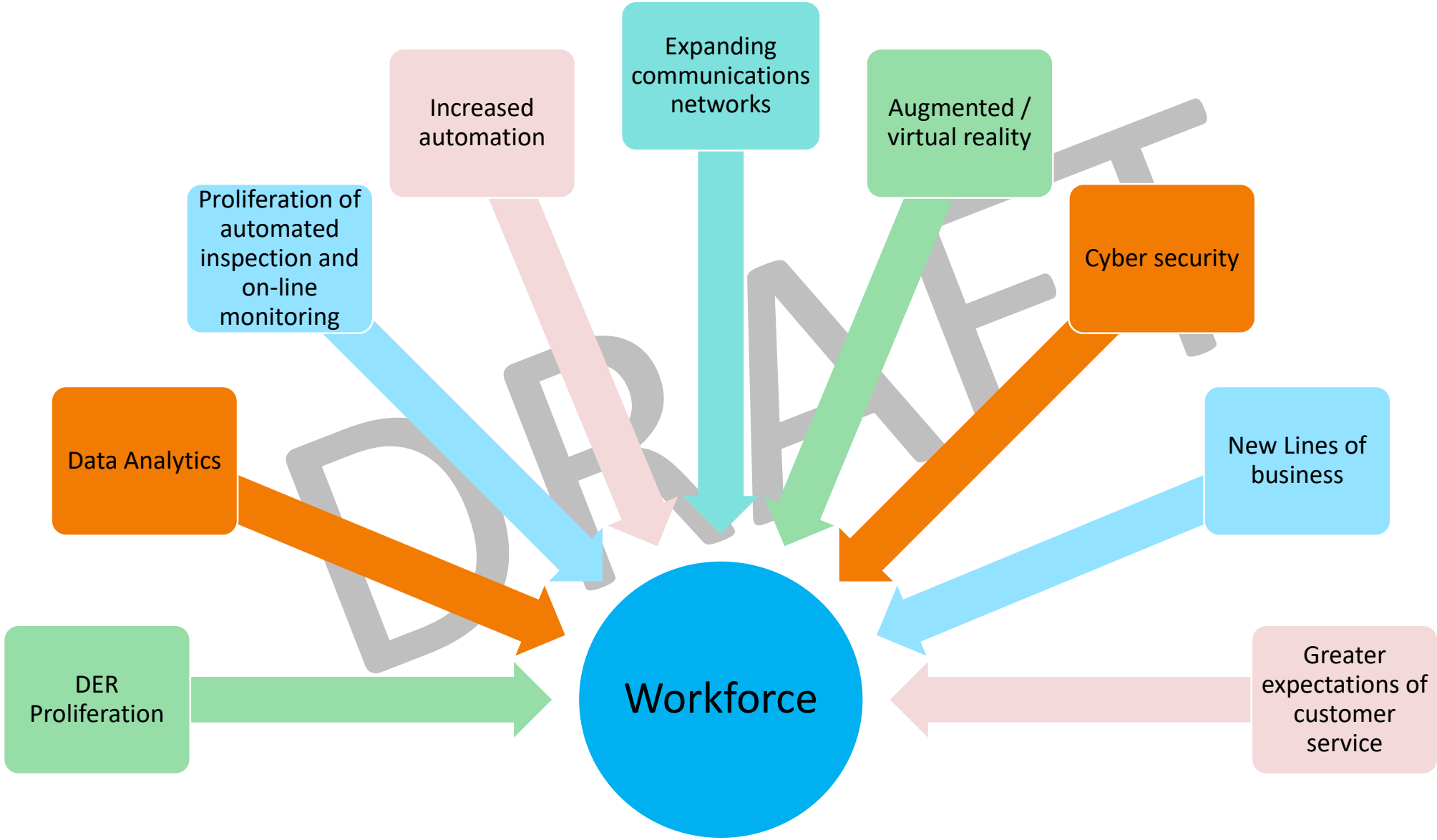
1. Early career workforce
2. Many new hires lack power systems education
3. Difficult to hire and retain top data science professionals
4. Power system transformation:
   - Renewables and distributed energy resources
   - Digital communication, cyber security, and data analytics

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.

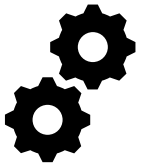
Creating "cultures" for Cyber Security and Data – similar to the safety culture that is now common within the industry, utilities will need to create both cyber security and data cultures. All workers will need to have a heightened awareness of cyber security and how it can impact their jobs. Workers 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

Workforce Categories



Distribution Operations

Distribution Planning

Asset Management

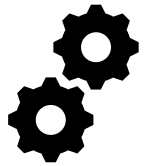
Engineering

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

How the job will change	Skillsets
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.	**Traditional:** ▪ Strong technical foundation: – Power system modeling and simulation – Load and DER forecasting – Protection and power quality – Control operations – Field implementation issues **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

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

How the job will change	Skillsets
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.	**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
	New: • Expertise with data analytic tools

Utility Field Worker

Driver	Impacts
DER Proliferation	• Understanding of O&M issues associated with new technologies
Data analytics On-line monitoring / automated inspection	• 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
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	Skillsets	
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.	**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

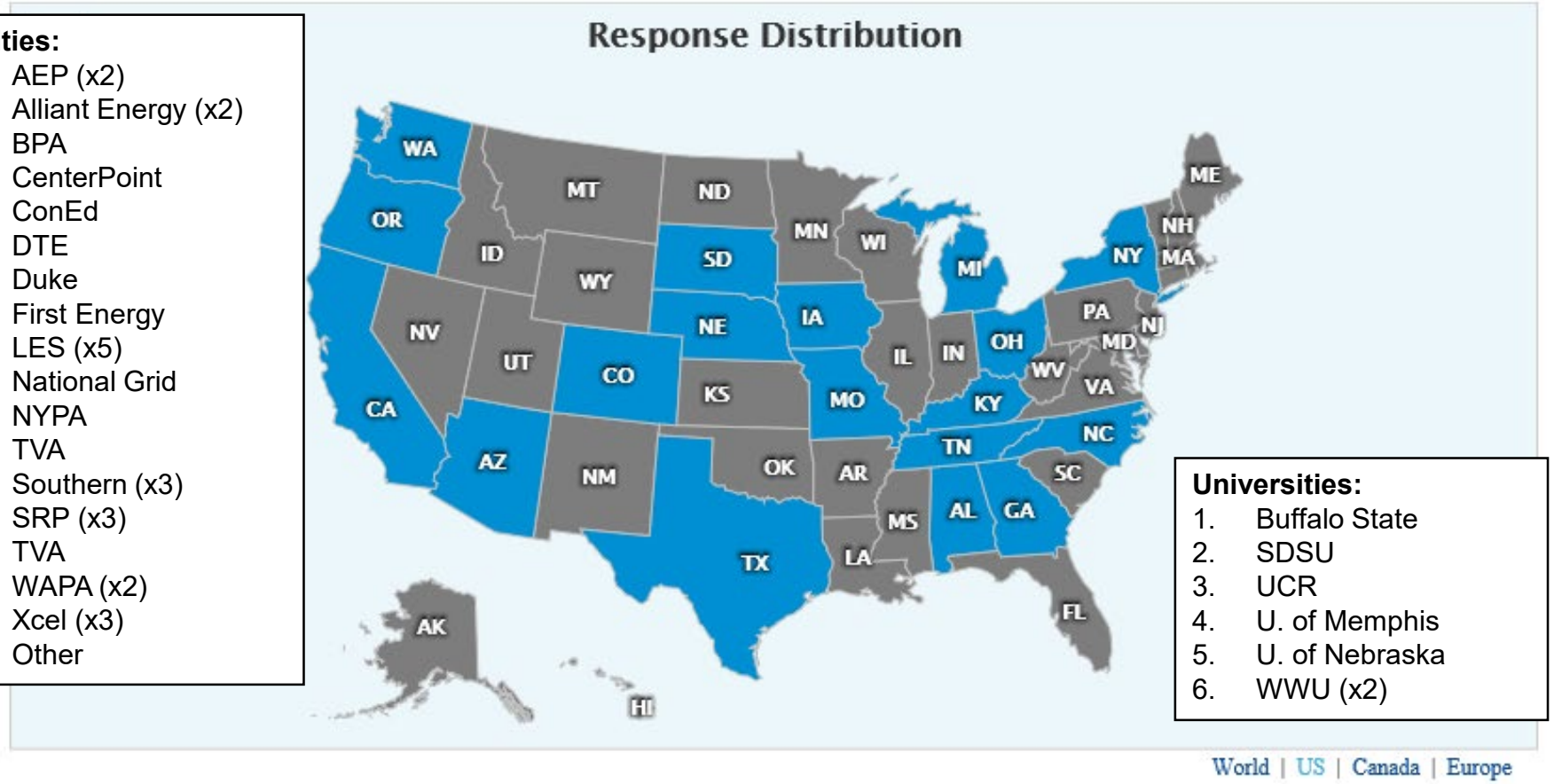
How the job will change	Skillsets
Customers expectations from service providers will increase in the future. To meet these expectations, utility customer service representatives will need to have greater levels of information and control available to them. As customers adopt more DER, utilities will 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.	**Traditional:** ▪ Interpersonal skills ▪ Gather information / assess situation ▪ Logical thinking / problem solving ▪ Conflict resolution ▪ Utilizing resources and information ▪ Inform customer about services **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

Prioritization of Training Topics in Key Areas

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%

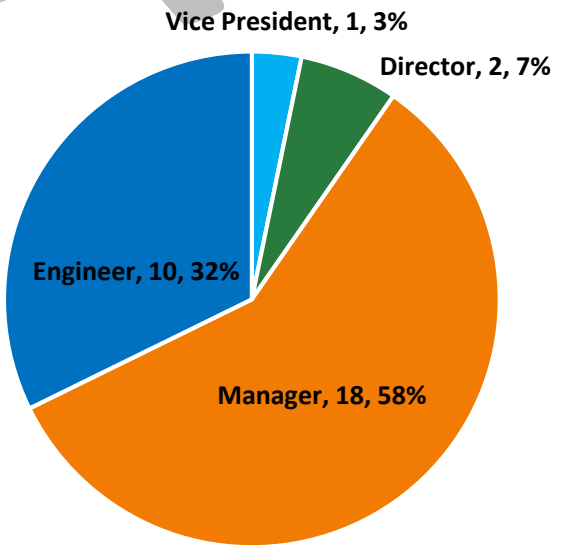
2019 Course Prioritization Responses

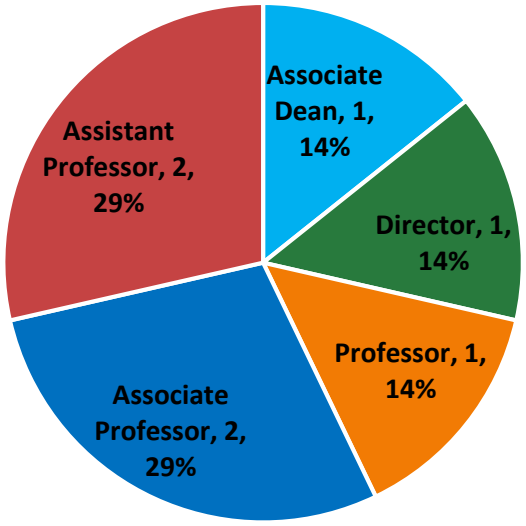
Utilities

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

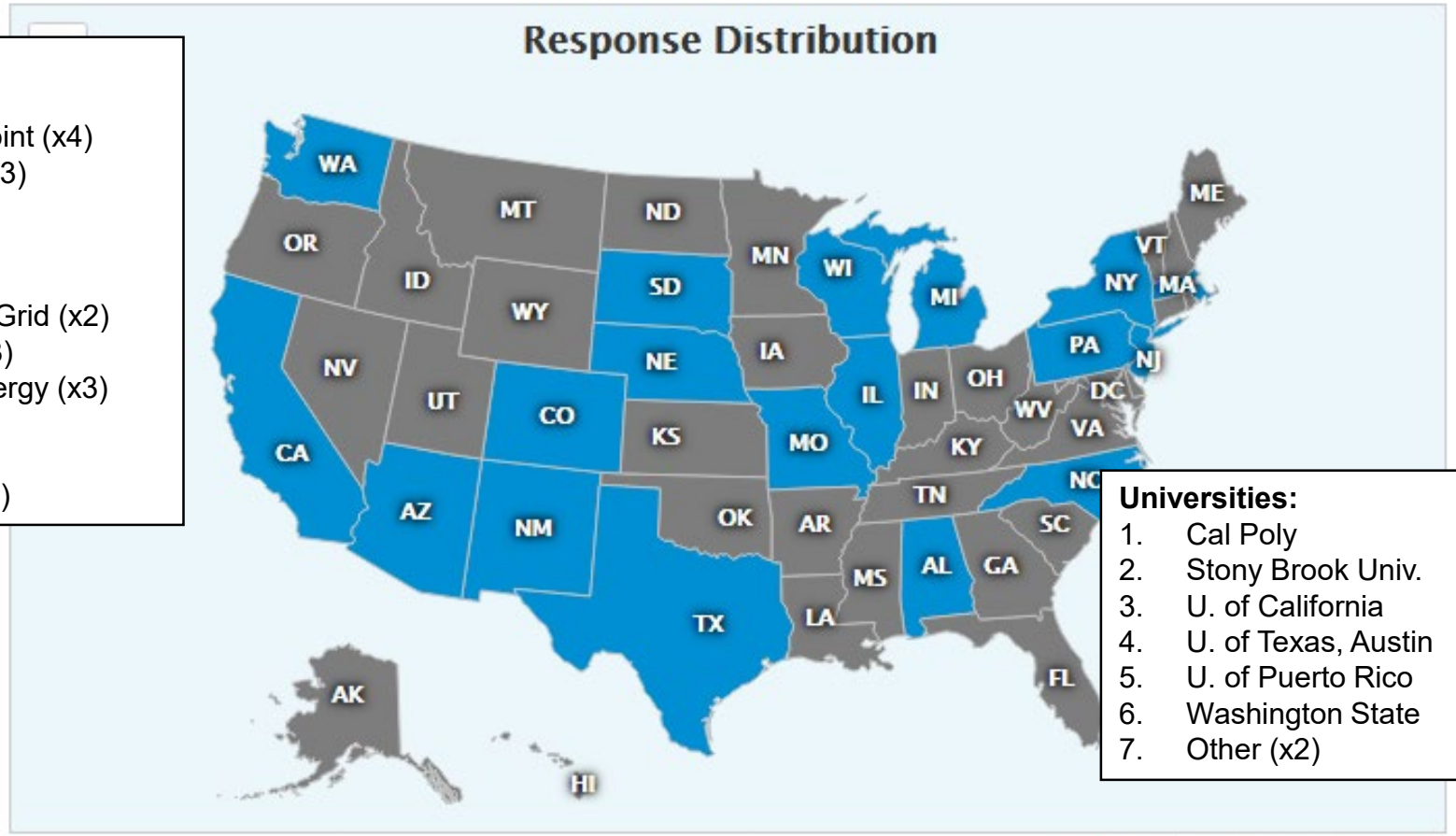




2020 Course Prioritization Responses

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%

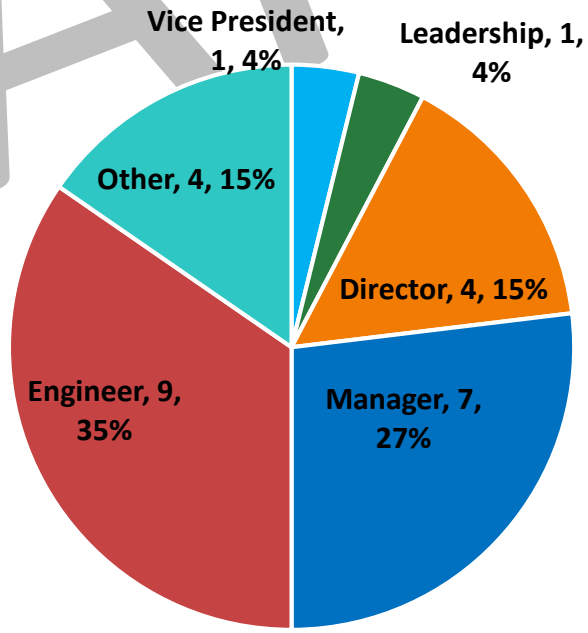
2020 Course Prioritization Responses

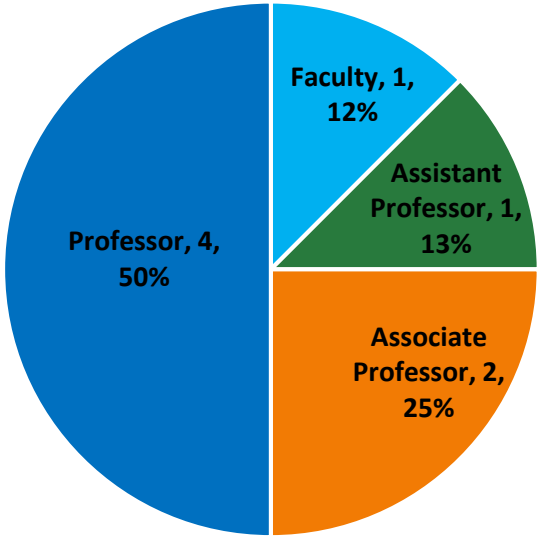
Utilities

Area	Role
Analytics	Program Strategist
Customer Programs	Manager
Distribution Automation	Manager
Distribution Engineering	Manager, Engineer
Evironmental Health and Saftey	N/A
Energy Efficiency/Demand Side Management	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
Transmission & Distritbutiont 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, Professor
Electrical Engineering	Professor

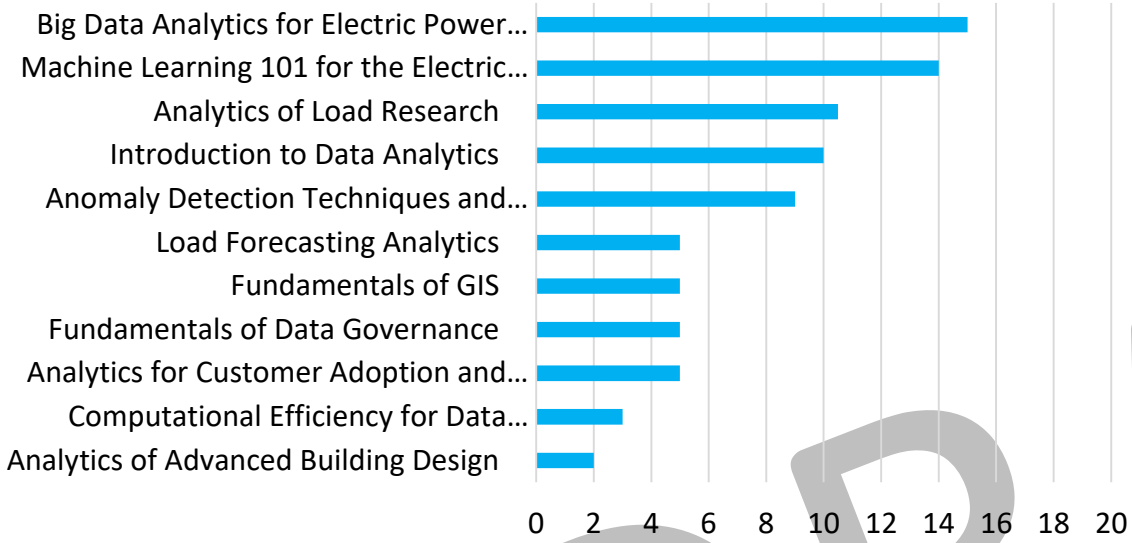




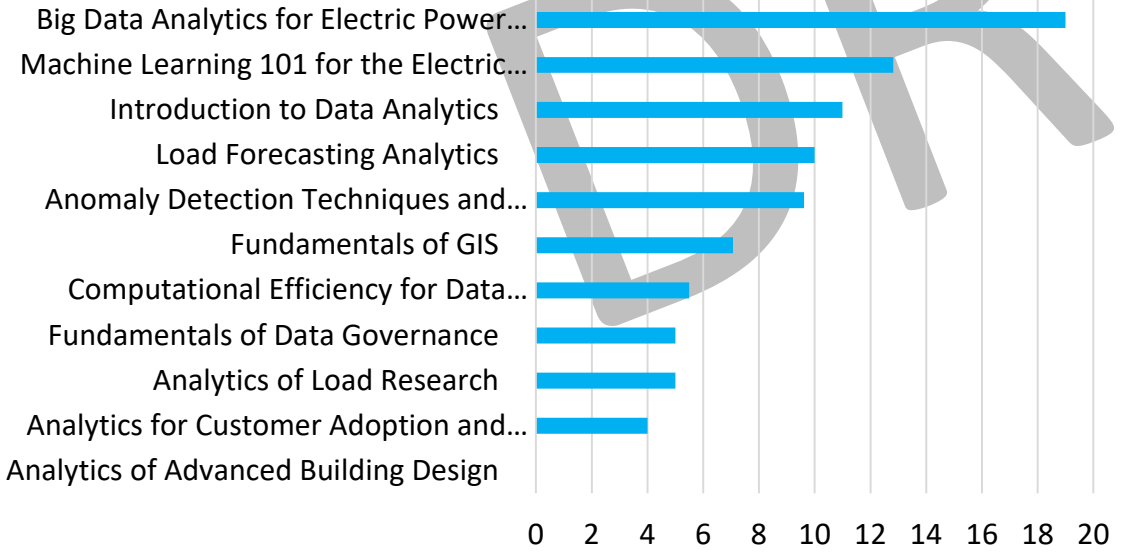
Data Science Course Prioritization Results

Median

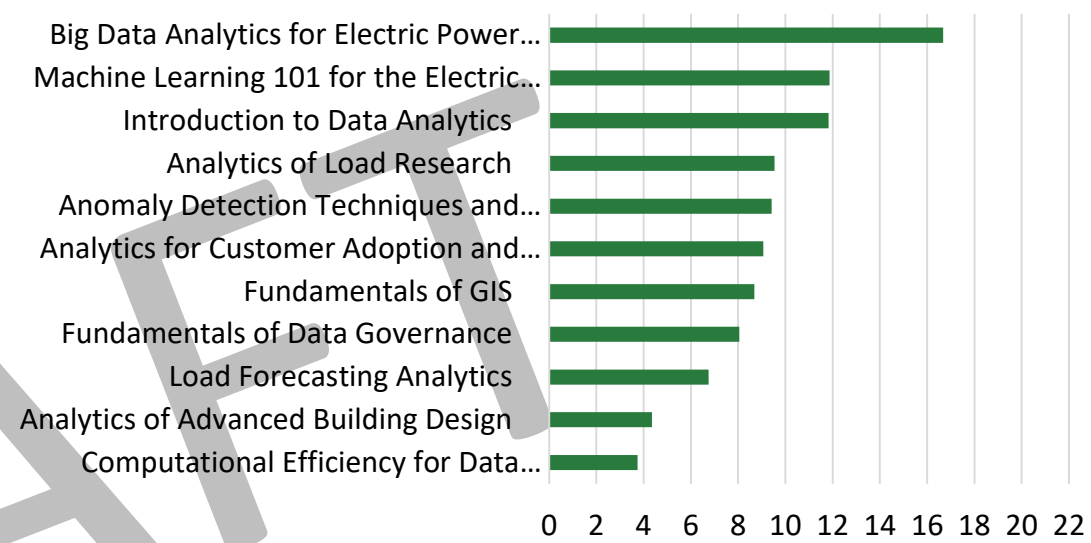
2020

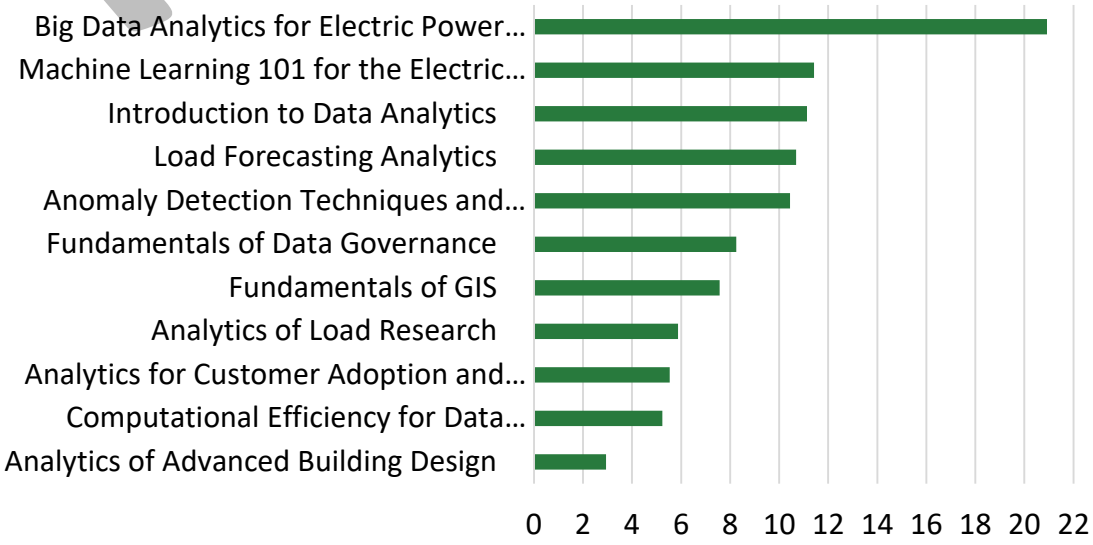


2019



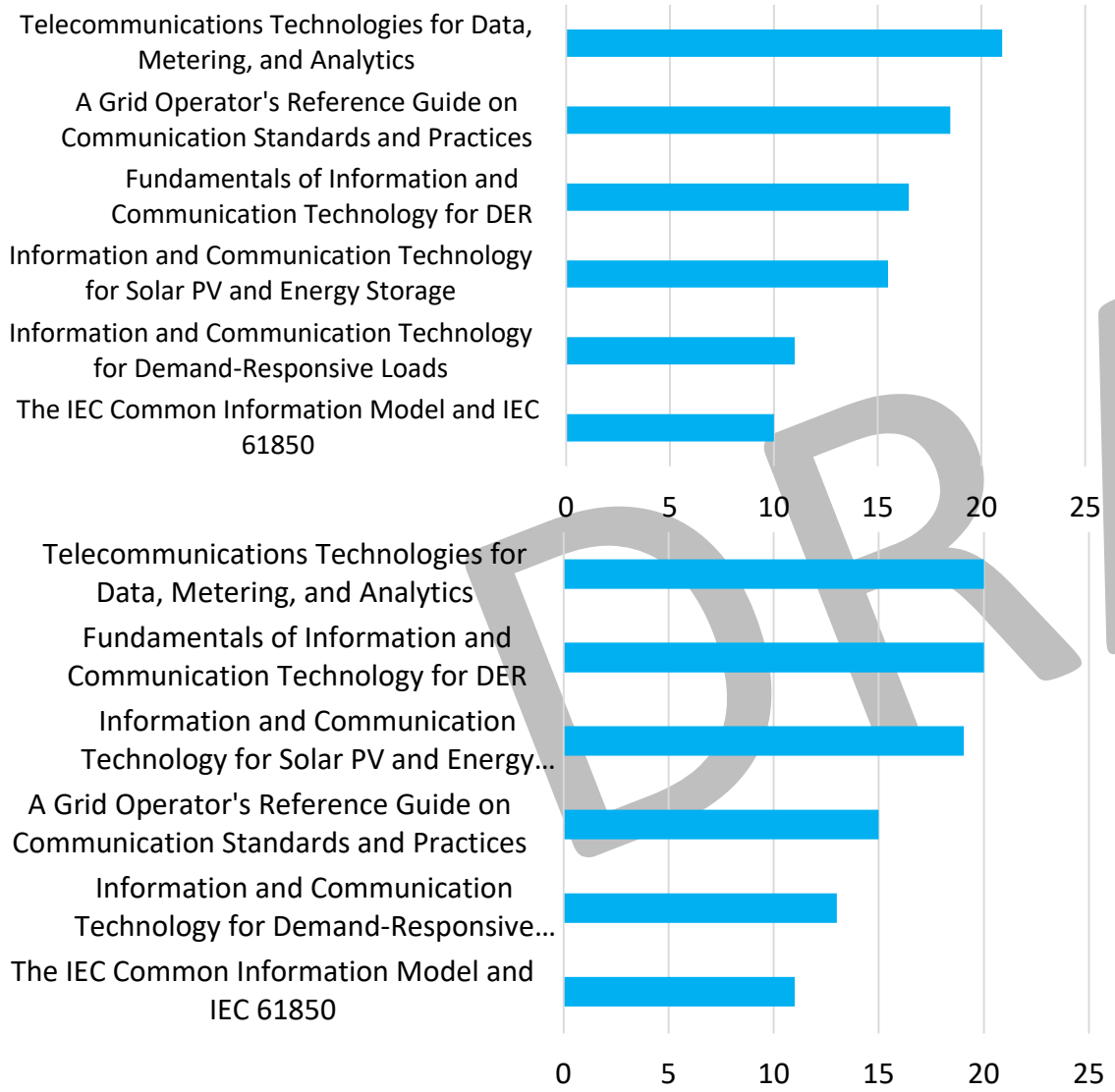
Average



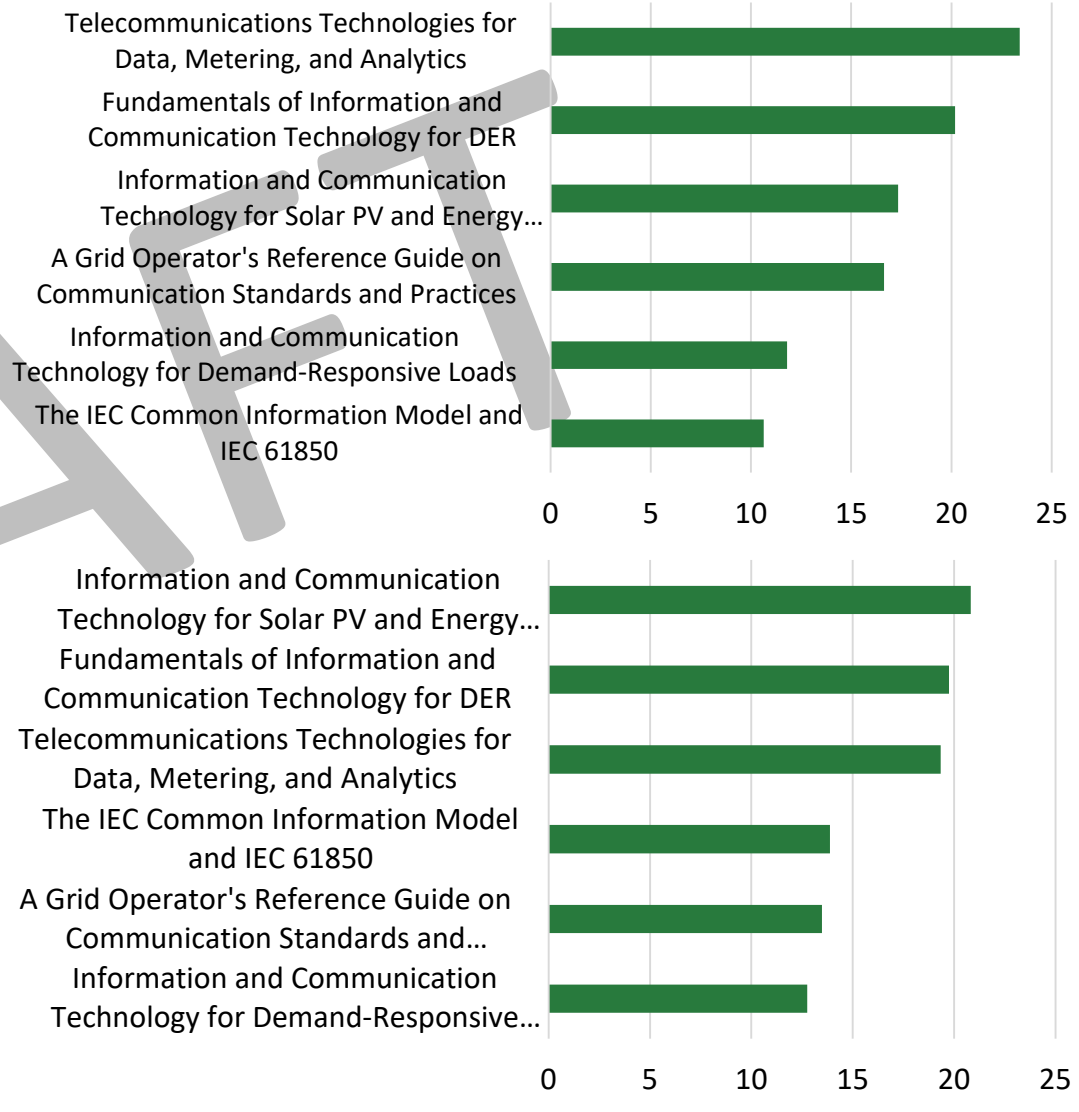


ICT Course Prioritization Results

Median



Average

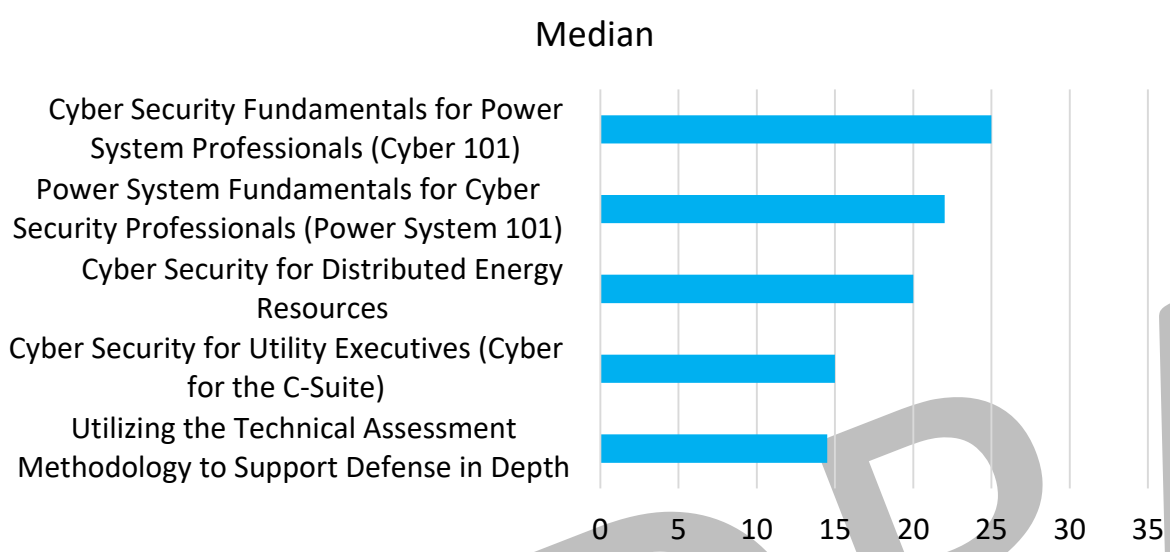


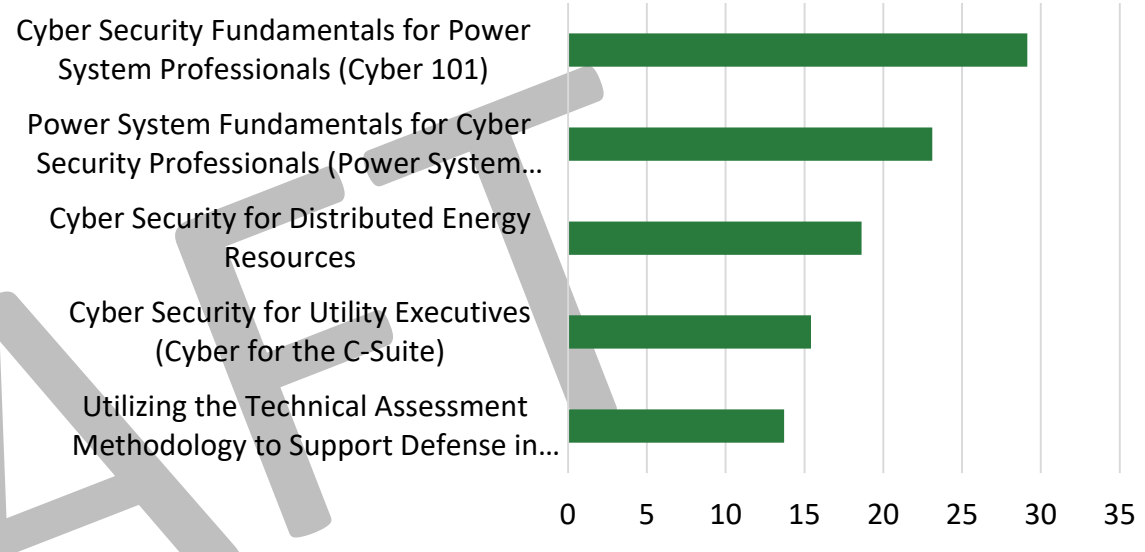
Cyber Security Course Prioritization Results

Median

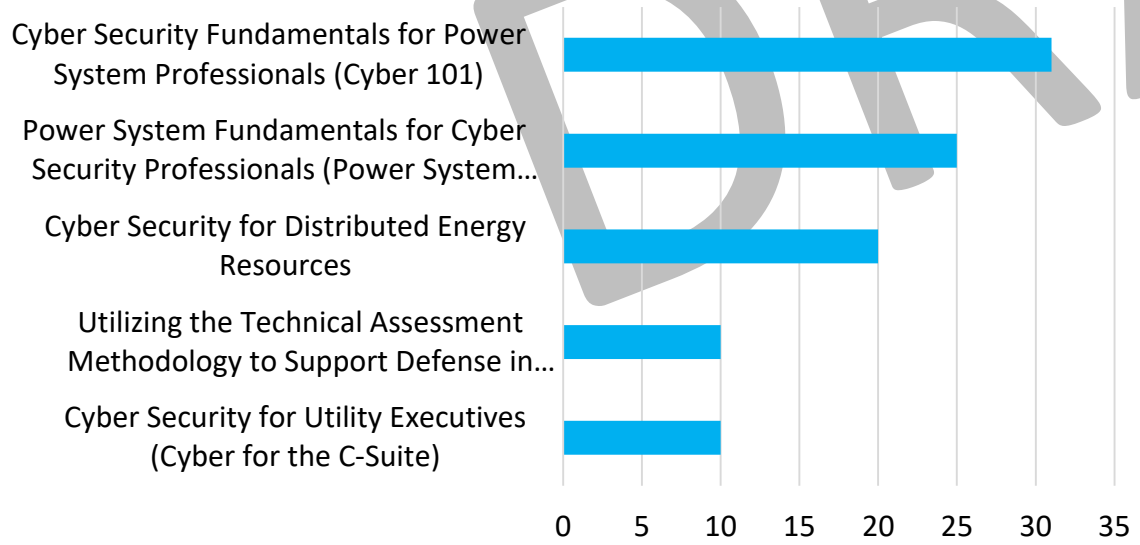
Average

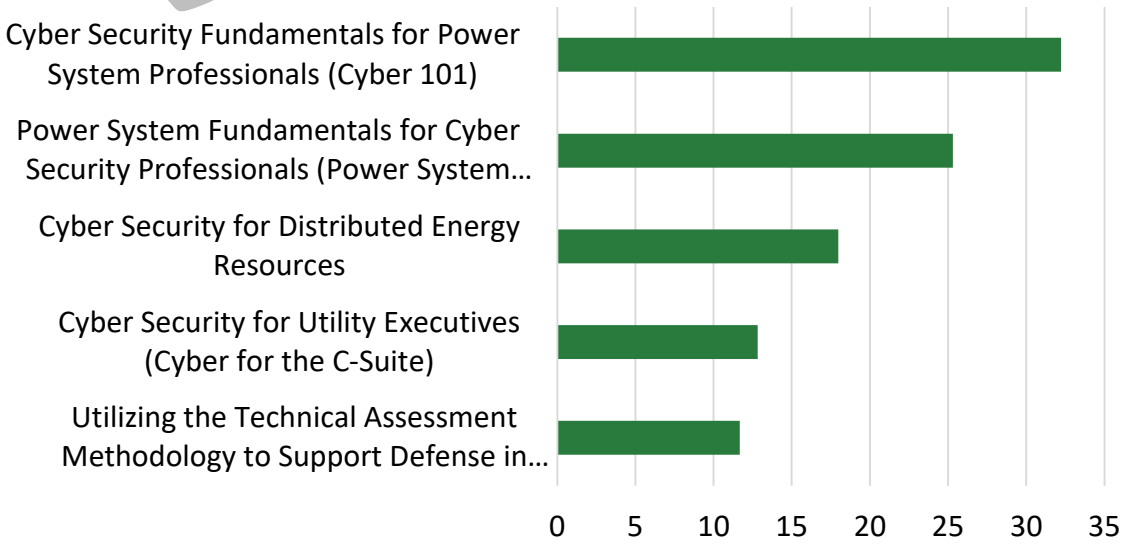
2020





2019

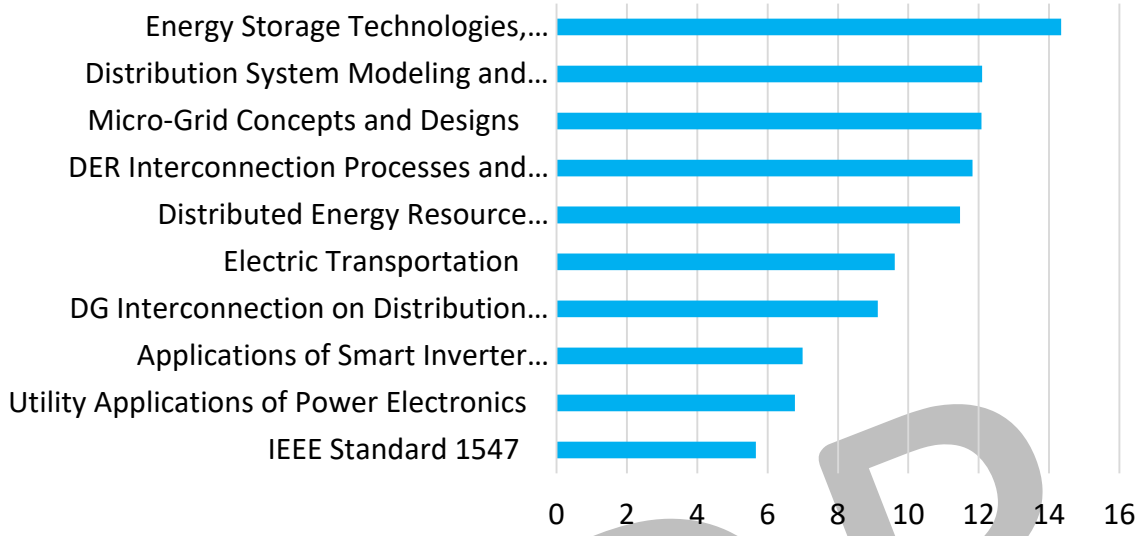




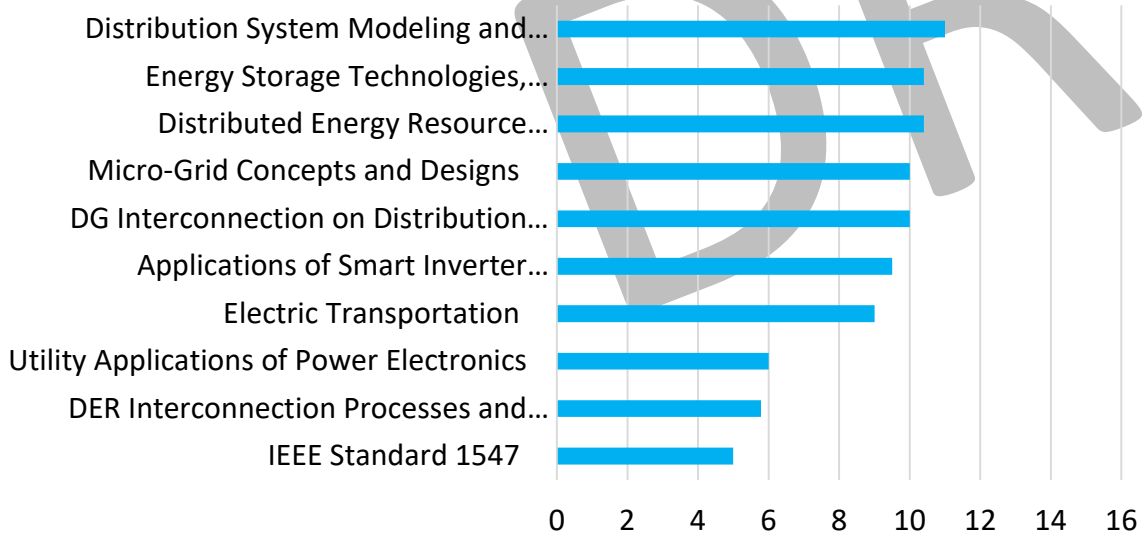
DER Integration Course Prioritization Results

Median

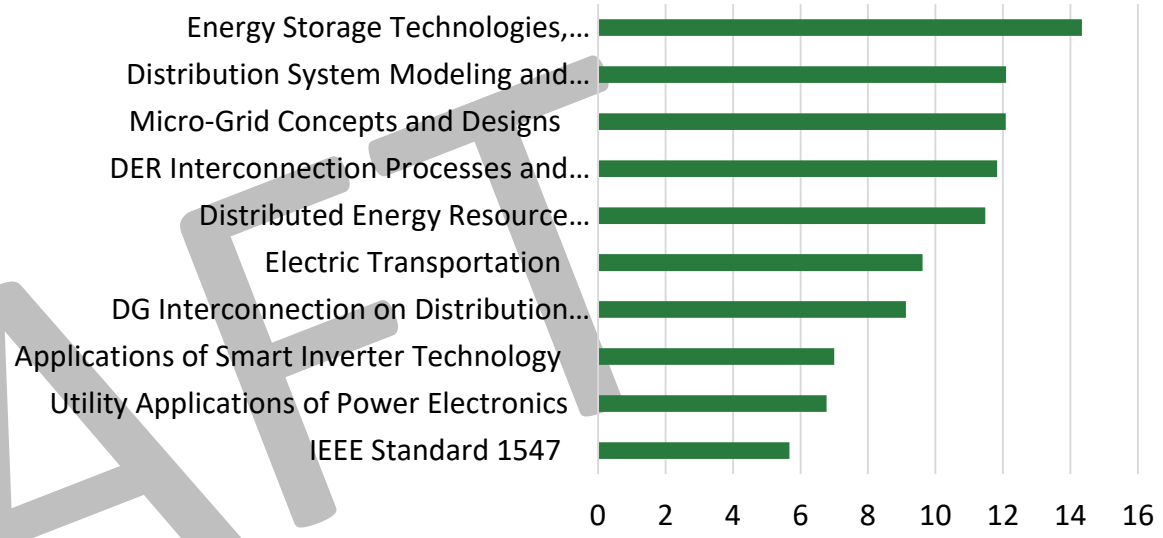
2020

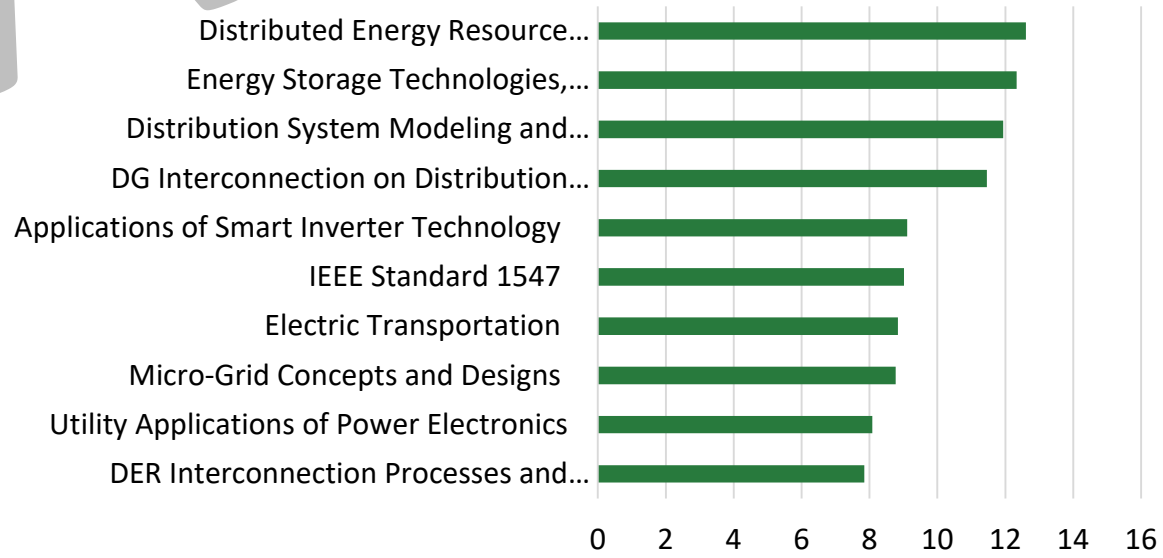


2019



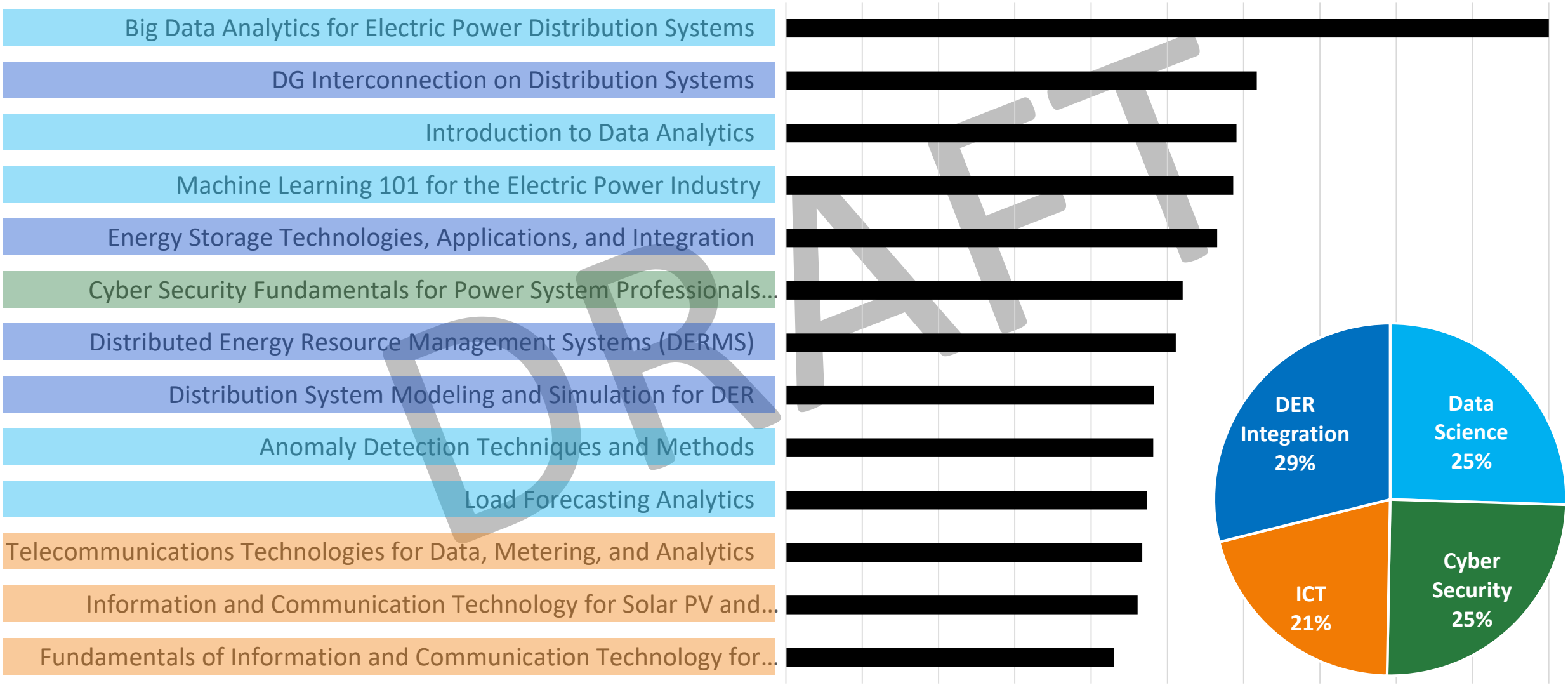
Average





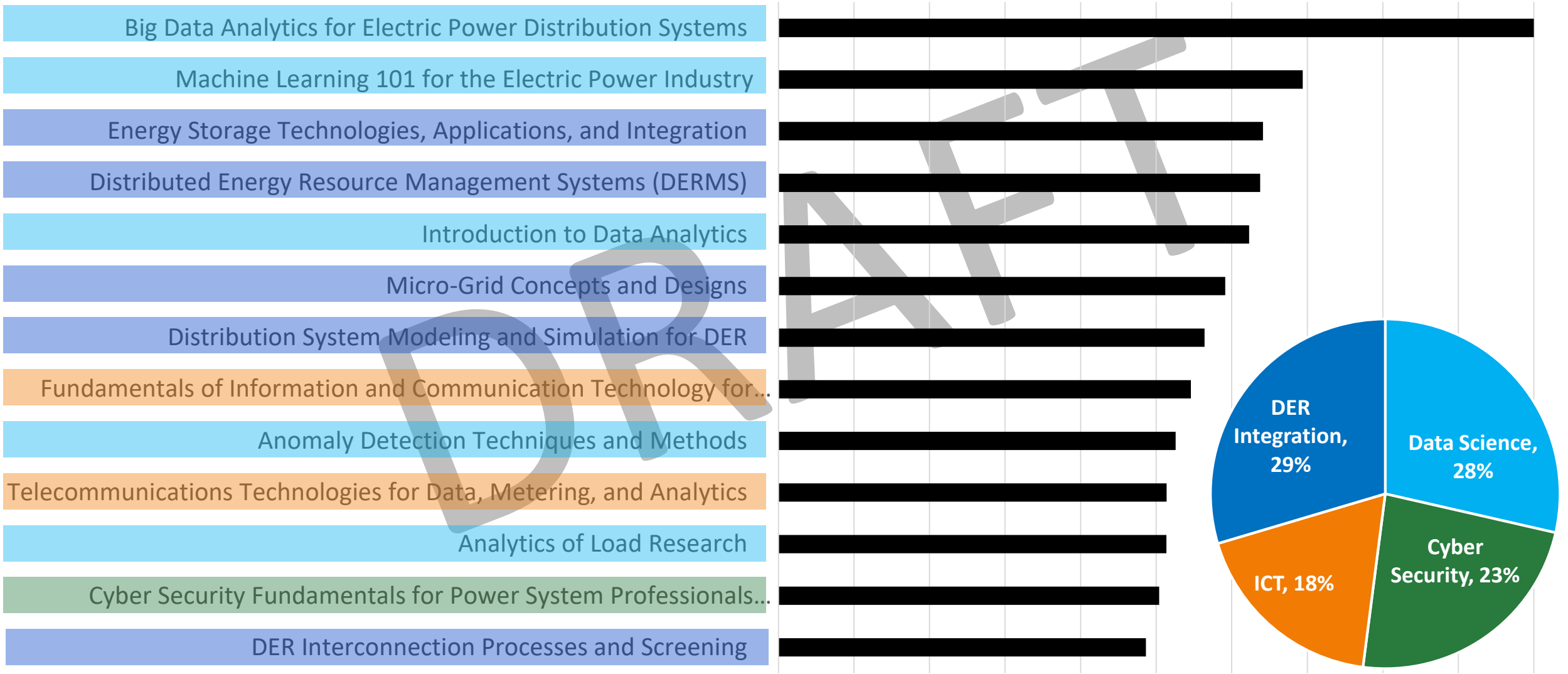
2019 Course Prioritization Results

Weighted Based on Topic Area and Mean/Median Combination



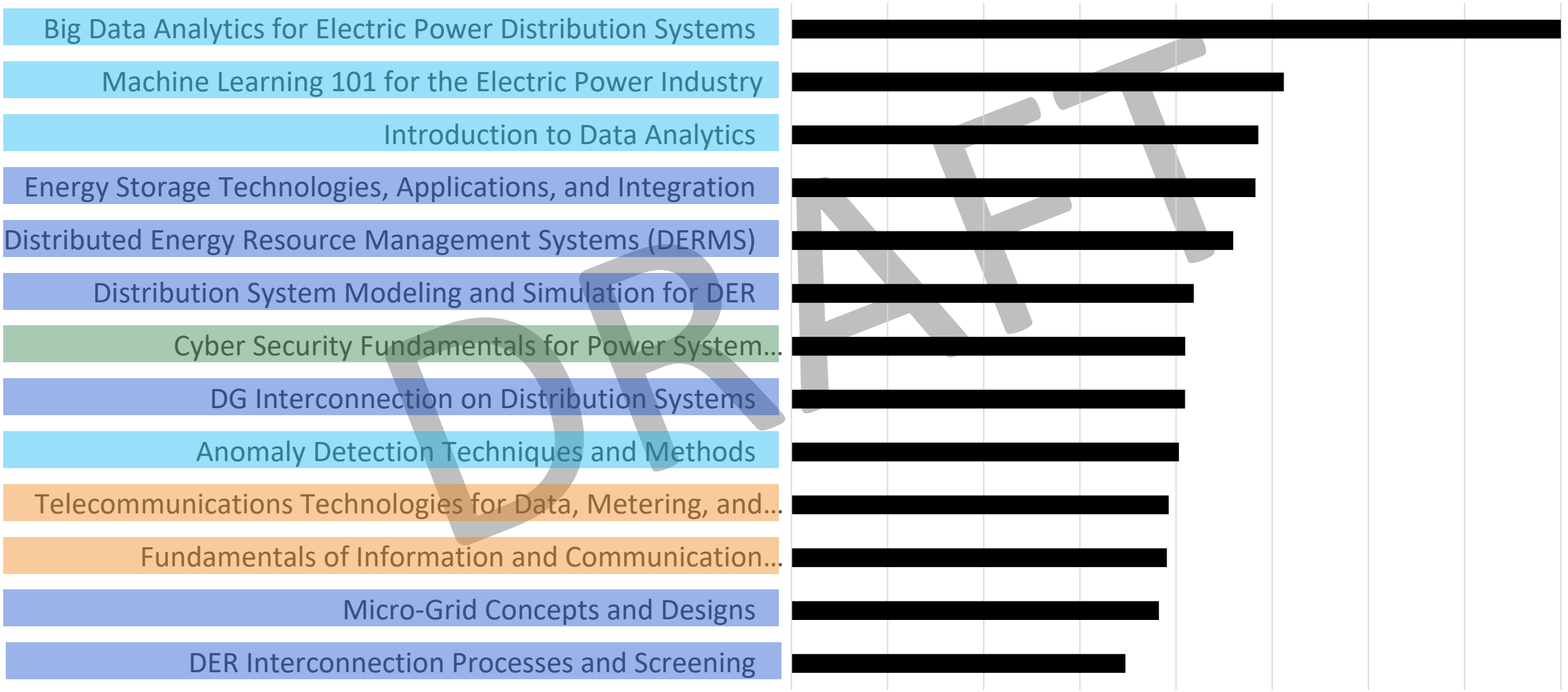
2020 Course Prioritization Results

Weighted Based on Topic Area and Mean/Median Combination



Combined 2019 & 2020 Course Prioritization Results

Weighted Based on Topic Area and Mean/Median Combination



Together...Shaping the Future of Electricity