The impact of Distributed Energy Resources (DER) on the Distribution System Operator (DSO) – an evolving complexity

VIRTUAL AMEU BRANCH MEETING

HOSTED BY KZN – 2 October 2020

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About EPRI, www.epri.com

- EPRI conducts **research and development** relating to the **generation**, **delivery** and **use of electricity** for the benefit of the public.
- EPRI brings together its scientists and engineers as well as experts from academia and industry to help address challenges in electricity, including **reliability**, **efficiency**, **affordability**, **health**, **safety** and the **environment**.
- **EPRI members** represent 90% of the electricity generated and delivered in the United States with international participation extending to nearly **40 countries**.

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VP, Innovation

Technology Innovation

Neil Wilmshurst
VP, Nuclear & Chief Nuclear Officer

Nuclear Power

Andrew Phillips
VP, Transmission & Distribution Infrastructure

- 34- Transmission Asset Management Analytics
- 35- Overhead Transmission
- 36- Underground Transmission
- 37- Substations
- 39- Transmission Operations
- 40- Transmission Planning
- 51-Transmission & Distribution: Environmental Issues
- 60- Electric & Magnetic Fields & Radio-Frequency Health Assessment and Safety
- 161- Information and Communication Technology
- 173- Bulk System Renewables & Distributed Energy Resources Integration
- 183- Cyber Security for Power Delivery & Utilization

Daniel Brooks
VP, Integrated Grid and Energy Systems

- 94- Energy Storage & Distributed Generation
- 174- DER Integration
- 178- Resource Planning for Electric Power Systems
- 180- Distribution Systems
- 197- Environmental Aspects of Fueled Distribution Generation & Energy Storage
- 200- Distribution Operations & Planning
- 201- Energy, Environmental, & Climate Policy

Rob Chapman
VP, Sustainability & Electrification

- 1- Power Quality
- 18- Electric Transportation
- 55- Ecosystem Risk & Resiliency: Wildfire & Extreme Events
- 62- Occupational Health and Safety
- 170- Customer Technologies
- 182- Understanding Electric Utility Customers
- 195- Endangered & Protected Species
- 198- Energy Sustainability
- 199- Electrification

Tom Alley
VP, Generation

- 49- Coal Combustion Product Management
- 54- Fish Protection
- 63- Boiler Life & Availability Improvement
- 64- Boiler & Turbine Steam & Cycle Chemistry
- 65- Steam Turbines- Generators & Auxiliary Systems
- 66- Advanced Generation & Bulk Energy Storage
- 68- Instrumentation, Controls, & Automation
- 69- Maintenance Management & Technology
- 71- Combustion & Fuel Quality Impacts
- 75- Integrated Environmental Controls
- 77- Continuous Emissions Monitoring
- 79- Combined Cycle Turbomachinery
- 87- Materials & Repair
- 88- Combined Cycle HRSG & Balance of Plant
- 104- Balance of Plant Systems & Equipment
- 108- Operations Management & Technology
- 165- Carbon Capture & Storage
- 185- Water Management Technology
- 192- Environmental Impacts of Renewables
- 193- Renewable Generation
- 194- Heat Rate Improvement
- 196- Water Quality
- 203- Air Quality & Multimedia Characterization, Assessment, & Health

P200 Technical Team

Over 350 combined years of experience analyzing, designing, deploying advanced distribution solutions


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Celso Rocha


Divya Godvarthi

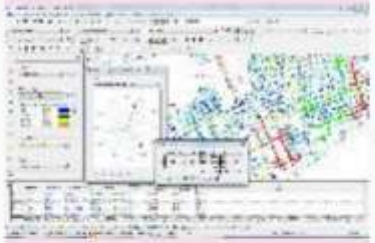
P200 2020 Program Membership

45 members of P200

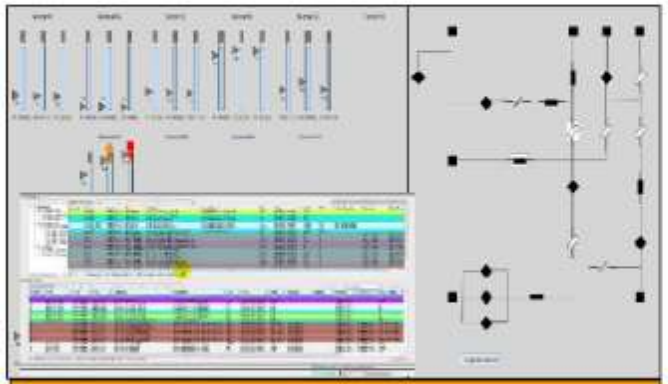
- Alliant Energy
- Ameren
- American Electric Power
- Arizona Public Service
- Austin Energy
- CenterPoint Energy
- Central Hudson
- Consolidated Edison
- Consumers Energy
- CPS Energy
- Dominion Energy
- DTE Electric
- Duquesne Light Co.
- ENMAX
- Entergy
- Eskom
- Evergy
- Eversource Energy
- Exelon
- FirstEnergy
- Fortis Alberta
- Great River Energy
- Hawaiian Electric
- Hydro One
- Idaho Power
- Korea Electric Power Corp.
- LG&E and KU
- Lincoln Electric System
- Manitoba Hydro
- National Grid
- NB Power
- Nebraska Public Power District
- OG&E
- Portland General Electric
- PPL
- Puget Sound Energy
- Salt River Project
- Seattle City Light
- Southern Company
- Taiwan Power Company
- Tennessee Valley Authority
- Tri-State Generation & Transmission
- United Illuminating
- WEC Energy
- Xcel Energy

Program Structure – Five Areas (Project Sets)

P200

Planning	Operations	Protection	Analytics	Tech Transfer
New planning processes, methods, and tools	Advanced distribution control and dynamic grid management	New and cost-effective protection schemes	Advanced analytics for operations and planning	Interest groups, workshops, and training
				
200B	200C	200D	200E	200A
Lead: Jason Taylor	Brian Deaver	Sean McGuinness	Matthew Rylander	Lindsey Rogers

Operations & Control for Modern Distribution Systems



Situational Awareness

DMS
Core & Advance Applications

Distribution Control Center

Distribution Automation

Roadmap: Distribution Automation

Year	Project	ID
2013	DMS Planning Guide: How to Run a DA Program	3002001292
	Cost/Benefit Analysis for Smart Distribution Applications v1.1	3002001294
2014	Automate	
	DA/FLISR	
2015	DA with FI	
2015	Advanced	
2017	Smart Dist Location I	
	Distributio	
2018	Comparisc	
	Operation	
	Innovative	
2019	Innovative	
2020	Video Trai	
	Applicatio	

Roadmap: DMS Core Capabilities

Year	Project	ID
2012	DMS Planning Guide	1024585
2013	Smart Distribution Applications for DER	3002001295
2016	DMS Planning Guide: Switch Order Management	3002007988
2017	Distribution Management System: Requirements Reference	3002011003
2018	Value of Di	
	Oper	
	State	
2019	State	
2020	State	
	Appl	

Roadmap: Advanced DMS Applications

Year	Project	ID
2011	Design and Assessment of Volt-VAR Optimization Systems	1022004
2014	DMS Planning Guide: How to Run a Volt/VAR/CVR Program	3002003244
	Smart Distribution Applications for DER: DMS Use Cases	3002002464

003244
006128
011003
013049
013410

Roadmap: Situational Awareness

Year	Project	ID
2018	The Importance of DER Visibility to Grid Support and Modernization	3002013388
	Distribution Control Center Alarm Management: Baseline Reports 2018	3002013424
	HMI/EMS Display Design – Common Design Elements across Generation, Transmission, and Distribution Control Centers	3002013492

2015266
2015270
2015268

Roadmap: Distribution Control Center Operations

Year	Project	ID
2017	Reclosing/ Fuse Saving Study	3002011006
2018	Cyber Security Considerations for Distribution Control Centers: Reference Architecture and Attack Modeling Methodology	3002013419
2019	Cyber Security Resilience in Distribution Operations – Document Opportunities	3002015277
	Distribution Operator of the Future Roles and Responsibilities	
	The Role of a Distribution and Transmission System Operator (TSO/DSO) in the Utility of the Future	3002015267
	Increasing the Resilience of the Control Center: Transferring Control out of the Control Center during major outage events	3002015269
2020	Cyber Security Resilience in Distribution Operations – Next Steps	
	TSO/DSO Interaction – Next Steps	
	Operator of the Future Training Curriculum	

AVAT

Supplemental Projects:
2019-2020: Distribution Control Center Visits

2020 Projects

P200

Transfer

- Grid Modernization Playbook
- Interest Groups
- Training Module: Distribution Automation Training

Planning

- Distribution Planning Guidebook
- Feeder Design Practices that Enable DER & Improve Reliability
- Benchmarking Distribution Planning Practices
- Screening of NWA Projects
- Assessing NWA Impact on System Reliability
- Assessing the Cost-Benefits of DER Forecasts
- System Configuration and Flexibility Assessment Tool
- Addressing Uncertainty in Project Evaluation & Prioritization

Analytics

- Automated DER Mitigation Assessment Tool
- Enhanced Load Modeling
- Assessment of Smart Inverter Modeling in Planning Tools
- Incorporating Future Load/DER Growth into Hosting Capacity Calculations
- Enhanced Grid Modeling Data for Planning and Operations
- Hosting Capacity Guidebook
- Guidance on Determining Voltage Regulator Settings with High Levels of DER
- DER Modeling and Simulation Workshop

Operations

- Distribution System Operator of the Future Training Curriculum
- DCC Alarm Management: Philosophy & Rationalization
- HMI Display Reference Document
- Preparing Distribution Operations for Cyber Attacks
- TSO/DSO Interaction
- Advanced DMS Algorithms (DA/FLISR, VVO) with DER
- Application of Machine Learning to Improve Predictive Reliability Assessments
- AMI Requirements for Distribution Operations
- Evaluation and Documentation of Operations Processes
- DSO Mutual Assistance Exercise
- Documentation of Leading Practices for Prewritten Switching and Checklists
- DER Forecasting for Distribution Operations

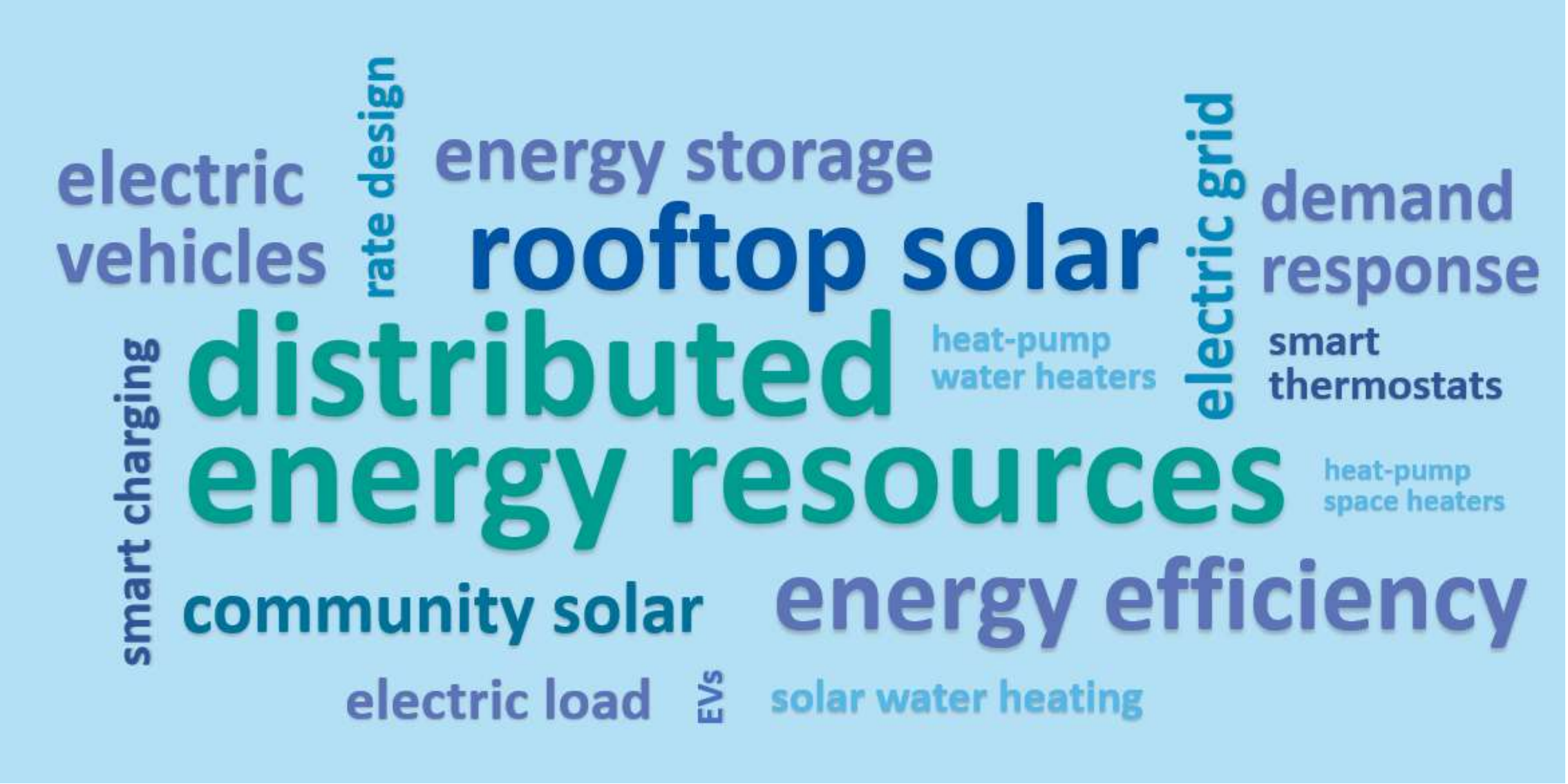
Protection

- Distribution Protection Analysis Toolkit for CYME & Synergi
- DER Modeling for Protection Studies
- Solutions for Mitigating Impacts of DER on Protection
- Grid Protection Against Unintentional Islanding of DER
- Effective Grounding of DER Connections
- Modern Low-Cost DTT Technologies
- Protection Challenges for Reverse Power at Substations
- DER Interface Protection Practices
- Adaptive Protection Scheme Selection, Design, & Testing – Proceedings from Workshop
- Protection of Microgrids

Joint Projects

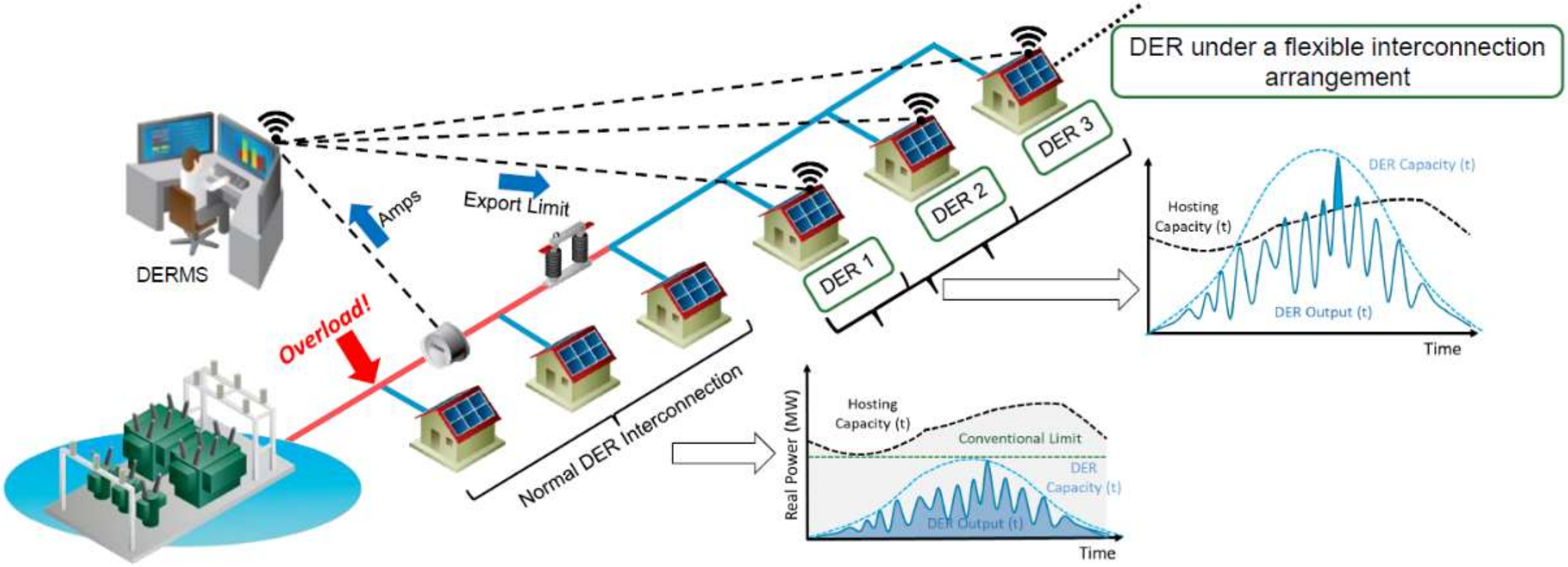
- 174
- 94
- 161
- 39

Understanding: DER – Distributed Energy Resources

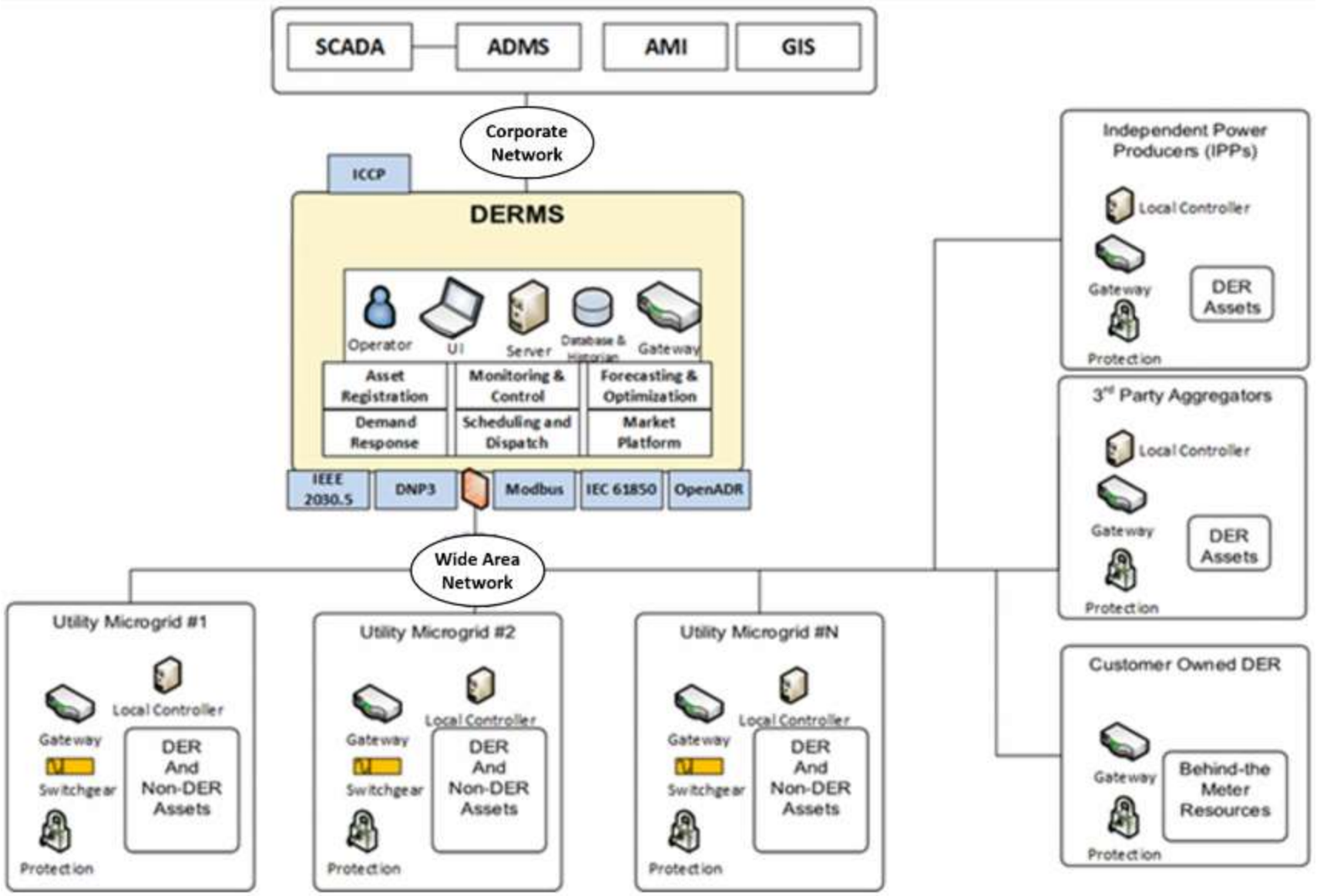


Example – Why DER Matters

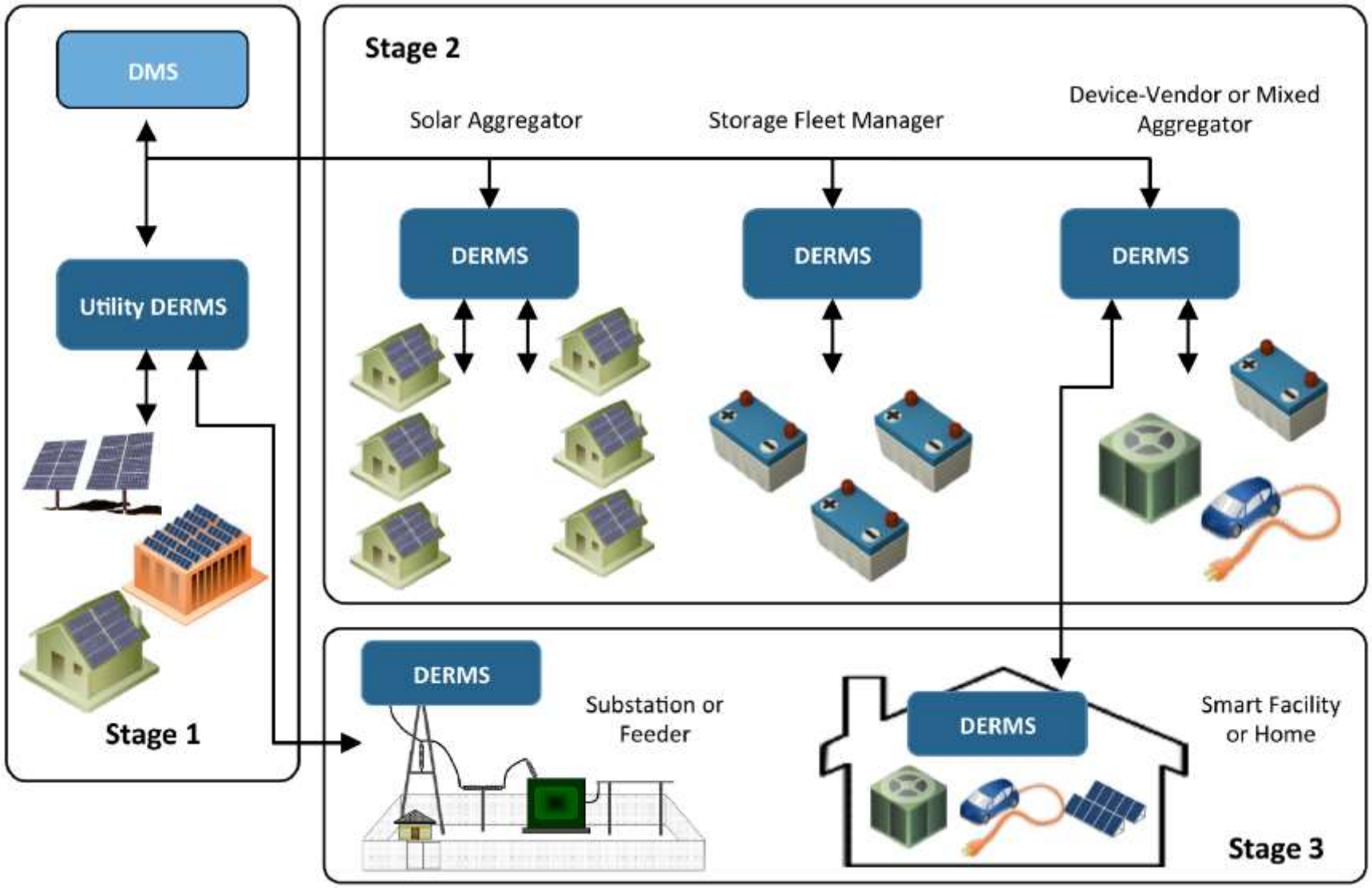
How to allocate constraints across multiple DER?



Understanding: DERMS – DER Management System

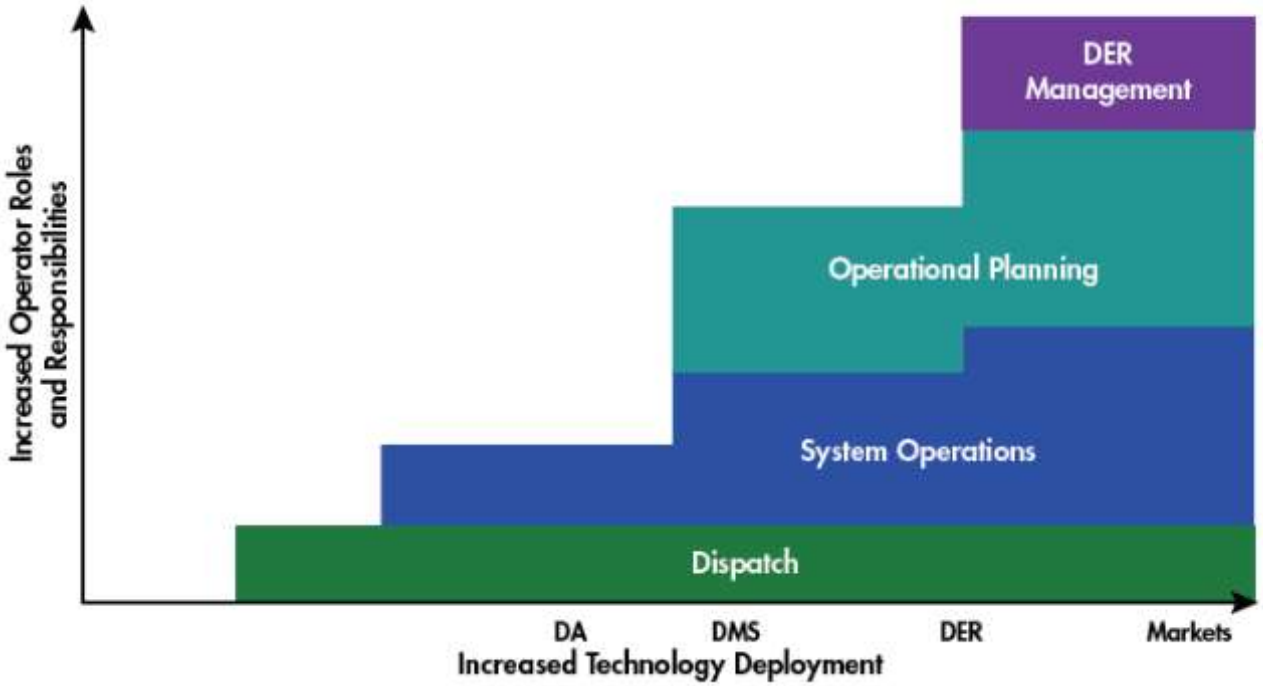


Multi – Level DERMS are possible



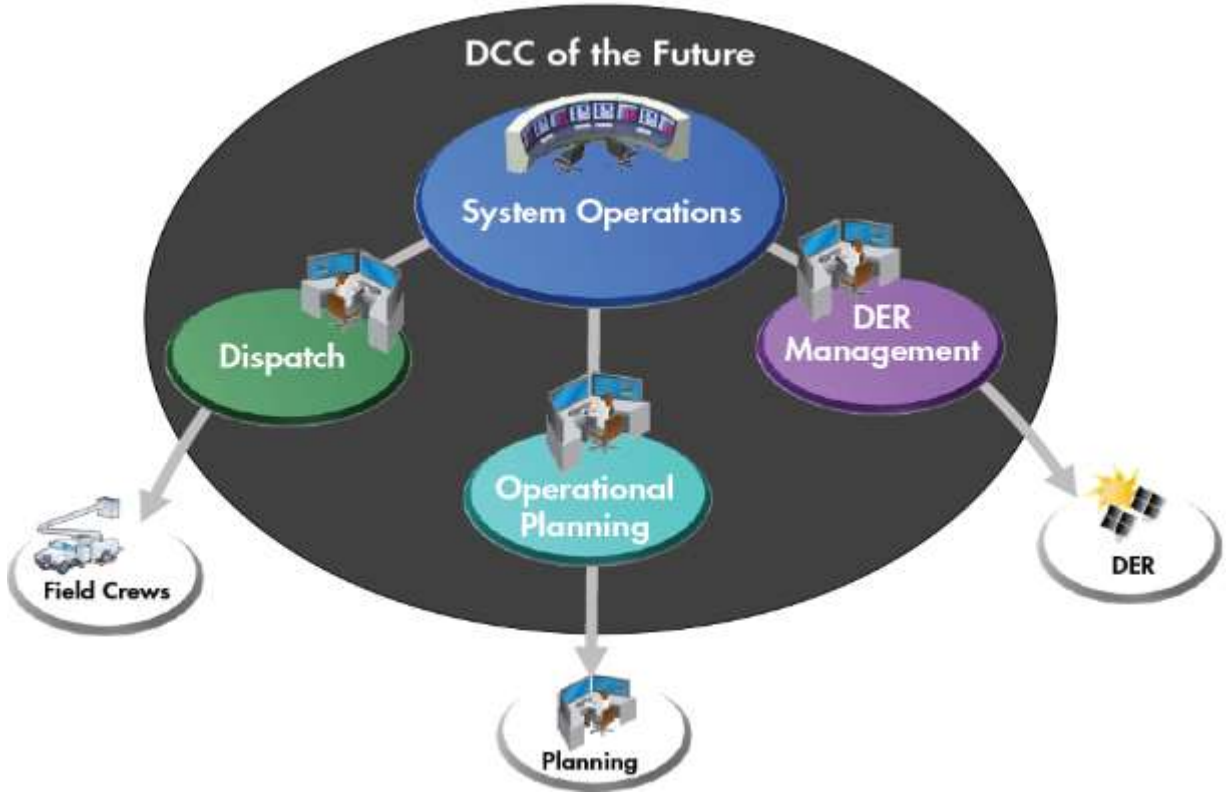
More is Being Required of Distribution Operators

Historically, the primary role of the distribution operator was to receive calls associated with customer outages and dispatch crews to repair the system to restore service. Operators were typically located locally and helped the line crews by being a resource they could call upon to get information about the state of the system. The operator typically came up from the ranks of the line department and had an intimate knowledge of the area. This person was commonly referred to as a *dispatcher*.



New Functions with High Penetration DER

- Volt/var evaluation
- Hosting capacity
- Congestion management
- DER forecasting
- DER dispatch and control
- Real-time DER aggregation
- DER group management
- 3rd party aggregator/ markets
- DER monitoring and verification of services

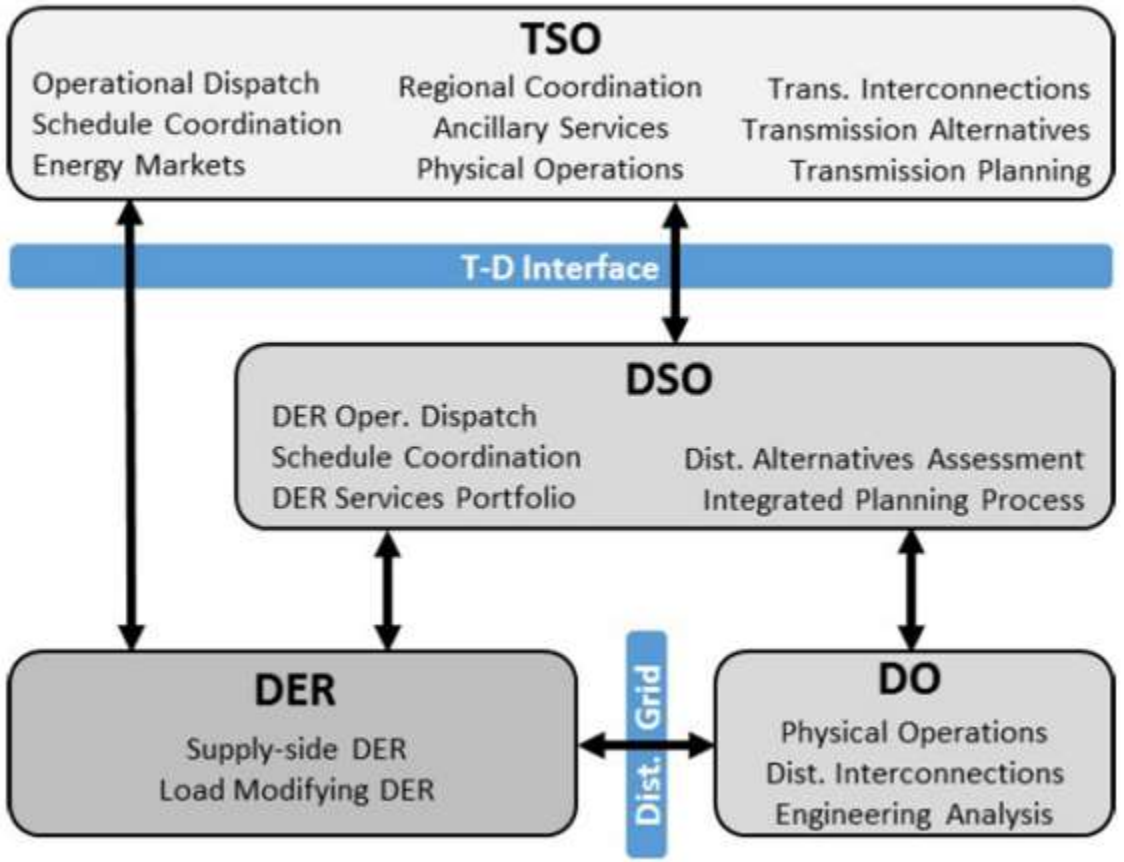


Concerns with Increasing DER Quantities

- DSO concerns
  - Thermal/voltage Dx violations when DER provide bulk system services
  - Wear & tear of Dx equipment
  - Under utilization of distribution assets
- TSO/ISO concerns
  - Under utilization/access of DER for bulk services
  - Rising impacts due to increased quantities
- DER owner (DER aggregator) concerns
  - Lost opportunity/decreased value

Critical to define TSO and DSO roles and boundaries

Distribution Functions	Total TSO	Minimal DSO	Market DSO
1. Planning			
A. Scenario based, probabilistic distribution engineering	DO	DO	DO
B. DER Interconnection studies and procedures	DO	DO	DO
C. DER Hosting capacity analysis	DO	DO	DO
D. DER Locational value analysis	TSO	DSO	DSO
E. Integrated T&D planning	TSO	TSO/DSO	TSO/DSO
2. Operations			
A. Design-build and ownership of distribution grid	DO	DO	DO
B. Switching, outage restoration & distribution maintenance	DO	DO	DO
C. Physical coordination of DER schedules	DO/TSO	DSO/TSO	DSO
D. Real-time Coordination with ISO at T-D interface	DO/TSO	DSO/TSO	DSO
3. Market			
A. Sourcing distribution grid services	TSO	DSO	DSO
B. Optimally dispatch DER provided distribution grid services	TSO	DSO	DSO
C. Aggregation of DER for wholesale market participation	TSO	Aggregators	DSO (C2)
D. Creation & operation of distribution level energy markets; transactions among DER	TSO	TSO/Others	DSO
E. Clearing and settlements for inter-DER transactions	TSO	TSO/Others	DSO
F. Market facilitation services	TSO	TSO/Others	DSO
	Stages 1-3	Stages 2-3	Stage 3



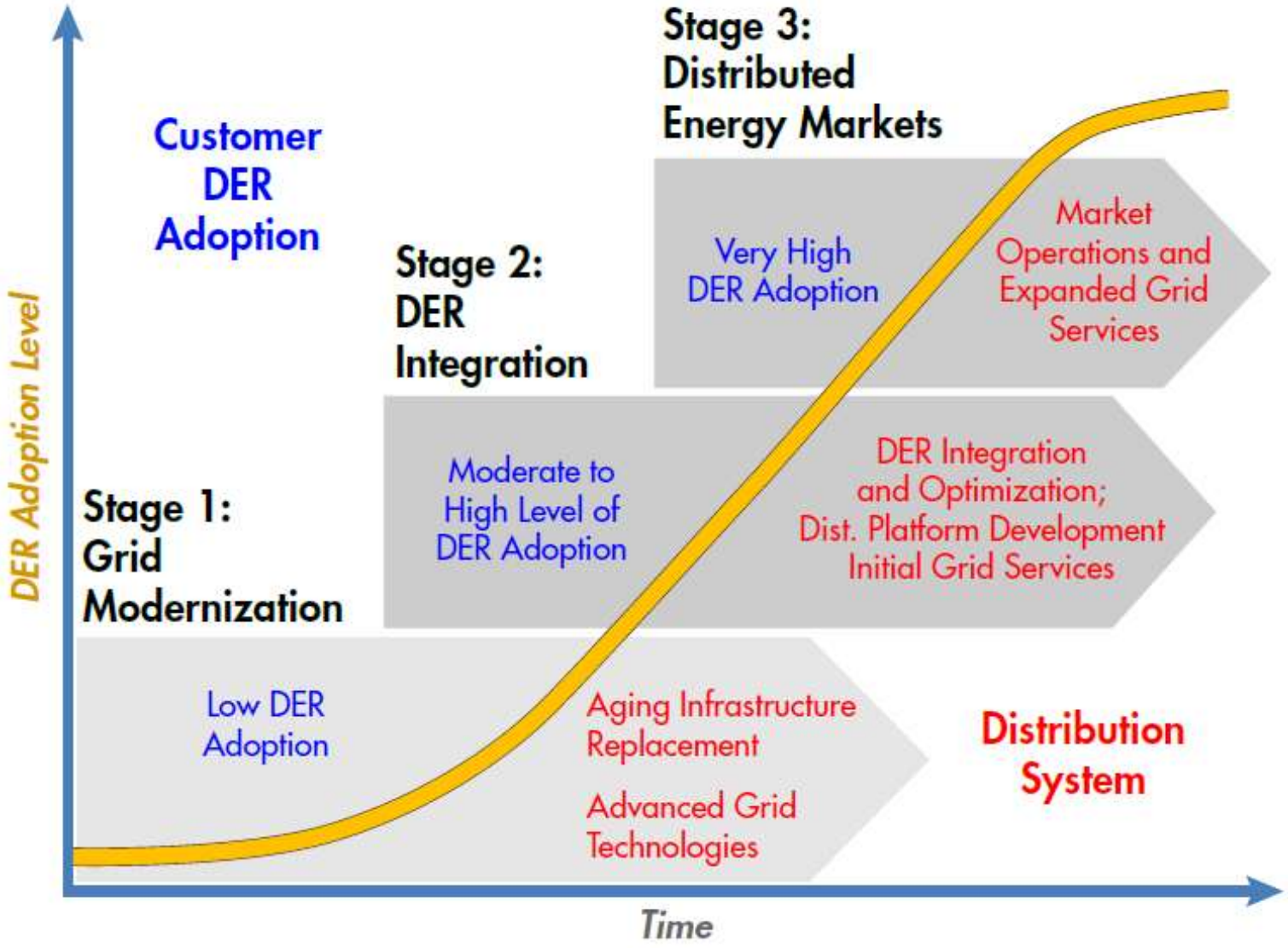
Source: DISTRIBUTION SYSTEMS IN A HIGH DISTRIBUTED ENERGY RESOURCES FUTURE – Berkeley Labs

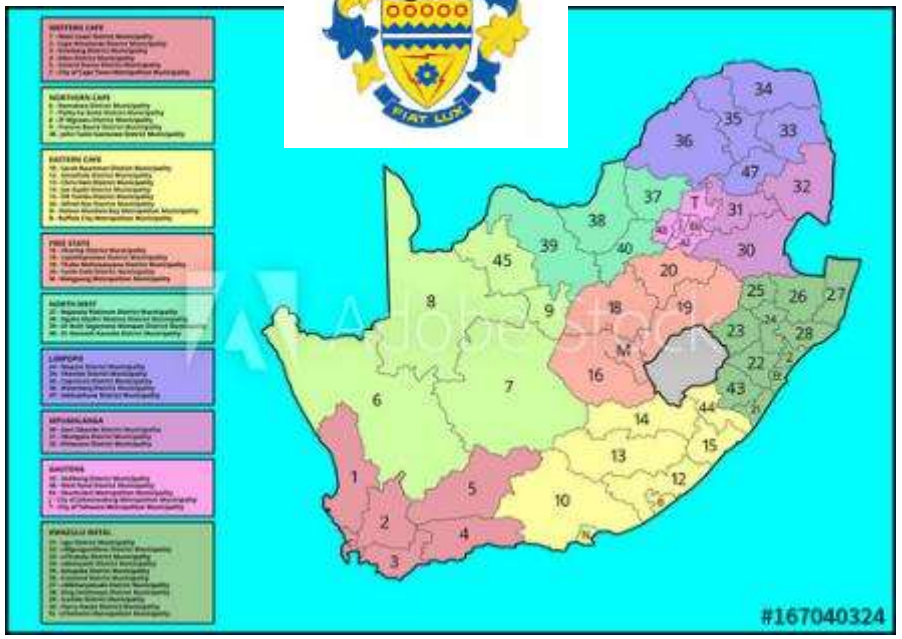
Conclusion 1 – The role of the DSO is expanding rapidly.

Energy Resource Functions	Operational Planning Functions	Real-Time Operations Functions
• DER forecast • DER Dispatch and control • Real-time DER aggregation • DER group management • 3rd party aggregator/markets • DER monitoring and validation of services	• Contingency analysis • Congestion management • Hosting capacity • Outage scheduling • Volt/var evaluation • FLISR evaluation • Optimal network reconfiguration • Load forecast • Alarm processing • Power quality • Forensics • Protection	• Switch order management • Clearance/tagging • Outage management • Restoration • Crew Dispatch • Alarm management • Voltage management • Real-time power quality • FLISR operations • Volt/var optimization

Figure 3-1
Future Roles in Distribution Operations

Conclusion 2 – S. Africa needs to coordinate a response plan to the DER S-Curve.





Conclusion 3 – There is much exciting work to be done.

Vision for the Modern Distribution System

Enhanced planning tools and processes, advanced operational sensing and controls, along with supporting communications and other technologies are needed to accelerate realization of an advanced, digitally-enhanced, and dynamically-managed "high-performing" electric grid.

Planning (Future States)

- Effective practices and methods accurately forecast DER and load
- Complete and accurate models of system assets, configuration, and loading support planning
- Models of all DER types capture representative dynamic characteristics
- Tools evaluate system hosting capacity under varying system conditions
- Automated tools accurately assess future planning scenarios and mitigation options
- Simulation and assessment tools enable evaluation and design of advanced DA & DMS applications
- Methods and guidance enable holistic evaluation of non-wires alternatives on an equivalent basis with traditional solutions
- Effective planning criteria and a process for a modern integrated grid are widely employed
- Accessible probabilistic planning methods account for increasing system and resource variability and uncertainty

Operations (Future States)

- More sophisticated automation and FLISR holistically utilizes all available technologies and resources to isolate and reconfigure the system
- Skilled operators leverage robust distribution control center operator training and development
- Robust DMS core capabilities, such as on-line power flow and state estimation, support advanced applications
- Intelligent, accurate, and cost effective sensors support advanced applications
- Situational awareness ensures safe, reliable, and efficient operation of the modern grid
- An advanced real-time distribution system optimization method and techniques manage voltage and reactive power flow
- A clearly defined and validated DERMS is well integrated with the DMS, supports DER management, and performs other functions

Supporting Technologies (Future States)

- Methods, technologies, and tools enable the effective control and coordination of smart inverter resources
- AMI implementations are effectively integrated with utility systems and support myriad analytic and application functions
- Enterprise architecture enables effective standards-based data management across applications and working groups
- Streamlined network model data management provides planning and operations with accurate and detailed models
- Device configuration and setting data are seamlessly managed across the enterprise and in the field
- Secure, reliable, resilient, and scalable multi-tier communication systems enable transport of field data
- Effective cyber security and data privacy strategies protect grids, which are increasingly dependent on information technology and third-party assets

Source: EPRI – New York Grid Modernization Roadmap

Together...Shaping the Future of Electricity

Barry MacColl

- Barry MacColl is appointed as the Senior Regional Manager for the Electric Power Research Institute covering Africa, South East Asia and Oceania. He is based in Johannesburg.
- Barry joined EPRI from Eskom Holdings, where he worked for 26 years in various positions.
- His early career years were spent in the Cape commissioning and maintaining control and instrumentation equipment and converting Eskom's systems from electromechanical and discreet component systems to those based on digital technologies. He was appointed as the manager of the telecommunications, protection, control and DC systems as well as a Regional control centre and ultimately became accountable for the planning, design, construction, commissioning, maintenance and refurbishment of all control plant equipment in the Eastern Cape.
- Recognized for his holistic view of the business, Barry was then moved into a strategic planning and integrated risk management role. He moved into the company's R&D group in 2007 and was promoted to General Manager of the Research, Testing and Development Business Unit in 2012, the last position he held before joining EPRI.
- Barry has a Bachelor of Science (Electronic Engineering) degree from the University of KwaZulu Natal and a Masters of Business Administration from Rhodes University. He is married to Carey, has three children and loves to spend time cycling and fishing in beautiful South Africa.