

Distribution System Planning WUTC

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Agenda



- ▶ Background
 - U.S. Department of Energy efforts
 - Resources
- ▶ Washington Context
- ▶ Distribution System Planning Tools Assessment
- ▶ Summary of Efforts in Other States Related to Five Questions
- ▶ Emerging Issues in IRP
- ▶ Possible Places to Start
- ▶ Next Steps for DOE Projects

DOE's grid modernization initiative



- ▶ Aggressive five-year grid modernization strategy
 - Alignment of the existing base activities among DOE Offices
 - An integrated Multi-Year Program Plan (MYPP)
 - Laboratory consortium with core scientific abilities and regional outreach
- ▶ Scope
 - Developing **new architectural concepts, tools and technologies** that measure, analyze, predict, protect and control the grid of the future
 - **Enabling the institutional conditions that allow for more rapid development and widespread adoption of these tools and technologies**
- ▶ Grid Modernization Lab Consortium
 - Collaboration among 14 DOE national labs and regional networks that will help develop and implement the MYPP
 - Includes support for PUCs and utilities on distribution planning

U.S. Department of Energy (DOE) – Grid Modernization Lab Consortium (GLMC)



- ▶ Four main institutional support activities under DOE's Multi-year Program Plan:
 1. Provide technical assistance to states and tribal governments
 2. Support regional planning and reliability organizations
 3. Develop methods and resources for assessing grid modernization: Emerging technologies, valuation and markets
 4. Conduct research on future electric utility regulations
- ▶ Each activity has specific goals and target achievements to be completed by 2020

GMLC 1.4.25 - Distribution System Decision Support Tool Development and Application



Project Description

Identify strategies and provide technical assistance to state regulators and utility organizations that focus on advanced electric distribution planning methods and tools, with a focus on incorporating emerging grid modernization technologies and significant deployment of DER

Project Participants and Roles

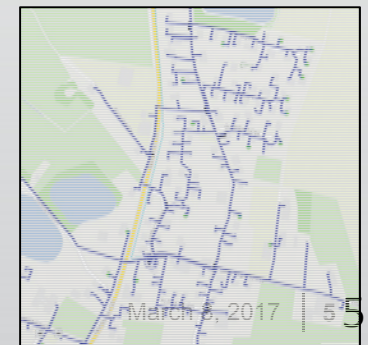
Michael Coddington – PI – NREL (Utility Practices)

Lisa Schwartz – Lead for LBNL (Regulatory)

Juliet Homer – Lead for PNNL (Tools & Regulatory)

Expected Outcomes

- ✓ Provide Technical Assistance to State Regulators in partnership with NARUC
- ✓ Identify Gaps in Existing and Emerging Planning Practices & Approaches
- ✓ Compile information on existing planning tools, identify gaps and make recommendations
- ✓ Provide Technical Assistance (guides) to Electric Utility industry through organizations



Resources



- ▶ Summary of Distribution Planning Activities in Leading States
- ▶ Summary of Distribution Analyses with a Focus on DERs
 - Summarizes analysis capabilities and relative maturity levels
- ▶ Upcoming: Distribution planning training for commissioners and staff (labs and NARUC)
- ▶ Email me for copies of these: Juliet.Homer@pnnl.gov
- ▶ DSPx project
 - A separate but connected effort also led by DOE
 - Instigated by CPUC and NYPSC and regulators from DC, HI and MN
 - *“DOE-OE, with the sponsoring commissions, has brought together a team with industry expertise in the areas of grid planning, operations, market design, related technologies, and policy to support this effort.”*
 - Volume I: Customer and State Policy Driven Functionality
 - Volume II: Advanced Technology Market Assessment
 - Volume III: Decision Maker Guide
 - www.doe-dspx.org

Washington Context



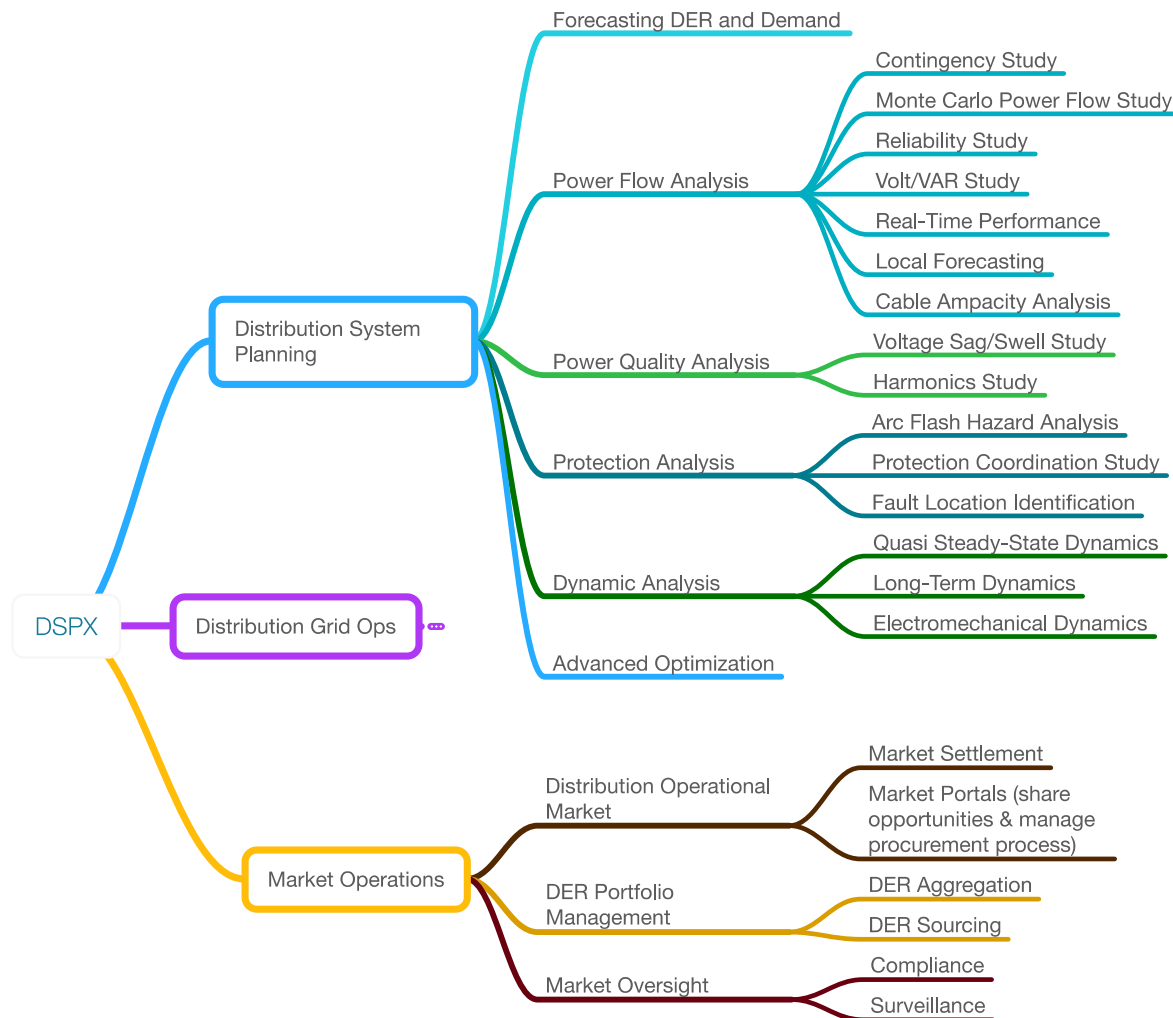
- ▶ Taken from Notice of Workshop and WUTC Concept Paper
- ▶ Goal: Ensure utilities are applying IRP principles as they consider T&D resource options – electric and natural gas
 - Improve transparency of T&D planning in IRP process
- ▶ Proposal: Electric and gas utilities analyze some subset of their distribution system in each IRP cycle
- ▶ Question topics:
 1. Baseline Information – granular understanding of current conditions, visibility, tools
 2. Scope of distribution plan – how prioritize lines, standard approaches to valuing and calculating levelized costs and benefits
 3. How to link T&D planning to resource acquisition – 5-year competitive bidding process
 4. Pros and cons of utilities versus others analyzing solutions
 5. Role of stakeholders

Tools Assessment



- ▶ Studied 10 Distribution System Analysis (DSA) tools
 - 8 commercial tools and 2 open source research tools
- ▶ Evaluated maturity levels of analysis types
- ▶ General categories considered:
 - Power flow analysis
 - Power quality analysis
 - Fault analysis
 - Dynamic analysis
 - Market analysis
- ▶ Distributed Energy Resources (DER) analyses considered:
 - DERs and net load projections
 - Basic distribution engineering with DERs
 - Time-series power flow analysis with DERs
 - Advanced optimization with DERs
 - Hosting capacity and interconnection
 - Dynamic studies with DERs
 - Co-simulation with transmission systems.

DSPx Planning Analysis Categories



Analysis Type Maturity Levels



Distribution System Analysis Types and Applications	Maturity Level
Power Flow Analysis	
Peak Capacity Planning Study	3
Voltage Drop Study	3
Ampacity Study	3
Contingency and Restoration Study	3
Reliability Study	3
Load Profile Study	3
Stochastic Power Flow Study	2
Volt/Var Study	2
Real-Time Performance	2
Power Quality Analysis	
Voltage Sag and Swell Study	3
Harmonics Study	2
Fault Analysis	
Arc Flash Hazard Analysis	3
Protection Coordination Study	3
Fault Location Identification	1
Dynamic Analysis	
Long-Term Dynamics	1
Electromechanical Dynamics	2
Electromagnetic Dynamics	3
Market Analysis	
Revenue and Customer Bill Analysis	3
TOU Pricing Analysis	3
Demand Response Analysis	3
Transactive Energy Analysis	1

Modeling DERs



- ▶ Integration of DERs may result in overcurrent, overvoltage, and miscoordination between protective devices
- ▶ Hosting-capacity studies determine the amount of DERs that can be accommodated without affecting feeder power quality or reliability
 - Four aspects: Voltage, power quality, protection and thermal limits
- ▶ Interconnection impact studies cover the same things as hosting-capacity studies but for a single DER project
- ▶ Most existing modeling tools can conduct basic distribution engineering studies and time-series simulations with DERs

Hosting Capacity Analysis Capability	Percentage of DSA Tools
Capability of Time-Series Voltage Analysis	90%
Capability of Power Quality Harmonic Analysis	90%
Capability of Fault analysis	100%
Capability of Thermal Limits Analysis	30%
Capability of DER Advanced Optimization Study	70%

Nascent Areas and Gaps

1. Projecting growth of types and locations of DERs
2. Developing and validating an accurate distribution system model**
3. Interactions between the distribution and transmission systems
4. Advanced optimization studies for DERs with storage systems
5. Automation of hosting capacity / interconnection analysis, including workflow management aspects
6. Multiple DER anti-islanding studies
7. Simulating microgrids with custom controls
8. Inverter modeling for volt/var control
9. Support for holistic planning for sensing and measurement devices:
Types, number, and location**

****Items 2) and 9) relate to Question 1 re: Baseline Info – Level of detail in feeder model and therefore granularity of data needed depends on analysis requirements. Start with questions that need to be answered.**

States are advancing distribution planning in a variety of ways.



- ▶ Requirements for utilities to file distribution system/grid modernization plans with stakeholder engagement (e.g., NY, CA, MA)
- ▶ Requirements for hosting capacity analysis (e.g., MN, CA, NY)
- ▶ Consideration of cost-effective non-wires alternatives (e.g., NY, RI, VT)
- ▶ Locational net benefits analysis for DERs at specific locations (e.g., CA)
- ▶ Investigations into DER procurement strategies (e.g., HI, NY, CA)
- ▶ Requirements for utilities to report regularly on poor-performing circuits and propose investments (e.g., PA)
- ▶ Storm hardening and undergrounding requirements (e.g., FL)
- ▶ Aggregation and participation of DERs in wholesale markets (e.g., TX)
- ▶ Reliability codes and annual compliance reports (e.g., OH, IL)
- ▶ Smart grid reporting (e.g., WA, OR)

General benefits of improved distribution planning



- ▶ Makes transparent utility distribution system investments before showing up individually in rider or rate case
- ▶ Provides opportunities for meaningful PUC and stakeholder engagement
- ▶ Considers uncertainties under a range of possible futures
- ▶ Considers all solutions for least cost/risk
- ▶ Motivates utility to choose least cost/risk solutions
- ▶ Enables consumers and third parties to participate in providing grid services

Stated Objectives of State DER Planning and Grid Modernization Activities



Stated Goals of Grid Modernization Efforts:	CA	DC	HI	IL	ME	MA	MN	NV	NH	NY	OR	TX
Protect and enhance reliability and resilience	X	X	X	X	X	X	X	X	X	X	X	X
Develop and integrate renewables and distributed resources	X	X	X		X	X	X	X	X	X	X	X
Lower costs	X	X	X		X	X	X	X	X		X	
Enhance customer service and choice	X		X	X			X		X	X	X	
Save energy, reduce peak, optimize demand		X			X	X			X	X	X	
Optimize existing generation, transmission and distribution systems			X		X		X		X	X	X	
Modernize / accommodate new smart technologies	X			X	X		X					
Animate markets / provide grid platform	X						X			X		X
Enhance safety and security				X			X				X	
Reduce emissions	X				X					X		
Support workforce and economic development				X		X		X	X			
Facilitate integrated planning							X					

Question 1) Baseline informational needs



- ▶ From CA DRP Rulemaking R.14-08-013 a “baseline” hosting capacity methodology was developed. First two (of four) steps are:
 - 1) Establish distribution system level of granularity
 - Establish Distribution Planning Areas (DPA)
 - Perform analysis down to specific nodes within each line section of individual feeders.
 - Nodes are to be selected based on impedance factor
 - Model and extract power system data
 - Load forecasting analysis tool (LoadSEER) must be used to develop load profiles at the feeder, substation and system levels by aggregating representative hourly customer load and generation profiles.
 - Load profile developed for each Distribution Planning Area (DPA)
 - Power flow analysis tool used to model conductors, line devices, load and generation components that impact circuit power quality and reliability.
- ▶ In District of Columbia the PSC ordered PEPCO to provide a load research plan (LRP) detailing how it will use digital grid information in expansion plans and rate designs.

Question 2) Scope of Distribution Plan



- ▶ From CA DRP Rulemaking R.14-08-013: Locational benefits and costs evaluation should be based on:
 - Reductions or increases in local generation capacity needs
 - Avoided or increased investments in distribution infrastructure
 - Safety benefits
 - Reliability benefits
 - Any other savings to the grid or ratepayers
- ▶ All CA utilities were required to use a common locational benefits methodology based on the Commission-approved E3 cost effectiveness calculator - Distributed Energy Resource Avoided Cost Calculator (DERAC)
- ▶ IOUs in CA were required to evaluate (at a minimum) one near-term (0-3 year project lead time) and one longer-term (3 or more year lead time) distribution infrastructure project for possible deferral.
 - In May 2016 original guidance was expanded on to include at least one voltage support/power quality or reliability/resiliency related deferral opportunity.

Value Components in PG&E's Locational Net Benefits Analysis



#	Component	PG&E Definition
1	Sub-Transmission, Substation and Feeder Capital and Operating Expenditures (Distribution Capacity)	Avoided or increased costs incurred to increase capacity on sub-transmission, substation and/or distribution feeders to ensure system can accommodate forecast load growth
2	Distribution Voltage and Power Quality Capital and Operating Expenditures	Avoided or increased costs incurred to ensure power delivered is within required operating specifications (i.e., voltage, fluctuations, etc.)
3	Distribution Reliability and Resiliency Capital and Operating Expenditures	Avoided or increased costs incurred to proactively prevent, mitigate and respond to routine outages (reliability) and major outages (resiliency)
4	Transmission Capital and Operating Expenditures	Avoided or increased costs incurred to increase capacity on transmission line and/or substations to ensure system can accommodate forecast load growth
5a	System or Local Area Resource Adequacy (RA)	Avoided or increased costs incurred to procure RA capacity to meet system or CAISO-identified Local Capacity Requirement (LCR)
5b	Flexible RA	Avoided or increased costs incurred to procure Flexible RA capacity
6a	Generation Energy and GHG	Avoided or increased costs incurred to procure electrical energy and associated cost of GHG emissions on behalf of utility customers
6b	Energy Losses	Avoided or increased costs to deliver procured electrical energy to utility customers due to losses on the T&D system
6c	Ancillary Services	Avoided or increased costs to procure ancillary services on behalf of utility customers
6d	RPS	Avoided or increased costs incurred to procure RPS eligible energy on behalf of utility customers as required to meet the utility's RPS requirements
7	Renewables Integration Costs	Avoided or increased generation-related costs not already captured under other components (e.g., Ancillary Services and Flexible RA capacity) associated with integrating variable renewable resources
8	Any societal avoided costs which can be clearly linked to the deployment of DERs	Decreased or increased costs to the public which do not have any nexus to utility costs or rates
9	Any avoided public safety costs which can be clearly linked to the deployment of DERs	Decreased or increased safety-related costs which are not captured in any other component

Question 2) Scope of Distribution Plan, cont.



- ▶ In Minnesota – Statute 216B.2425, subd.8. requires Xcel Energy to:
 1. Conduct a distribution study to identify interconnection points on its distributions system for small-scale distributed generation resources, and
 2. Identify upgrades necessary to support DERs
- ▶ Minnesota PUC required Xcel to complete a distribution study by 12/1/16 including hosting capacity analysis of each feeder for small scale distributed generation (< 1MW) and potential upgrades needed to support DG additions, including those in IRP filings.
 - Xcel must provide an updated hosting capacity analysis in the fall of 2017
- ▶ In New York, utilities required to submit Distributed System Implementation Plans (DSIP) to ((Case 14-M-0101):
 - Serve as a source of public information on objectives, needs and opportunities
 - Serve as a template for utilities to develop and articulate an integrated approach to planning, investment and operations
 - Enable the Commission to supervise implementation of REV in the context of system operations

Question 2) Scope of Distribution Plan, cont.



- ▶ NY PSC Staff released a Staff White Paper on Benefit-Cost Analysis that spells out the specific avoided cost calcs that should be performed by utilities in DSIPs
- ▶ Initial utility DSIPs included:
 - ❑ A self-assessment of utilities' current capabilities
 - ❑ A proposed roadmap for technology investments to improve grid intelligence and prepare it for higher DER penetration levels
 - ❑ Data that supports greater transparency for planning and distribution market development.
- ▶ Following individual utility DSIP submissions, a Supplemental Joint DSIP was filed that included:
 - ❑ A load and DER forecasting stakeholder engagement process;
 - ❑ A process for coordinating with NYISO on short- and long-term forecasting;
 - ❑ A non-wires analysis suitability framework (forthcoming implementation matrices);
 - ❑ A detailed roadmap for hosting capacity; and
 - ❑ An interconnection data platform and process roadmap.

Question 3) How link T&D planning to resource acquisition



- ▶ Hawaii requires utilities to submit Power Supply Improvement Plans (PSIP) to the PUC that detail utility's plans for major resource acquisitions and system operations (Docket 2014-0183).
- ▶ Massachusetts 10-year grid modernization plans must include:
 - A 5-year Short-Term Investment Plan (STIP) for capital investments
 - Comprehensive business case analysis to support capital investments in STIP

Question 4) Necessary for Utilities to Conduct Analysis of Solutions?



- ▶ From CA DRP Process – Results of Integration Capacity Analysis (ICA) must be published via online maps
 - Locational Net Benefits Analysis (LNBA) Working Group
- ▶ In Minnesota, Statute 216.B.2425, subd.8. says when considering a large transmission or generating investment, utilities must evaluate possible alternatives including efficiency, load management and DG
- ▶ One of the key drivers of NY REV is to better animate the market.
 - NY PSC looking closely at the concept of Distribution System Operator (DSO)
- ▶ In New York, utilities required to submit Distributed System Implementation Plans (DSIP) to ((Case 14-M-0101) that serve as a source of public information on objectives, needs and opportunities

Question 5) Role of Stakeholders



- ▶ From CA DRP Process after submittal of first DRP, CPUC directed through major IOUs to convene two working groups to monitor and provide input on demos and to refine methodologies:
 - Integration Capacity Analysis (ICA) Working Group
 - Locational Net Benefits Analysis (LNBA) Working Group
- ▶ In Minnesota, stakeholders participating in Commission workshops identified policy-related suggestions, including:
 - Making energy usage data easily accessible to customers
 - Enabling third-party aggregation of demand response
 - Offering consumers time-varying rates
- ▶ In New York's DSIP proceeding (Case 14-M-0101), the first step was for utilities to submit a plan and associated timeline for a stakeholder engagement process

Emerging Issues in IRP



- ▶ Distributed Generation (DG) can have significant impact on system operations, need for and timing of investments in conventional generation and T&D infrastructure
- ▶ Utilities have limited direct control over adoption
- ▶ That said, utilities:
 - Do have some ability to target DG adoption
 - Can plan for DG uncertainty
- ▶ Key areas:
 - How utilities are modeling DG adoption and its impact on bulk power system planning variables
 - How utilities are valuing DG in resource plans
 - How utilities and regulators are comprehensively assessing DG impacts, beyond traditional resource planning

From *The Future of Electricity Resource Planning* by Fredrich Kahrl (E3), Andrew Mills (LBNL), Luke Lavin, Nancy Ryan and Arne Olsen (E3), Berkeley Lab, September 2016: feur.lbl.gov

Emerging Issues in IRP



► Emerging best practices

- Generating DG forecasts using models of customer adoption behavior
- Assessing locational value of DG, incorporating distribution deferral values in DG evaluation
- Making use of “triggers” and “signposts” to revisit plans if adoption is significantly different than anticipated

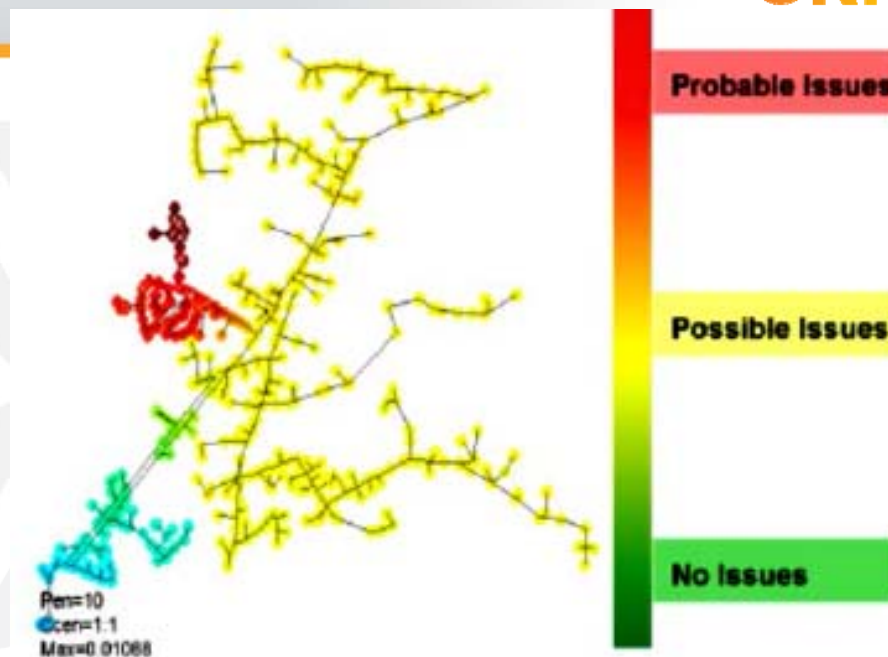
From *The Future of Electricity Resource Planning* by Fredrich Kahrl (E3), Andrew Mills (LBNL), Luke Lavin, Nancy Ryan and Arne Olsen (E3), Berkeley Lab, September 2016: feur.lbl.gov

Possible places to start:

- ▶ Take early integration steps - Consistency in inputs (assumptions, forecasts), scenarios and modeling methods — updated in time — across distribution planning, integrated resource planning and transmission planning
- ▶ Account for all resources – Consider energy efficiency, demand response (including direct load control, smart Tstats and time-varying pricing), distributed generation and energy storage, alongside traditional distribution solutions
- ▶ Specify DER attributes – In order to meet identified needs
- ▶ Analyze multiple possible futures – DERs plus other scenario drivers
- ▶ Consider CVR/VVO in distribution plans (and in IRPs)

Possible places to start - 2:

- ▶ Phase in hosting capacity analysis – To facilitate DG integration and indicate better or more difficult locations
- ▶ Pilot evaluation of locational impacts – Identify where DERs might offer greatest benefits
- ▶ Integration of new utility systems – If/when ADMS, AMI and other new systems are implemented, specify in advance how they will be used in distribution planning and lock in early consumer benefits
- ▶ Test new sourcing and pricing methods – e.g., competitive solicitations, tariffs, programs
- ▶ Training for staff – e.g., DOE-funded courses starting next summer



Future efforts:



- ▶ Part of DOE Distribution Support Tools Project:
 - Distribution planning training for commissioners and staff (labs and NARUC)
 - Phase II Analytical tools and gap assessment
- ▶ DSPx project
 - Decision Maker Guide

Thank you



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