U.S. DEPARTMENT OF
ENERGY
Office of
Electricity Delivery
& Energy Reliability

Overview of TRAC Program and SSPS Workshop

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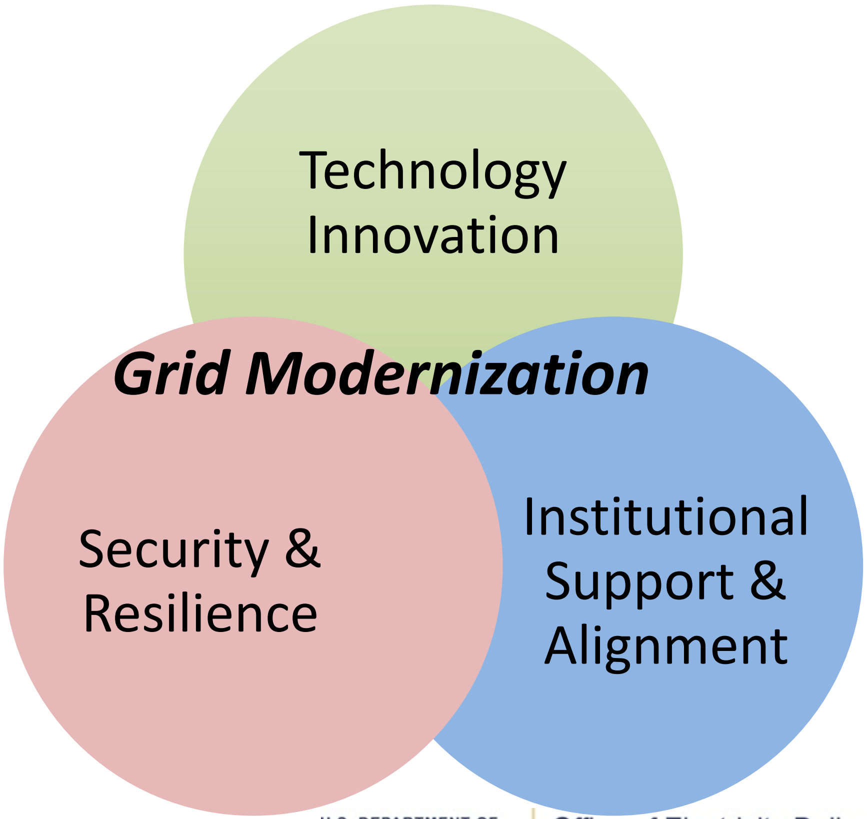
OE Mission

The Office of Electricity Delivery and Energy Reliability (OE) drives electric grid modernization and resiliency in the energy infrastructure.

- OE leads the Department of Energy's efforts to ensure a resilient, reliable, and flexible electricity system.
- OE serves as the Energy Sector Specific lead for the Federal emergency response when activated by DHS/FEMA.



Power System Trends

Changing Generation Mix

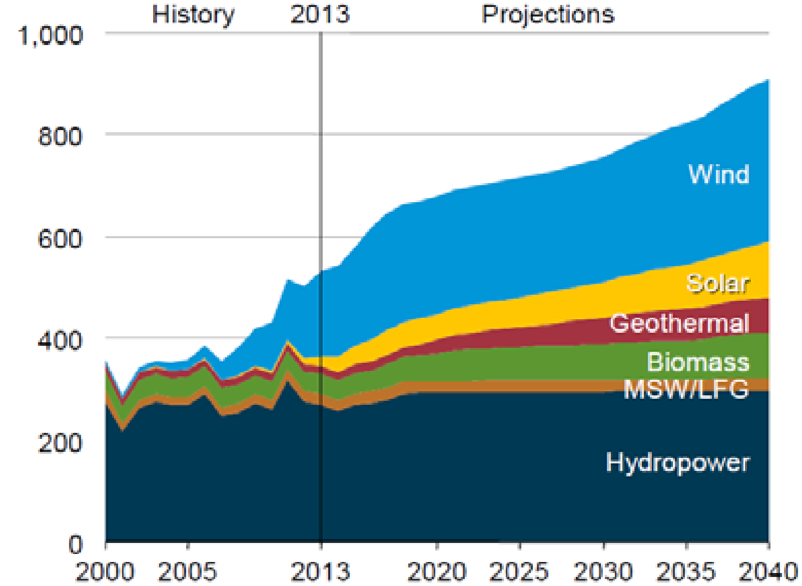
- More variable renewables and natural gas installations
- Coal and nuclear retirements

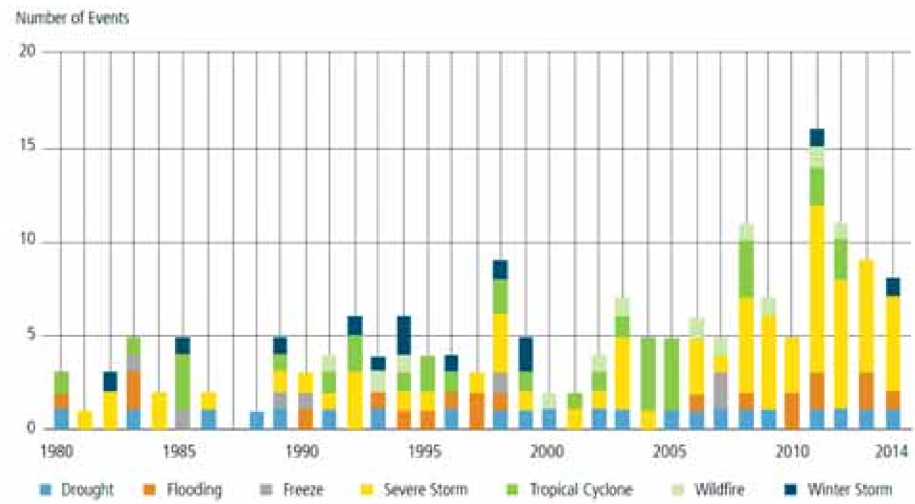
Evolving Customer

- More DER, efficiency, and EVs
- More connectivity and engagement (prosumer)

Increasing Risks

- More frequent and severe extreme weather events
- Cyber and physical attacks
- Aging infrastructure
- Complexity and interdependency





Costly weather-related disasters have been increasing in frequency over the past decade.

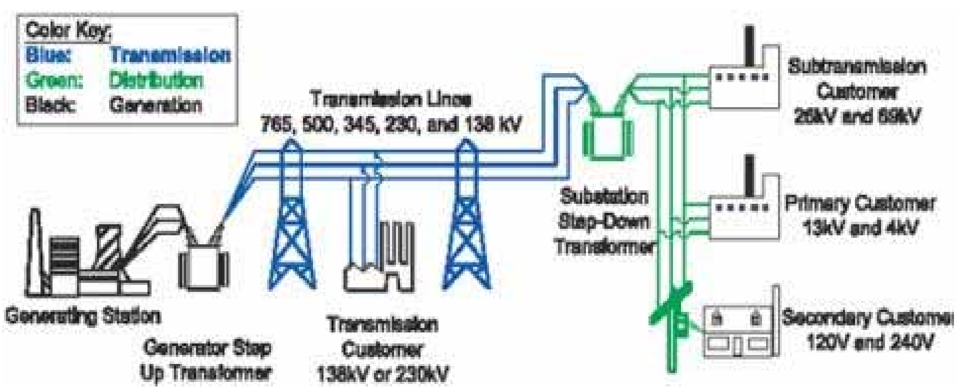
Transforming the Grid

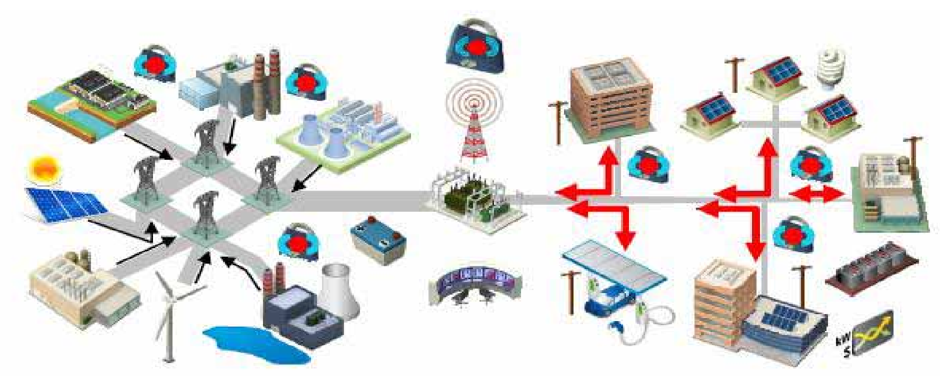
Current System

- Monolithic
- Centralized generation
- Decisions driven by cost
- Catastrophic events
- Limited energy choices
- Vulnerable to new threats

Future Paradigm

- Modular and Agile
- Centralized and distributed generation
- Decisions driven by cost and environmental sustainability
- Contained events
- Personalized energy options
- Inherently secure to all threats





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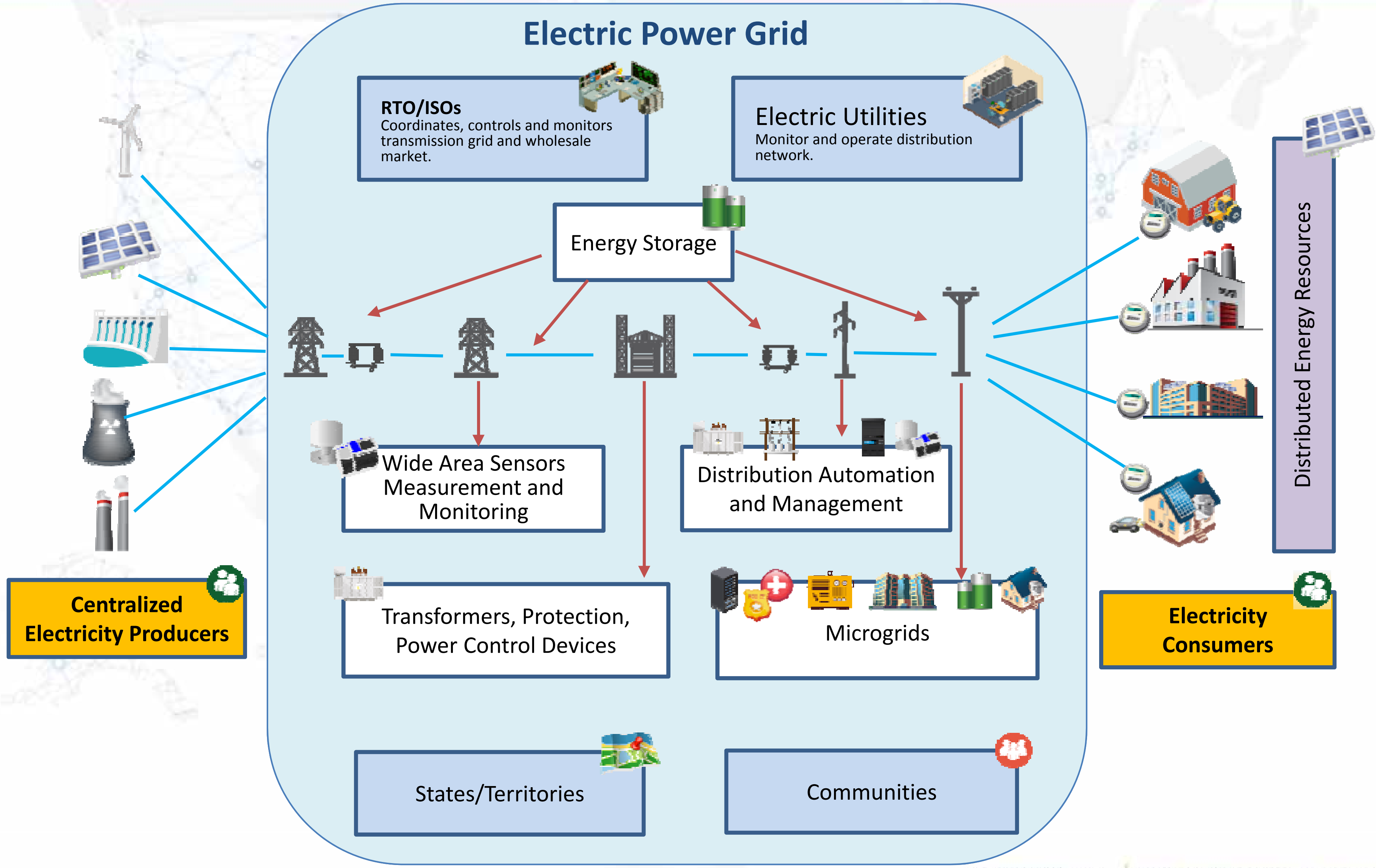
Advanced Grid Research and Development



Process for Research Prioritization

- DOE Workshops
- Industry Meetings
- Requests For Information

- Program Peer Reviews
- DOE Quadrennial Technology Reviews
- Internal Analysis

- DOE Strategic Plan
- Budget Appropriations
- Legislative Authorization

TRAC Program Overview

The Transformer Resilience and Advanced Components (TRAC) program accelerates modernization of the grid by addressing challenges with large power transformers (LPTs) and other critical grid components.

- Ensure the resilience of aging assets and identify new requirements for future grid components
- Accelerate the development, demonstration, and deployment of next-generation components

Advanced Grid Component Design Features

- Modular and scalable
- Local intelligence and adaptability
- Inherent cyber-physical security
- Environmental sustainability

High Impact Technical Focus Areas

Advanced Transformers	Low-Cost Power Flow Controllers	Enhanced Sensors and Intelligence	Advanced Grid Materials
			
• Flexible and adaptable LPTs • PE augmented distribution transformer • Solid State Power Substations	• Advanced power routers • Medium voltage DC converters	• Sensing elements • Integrated data processing and communications • Analytics and applications	• Dielectrics and insulators • Magnetics • Electrical conductors • Semiconductors

Program Activities

Requirement	Objective	Benefit
Market & System Impact Analysis	• Understand the system impact of new technologies • Techno-economic analysis of costs/benefits of advances	Reduces the uncertainty and costs of technology adoption
Component Design & Development	• Design and prototype components with enhanced functionality • Develop manufacturing ecosystem for cost, performance, adoption	Reduce the risk and cost of breakthrough components
Monitoring &Testing	• Develop embedded equipment sensors to improve design and operation • Testing and demonstration to show performance and value	Improve knowledge of component behavior and demonstrate viability
Applied Materials R&D	• Evaluate and develop new materials and devices that underpin advanced components	Foundational to improved performance and costs

Next-Generation Transformers – Flexible Designs

- The objective of this Funding Opportunity Announcement (FOA) seeks to stimulate innovative large power transformer (LPT) designs that *promote greater standardization* (i.e., commoditization) in order to *increase grid resilience* (i.e., faster recovery through greater interchangeability) in the event of the loss of one or more LPTs.
- This FOA is intended to stimulate new designs for LPTs that are more flexible and adaptable to facilitate transformer sharing and long-term replacement in the event of catastrophic failures, thereby increasing grid resilience.

All new LPT designs were to adhere with the following requirements:

- Maintain high efficiencies, have variable impedances, accommodate various high-side and low-side voltages and be cost-effective compared to traditional LPTs.

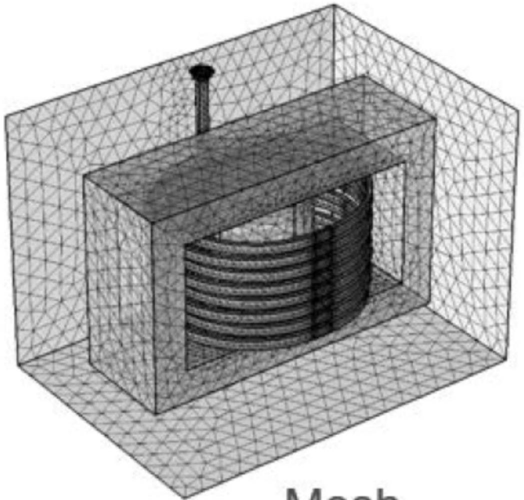
Other important specifications to compare include:

- Operating lifetime, size and weight (for transportation) and installed footprint.
- Projects are expected to involve modeling, analyses, and exploratory research to assess the performance and economics of proposed designs.

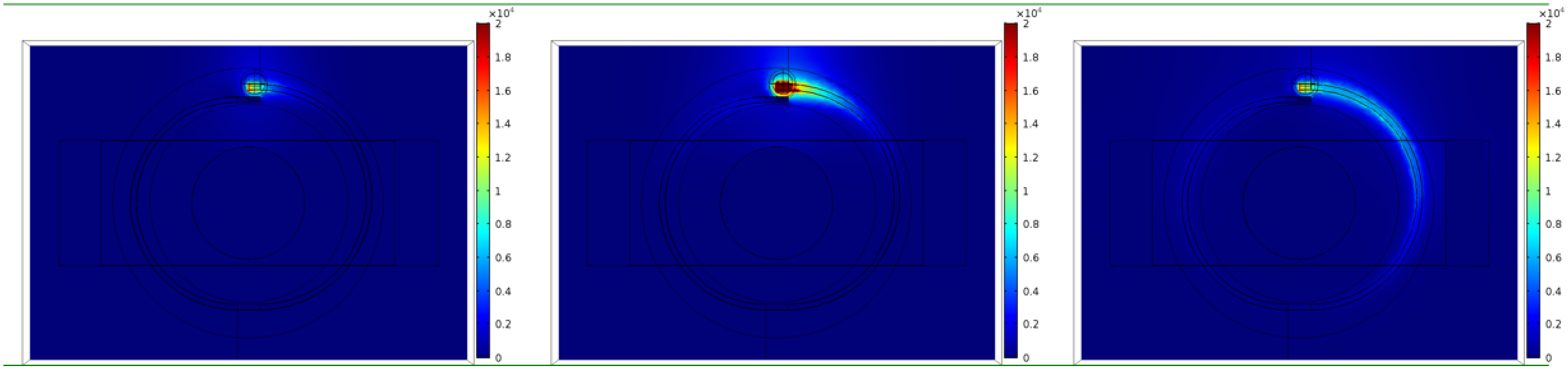
EMP/GMD Modeling and Testing

Multi-physics modeling and testing to improve understanding of transformer failure mechanisms when exposed to EMP/GMD

– Improved models of EMP coupling to transmission lines and transformers
– Experimental validation of bushings
– Modeling of system impact with GMD protection



Mesh

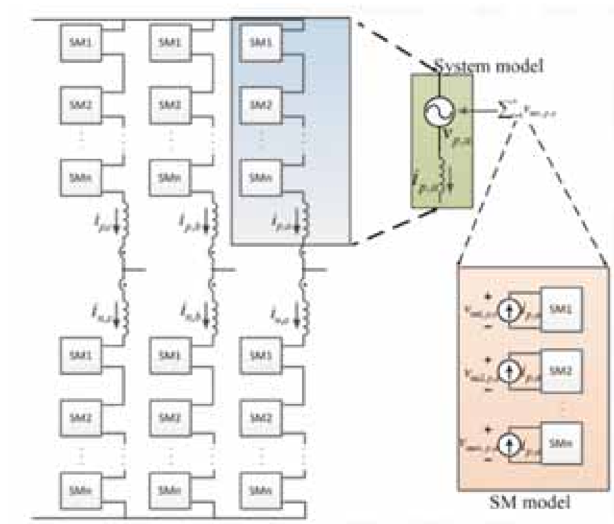


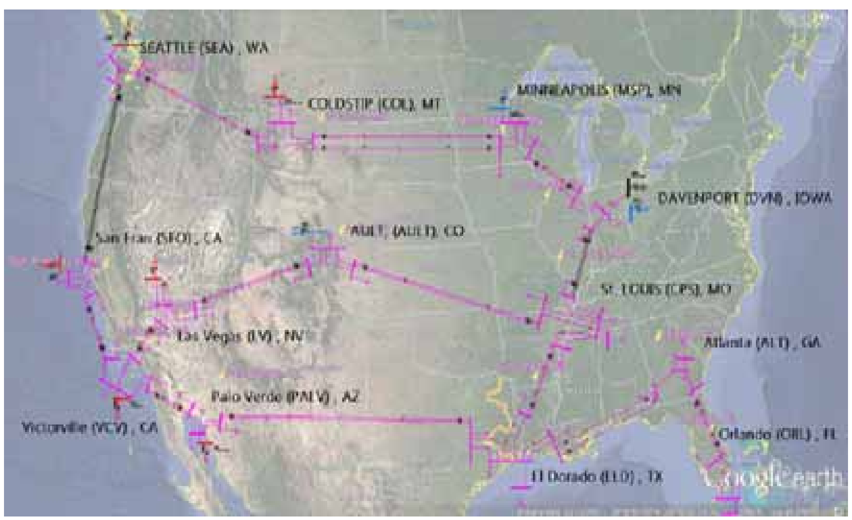
t = 9ns t = 18ns t = 54ns

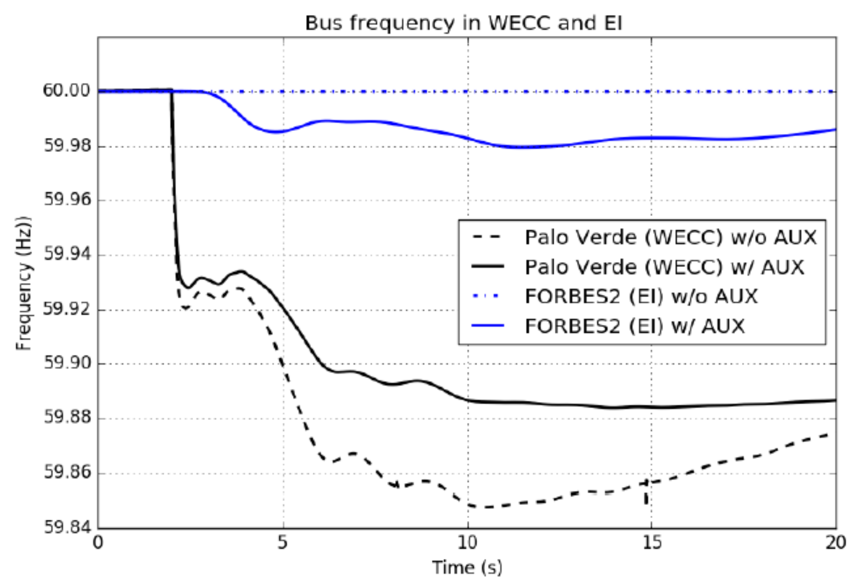
Advanced HVDC Control Analysis

Explore scenarios and use cases involving advanced HVDC control strategies

- Developed integrated EI and WI dynamic model with national HVDC network
- Modeled impact of frequency response sharing
- New models for VSC-HVDC for fast dynamic simulation (25x)







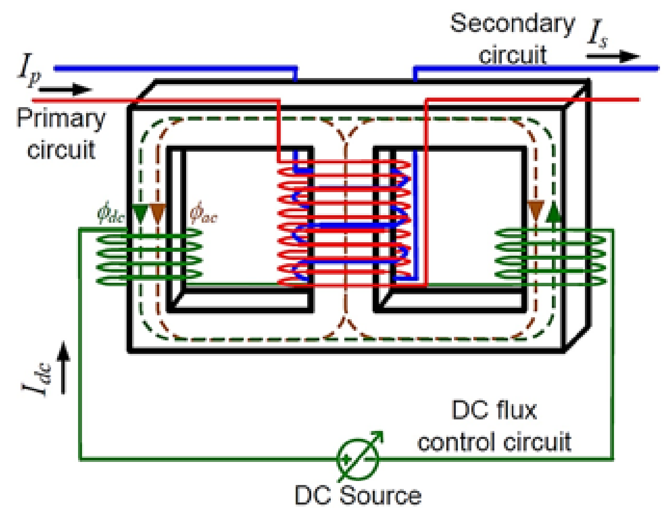
Other Relevant Projects

On-Going Projects

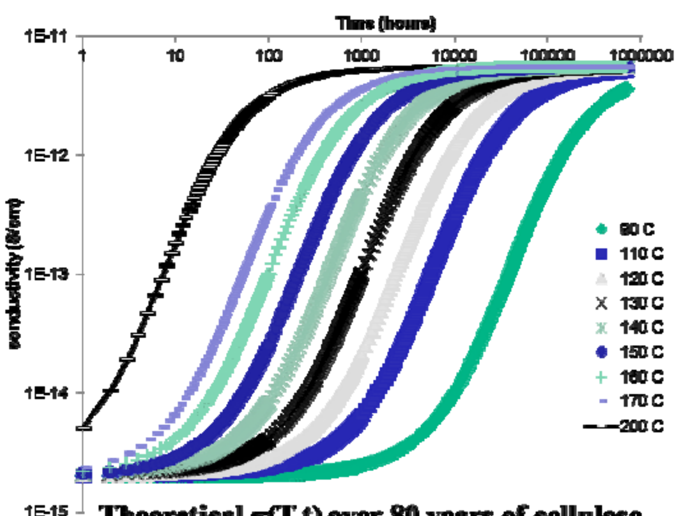
- Improved Dielectric Assessment for Transformer Health Prediction
- Characterization of HF magnetics

Future Projects

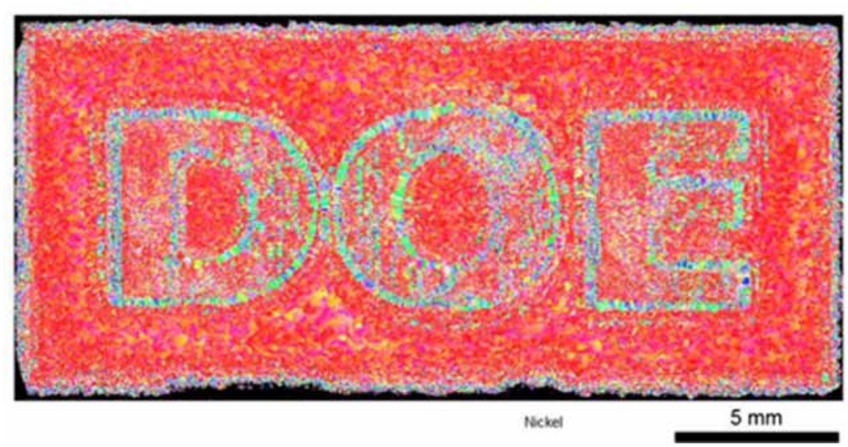
- Low-Cost Power Flow Controller
- Advanced Manufacturing of Grid Materials
- Resilient Component Design Study



Schematic of a single-phase tapless regu-lating power transformer (TAREX).



Theoretical σ(T,t) over 80 years of cellulose breakdown



Workshop Objective

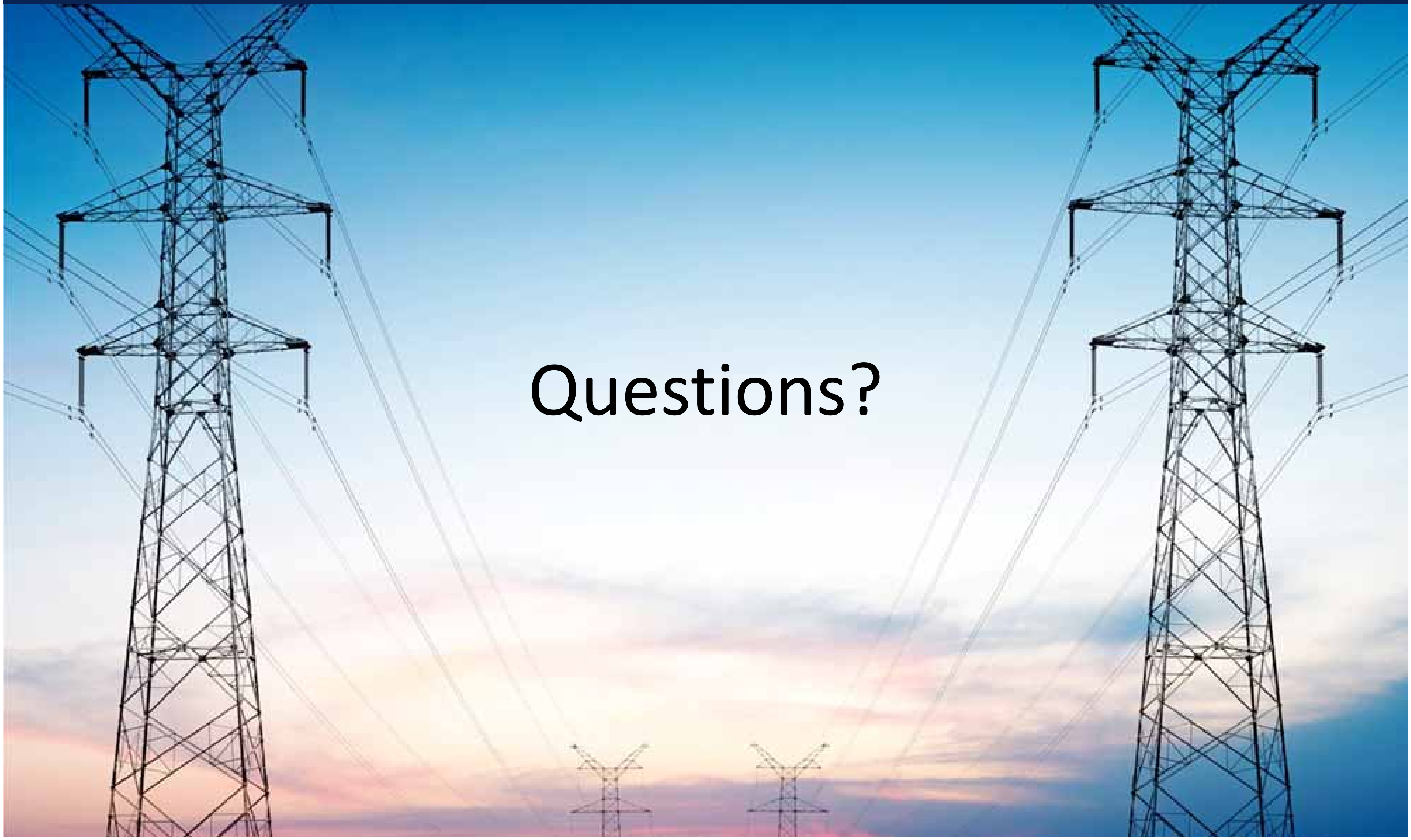
A Solid State Power Substation (SSPS) is defined as a substation with strategic integration of high voltage power electronics for enhanced capabilities that can provide system benefits and support evolution of the grid.

- To outline pathway to realize the SSPS vision, identify R&D challenges and gaps, and highlight priorities and metrics.
- Outcomes will inform development of a SSPS R&D Roadmap.

Workshop Agenda

TIME	DAY 1 - ACTIVITIES
8:45 am	Plenary 1 – Current Applications of Solid State Technology on the Grid
10:00 am	Plenary 2 – Future Capabilities and Advances in Solid State Technologies for the Grid
11:00 am	Plenary 3 – Solid State Power Substation Vision
12:00 pm	Lunch
1: 00 pm	Tour of SCE&G Energy Innovation Center
2:00 pm	Breakout Session 1 – Challenges Facing Substations/Grid
3:30 pm	Breakout Session 2 – Benefits of Utilizing SSPS Technology
5:00 pm	Report Outs

TIME	DAY 2 - ACTIVITIES
8:30 am	Breakout Session 3 – Identifying and Prioritizing R&D Challenges and Gaps
11:15 am	Breakout Session 4 – R&D Pathways Worksheets
12:15 pm	Lunch
1:15 pm	Report Outs
1:45 pm	Crosscutting Discussion



Questions?

Plenary Speakers

I. Current Applications of Solid State Technology

- Sandeep Bala, ABB
- Bob Yanniello, Eaton
- Alex Montenegro, S&C Electric

II. Future Capabilities and Advances in Solid State Technologies

- Wensong Yu, North Carolina State University
- Giri Venkataramana, University of Wisconsin
- Dushan Boroyevich, Virginia Tech

III. Solid State Power Substation Vision

- Klaehn Burkes, Savannah River National Lab
- Tom Keister, Resilient Power Systems