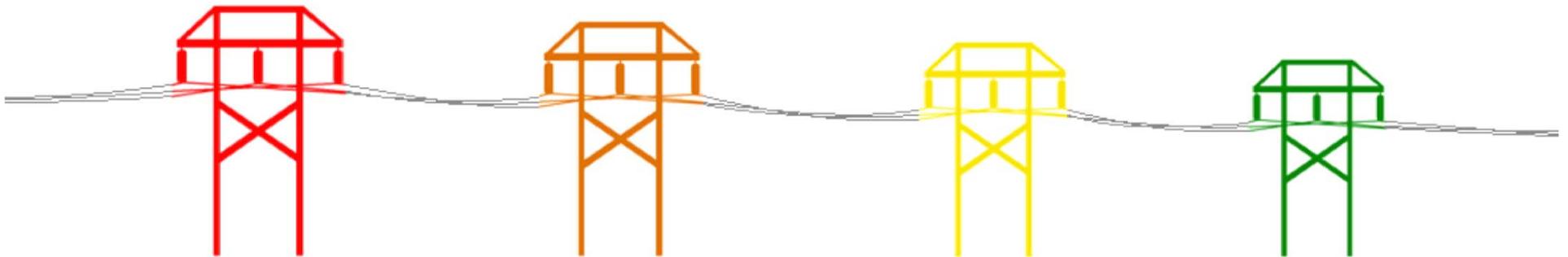


# The Electricity Transmission System

## **Future Vision & Grid Challenges**

Summary Results of  
Breakout Group Discussions



Electricity Transmission Workshop  
Double Tree Crystal City, Arlington, Virginia  
November 1, 2012

# Breakout Group Discussion Overview



## Future Vision and Grid Challenges

Each of the four breakout groups identified the key challenges facing the grid as it integrates all of the various technologies that are (or will be) deployed while ensuring a safe, reliable, and cost-effective system as described in the Future Vision. Utilizing the Grid Tech Team framework, each group identified integration challenges through a systems-based discussion that addressed all of the following topics:

- **Grid Visibility**  
*What challenges in the informational domain (sensors and relays, AMIs, PMUs, end-use energy management systems, communications hardware and protocols, etc.) impede the increase of visibility and controllability of the grid? What are the characteristics and functionalities needed to address the challenges identified and ensure a safe, reliable, cost-effective system? What are the metrics?*
- **Grid Understanding**  
*What challenges in the knowledge domain (databases, planning tools, models and simulators, analyses and assessments, etc.) impede the increase of understanding and controllability of the grid? What are the characteristics and functionalities needed to address the challenges identified and ensure a safe, reliable, and cost-effective system? What are the metrics?*
- **Grid Flexibility**  
*What challenges in the physical domain (component technologies, inverters, power flow controllers, transformers, cable and conductors, protection device, etc.) impede the increase of flexibility and controllability of the grid? What are the characteristics and functionalities needed to address the challenges identified and ensure a safe, reliable, cost-effective system? What are the metrics?*



# DOE Grid Tech Team

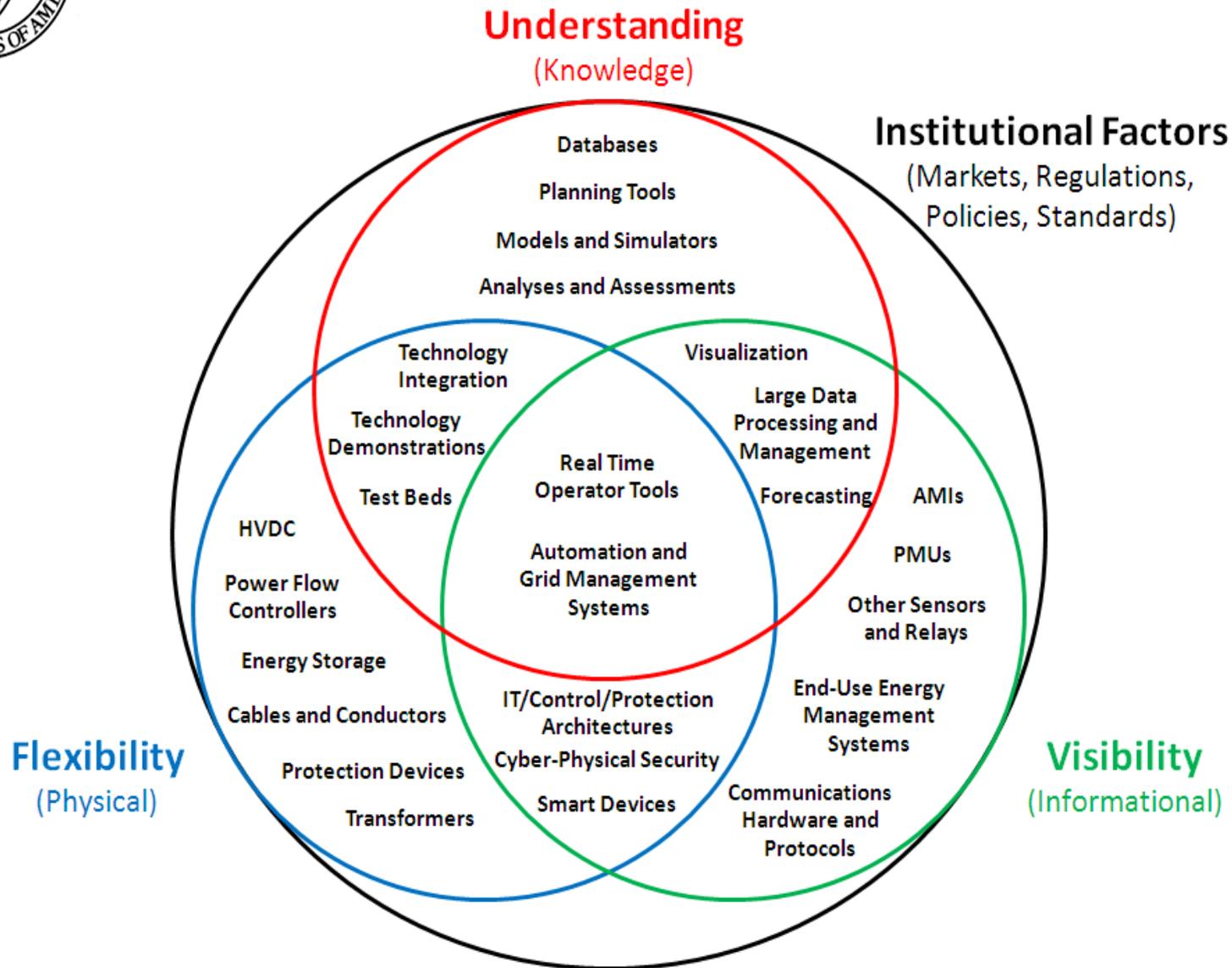
## Vision of a 21<sup>st</sup> Century Transmission System

**A seamless, cost-effective electricity system, from generation to end-use, capable of meeting all clean energy demands and capacity requirements, while allowing consumer participation and electricity use as desired:**

- Significant scale-up of clean energy (renewables, natural gas, nuclear, fossil with CCUS)
- Allows 100% consumer participation and choice (including distributed generation, demand-side management, electrification of transportation, and energy efficiency)
- 100% holistically designed (including regional diversity, AC-DC transmission and distribution solutions, microgrids, and centralized-decentralized control)
- Accommodates two-way flows of energy and information
- Reliable, secure (cyber and physical), and resilient

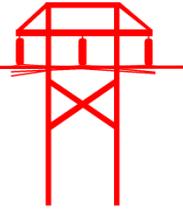


# DOE Grid Tech Team - Framework



# Grid Visibility





## Grid Visibility

1. **Lack of clear oversight/ownership/governance, e.g. for data sharing.**
  - a) Moving research to operational, e.g. data quality, CIM, etc. communication
  - b) Standardization
2. **What IT system do we need and what information to communicate at substations and among control centers, given the fact of uneven state of communication at/to substations?**
3. **Utilization of high-speed phasor data.**
4. **Existence of data gaps that limit accurate and comprehensive visibility along temporal and spatial scales.**
  - a) Grid resiliency to weather forecasting regarding emergency conditions (e.g. storms) and renewable generation.



## Grid Visibility

1. **Information Architecture: Understanding the availability, utility, maintenance, use, and exchange of data**
  - a) Who needs what and why? At what level of granularity, geographically and temporally? Defining needs can enable standards.
  - b) Lack of standardized communications and exchange protocols
  - c) Need for true knowledge of operational margins
  - d) Equipment is often not inter-operable
  
2. **Frameworks for evaluating and quantifying the cost-benefit of technology and data**
  - a) How do we value new technologies
  - b) How do we quantify ???



## Grid Visibility

### 1. Understanding what information is needed and when?

- a) Measuring the capacity of the transmission system
- b) Condensing needed information into actionable intelligence for transmission operators
- c) Using communications information from the distribution system and translating it to the transmission system. What is its business case?
  - a) Data for transmission needs is “not a distribution problem”

### 2. Technology implementation planning

- a) Sequencing and timing of technology (measuring and sensing) deployment over time - implementation plan
- b) Availability of resources (money, time) to implement



## Grid Visibility

### 1. Getting the Data

- a) Understanding data – how do we identify what specific information is needed; what data, time domain; e.g.
  - i. Define who needs the data and what their requirements
  - ii. How to securely access the data
  - iii. How to validate reliability
  - iv. Standardization of existing data and future data needs
  - v. How to store and archive data in order to synthesize; (answer questions like, “how much data should we store?”)

### 2. Synthesizing/Delivering Data

- a) Lack of architecture for mining and managing large amounts of data
- b) Lack of algorithms for synthesizing data
- c) Integrating the data
- d) Inability to visually display the right data

# Grid Understanding





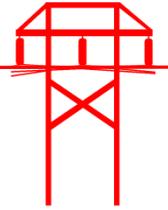
## Grid Understanding

### 1. Cyber Security

- a) How to identify devices that have cyber security vulnerabilities in the complexity of technologies?
- b) How to detect cyber security vulnerability?

### 2. Believability: Data Validation & Cross Checking

- a) Multi-scale modeling and validation in terms of temporal and spatial scales.
- b) Modeling gaps, seams in models (e.g. op vs. planning). G+T+D coupling. Life-cycle cost on operation.
- c) Trustworthy transparency at necessary levels.
- d) Data limitation in modeling.
- e) How to visualize data for rapid understanding? Address human factors issues.



## 3. Modeling and Simulation

- a) Speed of modeling and simulation. Look-ahead and “faster-than-real-time” capabilities – Predictive capabilities.
- b) Incorporate uncertainties/stochasticity. Understand new and existing generation and load behaviors via modeling of load composition, e.g. FIDVR. How to use stochastic information for operation/decision making/actions?
- c) Linking various tools. Lack of compatibility among different tools and need to address regional diversity.

## 4. New Applications and Tools

- a) Deploying existing data and tools for operators, e.g. intentional islanding.
- b) Future control paradigm, e.g. adaptive islanding. What are the benefits and metrics of new controls? How to define reliability at transmission level and distribution level?
- c) Open-minded towards what data could enable.

## 5. Understand Safety Issues Regarding Actions



## Grid Understanding

### 1. Seamless Modeling and Tools (as appropriate)

- a) Stochastic/Probabilistic
- b) Integrated simulation of transmission and distribution
- c) Integrated simulation of high-fidelity physics and markets
- d) Harmonization of planning and operations
- e) Value of scenario analyses

### 2. Engagement, Outreach, and Information Sharing to Non-technical Stakeholders

- a) Decisions necessary to create an advanced grid require informed consumers and decision makers. Social science is divorced from the engineering
- b) Regulatory fragmentation between state, local, and federal entities inhibits data-sharing and coordinated planning



## Grid Understanding

### 1. Current Modeling and Simulation Algorithms are Inadequate

- a) Need to improve dynamic models (also helps value proposition for PMUs and DLR) so they can replicate real life when validated
- b) Models need to be developed uniquely for each new technology and application – need interoperability between tools
- c) Develop consistent model architecture/data language for easy import to other applications

### 2. Need to Translate Data for Real Time Operations (not just forensics)

- a) Stability, voltage, capacity
- b) How to get the right data to the right people when it is needed
- c) What operational tools are appropriate for decision support and what should be automated-Determining what analysis is best done by a computer? What needs a human touch?
- d) Development of applications using electrical and thermal capacity data into a single model in real time and producing actionable operator information



## Grid Understanding

### 3. Control Structure & Data Processing

- a) What is the best mix of centralized and decentralized control and data processing? (with 1000x increase in control points)
  - i. What research is needed to develop this understanding? What do we need to understand?
  - ii. What information should go to whom? Who makes the decisions?



## Grid Understanding

### 1. Lack of “Scope”: Who Needs to Understand What and in What Detail?

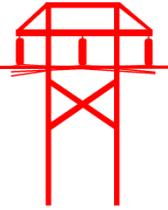
- a) Understanding neighboring systems (interconnection-wide)
- b) Historic capture of data: How do we use what we have now and use it for the future?
- c) Note of Operations vs. Planning – time horizons
  - i. Understanding – Planning (longer term)
  - ii. Visibility – Operations (shorter term)

### 2. Lack of Tools

- a) Algorithms to synthesize data; estimating and dealing with missing data; intelligent algorithms to give us better state estimation of grid
- b) Infrastructure interdependencies built into analytical tools for the grid
- c) Traditional planning & operating model and simulation techniques and reinforced by institutional and cultural barriers
- d) We have the data, so now what?

# Grid Flexibility





## Grid Flexibility

- 1. How to Design Markets for Grid Flexibility and Tech Adoption**
  - a) Especially ancillary services, e.g. storage in western TX?
  - b) Systematic way to optimize ancillary services: signaling, etc. cutting across trans and distribution to maximize flexibility.
  
- 2. How Test Beds Can Provide Insights?**
  - a) E.g. atmospheric forecasts to reduce uncertainties.
  - b) Need test beds to document value proposition and robustness.
  - c) Also to challenge the status-quo, e.g. no more infrastructure building in urban areas.
  
- 3. How to Engage Operators/Users in Tech Development?**
  
- 4. How to Use a Range of New Technologies?**
  - a) Including storage for grid flexibility?
  - b) How to reduce the cost and understand the impact?



## Grid Flexibility

### 1. How Do We Define Flexibility and Value It?

- a) Decisions that are made today which accommodate major future uncertainties (economic, technological, and regulatory)
- b) Flexibility can be more broadly defined as optionality at a given scale: information, controls, and incentives
- c) Regret minimization from contemporary decisions
- d) Better understanding on how to return benefits of flexibility to the providers of that flexibility (e.g. end use efficiency, storage, thermal flexibility)

### 2. Developing the Technologies Supporting Flexibility

- a) Mixed AC-DC networks with new control theory
- b) Low cost, low loss power electronics



## Grid Flexibility

### 3. Architecting/Deploying the Complexity of Multi-Disciplinary / Multi-Dimensional Systems

- a) Unstandardized (between utilities and vendors) interfaces raises the cost of diversity and flexibility
- b) Standardized modeling and communications framework



## Grid Flexibility

1. **What is “Flexibility”? What is the value?**
  - a) Need to develop metrics to measure flexibility
  - b) Temporal and spatial properties of flexibility
  - c) Valuation of resources that can provide flexibility
  
2. **How Do We Use Better Visibility and Understanding to Optimize the Existing Grid?**
  - a) PMUs/DLRs/DER?



## Grid Flexibility

3. **Transforming the Grid: Roles and Use of FACTS/Energy Storage/DSRs/HVDC?  
How Might We Need to Change How the Grid Works?**
  - a) Adaptation and re-configurability of FACTS controllers to minimize risk of variability on the system
  - b) Identifying services that can be provided
  - c) Values of storage and translation into tangible revenue (e.g.. Greenhouse gas savings)
  - d) Market mechanisms to compensate for services
  - e) How do you control spatially distributed storage units?
  - f) Large-scale energy storage (sub-surface) – need to expand the scope to use grid-scale storage in a variety of settings



## Grid Flexibility

### 1. Lack of Definition & Framework for Flexibility

- a) Understanding of current flexibility capability of system
  - i. Warning system of distributed devices and their status
  - ii. Age and life cycle of equipment limits the rate of introduction of new flexibilities
  - iii. Wide area situational awareness to take action – visibility
  - iv. Systems approach for grid flex
- b) Interdependencies of different resources
- c) Valuation of assets of flexibility; cost-effectiveness and cost-benefit
- d) Understanding value of distributed assets and modularity
- e) Common definition of grid flexibility, metrics – e.g. time scale, geographic scale



## Grid Flexibility

### 2. Lack of Optimization Capability & Coordination for Flexibility, Controls

- a) Lack of cost-effective, reliable hardware and software
  - i. Interactions & unintended consequences
  - ii. Understanding of how new technologies fit
  - iii. Cyber-security
  - iv. Inability to predict unexpected interactions among technologies – unintended consequences among these “active, low-cost controllable devices”; how does this link into protection schemes
  - v. Lack of bandwidth for two-way communication and components of system

# Synthesized C h a l l e n g e s



# Summary of Synthesized Challenges

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- A. Need improved understanding of the availability, utility, maintenance, exchange, and security of data and associated requirements.
- B. How to synthesize, process, integrate, visualize, and validate data for actionable intelligence?
- C. What are the ICT/sensor systems needed for the future grid and advanced applications?
- D. Lack of validated models and simulation algorithms to explore new dynamics, concepts, and technologies.
- E. Lack of adequate tools for grid operators and planners to perform credible analyses over multiple scales for the future grid.



# Summary of Synthesized Challenges

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- F. Lack of metrics and definitions for grid flexibility.
- G. How to value, evaluate, and control various technologies for flexibility on a level playing field?
- H. Need advanced technologies for grid flexibility and mechanism to extract flexibility from existing assets.
- I. Need new grid architectures including information, control, communication, and physical.

