TULANE ENGINEERING FORUM

SYSTEMATIC CHANGES NEEDED TO TRANSFORM THE U.S. ELECTRICAL GRID

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INTRODUCTION

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Glad to be here!
INTRODUCTION: THEME

• What **SYSTEM** conditions and constraints are shaping change in our industry?

• What **SYSTEMATIC** developments are key for effective and practical grid modernization?
AGENDA

1: Introduction

2: Grid System Perspectives

3: Systematic Changes
The smart grid is a “complex system”

- A set of connected things forming a complex whole
- Many stakeholders and competing interests
- Many contexts to “optimal” decision making

*Innovation is tied to the system conditions and constraints*
• What **conditions** and **constraints** are shaping change in the electrical grid?
The U.S. leads the world in Energy consumption. About 30% of that is electricity that needs to be generated and balanced with loads in real-time, with a small margin for error.

Energy use is tipping towards more electricity:

1.6% growth expected for 2017 (1)

Source: (1) EIA, 2016; (2) World Bank, 2014.
KEY SYSTEM CONSTRAINT: PATTERNS OF CONSUMPTION

Typical U.S. Power Supply and Demand Load Curves

- Wind + Solar
- Nat. Gas
- Hydro + Bio
- Coal
- Nuclear

Source: EIA, 2012
The “Duck Curve” shows steep **ramping** needs and **over-generation risk**

KEY SYSTEM CONSTRAINT: GENERATION & LOAD DYNAMICS

For illustration only.
KEY SYSTEM CONSTRAINT: PATTERNS IN GENERATION

Wind generation variability

Source: ERCOT, 2006

Solar generation variability

Source: CAISO, 2015
Stakeholders and Regulation are weighing in on grid resources:

› Renewable generation

› Demand response – limited cycling of consumer resources to “off” in order to offset other (higher priced or carbon intensive) generation

› Energy storage

› Distributed Energy Resources & Microgrids
KEY SYSTEM CONSTRAINT: PATTERNS IN DISTRIBUTED ENERGY RESOURCE GROWTH

Resources can be Utility or 3rd Party owned on the grid in front of the meter or Customer owned behind the meter.
KEY SYSTEM CONDITIONS: WEATHER & OPERATIONS

X% chance of severe storms

Y% chance of weather impacting system conditions

Regional conditions impact change through operations practices and investment decisions.

Source: NWS, 2016
KEY SYSTEM CONSTRAINTS: TIME AND SPACE

100% chance of night and seasonality


Source: astronomy.com, 2015
TODAY - Traditional Power Grid

Centralized, One-Way Power System

**EMERGING -** The Energy Cloud

Grid conditions and constraints have resulted in certain mega-trends underpinning industry transformation:

1. Greater **Customer** choice and demand for more **Energy** options.
3. New **ventures** and increased M&A, the Energy Internet of Things.
4. **Regionalization** of systems, investment in reliability and resiliency.
5. Mega-industry investment around **R&D** / growth opportunities.
6. Replacement of **Infrastructure** and transition toward an increasingly decentralized and smarter power grid architecture, the **Energy Cloud**.
AGENDA

1: Introduction

2: Grid System Perspectives

3: Systematic Changes
### CHALLENGE: COMMUNICATIONS & SECURITY

#### Layer | Communication Method
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**Back-Haul** | • MPLS Network  
| | • Fiber (TRANSCO)  
| | • Microwave  
**Wide Area Network (WAN)** | • 3G/4G (Etisalat)  
| | • MiMAX  
| | • Metro MiFi  
**Local Area Network (LAN)** | • RF Mesh  
| | • PLC  
| | • RF Point to Multi Point  
**Home Area Network (HAN)** | • Zigbee  
| | • WiFi  
| | • PLC

#### Key issue:

- **Different devices with different needs including:** bandwidth, latency, availability, and interoperability

- **System security across the system**
CHALLENGE: BIG DATA & ANALYTICS

Grid Data: Meter, System interaction & IoT information

Regional Data and 3rd Party Resource information

Data Analytics and Simulation:
Informed system models & historical data tracking

Supervisory information:
Automating the grid, control systems, market systems

Real-Time Situational Awareness & Automation Capability, Improved Planning & Investment
CHALLENGE: COMPUTATIONAL INTELLIGENCE

Computational intelligence here refers to adaptive, informed decision making by computers within a grid system.

- Utility Operations Components (sub-seconds to days)
- Distributed Utility, ESP and Customer Components (seconds to months)
- Regional Transmission Components (minutes to hours)

Coordination across time is key to “grid success” in terms of control and system optimization.
CHALLENGE: SYSTEM ARCHITECTURE

Stakeholder Choices and Technology

Physical Operations

Financial Flows and Incentives

Regulatory Mechanisms

Stakeholder Choices and Technology-driven evolution drives Operations

Operations drives Financial performance and Incentives, impacting new and existing Policy and Regulation

More incentive-oriented frameworks and markets are needed to support innovation and modernization and operations investments
1) **Communications & Security**
   The grid’s devices and infrastructure need to communicate quickly & securely

2) **Big data and Analytics**
   The grid needs capabilities to measure, capture and utilize data to improve planning, investment, operations and efficiency

3) **Computational Intelligence**
   The grid needs smart devices, services and control systems to manage complexity

4) **System Architecture**
   The grid needs new incentive-based frameworks and markets
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THANK YOU