Reliably Delivering a Clean Energy Future

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Factors Shaping The Clean Energy Transformation

Environmental regulations

Low natural gas prices

Declining technology costs

Diversification

Public policies

Financial incentives

Customer demand

New technologies, models and uses
Changes How We...

**Innovation:**
- Energy storage
- Power electronics
- Distributed intelligence
- Adaptive protection
- Layered architecture
- Self-diagnostic, healing
- Data, cyber, analytics

**Make Energy:**
- More distributed supply
- Accommodate growth

**Move Energy:**
- Flexible, intelligent, resilient
- Increase visibility

**Use Energy:**
- Integrate end-use activity
- Empower customers

Source: IEEE GridVision 2050
Compelling Evidence of Rapid Climate Change

**Rising Sea Levels**
Global sea level rose about 8 inches in the last century.

**Ocean Acidification**
Surface ocean acidity has increased ~30% from added CO₂ in the atmosphere: the upper layer absorbs ~2 billion more tons per year.

**Rising Global Temp**
Average surface temp has risen about 2°F (1.1°C) since the late 19th century, driven largely by increased CO₂ and other human-made emissions.

**More Extreme Events**
High temperature events in US has been increasing; low temperature events decreasing, since 1950.

**Less Ice, Glaciers, Snow**
The extent and thickness of Arctic sea ice has declined rapidly. Glaciers are retreating and the amount of snow in the Northern Hemisphere has decreased.

**Warming Oceans**
The top 700 meters (about 2,300 feet) of ocean showing warming of 0.302°F since 1969.

Source: NASA Global Climate Change: https://climate.nasa.gov/evidence
Managing the Grid Through Hurricanes

• Big storms happen often and are costly!
• Smart grid helps to restore
• FPL and Hurricane Matthew: Oct, 2016
  – FPL lost 1.2+ million customers
  – Restored 1+ million customers in less than 48 hours
  – Performance results from $2 B grid investment since 2006

Source: NOAA data - www.ncdc.noaa.gov/billions/overview
Solar is at Parity and Growing

As renewables reach parity, what changes?
“Move It” Old Grid

“Move It” Modern Grid

Reliability and Its Value Changes
US Reliability Trend, 2000 - 2012

Reference: "Assessing Changes in the Reliability of the U.S. Electric Power System" by Lawrence Berkeley National Laboratory, August 2015

Reliability can be a utility differentiator in the new world
UK Reliability Trend, 2002 - 2016

Reference: Ofgem publications

Regulation incents results!
Ready, Set, Go!!
Opportunities Remain

- Changing roles, enabling choice
- Momentary outage management
- Voltage management / stability
- Regulatory, ownership, price issues
- Integration and standards
- Workforce competencies
- Data analytics
- Cyber-security obscurities

Processes and coordination needed across multiple entities
In Closing...

• Industry transformation is underway: recognize trends and drivers
• Changing how we...
  – Make it
  – Move it
  – Use it
• Reliability is a utility differentiator
• Regulation makes a difference
• Many opportunities remain