Future of the Power Sector

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Agenda

- Necessary Infrastructure Investments
- Our Move to Natural Gas/Renewables
- Environmental Outlook
- Evolving Energy Grid
- Industry/Government Partnership on Power Restoration and Resiliency
Transformation Drivers

- New technologies, models and uses
- Low natural gas prices
- Declining technology costs
- Diversification
- Public policies
- Financial incentives
- Customer demand
- Environmental regulations
New Capacity – Gas & Renewables

Source: Velocity Suite, ABB Enterprise Software
Low Natural Gas Price Drives the Market

Henry Hub Spot Price

Major shale discoveries

Source: U.S. Energy Information Administration
Renewables Growing Across the U.S.

Installed non-hydro renewable capacity

Source: Velocity Suite, ABB Enterprise Software; June 17, 2014. Includes plants operating and under construction.
Electric Companies Driving Majority of Renewables Deployment

Our solar projects provide

~60% of all
INSTALLED U.S. SOLAR CAPACITY
and help bring cost-effective solar to everyone.

OUR SOLAR PV
HAD AN AVERAGE COST OF
$1.45 PER WATT IN 2015

RESIDENTIAL ROOFTOP SOLAR PV
HAD AN AVERAGE COST OF
$3.54 PER WATT IN 2015

Our wind projects provide almost
100% wind energy nationwide.
Large-Scale Solar Becoming Cost-Competitive

Power purchase agreements for universal solar have fallen to an average of $50/MWh, making large-scale applications competitive with natural gas plants.

Sources: LBNL, Utility Scale Solar 2015 Report, August 2016
Wind PPAs Now Averaging $20/MWh

Power purchase agreements for large-scale wind, aided by the 2.3 cent Production Tax Credit, have fallen to such low levels that wind is now outcompeting natural gas in many parts of the country.

Note: Area of “bubble” is proportional to contract nameplate capacity

Source: DOE/Berkeley Lab 2016 Wind Technologies Market Report
Environmental Outlook
Environmental Opportunities: 2017 and Beyond

Air
- Multiple NAAQS
- Interstate Transport
- Regional Haze/Visibility
- Mercury & Air Toxics
- Modeling, Permitting & Monitoring

Climate
- Evolving Policy Landscape
- State & Regional Initiatives
- International Negotiations
- Prospects for 111(d) & (b) Programs
- Technology Development & Deployment

Water
- Waters of the United States
- Effluent Guidelines Limitations
- 316(b)
- Total Maximum Daily Loads
- Waterbody-Specific Standards

Land & Natural Resources
- Infrastructure Siting and Permitting
- Endangered Species
- Avian Protection
- Vegetation Management

Waste & Chemical Management
- Coal Ash
- PCBs in Electrical Equipment
- TSCA
- HazMat Transport
Power Plant Emissions Drop Significantly Since 1990

1990 represents the base year. Graph depicts increases or decreases from the base year.

Sources: U.S. Department of Energy, Energy Information Administration (EIA), U.S. Environmental Protection Agency (EPA), and U.S. Bureau of Economic Analysis.
U.S. Power Sector Carbon Dioxide Emissions Declining (2005-2016)

- 1/3 of U.S. power generation comes from zero-emissions sources
- As of 2016, industry CO₂ emissions were nearly 25 percent below 2005 levels
- Trajectory will continue based on current trends

States: Key Players

- Major role – energy and environment
- Pres. Trump’s nominees come from state governments and support increased cooperative federalism
- Reduced rulemaking at Federal level will likely lead to increased state-level activities
  - Limitations allowing or restricting more stringent programs than at Federal level
Evolving Energy Grid
Energy Grid in Transition

Traditional Energy Grid
- One-way power flow from power company to customer
- Central station electricity generation

Evolving Energy Grid
- Two-way power flow between power company and customer
- Central station and distributed electricity generation

Source for graphics: EPRI, The Integrated Grid: Realizing the Full Value of Central and Distributed Energy Resources, February 2014
Rate & Regulatory Reform

CHALLENGES

1. Rapid Technology Change
2. Changing Customer Expectations
3. Slow & Inflexible Process
4. One Size Does Not Fit All

WAYS FORWARD

1. Informal Collaboration
2. Performance-Based Ratemaking
3. Flexible Rate Structures
4. Transparent Pricing for Grid & Energy
Distributed Energy Resources (DERs) are Growing

Historical and Projected Annual Solar PV Installations

Source: GTM/SEIA, U.S. Solar Market Insight: 2016 Year in Review
Private Solar Costs Falling, But Universal Remains Most Economic

2016 State Activity on Net Metering
By Policy Type

Source: NC CLEAN ENERGY
Evolving Residential Rate Structures

- Demand Charges
- Fixed Charges
- Minimum Bills
- TOU Rates
- Dynamic Pricing
- Stand Alone Service Class
Working With Customers is Critical

▪ Educate residential customers to be more price sensitive and give them the ability to respond

▪ Rate design must provide meaningful bill savings and energy savings opportunities and options and be sensitive to low-income and low-usage customers

▪ Enhanced customer service approaches and consumer protections are needed
Evolving Energy Grid Policy Issues

- How should the grid be designed and constructed?
- What planning process should be employed for the evolving grid?
- How and by whom should the grid be operated?
- How and by whom should the grid DER marketplace be designed and managed?
- What services behind the meter can be provided and by whom?
Level of Grid Modernization Activity

Activity Level: Intense, Significant, Moderate, Negligible

Vertically Integrated

Restructured
Energy Storage: No Longer Aspirational

Energy storage can be deployed in all parts of the energy grid, and has applications in all parts of the value chain.

Enhance Electric Company Operations
- Alleviate high energy prices through time shifts
- Reduce the need for new generation

Provide Grid Support
- Regulate frequency
- Reduce spinning, non-spinning, and supplemental reserve requirements
- Voltage support
- Black start electricity restoration

Optimize Power System
- Defer transmission and distribution upgrades
- Relieve electricity congestion

Enhance Customer Experience
- Higher power quality and reliability
- Retail electric energy time shift

Source: Adapted from DOE/EPRI Handbook, EEI (graphic)
Who is Building and Using Microgrids?

Electric companies are leading and/or partnering on 30% of all microgrid projects.

Source Data: GTM Research
Smart Communities
Powered by Smart Connections

Street Lighting

Smart Buildings

Distributed Energy Resources

Smart Transportation

Data Analytics & Intelligent Services

Powered by Smart Connections
Smart Meter Deployment

The number of **SMART METERS** installed in the United States through end of 2016

1/2 of U.S. households have a smart meter

Smart meters provide customers **CONTROL & FLEXIBILITY** over their energy use

**NUMBER OF SMART METERS**

- 2009: 13M
- 2011: 27M
- 2013: 46M
- 2015: 65M
- 2016: 70M
- 2020: 90M

Continued investment in smart meters is key to building a **SMARter ENERGY INFRASTRUCTURE**

Source: The Edison Foundation Institute for Electric Innovation
Data Analytics

**EARLY GAINS**

1. Enhanced Visibility Into Energy Grid
2. Predictive Energy Grid Maintenance
3. Rapid Outage Detection & Restoration
4. New Customer Services

**WHAT’S NEXT**

1. Next-Generation Energy Grid Management
2. DERs as Energy Grid Resources
3. Tailored Customer Services
4. Smart Cities
Industry/Government Partnership on Power Restoration and Resiliency
Cyber & Physical Security

- Securing and protecting our nation's critical electric grid assets are top industry priorities.
- The electric industry is the only critical infrastructure sector subject to mandatory, enforceable cybersecurity standards.
- Industry and government collaboration is essential. Exercises are taking place nationally and regionally to prepare for extraordinary scenarios.
- The industry is making significant investments to protect the most critical assets.
Hard Questions for all Stakeholders To Consider

- How hardened and resilient should the system be?
- What are customers willing to pay for—and when?
- Balancing Local, Regional and Inter-Regional Needs
Our Industry Vision Is Customer-Driven

Value-Focused

More Dynamic, More Secure Energy Grid

Cleaner Energy

Innovative Energy Solutions