Agenda

• ERCOT Forward Outlook
  • Bill Magness, President and Chief Executive Officer

• Future Resource Mix Changes
  – Solar Resources
    • Dan Woodfin, Senior Director, System Operations
    • Kenan Ögelman, Vice President, Commercial Operations
  – Distributed Energy Resources
    • Bill Blevins, Director, Grid Coordination
    • Kenan Ögelman, Vice President, Commercial Operations
  – Energy Storage
    • Warren Lasher, Senior Director, System Planning

• Transmission Supporting Load Growth
  • Warren Lasher, Senior Director, System Planning

• Cyber Security
  • Cheryl Mele, Senior Vice President and Chief Operating Officer
Solar Resources
Utility-Scale Solar Generation Capacity – October 2018

Cumulative MW Installed
IA Signed-Financial Security Posted
IA Signed-No Financial Security

Future outcomes uncertain
Geographic Distribution of Solar Interconnection Requests

- Total Interconnection Requests at any stage of interconnection process as of October 2018
- Future outcome of these requests is uncertain
• ERCOT has already implemented solar forecasting.

• Increasing geographic diversity will improve forecast and intra-hour variability.
Pattern of Load, Wind and Solar on Peak Days

- Daily pattern of wind and solar generation is generally complementary
- Solar is more coincident with demand in summer
Transmission congestion drives large Locational Marginal Price (LMP) differences in the region.
Distributed Energy Resources (DERs)
Distributed Energy Resources (DERs)

- DERs may include various technologies:
  - Gas/diesel
  - Wind/solar
  - Storage

- Historically, generation resources were only connected to the transmission system

- DERs are connected to the distribution system; ERCOT has limited visibility and interaction with distribution systems
Distributed Energy Resources in ERCOT

DER growth rate for 2015-2017 is 62%
Current 2018 DER total is ~1,300 MWs and is expected to continue to grow
Integrating Registered Distributed Energy Resources

- To reliably operate and plan the ERCOT system, ERCOT is working on DER-related improvements:
  - **Visibility**: Worked with regulated Transmission/Distribution Service Providers to map some (93) of the existing registered DERs; working to map all registered DERs to transmission system load
  - **Reliability**: Working to provide locational price signals to registered DERs to support reliability and efficiency
  - **Planning**: Need reporting to properly capture capabilities and capacity from continued growth of DERs in planning processes
Current: Zonal Pricing
• DERs currently receive the zonal price.
• The Load Zone price is a weighted average of Locational Marginal Prices (LMPs) in the zone and does not fully reflect the local reliability need.

Future: Nodal Pricing
• Grid-scale resources that receive the locational price may have to overcompensate if nearby generation does not respond to local price signals.
• A LMP represents the value of energy at a specific location.
• Nodal prices better reflect the local reliability need.
• Registered DERs should receive a LMP in the future.
Currently, a DER solar facility does not receive negative locational prices; instead, it receives the Load Zone price, which does not dip below zero.

A grid-scale solar generation resource receives the LMP at its location, and in this example, lowers output accordingly when LMPs go negative.
Energy Storage
Why is Energy Storage of Interest?

• Energy storage (batteries) can be used for a variety of grid and customer applications:
  – Store energy at a resource
  – Arbitrage energy prices
  – Provide grid-level Ancillary Services
  – Defer or eliminate the need for transmission/distribution upgrades
  – Allow customers to reduce peak demand (to save on demand and/or transmission charges)
  – Provide high reliability at customer location
  – Enable micro-grid capability
  – Provide fuel for electric transportation

• Energy storage is scalable
  – A Tesla PowerWall has a maximum output of 5 to 7 kW
  – Some battery facilities are greater than 200 MW

• Energy storage can take energy from variable generation (wind and solar) and provide a dispatchable resource

• Costs of battery technologies are declining rapidly
Current Storage Activity in ERCOT and Beyond

- Currently, ~89 MW of battery storage resources are registered with ERCOT and participating in ERCOT Ancillary Services markets.
  - There are smaller DER battery systems that are not registered with ERCOT.
  - There also is a 4 MW battery in Presidio, TX, which was installed to improve customer reliability at the end of a 60-mile radial transmission line.¹

- Approximately 1,889 MW of battery storage capacity is being studied in the ERCOT resource interconnection queue.

- In September 2016, American Electric Power applied to install batteries at two distribution substations in lieu of more costly system upgrades. The PUCT is reviewing the use of batteries as grid upgrades in Project No. 48023 (initial comments were submitted last week).

- FERC jurisdictional electric markets are subject to FERC Order No. 841, which requires increased access to energy, Ancillary Services and capacity markets for battery resources.

¹(Approved by the Public Utility Commission of Texas [PUCT] in April 2009 [Docket No. 35994].)
Integrating Energy Storage

Focus on increasing visibility and decreasing barriers to entry

• Develop increased system awareness of storage device operation and limitations in the control room

• Identify and reduce barriers to energy and Ancillary Services markets

• Adapt ERCOT system models to facilitate integration of storage technologies

Approach needs to be adaptable – we don’t know how the technology will develop in our market
Transmission Supporting Load Growth
Providing reliable electric service to meet the needs of oil and gas development in West Texas is a challenge.

- Existing infrastructure was not designed for recent increases in customer demand.
- Predicting the amount and location of future customer oil and gas demand growth is difficult.
- Major transmission projects take five years to plan and build. Many oil and gas development companies have 18-month planning horizons.
- Transmission upgrades, line maintenance and connecting new customers typically require line outages, which temporarily reduces existing available transmission capacity.
Culberson County Area Electricity Demand Growth

Permian Basin Rig Count

Permian Basin Oil Rig Count as of September 2018
Source: Baker Hughes North American Rig Count

Forecast Date
- Potential
- Confirmed 2/2018
- FWTP2 1/2018
- DRD Submittal 10/2017
- FWTP Approval 5/2017
- FWTP 2/2017
- FWTP submittal 4/2016
- Riverton - Sand Lake 2/2016
- PB - Culberson 6/2014
Transmission Development

Far West Non-CREZ Transmission Improvements ($Million)

Historic vs. Planned Improvements over the years 2009 to 2020.
Future Transmission Development

• The ERCOT Board of Directors recently endorsed a major transmission project in West Texas to ensure continued grid reliability in the region.

• This project should be fully constructed by April 2021.
Cyber Security
ERCOT Cyber & Physical Security Program

• ERCOT has strong executive management support for security.

• ERCOT has a dedicated and integrated cyber/physical security organization and established strategy.

• ERCOT uses layered cyber and physical security architectures known as a defense-in-depth strategy, along with careful monitoring.

• ERCOT is committed to external collaboration with relevant government agencies, law enforcement, industry and national labs to enhance its and the industry’s security posture.
Security Protection Approach

Cybersecurity Framework

1. Identify
   Establish a risk management strategy and governance and identify at-risk assets

2. Protect
   Implement protections for systems and data identified as at risk

3. Detect
   Determine how cyber threats are monitored and managed

4. Respond
   Execute incident response plan, which includes investigating the incident and containing the threat

5. Recover
   Review and discuss the recovery plan to identify improvements to policies and processes

National Institute of Standards and Technology
### Grid Security Collaboration

#### Federal/National
- US-CERT
- ICS-CERT
- National Electric Sector Cybersecurity Organization
- NERC
- E-ISAC
- MS-ISAC

#### State
- ERCOT

#### Industry
- Critical Infrastructure Protection Working Group (CIPWG)
- Grid Resilience Working Group (GRWG)

#### National Labs
- INL
- Pacific Northwest National Laboratory
- Sandia National Laboratories
- Argonne National Laboratory