Assessment of the North American Bulk Power System
A Reliability Perspective on Future Needs and Challenges

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Electricity Security Action Plan (ESAP) Workshop
October 01, 2013
To ensure the reliability of the North American bulk power system

- Develop and enforce reliability standards
- Assess current and future reliability
- Analyze system events and recommend improved practices
- Encourage active participation by all stakeholders
- Accountable as ERO to regulators in the United States (FERC) and Canada (NEB and provincial governments)
<table>
<thead>
<tr>
<th>Generation</th>
<th>Transmission</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 5,000 plants</td>
<td>Over 460,000 miles</td>
<td>Over 1,000,000 miles</td>
</tr>
<tr>
<td>Over 20,000 EGUs</td>
<td>&gt;100kV</td>
<td></td>
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<tr>
<td>65% of average customer monthly bill</td>
<td>5% of average customer monthly bill</td>
<td>30% of average customer monthly bill</td>
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<tr>
<td>Employs approximately 120,000 people</td>
<td>Employs approximately 15,000 people</td>
<td>Employs approximately 400,000 people</td>
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Background

- Peak demand forecasts
- Resource adequacy
- Transmission adequacy
- Key issues - emerging trends
  - Technical challenges
  - Evolving market practices
  - System elements/dynamics
  - Potential legislation/regulation
- Regional self-assessment
- Ad-hoc special Assessments
Risk Assessment for Emerging & Standing Issues

Emerging Issues Risk Evolution:

- **Environmental Regulations**
- **Transmission Siting**
- **Natural Gas Dependency**
- **Change in Resource Mix**
- **Economy Issues**
- **Variable Generation Models**
- **Demand-Side Management**
- **Nuclear Generation**

**Likelihood**

- **Higher**
- **Lower**

**Consequence**

- **6–10 Years**
2013 Long-Term Reliability Assessment
Preliminary Key Findings

- Significant Loss of Fossil-Fired Generation Capacity
  - ~70 GW of confirmed retirements/derates (2012-2023)

- Increases in Variable Generation
  - ~20 GW of on-peak capacity (2023); wind and solar

- ERCOT (Texas) below Target Reserve Margin throughout

- Demand-Side Management to offset 80 GW of 2023 peak demand
  - Penetration levels highest in PJM and MISO, ~12% of peak demand

- Nuclear Generation Retirements

- Increasing Dependency on Gas-fired Generation
  - 70-100 GW to be added; Total of nearly 500 GW by 2023
Uncertainty in the Future Calls for More Probabilistic-Based Analysis

- Common-mode failures and contingencies (beyond N-1)
  - Increasing variable generation and system dynamics
  - Interruption of gas deliver / catastrophic failure of pipeline transportation (*force majeure* curtailments)

- Transmission limit representations

- Fundamental changes in generation characteristics

- Stakeholder consensus for Reserve Margin targets
  - Paradigm shift recognizing limitations and potentially misleading deterministic planning targets
  - Potential increases in energy-limited systems

- Consistent definitions of reliability planning criteria:
  - Loss-of-Load and “1 in 10”
• Generation & Transmission Reliability Planning Models Task Force (GTRPMTF) was organized in January 2009 to develop composite G&T modeling methodology for assessing resource adequacy

• Successful execution of a long-term probabilistic-based reliability assessment is a significant step forward in determining future reliability of the bulk power system in North America
  ▪ Provide a common set of probabilistic reliability indices
  ▪ Recommend probabilistic-based work products
  ▪ Completed the very first continent-wide probabilistic assessment (2013)
Key Finding: Fossil-Fired Generation Retirements

Significant Fossil-Fired Generator Retirements Over Next Five Years

- Cumulative retirements between 2012 and 2022
- Slightly larger impacts than our 2011 generator retirement study
Key Finding: Change in Resource Mix

New Renewable/Variable Resources Introduce New System Planning and Operational Challenges

Growth in Expected On-Peak Capacity

- Hydro
- Pumped Storage
- Geothermal
- Wind
- Biomass
- Solar
The Need For Flexibility: A Future, Not a Scenario

Load, Wind & Solar Profiles --- Base Scenario
January 2020

Net Load = Load - Wind - Solar

- 6,700 MW in 3-hours
- 7,000 MW in 3-hours
- 12,700 MW in 3-hours

Load, Wind & Solar Profiles

- **Load**: Red line
- **Wind**: Green line
- **Total Solar**: Orange line
- **Net Load**: Blue line
Reliably integrating these resources into the bulk power system will require significant changes to traditional methods used for system planning and operation.

### Forecasting
- Variable Fuels Must Be Used When Available
- Forecast is only information; operator must make informed decisions
- “It’s the ramps, not the ripples”
- Methods for calculating expected on-peak capacity

### Flexibility
- More Ancillary Services
- Larger Balancing Authorities
- Flexible Resources
  - Storage
  - PHEV
- Leverage fuel diversity of other variable resources
- Distribution; Ride-through Capability

### Transmission
- Interconnect variable energy resources in remote areas
- Construct/site/permit transmission to deliver power across long distances
Improved measurement forecasting of variable generation output is needed

- **Challenge**
  - A forecast is only information
  - Operators need tools to react to forecast
  - Sufficient lead-time needed for preventive and corrective actions
Enhanced Flexibility is Needed

- Additional flexible resources, such as demand response, plug-in hybrid electric vehicles, and energy storage may help balance steep “ramps”

- Deploying complementary types of variable generation (e.g. wind and solar) leveraging fuel diversity over large geographic regions, and advanced control technologies show promise in managing unique operating characteristics

- Greater access to larger pools of generation and demand may facilitate the large-scale integration of variable resources

- Increased reliance on gas generation
• Four characteristics of conventional generation that VERs should also provide:

  ▪ Capability to provide reactive power support;

  ▪ Capability to increase or reduce energy output automatically, in response to system frequency;

  ▪ Ability to limit power production as needed for the promotion of reliability; and

  ▪ Capability to provide inertial response.
Next Steps:

- Interconnection Standards
  - Low-voltage ride through (disturbances)
  - Protection and Relay
  - Active/Reactive Power Control
- Communication
  - Telemetry
  - Control
- Data and Information
  - Standard non-proprietary models
  - Forecasting and availability

- Meteorological data
- Plant output
- Resource status
- Turbine capability
- Other information
Market Enhancements – California ISO

- Active flexible capacity procurement
- Dynamic transfers
- Lower bid floor to incentivize economic curtailment
- Pay-for-performance regulation
- FERC 764, intra-hour scheduling
- Proposed enhancements to the California Public Utilities Commission’s (CPUC) resource adequacy program
- Energy Imbalance Market (Regional Coordination)
- Dispatchable VERs
Key Finding: Transmission

Overall Growth of Transmission Infrastructure Responding to Increased Plans to Integrate and Deliver New Resources

Industry continues to meet higher-than-average 5-year plans

Historical average of transmission built within any given consecutive 5-year period between 1990 and 2012 is approximately 7,000 miles.
All of the Above

Generation
- Wider Operating Range (lower Pmin)
- Dispatchable
  - Wind/Solar
- Quick Start

Storage
- Voltage Support
- Regulation
- Over Generation Mitigation
- Load Shift

Demand Response
- Peak Load Reduction

Over Generation Mitigation
- Fast Ramping
  - Frequency Response

Wider Operating Range (lower Pmin)
- Dispatchable

Peak Load Reduction
- Dispatchable
  - Quick Start

Load Shift
- Over Generation Mitigation
- Fast Ramping
  - Frequency Response

Voltage Support
- Regulation
Questions and Answers
NERC Reports on Accommodating High Levels of Variable Generation:
- DRAFT Joint NERC-CAISO Special Reliability Assessment: Maintaining Bulk Power System Reliability While Integrating Variable Energy Resources to Meet Renewable Portfolio Standards
- Interconnection Requirements for Variable Generation, NERC, September 2012
- Potential Bulk System Reliability Impacts of Distributed Resources
- Methods to Model and Calculate Capacity Contributions of Variable Generation for Resource Adequacy Planning
- Ancillary Service and Balancing Authority Area Solutions to Integrate Variable Generation
- Operating Practices, Procedures, and Tools
- Potential Reliability Impacts of Emerging Flexible Resources
- Variable Generation Power Forecasting for Operations
- Standard Models for Variable Generation
- Flexibility Requirements and Potential Metrics for Variable Generation

NERC Reports on Accommodating and Increased Dependency on Natural Gas
- Primer (Phase I)
- Vulnerability Assessment (Phase II)

NERC Reliability Assessments (Long-Term and Seasonal)