Xcel Energy®
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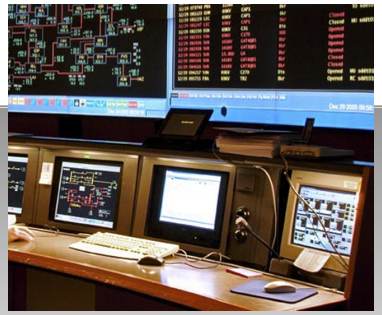
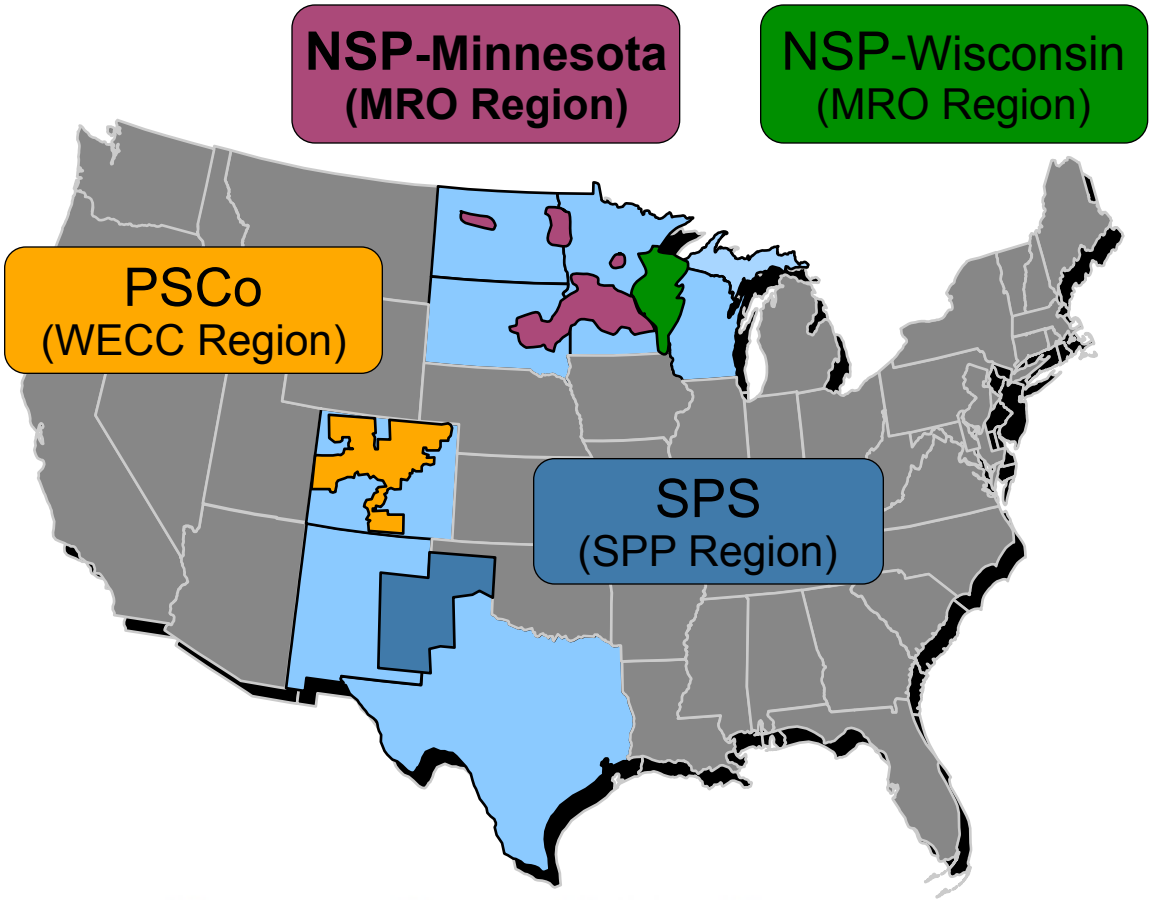


Risk-based Transmission Planning - Xcel Energy's Perspective

Who We Are…

Xcel Energy is dedicated to being an environmental leader



- **26,000+ MWs of generation**
- **Operating in 8 States**
- **No. 1 wind power provider**

No. 5 solar power provider

<u>Customers</u>

3.4 million electric
1.9 million gas

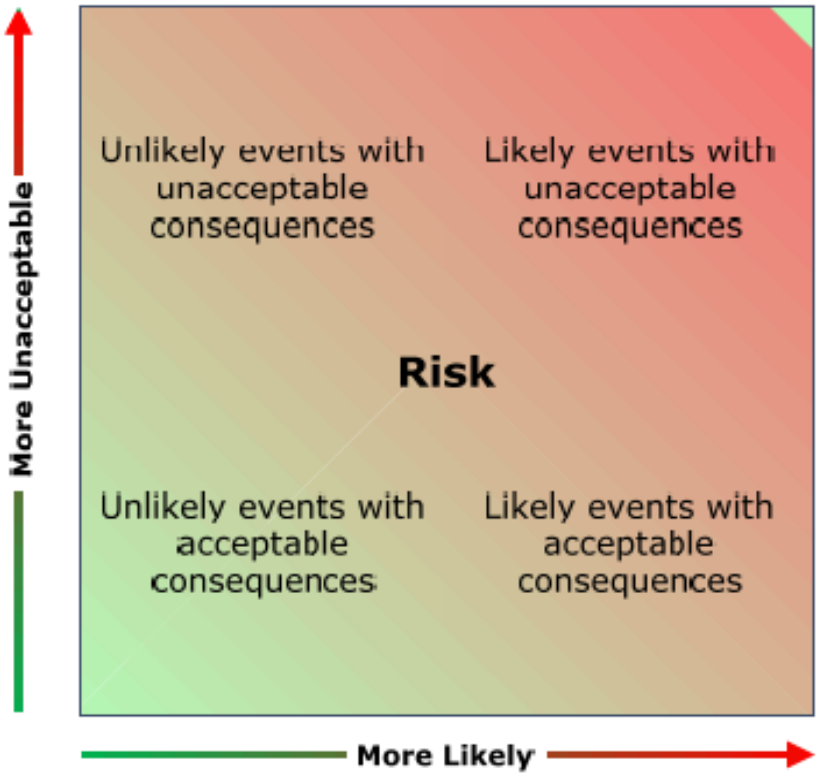
2013 Wind Resources in Xcel Energy

- **NSP System BAA = ~1600 MW**
  (2012 Peak Demand = ~9200 MW)

- **SPS System BAA = ~1025 MW**
  (2012 Peak Demand = ~5100 MW)

- **PSCo System BAA = ~2150 MW**
  (2012 Peak Demand = ~6300 MW)
  - **01:00 Jan.16, 2013 Wind Generation = ~1960 MW**
  - **2012 Demand met by Wind = 5750 GWh (~16% of sales)**
  - **03:00 April 15, 2012 Wind Generation = 57% of Load**

BES Reliability = Risk Management



Risk → the likelihood that an operating event (i.e. contingency) will reduce the BES Reliability to the point that the consequences are unacceptable

Goal → Plan, Design & Operate the BES to manage the impact of pre-defined credible contingency events and realize acceptable consequences

Acceptable Consequences → Prevent severe damage to BES equipment; Maintain BES integrity

Criteria → Acceptable Consequences for Credible Contingency Events

Adequate Level of Reliability (ALR) – NERC Definition

Characteristics of a System With an Adequate Level of Reliability

1. The System is controlled to stay within acceptable limits during normal conditions.
2. The System performs acceptably after credible Contingencies.
3. The System limits the impact and scope of instability and cascading outages when they occur.
4. The System's Facilities are protected from unacceptable damage by operating them within Facility Ratings.
5. The System's integrity can be restored promptly if it is lost.
6. The System has the ability to supply the aggregate electric power and energy requirements of the electricity consumers at all times, taking into account scheduled and reasonably expected unscheduled outages of system components.

Translate to System Performance Requirements in Table I of TPL Stds.

Table I. Transmission System Standards – Normal and Emergency Conditions

Category	Contingencies	System Limits or Impacts		
	Initiating Event(s) and Contingency Element(s)	System Stable and both Thermal and Voltage Limits within Applicable Rating [a]	Loss of Demand or Curtailed Firm Transfers	Cascading Outages
A No Contingencies	All Facilities in Service	Yes	No	No
B Event resulting in the loss of a single element.	Single Line Ground (SLG) or 3-Phase (3Ø) Fault, with Normal Clearing: 1. Generator 2. Transmission Circuit 3. Transformer Loss of an Element without a Fault	Yes Yes Yes Yes	No [b] No [b] No [b] No [b]	No No No No
	Single Pole Block, Normal Clearing [e]: 4. Single Pole (dc) Line	Yes	No [b]	No
C Event(s) resulting in the loss of two or more (multiple) elements.	SLG Fault, with Normal Clearing [e]: 1. Bus Section 2. Breaker (failure or internal Fault)	Yes Yes	Planned/ Controlled [c] Planned/ Controlled [c]	No No
	SLG or 3Ø Fault, with Normal Clearing [e], Manual System Adjustments, followed by another SLG or 3Ø Fault, with Normal Clearing [e]: 3. Category B (B1, B2, B3, or B4) contingency, manual system adjustments, followed by another Category B (B1, B2, B3, or B4) contingency	Yes	Planned/ Controlled [c]	No

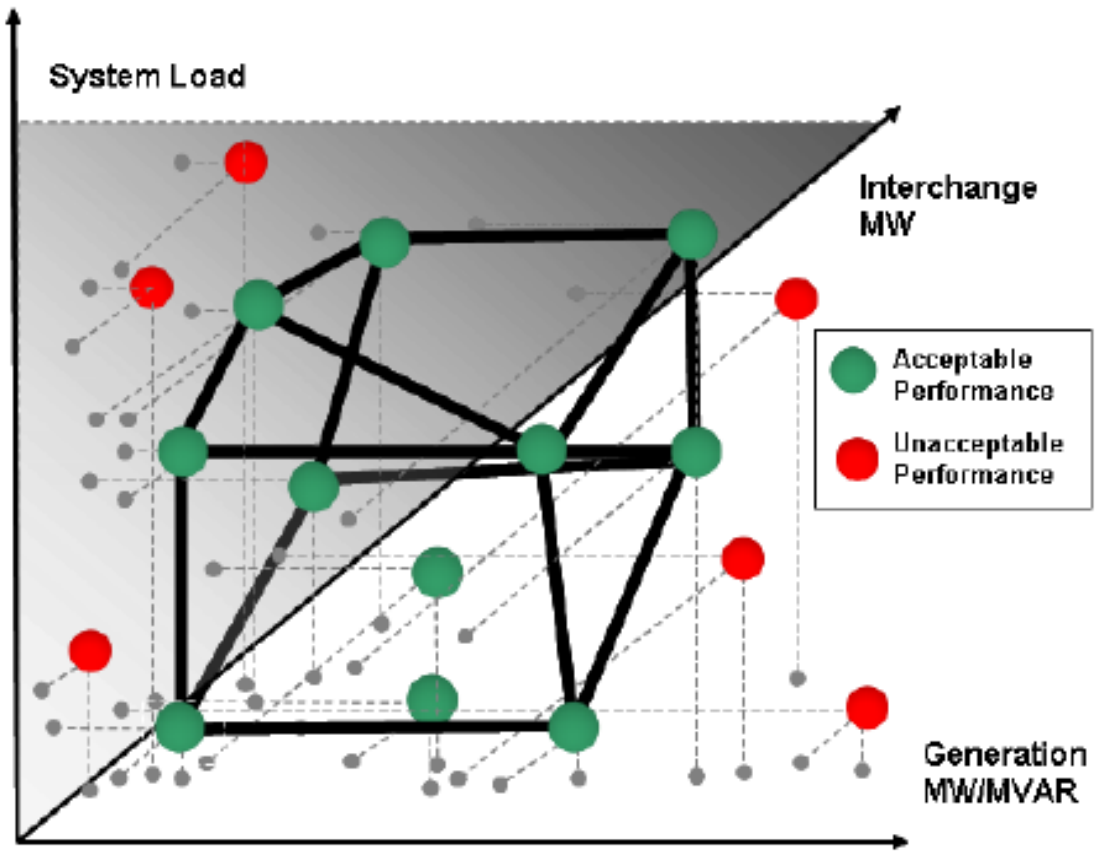
Expected Performance

Credible Contingencies

Managing Risk in Transmission Planning

- **Transmission Planning – Manage Risk to BES Adequacy and Operational Integrity by:**
  - translating future uncertainty and variability into Assumptions and Sensitivities for planning scenarios
  - assessing acceptable (projected) system performance during credible contingencies
  - establishing System Operating Limits & margins
  - identifying vulnerabilities and corrective action plans
- **Assumptions or Boundary Conditions**
  - Forecasted Load
  - Generation Dispatch
  - Firm Transfers or Net Interchange
  - Resource Locations (Retirements/Additions)

Managing Risk with Planning Studies

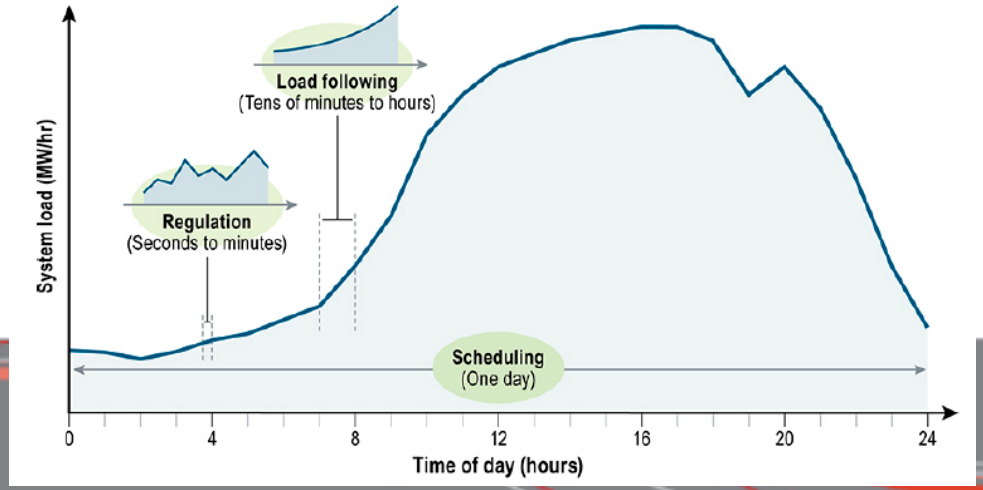


Recent Changes in Xcel's PSCo System

- **High Penetration of Variable Energy Resources**
  900 MW wind in 2011-12 (Total ~2150 MW)
- **Retirement of ~600 MW coal-fired generation in Denver-Boulder metro area for compliance with Colorado Clean Air Clean Jobs Act**
  258 MW (2011-13), 152 MW (2015), 186 MW (2017)
- **Termination of ~400 MW power sales agreement with wholesale load customer in 2012**

Reliability Risk of Increased VERs

- **Planning Horizon –**
  - **Transmission Adequacy & System Integrity aspects addressed in GI studies.**
  - **Planning Reserves require Capacity Credit of VER – based on ELCC (e.g. MISO = 13.3% CC in 2013)**
- **Operating Horizon – needs more system flexibility**
  - **Sub-hourly economic dispatch**
  - **Fast-acting operating reserves (regulating & contingency)**



Reliability Risk of Unit Retirements

- Depletion of Dynamic Reactive Resources – Increased Vulnerability to Voltage Instability
- Use higher (more stringent) planning criteria for voltage control & reactive resource adequacy – loss of 2x1 CC plant treated as N-1 event (B.1)
- Additional Static & Dynamic Reactive Resources to ensure adequate reactive margins at critical voltage support buses for N-1-1 event (B.1 + B.1)
- Risk-based planning outcome → Conversion of one retired unit to Synchronous Condenser

Risks to Actual System Performance

Transmission Related Events Resulting in Load Loss (2011)						
Date	Generation Loss (MW)	Transmission Loss	Load Loss (MW)	Equipment Failure	Protection System Misoperation	Human Error
1/13/2011	0	3 lines	135	✓		
3/27/2011	260	13 lines	295	✓		✓
4/25/2011	0	5 lines 1 transformer	140		✓	
5/10/2011	300	10 lines	462	✓		
6/6/2011	106	4 lines	450		✓	
6/30/2011	1	3 transformers	797	✓		
7/13/2011	599	14 lines 1 back to back converter 2 transformers	665	✓	✓	✓
7/22/2011	0	1 line	206	✓		
9/8/2011	6,981	32 lines 4 transformers	7,835			✓

Xcel Energy's Risk-based Reliability Enhancement Initiatives

- **Enhance Transmission Availability – Minimize reliability risk due to common / dependent mode events resulting in >3 elements outaged due to**
  - **Equipment Failure**
  - **Protection System Misoperations**
- **Ensure sufficient fast-ramping resources are available as operating reserves**
- **Champion for Energy Imbalance Market (EIM) to complement – not replace – existing bilateral transactions market based on contract-path transmission reservations**

Summary ...

- Credible contingencies in existing planning criteria (Table I) inherently provide risk-based planning framework to evaluate BES operational integrity & resiliency – mostly unaffected by VER penetration
- BES resource adequacy (LOLE, EUE) is more suited to probabilistic evaluation – more impacted by the uncertainty & variability of VER
- System Flexibility needed to support higher VER integration – may be more efficiently achieved with market (EIM) rather than transmission solutions

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