August 23, 2018

Daniel P. Wolf
Executive Secretary
Minnesota Public Utilities Commission
121 7th Place East, Suite 350
St. Paul, Minnesota  55101-2147

RE:  2020-2034 Upper Midwest Resource Plan
     August 23, 2018 Workshop Presentations
     Docket No. E002/RP-15-21

Dear Mr. Wolf:

Northern States Power Company, doing business as Xcel Energy, submits to the Minnesota Public Utilities Commission the three presentations that were presented at the August 22, 2018, The Evolving Electric System workshop (Part 1), regarding our 2020-2034 Upper Midwest Integrated Resource Plan (IRP) to be filed with the Commission by February 1, 2019.

We have electronically filed this document with the Commission, and copies have been served on the parties on the attached service list. Please contact Amber Hedlund at 612-337-2268 or amber.r.hedlund@xcelenergy.com or Bria Shea at (612) 330-6064 or bria.e.shea@xcelenergy.com if you have any questions regarding this filing.

Sincerely,

/s/

Bria Shea
Director, Regulatory and Strategic Analysis

Enclosures
cc: Service list
The Evolving Federal Landscape

August 22, 2018
Interconnection Reform - Jurisdiction

Jurisdictional boundaries (Order 2003)

- Generally, FERC has jurisdiction over transmission-level interconnections or distribution-level interconnections by wholesale sellers

- States have jurisdiction over QF interconnections and allocation of costs associated with QF interconnections

- States have jurisdiction over distribution interconnections not involving wholesale sellers
Interconnection Reform—Order 845

Order issued April 19, implementation required by November 4

- Reforms intended to:
  - Improve certainty for interconnection customers through expanded authority to construct upgrades and resolve disputes
  - Promote more informed interconnection decisions by increasing availability of study-related information and reporting study performance
  - Enhance the interconnection process through measures such as provisional interconnection service, common standards for use of surplus interconnection capability
Generator Replacement/Repower

- MISO has been working on tariff changes to enable an existing generator owner to retire a generator and use interconnection rights and facilities to interconnect a new generator

- Tentative filing timeline of late fall

- Will support replacement of Sherco Units 1 and 2 with natural gas units, previously approved by MN legislature
Transmission Cost Allocation

MISO Proposals

- Lower voltage threshold for market efficiency projects (MEPs) from 345 kV to 230 kV
  - Filing expected late September 2018

- Lower voltage for inter-regional cost allocation of MEPs on the PJM-MISO seam to 100 kV
  - Filing expected October, 2018

- Lower voltage for regional cost allocation of MEPs on the SPP-MISO seam to 100 kV
  - Significant stakeholder objection
  - Filing date undetermined but after the PJM-MISO seams filing
Order 1000

- US District Court for District of Minnesota upheld ROFR rights imposed under state statute in June
  - LS Power has appealed to the 8th Circuit

- Reviews on success of Order 1000 mixed
  - Some have concerns that more projects aren’t being competitively bid
  - Some have concerns that competitive process has significantly slowed new builds

- More experience with current requirements needed
Resource Adequacy

- Eastern capacity markets
  - State subsidies and mandates eroding market pricing
  - FERC show cause order would require states to chose whether to have subsidized resources subject to MOPR or taken out of market altogether

- CAISO working to develop forward capacity market

- MISO
  - Resources Availability and Need (RAN) concept IN initial stages of discussion
    - Could include seasonal, planned outages impacting unforced capacity accreditation
    - Changes to demand response accreditation
Resilience

- FERC request for comments on resilience
  - What is it?
  - How are RTOs/ISOs addressing it?
  - Awaiting further action

- Potential DOE plan to prevent economic retirement of coal and nuclear units
  - Authority
  - Payment
  - Units covered
PURPA Reform

- Federal legislation
  - Address one-mile rule
  - Reduce 20 MW threshold
  - Allow EIM participants or state with competitive resource procurement process an exemption from purchase obligation

- FERC review
  - Technical conference in June, 2016
  - May 2018 announcement that FERC will move forward with rulemaking
    - Process and scope TBD
Storage and DERs

- Order 841 issued March 2018
  - Requires RTOs/ISOs to accommodate all services that storage resources can provide
    - Xcel Energy sought rehearing as rule relates to DERs
  - Further comment requested on proposal to require RTOs/ISOs to set up structure to enable DER participation in market

- Xcel Energy concerns
  - Technological capability to distinguish between retail and wholesale activity
  - States should have the ability to opt out
Cyber Security

- Ever evolving, asymmetrical threat
- New standards under development
  - Supply chain
  - Incident reporting
- Cloud computing and virtualization
- DHS reports that most utility defenses protected against Russian hackers late last year
Outline

• Evolving Generation Fleet and Development of Transmission
  – Historic look
  – Development of Power Pools and Energy Markets
  – Projections into Future

• Capacity vs. Energy
  – Capacity Types
  – Are all types of energy the same?

• MISO Generation Processes
  – Generation Interconnection Process
  – Generation Retirement Process

• Shifting Focus
  – MISO Resource Availability and Need efforts
Evolving Generation Fleet and Development of Transmission
Origins of Transmission

• The first operational AC high voltage transmission line was installed in Rome in 1885
  – Supplied energy to public lighting within the city from generators located outside of the city
  – Operated at 2 kV and was only intended to power 200 lights
  – A second AC line was installed shortly after in London at 2.4 kV

• Fast Forward to late 1910’s and 20’s
  – Large government owned generators were being called on to serve increasingly distant customers,
    • Led to more transmission at higher voltages.
Regional Coordination

• Post World-War II era:
  – Increased industry and industry expertise led to the development of Power Pools and Reserve Sharing group
    • These efforts leveraged excess generation capacity through greater development of the transmission system
    • Mid-Continent Area Power Pool in the upper mid-west was one of the first Power Pools
    • Small electric cooperative were become part of a larger and more interconnected grid

• Advanced Technology led to increased efficiency
  – Due in part to advances in technology and the development of a market based approach to energy has led to decreased recurring costs and increased system efficiency
Comparing Capacity and Energy
Nameplate Capacity:
The maximum amount of power that can be produced by a generator.

Accredited Capacity:
This is the value of energy provided by a given generator that is expected to be available during system peak times.

Capacity Factor:
Capacity Factor is the amount of energy actually produced in a given time period.
Reserves Requirements

Reserves:

- Operating Reserves
  - This value represents the requirement to have enough additional generation online to cover what would be lost if the worst single element failure happened
    - Different for each Balancing Area
    - Is greatly impacted by the size and number of resources in that Balancing Area

- Planning Reserve Margin (PRM)
  - The PRM represents the amount of additional accredited capacity an area is required to have installed above and beyond the peak demand projected for that area
  - The PRM required is determined by the Loss of Load Expectation analysis performed by MISO annually, and is designated on a Local Resource Zone basis.
Accredited Capacity vs. Energy

- **MISO Average Accreditation by Generation Type**
  - Synchronous Generation Examples
    - Hydro: 100%
    - Nuclear: 100%
  - Variable Generation Examples
    - Wind: ~15.6%
    - Solar: Currently 50%, will be adjusted as penetration increases

- **Average Capacity Factor by Generation Type (EIA 2017 Data)**
  - Synchronous Generation Examples
    - Hydro: 45.2%
    - Nuclear: 92.2%
  - Variable Generation Examples
    - Wind: 36.7%
    - Solar: 27%
Energy Resource vs Peak Local Demand

MISO Wind vs LRZ 1 Demand

July 25 – August 4 (hours)
Wind output in the 10:00 am hour was -11 MW from over 17,000 MW of installed wind capacity
Energy Resource vs Off-Peak Local Demand

MISO Wind vs LRZ 1 Demand

March 30 - April 2 2018
March 31, 2018

Wind output in the 1:00 pm hour was 15,543 MW from over 17,000 MW of installed wind capacity.
MISO Generation Processes
MISO Generator Interconnection

- Generators seeking interconnection to the transmission system in the MISO footprint are:
  - Required to complete the interconnection study process
  - Required to fund any network upgrades that would not have otherwise been built “but for” the interconnection of that generator
Generators connected to the transmission system in the MISO footprint seeking to retire are:

- The proposed generation retirement must submit an Attachment Y application to MISO
- The receipt of an Attachment Y application by MISO triggers a retirement analysis
  - This analysis looks to see if there are any system reliability impacts created by the generator retirement
- If a system reliability issue is found, MISO designates that generator as a System Support Resource (SSR)
  - The costs of this generation is then the responsibility of the area in which the reliability need is found.
SSR Example – Presque Isle

• Presque Isle
  – Generator located in Michigan’s Upper Peninsula
  – Submitted Attachment Y in 2014
    • Designated as a System Support Resource (SSR) in August 2014
    • SSR Cost: Approximately $7.3 Million per year

• Transmission Solutions Proposed but found not to be cost effective
  – Finally, Presque Isle Attachment Y was withdrawn by owner
  – New generation requests in area may allow for eventual retirement of aging generators in the area.

• Key Issue:
  – Retirement of generation can become significantly delayed and local customers can incur significant cost if a retiring generator is designated as a System Support Resource
Ongoing Changes – MISO RAN
Resource Availability and Need

• Due to recent events in the MISO footprint, the Resource Availability and Need effort was kicked off.
  – Current rules only allow for load modifying resources to be called upon during times of formal conservative operations
    • Limits effectiveness of Demand Response and Load Modification programs

• This effort underscore the trend of changes to how the availability of resources are defined
  – Increased reserve requirements?
  – Decrease accreditation?
  – Wholesale shift away from capacity-based planning in favor of energy-based alternatives?
Questions?
Renewable Integration
Impact Assessment
Finding integration inflection points of increasing renewable energy

Xcel Energy’s IRP Stakeholder Workshop 2:
The Evolving Electric System—Part 1
August 22nd, 2018
MISO operates in 15 states in the central U.S. and 1 Canadian Province

Annual Energy Production – 657.1 TWh (2017)

Installed Capacity – 180 GW
Renewable Integration Impact Assessment (RIIA) seeks to find inflection points of renewable integration complexity.

Focus Areas:
- Resource Adequacy
- Energy Adequacy
- Operating Reliability

Renewable Integration Complexity

 RIJA begins by modeling the current system.

Inflection points are milestones where complexity significantly increases.

Illustrative example
High-level RIIA Process Map

- Retirement Analysis
- ELCC (Wind & Solar)
- Resource Adequacy Model
- Siting/Scenario Development
- Dynamic Model
- System Dispatch
- Production Cost Model
- System Upgrades/SOLS
- Power Flow Model
- System Upgrades/SOLS /New TX Constraints
- Synthesize Solutions
- Production Cost Model

FOCUS AREAS
- Resource Adequacy
- Energy Adequacy
- Operating Reliability

DO SOLUTIONS MEET FEEDBACK CRITERIA?

*SOLS = Other solutions
RIIA - 9/22/2018
RIIA Wind, UPV, and DPV Modeled Expansion
As renewable penetration increases, the risk of losing load shifts and compresses to a smaller number of hours.

- Probability of losing load is targeted at one day in ten years over all penetration levels.
- While aggregate risk remains constant, the risk in particular hours increases.

*Profile shapes represent hourly averages across all days of the 6 study years.*
Changes to net load shapes are seasonal, however the risk of losing load still occurs during the summer at higher penetration levels.

*Profile shapes represent seasonal hourly averages across the 6 study years.*

*Summer includes May, June, July, and August; Winter includes January, February, November, and December.*
As penetration levels increase and the net peak load timing shifts:

- ELCC* for wind decreases slightly
- ELCC for solar sees a steeper drop-off

These values are reflective of ELCC calculated separately for wind and solar to isolate the impacts of each technology.

Values between milestones were interpolated.

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*Effective Load Carrying Capability (ELCC) is a measure of the additional load that the system can supply with the particular generator of interest, with no net change in reliability.
Diversity of technologies improves the ability of renewable resources to mitigate the risk of losing load

![Graph showing the improvement in ELCC (% of Load Energy) with various renewable generation availability (%)]
Geographic diversity improves the ability of renewable resources to mitigate the risk of losing load.

*Generation at sites selected for 10% and 50% penetration levels was scaled to match the generation needed for the 100% penetration level.*

<table>
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<tr>
<th>Sites</th>
<th>ELCC</th>
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<tr>
<td>10% sites scaled to 100% level*</td>
<td>11.1%</td>
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<tr>
<td>50% sites scaled to 100% level*</td>
<td>13.4%</td>
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<tr>
<td>100% sites</td>
<td>14.0%</td>
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*Wind*  
*PV*  
*10% Sites*  
*50% Incremental Sites*  
*100% Incremental Sites*
Several options are available for improving the ELCC of wind and solar

- Load and generation shifting strategies to adapt to resource availability include storage, demand control, and energy efficiency.

- A larger load footprint (e.g. Eastern Interconnection) could potentially increase the ELCC of renewables in MISO.

*ELCC results are from a single year, not an average.*
For each region and milestone, ELCC values are calculated for all generators

The ELCC values developed in the Resource Adequacy focus area are used to determine assumed amount of retirements:

Conventional Generation $UCAP = (1 - FOR) \times ICAP$

*MISO Incremental Renewable Expansion (GW)*

*MISO Incremental Retirements (GW)*

UCAP of added renewables = UCAP of retirements

*UCAP = Unforced Capacity, ICAP = Installed Capacity, FOR = Forced Outage Rate*
Conventional generation is dispatched down as renewable penetration increases.

Installed capacity in MISO increases in each milestone.
The direction of ramping needs from conventional resources reverses as renewable penetration increases.

*Daily gas and coal generation for the peak renewable day*

Due to input assumptions, coal and gas have similar costs in the RIIA model. This causes their similar behavior.
Curtailment of wind and solar is increasing used as a grid management tool

Solar performance

Wind performance

Dotted lines = Peak renewable day
Solid lines = Peak load day

Curtailment is one factor considered in developing solutions for the Energy Adequacy focus area.
Three snapshots of stressful system conditions were identified to study reliability performance in the **Operating Reliability** focus area.
Identify system steady state thermal and voltage issues through running powerflow contingency analysis

**Thermal Overloading:**
Branch flow exceeds applicable ratings defined to limit the equipment temperature to within a secure range.

**Voltage Violation:**
Bus voltage goes beyond TO-defined reliability thresholds caused by lack of voltage support or other factors.

Thermal overloading observed from infrared remote sensing camera.

System voltage support

Load centers
System fix complexity is concentrated in areas of high renewable deployment, but is moderate at the 20% penetration level.

- Quantifies the magnitude of integration complexity in terms of approximate costs from all transmission fixes needed for steady state reliability issues up to the 20% renewable milestone.
Frequency response is examined to understand how the grid will respond to a sudden loss of generation with high levels of renewable resources.
Example result from the base model to illustrate good performance

Simulation results for loss of a 1120 MW generator in MISO

Time (seconds.milliseconds)

Frequency (Hz)

Peak load
Shoulder load
Peak renewable hour
By examining increasing penetrations of renewables, several key takeaways have been thus far found:

1. Risk of losing load compresses into a small number of hours and shifts to later in the day.

2. As a result of the shift in risk of losing load, the available energy from wind and solar during high risk hours decreases.

3. Diversity of technologies and geography improves the ability of renewables to meet load.

4. The direction of ramping needs from conventional resources reverses as renewable penetration increases.

5. Under RIIA assumptions for renewable penetration levels up to 20%, the integration complexity is mild.
Phase 2 will continue looking at higher penetration levels and is expected to be completed by the end of the year.
Thanks!

Questions?

Jordan Bakke jbakke@misoenergy.org

All RIIA-related documents can be found on MISO’s web page. https://www.misoenergy.org/planning/transmission-studies-and-reports/
CERTIFICATE OF SERVICE

I, Jim Erickson, hereby certify that I have this day served copies of the foregoing document on the attached lists of persons.

by depositing a true and correct copy thereof, properly enveloped with postage paid in the United States mail at Minneapolis, Minnesota

electronic filing

Docket No. E002/RP-15-21

Dated this 23rd day of August 2018

/s/

Jim Erickson
Regulatory Administrator
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