• Rates & Costs, Transition to Date, Challenges Ahead

• Renewables Integration – Regional Grid & Markets

• Emerging Issues – Grid Services, Flexibility, Electrification

• Modernization – Distribution Grid & Retail Rates

• Looking Forward – Planning for an Integrated Grid
Average price of electricity to consumers is a weighted average of total consumer revenue (energy, demand, fuel adj., riders, etc) and total sales across all sectors.
Affordable Electricity Costs
Average Residential Monthly Bill

Source: U.S. Energy Information Administration, EIA-861
Trends in MN Economic Growth, Electricity Use, and Emissions

Sources: U.S. Energy Information Administration
U.S. Bureau of Economic Analysis
Integrated Resource Planning
Framework to Date

Resource Plan

- Alternatives
- Forecast
- Existing Generation
- DSM
- Size, Type, & Timing

Rate Case

- Forecast Adjustments
- Finance Adjustments
- Assign Costs
- Design Rates
- Rate Increase Approved

Certificate of Need

- Alternatives
- Specific Facility Approved
- Forecast
- Environment & Socioeconomics

Energy Facility Permitting

- Alternatives
- Environmental Review
- Public Participation
- Siting/Routing Approved & Constructed

Assign Costs

Forecast Adjustments
MN Wind Capacity
as of September 2018

MN: 3700 MW

Source: MN Department of Commerce
MN Solar Capacity
as of September 2018

Source: MN Department of Commerce
Minnesota Generation Fleet Transition

Experience to date: 1990 - 2017

- **1990**: 66% Coal, 6% Natural Gas, 2% Renewables, 2% Nuclear, 2% Other
- **2005**: 62% Coal, 6% Natural Gas, 6% Renewables, 2% Nuclear, 2% Other
- **2017**: 40% Coal, 4% Natural Gas, 25% Renewables, 4% Nuclear, 1% Other
Minnesota Electricity in Transition
Current Plans: 2017 - 2030

2017
- Nuclear 23%
- Renewables 25%
- Natural Gas 12%
- Coal 40%

2030*
- Nuclear 21%
- Renewables 45%
- Natural Gas 22%
- Coal

* New natural gas plants added (3 intermediate combined cycle plants and 2 peaking combustion turbines) and new renewables added, per MN IOU IRPs & announcements.
## Minnesota Generation Fleet Transition

**Upcoming:** 2020 - 2040

<table>
<thead>
<tr>
<th>Power Plant</th>
<th>Commercial Operation</th>
<th>Capacity (MW)</th>
<th>Announced Retirement or End of Economic Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>MN Power Coal Boswell 1 &amp; 2</td>
<td>1960</td>
<td>130</td>
<td>2018 Retirement</td>
</tr>
<tr>
<td>Otter Tail Coal Hoot Lake 2 &amp; 3</td>
<td>1959, 1964</td>
<td>140</td>
<td>2021 Retirement</td>
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<tr>
<td>Xcel Energy Coal Sherco 1 &amp; 2</td>
<td>1976, 1977</td>
<td>1360</td>
<td>2026, 2023 Retirement</td>
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<td>Xcel Energy Nuclear Monticello</td>
<td>1971</td>
<td>670</td>
<td>2030 Operating license</td>
</tr>
<tr>
<td>Xcel Energy Nuclear Prairie Island 1 &amp; 2</td>
<td>1973, 1974</td>
<td>1100</td>
<td>2033, 2034 Operating license</td>
</tr>
<tr>
<td>Xcel Energy Coal Sherco 3</td>
<td>1987</td>
<td>860</td>
<td>2034 Economic life</td>
</tr>
<tr>
<td>Xcel Energy Coal Allen S. King</td>
<td>1968</td>
<td>510</td>
<td>2037 Economic life</td>
</tr>
</tbody>
</table>
Grid integration of large amounts of wind generation in the upper Midwest began in the early 2000s:


Study methods/models and depth of collaboration evolved as understanding of challenges developed.

Today, the regional grid is planned and operated differently; new approaches and tools; improved market rules.
Reducing Wind and Solar integration impacts

- Large, liquid, fast markets;
- Large balancing area with a strong grid; and
- Forecasting wind generation day-ahead

Midwest experience integrating wind

- Variability is mitigated by geographic diversity;
- Wind contributes to resource adequacy;
- Market rules have evolved to require fuller wind participation.

Wind and solar generators are power plants

- Are Dispatched; Ride through disturbances; Provide reactive power; Capable of fast and accurate ramping and active power control.
The changing resource mix motivates us to evolve our planning:
- Less coal, more renewables, more demand response, more gas;
- How will this affect grid attributes that we don’t explicitly plan for today?

Core grid services include:
- Voltage control;
- Frequency support;
- Ramping capability.

These essential reliability services can and increasingly will come from a range of resources.
Flexible load as a resource *and* the robust regional grid & markets are key to enabling the evolving resource mix.

U.S. National Electrification Assessment – 2015 to 2050

SCENARIO (Electricity Portion of Final Energy in 2015 & 2050)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Total Final Energy</th>
<th>Electric Load</th>
<th>Natural Gas</th>
<th>Economy Wide</th>
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</thead>
<tbody>
<tr>
<td>CONSERVATIVE (21% &amp; 32%)</td>
<td>20%</td>
<td>24%</td>
<td>33%</td>
<td>19%</td>
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<tr>
<td>REFERENCE (21% &amp; 36%)</td>
<td>22%</td>
<td>32%</td>
<td>40%</td>
<td>20%</td>
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<td>PROGRESSIVE (21% &amp; 39%)</td>
<td>27%</td>
<td>35%</td>
<td>31%</td>
<td>57%</td>
</tr>
<tr>
<td>TRANSFORMATION (21% &amp; 47%)</td>
<td>32%</td>
<td>52%</td>
<td>18%</td>
<td>67%</td>
</tr>
</tbody>
</table>

For more information on EPRI’s Efficient Electrification Initiative: https://www.epri.com/#/pages/sa/efficient electrification
MN Grid Modernization

- *Maintain and enhance* the **safety, security, reliability, and resilience** of the electricity grid, **at fair and reasonable costs**, consistent with the state’s energy policies;

- *Enable* **greater customer engagement, empowerment, and options** for energy services;

- Move toward the creation of **efficient, cost-effective, accessible grid platforms for new products, new services**, and opportunities for adoption of new distributed technologies;

- *Ensure* **optimized utilization of electricity grid assets and resources** to minimize total system costs;

- *Facilitate* **comprehensive, coordinated, transparent, integrated distribution system planning.**
Integrated Distribution Planning

MN PUC Modernization Dockets

- **Interconnection Standards**
  - Interconnection Process (2018)
  - Technical Standards (2019)

- **Distribution Grid**
  - Distribution Planning (2018)
  - Grid Upgrades - AMI/ADMS

- **Rate Design**
  - TOU/Critical Peak Pricing
  - EV Infrastructure and Rates

- **Performance Considerations**
  - Xcel Multi-Year Rate Case
  - Metrics/Incentives
Evolving Electric Grid

The grid is at a time of significant change, as:

• Large infrastructure ages;
• Consumer demands evolve;
• New technology costs fall.

=> Decarbonization, Decentralization, Digitization

Tomorrow’s integrated grid will optimize and extract value throughout the system:

• will be more distributed and flexible;
• will operate resiliently;
• will be reliable, affordable, and cleaner.

Distribution will need updated planning & investment;
Regional transmission will continue to be vital; and,

Resource planning must evolve to identify and capture benefits for consumers of an increasingly integrated system.
Thank you!

Matthew Schuerger, Commissioner

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