Minnesota Energy Landscape

Energy Transition Lab

University of Minnesota
Driven to DiscoverSM

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A Postcard from the Future
I. Overview
Utilities by the Numbers:

- 3 IOUs: Northern States Power (Xcel), Allete Inc (MN Power), Otter Tail Power

- 45 Distribution Co-ops

- 6 G&T Co-ops

- 126 municipal electric and 31 municipal gas utilities

Source: PUC

Total Generation Capacity 17,707 MW

Source: EIA

Source: http://www.mngeo.state.mn.us/eusa/#
Strategen White Paper, EIA data varies slightly from the 2012 Minnesota Utility Data Book, with Co-op being 21%, Muni 14%, and IOU 65% (source: November 22nd, 2013 email from Lise Trudeau of MN Commerce to Strategen)
Source: Minnesota 2025 Energy Action Plan, citing EIA data
FIGURE 5: TOTAL MINNESOTA ENERGY CONSUMPTION, 1960–2013

Minnesota Energy Landscape Summary

- No indigenous fossil fuel supply
- Import 26% of electricity used
- Abundant wind, solar, and bio-based energy resources
- 4th in nation in ethanol production
- A top 10 state in wind generation
- Per capita energy consumption ranks 18th despite third-coldest winters in U.S.

Source: Minnesota 2025 Energy Action Plan, Photo source: goodmedicineapothecary.com
II. Key Minnesota Energy Policy Drivers

<table>
<thead>
<tr>
<th>Xcel Energy:</th>
<th>All other utilities:</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012 18%</td>
<td>2012 12%</td>
</tr>
<tr>
<td>2016 25%</td>
<td>2016 17%</td>
</tr>
<tr>
<td>2020 30%</td>
<td>2020 20%</td>
</tr>
<tr>
<td></td>
<td>2025 25%</td>
</tr>
</tbody>
</table>

All utilities are meeting targets. Several are ahead of schedule.

Includes IOUs, Municipal Utilities, Co-ops

Minnesota Greenhouse Gas Reduction Statute

From 2005 levels:

<p>| | |</p>
<table>
<thead>
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<tbody>
<tr>
<td>2015</td>
<td>15%</td>
</tr>
<tr>
<td>2025</td>
<td>30%</td>
</tr>
<tr>
<td>2050</td>
<td>80%</td>
</tr>
</tbody>
</table>

NOT on track to meet these goals

Image: [http://www.ucsusa.org](http://www.ucsusa.org) Tracy, MN
2013 Solar Energy Policies

Solar Energy Standard

• 1.5% by 2020, IOU’s only (exemptions)
• In addition to 2007 RES

Community Solar Gardens

• 1 MW limit per garden but no overall cap
• Requirement for Xcel, voluntary for others
• Xcel Filing: 0.40 MW in service, 150-200 MW of Community Solar by end 2016
• 620 MW more in interconnection queue, 83 MW under construction
Other Clean Energy Policies

Energy Efficiency

**Requirement:** 1.5% reduction of retail sales per year

**Made in Minnesota incentives** for Solar PV and Solar Thermal

Value of Solar Tariff

State Goal of 10% Solar by 2030

Grid Modernization & Distribution Planning Law
40% Renewables in Minnesota:
- Can be reliably accommodated with upgrades to existing transmission
- Wind and solar increase by 8.5 TWh, balanced by decrease in imports;
- Very little change in conventional generation
- MN-Centric region goes from net importer to net exporter

50% Renewables in Minnesota, 25% RPS in MISO North/Central
- Can be accomplished with more substantial transmission upgrades;
- Increase in MN wind and solar balanced by decrease in coal, increase in exports
- Gas-fired, combined-cycle generation declines from 5.0 TWh to 3.0 TWh
- 2% of Minnesota wind curtailed in this scenario
II. Energy Storage To Date in Minnesota
Smaller Battery Energy Storage:

- **Smaller Projects Totaling 311 kw**

  - Hartley Nature Center, Duluth, MN
    Solar + storage creates resilient emergency center. 6kw/2:22.50 hour

  - Univ. of St. Thomas, St. Paul
    Solar + storage microgrid project. 50 kw.

  - Rural Co-op (Jackson and Litchfield)
    Utility office buildings for demand charge reduction and backup power. 5kw/2 hr

  - Wright-Hennepin Co-op
    Demand charge reduction and backup power. 51kw/2 hr.

  - Wright-Hennepin Solar Community, Rockford
    31 kw solar array + 37 kw/2 hr.
Residential Storage Project, Jordan
Eleven 5kw and six 10kw units installed at co-op member locations. 115kw/3 hr

MN Valley Electric Co-op, Jordan
Demand charge reduction and backup power. 33kw/2:30 hr

Austin Municipal Utilities
Sited in municipal bldg for peak demand mgmt. 37kw/2 hr

Brainerd Public Utilities
Utility Office Bldg for demand charge reduction and backup power. 5kw/2 hr

Shakopee Public Utilities
Solar + ES at high school environmental learning center. 9kw/2hr.
Larger Energy Storage

Xcel MN Wind-to-Battery, Luverne
First U.S. application as direct wind storage, move to grid as needed. 1MW 7:12 hr

Proposed Xcel Belle Plaine Battery Project
Proposed dist. deferral project. 6MWh, 2MW battery + 1MW solar. Volt/Var, loss impact analysis, reg, power quality, DER smoothing.

Minnesota Power with Manitoba Hydro
PPA with Manitoba Hydro to store wind energy from N.D. and transmit 250MW of resulting hydroelectric power to MN via the Great Northern Transmission Line(in process)

Otter Tail Power Thermal Storage
18,000 customers = 20 MW thermal battery for peak shifting. Thermal in-floor storage

Great River Energy Thermal Storage
60,000 utility-controlled residential electric hot water heaters, shift 1 GW to off-peak
Minnesota Energy Storage Legislative Initiatives

**In Law:**

**2013 Value of On-Site Energy Storage**
Required state analysis of costs and benefits of utility-managed, grid-connected on-site energy storage

**Proposed:**

**2015 Made in MN Energy Storage Bill**
Proposed to expand energy conservation improvement plan program eligibility to include E.S. systems; Made in MN E.S. systems rebate program

**2016 MN Energy Storage Tax Credit Bill**
Proposed state income tax credit of 30% of cost (up to $5,000 residential, $25,000 commercial/agriculture) for E.S. systems
Investigated 4 use cases for energy storage:

1. Customer controlled for bill savings
2. Utility controlled for distribution system benefits
3. Utility controlled for distribution & market benefits
4. Shared customer & utility controlled for bill savings and market revenue

Results: Case 3 has positive benefit:cost
Energy Transition Lab held Energy Storage Summit in July 2015 with 200 attendees

- Led to MESA formation.

- More than 150 stakeholders involved from all sectors

MESA Activities:

- Knowledge sharing: Hot Topics Events, Upcoming Summit II

- Submitting comments on market opportunities and barriers to FERC, MISO, PUC

- Energy Storage Strategy Workshop
MISO and Energy Storage


- ES Issues Identified by Stakeholders - In Committee Process

**Market Subcommittee**
Market Roadmap prioritization process includes storage-related items

**Resource Adequacy Subcommittee**
How to credit storage as a capacity resource

**Interconnection Process Task Force**
How storage assets go through interconnection queue process

**Planning Subcommittee**
Considering storage as a Non-Transmission Alternative; deferred to FERC on how a storage asset can be considered a transmission asset
III. Challenges and Opportunities for the Future

- Energy System Efficiency
- Aging Infrastructure
- Cost & Affordability
- Meeting Future System Needs: Minnesota, MISO Region
- Grid Modernization
- Electrification of Transportation
- New Utility Business Models (e21)
- Growth of Distributed Energy Resources
- Reliability & Resiliency
- Growth of Renewable Energy
- Climate Change & Regulatory Framework
- Managing Peak Demand
Infrastructure Investment & Utilization

- Utilities spend hundreds of millions on infrastructure
- Much of system (generators, transmission, distribution) underutilized
- Opportunity to reduce system costs by better utilizing system assets
Xcel Energy: 2016-2030 Energy and Demand Forecast

Xcel Energy: Annual Net Energy and Peak Demand

- 0.4% annual growth rate
- 56% Load Factor

Annual Net Energy (MWh)

Estimated Minnesota Energy Use In 2012
~1700 Trillion BTU

Source: LLNL 2011. Data is based on DOE/EIA-0214/2011, June 2013. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for non-thermal resources (i.e., hydro, wind and solar) in BTU-equivalent values by assuming a typical fossil fuel plant “heat rate.” The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. Interstate and international electricity trade are lumped into net imports or exports and are calculated using a system-wide generation efficiency. End use efficiency is estimated for each sector as 65% residential, 60% commercial, 80% industrial and 21% transportation. Totals may not equal sum of components due to independent rounding. LLNL-MI-410927
# Aging Infrastructure

**Table 1.1, Distribution System Summary Statistics by Utility**

<table>
<thead>
<tr>
<th>Utility</th>
<th># of Substations</th>
<th>Distribution Feeders</th>
<th>Distribution Customers</th>
<th>Distribution Peak</th>
<th>Average Asset Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dakota Electric</td>
<td>30</td>
<td>164 feeders 4.5k miles 12.5 kV</td>
<td>104,000</td>
<td>500 MW</td>
<td>35 yrs – poles (also median age of system)</td>
</tr>
<tr>
<td>Minnesota Power</td>
<td>317</td>
<td>4.5k miles OH 1.5k miles UG</td>
<td>142,700</td>
<td>690 MW</td>
<td>41 yrs – OH distribution</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.5k miles OH 1.5k miles UG 2.4 - 25 kV</td>
<td>130,000</td>
<td>652 MW (Summer) 840 MW (Winter)</td>
<td></td>
</tr>
<tr>
<td>Otter Tail Power</td>
<td>500</td>
<td>730 monitored 4.5k miles OH 1.5k miles UG 2.4 - 25 kV</td>
<td>130,000</td>
<td>652 MW</td>
<td>38 yrs – UG distribution</td>
</tr>
<tr>
<td>Rochester Public Util.</td>
<td>9</td>
<td>181 miles OH 528 miles UG</td>
<td>51,000</td>
<td>292 MW</td>
<td>20 yrs (UG) to 40 yrs (OH tap)</td>
</tr>
<tr>
<td>Xcel Energy</td>
<td>228</td>
<td>1,116 feeders 16k miles OH 9.5k miles UG 4 - 34.5 kV</td>
<td>1,200,000</td>
<td>~7 GW</td>
<td></td>
</tr>
</tbody>
</table>

Source: September 25, 2015 meeting presentations. OH = Overhead; UG = Underground.

Source: PUC Staff Report on Grid Modernization
Reliability & Resiliency

The 7 largest MN utilities were below national median on SAIDI/SAIFI scores (excluding major event days) (2014)

Cost of U.S. electric outages was $112 billion (2013)

From 1997-2013: 32 severe weather natural disasters cost MN nearly $500 million

In 2013, Minnesota had some of the highest weather-related disaster claims in the country
PUC Staff Report on Grid Modernization:
Potential Near Term Action Items

- Integrated Distribution Planning
- Smart Inverters
- DG Interconnection Order
- Hosting Capacity Analysis
- Advanced Metering Infrastructure
- Volt/VAR Optimization
- Customer Energy Usage Data
- Time-Varying Rates
- Third-Party Aggregation
Expansion of Renewable Energy

Governor Dayton and others support raising RES to 40-50%

MRITS study shows Minnesota could be net energy exporter

Utilities adding renewable energy and natural gas and reducing coal

Source: OTP IRP (PUC Docket 16-386); MP IRP (PUC Docket 15-690); Xcel IRP (PUC Docket 15-21)
Over 50% of MN EV drivers surveyed use renewable energy-sourced electricity rate.

EV present new market for utilities and opportunity as storage.

3,888 Plug-ins in MN, Aug BEV sales up 123% [per zevfacts.com]

Drive Electric MN Bulk Buy Program
+54 Leafs in 2016

242 public electric charging stations with 542 charging outlets

EV Charging Tariff
Xcel Energy: Future Load and Resource Mix

Current Preferred Plan (without Expansion Plan)

- Load Management
- Natural Gas
- Nuclear
- Biomass/RDF/Hydro/Wind
- Coal
- Solar
- Obligation

Capacity reflects Unforced Capacity Values (UCAP); Current Preferred Plan includes retirement of Sherco Units 1 & 2
Xcel Energy: Future Load and Resource Mix

Capacity reflects Unforced Capacity Values (UCAP)
The 2017 results show the impacts of potential or actual generation retirements, as well as changes in load.

2017 Outlook
Comparison of High Certainty Resources
In GW (ICAP)

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forecasted Regional Surplus: 2015 OMS-MISO Survey</td>
<td>2.6</td>
</tr>
<tr>
<td>Point Load Reductions</td>
<td>1.2</td>
</tr>
<tr>
<td>Forecasted Load Reductions</td>
<td>1.5</td>
</tr>
<tr>
<td>Increase in Reserve Requirement (Average Forced Outage Rate Increase)</td>
<td>0.8</td>
</tr>
<tr>
<td>Increase In New Resources</td>
<td>0.7</td>
</tr>
<tr>
<td>Decrease in High Certainty Resources (Confirmed and potential retirements)</td>
<td>2.5</td>
</tr>
<tr>
<td>Forecasted Regional Surplus: 2016 OMS-MISO Survey</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Source: 2016 OMS MISO Survey Results (June 2016)
MISO Assumed Retirements
Policy Regulations Future

Unit Size (MW)
- 600 to 900
- 300 to 600
- 0 to 300

Fuel Type
- Gas/Oil
- Coal

Retirement Type
- Age
- Policy
# MISO Wind Siting

## Table

<table>
<thead>
<tr>
<th>Wind Tier</th>
<th>Total Available Tier Capacity (MW)</th>
<th>Existing Fleet (MW)</th>
<th>Policy Regulations (MW)</th>
<th>Accelerated Alternative Technologies (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 1: RGOS Zones</td>
<td>15,810</td>
<td>2,400</td>
<td>15,810</td>
<td>15,810</td>
</tr>
<tr>
<td>Tier 2</td>
<td>15,795</td>
<td>--</td>
<td>990</td>
<td>14,190</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>31,605</strong></td>
<td>2,400</td>
<td><strong>16,800</strong></td>
<td><strong>30,000</strong></td>
</tr>
</tbody>
</table>
Congestion Driver:

- Lower cost generation in Southern MN and Northern Iowa trying to serve Twin Cities load via 345kV
- Future wind additions in MN/Iowa and coal retirements in Iowa tend to aggravate the congestion

MCPS North Central Congested Flowgates

- Top flowgates were identified using 2030 future weighted congestion
  - Most severe congestion was on the border of Iowa and Minnesota
Resources


"Minnesota and Climate Change: Our Tomorrow Starts Today." Minnesota Environmental Quality Board.


"Electric System Reliability and EPA's Clean Power Plan: The Case of MISO." Analysis Group. (June 8, 2015)

"Climate Solutions and Economic Opportunities (CSEO): A foundation for Minnesota's state climate action planning." Minnesota Environmental Quality Board (March, 2016)

Minnesota Public Utilities Commission Staff Report on Grid Modernization (March, 2016)


Keep your eyes open for: CEE's Energy Storage Report (soon), GPI e2 Initiative Phase II and white papers (soon), Xcel Hosting Capacity Analysis (Dec)
III. Challenges and Opportunities for the Future

- Energy System Efficiency
- Aging Infrastructure
- Cost & Affordability
- Meeting Future System Needs: Minnesota, MISO Region
- Grid Modernization
- Electrification of Transportation
- New Utility Business Models (e21)
- Growth of Distributed Energy Resources
- Reliability & Resiliency
- Growth of Renewable Energy
- Climate Change & Regulatory Framework
- Managing Demand (?)
End
Definition of Grid Modernization

PUC Staff Proposal

“A modernized grid assures continued safe, reliable, and resilient utility network operations, and enables Minnesota to meet its energy policy goals, including the integration of variable renewable electricity sources and distributed energy resources. An integrated, modern grid provides for greater system efficiency and greater utilization of grid assets, enables the development of new products and services, provides customers with necessary information and tools to enable their energy choices, and supports a standards-based and interoperable utility network.”
MISO Solar Siting

Note: Table represents capacity sited in solar tiers. Solar capacity additions split between tier and demand-side siting.

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<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Tier 1</td>
<td>4,600</td>
<td>1,600</td>
<td>4,600</td>
<td>4,600</td>
</tr>
<tr>
<td>Tier 2</td>
<td>5,400(^1)</td>
<td>--</td>
<td>1,000</td>
<td>5,400</td>
</tr>
<tr>
<td>Tier 3</td>
<td>4,550(^1)</td>
<td>--</td>
<td>--</td>
<td>4,400</td>
</tr>
<tr>
<td>Total</td>
<td>14,550(^1)</td>
<td>1,600</td>
<td>5,600</td>
<td>14,400</td>
</tr>
</tbody>
</table>

\(^1\)Total capacity scaled to accommodate solar capacity expansion in Accelerated Alternative Technologies future.
Sources of Greenhouse Gas Emissions in Minnesota

Greenhouse gas emission changes by economic sectors: 2005-2012

Source: MPCA 2015 Greenhouse Gas Emissions Reduction report
MN Renewable Energy Integration and Transmission Study (MRITS, 2014)

40% RPS in Minnesota

- Can be reliably accommodated with upgrades to existing transmission
- Wind and solar increase by 8.5 TWh, balanced by decrease in imports
- Very little change in conventional generation
- MN-Centric region goes from net importer to net exporter

50% RPS in Minnesota, 25% RPS in MISO North/Central

- Can be accomplished with more substantial transmission upgrades
- Increase in MN wind and solar balanced by decrease in coal, increase in exports
- Gas-fired, combined-cycle generation declines from 5.0 TWh to 3.0 TWh
- 2% of Minnesota wind curtailed in this scenario
Grid Modernization & Distribution Planning Law
H.F.3 (2015)

1. Applies to IOUs operating under a multi-year rate plan (Xcel)

2. Incorporates distribution grid modernization investment and planning into biennial transmission plan filing requirements

3. Utility must conduct distribution study to identify points for distributed generation and needed upgrades for DG

4. Xcel will file EPRI Hosting Capacity Analysis in December 2016

5. Utility must identify investment needed to modernize Transmission & Distribution to:
   - Improve reliability, security, conservation, and two-way communication between utility and customers
   - Through technology including energy storage
New Utility Business Models: e21 Initiative

Stakeholder-driven process

Led by Great Plains Institute & Center for Energy and Environment

Goal: “to develop a more customer-centric and sustainable framework for utility regulation, better aligning utility revenue with public policy goals, changing customer expectations, and the changing technology landscape.”

Phase I Report (Dec. 2014)

Phase II Report (by end 2016): White papers on Grid Mod, Performance-Based Compensation, Integrated System Planning
Key White Paper Findings

Energy storage value driven primarily by:

- Distribution upgrade deferral
- Frequency regulation
- System capacity
- ITC and accelerated depreciation (MACRS)

1. Study limited in scope to certain distribution-connected use cases

2. Benefit to cost ratio could increase assuming: storage costs continue to decline & increased need for flexibility with more solar and wind

3. Storage has potential to provide multiple sources of value for customers and utilities—both economic value and in grid reliability.

4. Results subject to change based on tax policy changes, tariff changes, expansion of time-of-use energy prices, substantive changes in cost of storage, renewable energy, or conventional energy
White Paper

Recommendations

1. Encourage cost recovery for storage + solar projects to defer distribution upgrades

2. Utility-controlled, customer-sited distribution upgrade deferral considered mitigation study under MRITS Study

3. Establish pilot projects to demonstrate benefits

4. Ensure projects can capture ITC benefits

5. Encourage MISO to establish clear process to value frequency regulation, other storage market products

6. Consider rate designs and demand response programs accounting for value of behind the meter storage

7. Utilities should define multiple options for control of systems and valuation metrics.
PUC: Grid Modernization

2015 Grid Modernization & Distribution Planning Law (June 2015)

PUC Initial Inquiry: Grid Modernization Presentation at May 12, 2015 meeting

PUC Grid Mod Stakeholder Meetings: 9/25/15, 10/30/15, 11/20/15

PUC Staff Report on Grid Mod (March 2016) Proposed Three-Phased Approach:
• Adopt Definition and Principles
• Potential Action Items
• Long-term Vision for Grid Mod
MISO Interconnection Queue - Active Minnesota Projects

Source: MISO Interconnection Queue
Iowa/Minnesota Congestion

- Congestion driver for FG E
  - Lower cost generation in Northern IA and Southern MN trying to serve Twin Cities load via Lakefield to Wilmarth 345kV
  - Future wind additions in IA/MN and coal retirement in MN tend to aggravate the congestion

<table>
<thead>
<tr>
<th>ID</th>
<th>Monitored Element</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>Huntley - Blue Earth 161kV</td>
</tr>
<tr>
<td>M</td>
<td>Wapello 161/69kV XFMR</td>
</tr>
</tbody>
</table>
IRP Plans

Xcel 2015 Upper Midwest Resource Plan (Docket 15-21)(Before PUC)
- 1000-1,500 MW wind by 2020
- 650 MW solar by 2020
- First Sherco coal retire 2023
- Second Sherco coal retire 2026
- Analyze older CT’s on system to avoid impact of forced outages
- Add CT in N.D. by end of 2025
- 3,200 MW new renewables by 2030

MN Power IRP (approved w/ modif. 7/18/16)
- 100-300 MW wind by end 2017
- 33 MW solar by 2025 (11 MW 2016, 12 MW 2020, 10 MW 2025)
- PUC: up to 100 MW solar by 2022 likely economic resource for MN Power must account for this in competitive acquisitions
- Wind + Manitoba Hydro (storage)
Continued commitment to firming up planned generation interconnections through the MISO process will be required

Potential Generation Additions, in GW*

- 2021 Capacity against Reserve Requirement
  - LRZ 1: 0.4
  - LRZ 2: 0.3
  - LRZ 3: -0.5
  - LRZ 4: -1.7
  - LRZ 5: -1.3
  - LRZ 6: -0.8
  - LRZ 7: 0.9
  - LRZ 8: 0.8
  - LRZ 9: 0.5
  - LRZ 10: 0.5

- Regional High Certainty Balance
  - 2017: 0.9
  - 2018: -0.4
  - 2019: -0.5
  - 2020: -1.9
  - 2021: -2.6

* Wind and solar resources are represented at their expected capacity credit

Source: 2016 OMS MISO Survey Results (June 2016)