



Overcoming Barriers: Wind Integration

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**Northern States Power
Company- Minnesota**

**Northern States Power
Company- Wisconsin**

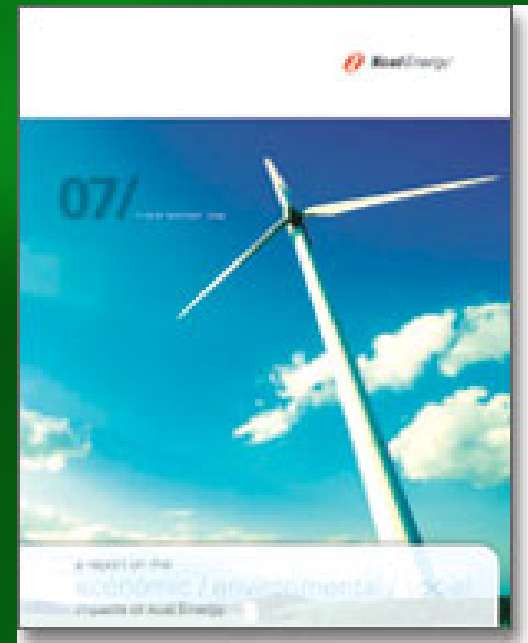
**Public Service
Company
of Colorado**

**Southwestern
Public Service**

**5th Largest Combination
Electric and Gas Utility
(based on customers)**

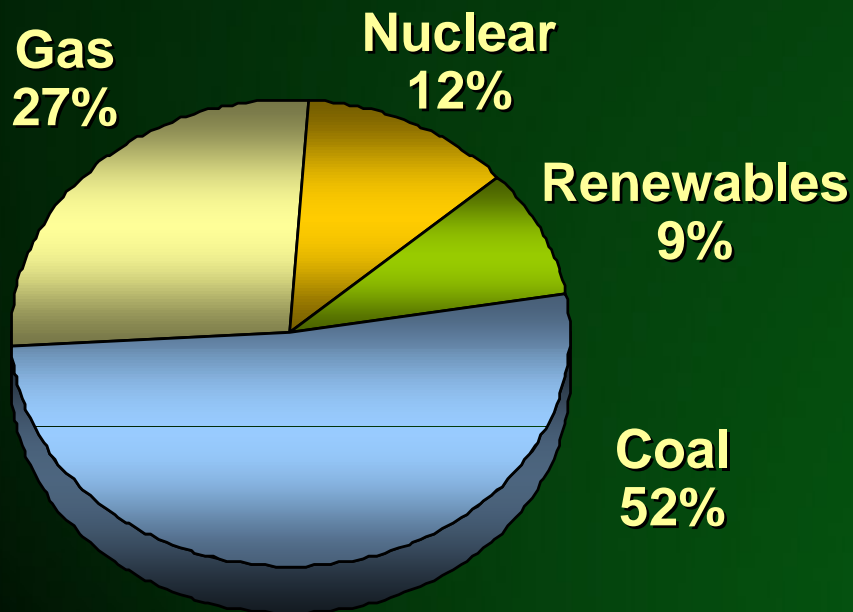
Xcel Energy's Environmental Leadership

- ◆ No. 1 wind energy provider
- ◆ Industry-leading voluntary emission reductions
- ◆ Voluntary carbon management strategy
- ◆ Carbon Disclosure Leadership Index
- ◆ New technologies
- ◆ Member of

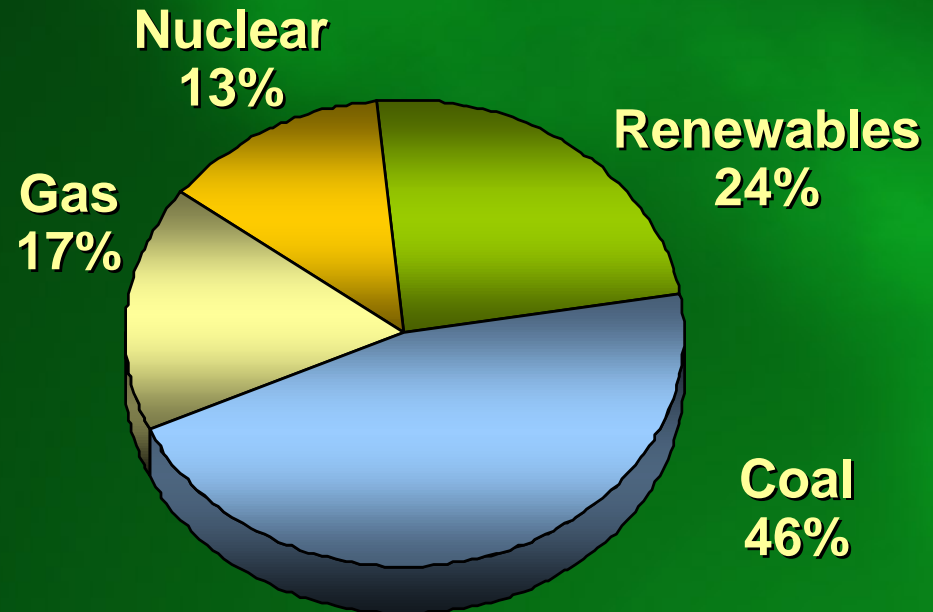


Changing Xcel Supply Mix

**2006
Energy Supply Mix ***

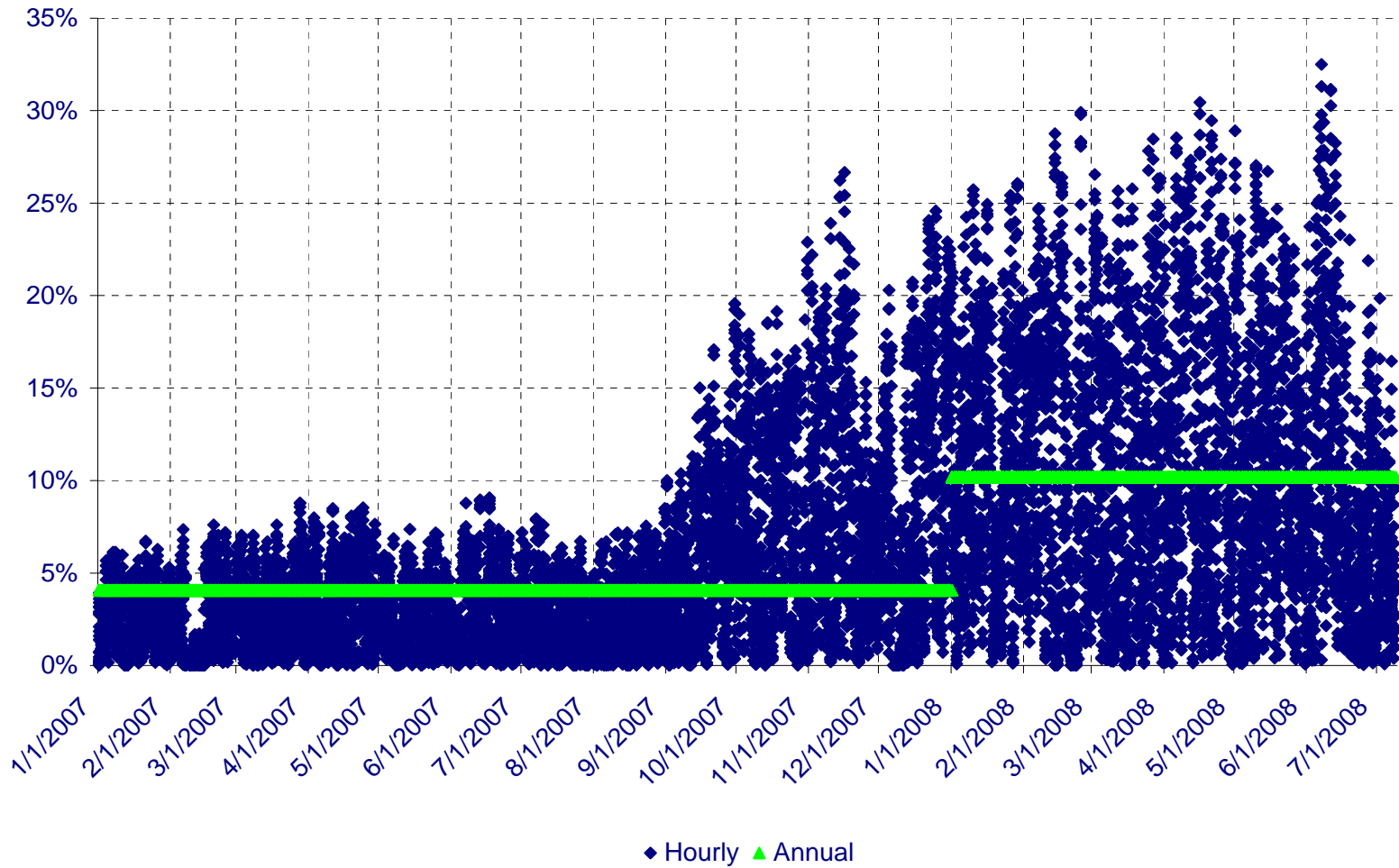


**Estimated 2020
Energy Supply Mix ***





PSCO 1/1/2007 thru 7/8/2008 Wind as a Percentage of Obligation Load



Operating Concerns at High Penetration Levels

- ◆ **Unit Commitment and operating inefficiencies caused by unreliable wind forecasts**
 - ◆ Nearest NWS forecast point to any wind farm 15 miles
 - ◆ No Met Tower data
 - ◆ No data on individual turbine availability
- ◆ **How to move hundreds of MW on and offline**
 - ◆ Usually in 2 hours or less
 - ◆ Combined wind changes bigger than largest unit
- ◆ **System Bottoming out**
 - ◆ Load dropping and wind increasing
- ◆ **Lack of geographic diversity**
 - ◆ Significant number of MW on Wyoming/Colorado Border
- ◆ **Overspeed trips**
 - ◆ RMRG does not recognize wind events as contingencies
- ◆ **Relatively small control area**
- ◆ **Gas System Flexibility**

Challenges Today

- Intra-hour volatility can create operational concerns, especially with PSCo
 - ✓ PSCo - max hour-to-hour wind output change +743 MW and -485 MW (2008)
 - ✓ NSP - max hour-to-hour wind output change +517 MW and -488 MW (2008)
 - ✓ SPS - max hour-to-hour wind output change +260 MW and -233 MW (2008)

Recent Study Results

- ◆ Forecasting
 - ◆ Weather forecasting number one tool to integrate the wind
 - ◆ Needs lots of data from the farms (weather and turbine availability)
 - ◆ NCAR Wind Forecasting system
- ◆ Operations
 - ◆ Flexible generation response to wind changes
 - ◆ Monitor impact on generators
 - ◆ Less than a year operating at these higher penetrations
- ◆ Gas system
 - ◆ Adding storage and balancing flexibility
- ◆ Geographic diversity
 - ◆ Likely decreases ramping burden
- ◆ Market products to assist with balancing

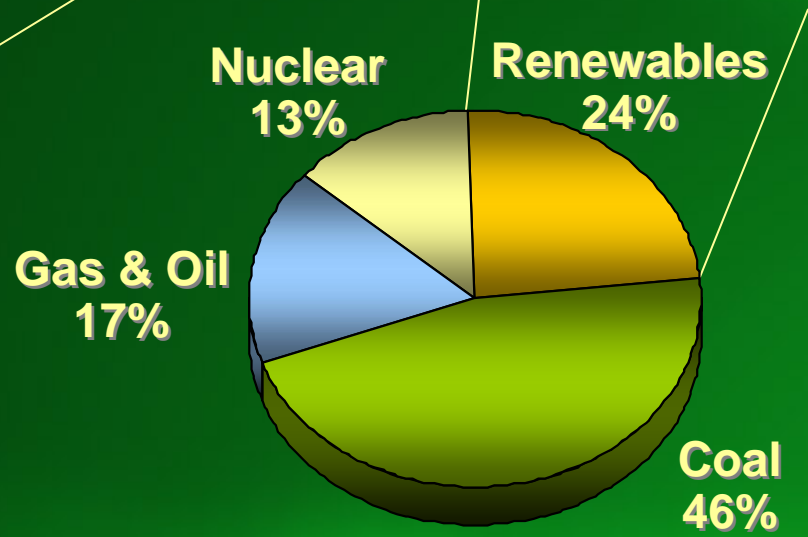
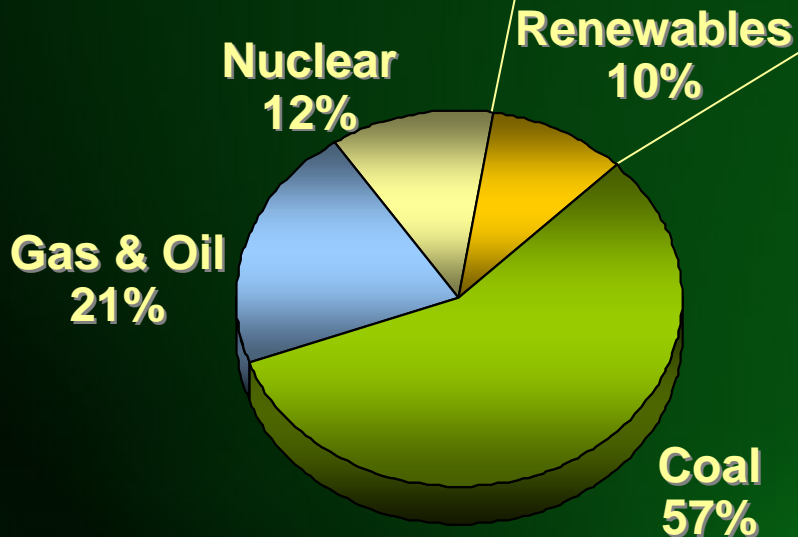
Projected Renewable Resources

MW

Wind
Hydro
Solar
Biomass
RDF
Landfill
Geothermal

<u>2007</u>
2,696
365
17
182
100
15
0

<u>2020</u>
7,400
400
600
250
60
20
20



Conclusion

- ◆ We will continue to add more wind to the system
 - ◆ Steady additions to monitor impacts
 - ◆ Improving forecasting is key
 - ◆ Aligning existing and new generation to support intermittence of wind and solar
 - ◆ Gas system flexibility
 - ◆ Market products to assist with balancing

