

GRE Wind Integration Study

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Wind Integration Key Points

- ◆ GRE studied the impacts of wind variability
- ◆ Variability of wind has cost implications, but they are not prohibitive
- ◆ GRE study concluded that costs range from \$3.19 MWh at 2.4% wind (energy) to \$4.53 MWh at 10% wind (energy). Study evaluated only intra-hour costs.




Who is Great River Energy?

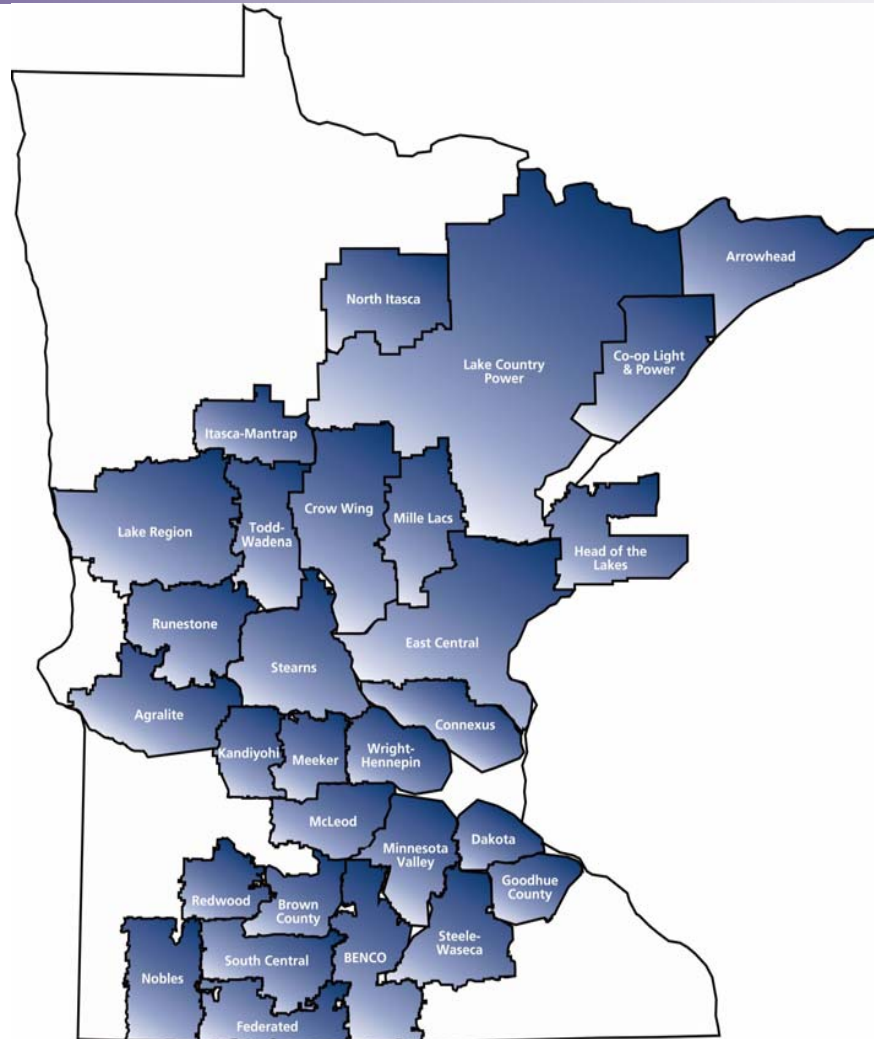
- ◆ G & T Cooperative - provide wholesale electricity to 28 distribution cooperatives
- ◆ Headquartered in Elk River, MN
- ◆ 550,000 meters / 1.5 million people served in MN and northeast WI
- ◆ 2361 MW peak in summer 2003
- ◆ Growing at 3-4% year



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GRE Service Territory



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GRE Wind Experience

- ◆ **6 MW** on-line Chandler MN ('99/'01)
- ◆ **6 MW** on-line Dodge Center MN ('03)
- ◆ **6 MW** under construction Jackson Co.
- ◆ Contract negotiations with Trimont Wind Area LLC for a **100 MW** '04-'05 wind project. Believed to be the largest locally-owned wind project in North America.



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Growing Role for Wind at GRE

- ◆ Growing need for energy
- ◆ Wind energy dropping in price
- ◆ Alternatives becoming more expensive
- ◆ Customers want wind energy
- ◆ MN renewable energy objective requires 1% renewable energy in '05 ramping up 1% per year to 2015 (10% by 2015)



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Wind Required to Meet REO

- ◆ If GRE met REO entirely with wind, it would add wind as follows:
 - **100 MW in 2005**
 - **100 MW in 2007**
 - **100 MW in 2010**
 - **100 MW in 2012**
 - **100 MW in 2015**



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Wind System Impacts Unclear

- ◆ Wind is not dispatchable. When wind generators on-line, other generators need to adjust. Cost impacts unclear at high wind integration levels.
- ◆ Utilities in North America - no experience with wind integration up to 10%.
- ◆ GRE commissioned study of wind ancillary service costs with Electrotek.



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GRE Wind Impact Study

- ◆ Study Objectives - intra-hour impacts
 - cost impacts of wind variability (assuming perfect forecast)
 - cost impacts of wind due to imperfect forecasting
 - additional operating reserves
 - use of less efficient resources
 - control performance degradation
 - cost of unserved energy



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Study Assumptions

- ◆ GRE adds wind in five 100 MW increments in '05, '07, '10, '12 and '15
- ◆ 50% of wind from Buffalo Ridge, MN and 50% of wind from Storm Lake, IA
- ◆ GRE provides ancillary services from its own resources
- ◆ GRE adds 600 MW combined-cycle in '07 (subsequently cancelled)



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Ancillary Service Costs

- ◆ GRE ancillary service costs
 - \$3.19 MWh for 2.4 % wind energy/4.3% capacity
 - \$4.53 MWh for 9.5% wind energy/16.6% capacity
- ◆ \$5.50 per MWh - PacificCorp for 20% wind (capacity)
- ◆ \$2.82 per MWh - Wisconsin Electric for 1,000 MW of wind in 2012
- ◆ \$1.85 per MWh - Xcel for 280 MW of wind today



Why are GRE Costs Higher

- GRE opted to study providing ancillary services from its own generating resources. Currently, there is no market for ancillary services.
- GRE lacks “intermediate” resources that can follow wind economically like marginal coal, hydro or combined-cycle gas.



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Why GRE Costs Higher?

- ◆ GRE used static model in study since smaller generation fleet. Xcel and WE used dynamic models which led to lower costs.
- ◆ Without combined-cycle, GRE's costs would have been higher.



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Conclusion

- ◆ Wind ancillary service costs need to be considered
- ◆ Study costs need to be compared to real costs as wind penetrations rise
- ◆ More emphasis on wind forecasting tools necessary
 - EPRI on-going study
- ◆ Will need a market for ancillary services
 - MISO 2 Q 2005

