

Overview of “Utility Wind Integration and Operating Impact State of the Art”

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AIM SOP Phase I LP

Overview

- Wind is variable
- Primarily an energy source rather than a capacity source
- Present conclusions from UWIG study-of-studies

What is UWIG?

- Non-profit corporation established by 6 utilities in 1989 with support from EPRI and DOE/NREL
- Current membership in excess of 120, including utilities, developers, manufacturers, consultants, government organizations
- Focus on technical issues
- Mission: To accelerate the development and application of good engineering and operational practices supporting the appropriate integration of wind power into the electric system

Utility Wind Integration and Operating Impact State of the Art

- Review after nearly 74,000 MW of wind installed worldwide
- Installed capacity in the US grew from appx. 9,000 MW to 11,600 MW in 2006
- *“Because of this rapid growth, utilities with significant wind potential in their service territories have performed studies of the technical and economic impacts of incorporating wind plants into their systems”*

Primary Conclusion

“On the cost side, at wind penetrations of up to 20% of system peak demand, it has been found that system operating cost increases arising from wind variability and uncertainty amounted to about 10% or less of the wholesale value of the wind energy”

Ancillary Costs from Studies Cited

| Date | Study | Wind Capacity Penetration (%) | Regulation Cost (\$/MWh) | Load Following Cost (\$/MWh) | Unit Commitment Cost (\$/MWh) | Gas Supply Cost (\$/MWh) | Total Operating Cost Impact (\$/MWh) |
|----------|----------------------------|-------------------------------|--------------------------|------------------------------|-------------------------------|--------------------------|--------------------------------------|
| May 03 | Xcel-UWIG | 3.5 | 0 | 0.41 | 1.44 | na | 1.85 |
| Sep 04 | Xcel-MNDOC | 15 | 0.23 | na | 4.37 | na | 4.60 |
| Dec 06 | MN/MNDOC | 33 | na | na | na | na | 4.41 |
| July 04 | CA RPS Multi-year Analysis | 4 | 0.45 | na | na | na | na |
| June 03 | We Energies | 4 | 1.12 | 0.09 | 0.69 | na | 1.90 |
| June 03 | We Energies | 29 | 1.02 | 0.15 | 1.75 | na | 2.92 |
| 2005 | PacifiCorp | 20 | 0 | 1.6 | 3.0 | na | 4.6 |
| April 06 | Xcel-PSCo | 10 | 0.20 | na | 2.26 | 1.26 | 3.72 |
| April 06 | Xcel-PSCo | 15 | 0.20 | na | 3.32 | 1.45 | 4.97 |

Wind Plant Interconnection

- Early operational procedure during a system disturbance was to disconnect wind plant until normal grid operation resumed
- Modern grid codes require LVRT
- Stability studies show that modern wind plants improve system performance by damping power swings and supporting post-fault recovery

Wind Plant Integration Operational Impacts

- Worldwide experience has demonstrated the need for multiple years of wind and load data from diverse sources for meaningful study
- Utilities have experience in variability and uncertainty in load, currently less so with variable/uncertain output
- Variability in wind plant output cannot be dealt with in isolation

Wind Capacity Value

- Well established techniques exist to calculate the ELCC of a wind plant
- Capacity value of wind is 10-40% of nameplate

Transmission Planning and Market Operations

- New transmission will be required for large-scale wind
- Many planning studies underway to investigate changes required to system rules in recognition of the unique characteristics of wind energy

Accommodating More Wind in the Future

Requirements:

- Good wind plant output and behaviour models, along with good forecasting
- Advances in wind plant operational capability, along with increased system flexibility
- Development of deep, liquid day-ahead and hour-ahead markets over broad geographical regions
- Market rules and tariff provisions appropriate to weather-driven resources

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www.nrel.gov/docs/fy07osti/41329.pdf