Southwest Wind Integration Study

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Background

- Issues
  - Meeting Renewables Portfolio Standards
  - Planning of long distance transmission projects
  - Insufficient/inadequate wind data
  - How can wind contribute to meeting energy needs in the southwest?
- Goal
  - To support multi-state interests in understanding the operating and cost impacts of varying penetrations of wind on the grid
    - Western Governor's Clean and Diversified Energy Initiative
    - President's Clean Energy Initiative of 20% wind by 2030
- Proposal
  - To examine southwest, especially loads in Phoenix and Las Vegas, and wind resources in southwest and up through Rocky Mountain area
  - Examine long distance transmission of wind


Wind resources
Loads
Saanich
Bellingham
Seattle
Washington
Tacoma
Spokane
Kalispell
Great Falls
Missoula
Helena
Montana
Williston
Dickinson
Yakima
Kennewick
Butte
Billings
Bozeman
Portland
Salem
Corvallis
Eugene
Oregon
Boise
Idaho
Idaho Falls
Rapid City
Wyoming
Pocatello
Medford
Klamath Falls
Ogden
Cheyenne
Eureka
Redding
Salt Lake City
Greeley
Denver
Chico
Reno
Nevada
Utah
Colorado
Colorado Springs
San Francisco
Sacramento
Stockton
San Jose
California
Fresno
Las Vegas
Santa Fe
Bakersfield
Flagstaff
Albuquerque
Santa Maria
Los Angeles
Victorville
Arizona
New Mexico
Riverside
Costa Mesa
Oceanside
Phoenix
Roswell
Las Cruces
Yuma
San Diego
Midland
Tucson
El Paso
Nogales

Questions to address

- Is it cheaper to use local wind resources or import better class resources from out-of-state?
- How do out-of-state resources compare to local wind resources for matching load profiles? Does geographical diversity help reduce system variability?
- What are the benefits from long distance transmission that accesses multiple wind resources that are geographically diverse?
- Can the required transmission costs be covered by wind or other future generation sources?
- What additional aggregate system operational impacts or costs are imposed by wind variability? What kinds of mitigation measures help to manage that incremental variability?
- How does hydro help with wind integration?
- What is the role and value of wind forecasting?
- What benefit does Balancing Area cooperation or consolidation bring to wind variability management?
- Is there a benefit to aggregating regional wind demand instead of individual utility action?
- How does each wind area contribute to reliability and capacity value?

Phase 1

- Stakeholder group
  - Provide input on scope of study and data
  - Review results
- Technical review committee
  - Carry out study and provide technical review
- Meso-scale modeling of wind
  - Time-coincident 10 minute data for 3 years
- Examine load and wind profiles
  - Examine correlation of diurnal, seasonal patterns
- Preliminary control area consolidation analysis
  - Examine load statistics and compare individual versus consolidated areas

Phase 1 (cont.)

- Build wind/transmission supply curves
  - What are the least cost wind resources, including transmission?
- Select wind penetration levels for scenarios
  - 10, 20, 30%
- Design scenarios that will address questions of stakeholder group. For example:
  - Least cost wind sites (incl transmission costs)
  - Best correlated wind sites
  - Even geographic spread of wind sites across region
  - Wind-only transmission

Phase 2

Evaluate scenarios for cost and operational impacts

- Types of Analysis
  - Production Cost Simulation
    - Hour-by-hour simulation of operations for year
  - Quasi-Steady-State Simulation
    - Minute-by-minute flows for WECC grid for several hours
  - Statistical Analysis
- Production Simulation Analysis
  - Entire WECC system modeled to capture interaction between regions
  - Each scenario examines system relative to common baseline
  - Evaluate based on ‘rational market’
  - Examine impact of varying amounts of wind penetration on the overall operation of the WECC system

Phase 2 (cont.)

- Evaluate physical performance and limitations of power grid
  - Transmission Congestion
  - Generation Capability
  - Available spinning reserves
  - Available regulation and CPS compliance
- Evaluate economic/financial performance
  - Must-take and other bilateral generation contracts
  - QF's and related limitations on market participation

Phase 2 (cont.)

- Evaluate mitigation measures
  - Operational strategies
    - Modification of existing financial, contractual and regulatory requirements
    - Control area consolidation
  - Technology options
    - Improved intelligence
      - Forecasting, Real-time equipment ratings
    - Advanced controls on existing system resources
    - System infrastructure
      - Storage, complementary generation and intermittency management strategies
      - Balanced generation mix, power management transmission
    - Advance controls at wind farms: ramp rate limits, operating with reserve margins, etc.

Seeking input

- Stakeholder group participation
- Input on questions to address in study
- Data for study
- Scheduling of study outputs

- Contact Debbie Lew at debra_lew@nrel.gov or 303-384-7037

Detailed slides

Comparison of Cost-Based U.S. Operational Impact Studies

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
June '06	CA RPS Multi-year	4	0.45*	trace	na	na	0.45
Feb '07	GE/Pier/CAIAP	20	0-0.69	trace	na***	na	0-0.69***
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	4.60
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
Dec '06	MN 20%	25 (energy)					4.41**

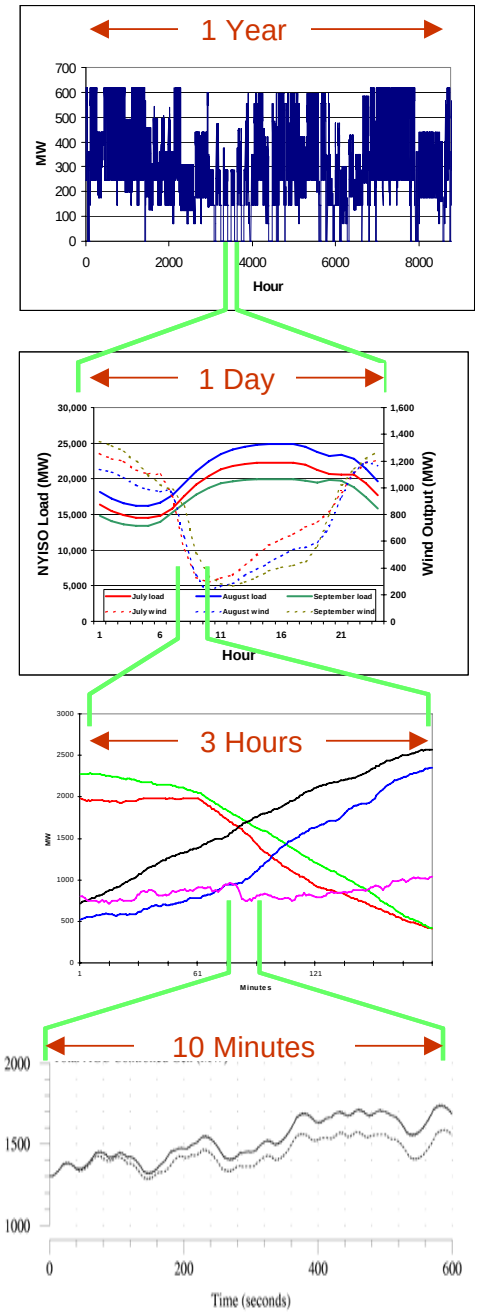
* 3-year average; total is non-market cost

** highest of 3 years

*** found $4.37/MWh reduction in UC cost when wind forecasting is used in UC decision

Time Scales for System Planning and Operation Processes

Time Frame	Planning and Operation Process	Technology Issues
Slower (Years)	Resource and Capacity Planning (Reliability)	Capacity Valuation (UCAP, ICAP) and Long-Term Load Growth Forecasting
Time Frame	Unit Commitment and Day-Ahead Scheduling	Day-ahead and Multi-Day Forecasting
Time Frame	Load Following (5 Minute Dispatch)	Hour-Ahead Forecasting and Plant Active Power Maneuvering and Management
Faster (seconds)	Frequency and Tie-Line Regulation (AGC)	Real-Time and Autonomous Protection and Control Functions (AGC, LVRT, PSS, Governor, V-Reg, etc.)



Analytical Flow for Evaluation of One Scenario