Wind Energy Assessment for Nevada – Measurements and Modeling

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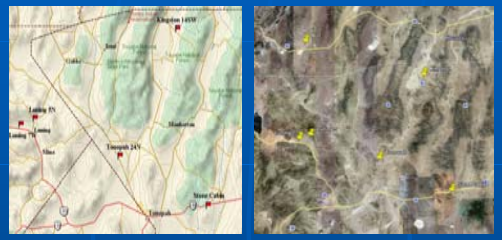
Objectives

Wind energy assessment study for Nevada and the U.S. Southwest

Improved estimates of wind energy potential using tower measurements and high-resolution mesoscale/regional scale modeling.

Measurements: Meteorological towers



Landscape and the locations of Meteorological towers in Nevada (Source: google-earth)

Tower location	Measurements (anemometer type)	Coordinates Lat (° N); Long (° W)	Station Elevation (m)
Tonopah (T)	10,20,30,40, and 50 m (standard)	38.3722; 117.4717	1535
Stone Cabin (SC)	40, 60, and 80 m (sonic)	38.1114; 116.7394	2004
Kingston (K)	10,20,30,40, and 50 m (standard)	39.0455; 117.0008	1780
Luning 5 (L5)	10,20,30,40 and 50 m (standard)	38.5725; 118.1755	1523
Luning 7 (L7)		38.5408; 118.2942	1354
Naval air station B17, Fallon (F)	10 m (standard tower; sonic)	39.3242; 118.2228	1291

Table 1. Meteorological towers in Nevada.

Modeling

Fifth-generation PSU/NCAR Mesoscale Model (MM5)

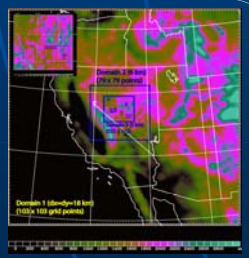
Weather Research and Forecasting Model (WRF)

Model setup: High-resolution simulations on five domains (horizontal grid resolutions: 18, 6, 2, 0.666, and 0.222 km)

40 unequally spaced layers in the vertical (about half of them resolve the boundary layer processes in the lowest kilometer of which 10 layers from the ground are arranged at about 10 m intervals in accordance with the meteorological tower measurements for verification)

Model initialization: Eta model outputs (40-km grid resolution)

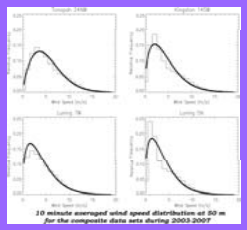
Period: 9 February 2007 – 11 March 2007.



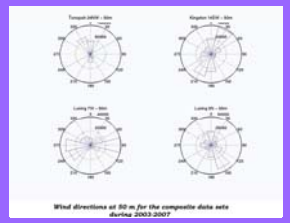
MM5 and WRF Modeling Domains
(D1: 18 km grid; D2: 6 km; D3: 2 km)
sub kilometer grids: D4 (666 m) and D5 (222 m)

Measurements

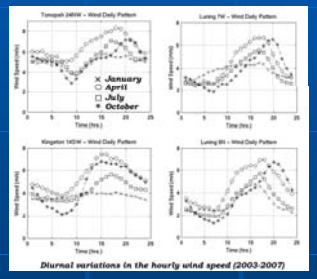
Wind distribution at 50 m



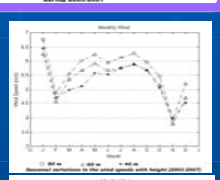
10 minute averaged wind speed distribution at 50 m for the composite data sets during 2003-2007

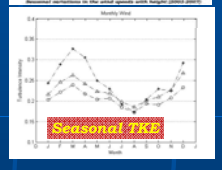


Wind directions at 50 m for the composite data sets during 2003-2007

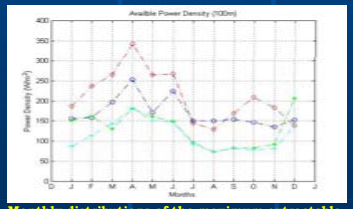


Diurnal variations in the hourly wind speed (2003-2007)

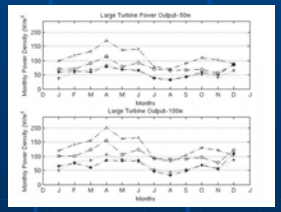




Diurnal



Monthly distributions of the maximum extractable wind power density extrapolated to 100 m using 2003-2007 composite tower data.



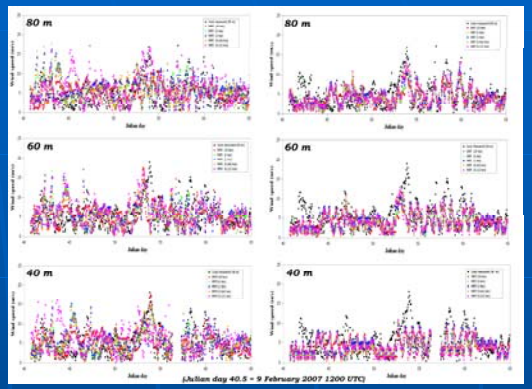
Monthly output wind power density of an ideal large size wind turbine at 50m height (upper panel) and at 100m level (lower panel) using 2003-2007 composite data

The study indicates that larger wind power is available in Nevada from early spring to summer and moderate wind power during fall and winter months.

Belu, R., and Koracin, D., 2009: Wind characteristics and wind energy potential in western Nevada. *Renewable Energy (in press).*

Modeling

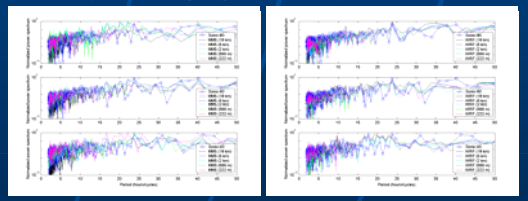
Observed (sonic anemometer wind measurements) and MM5/WRF-simulated wind speeds at Stone Cabin for the Julian days 40-65. (Julian day 40.5 = 9 Feb 2007 1200 UTC).
(Top) 80-m, (center) 60-m, and (bottom) 40-m heights



Wind speed statistics at height 80 m between the MM5 and WRF model results obtained from different model grid resolutions and the sonic measurements at the Stone Cabin tower

Grid resolution	MM5 (RMSE; m s^{-1}) Height = 80 m	MM5 (Index of Agreement) Height = 80 m	WRF (RMSE; m s^{-1}) Height = 80 m	WRF (Index of agreement) Height = 80 m
18km	3.542	0.360	3.293	0.536
2 km	4.399	0.381	3.201	0.604
0.222 km	4.005	0.582	3.128	0.648

Power spectrum of sonic measured and MM5/WRF simulated wind speeds at 40, 60 and 80 m obtained from different model grid resolutions. The power spectrum is normalized by the maximum value.



WRF simulated wind speeds show better track of the diurnal cycle computed from measurements as compared to MM5. The sub-kilometer grid predictions show improvement in the index of agreement of modeled and observed winds.

Acknowledgements

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