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Office of Energy Efficiency & Renewable Energy

National Renewable Energy Laboratory

Innovation for Our Energy Future

MODEL VALIDATION AT THE 204-MW NEW MEXICO WIND ENERGY CENTER

E. Muljadi and C.P. Butterfield
National Renewable Energy Laboratory
Golden, CO 80401

A. Ellis and J. Mechenbier
Public Service of New Mexico
Albuquerque, NM 87104

J. Hochheimer and R. Young
FPL Energy LLC
Juno Beach, FL 33408

N. Miller and R. Delmerico
General Electric International, Inc.
Schenectady, New York 12345

R. Zavadil and J. C. Smith
Utility Wind Interest Group
Reston, VA 20191

Participants

- Public Service Company of New Mexico (PNM): Abraham Ellis, Jeff Mechenbier
- FPL Energy LLC (FPLE): Jack Hochheimer, Russell Young
- General Electric (GE): Bob Delmerico, Nick Miller
- Utility Wind Interest Group (UWIG): Bob Zavadil, Charlie Smith
- National Renewable Energy Laboratory: Ed Muljadi, Sandy Butterfield, Yih-huei Wan, Brian Parsons

Model Validation at the 204-MW New Mexico Wind Energy Center

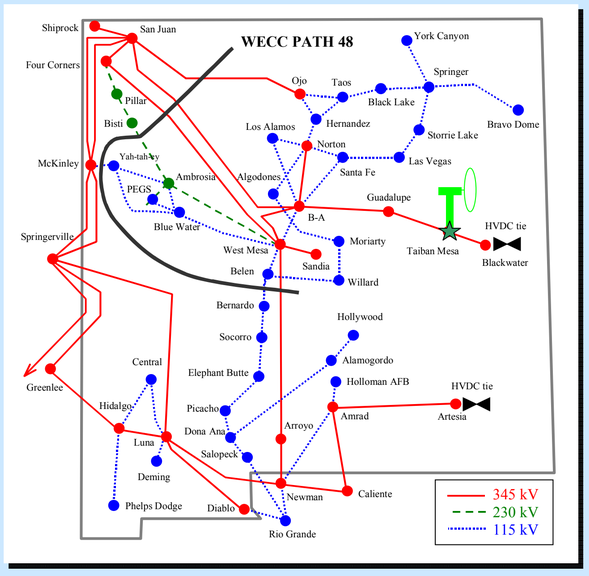
Objectives

- To investigate the impact of aggregation on a large wind farm.
- To explore the dynamic behaviors of the power system and the wind turbine.

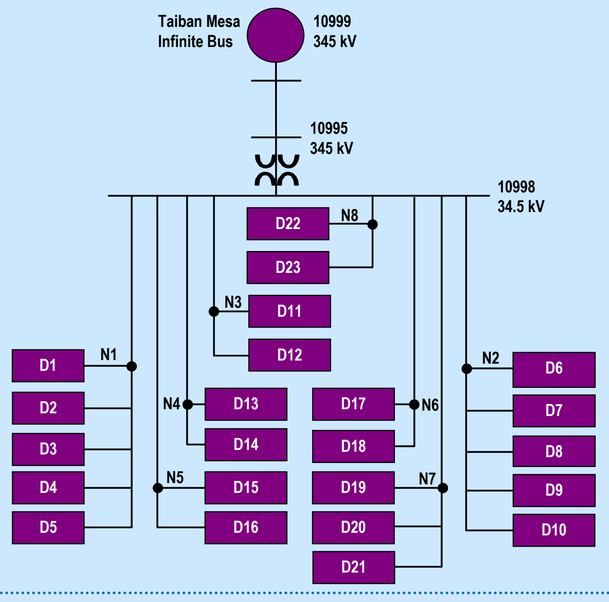
Methods

- Use equivalencing method previously developed to simplify Taiban Mesa wind power plant.
- Use PSLF dynamic analysis to simulate the wind power plant with AWEA-proposed low voltage ride through (LVRT) used to test the systems.
- Represent a 204-MW wind plant two ways, 1) treat the entire wind farm feeding a large power system network as a single generator 2) treat each wind turbine within the wind farm as an individual generator (136 generators) feeding the large power system network.

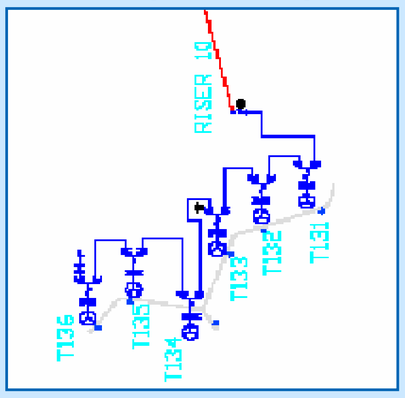
Power System Network Transmission Lines under PNM Service Territory



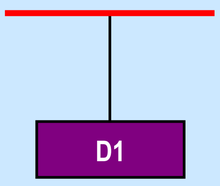
Complete Collector System in the Wind Farm



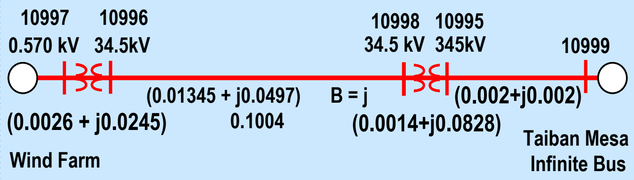
Single Series Daisy-Chain Physical Diagram



Equivalent Representation of Circuit



Single-Turbine Equivalent Circuit for the Wind Farm



Equivalent Circuit of Collector System

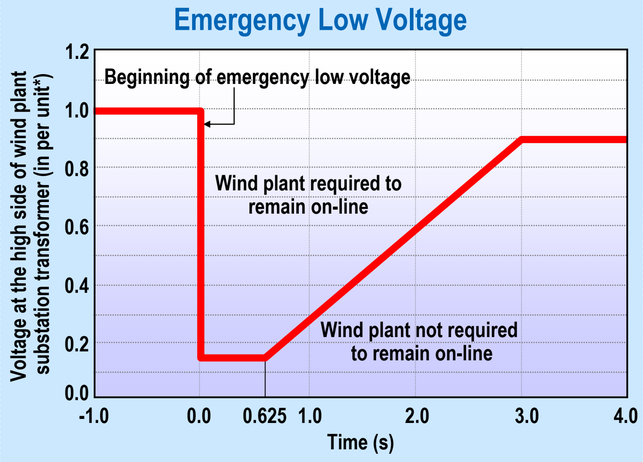
Circuit Representation	Impedance-Shunt Admittance		
	R	X	B
Analytical	0.01345	0.0497	0.1004
Deduction	0.0104	0.0388	0.1004

1. Analytical: simplification of equivalent circuits using series-parallel circuit reduction methods.
2. Deduction: simplification of equivalent circuit based on load flow analysis using losses, branch currents and power flow.

Test Voltage Profile

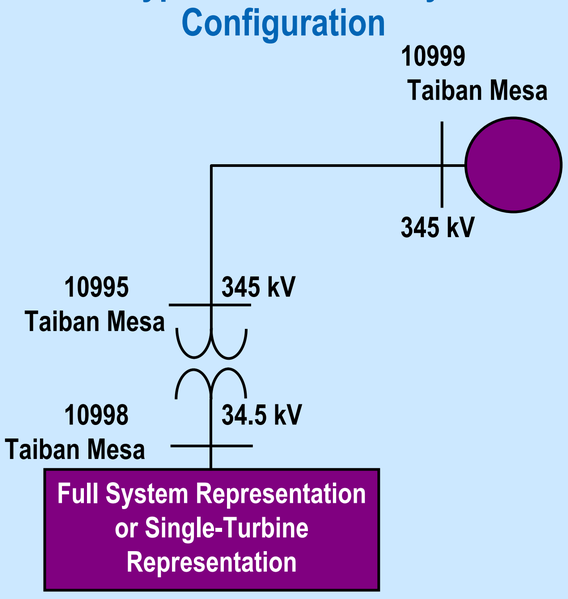
(This test profile was modeled after the LVRT proposal that appeared in FERC NOPR Jan. 24, 2005)

Minimum Required Wind Plant Response to Emergency Low Voltage



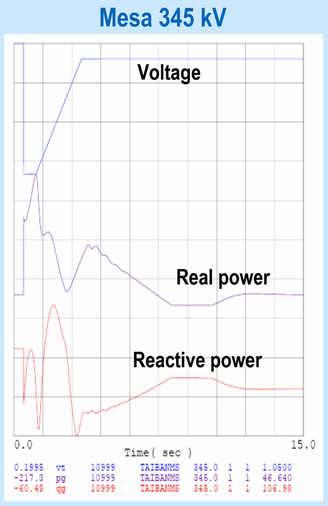
*per unit = ratio of actual to nominal voltage

Single Line Diagram of the Wind Farm for Two Types of Collector System Configuration



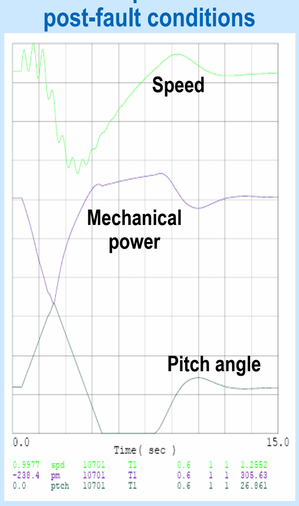
Single Turbine Representation (STR)

Voltage, real power, and reactive power response to the fault at the Taiban Mesa 345 kV

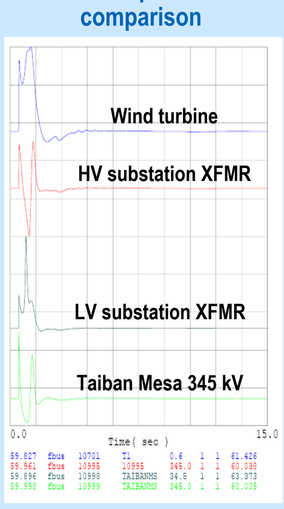


Voltage, real power, and reactive power response to the fault at the wind turbine terminals

Rotor speed, mechanical power, and pitch angle variation pre-fault and post-fault conditions



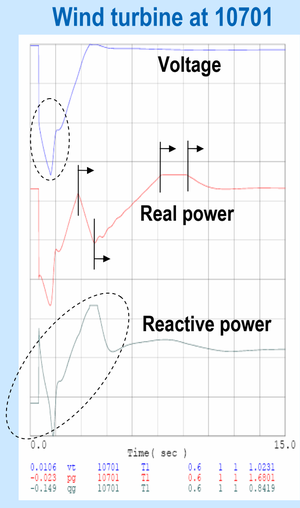
Bus frequencies comparison



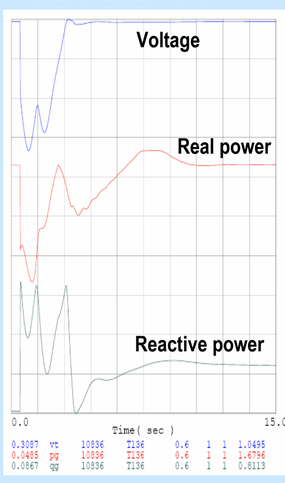
Full System Representation (FSR)

Voltage, real power, and reactive power at two turbines

Wind turbine at 10701

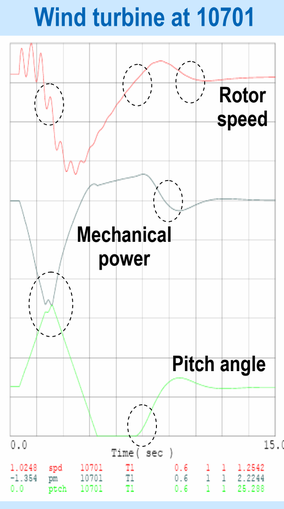


Wind turbine at 10836

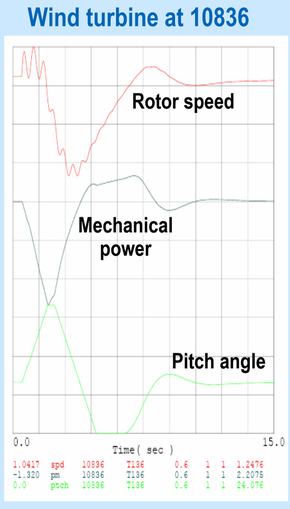


Rotor speed, mechanical power, and pitch angle variations

Wind turbine at 10701

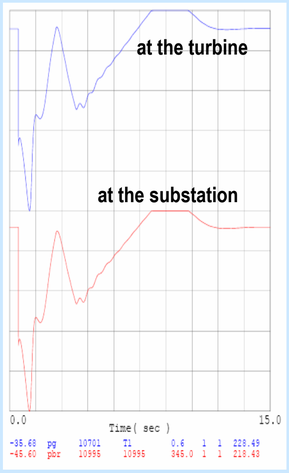


Wind turbine at 10836

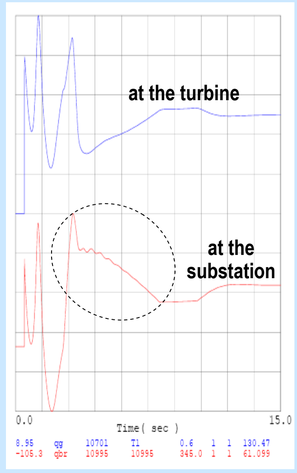


Response at the Point of Interconnection (POI) and Equivalent Wind Turbine

Real power comparison



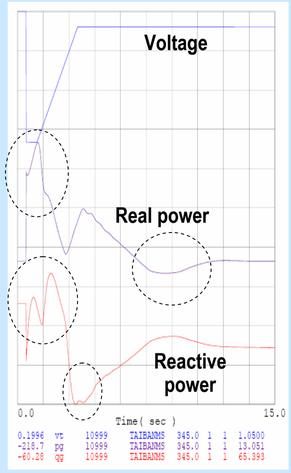
Reactive power comparison



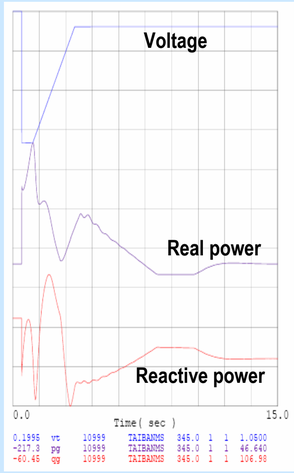
Comparison Between FSR and STR at the POI

Voltage, real power, and reactive power at bus 10999

Full system representation (136 WTGs)



Single turbine representation



Model Validation at the 204-MW New Mexico Wind Energy Center

Results

- Using AWEA proposed LVRT profile, we compare STR and FSR.
- At the point of interconnection, the dynamic response for STR tends to show a sharp change, while the FSR tends to smoothen the response.
- At the turbine level, due the diversity of the wind power plant, each turbine shows a different response.
- STR provides sufficient accuracy for large-scale system studies.

Summary

The results and progress related to this work are reported in the following:

- "Equivalencing the Collector System of a Large Wind Power Plant" to be presented at the IEEE-Power Engineering Society, Annual Conference 2006, June 18–22, 2006, Montreal, Quebec, Canada.
- "Model Validation at the 204-MW New Mexico Wind Energy Center" to be presented at the Wind Power Conference, June 4–7, 2006, Pittsburgh, Pennsylvania.

WINDPOWER 2006 • Pittsburgh, PA • June 4–7, 2006 • NREL/PO-500-39771