

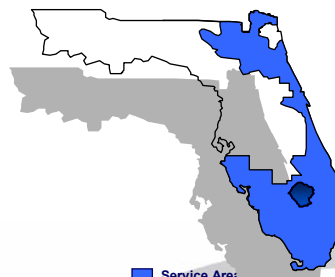
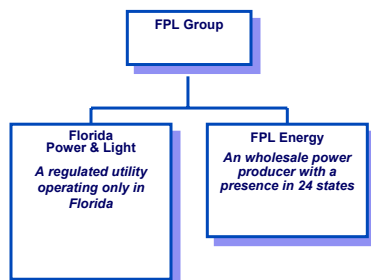


Wind Generation Part I – Planning, Design & Operations

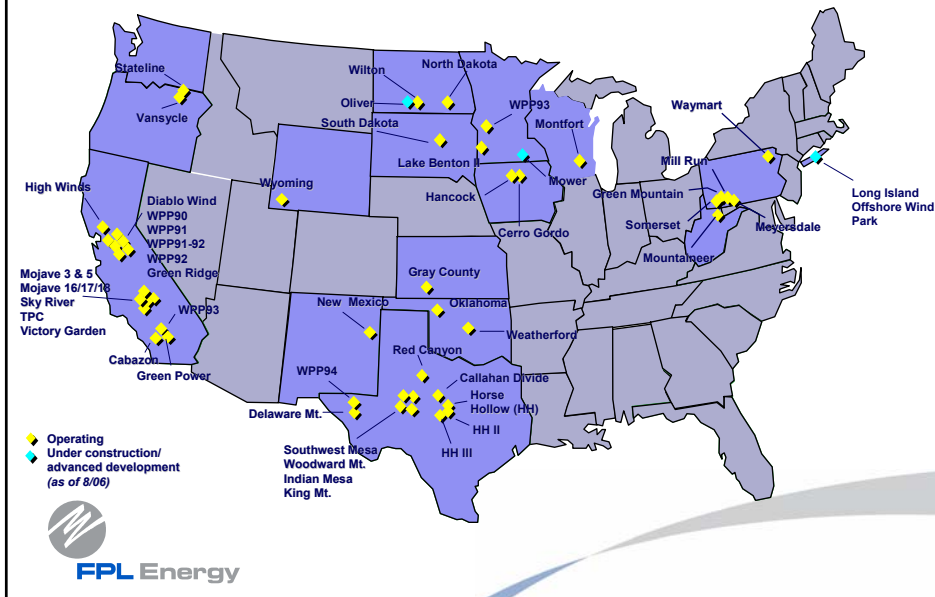
Jack Hochheimer, FPL Energy, LLC

Providing Safe, Reliable Power for 75 Years

***FPL Group —
one of the nation's largest providers
of electricity-related services***



FPL Energy Wind Portfolio



FPL Energy – Wind Facts

- Largest U.S. generator of wind power
- 47 wind farms in 15 states
- More than 3,600 net megawatts
- Approximately 28 percent of FPL Energy's total generation
- 2005 pollution offsets that would have otherwise been released into the atmosphere from other sources of power generation:
 - nearly 4.9 million tons of carbon dioxide
 - more than 13,000 tons of sulfur dioxide
 - nearly 9,000 tons of nitrogen oxide



Fun Wind Facts

- The earliest known windmills were in Persia (Iran) and looked like large paddle wheels.
- Today, the largest wind turbines in the world have blades longer than a football field.
- A typical horizontal wind turbine stands as tall as a 20-story building and has three blades that span 200 feet across.
- One wind turbine can provide enough electricity for about 300 homes.
- Wind turbines in the U.S. generate 17 billion kilowatt-hours per year of electricity, enough to serve 1.6 million households.
- Wind energy is generated in 30 different states. Those with the most wind production are California, Texas, Minnesota, Iowa and Wyoming.
- The U.S. ranks third in the world in wind power capacity, behind Germany and Spain.



Wind Generation Technology

- Asynchronous machines (1.5 to 5 MW ea.)
 - Wound rotor induction machines with external variable resistor to control slip
 - Doubly-fed induction machines
 - Induction machines with full AC-DC-AC converter
- Reactive capability
- Ability to “ride-through” extreme voltage excursions

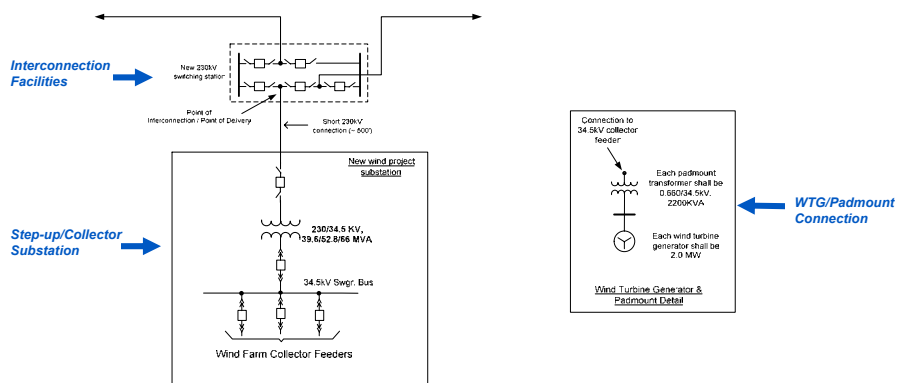


Schedule Considerations

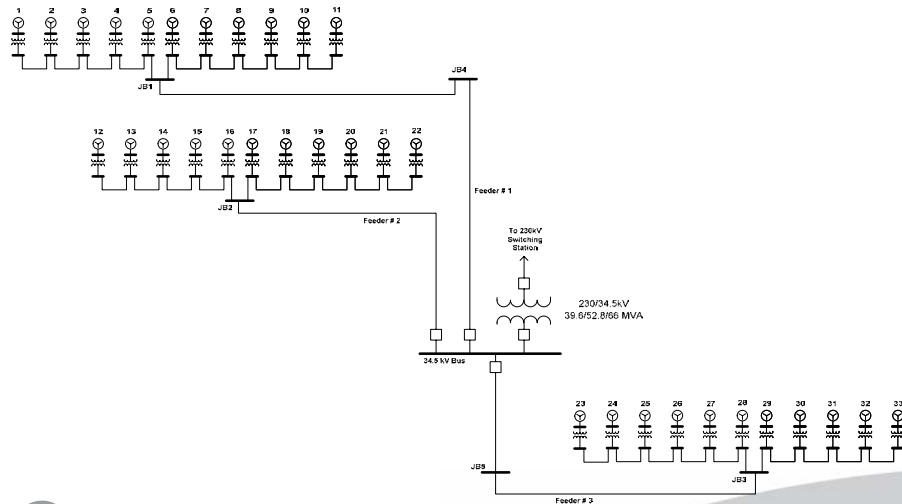
- Production Tax Credit Expiration/Renewal
- Relatively slow interconnection process
 - Studies
 - Agreements
 - Upgrades
- Wind projects go in very fast
 - Hancock 100MW project - 80 days from groundbreaking to full COD.



Interconnection & Step-Up Facilities



Collector System



Collector System

- Large modern wind farms have many miles of medium voltage collector feeders.
- Real & reactive losses.
 - Typical real losses: 2-1/2%
 - Reactive losses much higher
 - Feeder reactances
 - Substation step-up transformer reactance
 - Individual wind turbine padmount transformers
- Voltage gradients across feeders may lead to high voltages at feeder ends – which may limit generator reactive output



Wind Turbine Generator Models

- Relatively recent/strong interest in stability performance.
- Lack of PSLF and PSS/E library models has added time and cost to impact studies.
- Many models now available due to efforts of Suppliers, PTI, GE and Consultants.
- Model validation efforts underway.



Collector Equivalents

- Need to simplify wind farm model
 - Reduce number of buses, branches, transformers, generators
- Accuracy of equivalent
- Current efforts by NREL / PNM / FPLE / GE / UWIG



Dynamic Voltage Deviations

- Occasionally, internal protection trips WTG's for low voltage during nearby faults
- FERC/NERC/AWEA standards:
 - 15 % of nominal: 2006/07 projects
 - 0 %: after 2007
- Solutions (all add cost to projects)
 - WTG control mods
 - Fast VAR injection



Reactive Capability

- Some newer WTG's have reactive capability.
- Transmission Providers expect synchronous machine type performance.
- Wind projects often tie into weak grid locations.
- Possible need for supplemental reactive.
- Feeder voltage regulation considerations.



Communications & Control

- Remote command and control of plant output;
- Telemetry communication for “automatic” forecasting/scheduling.



Thermal Considerations

- Wind generation is often at its lowest levels during Summer peak periods.
- Thermal cooling of conductors and equipment due to high winds may allow higher ratings during periods of peak wind production.
- Some Transmission Providers are willing to take higher ambient wind into account..



Operational Considerations

- Transmission system availability
 - Wind farms often in the boondocks >>> flimsy grids
 - Planned & forced outages
- Reactive capability of modern WTG's can provide needed voltage support to weak grid areas.



QUESTIONS ???