Motivation

- DOE goal of 20% of U.S. energy from wind by 2030
- Gearboxes used in most conventional wind turbines have been a major cause of maintenance and premature failure
- Wind turbines should be made as simple as possible while achieving high reliability and power quality
- Conventional variable speed wind turbines require power electronics to allow the generator to operate at varying rotational speeds
- Power electronics also contribute to system unreliability as well as overall cost and complexity
- It would be ideal if the functions of the gearbox and power electronics could be performed by a single, robust system
- Mid-size wind turbines (10 – 1000 kW) are an underserved market niche that aligns well with the current state of the art in hydrostatic transmissions

Goals

- Design a continuously variable hydrostatic transmission (HST) capable of improving reliability and productivity of mid-size wind turbines
- Build a test stand to allow for system and component testing as well as development of controls for optimized performance

Additional Benefits

- Fluid link between turbine blades and generator in an HST wind turbine allows for more flexible layout options
- Generator can be removed from the nacelle and placed at ground level
- An HST is inherently more compliant than a gearbox, reducing high stress transients through the system
- The HST decouples the wind power from the generator, allowing power spikes from the wind to be better controlled
- Loads within an HST can be carried by a fluid film, allowing theoretical infinite life

Simulation

- Interface NREL’s NWTC design code software with Matlab/Simulink model of continuously variable hydrostatic transmission
- Use available aerodynamic blade performance data for the AOC 15/50 50 kW wind turbine

Preliminary Findings

- HST using typical components modeled and simulated to steady state for range of wind speed through region 2
- Variable HST with typical component efficiencies compared with a fixed speed gearbox
- Typical hydrostatic pumps/motors have low efficiency at low displacement settings
- Despite low efficiency at low wind speeds, higher power is achieved near rated wind speed
- Nearly constant Cp

Test Stand

- In order to run repeatable tests to analyze system design and control strategy options, a test stand will be built to replicate wind turbine loads in the laboratory
- Software will calculate the ‘wind torque’ for a specified wind profile and controls the test stand to apply that torque to the transmission under test
- The test stand is regenerative, so it consumes less power than what is applied during testing

Next Steps

- Develop advanced controls to optimize power generation by analyzing trade-offs between aerodynamic, electrical and mechanical efficiency
- Investigate tandem pump/motor configurations to eliminate low-efficiency displacement requirements
- Development of high efficiency pumps and motors will be driven by this new application

Industry and university collaborators