



Economic and Performance Analysis of Gear Box Failures

Cooperative Research and Development Final Report

CRADA Number: CRD-07-236

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CRADA Report
NREL/TP-5000-65094
October 2015

Contract No. DE-AC36-08GO28308

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In accordance with Requirements set forth in Article XI, A(3) of the CRADA document, this document is the final CRADA report, including a list of Subject Inventions, to be forwarded to the Office of Science and Technical Information as part of the commitment to the public to demonstrate results of federally funded research.

Parties to the Agreement: Xcel Energy

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CRADA Title: Economic and Performance Analysis of Gear Box Failures

Joint Work Statement Funding Table Showing DOE Commitment:

Estimated Costs	NREL Shared Resources
Year 1	\$ 2,400,000.00
Year 2	\$2,300,000.00
Year 3	\$1,500,000.00
TOTALS	\$6,200,000.00

Abstract of CRADA Work:

The National Renewable Energy Laboratory (NREL) in Golden, CO, USA is forming a collaborative within the wind energy industry to address reliability issues on wind turbines. The National Wind Technology Center (NWTC), leading the collaborative effort, will allow gearbox manufacturers, bearing manufacturers, wind turbine owner/operators, and wind turbine manufacturers to team up for joint projects that address specific issues regarding design and reliability of wind turbine gearboxes. The primary means of investigation will be through full scale testing and analysis of actual gearboxes, both in the field and in the NREL 2.5 MW dynamometer test facility. These teams would contribute resources into a campaign that is intended to serve the mutual interests of a majority of the wind and gearbox industry stakeholders in addition to the specific project team objectives.

Summary of Research Results:

Xcel Energy collaborated with NWTC engineers to test two highly instrumented, non-proprietary 750 kW wind turbine gearboxes. The tests were performed uptower in the Xcel Energy Ponnequin wind farm from July to October 2009, and also in the NWTC 2.5 MW dynamometer both from April 2009 to September 2010 and from December 2013 to January 2015. Additional supporting calibration and characterization tests were also performed at both Ponnequin and in NWTC facilities. The NWTC dynamometer facility's unique capabilities for non-torque loading and variable speed and power testing allowed the collaborative to conduct a variety of valuable tests over a short period of time. A comprehensive test plan allowed the collaborative to examine the influence of static and variable non-torque loads on gearbox motion and gearbox planetary

system load sharing, as well as generator misalignment, grid loss, and braking on the high speed bearing loads. Knowledge gained by comparing publicly available engineering models to measured data is disseminated to the industry, which facilitates a greater understanding of gearbox failures and can result in gearbox reliability improvements. Among many technical publications that have been published are detailed test reports, including NREL/TP-5000-51885- and NREL/TP-5000-63693.MP-5000-52587

Subject Inventions Listing: N/A

Report Date: 7/22/2015

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