U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

2021 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
WIND ENERGY TECHNOLOGIES OFFICE

T30 - Advanced Next Generation High Efficiency Lightweight Wind Turbine Generator

Program – Activity Area

Tim MacDonald

American Superconductor Corp.

August 8, 2021

FY21 Peer Review - Project Overview

Project Summary:

- The primary objective was to develop a lightweight, more efficient drive train for wind power generation at turbine ratings of 10MW+ for offshore use while eliminating the reliance of rare earth elements culminating in the manufacturing and demonstration of a prototype unit in an up-tower test.
- AMSC was the prime contract awardee.
- AMSC engaged Spring Fabrication and Everson-Tesla, Inc. for manufacturing support
- NREL performed the levelized cost of energy (LCOE) analysis with input from AMSC

Project Objective(s) 2019-2020:

- Reduce LCOE by 10% minimum with 15% stretch target
- Reduce mass by 35% minimum with 50% stretch target
- Increase system efficiency by 1% minimum with 2% stretch target
- Reduce rare earth elements by 25% minimum with 100% stretch target
- Increase torque density by 35% minimum with 50% stretch target

Overall Project Objectives (life of project):

- The project will lower the cost of energy for offshore wind power generation by at least 10% while eliminating the reliance on rare earth elements.

Project Start: [September 2019]
Expected Completion: [August 2020]
Period of Performance: [1] years

DOE Share: $500,000
Cost Share: $125,000
Total Project Budget: $625,000

Key Project Personnel: Tim MacDonald, Peter Winn, John Sullivan

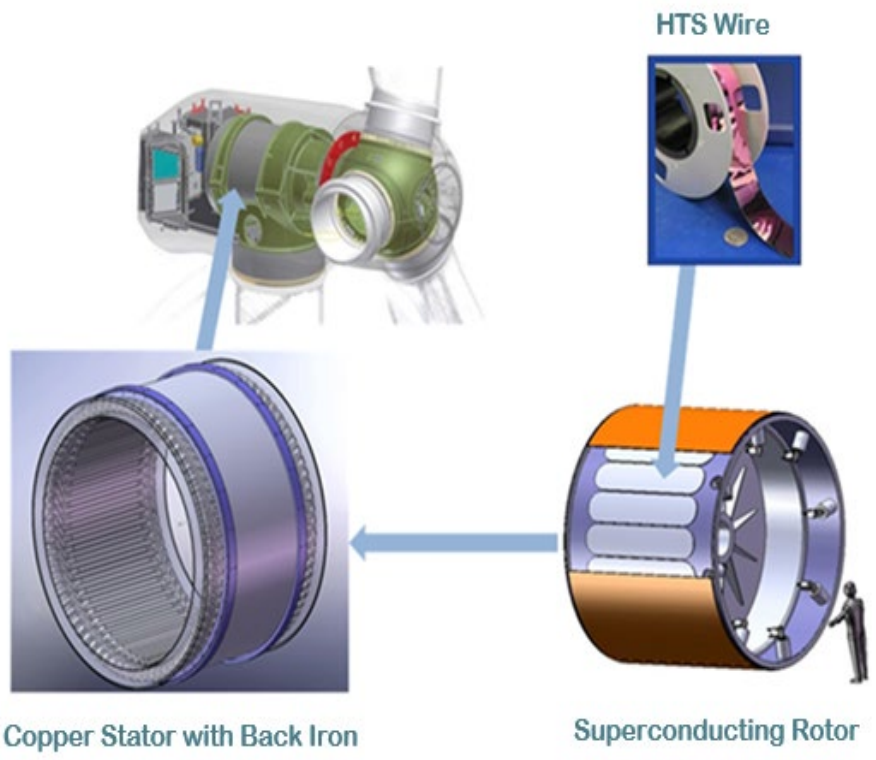
Key DOE Personnel: Michael Carella, PM
Nathan McKenzie, Technical Lead

Program Tasks

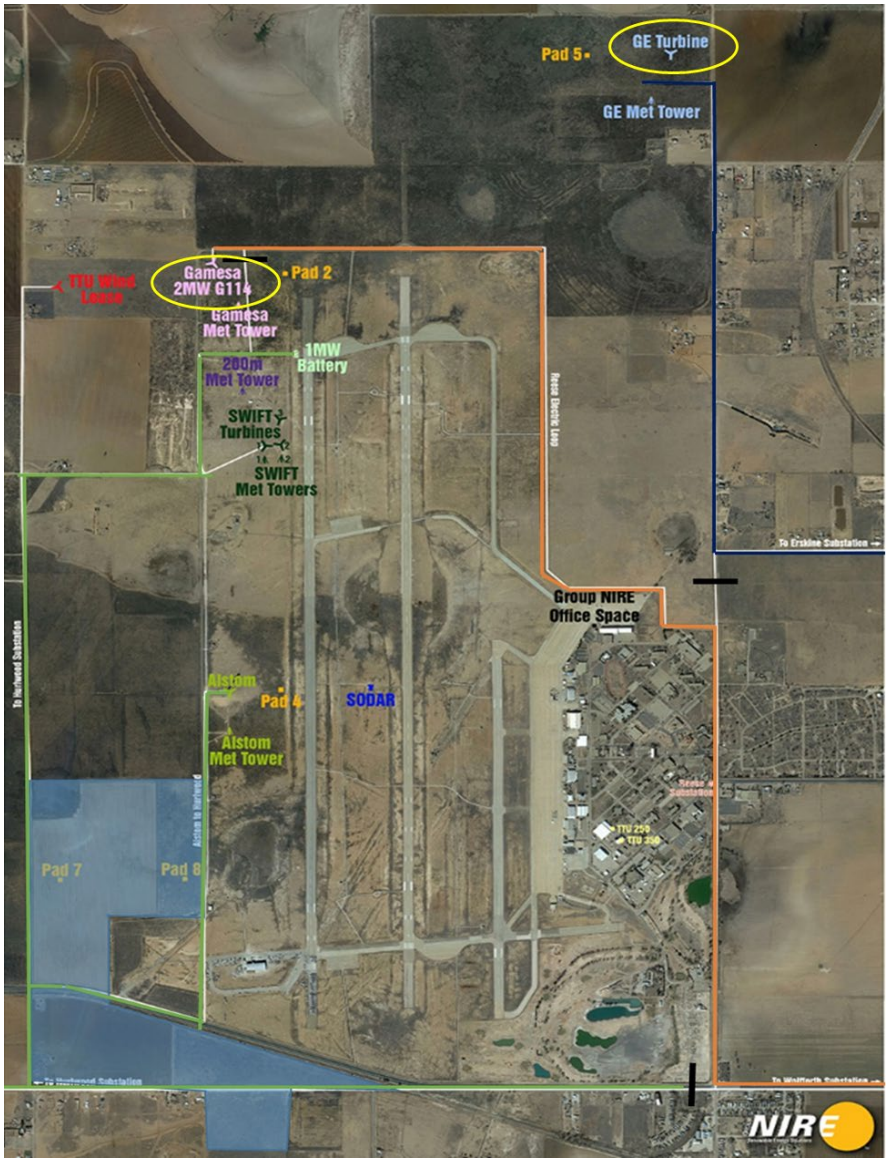
Program Management	Develop schedule and resource plan for Budget Period 2 and 3 Initial FMEA to quantify risk
Preliminary design of prototype drive train for up-tower demonstration	Select manufacturing partners Develop plan for prototype and serial production
Identify up-tower test site	Develop plan to obtain all necessary agreements, licenses, and permits for the installation and demonstration of prototype drive train
Perform LCOE analysis in conjunction with NREL	Calculate key performance indicators

Novel Drive Train Solution

- **Direct-drive HTS generator for wind power applications scalable to 10MW+**
  - Lighter weight
  - Increased power density
  - Increased system efficiency
  - Eliminate rare earth element reliance, specifically neodymium

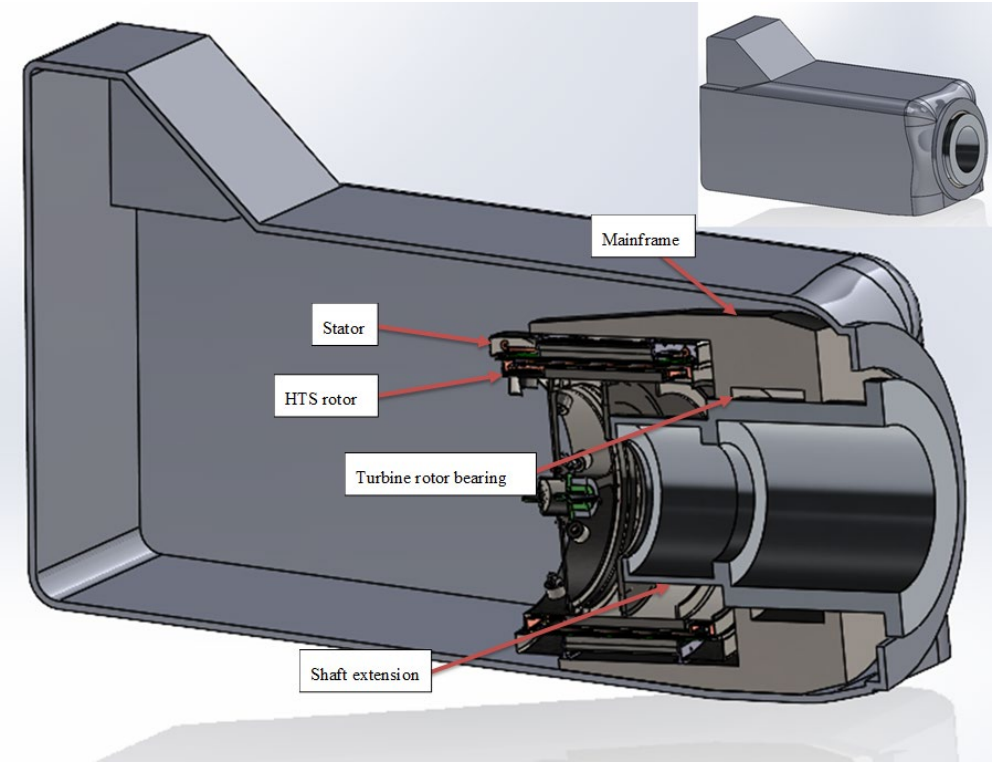


Up-tower test site



- Reese Technology Center outside Lubbock, TX
- Turbines circled in yellow no longer present
- Pad “X” are open sites
- Group NIRE assist with permitting, agreements, and licenses necessary for new construction
- Towers below 100m height and 6.5MW generation do not require special permitting and fit under current agreements

Modify AMSC 5.5 MW Turbine



- AMSC 5.5 MW onshore wind turbine with 100m tower height and 140m rotor diameter
- Minor modifications to nacelle to incorporate 10MW HTS generator drive train
- Tower height and turbine rating align with Group NIRE's agreement so no special permits required

LCOE Analysis

- **NREL performed LCOE analysis using Wind-Plant Integrated System Design and Engineering Model (WISDEM)**
  - Modeled wind farm using a turbine with HTS drive train versus current state of the art technology
  - Calculated Key Performance Indicators
- **AMSC supplied necessary information for LCOE and Key Performance Indicator calculations**
  - Detailed BOM and man-hours for HTS generators
  - Supplied COTS support equipment costs for cabling, auxiliary cooling equipment, transformers, and converters

LCOE Analysis Results

Metric/KPI	Unit	Target	Stretch Target	HTS Generator Standard Wire			HTS Generator Irradiated Wire		
				10 MW	15 MW Fixed	15 MW Floating	10 MW	15 MW Fixed	15 MW Floating
Mass Reduction (generator subsystem)	kg	-35%	-50%	-26.7%	-29.5%	-29.5%	-31.7%	-41.0%	-41.0%
Rare Earth Elements (Nd) Reduction	%	25%	100%	100%	100%	100%	100%	100%	100%
Torque Density Increase (generator subsystem)	$\frac{kN * m}{kg}$	35%	50%	48.5%	67.3%	67.3%	52.1%	80.4%	80.4%
Full Load System Efficiency Increase	%	+1%	+2%	1.51%	0.11%	0.11%	1.93%	0.54%	0.54%
Reduction in Wind Turbine LCOE	$\frac{USD}{kWhr}$	-10%	-15%	-1.47%	-2.5%	-2.64%	-4.68%	-5.20%	-4.62%

Proposed Prototype HTS generator for up-tower demonstration

Future Work

- **Analysis shows first cost of the drive train main influence in LCOE reduction**
  - Reduce cost of HTS wire through manufacturing improvements – 2021/2022
  - Implement irradiation process in HTS manufacturing process – 2022/2023
- **Engage with wind energy partners for pathway to market**
  - MHI Vestas
  - Doosan Heavy Industries
  - Inox India

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