



Frontier Wind
Reinventing Wind Power™

Bat Impact Minimization Technology

NWCC/AWWI Webinar

December 2015

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Frontier Wind Overview

Halloran Energy Group

Broad Experience

Operations

Energy Unlimited Inc.

- US wind pioneer
- ~400 operating turbines
- 30MW of V100's
- 300+ MW in development

Service



- Leading drivetrain inspections & condition monitoring provider
- >15,000 turbines inspected

Technology Development



- Global leader: active load mitigation solutions
- Founded: 2008
- HQ: Sacramento
- Patents > 200



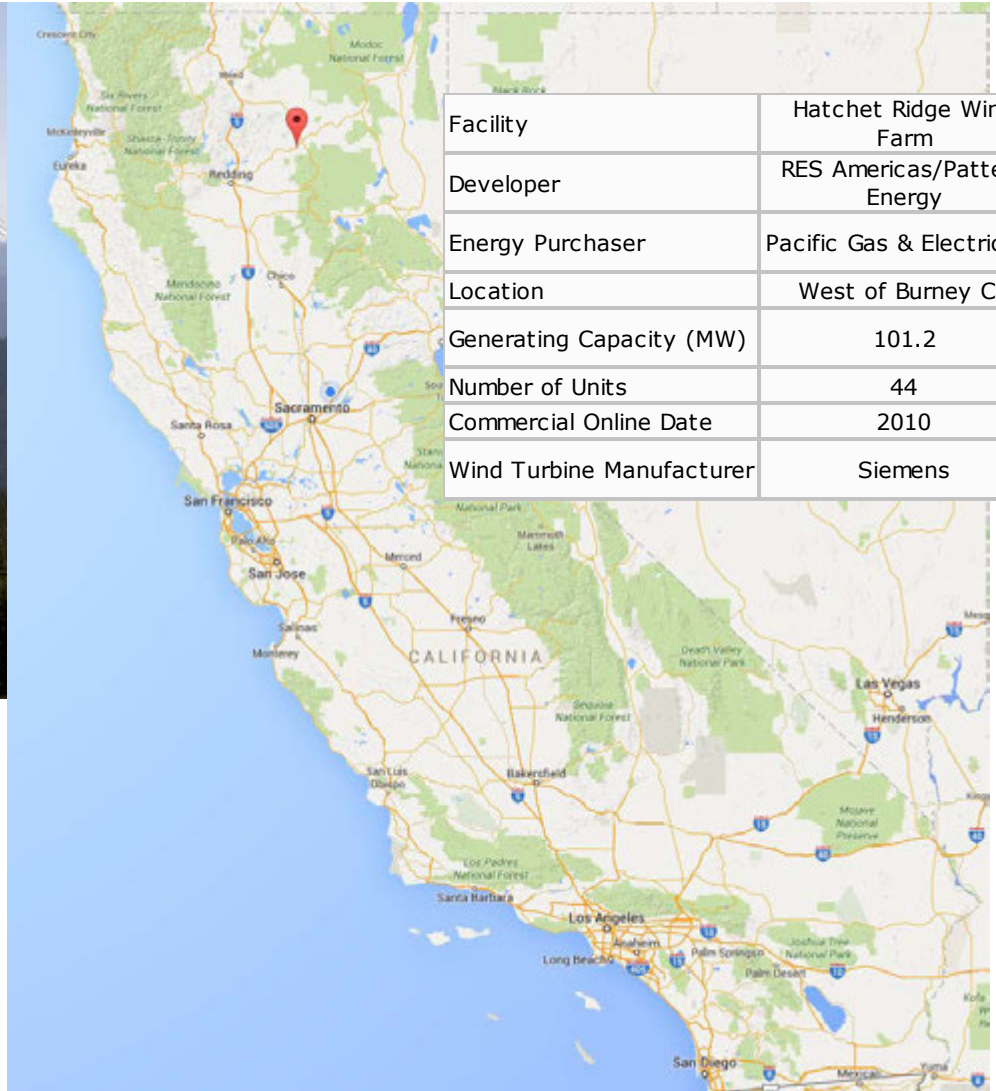
Project Overview

Collaborators

- Pattern Energy
- US Forest Service
- WEST, Inc.
- Bruce Walker, Ph.D., INCE Cert
- Frontier Pro Services
- California Energy Commission
- Department of Energy



Hatchet Ridge Wind Farm Overview



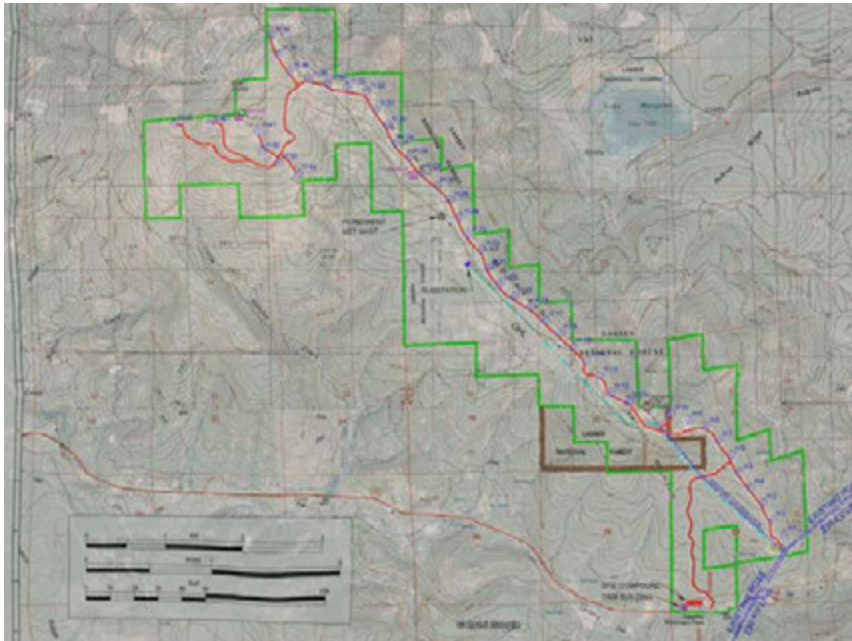
Facility	Hatchet Ridge Wind Farm
Developer	RES Americas/Pattern Energy
Energy Purchaser	Pacific Gas & Electric Co
Location	West of Burney CA
Generating Capacity (MW)	101.2
Number of Units	44
Commercial Online Date	2010
Wind Turbine Manufacturer	Siemens

Siemens 2.3 MW Wind Turbine Specs

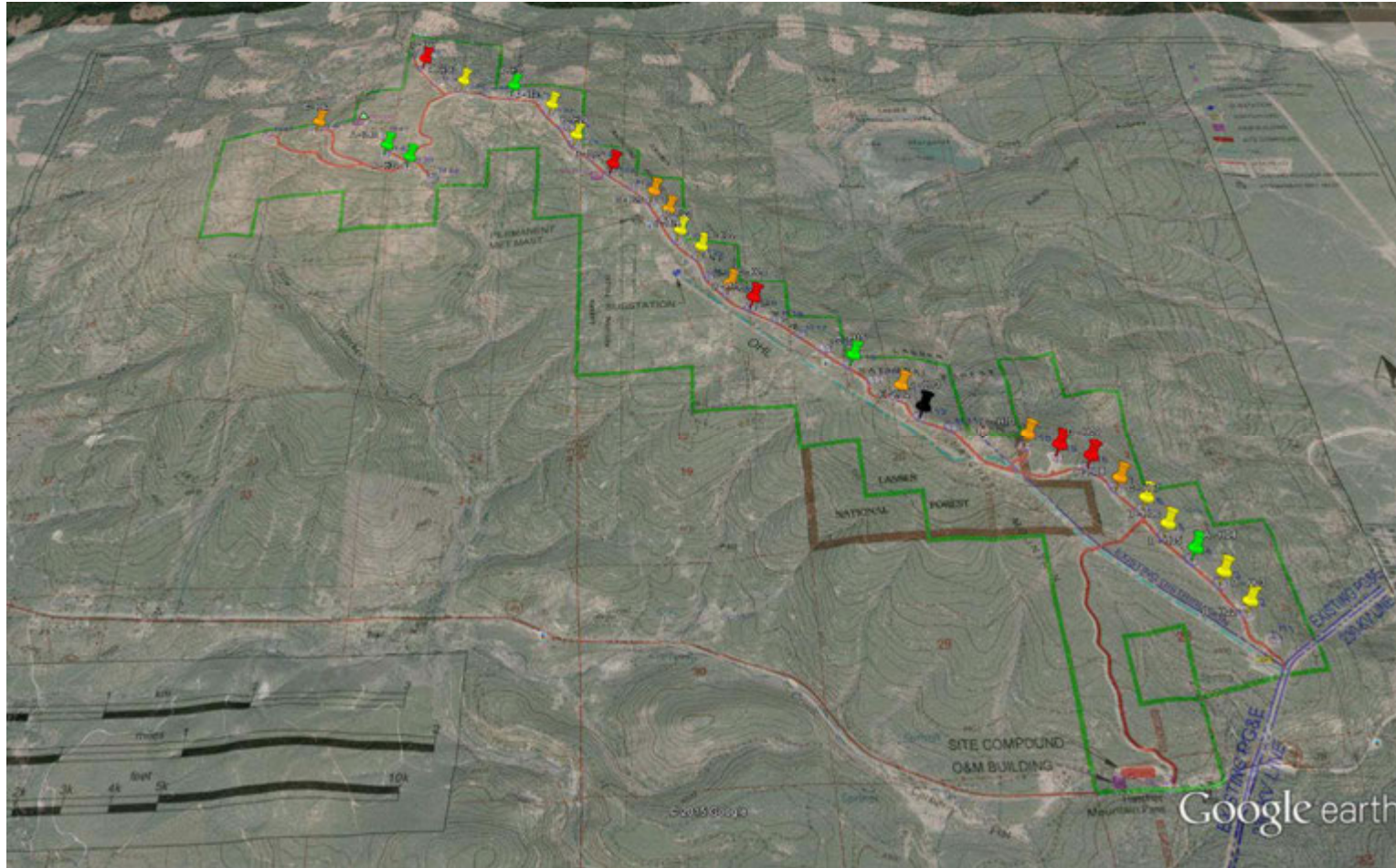
Rotor Diameter: 93m
 Tower Height: 80m
 Cut-in: 4 m/s
 Cut-out: 25 m/s

Hatchet Ridge Specifics

- Elevations range from 4,300 ft (1310m) to 5,470 ft (1667m)
- Stretches along a 6.5 mile (10.5 km) ridgeline



Hatchet Ridge Wind Farm



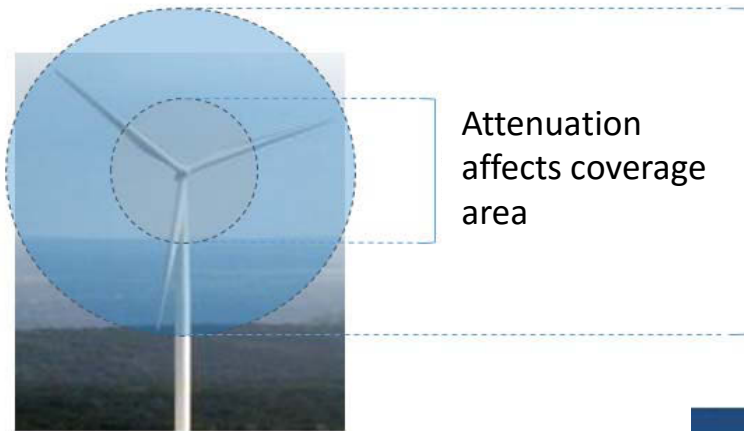
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Motivation

- Hatchet Ridge lies within the migratory path of bats (Silver-haired, Hoary, Brazilian Free-Tailed, Big Brown)
- Wind farm was monitored over a three-year period after commissioning
- Located in California
 - One of the criteria for CEC funding
 - Frontier Wind headquartered in Sacramento

Bat Impact Deterrence Systems (BIDS)

FW Bat Impact Deterrence System



Blade-mounted System can mitigate attenuation affects

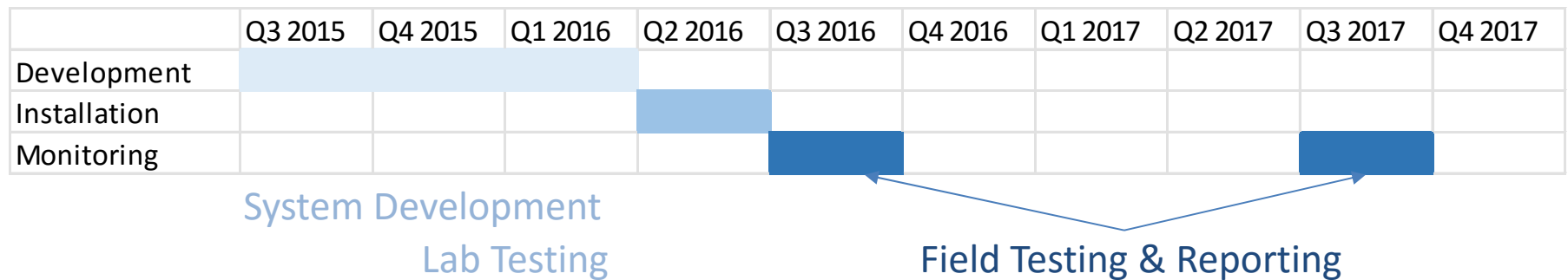
- Bat grants assist in the development of FW bat deterrence system
- Customizable for local bat species
- Compensates for atmospheric and turbine operating conditions
- Retrofit solution
- Designed to maintain blade warranty



Timeline

Project Timeline

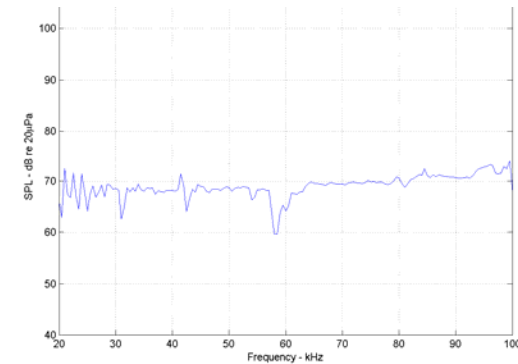
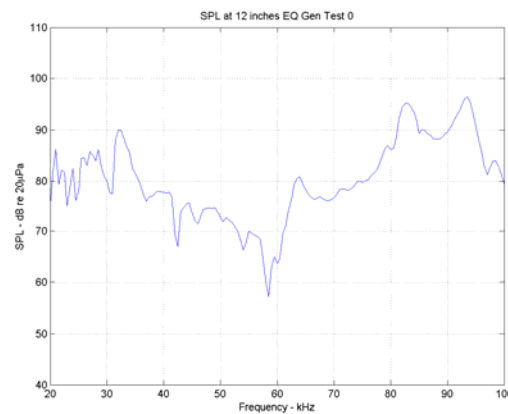
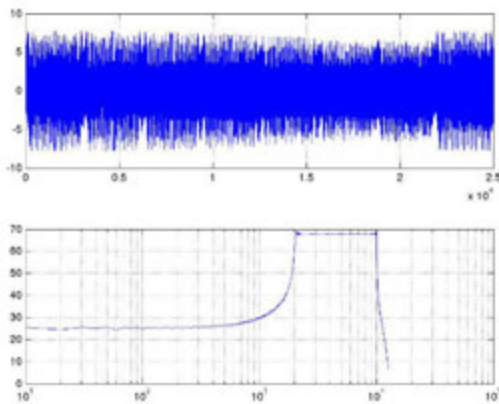
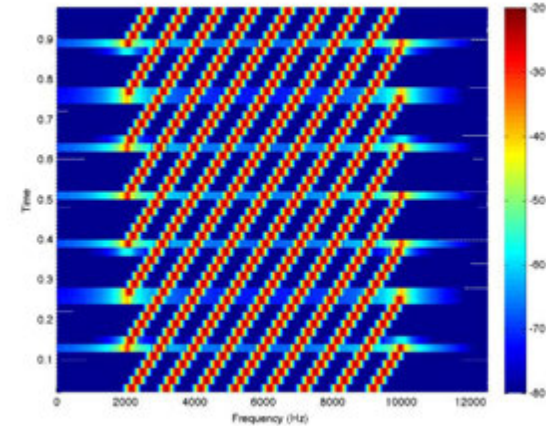
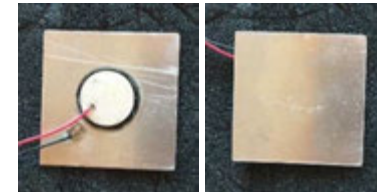
- System development completed Q1 2016
- Two-year monitoring program
 - Monitoring program designed by WEST, Inc. and Ted Weller (US Forest Service)
 - WEST, Inc. to conduct searches
 - Daily searches for 8 weeks



Project Progress

Progress to-date

- Acoustics
 - Transmitter family selected
 - Signal generation method identified
 - Equalization methods identified



Measured Transmitter Response

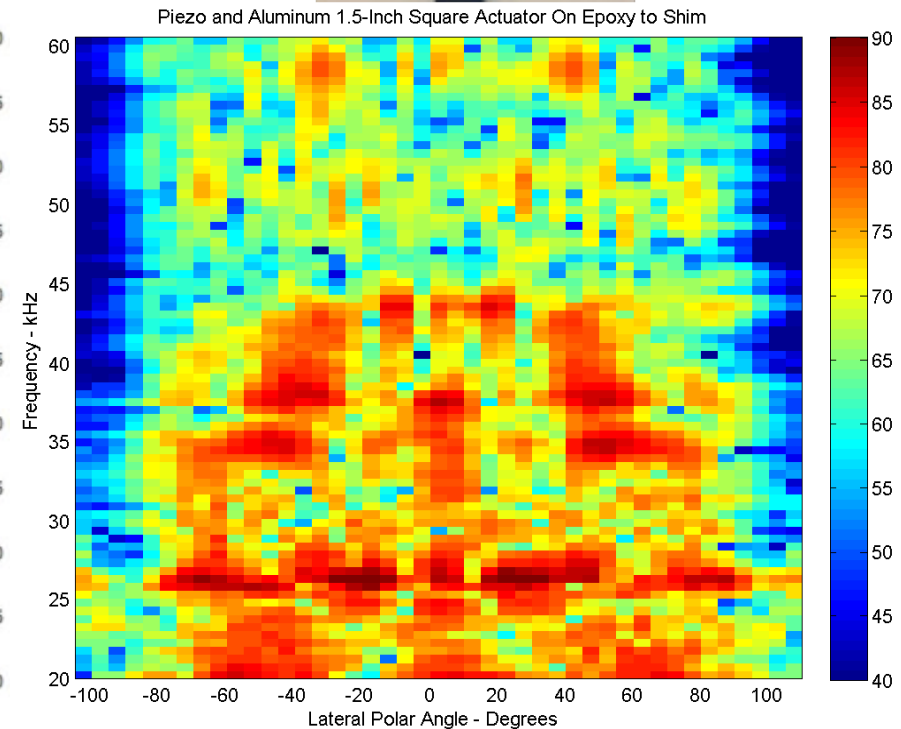
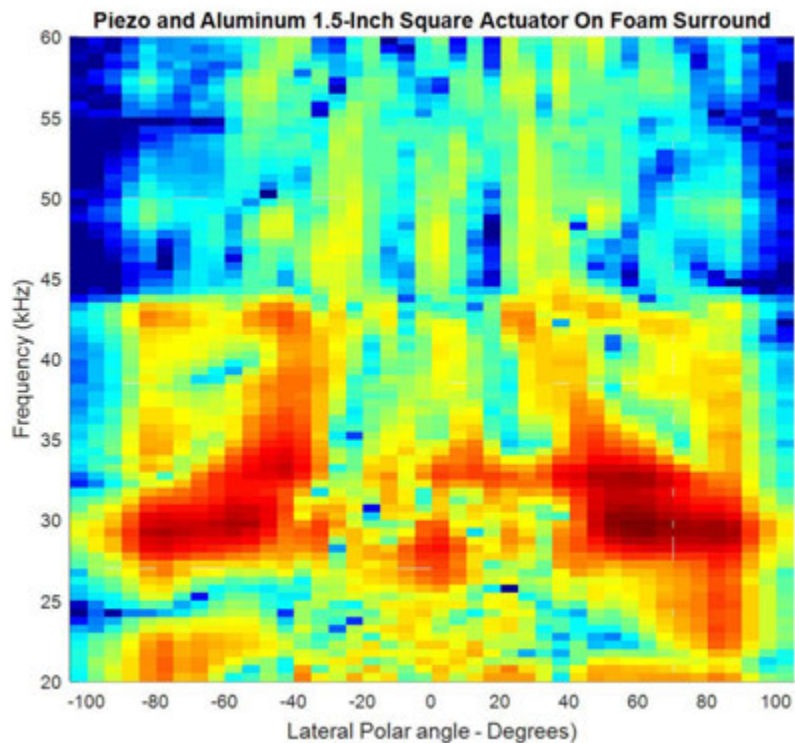
First Prototype Actuator – Boundary Condition Trials



Foam Surround

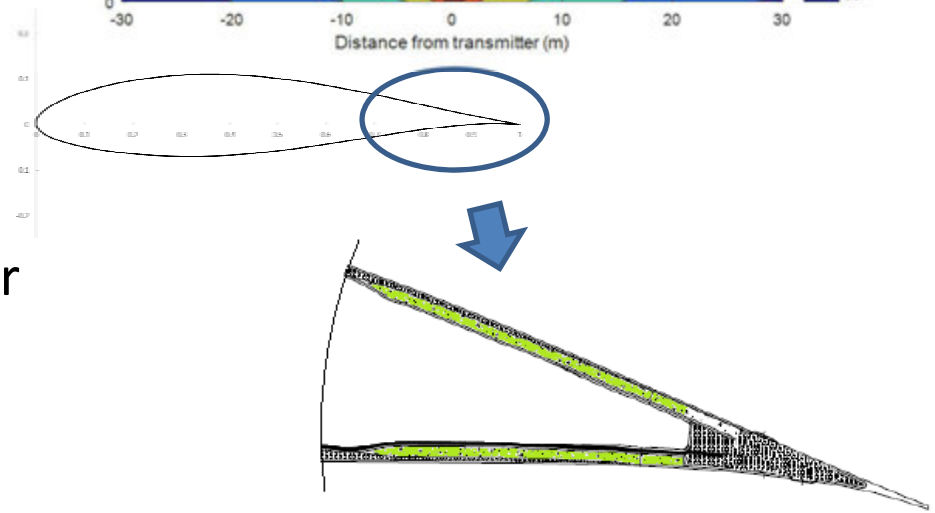
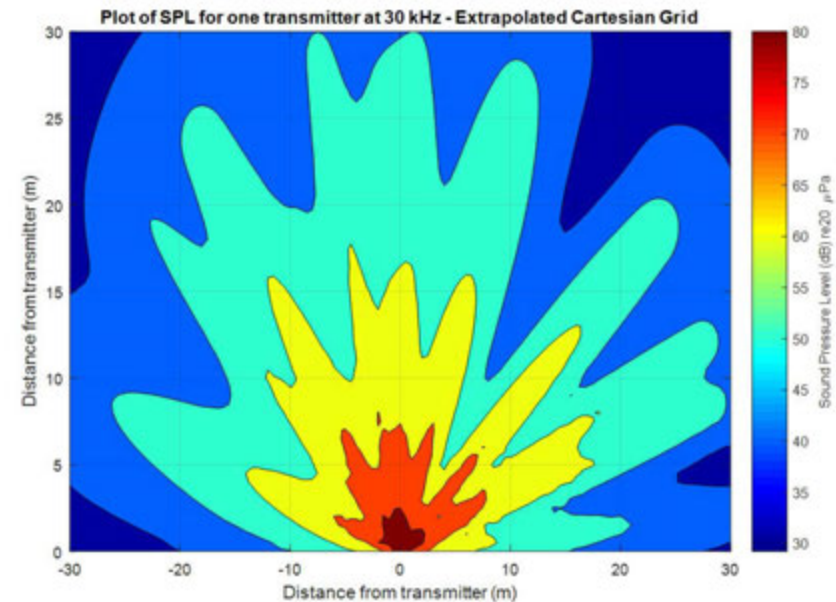


Plastic Surround



Progress to-date

- Acoustics
 - Off Axis performance measurements
 - Modelling of atmospheric absorption, and wave loss to determine spacing
- Turbine Integration
 - Transmitter placing does not interfere with lightning protection system
 - Airfoil go-zones defined
 - Surface-mount does not alter blade warranty

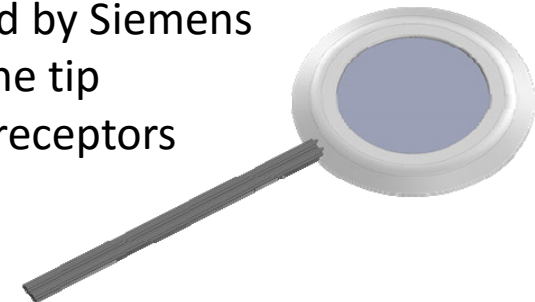


Wire Harness schematic and Blade Integration

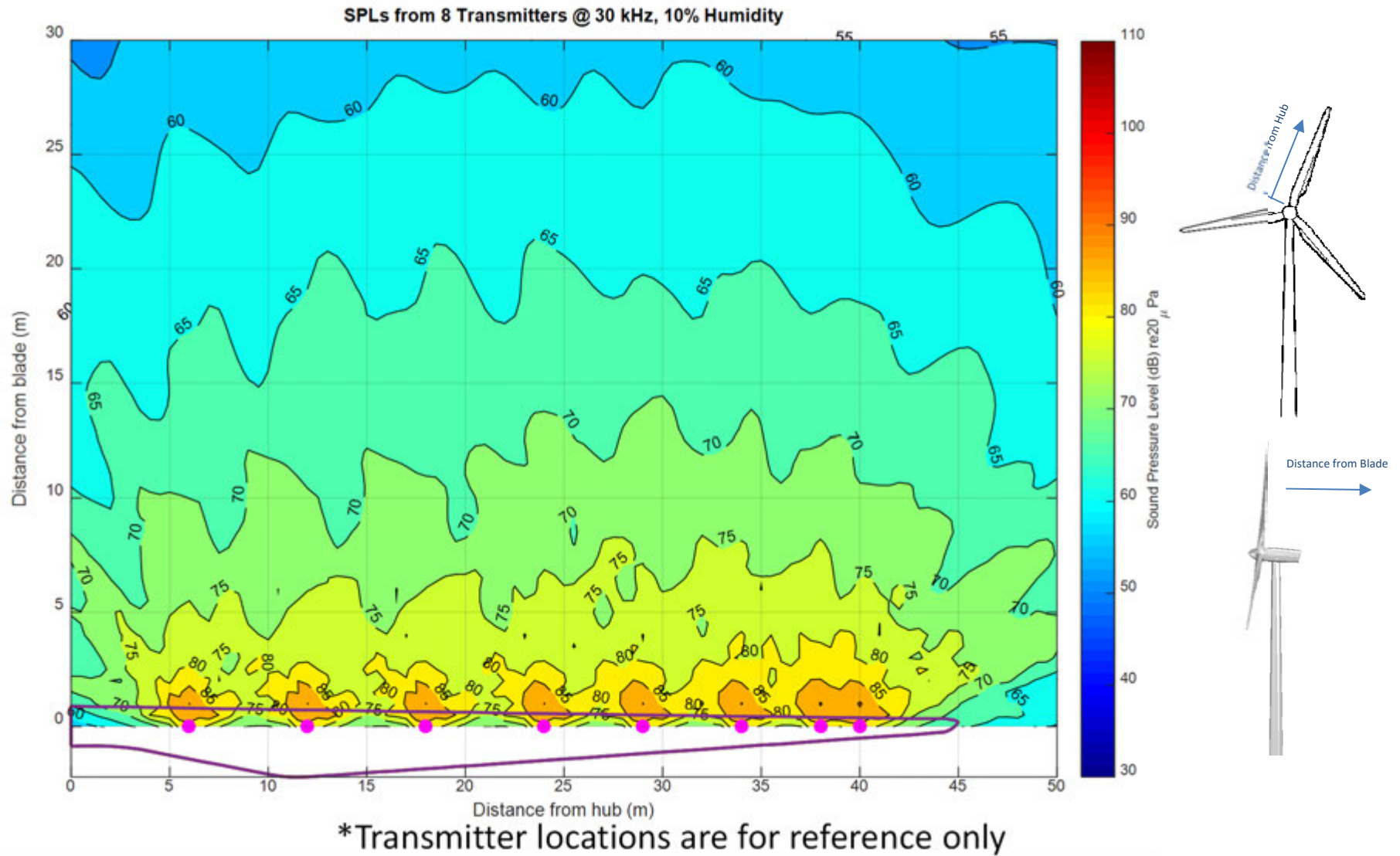


- Transmitter Locations
- Lightning Receptors
- Wire Harness

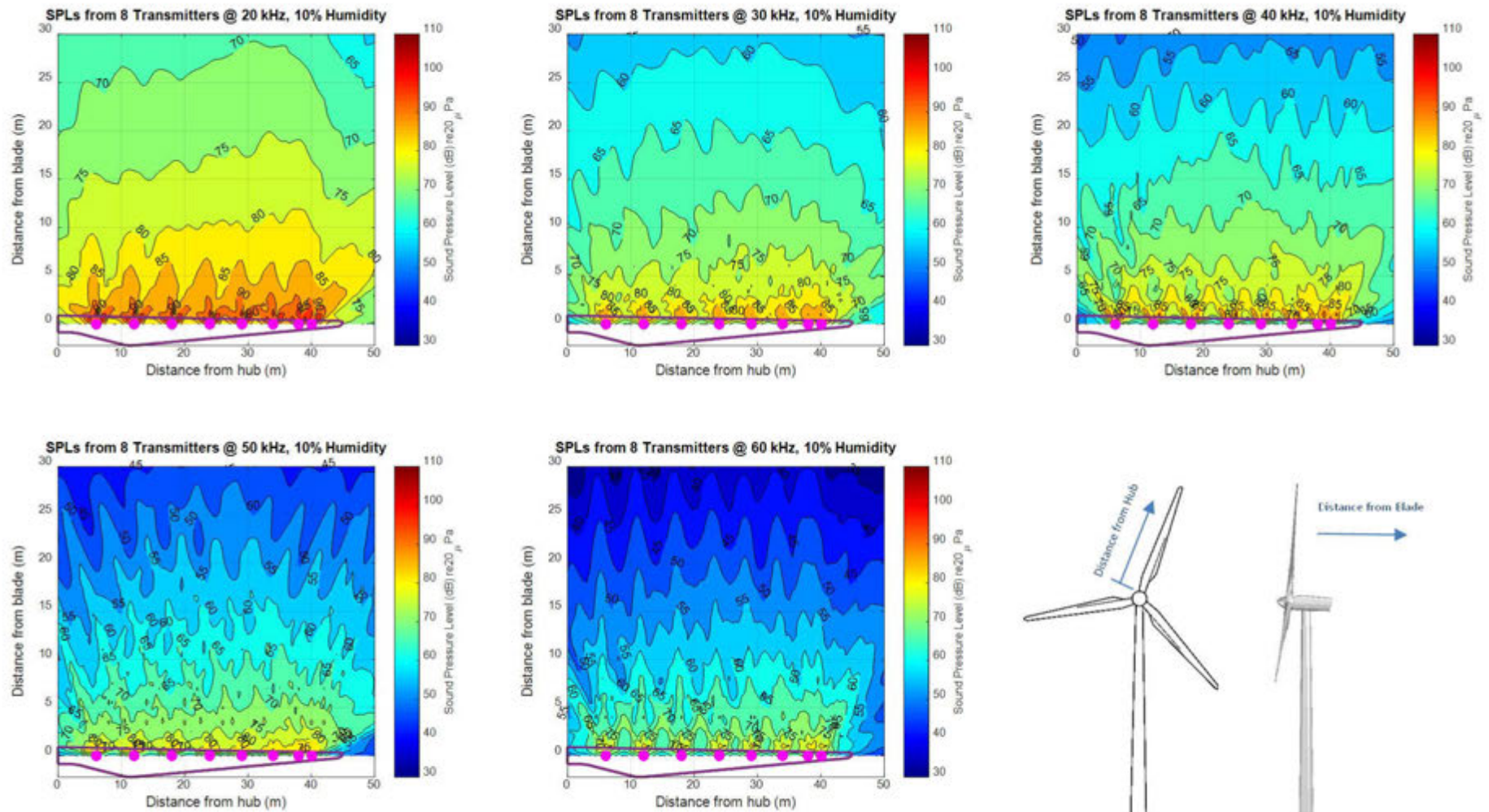
- Eight transmitters are distributed along the blade
- Installation locations are within the “Go-zone” as defined by Siemens
- Transmitters must be placed five or more meters from the tip
- Transmitters must be two or more meters from lightning receptors



Blade – Transmitter Model



Frequency Dependence



*Transmitter locations are for reference only



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