NEXRAD Weather Radars and Wind Turbines: What You Need to Know to Avoid Impacts and Successfully Develop your Project
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WSR-88D and Wind Turbines

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NEXRAD Program

- **NEXRAD:**
  - Next Generation Weather Radar Program

- **WSR-88D:**
  - Weather Surveillance Radar – 1988 Doppler

The radar is referred to as the “WSR-88D” or the “NEXRAD”
NEXRAD Program

- Tri-Agency Funded:
  - Department of Commerce – National Weather Service
  - Department of Defense – Air Force Weather Agency
  - Department of Transportation – Federal Aviation Administration

- Purpose & Goals:
  - Establish a national network of weather radars
    - Forecasts, warnings
    - Safe, efficient aircraft operations
    - Enhancement of national economy
    - Resource protection of military assets and personnel

- Most WSR-88Ds deployed 1990-1996
NEXRAD Coverage Below 10,000 Feet AGL

OCONUS:
4 DoD Radars
12 FAA Radars (including Puerto Rico)
NEXRAD Program

• Tri-agency Network:
  o 122 owned/maintained by NWS
  o 25 owned/maintained by DoD
  o 12 owned/maintained by FAA

• All WSR-88Ds are critically valuable to all three agencies
Radar Operations Center

- WSR-88D Life-cycle support
- Tri-agency staffed and funded
- Responsible for wind farm analyses for all WSR-88Ds
Future of NEXRAD

• Dual polarization completed in 2013
• Service Life Extension Program (SLEP)
  o 7-Year (2015-2022), $150M tri-agency investment
  o Keep radars viable into 2030s
  o Signal processor, transmitter, pedestal, equipment shelters
• Next radar system in 2030s? Phased Array?
How Does NEXRAD Work?

Radar tilts at multiple elevation angles to scan the atmosphere. In Volume Coverage Pattern (VCP) 12, there are 14 elevation angles.

For early detection of hazardous weather, the low angles are the most important, but also the most impacted by wind turbines.
How Does NEXRAD Work?

Most common operation modes during severe weather are VCPs 12 and 212, which scan the atmosphere rapidly. New technology allows scans of the lowest elevation angle every 75-90 seconds. These low level views are critical to detecting tornadoes, high winds/downbursts, wind shifts affecting aviation, and accurate precipitation estimates.
Wind Turbines and Radar
Wind Turbines and Radar

- Wind turbine blades reflect the radar’s energy, scattering back toward the radar
  - Gives appearance of “false returns”; looks like severe weather on radar
  - Contaminates low level base data (precipitation, wind) and algorithms (tornado signatures, hail signatures)

- Risk of missed/delayed severe weather warnings, misleading algorithm output, and erroneous precipitation estimates

- Greater the number of low elevation angles contaminated, the greater the risk to the DoD, NWS, FAA missions
Wind Turbines and Radar

• Wind turbine contamination is a growing problem
  • Since 2008, ROC has analyzed over 1600 projects
  • Increasing with each year:
    • 180 projects Jan 2017-Jan 2018
    • 132 projects Jan 2016-Jan 2017
  • These are projects we know about!

• Turbines are getting larger
  • We routinely see proposals for turbine heights 180 – 210 meters
  • This is up from the average of 150 meters five years ago
  • Developers are repowering older projects
    • Reducing number of turbines, but increasing heights
    • For weather radar, any increase in height is an impact to the data regardless if the number of turbines decrease
Wind Turbines and Radar

New Wind Farm approx 4 km from Hastings, NE radar
Wind Turbines and Radar
Turbine Contamination appears as Precipitation

“Ghost” Echoes from radar beam scattering through wind turbines

Maple Ridge Wind Farm
Fort Drum (KTYX): Wind Turbines and Severe Weather

Weather Event: August 22, 2017
18:07 UTC to 19:08 UTC
KTYX 8/22/17 18:07 UTC – Lowest elevation angle

Reflectivity  Base Velocity
KTYX 8/22/17 18:08 UTC – Second lowest elevation

Reflectivity

Base Velocity
KTYX 8/22/17 18:52 UTC – Lowest elevation angle

Reflectivity  

Base Velocity
KTYX 8/22/17 18:50 UTC – Second lowest elevation

Reflectivity

Base Velocity
KTYX 8/22/17 19:06 UTC – Lowest elevation angle

Reflectivity

Base Velocity
KTYX 8/22/17 19:08 UTC – Lowest elevation angle

Reflectivity  Base Velocity
• Currently, we find out about proposals through NTIA (National Telecommunications and Information Administration)
  • Developers voluntarily submit proposals through this agency
  • Some proposals are never submitted, so we are unaware

• Occasionally find out about proposals directly from the developer or through concerned local stakeholders
ROC Wind Turbine Analysis

• Distance from radar and terrain is important
  • 4km NO BUILD Zone to protect radar from mechanical damage due to strong returns from turbines
  • Closer turbines generally contaminate more elevation angles, and is dependent on terrain

• We determine how many elevation angles will be contaminated
  • More angles = greater impact
  • Contamination of lowest three angles or more = automatic NO BUILD recommendation
    • Going higher in the atmosphere than three elevation angles greatly diminishes ability to detect severe weather features and significantly reduces accuracy in precipitation estimation
Mitigation and Curtailment

• Mitigation
  • Work with the developer to voluntarily reduce turbine heights, eliminate turbines of greatest concern, move turbines greater distance from radar

• Curtailment
  • Developer agrees to cease operations during periods of hazardous weather
    • Tri-agencies will insist on binding agreement
Other Options?

• Why not move the radar?
  • Temporary fix at best
  • Tri-agencies have siting requirements, which reduces the area where radar could be moved
  • Wind developments at new radar site will put us back in same position

• Can technology fix the problem?
  • Weather radar is different than air traffic
    • No signal processing solution on horizon for weather radar
  • How to remove wind turbines without removing important weak and strong features is unknown
  • International colleagues suffering from same challenges
Other Options?

• Why not add a new, off-the-shelf radar?
  • Would require yearly O&M costs, comms, display
    • High costs (unfunded) for agencies to maintain after initial installation
  • Does not meet same standards as WSR-88D
  • Would be very difficult to integrate 88D software into commercial system
    • Agency required algorithms, products would not be replicated
    • Is not a substitute for reducing 88D capabilities
Working Together

• We must work together and engage early in the process to find the most reasonable solution
Resource

- NEXRAD Screening Tool on Radar Operations Center website is a good first look, but still need ROC analysis
- https://www.roc.noaa.gov/WSR88D/WindFarm/WindFarm.aspx
Questions?

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Thank you for joining today’s program.