Review of Wind Turbine Icing Hazards and Mitigation Options – Town of Kingston

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Presentation to the Kingston Green Energy Committee

October 21, 2008

Project Overview

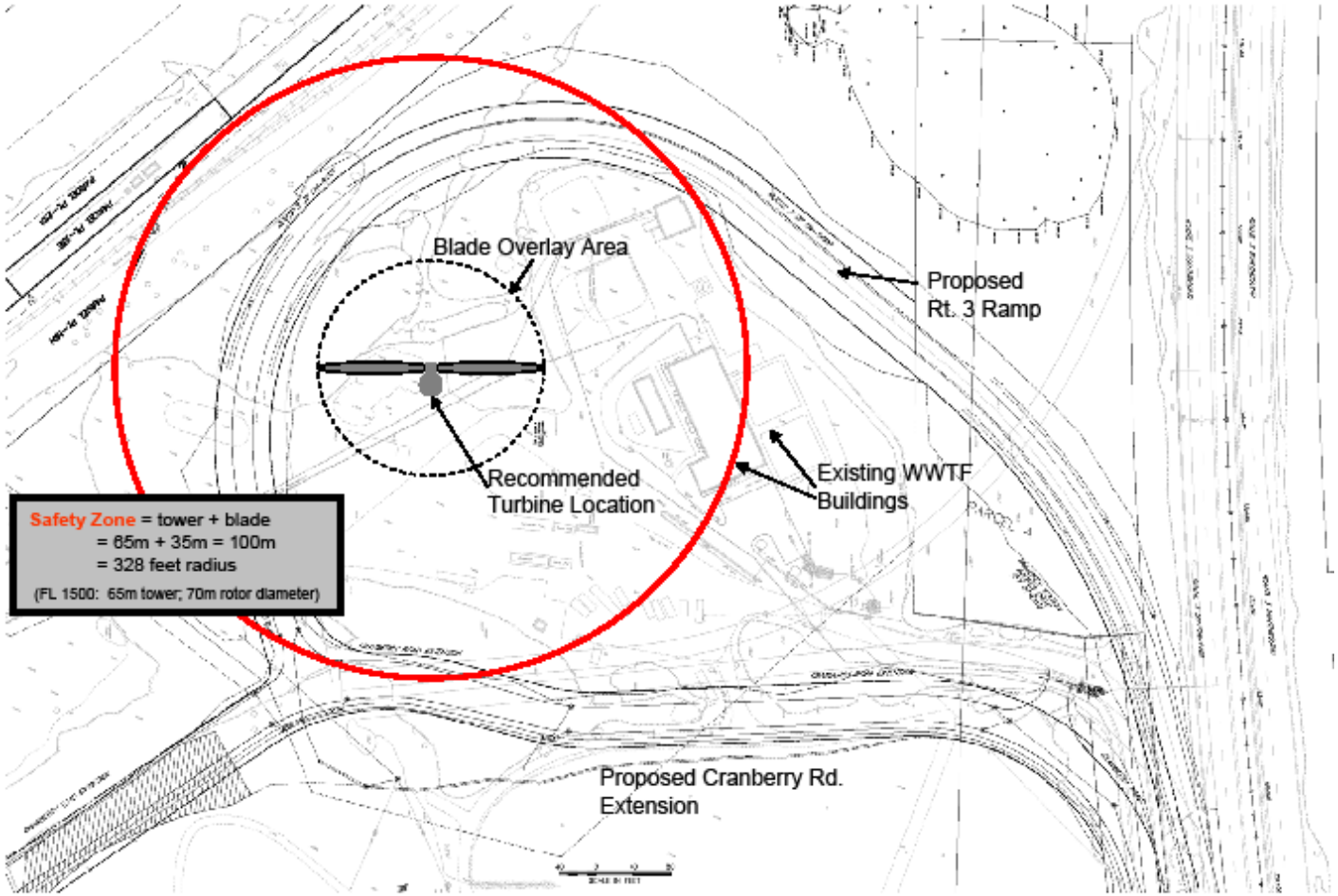
- KEMA prepared a Feasibility Study for a wind turbine at the Kingston Wastewater Treatment Facility (WWTF) – completed June 2008

- Due to proximity of proposed turbine to the WWTF and public accessways, Kingston Green Energy Committee and MTC requested KEMA to conduct a review of icing hazards and mitigation strategies

- Study based on:
  - Interviews with manufacturers and operators of wind turbines
  - Review of technologies for ice prevention and detection
  - Review of available literature

Aerial Photo of Project Site

Proposed Site Layout Plan



Note: Turbine drawing represents a FL 1500. Turbine scale is accurate to +/- 10%.

Wind turbine overlay by Kema, Inc., safety zone overlay by MTC (September 22, 2008).

Potential Icing Concerns

- Safety Considerations:
  - Ice fragments from the rotor blades can be thrown from an operating turbine
  - Melting ice fragments can fall from idle turbine blades
- Economic Considerations:
  - Lost revenue due to extended shut-down

Types of Ice

- Glaze ice
  - Result of liquid precipitation striking surfaces at temperatures below the freezing point
  - Transparent, hard, attaches well to surfaces

- Rime Ice
  - Primary concern in high elevations such as hills or mountaintops
  - Greater concern than glaze ice
    - Greater thickness
    - Attached more loosely

Rime ice on control anemometer and wind vane, Finland

Icing in Coastal Massachusetts

- Combination analysis
  - Reviewed meteorological data
  - Interviewed operators of nearby turbines in:
    - Hull (Hull High School, “Hull 1”)
    - Buzzard’s Bay (MA Maritime Academy)

- Meteorological occurrence of ice
  - NOAA weather data suggests freezing rain or freezing fog less than 1/8th inch (0.25 cm) occurs about 15 days per year
    - However, icing is usually followed by melting – on average only 4 days per year freezing precip is followed by high temps below 32° F
  - Ice storms (>¼ inch or 0.63 cm) occur less than once per year on average (Tattelman et al.)

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Frequency of Icing – Experiences of Other Towns

- Hull 1 - Hull, MA
  - Turbine located adjacent to Hull High School
  - Does not have ice detection equipment installed
  - Has reportedly never shut down because of icing

- MA Maritime Academy – Buzzard's Bay, MA
  - Received direct training from Vestas (turbine manufacturer)
  - Aware that ice throw occurred on one occasion (~200')
  - Can observe changes in sound when icing occurs
  - Have trained staff to monitor ice development on buildings, ground, roads and listen for audio clues
  - Shut down turbine at first indication of icing
  - Restrict access under turbine blades while melting occurs

Icing Mitigation Strategies

- Automatic Shut-Down Systems
  - Loss of efficiency or imbalance triggers “fault” and automatic shutdown and alarm notification. Requires manual reset after fault condition remedied.
  - Readily available on modern turbines as part of standard or optional packages
- Ice Detectors
  - Ultrasonic ice detectors
    - Well-developed technology for airline industry
    - Estimated Cost: $5,000-$10,000

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Icing Mitigation Strategies

- Passive Icing Prevention
  - Paint the turbine blades black
    - Accelerates melting
    - Creates more visual impact
    - Estimated cost: $5,000 to $10,000
  - Anti-Adhesive Coatings (Teflon, fluoroethane)
    - Case studies in Pennsylvania and the Yukon
    - Estimated cost: $10,000 - $20,000

Additional Technologies

- When more commercially available/developed, these may complement existing methods:
  - Applied heat
    - Not yet commercially available
    - Would use portion of turbine output for power
    - Expect cost to be high relative to risk in Kingston
  - Web cams
  - Analyzing indirect signals of turbine performance

Conclusions

- Sporadic icing of a wind turbine at the WWTF may occur
- Preventative measures such as alarm systems, ice detection monitors, or anti-adhesive coatings would minimize risk of ice throw
- Conservative operational procedures and WWTF staff training would further reduce risk of ice throw and ensure safety during melting
- Expected down-time due to ice is limited
- Economic impact of icing is expected to be minimal

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Thank You.

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