Leeward Renewable Energy

Blade Health Management

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Blade Health Monitoring

External/Drone Inspection

Common ~ 100% of Fleet

Internal Inspection

Less Common ~ 10% of Fleet

Data Monitoring / Alarms

Rare ~ 5% of Fleet

*unless we count power curve monitoring!
Condition Assessment

- Establish Condition of Blade from Monitoring Mode
- Evaluate Defect
  - Likelihood and speed of propagation
  - Risk of defect propagation to complete failure
  - Compare to similar defect history
- Categorize Defect / Determine Operation Impact
  - Shutdown
  - Derate
  - Operate & Monitor
### Component Damage Ratings

<table>
<thead>
<tr>
<th>Damage Category</th>
<th>Observations</th>
<th>Stage of Damage</th>
<th>Planned Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAT1</td>
<td>No observable damage</td>
<td>N/A</td>
<td>No Action Required</td>
</tr>
<tr>
<td>CAT2</td>
<td>Minor signs of damage</td>
<td>No obvious failure developing</td>
<td>No Action Required</td>
</tr>
<tr>
<td>CAT3</td>
<td>Moderate signs of damage</td>
<td>Failure developing</td>
<td>Plan Follow up Inspection</td>
</tr>
<tr>
<td>CAT4</td>
<td>Advanced signs of damage</td>
<td>Failure imminent</td>
<td>Schedule Repair or Replacement</td>
</tr>
<tr>
<td>CAT5</td>
<td>Failed Component</td>
<td>Component won't operate as intended or risk of catastrophic failure imminent</td>
<td>Remove equipment from service and schedule replacement</td>
</tr>
</tbody>
</table>

**Leeward Damage Categories Reflect Planned ACTION**
Common Examples

- Leading Edge Wear
- Lighting Damage
- Lighting Damage
Special Case - Derate

- Possible when...
  - Defect not affected by edgewise loading
    - Why? Rotational gravity loads don’t change much with derating
  - Load reduction mitigates risk of defect propagation
    - Will derate reduce risk of further cracking/tearing/etc.?
  - Clear technical justification

Point of View: Derating not a commonly used damage mitigation tool
Summary

- Basic strategy to mitigate risk is to monitor blade health

- Monitoring modes are risk based
  - All blades are subject to external visual type inspection
  - Internal and data monitoring set up for specific defect monitoring

- Damage ratings focus on next action to take (operations focused)
Challenges

- Operational – Planning & Scheduling of repairs


- Technical – actual risks of doing nothing compared to doing something. Especially true of LE related production losses