

Improving Wind Farm Performance Using Reliability Centered Maintenance



B9 Energy Group



B9 Energy Operation & Maintenance

- UK and Ireland's No.1 O&M company
- Asset Management
- Triple Accreditation

Benign Energy Canada Inc

- Kettles Hill Wind Farm, Southern Alberta

B9 Energy USA Inc

- Boston, MA



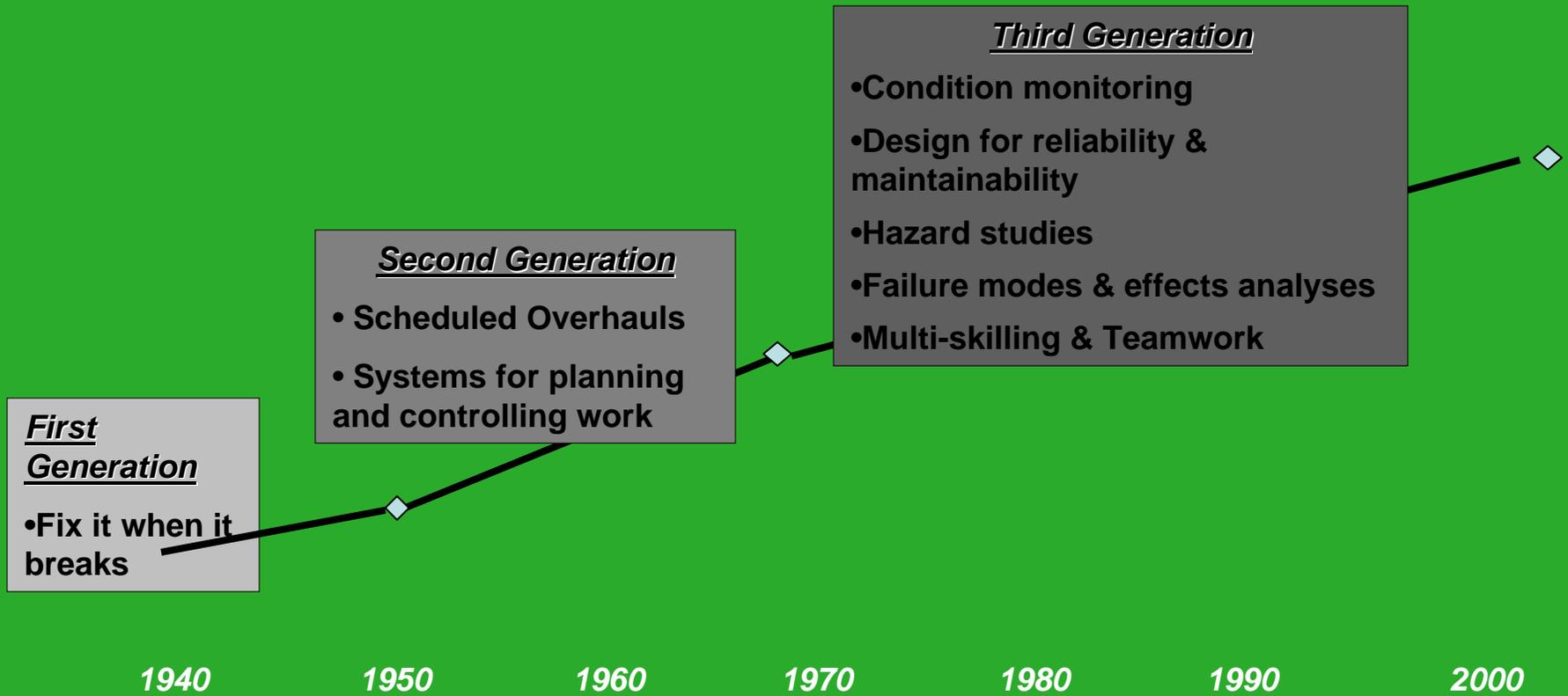
Wind Farm Operation & Maintenance

Reliability Centered Maintenance

“All actions which have as an objective to retain an item in or restore it to, a state in which it can perform its required function. The actions include the combination of all technical and corresponding administrative, managerial and supervisory actions.”



The Changing Face of Maintenance



RCM and the Wind Industry



- Reliability Centered Maintenance (RCM) is a process of identifying the best way to operate and maintain plant and equipment
- First developed in 1970s as tool for Civil Aviation Industry, and under constant review
- 1980's the application was expanded to other industries
- 1990s RCM2 launched specifically for non-aviation sectors
- Wind industry?



What RCM achieves

- Greater safety and environmental integrity
- Improved operating performance
- Greater maintenance cost-effectiveness
- Longer useful life of expensive items
- A comprehensive database
- Better teamwork



How RCM achieves its goals

RCM ensures that operators:

1. Understand the asset's function

A wind turbine's function is to capture energy from the wind and convert this into electricity

2. Understand in what way it can fail to fulfill its functions

It fails to convert wind energy into rotation via the blades and hub and transmit this rotational energy to a generator to produce electricity

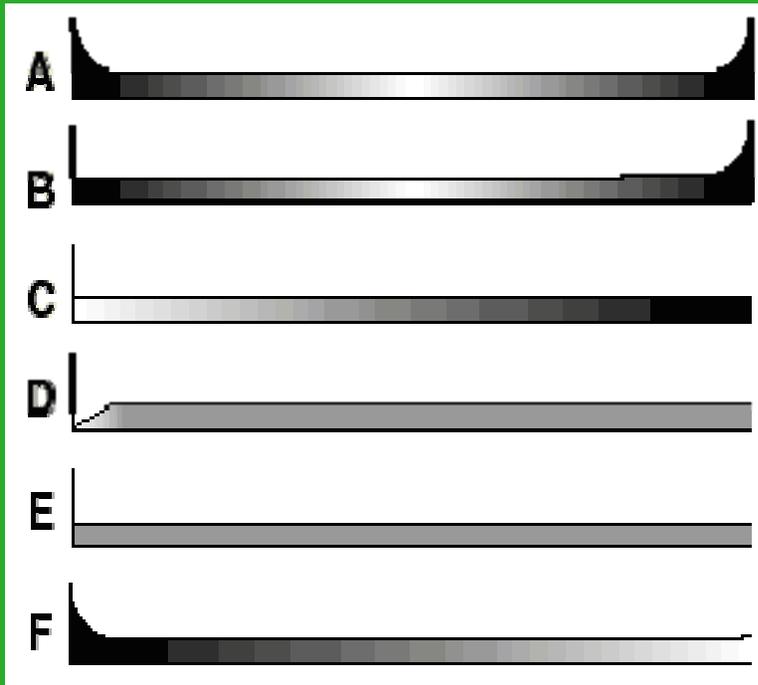
3. Evaluate the consequences of a failure

- Hidden failures
- Safety & Environmental consequences
- Operational
- Non-operational

4. Select an appropriate task



The reality of failure....



A. *Bathtub Curve*. Infant mortality followed by constant failure rate, then by wear out zone.

4%

B. *Traditional view*. Steady failure rate followed by wear out zone

2%

C. Slowly increasing failure rate, no identifiable wear out age

5%

D. Low failure rate when new, followed by rapid increase to constant failure rate

7%

E. Random failure regardless of age

14%

F. High Infant mortality, dropping to slowly increasing failure rate

68%



Site Downtime



RCM analysis of stall regulated 600kW WTG

Blade tip retaining cable failure due to fatigue

•Function	To capture power from the wind
• Functional Failure	Fails to capture power from the wind
• Failure mode	Blade tip retaining cable fails due to fatigue
• Failure effects	Tip comes out & turbine faults with vibration error or wind power measurement error
• TTR	2-7 days
• Manpower hours	250
• Equipment	Cherry picker or crane & man basket
• Cost of spare	£200
• Total cost of FE	£8500
• Proposed modification	Redesign of cable & reduce hydraulic pressure on cable



Bottom Line

RCM has proved to be effective at minimizing safety, environmental and operational risk, maximizing profit, and minimizing asset management and maintenance costs.



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