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Benchmarking Performance Trends

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WEBS

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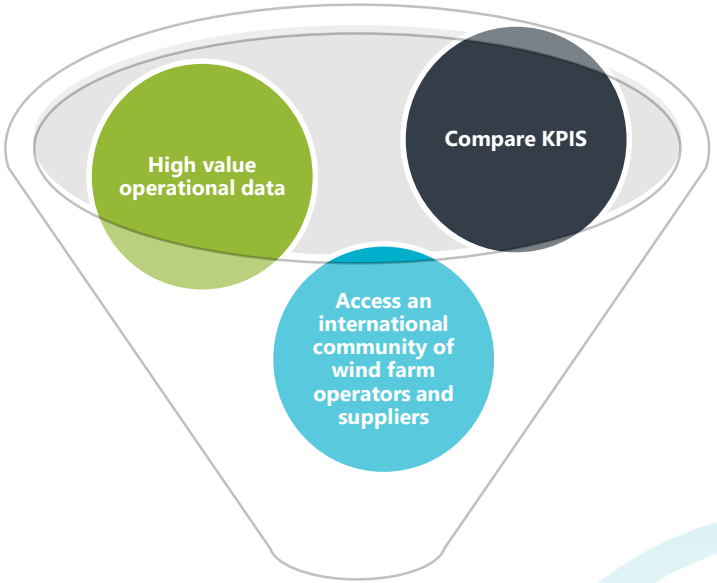
- **WEBS** is an independent performance benchmarking Company.
- **WEBS** is a secure, anonymised, industry level, independent web-based benchmarking subscription service for wind farms.
- **WEBS** is a partnership between Offshore Renewable Energy Catapult and Natural Power. Combining our independent world-class benchmarking and asset management know-how.



The value of benchmarking

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Benchmarking is the process of regularly comparing one's business processes and performance metrics to others in the same industry, whether absolutely or relatively, with the aim of **determining relative performance**

- As the wind industry matures, the pressure is on reducing costs and increasing revenue – Extracting value from operational data is increasingly important.

- Future cost reduction opportunities:
  - Advances in turbine design
  - Efficiencies in the supply chain and manufacturing
  - **"Smarter operations"**

- The focus of asset owner is now on:
  - Actively managing WTG performance and reducing downtime, whilst:
  - Decreasing/optimising costs in the O&M phase, and:
  - Extending the life of assets.

How it works

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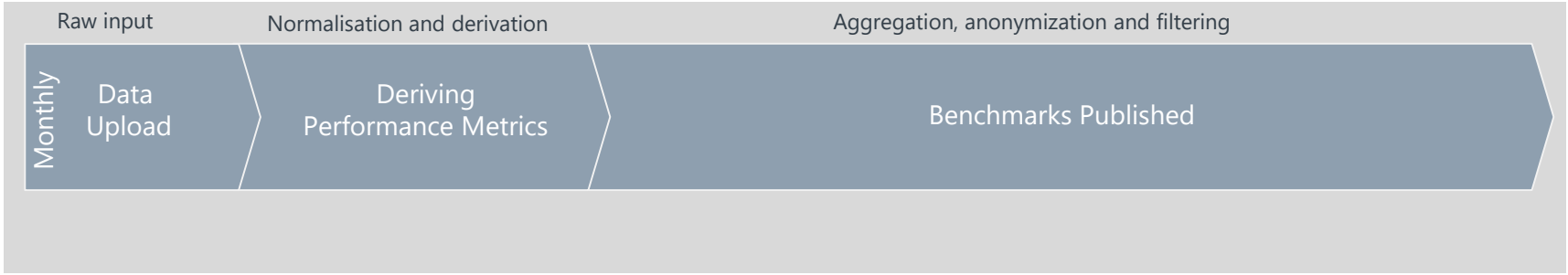

Fixed Referential Metrics* (one-time entry/setup)

Wind Farm Details
Reference, Geographic Location, Capacity ...

Turbine Details
Count, Manufacturer, Model ...

Balance of Plant
Foundations, Sub, Cables ...

Development Dates
Full Commissioning Date ...

Variable Monthly Performance Metrics* (data uploaded every month)

Production
- Exported Production
- Lost Energy Production [IEC 61400-26-2]
- Capacity Factor
- Number of Generating Hours

...

Availability
- Production Based Availability:
  Technical and System [IEC 61400 26-2]
- Time Based Availability
  Technical and System [IEC 61400 26-1]

Reliability
- Number of Repairs
- Downtime Due to Repairs
- Repair Related Costs
- Taxonomy is compliant with RDS-PP

...

Operations
- Days of Service Activity
- Number of Non-Access Days
- Number of Turbine Visits
- Mean Site Wind Speed

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* non-exhaustive list of metrics

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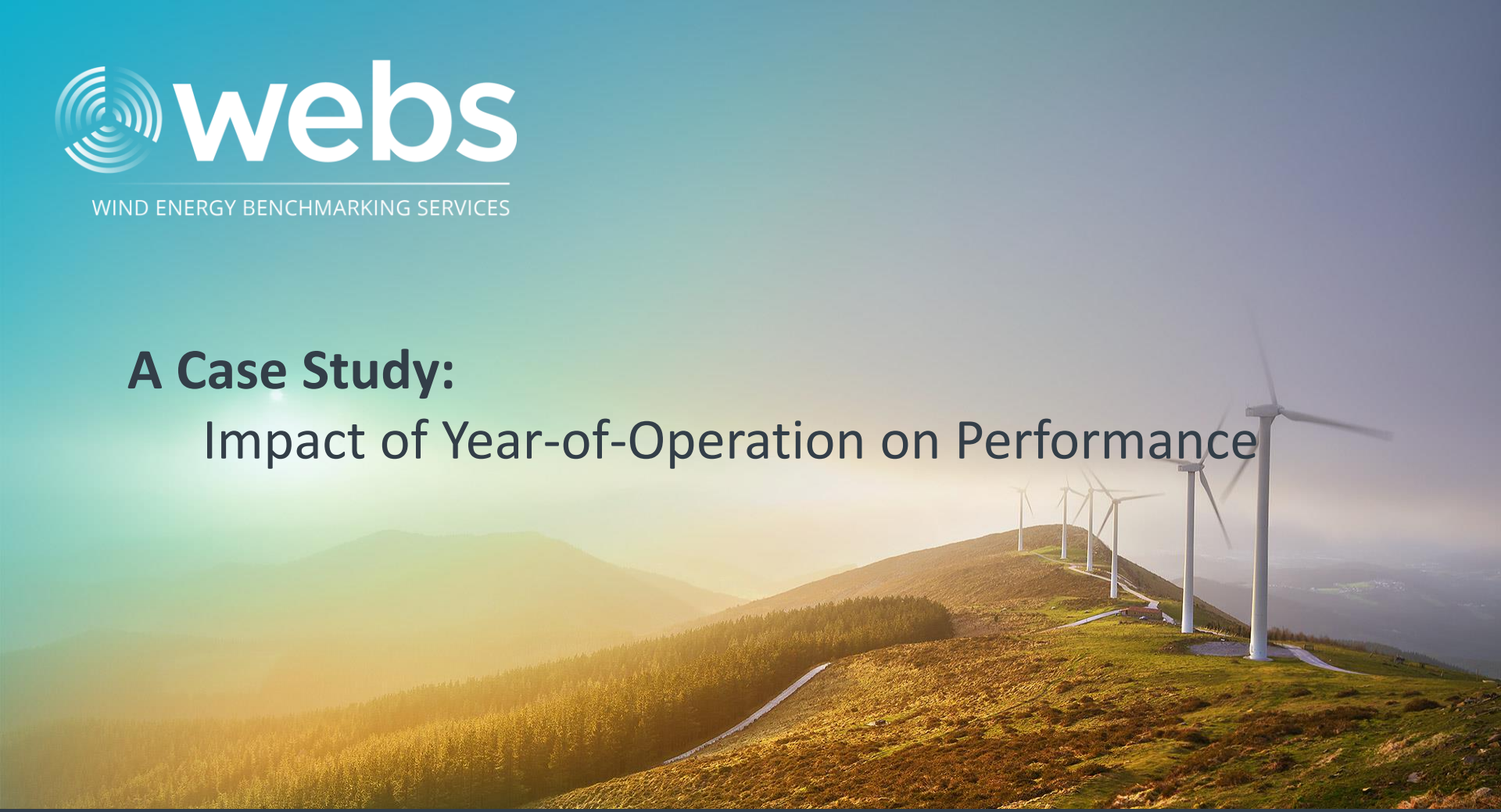
A Case Study:

Impact of Year-of-Operation on Performance



Impact of Year-of-Operation on Performance

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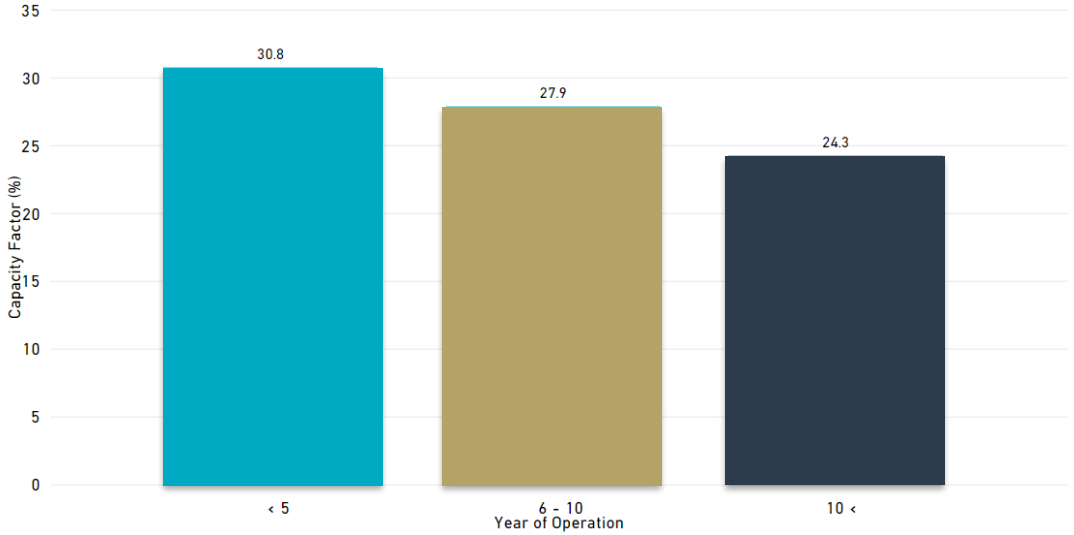
- **Year of Operation**
  - Age of a Windfarm: <5, 5-10, 10<
- **Measure of performance**
  - Production
  - Availability
  - Reliability (Failure rates, Downtime, Major System Repairs)
  - Logistics

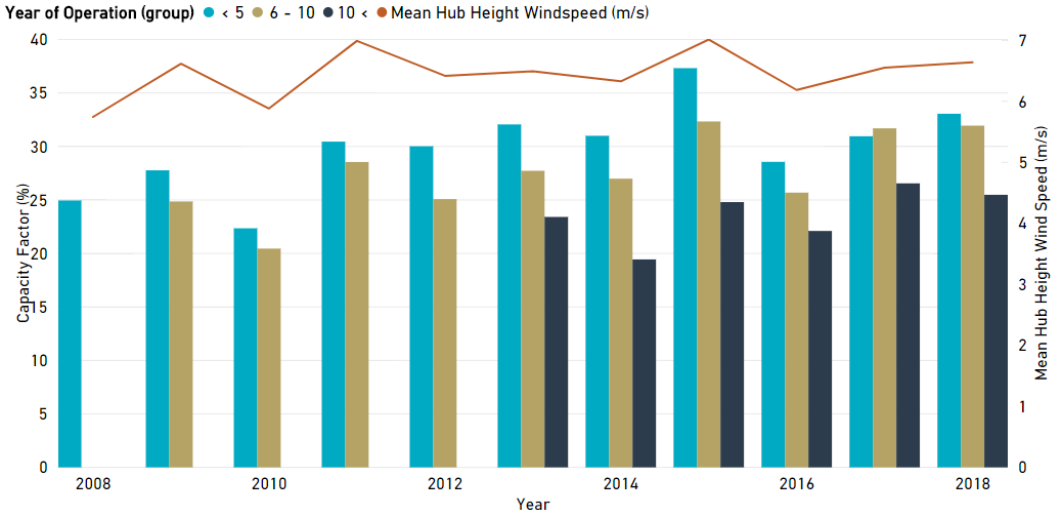
- **Key Question:** How does increasing age effect the production, reliability and operations of onshore windfarms?

Production



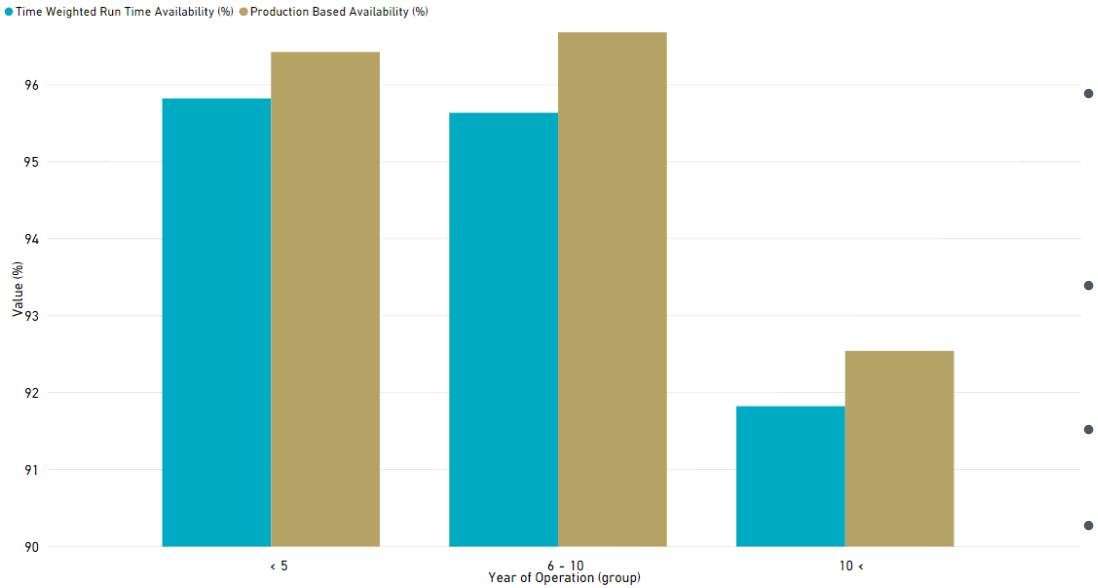
- Production (Capacity Factor) drops with the aging of farms
- Is this trend driven by improvement in new technology or reduction in performance from reduced reliability or service provisions?

Production



- Production (Capacity Factor) drops with the aging of farms
- Windspeed not a significant factor
- Consistent over the years
  - Some years are exceptional

Availability



- Availability:
  - Production Based
  - Time Weighted Run Time
- Farms over 10 years of operation have about 4% less availability
- **P**roduction **B**ased **A**vailability
- Drop in PBA indicates more unforeseen downtime

Reliability: Annual Failure rates

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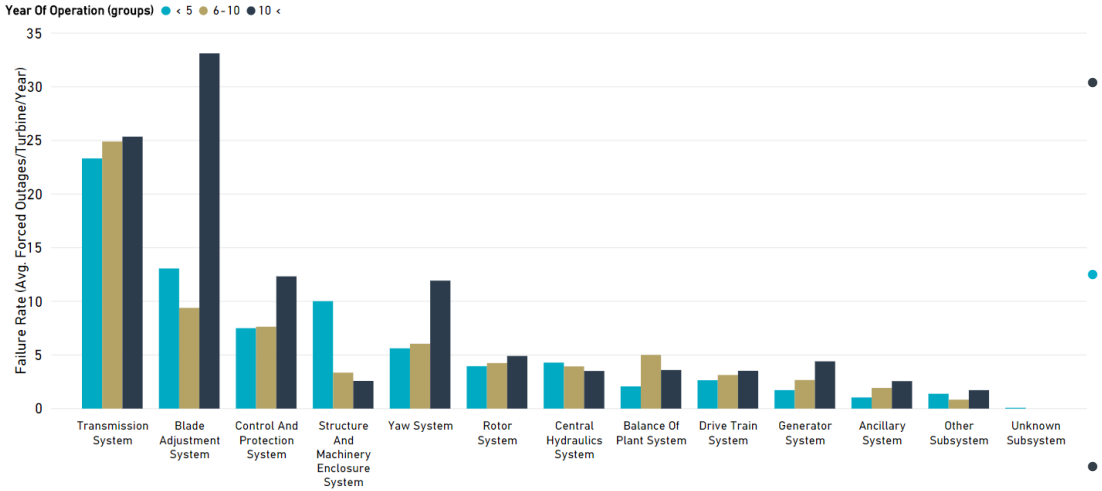
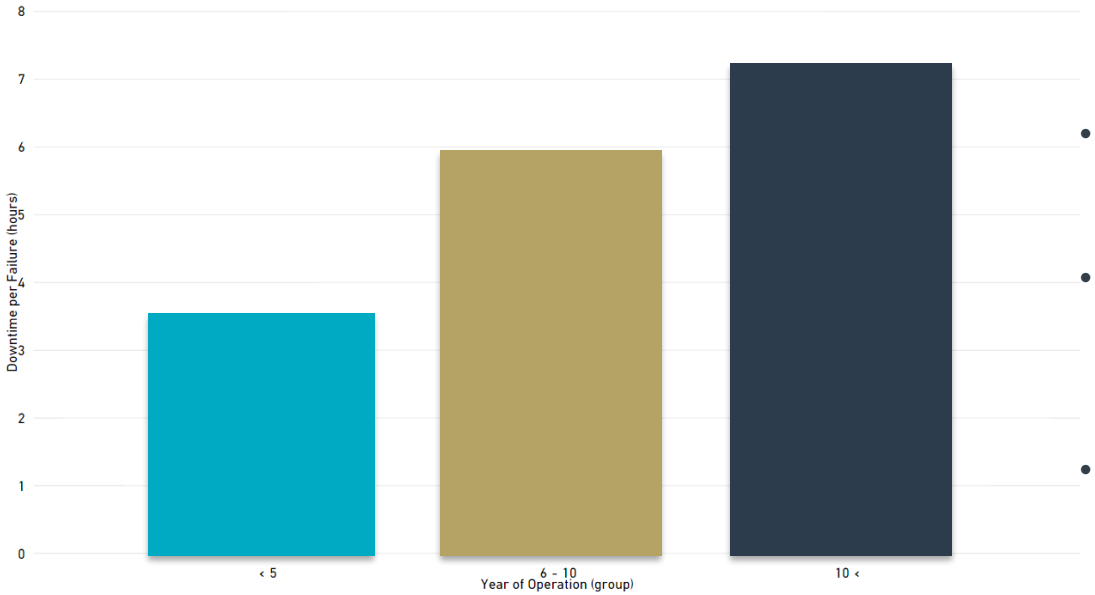


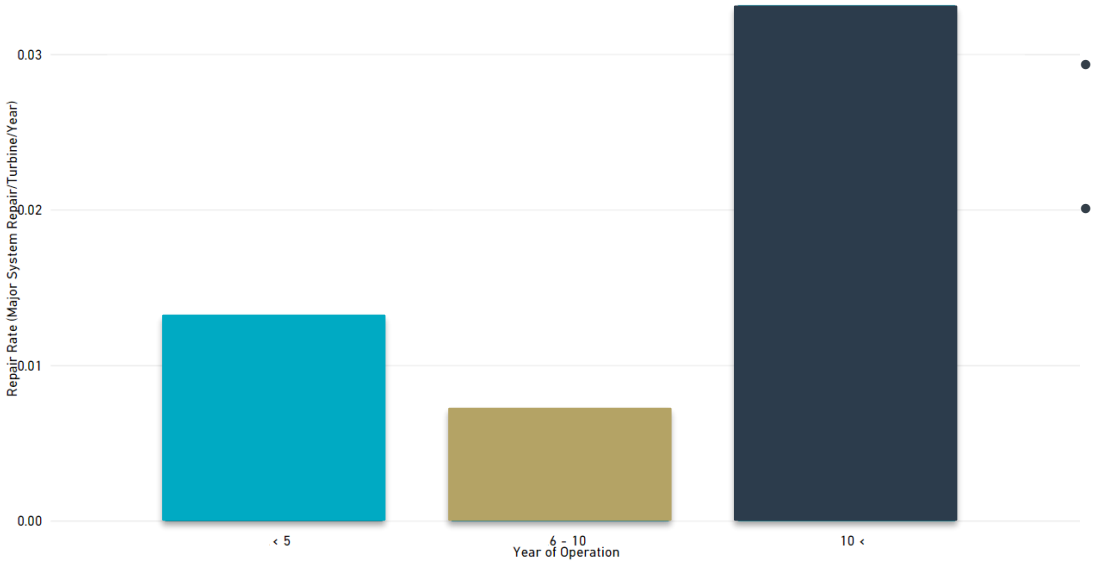
- High number of Failures due to counting of Forced Outages
- Generally
  - **New farms** > **6-10 year old**
  - **Old farms** > **6-10 year old**
- **New farms** have higher 'Structure and Machinery Enclosure System' failures
  - Early life issues
- **Older farms** have more 'Blade Adjustment' and ' Yaw System' failures
  - Wear of moving parts
  - Deeper dive can consider trends at component level

Reliability: Downtime per failure



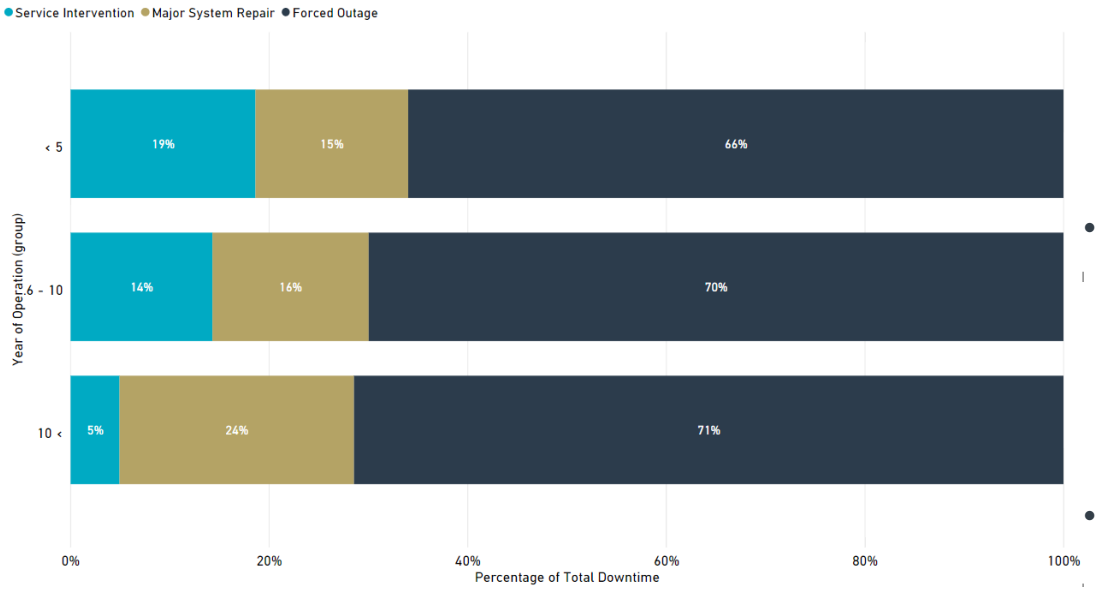
- Downtime per failure is seen to increase with age
- Alongside higher failure rate, vastly increased downtimes
- Indicates that level of servicing is reducing or more significant root-cause failures
- If understood, cost benefit of increased servicing can be considered

Reliability: Major System Repair rates



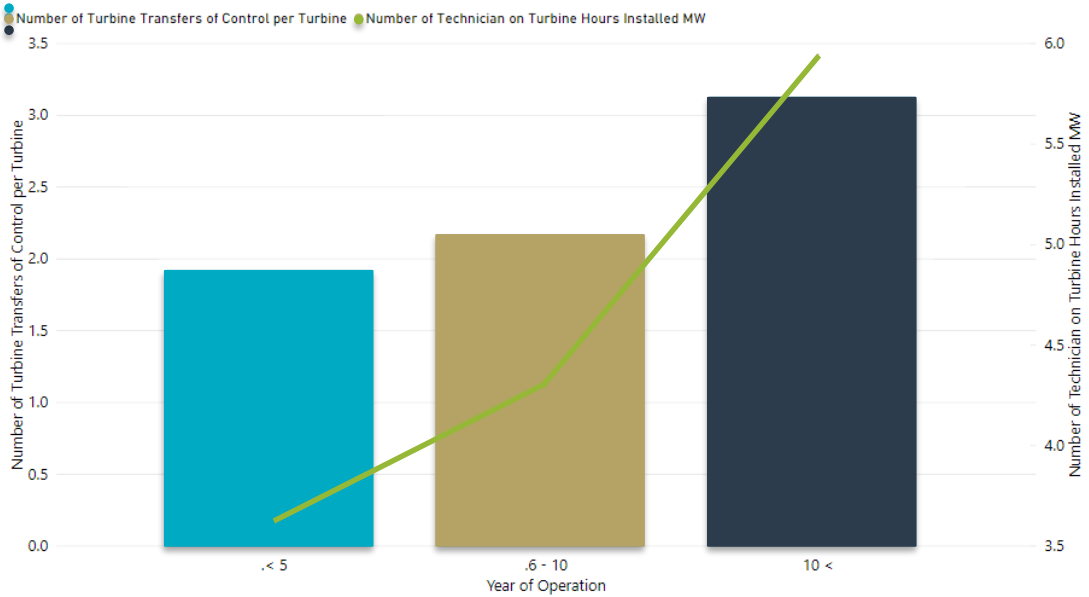
- 206 Major System Repairs
- Farms between 5 and 10 year of age have a significantly lower rate
- Modern farms tend show an increase, this is attributed to introduction of new technology as turbine size moved from 1-2 to 2.5+ MW range

Reliability: Downtime breakdown



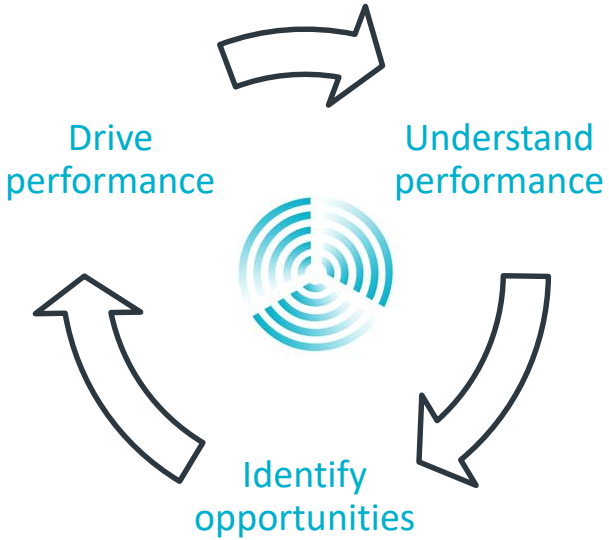
- Over time:
  - **Forced Outages** increase slightly
  - **Major System Repairs** take more time
  - Drop in **Service Intervention**
- Over time Service Interventions drop, partly as they are done while having a Major System Repair and driven by focus of portfolio management on newer sites
- Considered with site specific PPA arrangements can help optimise portfolio management

Logistics



- Number of Turbine Transfers of Control increases with age
- Number of Technician on Turbine Hours per Installed MW increases following a similar trend
- Servicing time is increasing but performance is not! End of life decision making needs to understand this relationship

Conclusions



- Farms over 10 years have less production
- Possibly due to a lower availability in both time as production based.
- Turbines fail more often and caused downtime increases over time
- More work is done on turbines as the farm ages
- Contextual understanding of the industry via benchmarking is key to optimising your servicing strategy.

webs Quarterly Report

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What is it?

- A thought leadership and insight paper that will be released on a quarterly basis.

Who is it for?

- Anyone! An overview will be available for free and the full report will be available on a subscription basis.
- webs customers will get free access to the full report.

What is included?

- The content involves ‘quarterly indices’ and ‘deep dive investigations’.
- The first deep dive was on the topic of scheduled maintenance
- The second is taking the analysis presented today a step further.

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