A Engenharia e Tecnologia dos WEC para assegurar Períodos de vida além IEC (Beyond 20 year of IEC)

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O Futuro do Setor Eólico | Extensão de Vida Útil e Repowering das Centrais Eólicas

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wind energy solutions

Agenda

- Wind turbine Design
  - Design Life and Operational Life Time
- Operational Life time critical path
  - Site specific Operational Life Time design
- Site Conditions vs Components
  - How key components are affected
- Ways to extend Operational Life Time and AEP
  - Software based developments
  - Hardware developments

Wind turbine Design

Design Life and Operational Life Time

- The Wind Turbine Certifications can set a Design Life Time of 20, 25 or even more years.
  - Senvion new **(3.XM 140+) EBC platform** already comes with a Type Certificate for 25 years
  - The Design Life Time is 25 years
- Operational Life Time is calculated by the WEC Load Model and considering components stress reserve analysis.
- Some components have larger life time periods, parameters impact components differently
- Operational Life Time of Wind Farms with several years of operation can be assessed
- Operational Life Time assessment is costly and time consuming

Operational life time Critical path

Site specific Operational Life Time design

Turbulent sites:

- Turbulence drives mean flow fluctuations and its first impact is on the blades, as well as the shear which drives the wind speed change with height.
- **Blades** are in the critical path for Life Extension when we face medium to low wind speed sites with high turbulence

- Blade design needs to balance aerodynamics, weight and cost, thus projects specific improvements are not efficient

High average wind speed sites:

- **Drive Train** is in the critical path for the low turbulence sites with high wind speeds

Most of the sites are not either just turbulent or just with high wind speeds thus: a balance of loads needs to be assessed

It is possible to estimate which components at a given time will theoretically need to be changed, the components replacement for life extension can be considered on an early stage of the project

Site Conditions vs Components

How key components are affected

Overall wind conditions and normal operation mode wears out components

However some conditions have different impact in main components

- **Blades** Life Extension is more limited due to:
  - Extreme Turbulence environments
  - Extreme Shear Values
- **Gear Box** Life Extension is more limited due to:
  - Number of rotations, driven by high Average Wind Speeds
- **Main shaft** Life Extension is more limited due to:
  - Number of rotations, driven by high Average Wind Speeds
  - The combination of high Average Wind Speed, Shear and Turbulence

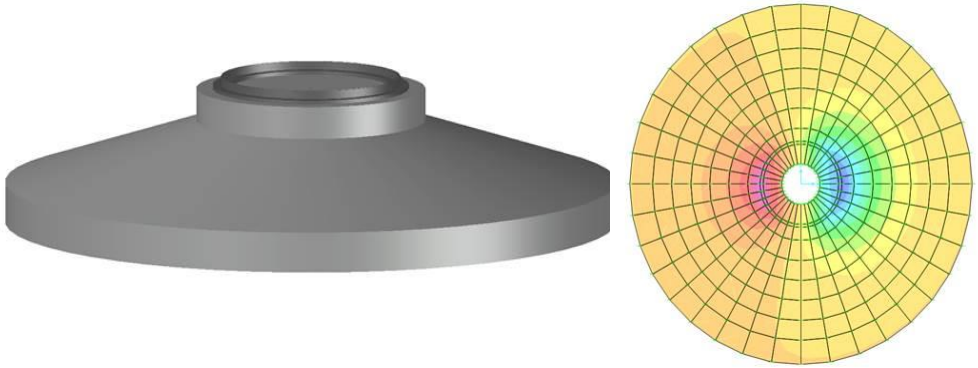
Site Conditions vs Components

How key components are affected

Overall wind conditions and normal operation mode wears out components, However some conditions have different impact in main components.

- **Tower** Life Extension is more limited due to:
  - Turbulence, shear and mean wind speed
  - Extreme events (eg. emergency stops) and the way they are handled

- **Foundations Fatigue**:
  - The Foundation needs to withstand life extension
  - Fatigue is not normally a design driver
  - Fatigue spectrum for the life extension period needs to be considered



Exceedances on one of the several wind conditions parameters can be balanced by other, allowing a longer Operational Life Time, thus the importance of a detailed load assessment

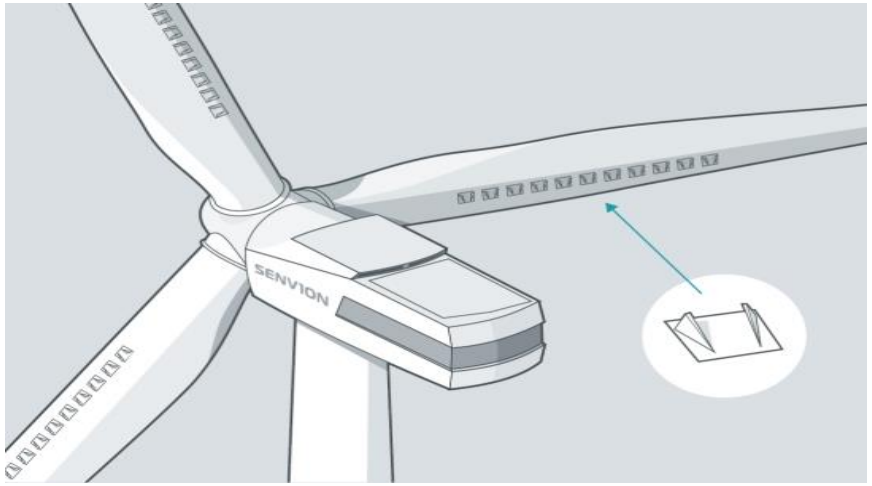
Ways to extend Operational Life Time and AEP

Hardware developments - Improved aerodynamic of blades

Product characteristics

Vortex Generators developed by Senvion for improved aerodynamic efficiency of blades

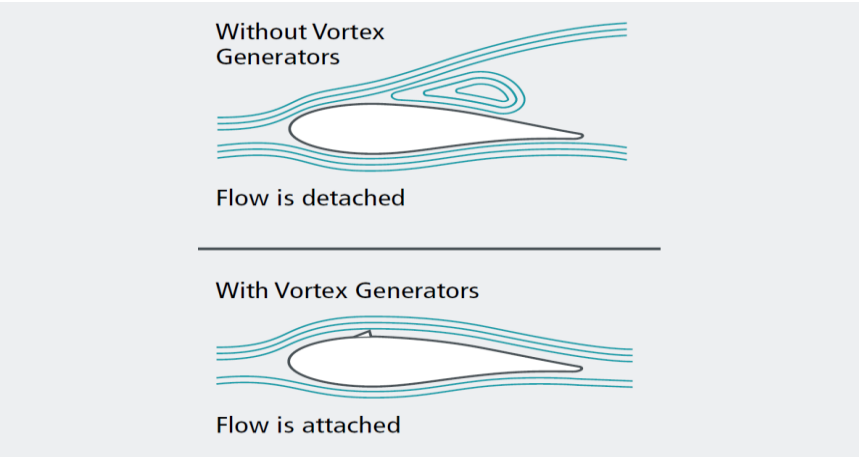
- Delay stall at root region of blade
- Improve aerodynamic efficiency by increasing lift of blades resulting in AEP increase
- SoC for the MM92 and 3.2M114
- Further developed for the most popular blade/ turbine combinations (MM82, 3.4M104)



Customer Benefit

Product is easy to apply as a retrofit

- Proven technology from air craft industry patented in 1956
- Increased AEP
- Additional benefit not dependent upon age of blade
- Development and installation by Senvion
- Negligible impact on sound or loads



Ways to extend Operational Life Time and AEP

Hardware developments - Improved aerodynamic of blades

Testing & Validation

Validation

- Existing experience with VG since 2014
- 3.2M114 retrofitted with VG's and launched as 3.2M114VG in 2015
- MM92 equipped with VG's and currently tested
- Validation based on calculatory proof

AEP

- Average wind speed of 7.5 m/s increases the yield from a 3.2M114VG by 1.5 % compared to the 3.2M114
- ~ 0,7 % of additional AEP expected for the MM92

Requirements & Markets

Product requirements

- Platforms: MM92 with RE45 blade HH 100m (80m), 3.2M114

Markets & Customers

- Available on all Senvion markets
- Better results expected for turbines at low-wind sites compared to strong-wind sites

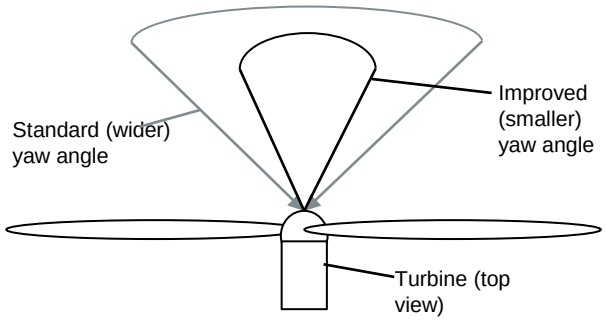
Ways to extend Operational Life Time and AEP

Software developments - Improved algorithm

Turbine Control Upgrade 1.0

- Bundle of performance enhancing products increasing AEP up to 1,5%
- Based on improved parameters and self-learning software algorithms
- Turbine Control Upgrade 1.0 comprises two products (Dynamic Yaw, Smart Turbine Start)

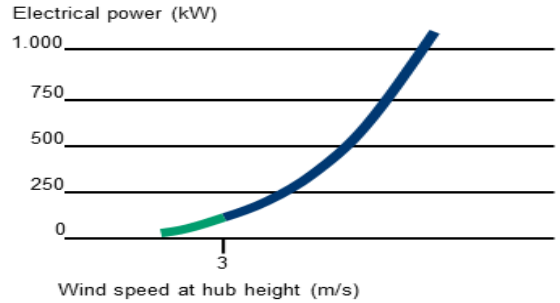
Dynamic Yaw



Product characteristics

- Reduces the acceptable “out of wind” angle
- Improved balance between yaw activity and power output
- Turbine points into the wind more accurately

Smart Turbine Start



Product characteristics

- Self-learning algorithm adapting to site specific conditions
- After each successful start of a turbine “Smart Turbine Start” reduces start-speed successively
- Unsuccessful start leads successive adjustment of start speed towards 3m/s

Ways to extend Operational Life Time and AEP

Software developments - Improved algorithm

- Turbines are better prepared to react and manage extreme loads and extreme events
- Improved algorithms were design to manage loads more efficiently
- Old turbines can be retrofitted (case by case analysis)

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