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Performance Upgrades of Operational Wind Turbines

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Abstract

- At the 2013 NZWEA conference we gave a presentation on the functionality of High Wind Ride Through (HWRT) that was tested and subsequently installed in the West Wind turbines. This is a software upgrade implemented into the turbines that extended their operation above 25 m/s. This year we will update on the actual performance realised on the West Wind site and outline other wind turbine performance upgrades developed by Siemens that are under consideration for application on the Te Uku wind turbines. Siemens will outline the functionality of these features while Meridian will offer its view on these wind turbine performance upgrades from an owner/operators perspective.

HWRT introduced to increase operation above 25m/s

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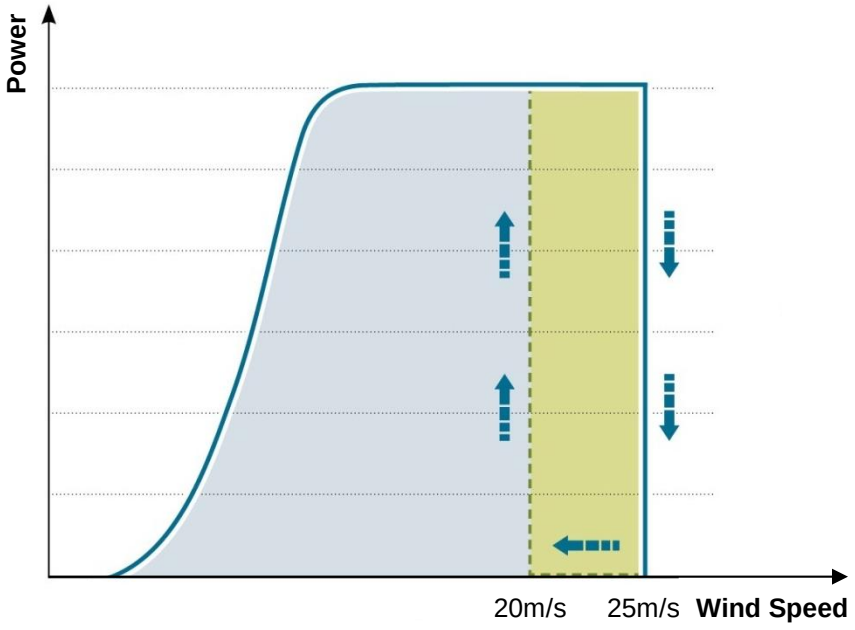
- Wind Turbines typically shut down when the wind speed exceeds 25 m/s (10 min. av.), restarting when the average wind speed falls below 20 m/s.
- Shutdown can have a severe impact on grid stability as production goes from full capacity to zero instantly.
- Shutdowns result in extended production losses due to the resulting hysteresis loop, as indicated in the figure.

Traditional power curve, including the hysteresis loop



Extending the operational range for improved park performance

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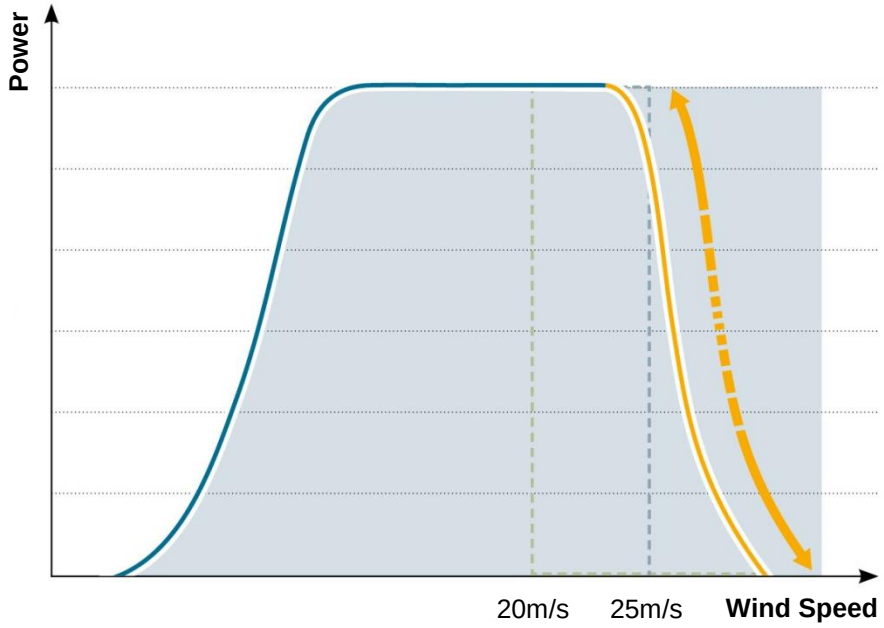
- Extended operation during high wind speeds.
- Intelligent de-rating of rotor speed and power output without impacting structural integrity.
- Reduces production losses due to significant reduction of high wind shutdowns.

Power curve, with the Siemens High Wind Ride Through application



West Wind Results

- Information provided on the HWRT capability showed that the introduction of HWRT at West Wind would introduce a 1.6% improvement in energy production.

- After 4½ months of operation, Meridian undertook an exercise to quantify the actual upside at West Wind.

How to quantify the improvement

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- Quantifying the improvement is not straightforward, particularly as high wind shut down not dependant on turbine mean wind speed only.
- Shut down dependant on turbine control algorithm but typically includes a gust wind speed or some averaging period less than 10 minutes.
- Our approach was to look at the cut-out and high wind re-start of each individual turbine in a northerly and southerly wind direction and use that as a basis for determining the relative cut out wind speeds.
- Based on those values, we could derive a theoretical high wind speed loss and compared that with the actual loss, prior to HWRT being implemented i.e. based on 3 years of performance data.

West Wind Turbine Cut-out

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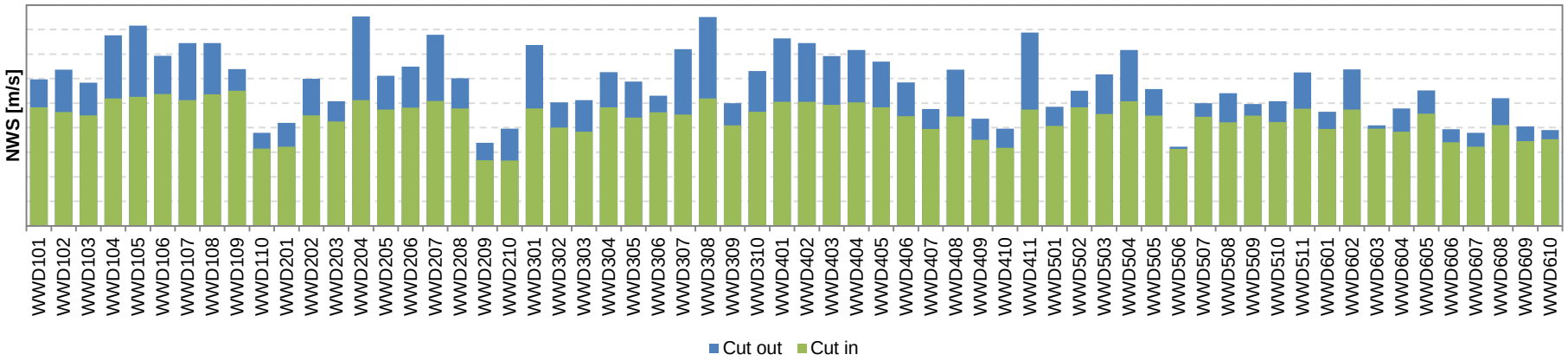
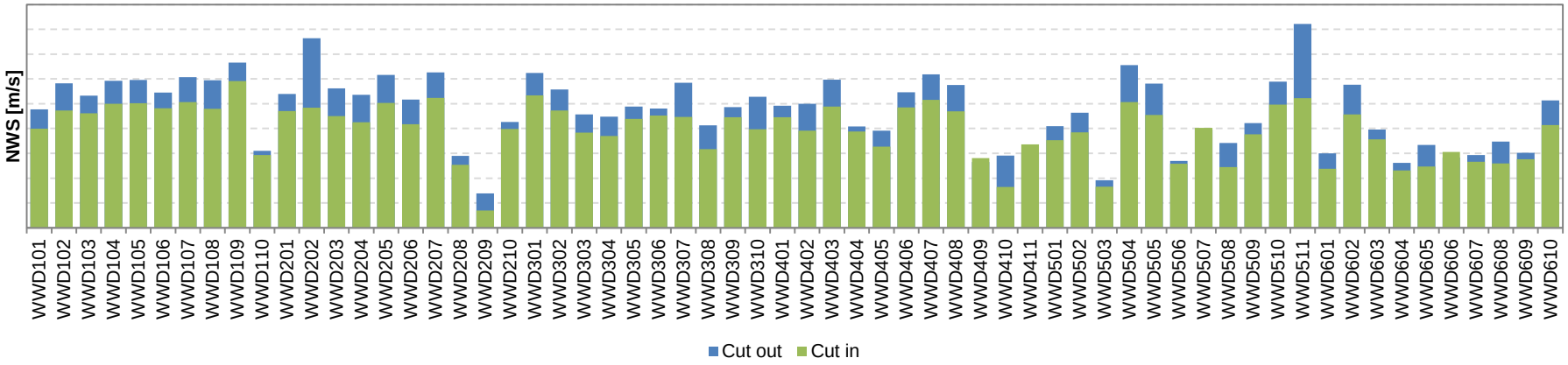
Cut out and cut in wind speeds for all WWD turbines, prior to HWRT
Northerly winds



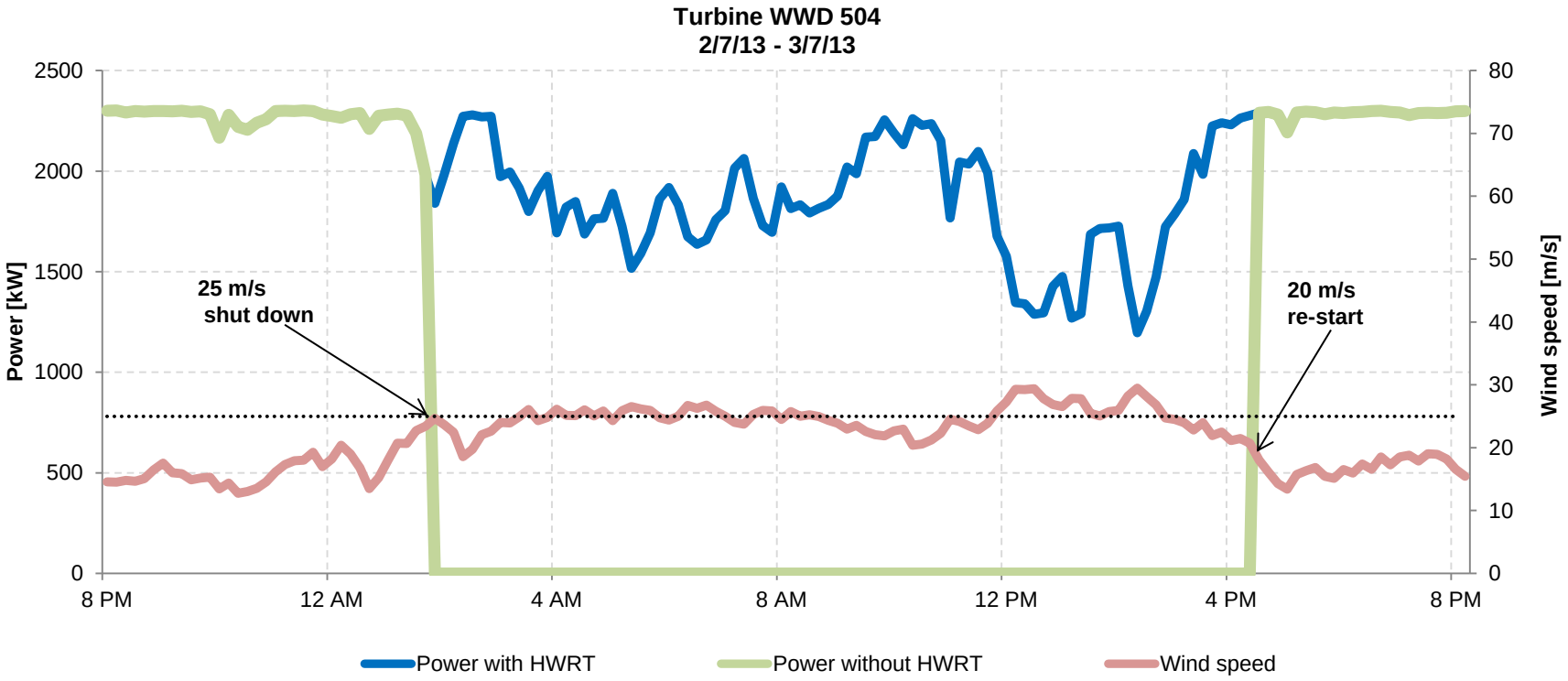
Cut out and cut in wind speeds for all WWD turbines, prior to HWRT
Southerly winds



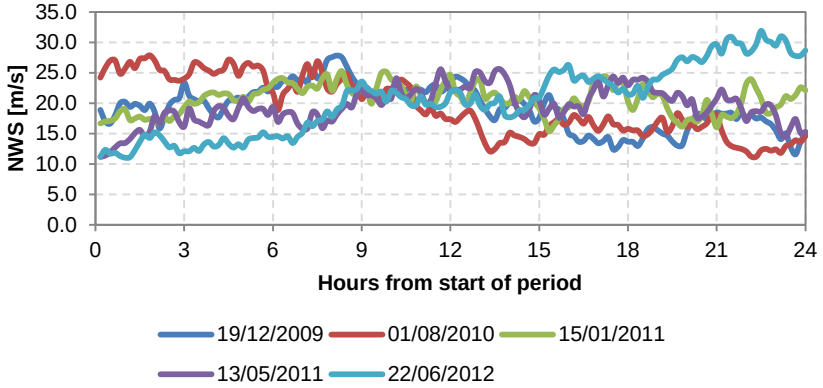
Calculating performance improvement

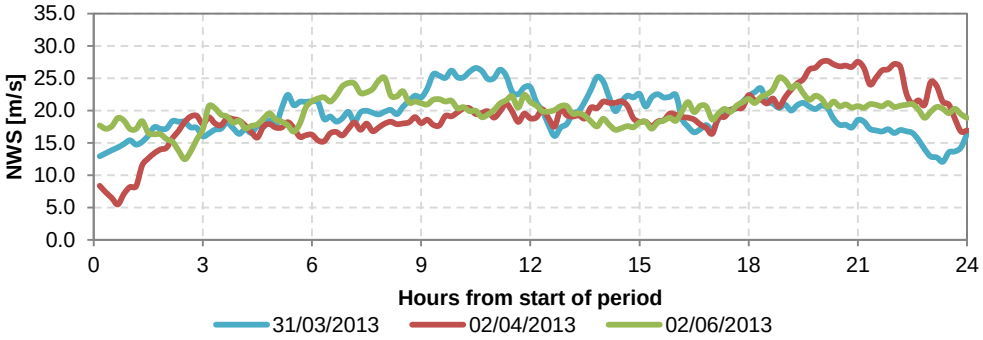
- Having established the turbine/wind direction specific cut-out and high wind speed cut-in, the theoretical loss, if HWRT was not operational, could be calculated.

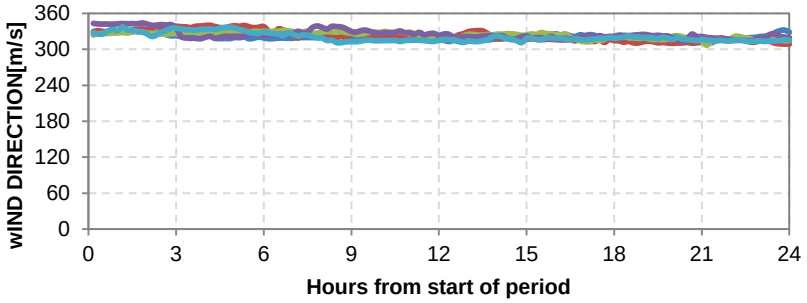
- Analysis shows actual performance improvement was in the order of 1.7%.

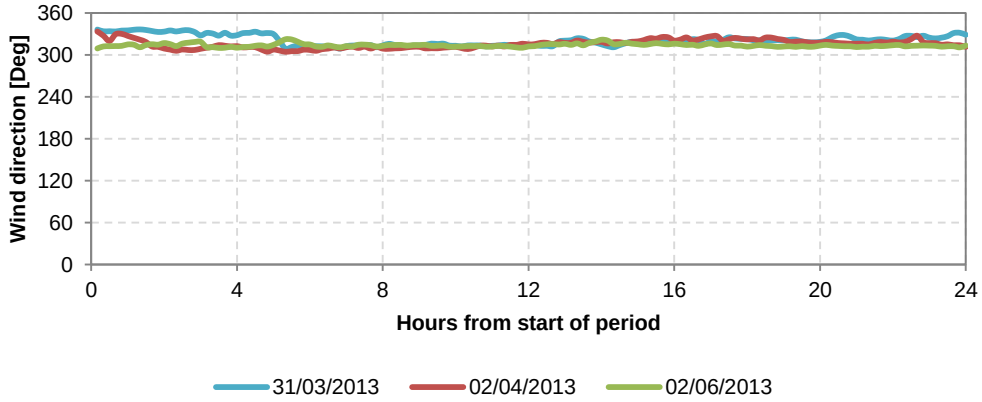


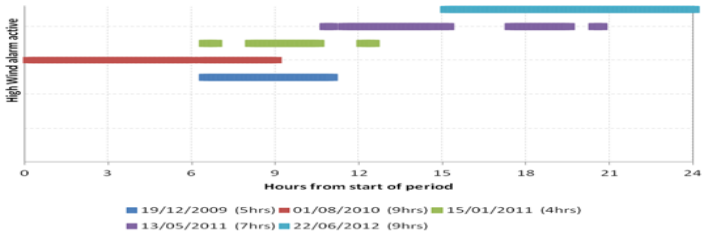
West Wind Results - illustration











West Wind Results

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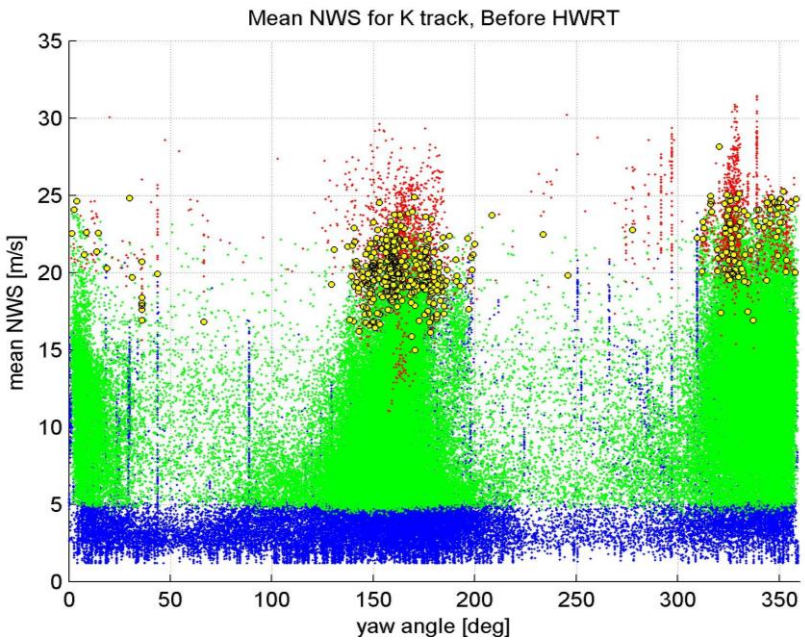

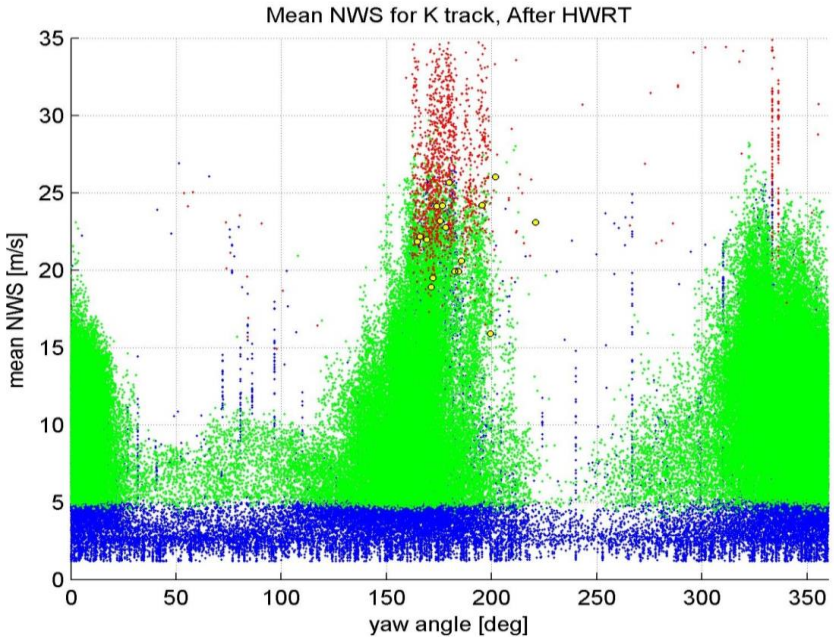

Summary - HWRT

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- High Wind Ride Through has delivered quantifiable benefits to the West Wind project and will deliver likewise at Mill Creek
- Easily implemented through a software upgrade

Further performance enhancements

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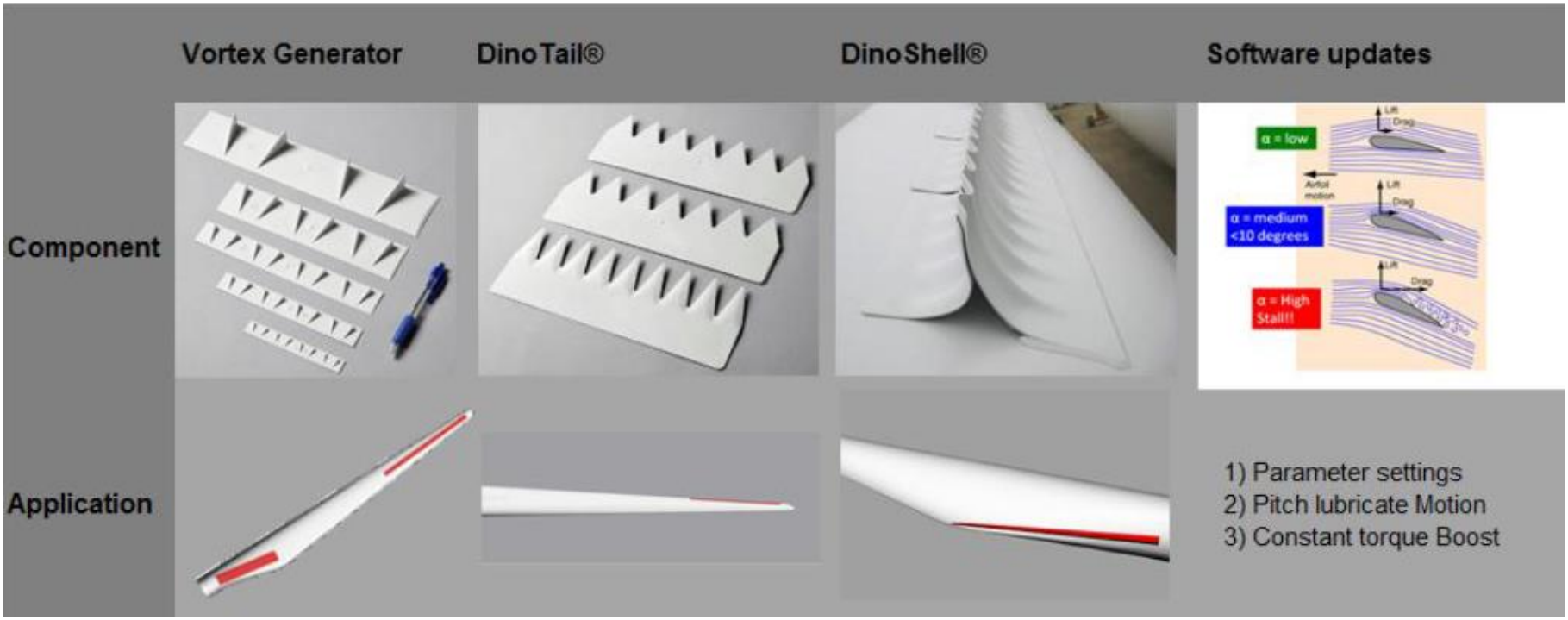
- Siemens continue to develop and make aerodynamic improvements to our blades.



Vortex Generators

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Components
Vortex Generators

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What is a Vortex generator?

- Injection molded thermoplastic components made out of a compound polymeric material (pic 1)
- Small vertical fins with heights of 4 – 24 mm (five sizes) that jut out of the surface of the blade

Where is it located?

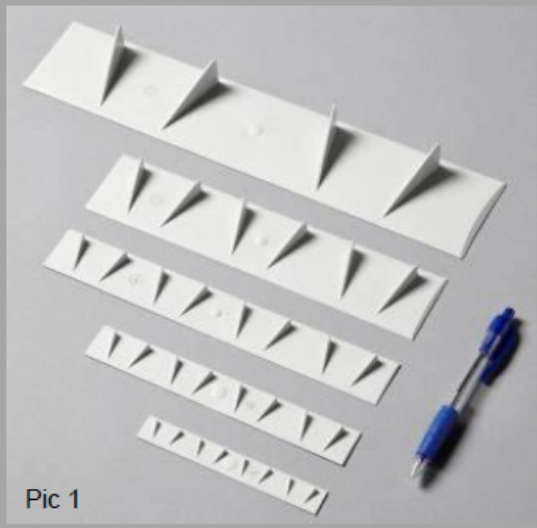
- They are mounted both inboard at the root section of the blade as well as outboard at the tip of the blade

How does it work?

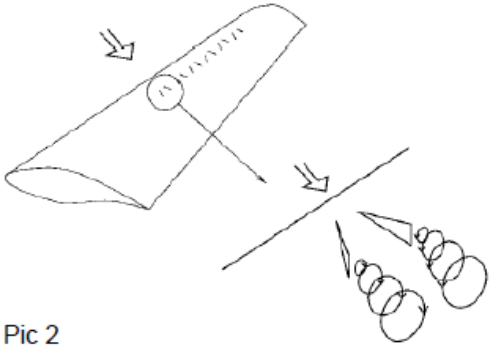
- It mixes the air very close to the blade surface with the air further away (pic 2).
- It thereby delays the airflow separating from the blade surface and thus increases lift.

Why is it of benefit?

- It reduces roughness sensitivity
- It increases lift and thereby the energy production



Pic 1



Pic 2

DinoTail®

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Components
DinoTail

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What is a DinoTail®?

- Injection molded thermoplastic components made out of a compound polymeric material (pic 1)
- Siemens patented flaps with serrated edges that are glued onto the trailing edge of blade tip

Where is it located?

- They are mounted at the tip section of the blade

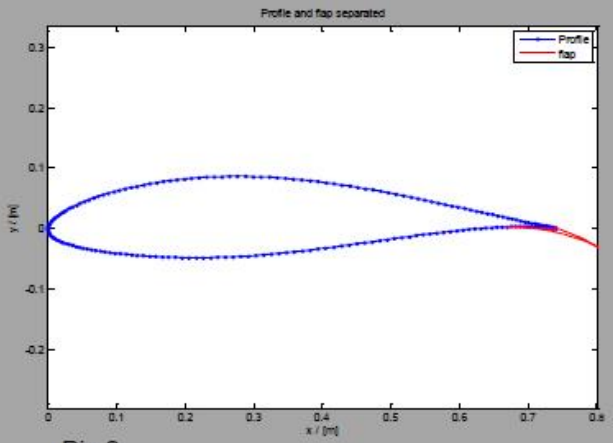
How does it work?

- It enhances the lift by extending the blade chord (pic 2)

Why is it of benefit?

- It increases lift and thereby the energy production

Pic 1



Pic 2

DinoShells®

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Components
DinoShell

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What is a DinoShell®?

- Injection molded thermoplastic components made out of a compound polymeric material (pic 1)
- Siemens patented flaps that are glued onto the trailing edge of blade root

Where is it located?

- They are mounted at the root section of the blade (pic 2)

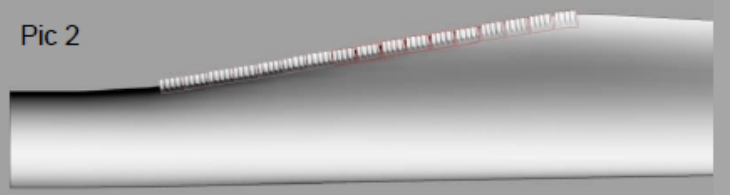
How does it work?

- It enhances blade lift. However, in contrast to other types of flaps, the DinoShell® does not extend beyond the original chord length (pic 3).

Why is it of benefit?

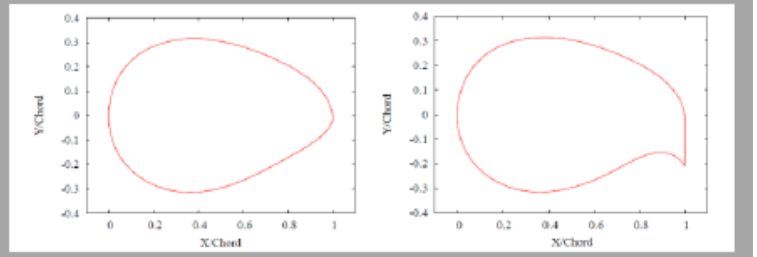
- It increases lift and thereby the energy production

Pic 1



Pic 2

Pic 3



w/o DinoShells®

w DinoShells®

Power Curve comparison SWT-2.3-101

Clear improvement between 6m/s & 12 m/s

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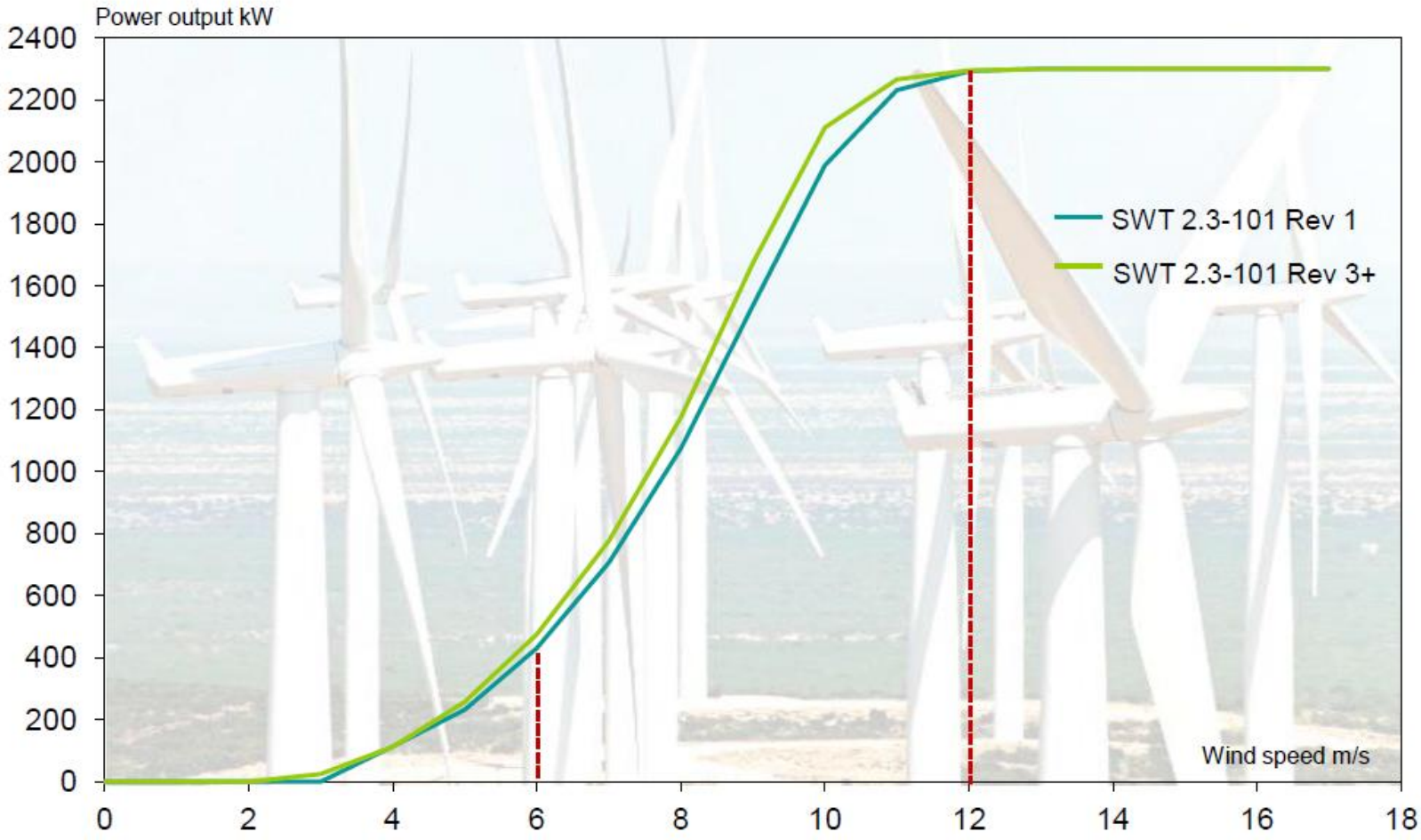
When comparing the standard power curves of revision 1 and revision 3+ of the SWT-2.3-101 we see a clear improvement between 6 m/s and 12 m/s.



Power Curve comparison SWT-2.3-101

AEP comparison rev.1 & rev 3+

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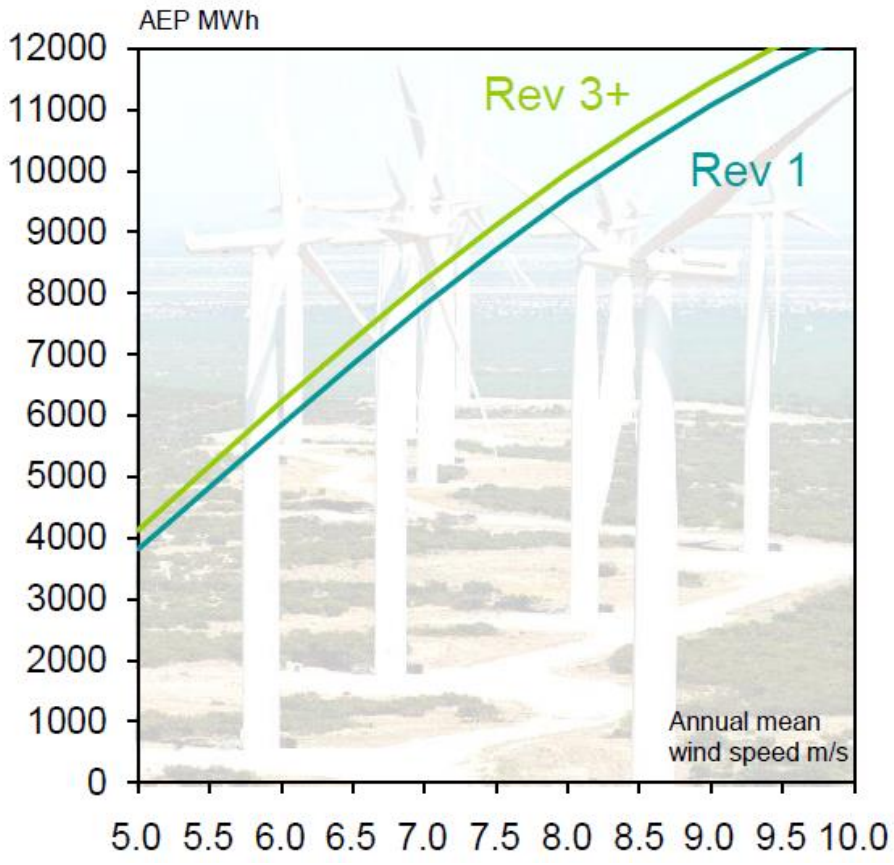
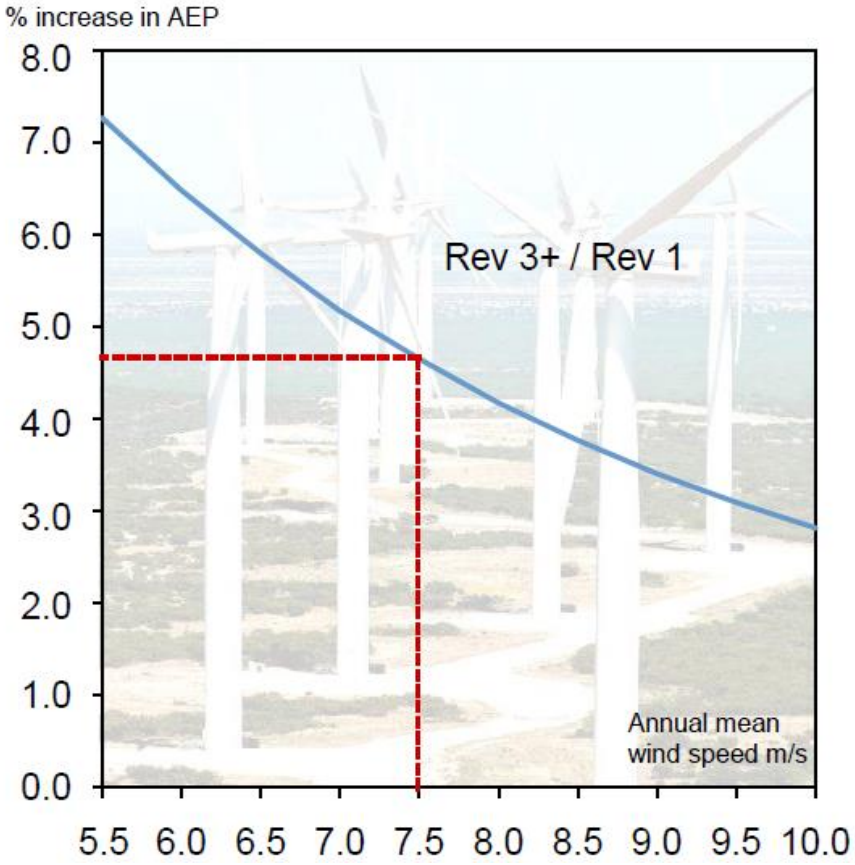
Based on the standard power curves the calculated AEP for revision 3+ shows a clear improvement compared to revision 1 (left graph). For the SWT-2.3-101 the calculated increase in AEP at an annual mean wind speed of 7,5 m/s equals 4,65% (right graph).





Te Uku – Possible Blade upgrade

- Meridian has calculated that there is a potential 3% theoretical increase if the blade upgrade was implemented at Te Uku
- This upgrade is more complex than a simple software upgrade as was the case with HWRT; considerations include:
  - Cost of additional hardware
  - Cost of specialised technicians to install the hardware
  - Time required to fit hardware and consequential turbine down time during fitting
- Meridian is working through this process with Siemens to determine whether there is a business case for this improvement.

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