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Increase in the Annual Energy Production due to a Retrofit of Vortex Generators on Blades

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Increase in the Annual Energy Production due to a Retrofit of Vortex Generators on Blades

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$$P = \frac{1}{2}\rho A v^3 C_p$$

DTU Wind Energy
Department of Wind Energy
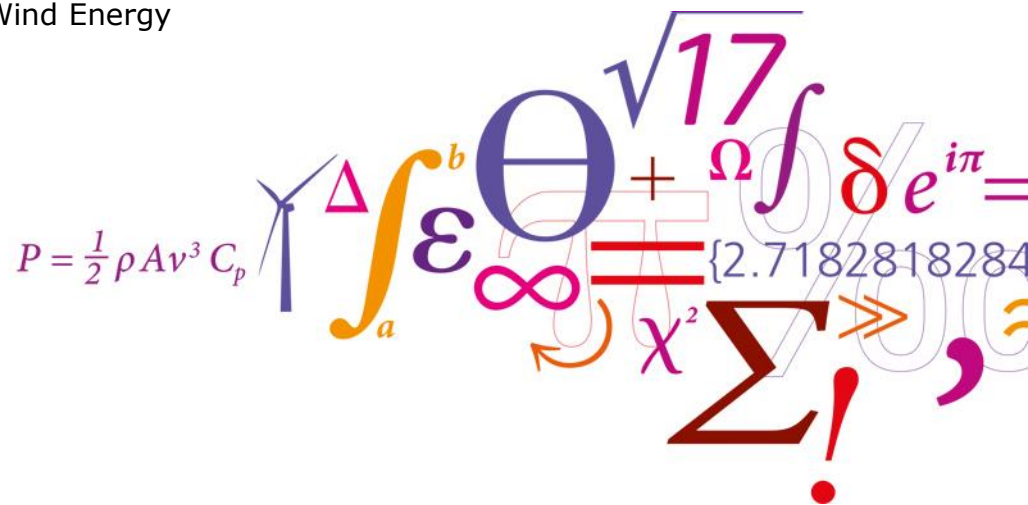
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15 June
2016

Introduction:
Examples of surface roughness
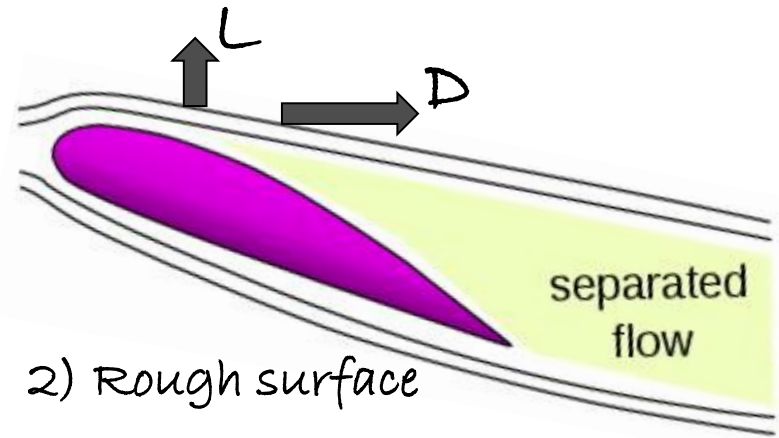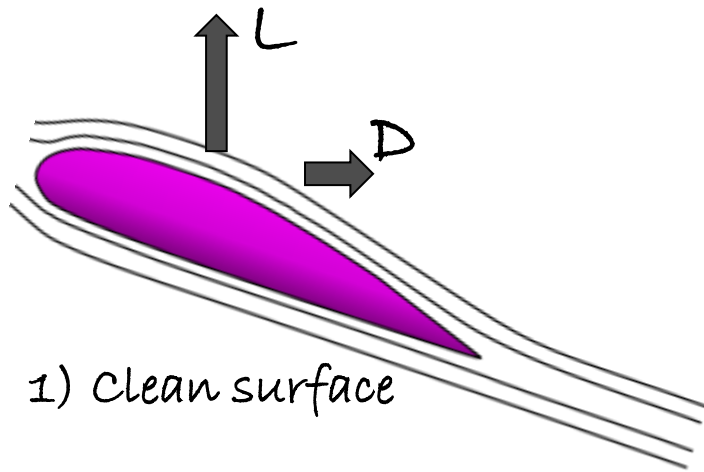

Pic: Renewable Advice

Surface Contamination

Leading Edge Erosion

Pic: Deutsche Windtechnik

Introduction:
Surface roughness - Energy production – VG's

So, how it all works?

Energy Production ~ L/D

L

D

1) Clean surface

L

D

separated flow

2) Rough surface

Array of VG's

L

D

3) Rough surface + VG's
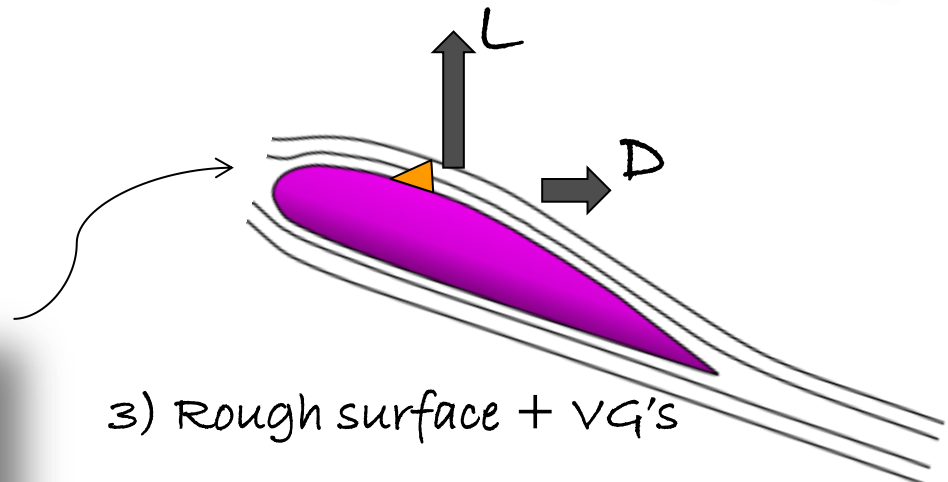
http://en.wikipedia.org/wiki/Stall_%28fluid_mechanics%29
"StallFormation" by Interiot

Methods:
Engineering modelling - **Procedure**

1. Emulate the effect of surface roughness and VG's by modifying the aerodynamic coefficients.

2. Account for the three dimensional effects.

3. Carry out BEM computations with each of the data sets from steps 1-2 along the whole blade span for all the wind speeds in the turbine control scheme.

4. For each discrete radial position determine independently whether it is beneficial to install VG's in the clean and *rough case.*

Methods:
How the engineering model works

✓Modelling based on wind tunnel experiments.

✓Lift coefficient as a weighted sum of a fully attached and a fully stalled lift coefficient

✓The weight factor is the separation function. Values between 1 for the fully attached and 0 for the fully stalled flows:
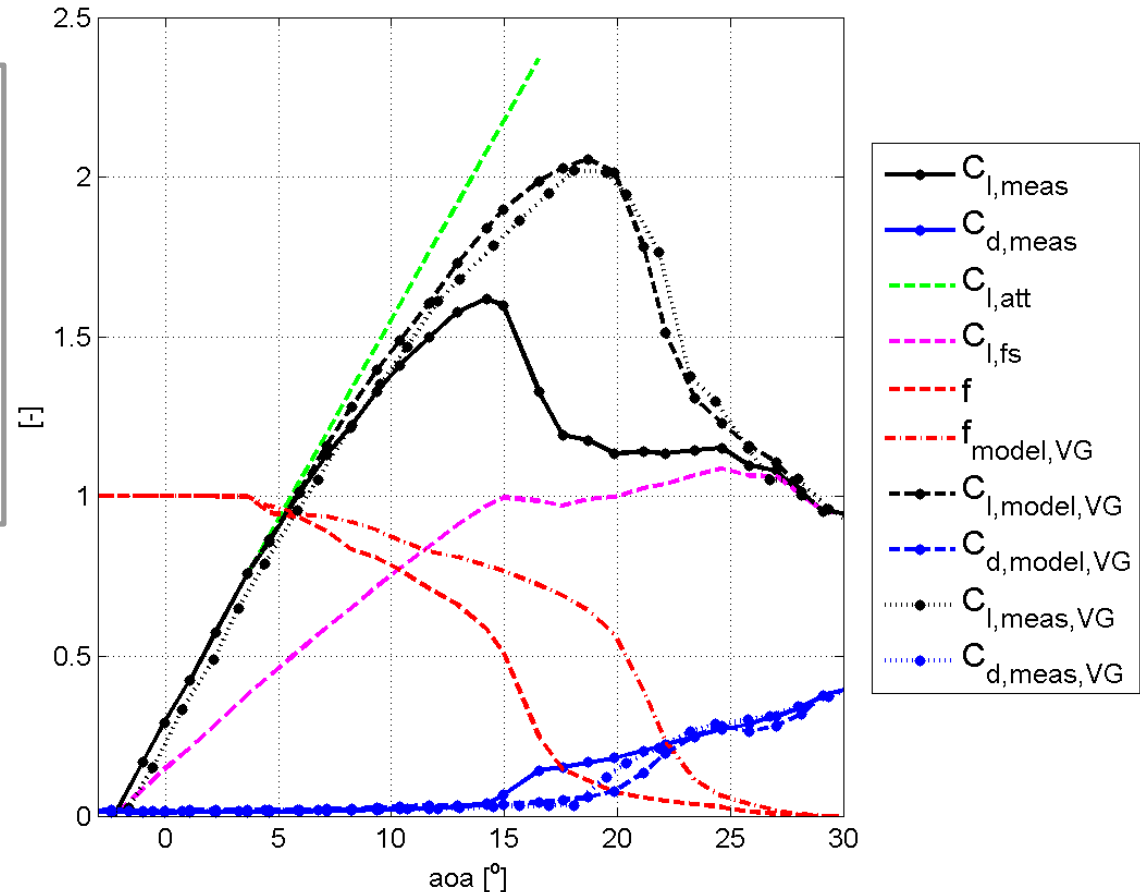
$$C_l(\alpha) = C_{l,att}(\alpha)\, f(\alpha) + C_{l,fs}(\alpha)\, (1 - f(\alpha))$$

✓Only the separation function altered in the model*!*

✓Drag coefficient also as a function of *the separation function* with 3 contributing terms*.*

Methods:
Engineering model – A figure not as complex as it seems.

- Comparison of the present VG modelling and wind tunnel results

- Risø-B1-24

- Re=1.6*1e6.
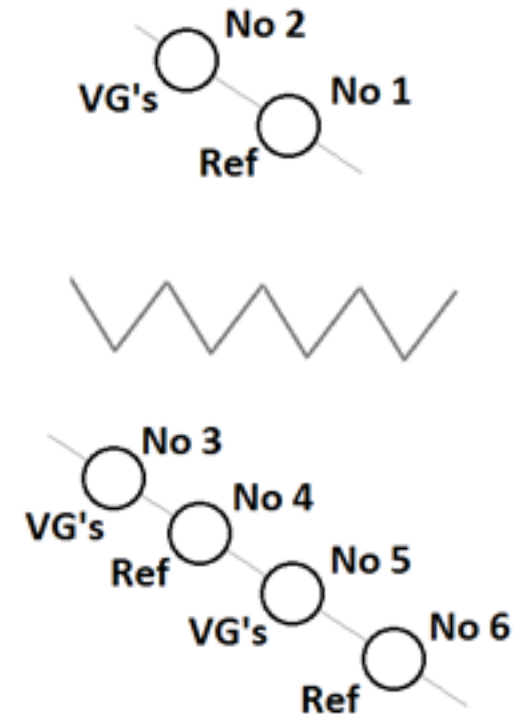
- VG's mounted at x/c=0.2

Methods:
Full-scale experiment

1. The power generated by the rotors, wind speed and direction logged for 12 months

2. VG's installed on 3 turbines

3. Data logged for the following 2 months on all 6 turbines

4. The measurement time series from both turbines was divided into temporal bins

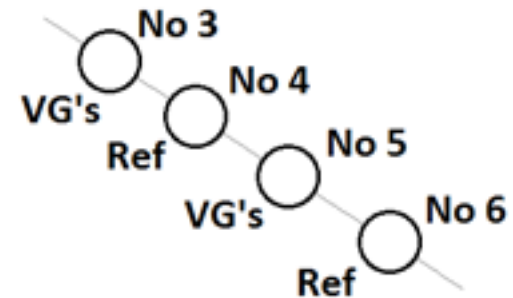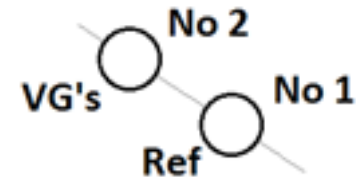5. Power curve was calculated for each bin and each turbine

Full-scale experiment

6. Assumed a constant statistical wind speed distribution

7. Energy production was calculated for each temporal bin and each turbine

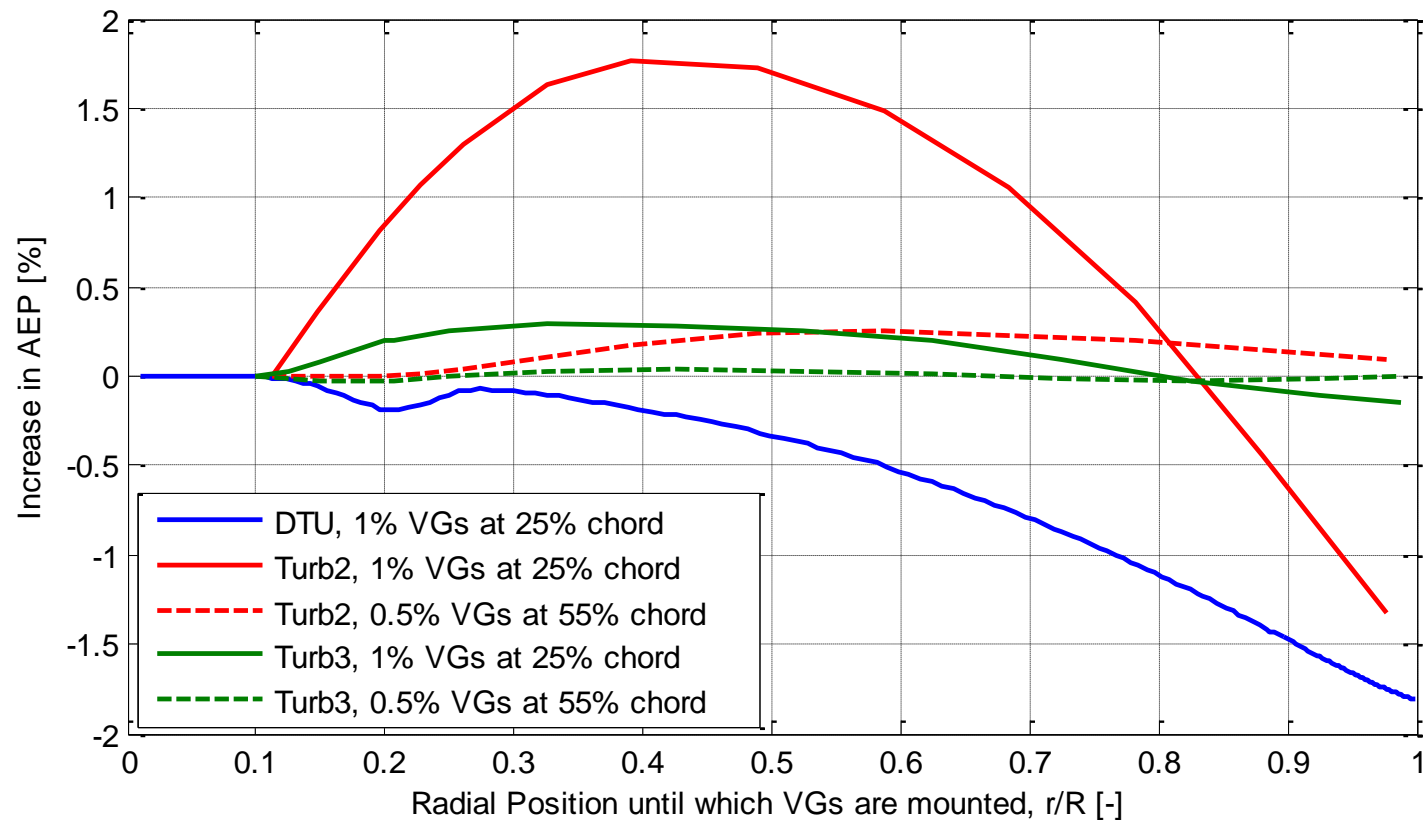8. The relative difference between those values was calculated as:

$$EP_{diff} = \frac{\left(EP_{VG} - EP_{ref}\right)}{EP_{ref}} \; [\%]$$
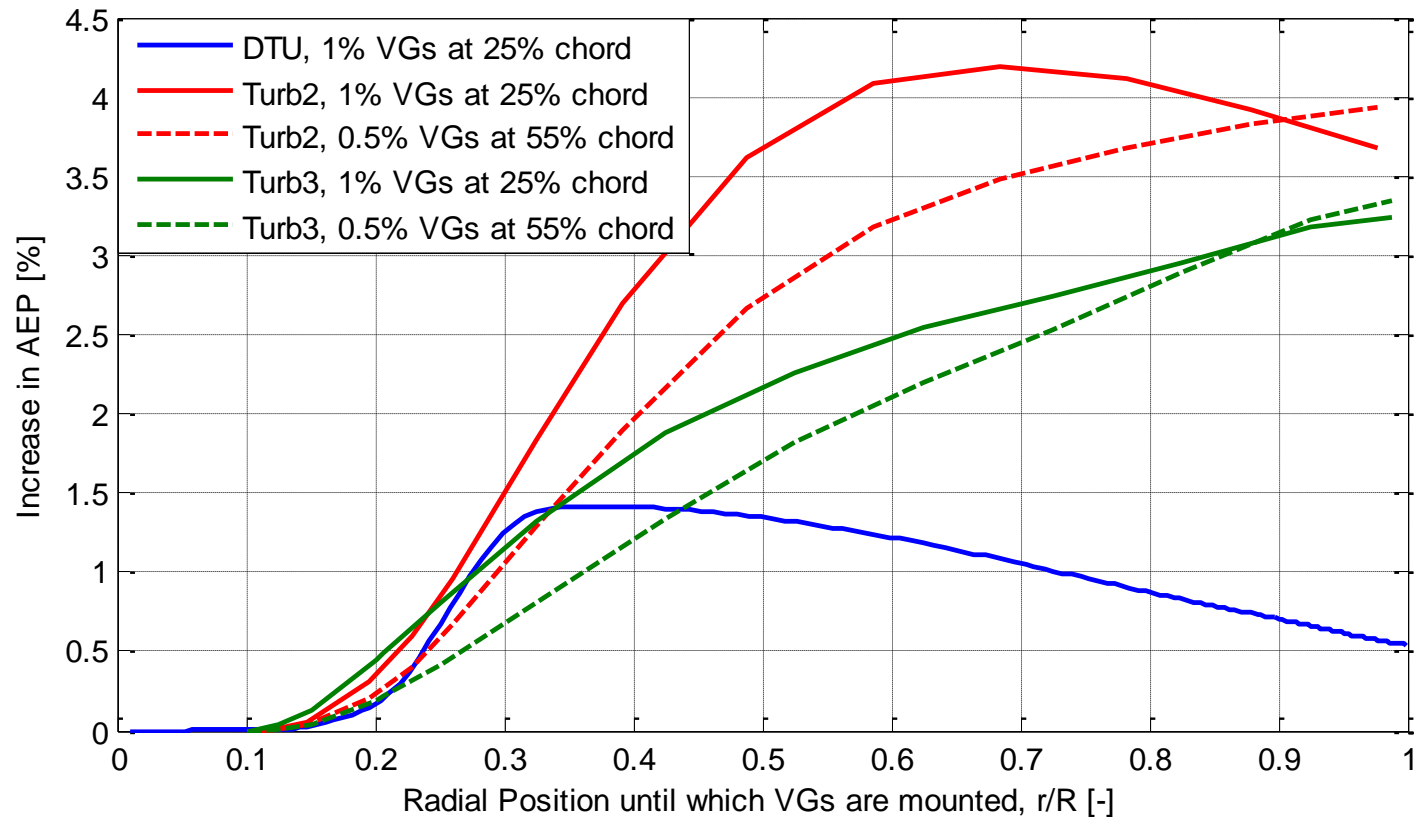
Modelling – Clean blades

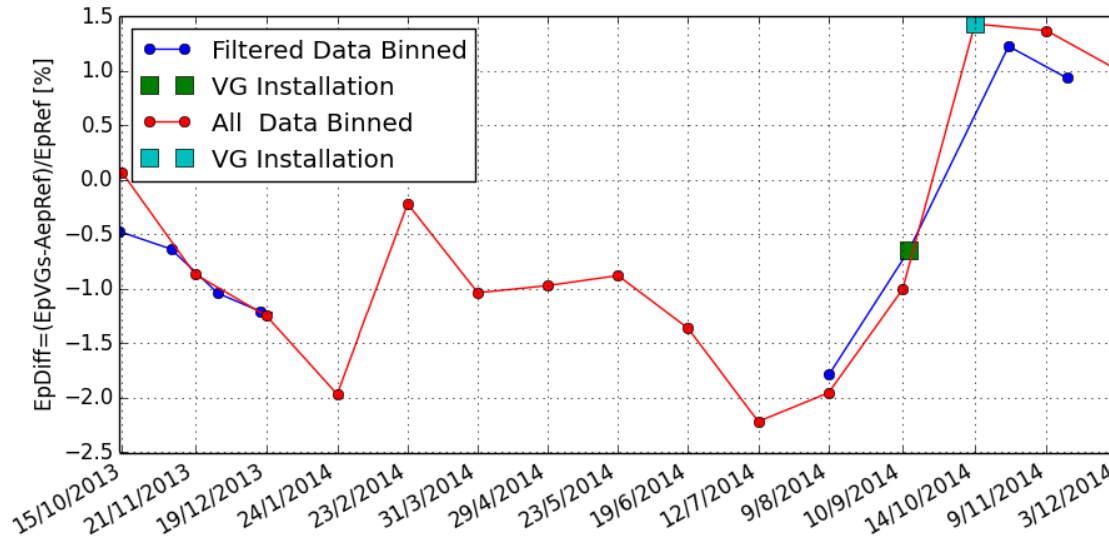Relative increase in the AEP as a function of the radial position until which the VG's were modelled

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Modelling – Blades with surface roughness

Relative increase in the AEP as a function of the
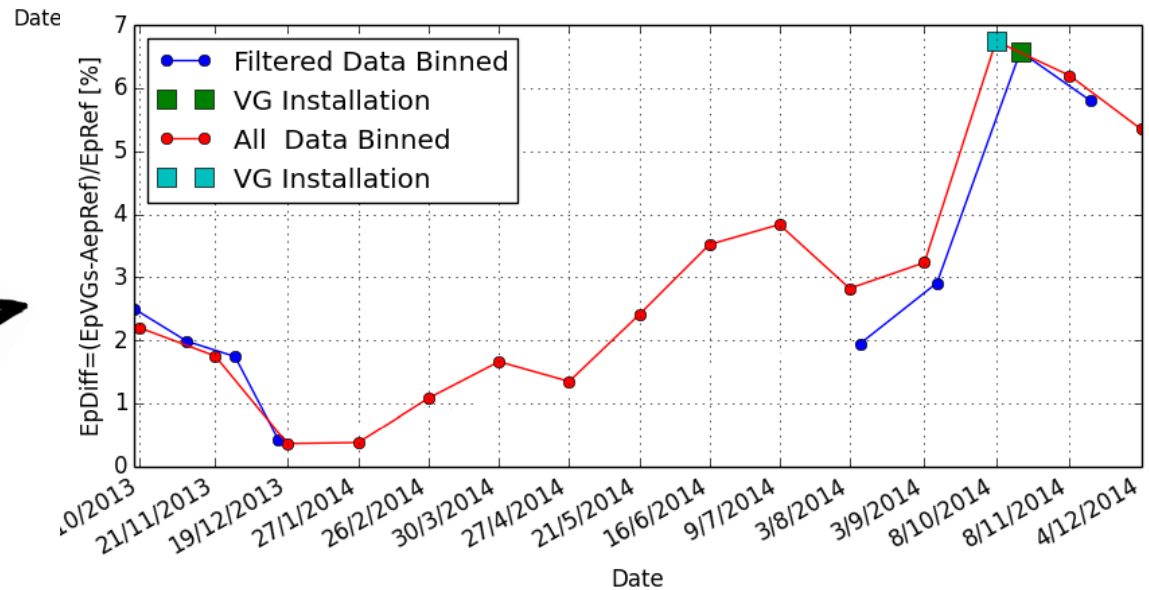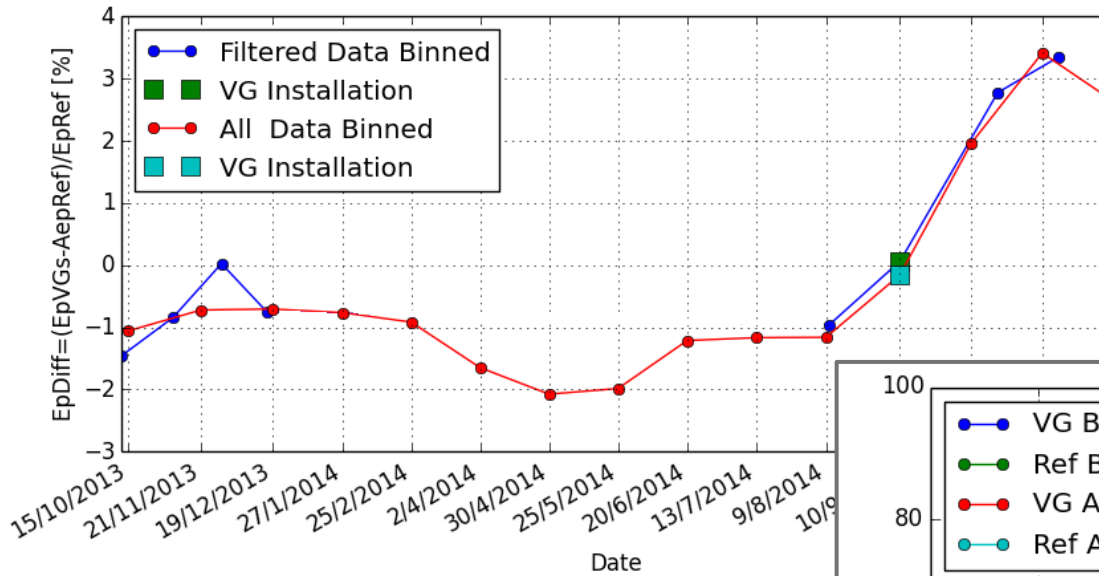radial position until which the VG's were modelled

Results: **Experimental**

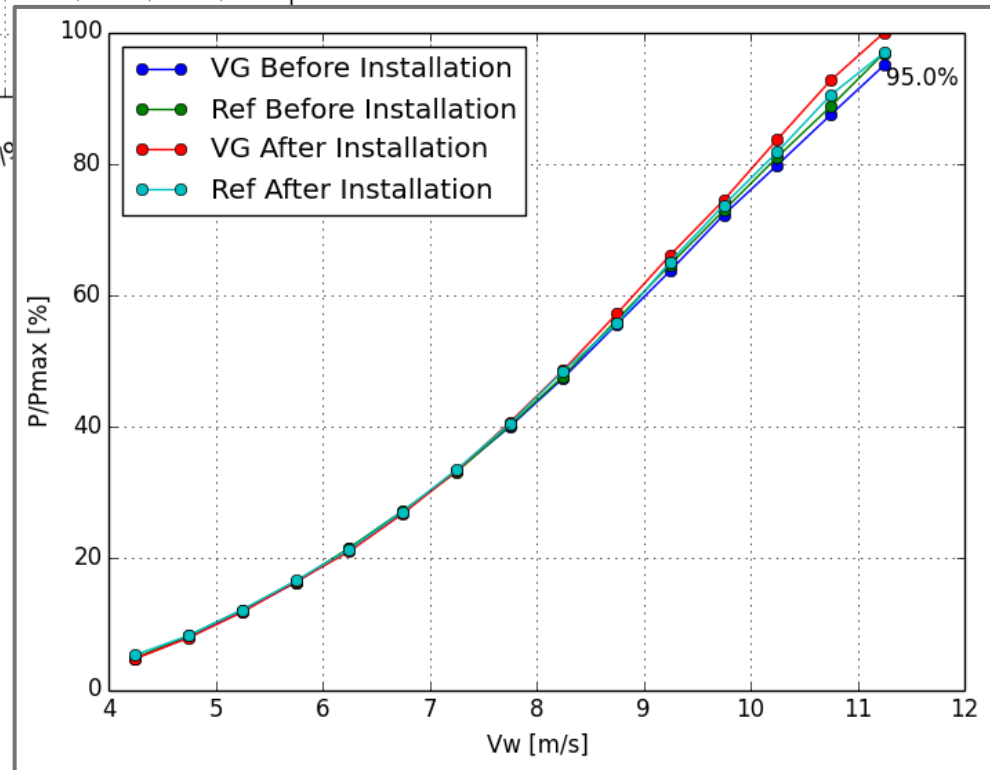# *Results:* **Experimental**

Pair No 5-6

Mean increase
of 3 pairs:
3.1%

Thank you!