Vestas technology and challenges entering Norway

Industry meets Science

Mads Kolby
Senior Specialist, Sales
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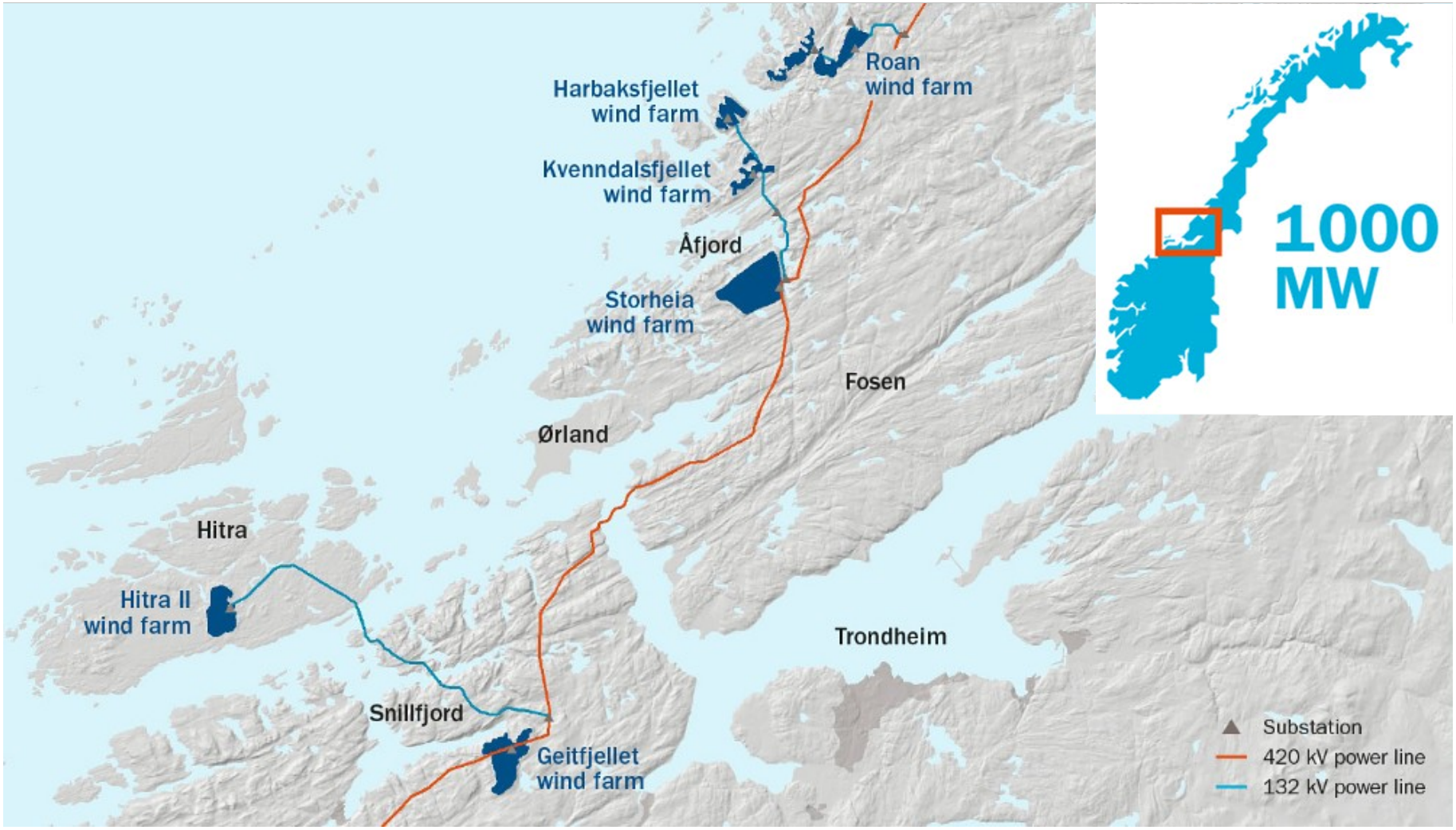
Vestas is going to Norway – Fact and figures

- Total number of turbines is 278
- Turbine rating is 3.6MW with rotor diameter 117m (112m)
- Tower height is 87m
- Coastal area providing some of the best conditions for renewable energy production from wind in Europe
- Very good wind speeds 7m/s – 9.8m/s
- Rock foundations
- Sites are: Roan, Storheia, Hitra II, Geitfjellet, Harbaksfjellet and Kvenndalsfjellet

Europe's largest onshore wind power project to be built in Central-Norway

Projects and power line

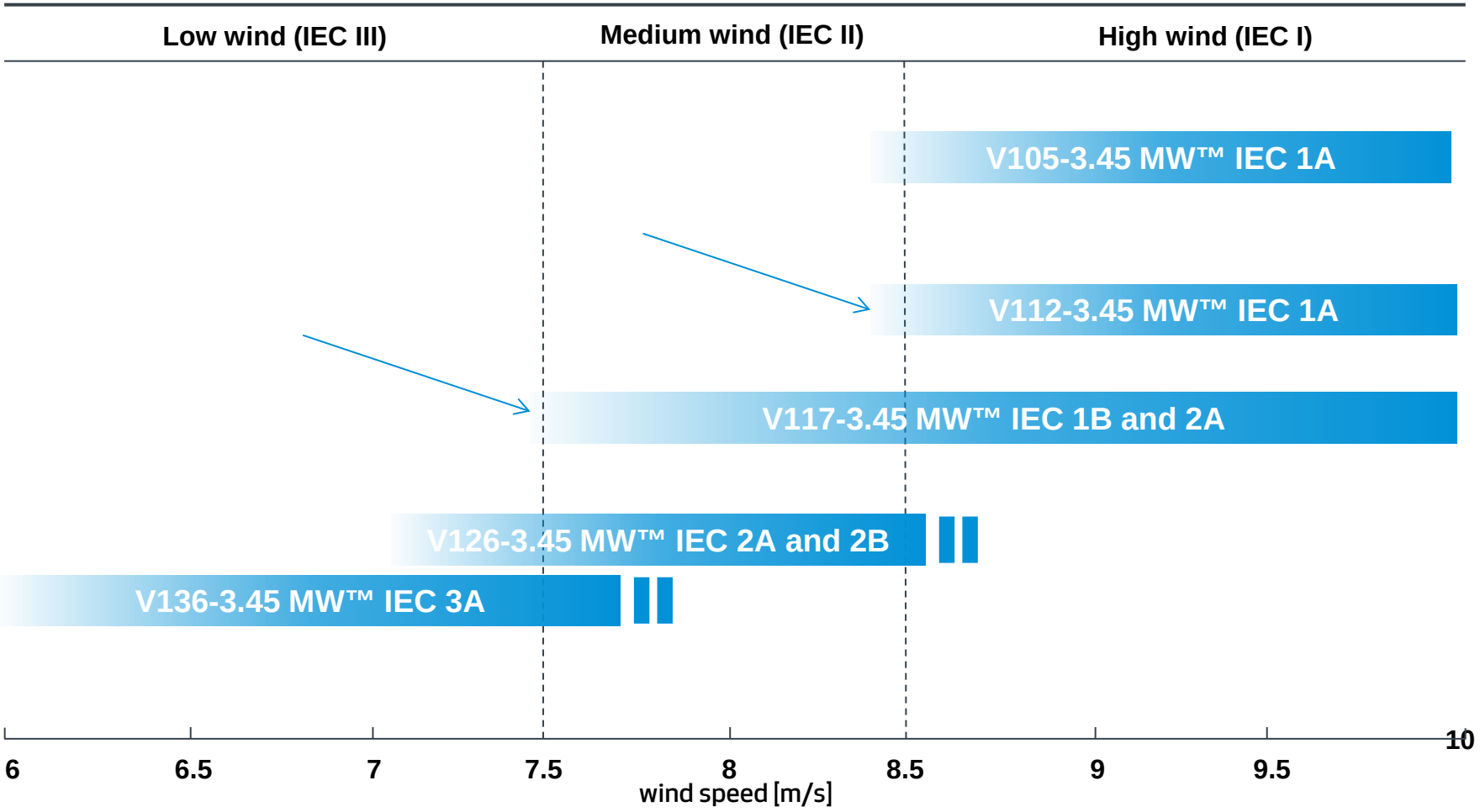
Europe's and Vestas largest onshore wind project | 1000.8 MW | 278 turbines | 6 sites



The Product

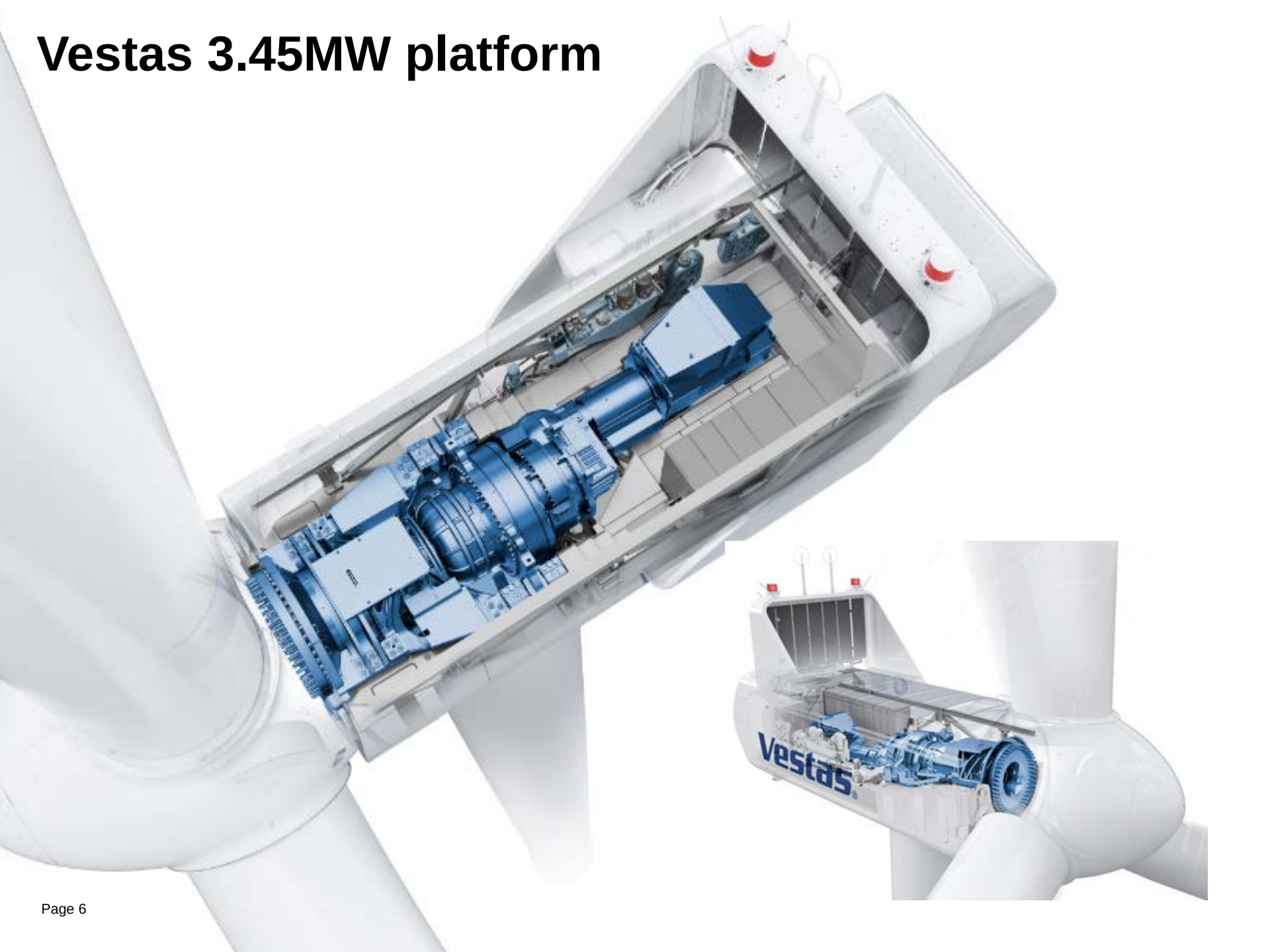
Turbine overview

Vestas® turbines cover across wind classes



All turbines can be deployed on sites with lower wind speeds than indicated. Furthermore the turbines can also go into a higher wind speed if other parameters allow i.e. temperature, turbulence, grid

Vestas 3.45MW platform



The Challenges

The Main Challenges

- Site accessibility
- Towers
- Ice
- Turbulence
- Installation, Safety and installation program
- Noise
- Shadow cast

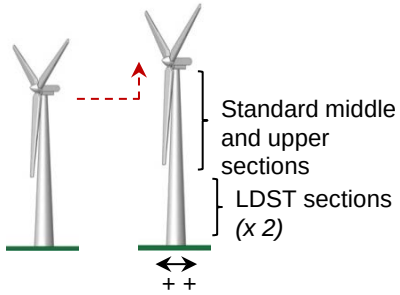
The LDST Concept

Due to a large diameter LDST can go to higher hub heights while reducing the usage of steel. Slicing each LDST section into 3 segments (re-assembled at site) is needed for transport issues

Large diameter

Hub height:
By increasing the diameter using LDST the tower gets stiffer / stronger and can go to higher hub heights:

LDST tower

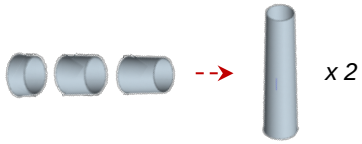


Cost:
By increasing the diameter the steel plate thickness can be reduced and still withstand the same loads.

Production

LDST sections:
Each LDST section is composed of regular shells (i.e. tubes) with a larger diameter:

LDST section

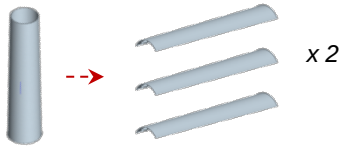


Standard middle and upper sections

Transportation

Slicing:
Due to transport the LDST sections are sliced into three segments after production.

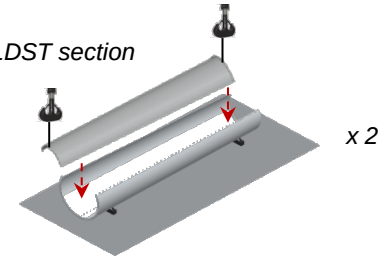
LDST section



At site

Re-assembly:
The segments of each of the LDST sections are bolted (bolzen) together with longitudinal flanges:

LDST section



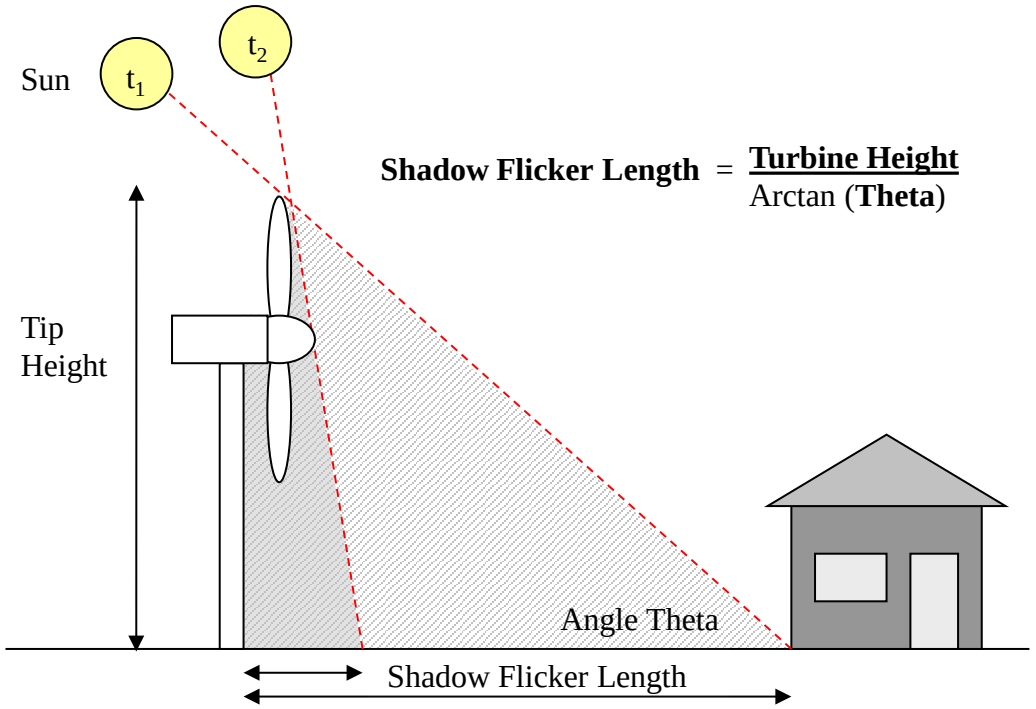
Shadow Flicker Fact Overview

Two Definitions of WTG Shadow Casting:

1. **Theoretical** = Worst Case Casting Ignoring Weather or Operational state of WTG
2. **Actual** = Includes Weather and if the Turbine is Running

Shadow Casting Impact is Primarily Dependent on:

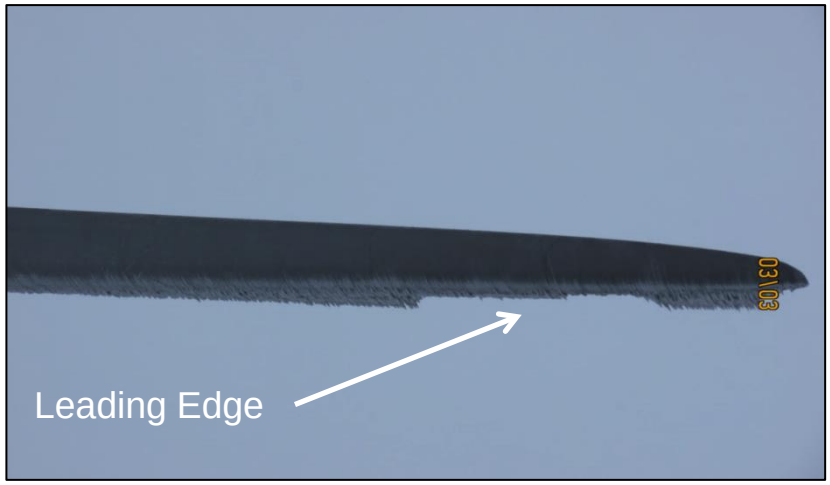
- Angle and Position of the Sun in Relation to Turbine and Object at Risk
- Distance from Turbine to Object
- Size of Rotor
- Hub Height



Vestas De-icing

System performance

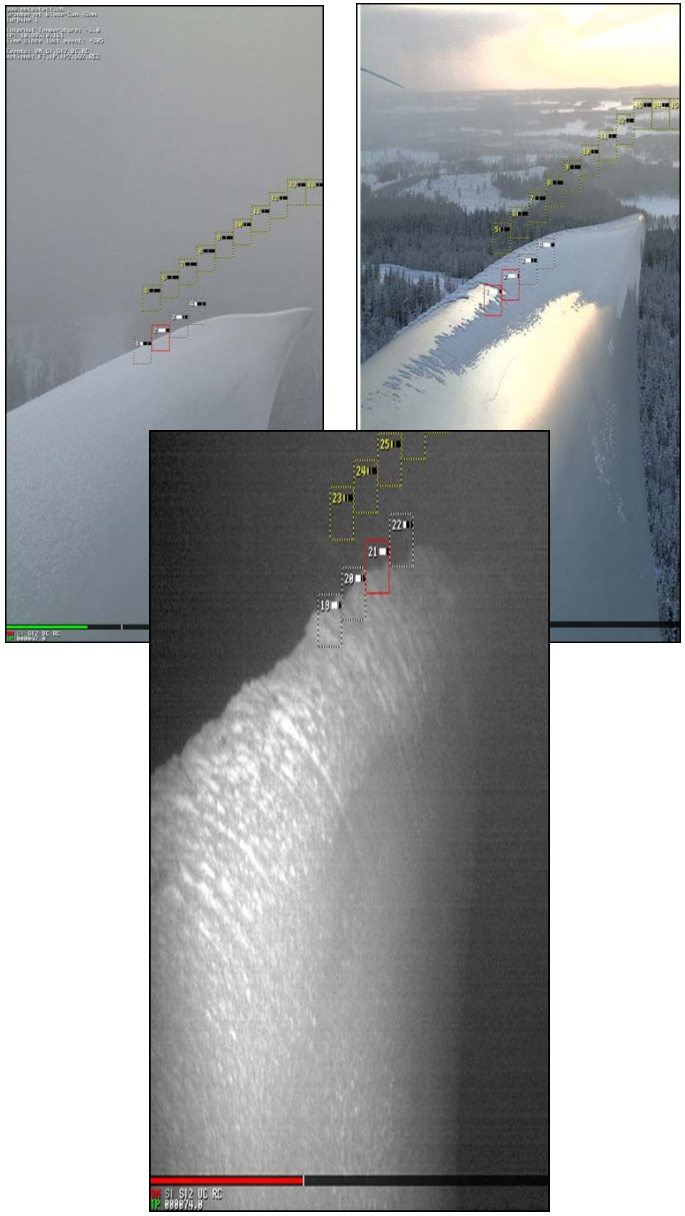
Blade with Ice



- 90% of the aerodynamic performance is coming from the tip end of the blade
- Ice accretion typically start from tip and up the leading edge, and eventually cover the full chord starting from tip end
- Target area is the outer 1/3 of the blade, full chord & 2/3 of leading edge
- Fast recovery of production
- Controlled de-icing cycle to reduce ice throw
- Minimize risk of run back icing due to large blade heating area

Vestas Ice Detection

Designed to reduce safety risk in icy conditions



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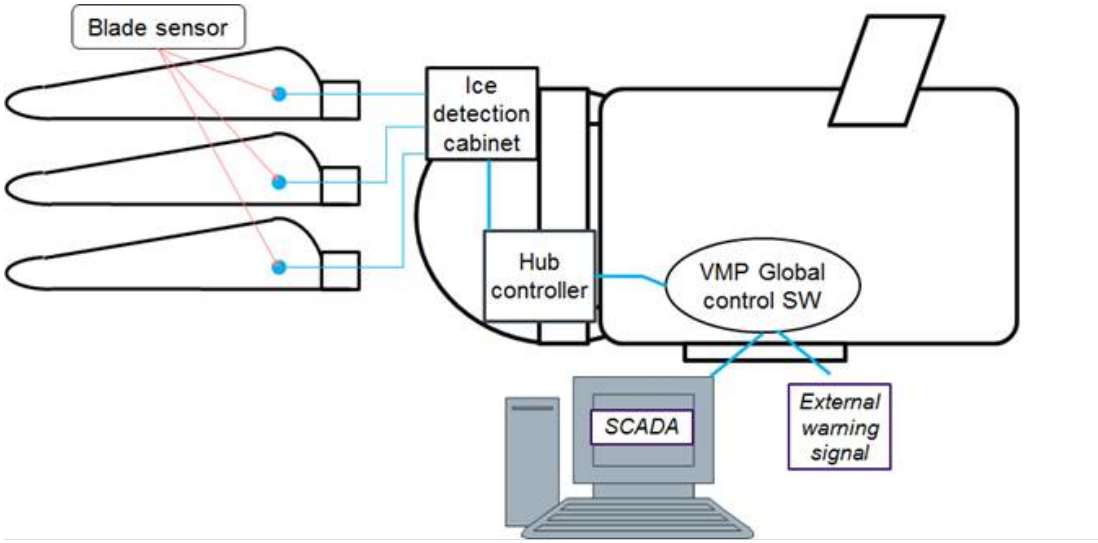

Challenges going forward?

RISK

TRUST

Fast return of money

More production

Low prices

Green profile

Easy installation

Longer lifetime

SAFETY

Predictability

simplicity