

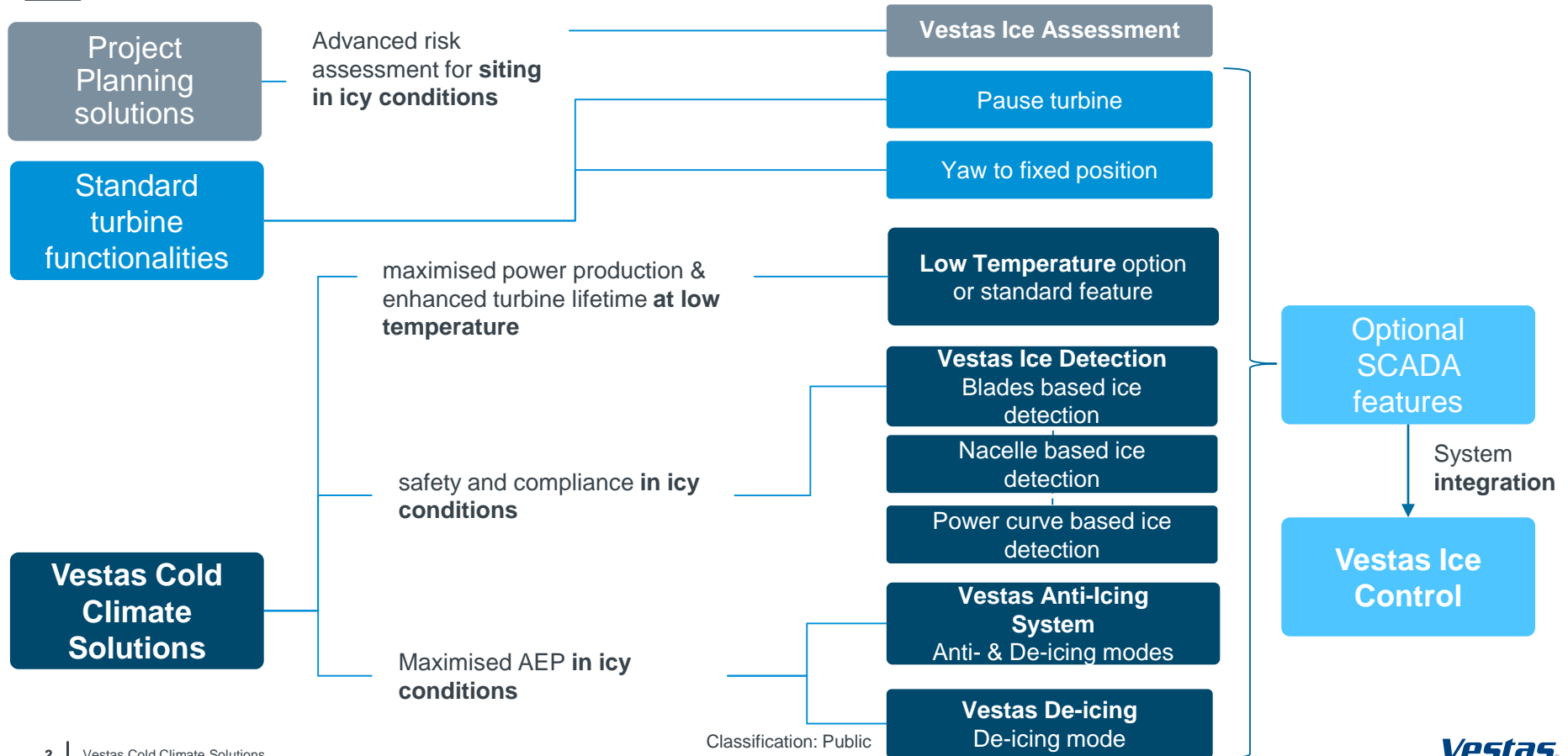
# Vestas Cold Climate Solutions

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Winterwind 2020, Åre

Karl Gregory  
Senior Specialist, Power Solutions

# Vestas Cold Climate Program

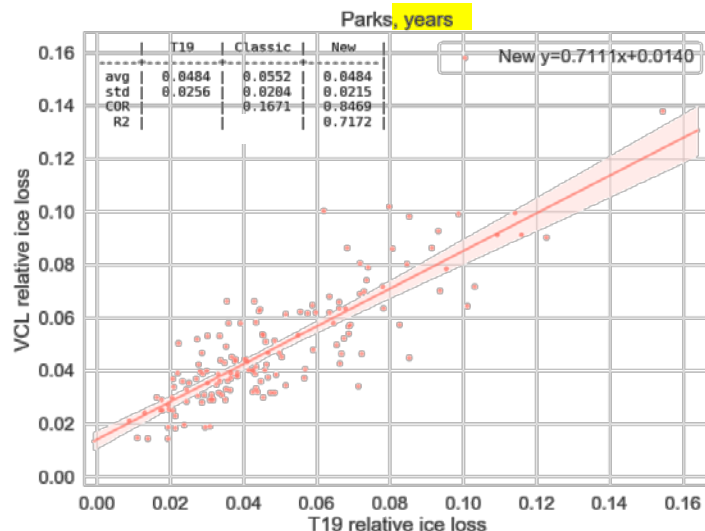
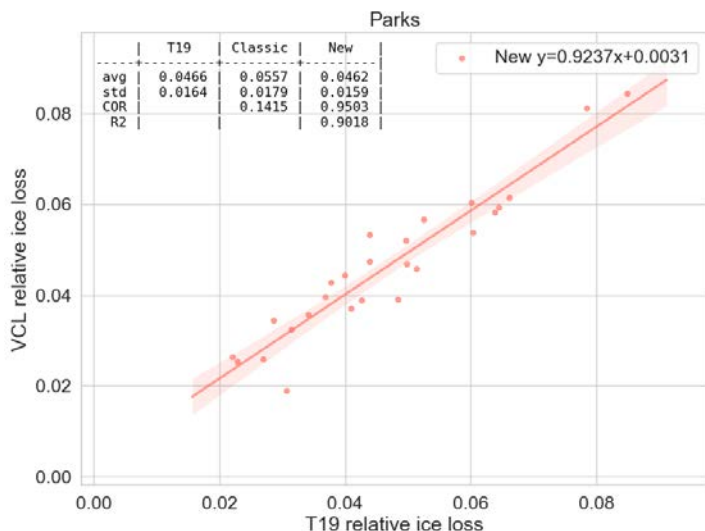


# Siting in Cold Climate Conditions

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# New site-level pre-construction icing loss estimate

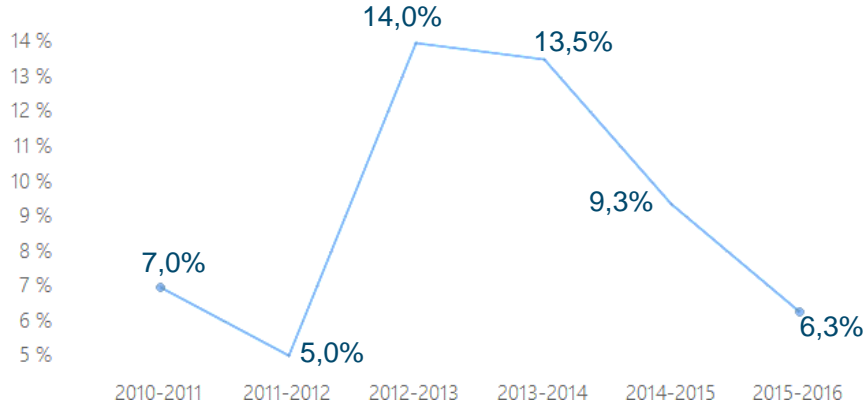
- Fast, robust method for early icing assessment
- Using meteorological input (wind speed/direction, temperature, clouds) from a 3km mesoscale model
- Trained and validated against the IEA Task-19 ice loss calculation method on 26 wind farms in SE and FI.



\*VCL = Vestas Climate Library; a 20-year global mesoscale climatology database

# Production loss within a park varies per year and turbine

Total park production ice loss average per year  
[% AEP]

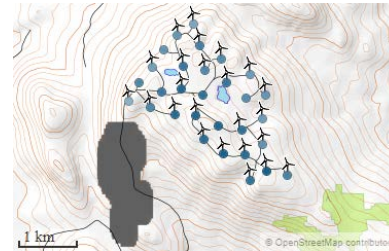


Production ice loss per turbine  
[% AEP]



## Advanced siting methods and capabilities

are required to assess the variability of icing impact within a power plant and implement active cold climate mitigation actions to maximise the value of the site.

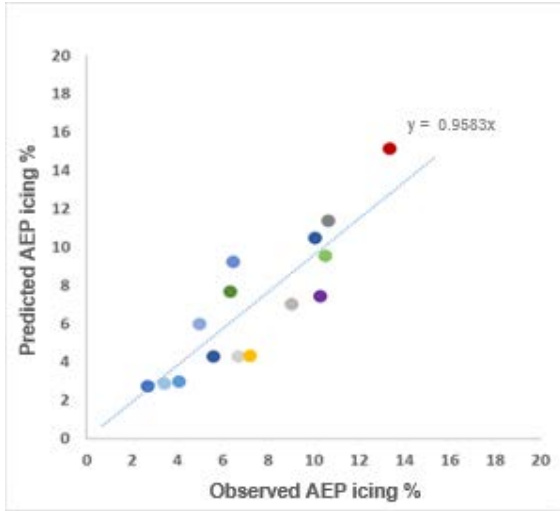


Wind park setup used as example to extract ice loss data

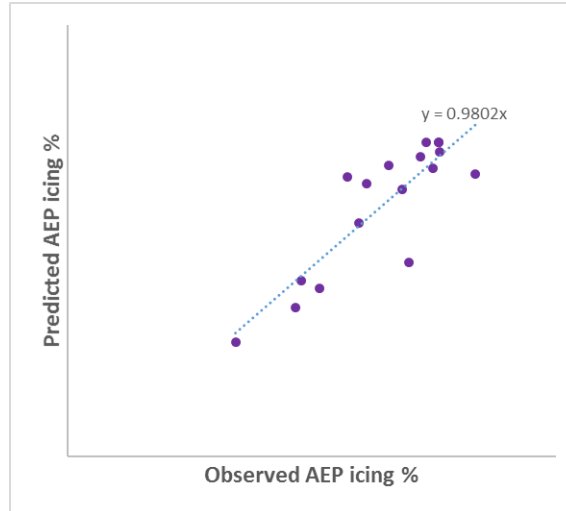
# Validation of power loss due to icing

Vestas Ice Assessment™ - Predicting absolute park losses and relative intra-park variability

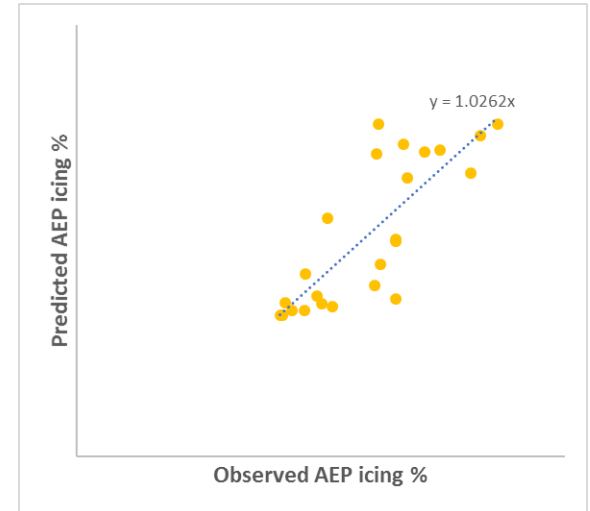
### Total park losses



### Individual WTG losses, park 1



### Individual WTG losses, park 2

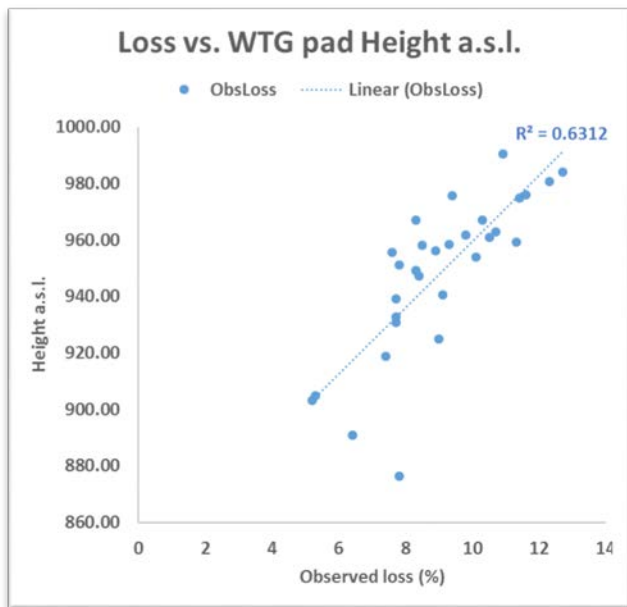


# Causes of icing variability within a wind park

A

## Height of the pad

Explains ~60% of the variability



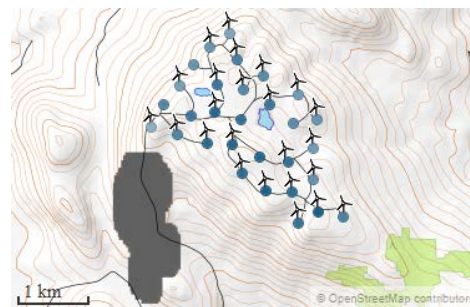
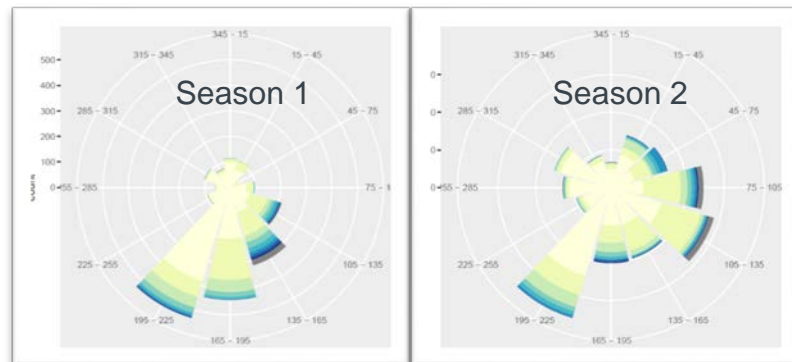
C, D, E, ...

More research needed

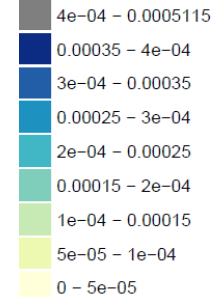
B

## Ice rose and terrain slopes

Challenging for the long-term correction



LWC as Ice (kg/kg)



# Vestas Cold Climate Solutions

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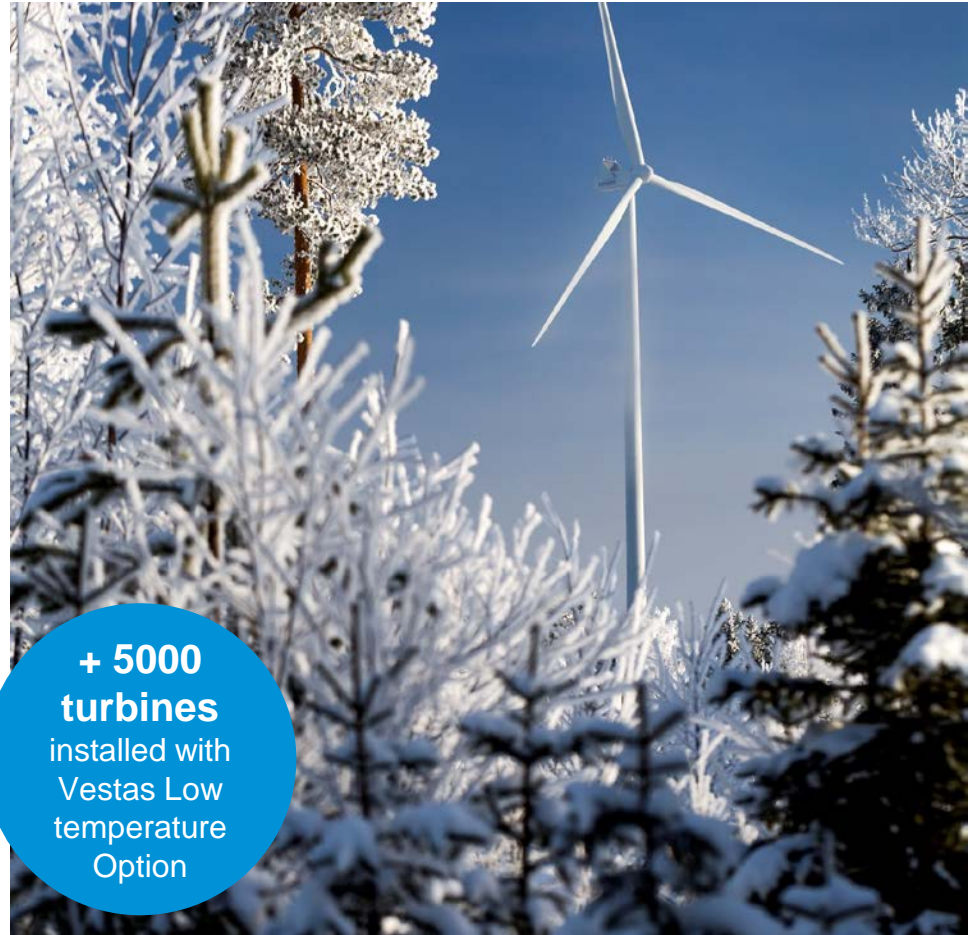


# Low Temperature Option

- Designed to operate in areas where temperatures fall below  $-20^{\circ}\text{C}$  ( $-4^{\circ}\text{F}$ )
- Allows **wind turbine operation** at ambient temperatures as low as  $-30^{\circ}\text{C}$  ( $-22^{\circ}\text{F}$ )
- Provides wind turbine **structural resistance limits of  $-40^{\circ}\text{C}$  ( $-40^{\circ}\text{F}$ )** at standstill

## Key design features:

- Temperature monitored control – shutting down the WTG and activating heaters within threshold parameters
- Site check of impact of high air density on structural load
- Fan heaters in nacelle maintain operating environment
- Heating blankets in hub's hydraulic accumulator



+ 5000  
turbines  
installed with  
Vestas Low  
temperature  
Option

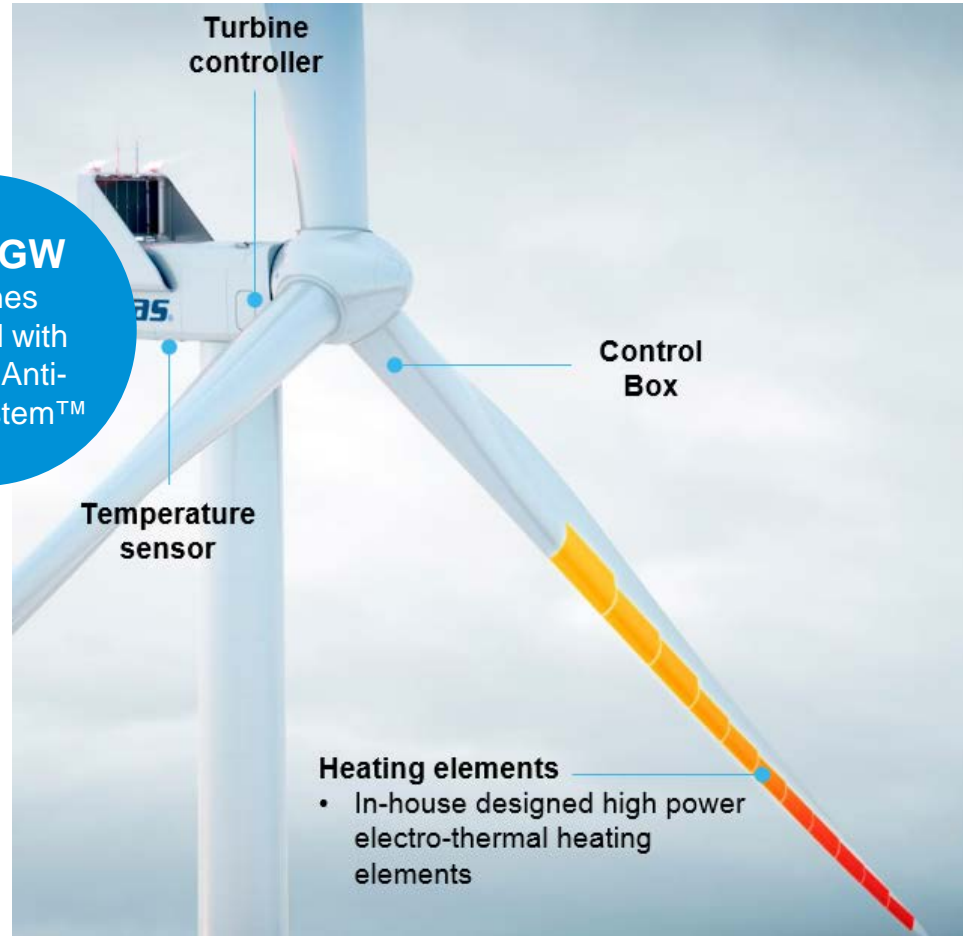
# Vestas Anti-Icing System™

- Continuously monitors the effects of ice formation and intelligently engages to **remove ice and secure continued operation** to maximize performance

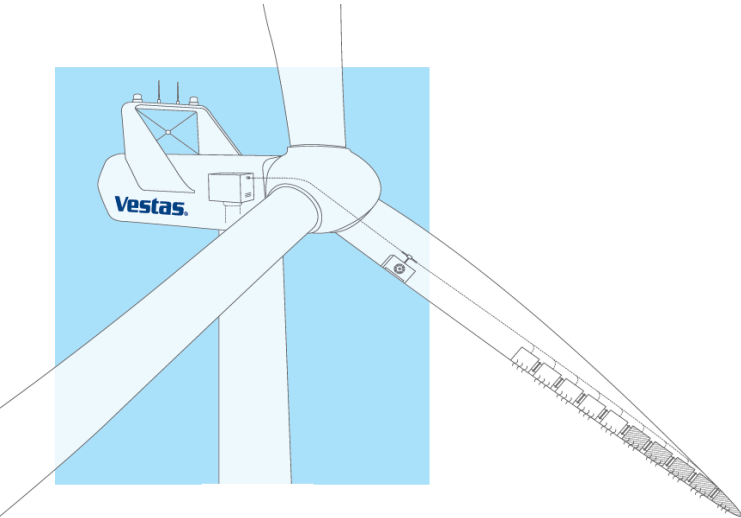
## Key design features:

- Individual powering of heating elements to secure equal power distribution where it is needed
- Compatible with Vestas Ice Control
- Environmental conditions for heating system activation: -25°C & 22.5 m/s
- Compliant with IEA task 19 IPS warranty guideline

**+ 1.5 GW**  
turbines  
ordered with  
Vestas Anti-  
icing System™



# Vestas Anti-Icing System™



Operating modes:

- **Anti-icing mode:** 230-280kW Power available from WTG's own energy production while in rotation
- **De-icing mode:** Up to 75kW Power from grid. Mode designed for more severe conditions requiring the turbine to pause operation (30 minutes)
- **Design:**
  - Electro-thermal heating elements embedded in the laminate directly below the blade's surface for rapid heating response but high robustness in transport and handling
  - The VAS is activated automatically based on a detected degradation in turbine performance and environmental factors
  - Embedded certified level 1 lightning protection
  - Safety monitoring functions run continuously in parallel to ensure that the VAS operates safely and prevents overheating of system
  - Optional control features to fit site conditions through SCADA

**Serviceability:** Robust system to secure operation even in unlikely event of failure mode of the elements

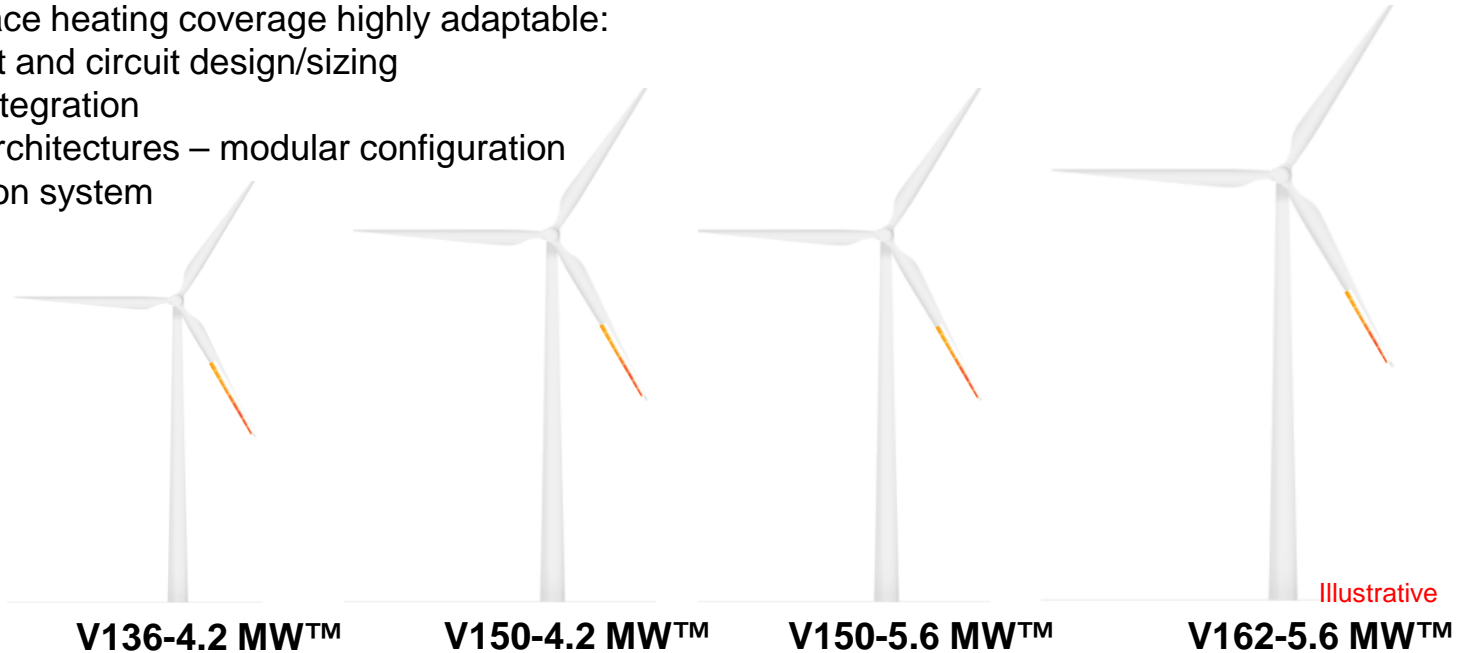
# Vestas Anti-Ice System™ Availability

One module, applicable to multiple turbine variants

Designed to encompass a **wide range of turbine configurations** the **Vestas Anti-ice system™** designs **apply advanced modularity** to meet customisation and market demands more efficiently.

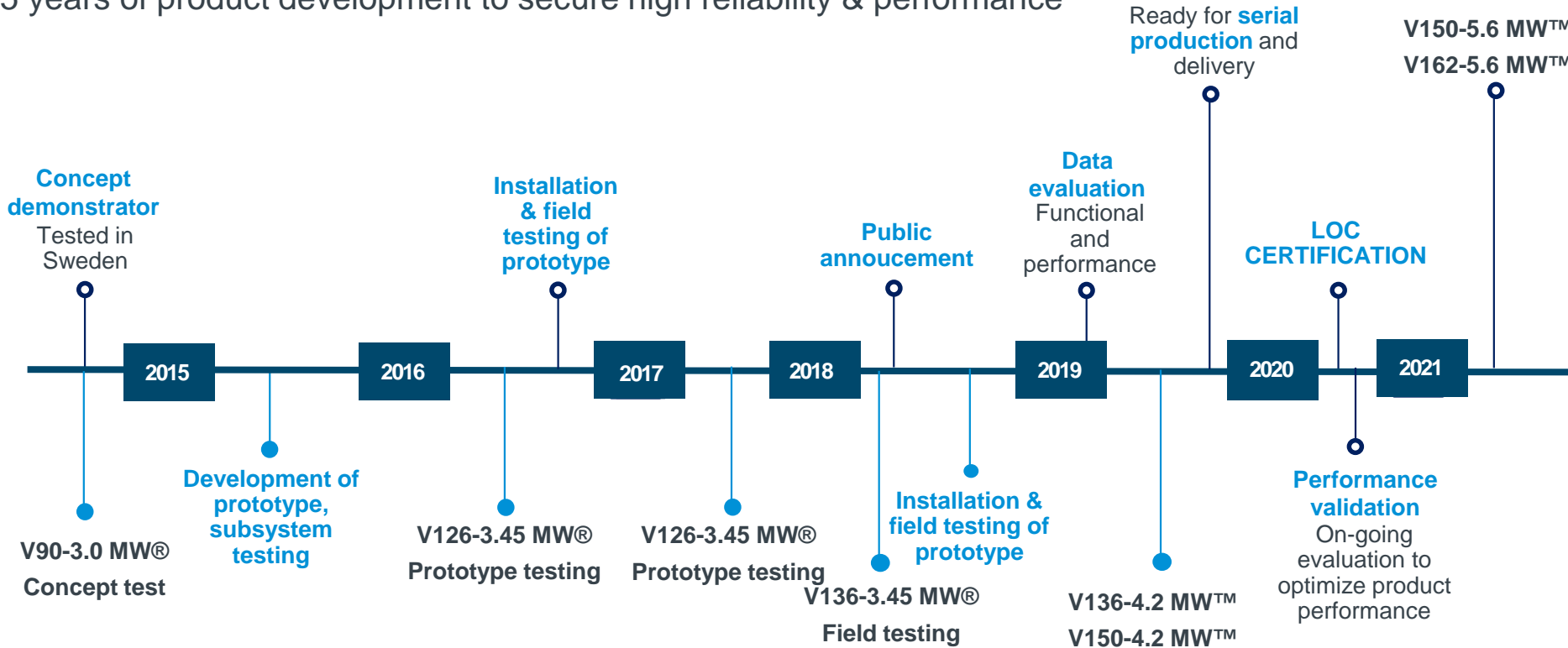
By design – blade surface heating coverage highly adaptable:

- Common component and circuit design/sizing
- Modular hardware integration
- Common software architectures – modular configuration
- Common ice detection system



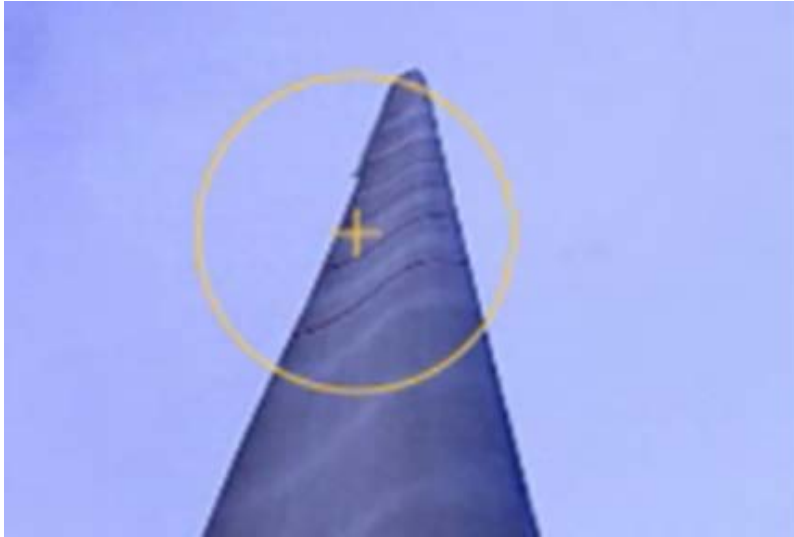
# Vestas Anti-Icing System™ timeline

5 years of product development to secure high reliability & performance

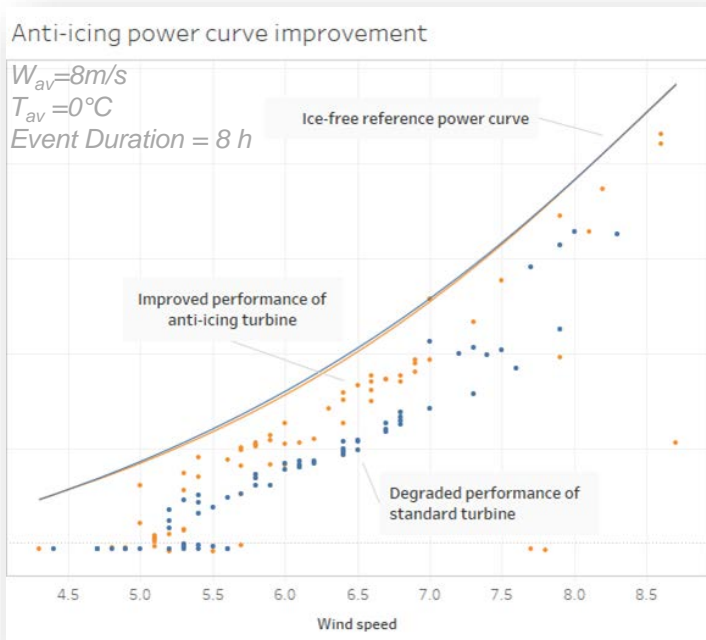


# Anti-ice Turbine – Blade heating IR image (Sweden, winter 2019-20)

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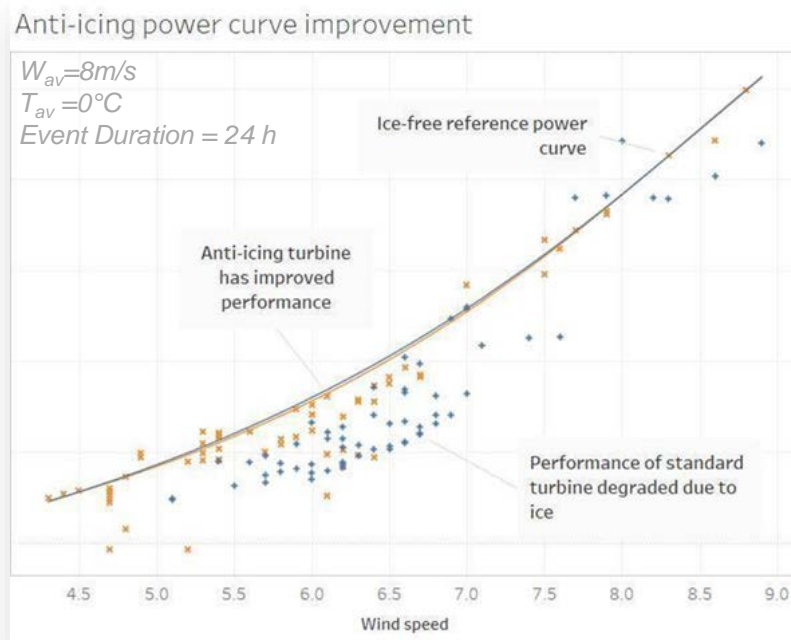


# Anti-ice Turbine – Field Test results (Sweden, winter 2019-20)



Turbine #1 (20 December 2019)

*Ice Mitigation Ratio >70%*



Turbine #2 (13-14 December 2019)

*Ice Mitigation Ratio >75%*

# Vestas


## Cold Climate Solutions

Ensuring safe and efficient energy production in cold climates

- Continuing to build on years of experience...
- Advanced ice assessment siting tools
- Ice detection and removal systems and low temperature operation product options
- Vestas Ice Control to help further enhance cold climate performance





A scenic photograph of a wind farm in a winter landscape. The foreground is covered in deep snow with some small evergreen trees. In the middle ground, a dense line of evergreen trees stretches across the frame. Several wind turbines are visible, with one large one in the upper right corner and others scattered in the background. The sun is low on the horizon, creating a warm, golden glow and long shadows across the snow.

# Vestas Cold Climate Solutions Thank you for your attention

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