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VestasOnline® Business

Ice Control

General Description

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1 Introduction

Vestas Ice Control is an optional module covering various Ice Detection methods and various Ice Mitigation Actions. The Ice Control system provides the ability to use one or more ice detection inputs to trigger one or more Ice mitigation actions.

Some ice mitigation actions are to reduce ice throw risk, while other ice mitigation actions are to optimise power production by removing ice from blades.

This document provides a high-level description of the Ice Control option available in the VestasOnline® SCADA system.

1.1 Abbreviations List

Abbreviation	Explanation
PCID	Power Curve Ice Detection – ice detection method based on Power degradation compared to reference Power Curve
SCADA	Supervisory Control and Data Acquisition
VOB	VestasOnline® Business large-scale SCADA system
VOC	VestasOnline® Compact small-scale SCADA system
VDS	Vestas De-Icing System (hot air heating of blades – heater and fan mounted in root of blades)
VAS	Vestas Anti-Icing System (heating elements embedded in surface of blades - on leading edge of blades)

2 Ice Control Overview

The Vestas Ice Control system is developed to ensure enablement of icing features to have a common control strategy to

- reduce ice throw from the turbine blades and/or
- optimize the power production from turbines when operating in controlled icy environments.

Ice throw reduction is done by stopping the turbine - letting it idle - to avoid ice being thrown from rotating blades. This can be extended with yawing the turbines to fixed positions to reduce ice drop onto roads or similar areas below the blades.

The production optimisation is done by heating the blades to melt off the ice either while still operating, or while being stopped to resume operation when ice has been removed.

The Ice Control option is a system consisting of a software control module that handles inputs from various ice detectors and enables one or multiple ice mitigations actions to be applied based on user selected configurations.

The system enables inputs from one or more of the ice detection methods:

- A. Power Curve Ice Detection (PCID),
- B. Nacelle based ice detector (interfaced to turbine controller),
- C. Vestas Ice Detector system (VID) – blade-based ice detection (interface to turbine controller),

to trigger one or more of the ice mitigation actions supported by Vestas:

- A. Pause turbine (idle mode)
- B. Pause turbine; Yaw to Position
- C. Command turbine to De-Ice (VDS)
- D. Command turbine to do Anti-Icing rotating (VAS)
- E. Command turbine to do Anti-Icing standstill (VAS)
- F. Pause turbine; Yaw to Position; command turbine to De-Ice (VDS)
- G. Pause turbine; Yaw to Position; command turbine to do Anti-Icing standstill (VAS)

Additional to above there is also selectable reset options so that, when an Ice detection method reports 'no ice detected', the Ice control module can start the turbine again automatically if desired and allowed by local authorities. It will be possible to e.g. Pause the turbine on 'ice detected' signal and restart the turbine automatically on 'no ice detected' signal, and the same applies to Yaw to Position option as well. For VDS or VAS Standstill it is configurable if the turbine will revert to operation or stay in idle mode when de-icing cycle has ended.

Based on above list of ice detection methods vs. ice mitigation action, the Ice Control module is designed to minimise ice throw due to Ice build-up on the blades, except for the VAS rotating option which is used to optimise power production by continuously trying to avoid ice build-up on the blades.

The functional relations between Ice detection methods and Ice mitigation actions/reset options can be seen in Figure 2-1. *Capability* shows the capability of the ice detection method to detect 'no ice on blades'; *Start Action* show the ice mitigation actions possible when ice detection methods detect ice and *End Action* show the possible actions once when 'no ice on blades' signal has been detected (if supported by ice detection method). Manual restart is always an option if local requirements demands this.

Ice detection method:	Action:	Detect 'Ice OK' (Ice detector can detect 'no ice' on blades)	Pause turbine	Pause Yaw to fixed position	Pause Yaw to fixed position, Do De-Icing (VDS)	Pause Yaw to fixed position, Do De-Icing (VAS Standstill)	Do De-Icing (VDS)	Do Anti-Icing (VAS - Rotating)	Do Anti-Icing (VAS - Standstill)	Automatic start of turbine	Yaw to start position, Automatic start of turbine	Manually restart turbine (stay paused until 'reset')
		CAPABILITY	START ACTION							END ACTION		
Nacelle based ice detection	No	X	X	X	X	X	on request	X	X	X	X	
Blade based ice detection (VID)	X	X	X	X	X	X	n/a	X	X	X	X	
Power Curve based ice detection	No	X	X	X	X	X	X	X	n/a	n/a	X	

Figure 2-1: Ice detection methods vs. Ice mitigation actions

Several ice detection methods can be combined e.g. Nacelle based ice detection will be operational from 0 m/s windspeed while VID is operational from 3 m/s, so a combination of these will ensure detection at all windspeeds if required.

Some of the ice mitigation actions can be used in a sequence if needed, e.g. as shown in examples in

Figure 2-2 (not showing all possible combinations!).

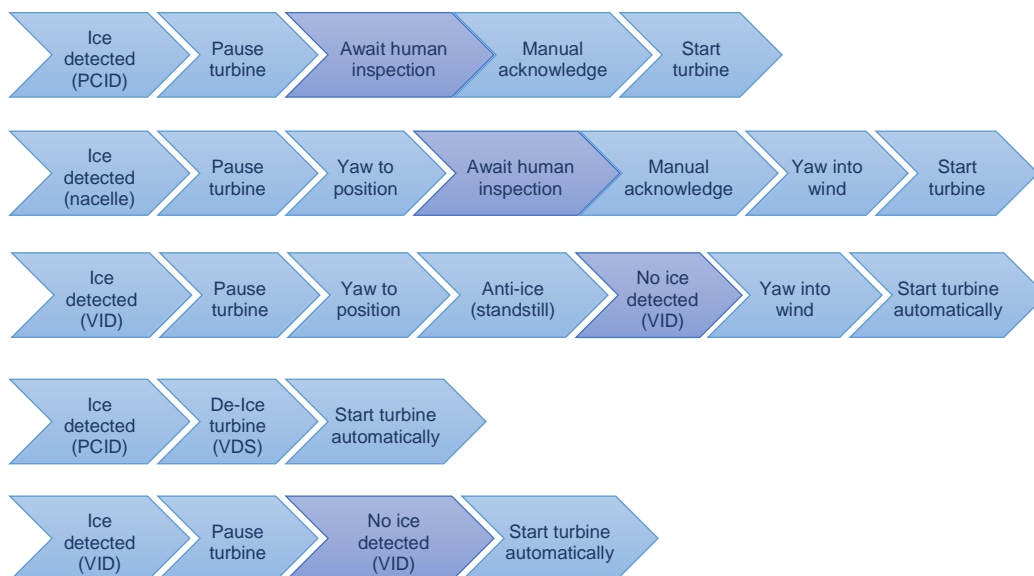


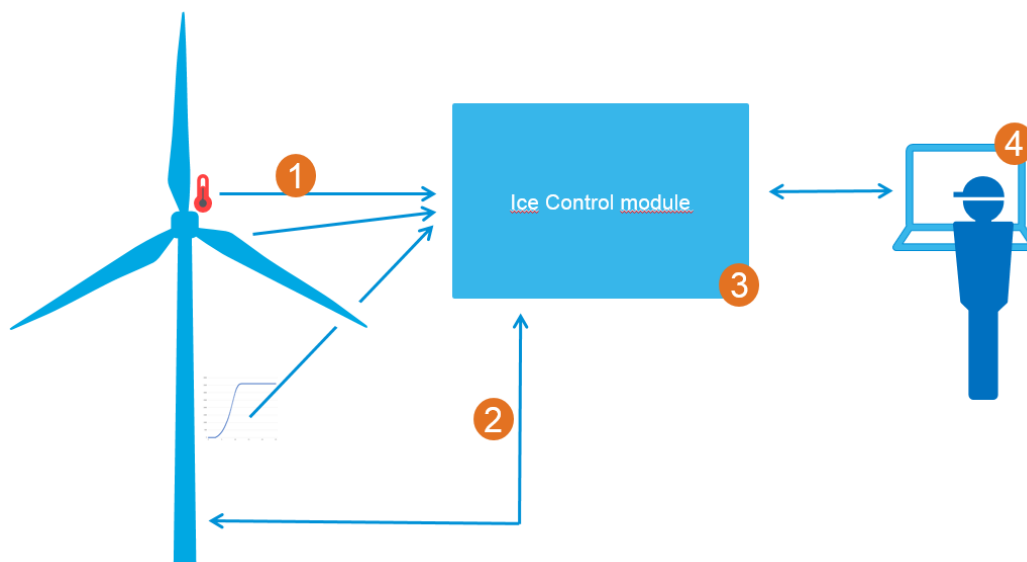
Figure 2-2: Ice detection method / mitigation sequence

Safe operation is built-in by enabling multiple Ice detectors to be used to trigger different Ice mitigation actions or to trigger the same action if needed.

Configuration of Ice detection method and related Ice mitigation action is selectable for the operator in the Environmental Control UI, accessible from VestasOnline® Client. Also, the status of Ice detection(s) and mitigation actions can be monitored in the very same UI as well.

3 System Architecture

The Ice Control system has a number of components and algorithms which is the basis of the Ice Control functionality. The components and options are described in the following graphic and table.



1	Ice detection sensor inputs	Ice detection inputs are taken from either sensors mounted on the turbines or deduced via algorithms based on turbine production, windspeed and temperature data.
2	Turbine status and commands	The turbine status signals are read from turbine via Vestas' communication protocol and commands are sent via the same for mitigation actions.
3	Ice Control module	<p>The VOB/VOC based software control module handles the communication with sensors and turbine and the communication of status, actions and accepts commands or configuration changes from the operator.</p> <p>This module further handles the logics behind evaluating sensor/PCID inputs and deducing which ice mitigation action to take, while logging all actions and monitor the status of turbines.</p>
4	VOB Client	The VOB Client application is used to visualise the configuration of the Ice Control system and shows the operational status and reports the actions taken by the system. The operator is able to select which features are enabled and may do manual ice mitigation controls.

The Ice Control module will read ice detector inputs and evaluate from configuration what ice mitigation action to take, and then send appropriate commands to the turbines to have it execute the Ice Mitigation actions.

The turbine itself will handle the Pausing / Yawing / De-Icing or Anti-Icing cycles.

There is a heartbeat mechanism between SCADA and turbine for Yawing to Position action (900 sec.) and for Anti-Icing action (30 sec.) to avoid turbines being left in active conditions if communication breaks between SCADA and turbines.

The VDS De-Icing cycles are not covered by heartbeat monitoring as the turbine will by itself finish the cycle and return to the state selected by operator when finished.

4 Compatible Systems

The Ice Control system can be implemented on Vestas Power Plants fulfilling the following system requirements:

- VestasOnline® Business Mk4/Mk5 and VestasOnline® Compact Mk3/Mk4 with software version 3.25 and later
- Compatible Ice Detection option (see Figure 4-1)
- Turbines equipped with VDS or VAS option if required

Turbine compatibility matrix for Ice detectors and Ice mitigation actions are shown in Figure 4-1:

Option:						
Platform:	Nacelle based ice detection	Blade based ice detection	Power Curve Ice Detection	Yaw to Fixed position	De-icing (Hot Air Technology) De-ice mode only	Vestas Anti-icing (anti- and de-icing mode)
2 MW PLATFORM	Yes	No	Yes	Yes	No	No
4 MW PLATFORM	Yes	Yes	Yes	Yes	Specific Turbines V112, V117, V126	Specific Turbines V136 & V150
EnVentus™ PLATFORM	Yes	Specific Turbines V150 & V162-5.6MW	Yes	Yes	No	Specific Turbines V150 & V162-5.6MW

Figure 4-1: Turbine compatibility matrix – ice detectors / ice mitigation actions

Other Vestas turbines may be compatible and can be reviewed on a project specific basis.

5 Information available in VestasOnline® Client

Ice detection statuses and Ice Mitigation action statuses are visible in dedicated Environmental Control UI pages, accessible via the VestasOnline® Client.

Logging of all Ice Control related ice detection inputs and related actions are accessible via the Logbook interface in VestasOnline® Client.

6 Hardware Integration

No hardware is delivered as part of the Ice Control option.

Any Ice detection sensors/ equipment to be used must be interfaced toward the turbine controller and made available as turbine controller signals.

Networking equipment between the Ice detection sensors and the VOB and all connections between the Ice detectors and turbine equipment is out of scope of this option, i.e. this must be solved locally if needed.

Please consult with your Vestas representative for requirements.

7 References

Following references may give more information on parts or components discussed in this document.

Reference	Title
Ref#1	General specification, VDS: <ul style="list-style-type: none"> V112 3.3MW 0042-2458 V117 3.45MW 0047-5222, Mk3E 0076-3494 V126 3.45MW 0047-8637
Ref#2	Vestas Anti-ice System Gen. Description – 0068-6577
Ref#3	Gen. specification SCADA Ice Detection – 0073-6291 (PCID)
Ref#4	VOB/VOC De-Icing/Anti-icing Client Manual – 0080-7178
Ref#5	General specification Vestas Ice detection 0049-7921
Ref#6	General specification Nacelle based Ice detection – 0089-5227

8 General Reservations, Notes and Disclaimers

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- The general specifications described in this document apply to the current version of the Ice control. Updated versions of the Product, which may be manufactured in the future, may differ from these general specifications. In the event that Vestas supplies to recipient an updated version of the Product, Vestas will provide to such recipient an updated Product general specification applicable to the updated version.
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- Images and illustrations in this document may differ from the actual design.
- A VOB or VOC system is required to use the Ice Control option.
- The De-Icing and Anti-Icing actions may not be able to remove all ice on blades if icing conditions endure during operation of these.