

# 15 YEARS OF ANTI-ICING EVOLUTION

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**40**  
1985  
2025  
YEARS  
**NORDEX  
GROUP**

# LOOKING BACK → Winterwind 2011-2024

2011



2013



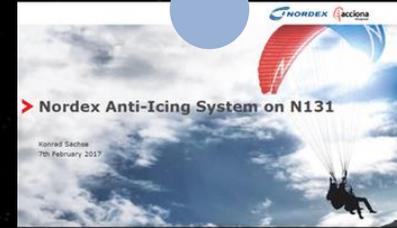
2015



2016



2017



2018



2019



2020



2022



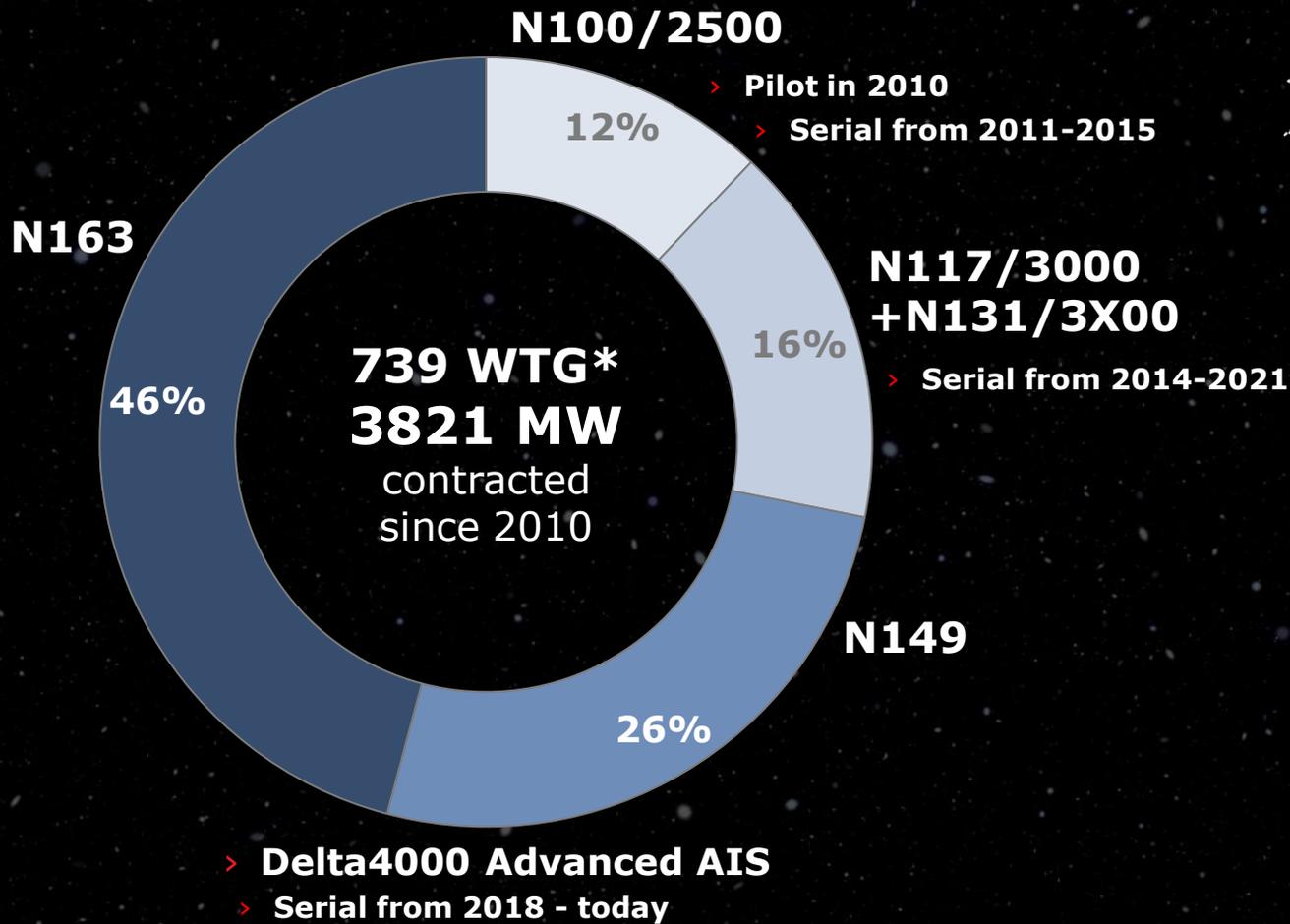
2023



2024



➤ **TRACK RECORD - 15 years experience in operating anti-icing systems with different rotor sizes in severe icing conditions**



SWEDEN	1,425 MW
FINLAND	939 MW
CANADA	776 MW
NORWAY	400 MW
TÜRKIYE	237 MW
GERMANY	39 MW
NETHERLANDS	6.8 MW

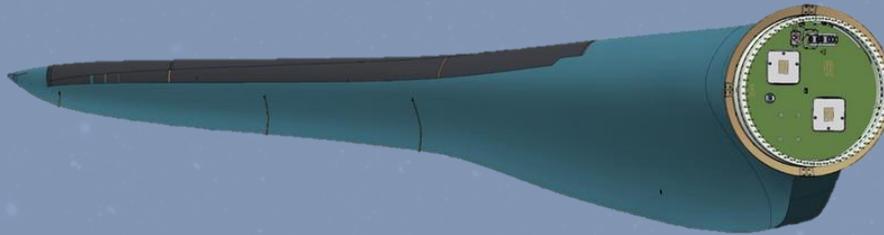
**CONTINUOUS IMPROVEMENT:** based on more than 15 years of operational experience

\* Order intake status 12/24

# 15 YEARS OF TECHNOLOGY EVOLUTION: simplification is the key to get a robust and reliable anti-icing system

## Legacy (Gamma & Delta)

AI-A/B/C carbon heating element - Installed from 2010-2021



### Lessons learned:

- > Keep it simple, remove unnecessary equipment from the rotor blade
- > Change from carbon fibre to electrical resistance heater
- > Improve redundancy through segmentation of heating mats
- > Ease repair process
- > Improve lightning protection
- > Focus on production quality process



# ➤ 15 YEARS OF TECHNOLOGY EVOLUTION: simplification is the key to get a robust and reliable anti-icing system

## Today (Delta4000)

Installed from 2018 onwards

### Improved:

- Redundant, segmented electrical resistance heating mats
- Qualified blade technician can repair a heating mat
- Increased power supply
- Fully integrated lightning protection concept
- AIS and turbine control merged
- Covering more blade area for higher efficiency
- 100% end of line check in production



## ➤ Specific Changes N163 vs N175

Overall technology stays the same but with some minor detail improvements

**N163/6.X**



➤ covering 69% leading edge

**N175/6.X**



➤ 16% more segments, covering 75% leading edge

- Control/electrical design same for N163/6.X and N175/6.X Anti-Icing System
- Heating mat design of N175/6.X optimized to cover more area
- Heat distribution of N175 AIS heating mats pushed slightly further towards the blade tip, optimizing performance at icing conditions around -20°C

# ➤ Value Capture of AIS: The Energy market has changed over the years

## Icing only happens if:

1. It's wintertime » In the Nordics power prices are higher in the winter than in the summer
2. Wind speed is low » Due to high wind penetration in the grid, prices are higher when wind is low
3. If icing takes place, large parts of the installed fleet (w/o AIS) stop operating.
  - » Even less wind in the system, therefore even higher prices

Icing conditions = high price conditions

**Conclusion** » During icing events, power prices are usually at least 2-3x higher than average annual power prices



\*AEP recovery depends on the customer evaluation and usually is between 60-80% of the ice losses

➤ Increased certainty of production in periods of icing can also lead to cost benefits in power planning/dispatching

# ➤ Latest Development: AIS Staggered Start Option

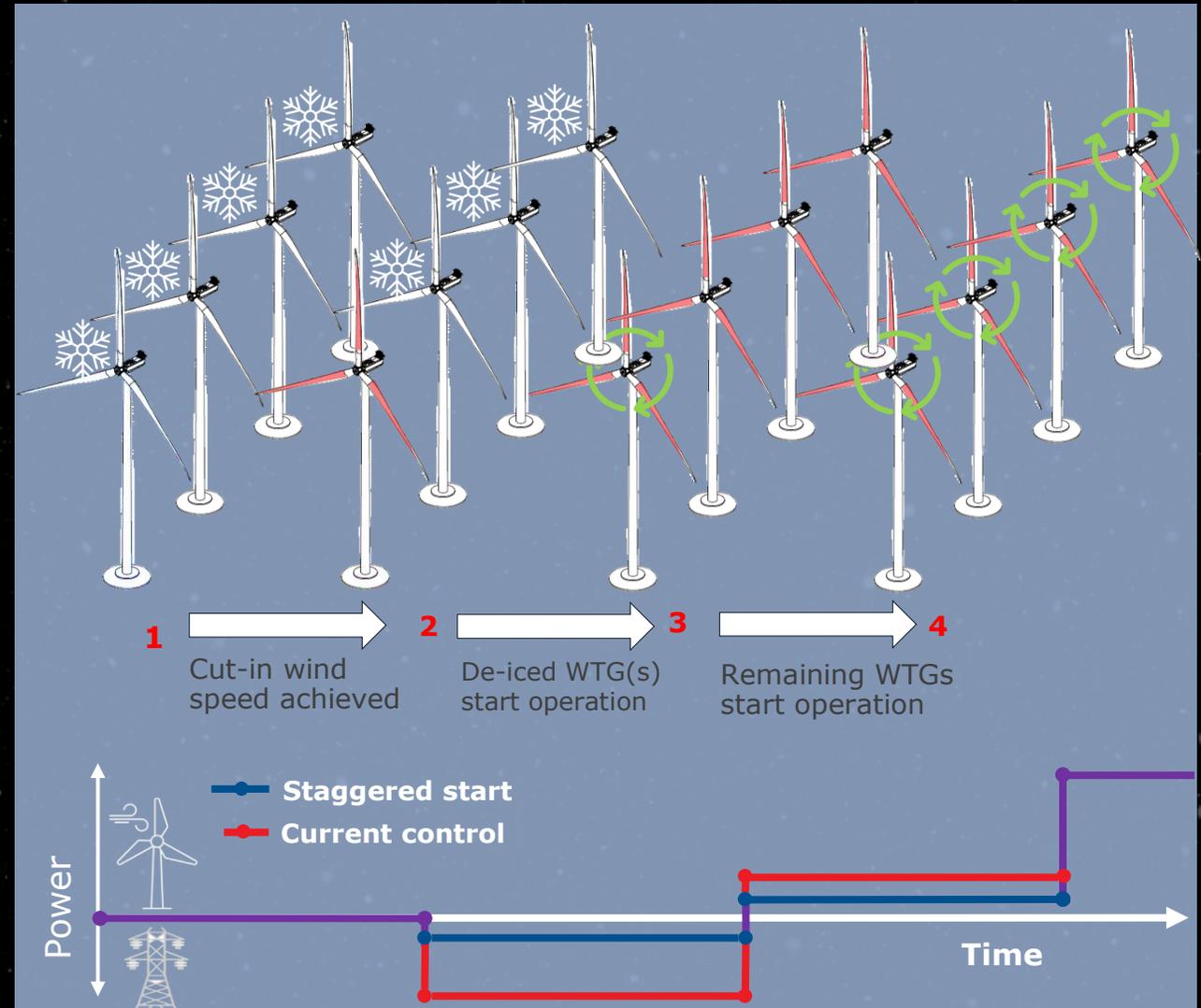
New AIS control feature enables power consumption optimization at cold start

## AIS STAGGERED START

- 1. AIS is turned off when idling**
  - After forced stop or low wind speeds
  - Reduces idling energy consumption
- 2. AIS is limited to a fraction of the WF (~25%)**
  - Reduces grid consumption (High capture price)
- 3. AIS is powered by local production**
  - Operating WTGs power AIS for the rest of the WF
- 4. WF fully operational**

## Overall

- Reduces total AIS energy consumption
- Less reserved grid capacity required
- No penalties for excess energy consumption
- Contributes to grid-stability





## WRAP UP

# NORDEX ANTI-ICING SYSTEM SUPPORTS YOUR BUSINESS CASE

- Robust, performant and simplified system based on 15 years of lessons learned
  - > optimized for service, maintenance and repair
- Anti-icing not De-icing
  - > No shut down of the turbine, continuous operation
- Smart control with constantly optimized functionality
  - > Staggered start of AIS
- Higher value capture
  - > Usually at least 2-3X revenue at icing conditions
- Available for our latest Delta4000 series turbines
  - > N163/5.X, N163/6.X and N175/6.X



➤ Thank you for  
your attention



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