Vestas Cold Climate Solutions

Vestas Wind Systems A/S

Winterwind 2016

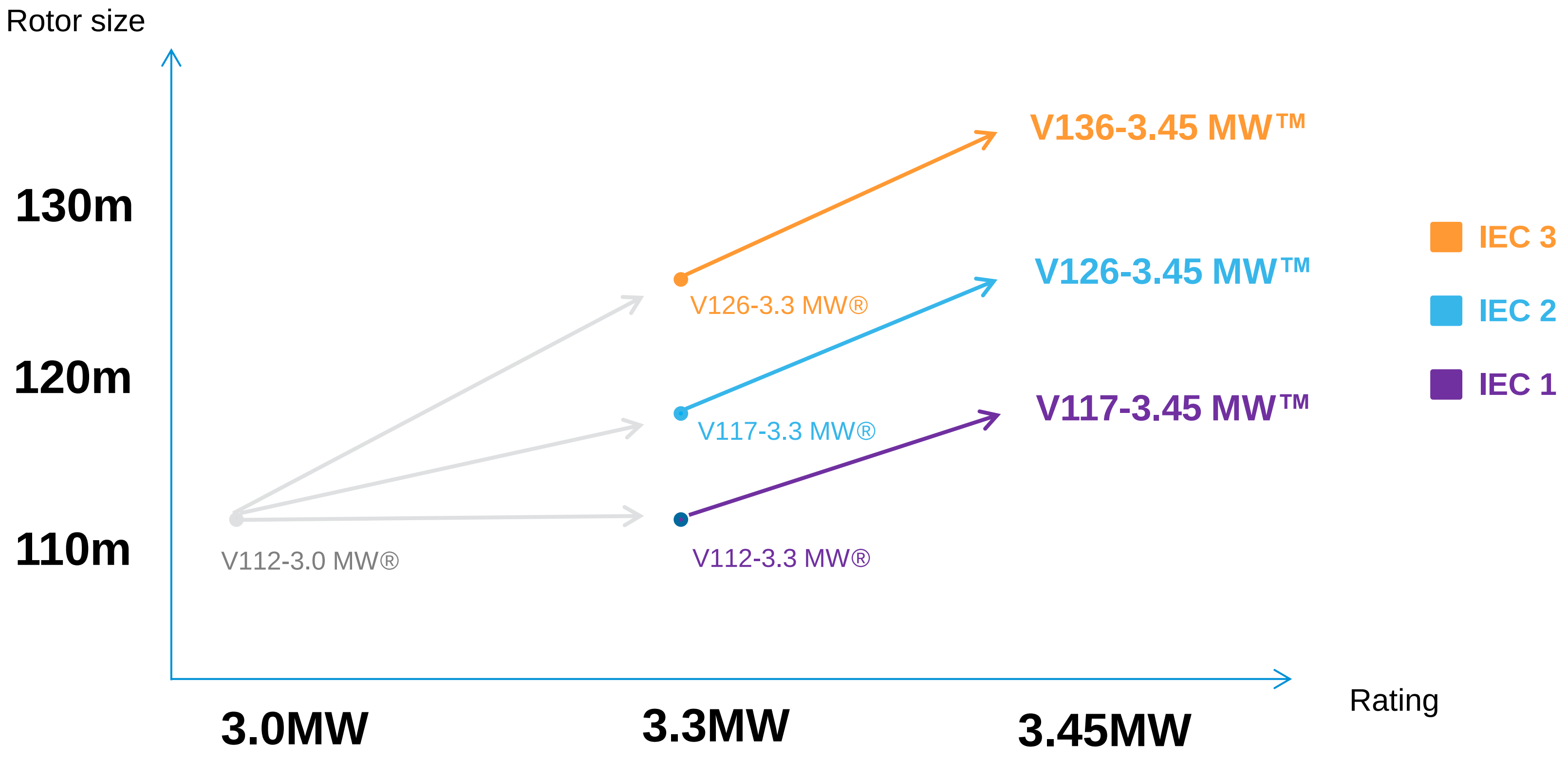
Brian Daugbjerg Nielsen, Product Management

Agenda

1. Vestas present work on climate solutions
2. Vestas experience and reflections
3. Vestas view on the main challenges for the future

Strong: Boosting AEP performance in all wind classes

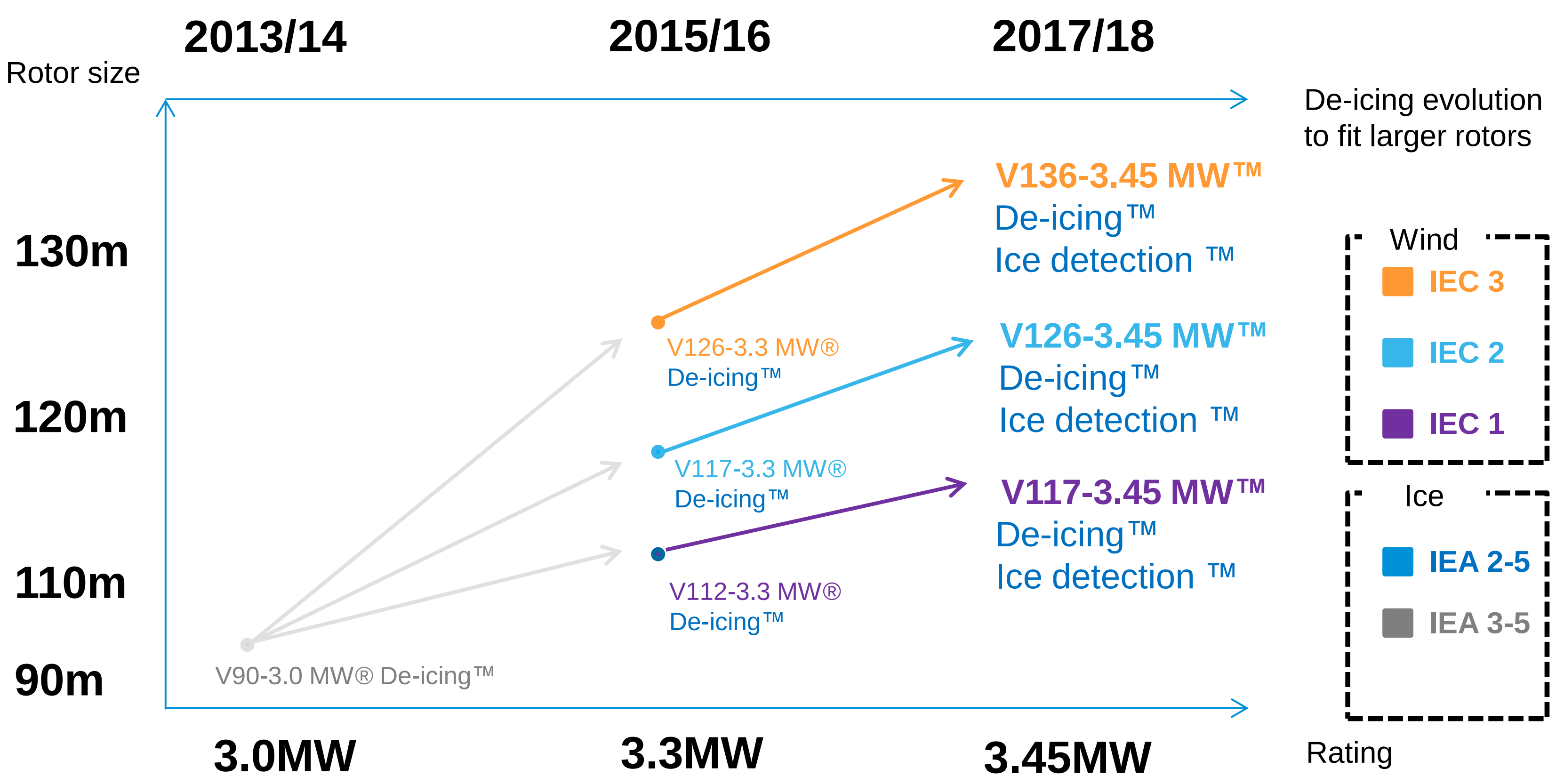
Platform upgrade enables wind class upgrade



*AEP=Annual Energy Production. Actual figures depend on site specific conditions.

Adding De-icing and Ice detection

Platform upgrade and de-icing evolution is enabling cold climate market



*AEP=Annual Energy Production. Actual figures depend on site specific conditions.

Vestas De-icing System – Track record

10 project firmed: 365MW with De-icing in Sweden, Finland & Austria
Up to date: 65 turbines installed

Glötesvålen
30 x V90-3.0MW HH80m - In operation since Q4 2014

Rödstahöjden
6 x V112 3.3MW HH94m - In operation since Q4 2015

Fäbodliden
24 x V112 3.3MW HH129m - In operation since Q4 2015

Puuska II
5 x V112 3.3MW HH119m -In operation since Q2 2015

Alavieska Saarenkylä
1 x V126 3.3MW HH137m - In operation Q1 2016

Posio I
7 x V126 3.3MW HH137m -In operation Q3 2016

Tohkoja
22 x V117 3.3MW HH137m - In operation Q3 2016

Maevaara
10 x V126-3.3MW HH117m - In operation Q3 2016

Jouttikallio
6 x V126-3.45MW HH147m - In operation Q4 2016

Sternwald
2 x V112-3.3MW HH119m - In operation Q2 2016

* as of 18th January 2016

De-icing System – Winter 2014/15

De-icing performance assessment – V90-3.0 MW, Northern, SE

					During Run		Post Run		
Event	Date	Turbine	Time	Trigger	Avg Temp (°C)	Avg Wind (m/s)	Temp Range (°C)	Wind Range (m/s)	Recovery Max
1	1/8/2015	12	6:03:24	70%	0.00	10.29	-0.25 to + 0.25	9 to 10	100%
2	1/29/2015	26	3:13:48	50%	-3.03	11.14	-2 to -4	8 to 9	85%
6	2/25/2015	29	10:43:39	50%	0.14	9.90	-0.75	10 to 6	80%
7	2/3/2015	29	11:53:33	50%	0.06	9.41	-1	9 to 5	85%

...the minimum recovery is 80%

VDS Blade after de-icing cycle

Blade from reference turbine

Clear removal of ice

Winter 2015/16 performance data is being tracked..

Risk vs. Reward

Designing and Building cold climate turbines has challenges

Pre-Sales

- What is the risk?
- Prediction of AEP % losses due to ice
- Ice throw risk

Negotiation

- What is the requirements
- Building permits
- Track record
- Documentation
- De-icing/ice sensor investment
- Warranties

Installation

- Winter window

Operation

- How to operate cold climate turbines
- How to calculate the losses due to ice

Risk vs. Reward

Designing and Building cold climate turbines has challenges

Pre-Sales

- What is the risk?
- Prediction of A
  % losses d
  ice
- Ice thr

Negotiation

- What is the requirements
- Building permits
- Track record
- Documentation
- De-icing/ice se
  investme
- Warrantie

Installation

- Winter window

Operation

- How to operate cold cli te turbi
- H culate es due to

Design requirement spec.

- What to design for?
- Lack of standards
- Lack of acceptance of failures
- Competence development

Lab test

- How to model and lab test
- How to build confidence in lab test

Field test

- Expensive
- Resource demanding
- Short window of testing
- Risk of “good” winter season
- Test site identification

Manufacturing

- Ramping up
- Impact on factories
- Training and competences

Thank you for your attention