Developments in offshore wind turbine technology

ANDREAS WÆRN MADSEN
Sales and Market Entry, APAC

Established in 2014 on decades of experience

Delivering affordable offshore wind power

- A joint venture between two **industry leaders**: Vestas Wind Systems A/S (50%) and Mitsubishi Heavy Industries Ltd (50%)
- Founded 1 April 2014, now employing **~3,000 employees**
- Sole focus on **offshore wind**
- Our business is to **design, manufacture, install and service wind turbines**
- Our approach is truly **collaborative** – we aim to create strong partnerships with customers, suppliers and other stakeholders in the industry

MHI VESTAS OFFSHORE WIND™

MVOW global footprint – our offices, manufacturing & assembly facilities

MHI VESTAS OFFSHORE WIND™

Our Track Record ~ 4.2 GW Installed

1,147 turbines installed across 30 projects, ~3.6 GW under service

TUNOE KNOB
10 x V39-500 kW
(5 MW)
Npower Renewables
Denmark, 1995

IRENE VORRINK
28 x NEG Micon 600kW
(16,8 MW)
NUON (Vattenfall)
Netherlands, 1996

BOCKSTIGEN
5 x Windworld 550 kW
(2,75 MW)
Vindkompagniet (Vattenfall)
Sweden 1997

YTTRE STENGRUND
5 x NEG Micon 2MW
(10 MW)
Vindkompagniet (Vattenfall)
Sweden 2001

HORNS REEF
80 x V80-2.0 MW
(160 MW)
Vattenfall, Ørsted
Denmark, 2002

SCROBY SANDS
30 x V80-2.0 MW
(60 MW)
E.ON, United Kingdom
2004

NORTH HOYLE *
30 x V80-2.0 MW
(60 MW)
Npower Renewables
United Kingdom, 2004

KENTISH FLATS *
30 x V90-3.0 MW
(90 MW)
Vattenfall, United Kingdom
2005

BARROW *
30 x V90-3.0 MW
(90 MW)
Ørsted, United Kingdom
2006

EGMOND AAN ZEE
36 x V90-3.0 MW
(108 MW)
Shell, NUON
Netherlands, 2006

PRINCESS AMALIA *
60 x V80-2.0 MW
(120 MW)
Q7 Holding, Netherlands
2007

SPROGOE *
7 x V90-3.0 MW
(21 MW)
Sund & Baelt, Denmark
2009

ROBIN RIGG
60 x V90-3.0 MW
(180 MW)
E.ON, United Kingdom
2009

BELWIND 1 *
55 x V90-3.0 MW
(165 MW)
Belwind N.V., Belgium
2010

THANET *
100 x V90-3.0 MW
(300 MW)
Vattenfall, United Kingdom
2010

WINDFLOAT
1 x V80-2.0 MW
(2 MW - floating)
Windplus, Portugal
2011

KAAREHAMN *
16 x V112-3.0 MW
(48 MW)
E.ON, Sweden
2013

NORTHWIND *
72 x V112-3.0 MW
(216 MW)
Northwind N.V., Belgium
2013

HUMBER GATEWAY *
73 x V112-3.0 MW
(219 MW)
E.ON, United Kingdom
2014

KENTISH FLATS EXT *
15 x V112-3.3 MW
(50 MW)
Vattenfall, United Kingdom
2015

ENECO LUCHTERDUINEN *
43 x V112-3.0 MW
(129 MW)
Eneco, Mitsubishi
Netherlands, 2015

MAADE *
2 x V164-8.0 MW
(16 MW)
European Energy
Denmark, 2016

BURBO BANK EXT *
32 x V164-8.0 MW
(254 MW)
Ørsted, United Kingdom
2017

NOBELWIND *
50 x V112-3.3 MW
(165 MW)
Parkwind, Belgium
2017

BLYTH *
5 x V164-8.3 MW
(41,5 MW)
EDF Energy Renewables
United Kingdom, 2017

RAMPION *
116 x V112-3.45 MW
(400 MW)
E.ON, United Kingdom
2017

WALNEY EXT *
40 x V164-8.25 MW
(330 MW)
Ørsted, United Kingdom
2017

ABERDEEN BAY*
9 x V164-8.4 MW
2 x V164-8.8 MW
(92.4 MW)
Vattenfall, UK, 2018

BORKUM RIFFGRUND 2*
56 x V164-8.3 MW
(450 MW)
Ørsted, Germany
2018

HORNS REEF 3*
49 x V164-8.3 MW
(406 MW)
Vattenfall, Denmark
2019

* Currently under service contract (3,662.9 MW)
IN YELLOW – not yet commissioned

DECOMISSIONED

Total installed: 4,207.45 MW

Our Pipeline

3,431.5 MW of firm orders, in line to supply 2 GW +

Under Installation / Unconditional Orders

NORTHER
44 x V164-8.4 MW
(370 MW)
Norther NV, Belgium
2019

DEUTSCHE BUCHT
31 x V164-8.4 MW
(252 MW)
British Wind Energy, Germany
2019

NORTHWESTER 2
23 x V164-9.5 MW
(224 MW)
Parkwind, Belgium
2019

BORSSELE III/IV
77 x V164-9.5 MW
(731,5 MW)
Consortium, Netherlands
2020

BORSSELE V
2 x V164-9.5 MW
(19 MW)
Consortium, Netherlands
2020

TRITON KNOLL
90 x V164-9.5 MW
(860 MW)
Consortium, United Kingdom
2021

WINDFLOAT ATLANTIC
3 x V164-8.4 MW
(25 MW)
Consortium, Portugal
Not disclosed

MORAY EAST
100 x V164-9.5 MW
(950 MW)
Consortium, United Kingdom
2022

Conditional Orders

Preferred Supplier

VINEYARD WIND
84 x V164-9.5 MW
(800 MW)
Consortium, USA
2021

ZONE 27
Turbines not disclosed
(100 + 452 MW)
CIP, Taiwan
2021 + 2023

BALTIC EAGLE
52 x V174-9.5 MW
(476 MW)
Iberdrola, Germany
2022

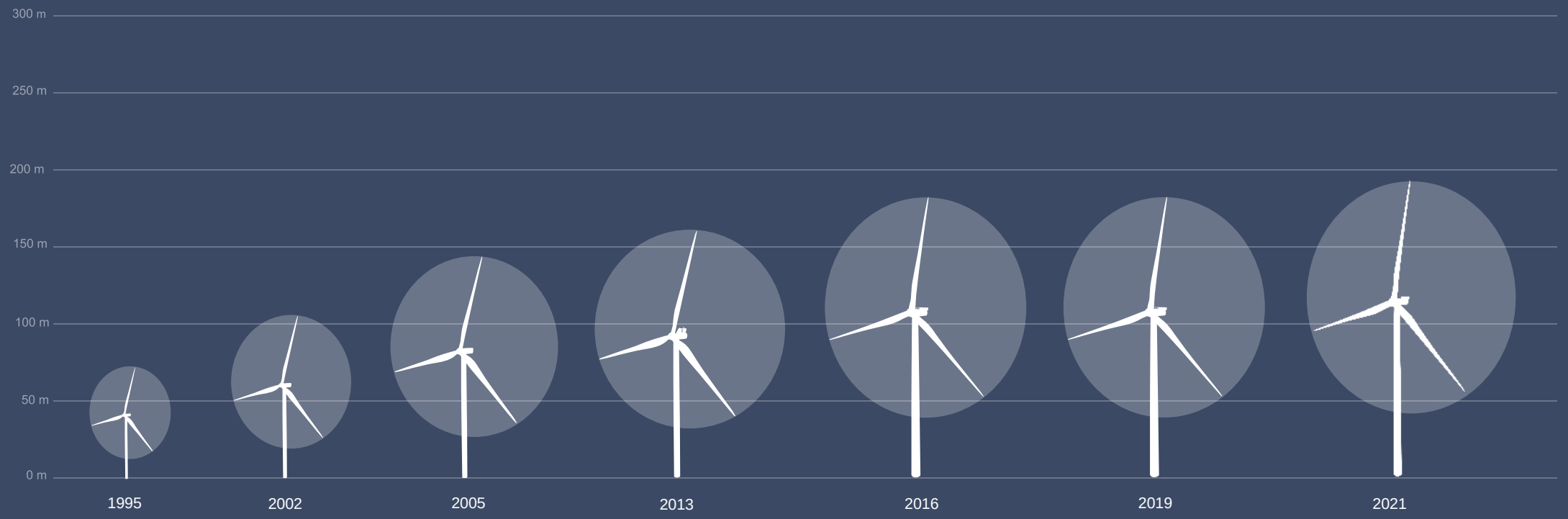
ZONE 29
Turbines not disclosed
(300 MW)
CSC, Taiwan
2024

XI DAO
Turbines not disclosed
(48 MW)
CIP, Taiwan
2024

Information on this page is subject to change

Innovation and performance improvement.

From an on-shore turbine to a purpose build offshore turbine



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A look at turbine development

Tunoe Knob vs Walney Extension

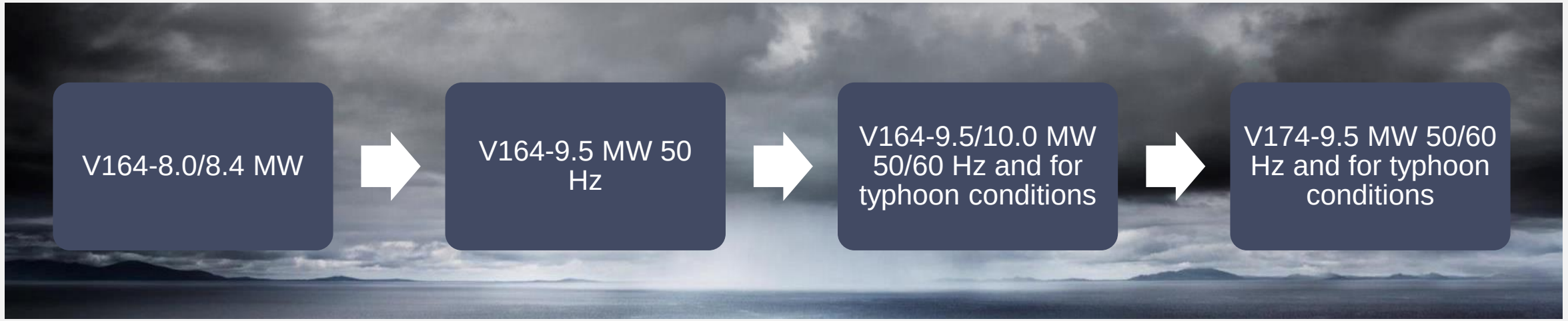
Tunoe Knob, DK 1995
10 x V39-500kW

Walney Extension, UK 2017
40 x V164-8.0 MW

9 MW Platform

Controlled product development based on initial platform development and incremental steps

- We are **building on the experience** from our V164-8.0/8.4 MW WTG since 2014
- Product optimisations are introduced in **incremental steps**, enabling us, our customers, banks and advisors to **benefit from the Type Certification** of the V164-8.0 MW
- The **track record and field experience** makes the V164-9.5/10.0 MW WTG a low risk choice
- V164-9.5/10.0 MW 50/60 Hz and **IEC T (60 Hz version type certificate received in May 2019)**
- V174-9.5 MW 50/60 Hz is a **new variant based on same platform design, also IEC T**



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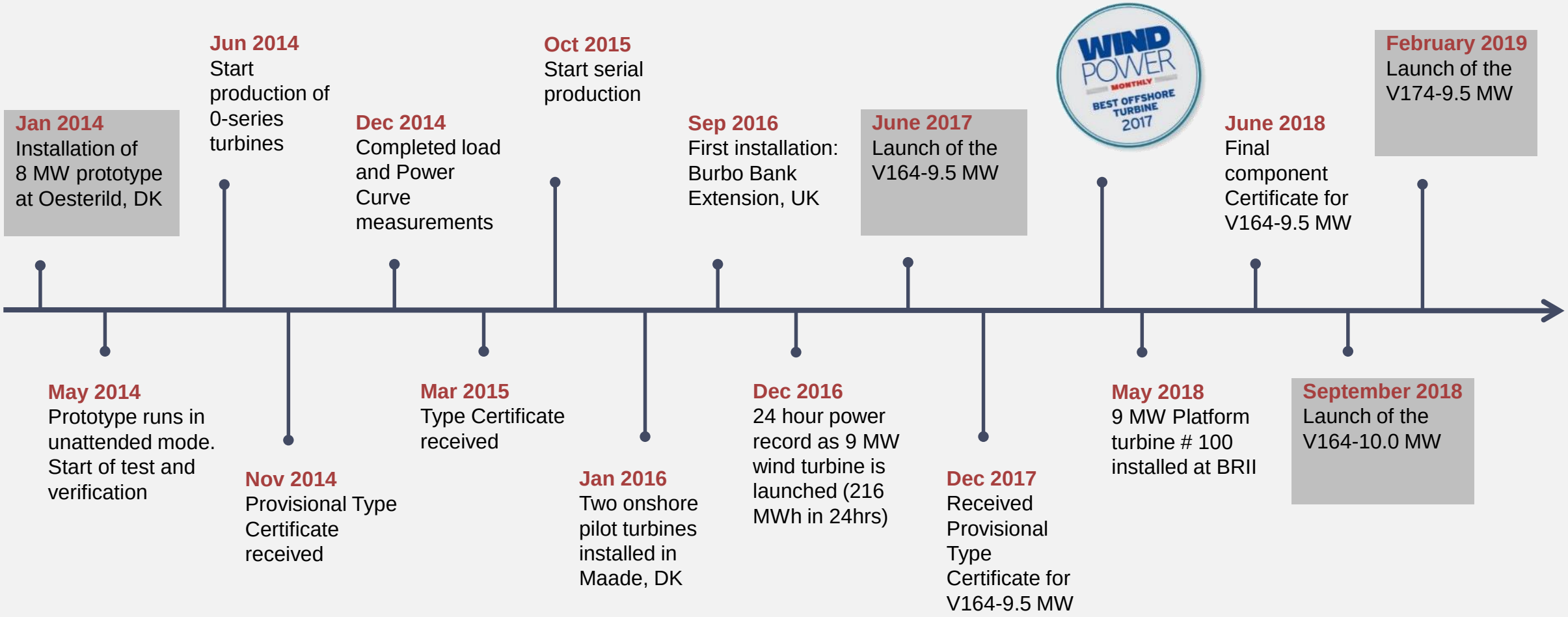
9 MW Platform development history

From 8.0 MW to 10.0 MW in 4 years – proven concept, commercially available



MHI VESTAS OFFSHORE WIND™

The first double digit commercial offshore wind turbine

The V164-10.0 MW™ is commercially available, and ready for installation from 2021

- Built on **proven technology** with a strong track record from the 9 MW Platform family
- More than **200 V164 turbines have already been installed**
- **Minor upgrades** required:
  - a stronger gearbox
  - minor mechanical upgrades
  - a small design change to enhance air flow and increase cooling in the converter
- Upgrades ensure the V164-10.0 MW can **run at full power**, at a site with wind speeds of 10 m/s, for 25 years

Our largest rotor and IEC T class turbine introduced

The V174-9.5 MW™ is commercially proven and ready for the Vietnamese market

- Built on **proven technology** with a strong track record from the 9 MW Platform family
- **Minimal design changes** required
- Designed to operate in areas prone to tropical storms with extreme wind speeds (IEC T)
- Configured to **50Hz** operation
- Accommodating international norms on legislation and design standards – ready to adapt to local standards as they develop