A symposium on Energy Transitions & Energy Technologies:
Moving towards sustainable futures in Denmark and Japan

How can we deploy affordable offshore wind power in Europe and Japan

MASATO YAMADA
Vice President, Chief Strategy Officer

Agenda

- **Who we are**
- **Offshore Wind Market in Europe**
- **What we can deploy in Japan**

Competencies for Synergies

MITSUBISHI HEAVY INDUSTRIES, LTD.

Our Technologies, Your Tomorrow

Founded in 1884 (Established in 1950)
Head Office Tokyo, Japan
Sales 3,914.0 billion Yen ※1 (35,191 million Euro)
Number of Employees 82,728 (consolidated) ※2
16,824 (Non-consolidated) ※2
Products and Operations;
Engineering, manufacture and sale of ships, power systems, environmental improvement equipment, industrial machinery, aircraft, space systems, air-conditioners, etc.

※1 1 April 2016～31 March 2017 ※2 as of 31 March 2017

- MHI has Strong and long-standing presence in global power unit industry
- MHI has brought not only financial foundation but a wide range of technology background, advanced manufacturing management and network with Japanese industry.

Vestas®

Wind. It means the world to us.

Founded in 1898 (Sold and installed its first turbine in1979)
Head Office Aarhus, Denmark
Sales 10,237 million Euro ※3
Number of Employees 21,824※4
Products and Operations;
R&D, engineering, procurement, manufacture, sale and service of wind turbines

※3 1 January～31 December 2016
※4 as of 31 December 2016
※5 as of 31 March 2016

- Vestas has a proven track record of 83GW※5 of installed wind turbines
- A pioneer in offshore wind and the most knowledgeable player in the wind industry
- High reliability based on extensive verification testing

MHI VESTAS™ OFFSHORE WIND

Powerful. Partnerships.

Established in 2014 on decades of experience

Delivering affordable offshore wind power

Company name	MHI Vestas Offshore Wind A/S (MVOW)
Head Office	Aarhus, Denmark
CEO / Co-CEO	Jens Tommerup / Tetsushi Mizuno
Product and Operations	R&D, engineering, procurement, manufacture, sales and service of offshore wind turbine
Number of Employee	2336 employees (as of 13 Nov 2017)
Establishment	1st April, 2014
Equity Rate	Mitsubishi Heavy Industries, Ltd.(MHI) 50% VestasWind Systems A/S (VWS) 50%

Product Line-up

: M

: V

	V39-500kW	V80-2.0MW	V90-3.0MW	V112/117-3.0/3.3/3.45MW	V164-8.0MW-9.5MW
Sales				M	M
Procurement・Manufacturing				V	M
Construction				M	M
O&M	M	M	M	M	M

The V164-8.0 MW turbine – the world's most powerful available turbine –

Rated power	8,000 kw
Rotor diameter	164 m
Blade length	80 m
Blade weight	35 tonnes/each
Swept area	21,124m2
Nacelle dimensions	H 8m x L 20m x W 8m
Nacelle weight	approx. 390 tonnes
Tower height	105 m

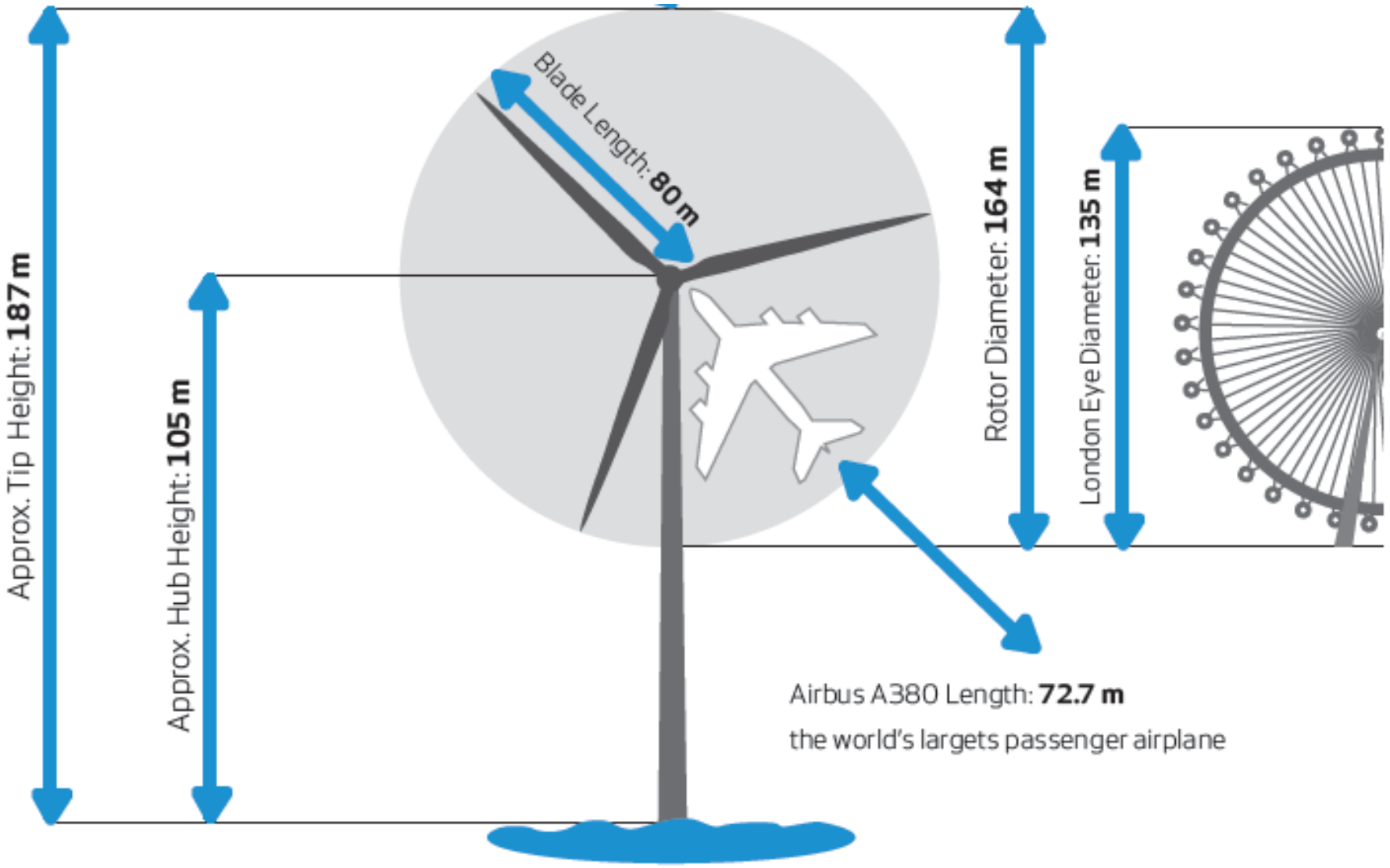
Burbo Bank Extension
United Kingdom

(V164-8.0MW x 32 units)

The first 8MW class offshore wind turbine in the world

In operation since May 2017

Dimensions – V164-8.0MW



MHI VESTAS OFFSHORE WIND™

V164 - Blades

V164 Blade 80m

B747-8 76m

MHI VESTAS OFFSHORE WIND™

MVOW Footprint in Denmark


Østerild test centre

Østerild test centre
(V164/V126 prototype WTG)

MVOW HQ
(Aarhus)

Lindø factory
(V164 Nacelle assy.)

Lindø factory

Esbjerg facility (ESPF*)
(WTG Pre-assy.)
Esbjerg factory
(PCM** assy.)

* Esbjerg Pre-Assembly Facility
**Power Conversion Module


Esbjerg facility

Nakskov factory
(V164 Blade mfg.)

MVOW Footprint in UK

Isle of Wight
Blade Factory

MHI VESTAS OFFSHORE WIND™

Our Track Record – 2.7 GW Installed

953 turbines installed across 23 projects, ~ 2.2 GW under service contract

BARROW*

Country	United Kingdom
Owner	Dong Energy
Installation year	2006
Number of turbines	30
Turbine type	V90-3.0 MW
MW:	90

SCROBY SANDS

Country	United Kingdom
Owner	E.ON UK
Installation year	2004
Number of turbines	30
Turbine type	V80-2.0 MW
MW:	60

HORNS REV

Country	Denmark
Owner	Vattenfall & Dong
Installation year	2002
Number of turbines	80
Turbine type	V80-2.0 MW
MW:	160

TUNØ KNOB

Country	Denmark
Owner	Npower Renewables
Installation year	1995
Number of turbines	10
Turbine type	V39-500 kW
MW:	5

MAADE*

Country	Denmark
Owner	European Energy
Installation year	2016
Number of turbines	2
Turbine type	V164
MW:	16

SPROGØ*

Country	Denmark
Owner	Sund & Bælt
Installation year	2009
Number of turbines	7
Turbine type	V90-3.0 MW
MW:	21

NORTH HOYLE*

Country	United Kingdom
Owner	Npower Renewables
Installation year	2004
Number of turbines	30
Turbine type	V80-2.0 MW
MW:	60

ROBIN RIGG

Country	United Kingdom
Owner	E.ON UK
Installation year	2009
Number of turbines	60
Turbine type	V90-3.0 MW
MW:	180

Blyth Offshore Wind Farm*

Country	United Kingdom
Owner	EDF Energy Renewables
Installation year	2017
Number of turbines	5
Turbine type	V164-8.0 MW
MW:	41.5

Rampion*

Country	United Kingdom
Owner	E.On
Installation year	2017-18
Number of turbines	116
Turbine type	V112-3.45 MW
MW:	400

NORTHWIND*

Country	Belgium
Owner	Northwind NV
Installation year	2013
Number of turbines	72
Turbine type	V112-3.0 MW
MW:	216

KENTISH FLATS*

Country	United Kingdom
Owner	Vattenfall
Installation year	2005
Number of turbines	30
Turbine type	V90-3.0 MW
MW:	90

Burbo Bank Extension*

Country	United Kingdom
Owner	DONG Energy
Installation year	2016-17
Number of turbines	32
Turbine type	V164-8.0 MW
MW:	258

ENECO LUCHTERDUINEN*

Country	The Netherlands
Owner	Eneco & Mitsubishi
Installation year	2015
Number of turbines	43
Turbine type	V112-3.0 MW
MW:	129

KENTISH FLATS EXT.*

Country	United Kingdom
Owner	Vattenfall
Installation year	2015
Number of turbines	15
Turbine type	V112-3.3 MW
MW:	50

Nobelwind*

Country	Belgium
Owner	Parkwind
Installation year	2016-17
Number of turbines	50
Turbine type	V112-3.3 MW
MW:	165

KÅREHAMN*

Country	Sweden
Owner	E.ON
Installation year	2013
Number of turbines	16
Turbine type	V112-3.0 MW
MW:	48

WINDFLOAT-FLOATING FOUNDATION

Country	Portugal
Owner	Windplus
Installation year	2011
Number of turbines	1
Turbine type	V80-2.0 MW
MW:	2

THANET*

Country	United Kingdom
Owner	Vattenfall
Installation year	2010
Number of turbines	100
Turbine type	V90-3.0 MW
MW:	300

BLIGH BANK*

Country	Belgium
Owner	Belwind N.V.
Installation year	2010
Number of turbines	55
Turbine type	V90-3.0 MW
MW:	165

OFFSHORE WINDPARK Q7*

Country	The Netherlands
Owner	WP Q7 Holding B.V.
Installation year	2007
Number of turbines	60
Turbine type	V80-2.0 MW
MW:	120

HUMBER GATEWAY*

Country	UK
Owner	E.ON
Installation year	2014
Number of turbines	73
Turbine type	V112-3.0 MW
MW:	219

EGMOND AAN ZEE

Country	The Netherlands
Owner	Shell & NUON
Installation year	2006
Number of turbines	36
Turbine type	V90-3.0 MW
MW:	108

*Currently under service contract

Order pipeline

1,900 MW of firm orders secured, in line to supply a further 2,490 MW

Unconditional orders/ under installation

Aberdeen Bay

Country	United Kingdom
Owner	Vattenfall
Installation year	2018
Number of turbines	11
Turbine type	V164-8.0 MW
MW:	92

Horns Reef 3

Country	Denmark
Owner	Vattenfall
Installation year	2018
Number of turbines	49
Turbine type	V164-8.0 MW
MW:	406

Walney Extension

Country	United Kingdom
Owner	DONG Energy
Installation year	2017
Number of turbines	40
Turbine type	V164-8.0 MW
MW:	330

Borkum Riffgrund 2

Country	Germany
Owner	DONG Energy
Installation year	2018
Number of turbines	56
Turbine type	V164-8.0 MW
MW:	450

Norther

Country	Belgium
Owner	Norther NV
Installation year	2019
Number of turbines	44
Turbine type	V164-8.0 MW
MW:	370

Deutsche Bucht

Country	Germany
Owner	British Wind Energy
Installation year	2019
Number of turbines	Not disclosed
Turbine type	V164-8.0 MW
MW:	252

Conditional orders

Borssele III & IV

Country	The Netherlands
Owner	Consortium
Installation year	Not disclosed
Number of turbines	Not disclosed
Turbine type	Not disclosed
MW:	680

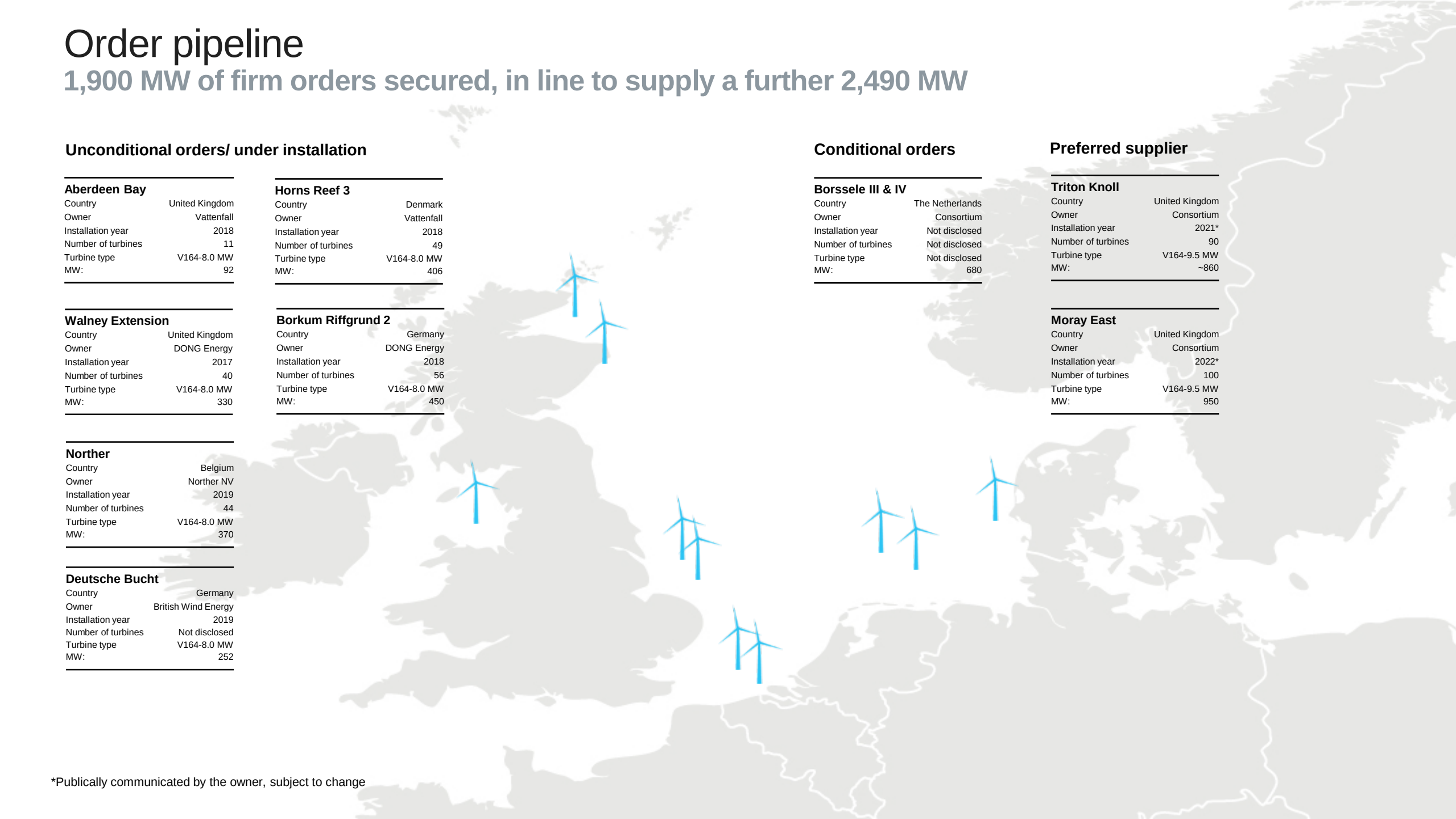
Preferred supplier

Triton Knoll

Country	United Kingdom
Owner	Consortium
Installation year	2021*
Number of turbines	90
Turbine type	V164-9.5 MW
MW:	~860

Moray East

Country	United Kingdom
Owner	Consortium
Installation year	2022*
Number of turbines	100
Turbine type	V164-9.5 MW
MW:	950



*Publically communicated by the owner, subject to change

Reliable turbine supply

Product development & launching

【V112-3.0/3.3/3.45MW】

1. Rich experience

- 219 V112-3.0 MW turbines or the equivalent of 662 MW installed offshore since 2013.
- Since 2010 more than 10 GW of V112-3.X MW turbines including for onshore have been installed around the world.

2. Thorough verification makes marvellous performance

- Various verification of components in a modern wind turbine test facility and in pre-production of actual wind turbines before serial production.

【V164-8.0MW】

Turbine design is based on the V112 proven technology and thorough verification is executed before serial production which enables both reliability and high performance as well as V112.

Full scale test facility for the entire power train
Aarhus, Denmark

Full scale nacelle testing
Lindø, Denmark

Stress and fatigue testing of blades
Isle of Wight, UK

Reliable turbine supply

Product development & launching

Prototypes are installed to test power curve, power quality, installation techniques and service. Three V164-8.0MW provide invaluable knowledge and experience prior to going offshore.

The V164-8.0 MW prototype set a record in October 2014, producing 192,000 kWh in a 24 hour period, enough to power approximately 13,500 Danish households, demonstrating full capability.

Østerild Test Center, V164-8.0MW installed, Denmark

Logistics, construction and installation techniques were tested during the erection of two V164-8.0 MW at Maade.
Service teams will also have invaluable opportunity to service and maintain the turbines.

2 x V164-8.0MW installed, Maade Denmark

Reliable turbine supply

Reduction of delivery period of reliable wind turbines owing to over 20 years experience and continuous improvement

- Pre-assembly and onshore commissioning at Esbjerg facility enable lead-time reduction and reliability of products
- Continuous improvement for installation

2010 Thanet project (UK)
V90-3.0MW x 100WTGs in 100days

FACTS

Country
United Kingdom

Owner
Vattenfall

Installation year
2010

Number of turbines
100

Turbine type
V90-3.0 MW®

Total output capacity
300 MW

2015 Luchterduinen project (Netherlands)
V112-3.0MW x 43WTGs 2 WTGs/1day

FACTS

Country
Netherlands

Owner
Eneco (50%),
Mitsubishi Corporation (50%)

Installation year
2015

Number of turbines
43

Turbine type
V112-3.0 MW®

Total output capacity
129 MW

Installation of Luchterduinen, the Netherlands (Film)

Project completed 3 months ahead of schedule

ENECO LUCHTERDUINEN

Country	Netherlands
Owner	Eneco & Mitsubishi Corp.
Installation year	2015
Number of turbines	43
Turbine type	V112-3.0 MW
MW:	129

Embed Installation Video here

MHI VESTAS OFFSHORE WIND™

Reliable turbine supply

Commitment to the market; big data and predictive service reduces production loss

Monitoring **33,000+** wind turbines worldwide, by the Vestas Performance & Diagnostics Center (VPDC):

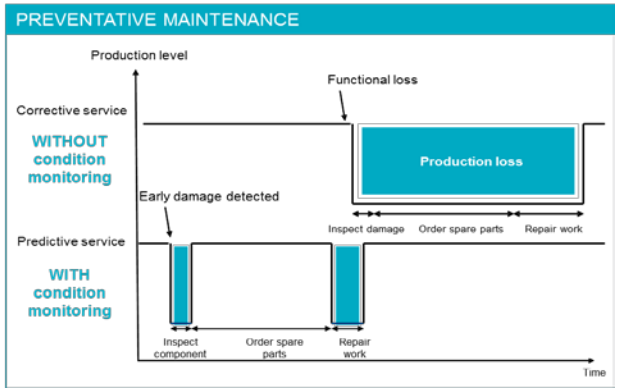
- Upto 500 data points /turbine every 10 mins
- Big data: 60 TB in total
- High speed event logging
- Vibration monitoring

Analysis of the data allows early anomaly detection:

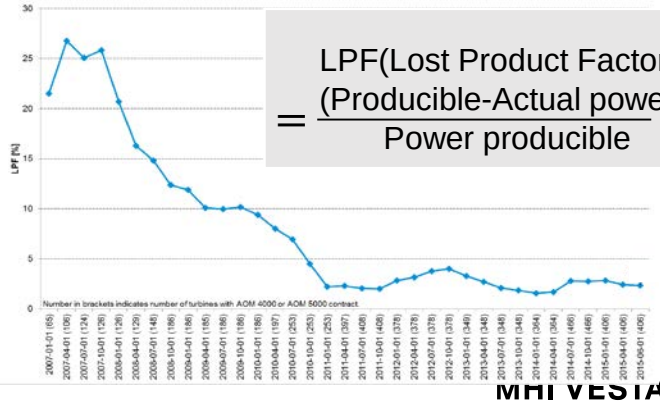
- Vibration patterns can reveal component irregularities that might need attention
- Preventive maintenance is therefore planned before potential damage to the wind turbine
- Planned regular maintenance and replacement

Minimize Lost Production Factor and warranty order

The Supercomputer



MVOW Fleet Lost Production Factor (LPF)



$$= \frac{\text{LPF(Lost Product Factor)}\ (\text{Producible-Actual power})}{\text{Power producible}}$$

MHI VESTAS OFFSHORE WIND™

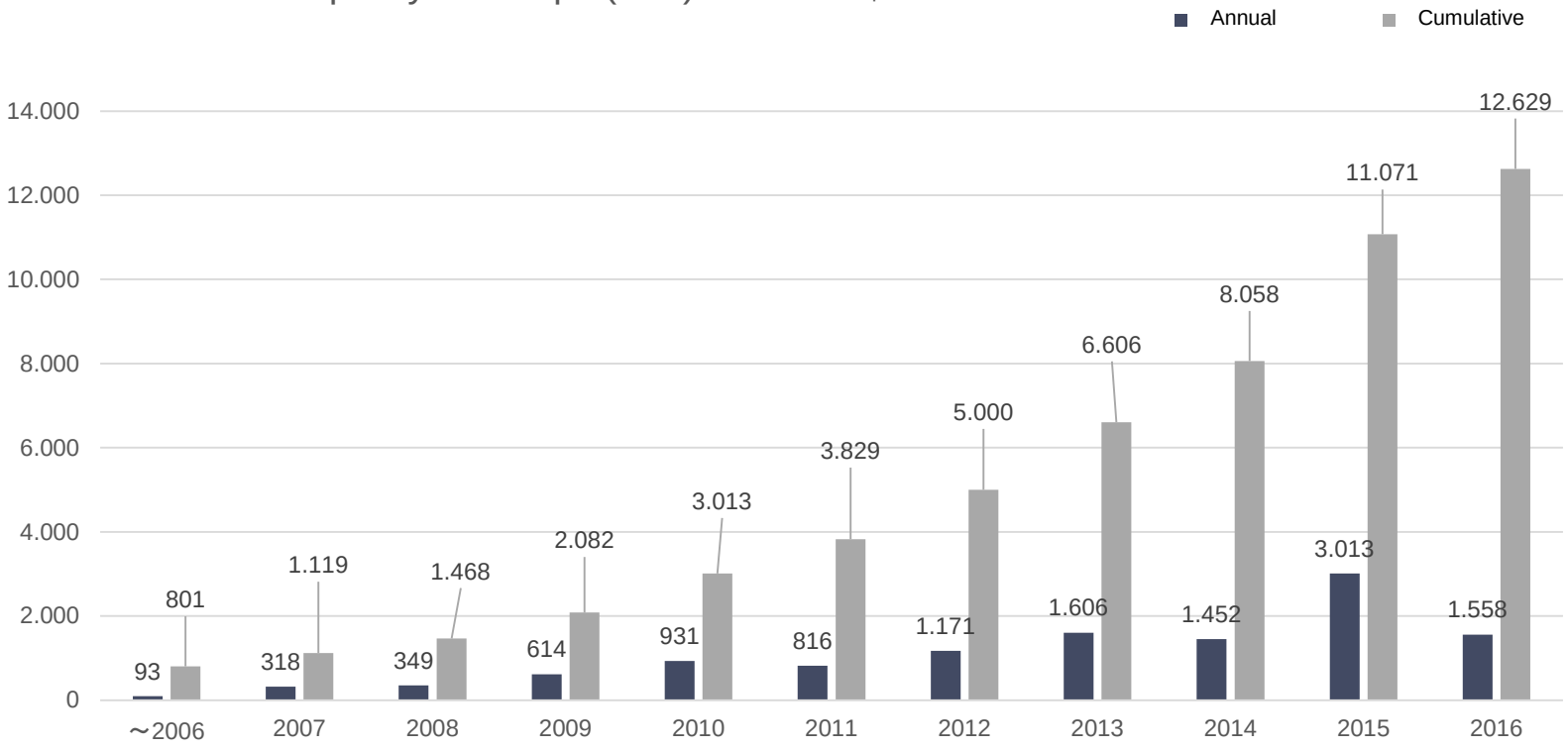
Agenda

- **Who we are**
- **Offshore Wind Market in Europe**
- **What we can deploy in Japan**

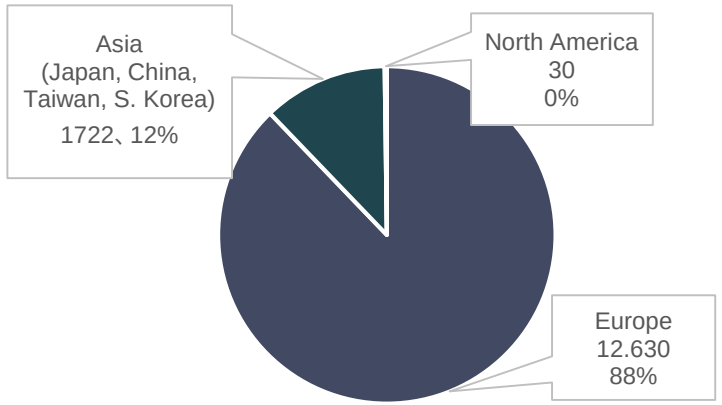
Offshore wind power

Over 90% are installed in Europe with high growth of 1 -2 GW/year. In European market, 5 countries (UK, Denmark, Germany, Belgium and Netherland) strongly lead the development and account for 97% of the market.

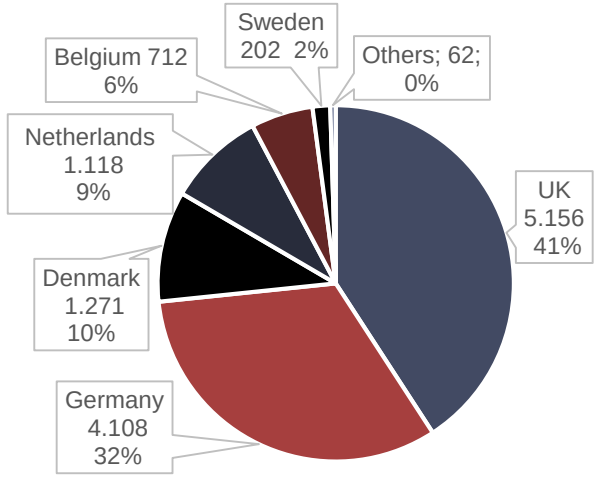
Installed capacity in Europe (MW) Source:WindEurope



Installed capacity in the world
- Cumulative share by region (MW)
(Until 2015E, Source:GWEC)



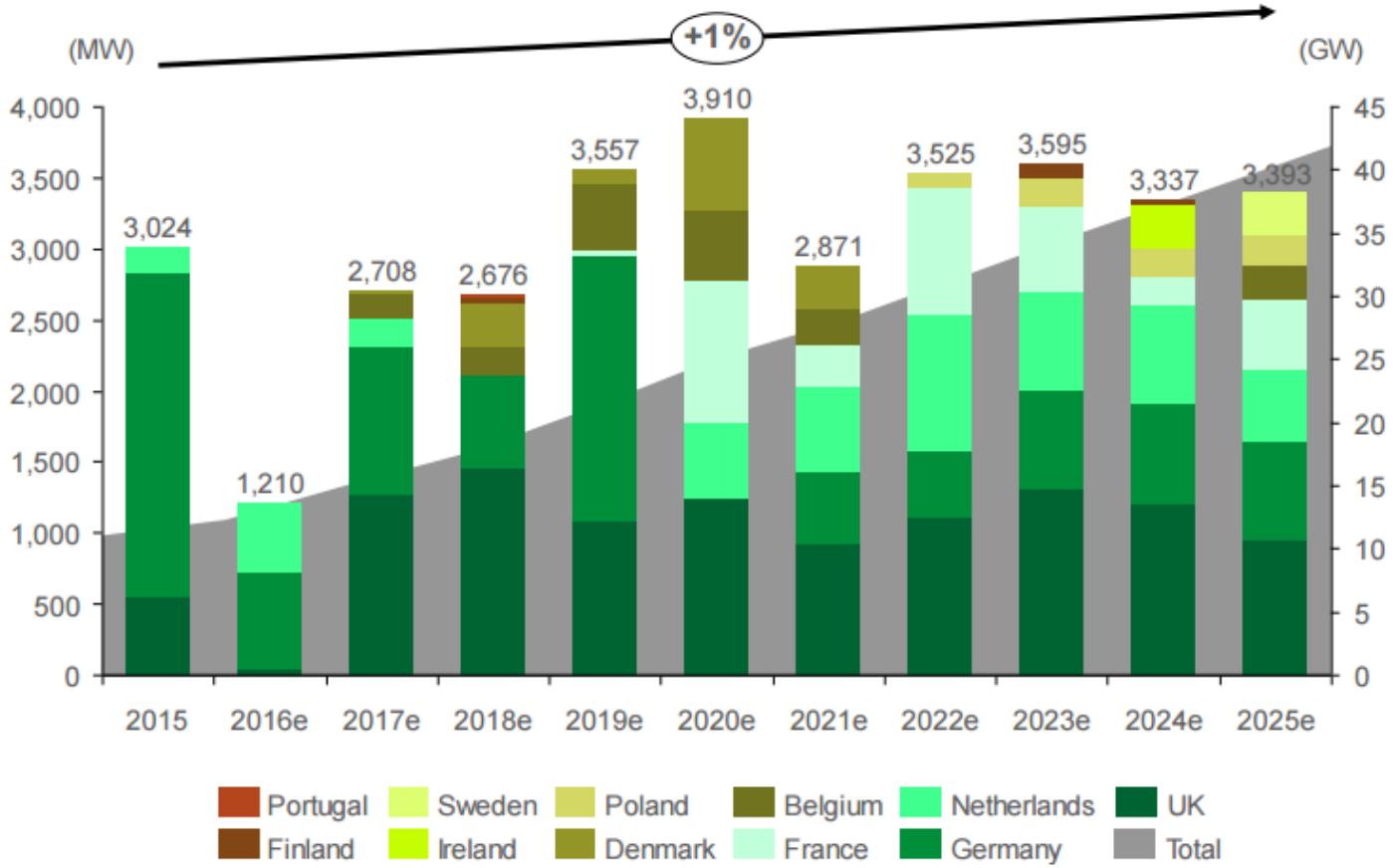
Installed capacity in Europe - Cumulative share by country (MW)
(Until 2016E, Source: WindEurope)



European Offshore Wind Market | Future outlook

Driven by UK, Germany and Netherlands, so far the government has targeted new market of around 3GW/per year.

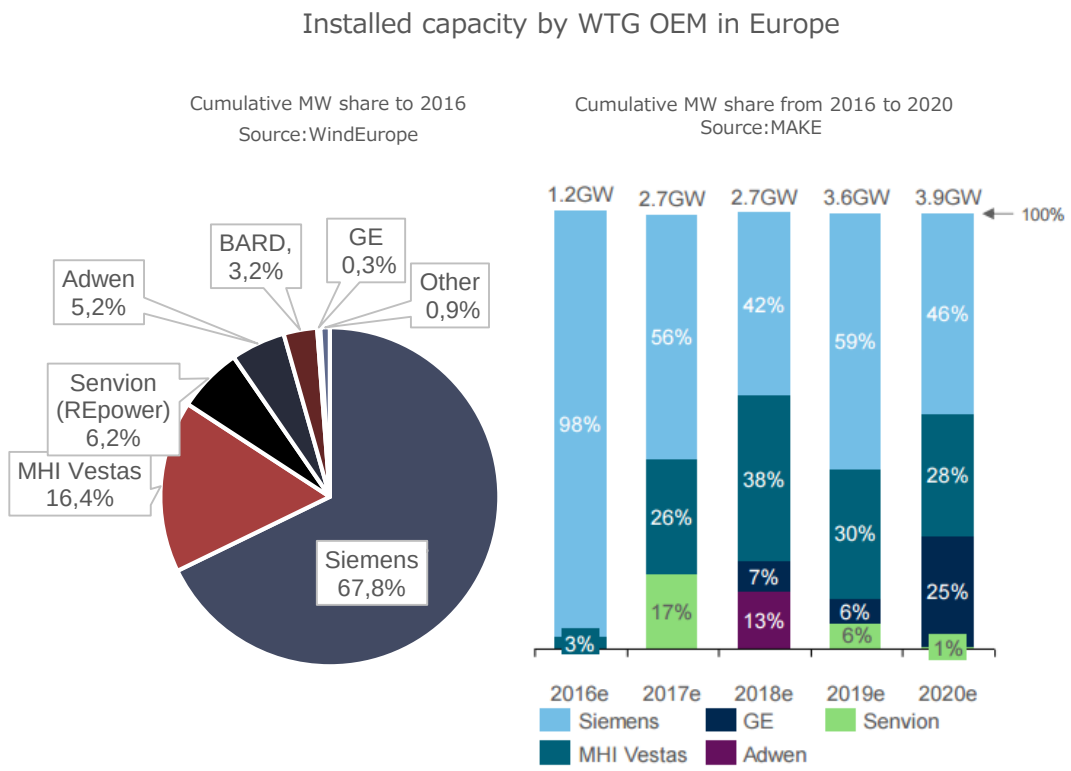
Figure 2. Offshore wind power market outlook for Europe, 2015 to 2025e

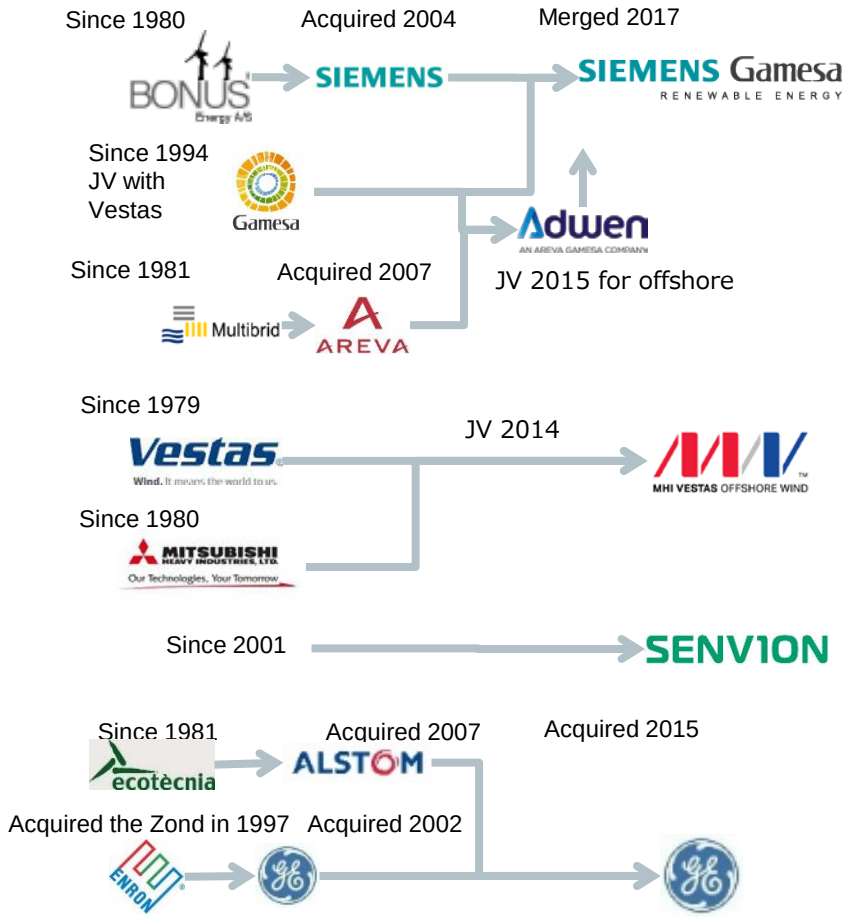


Source: MAKE

Offshore market overview – Competitors

Huge scale and risk of current offshore wind projects have accelerated consolidation by global power engineering giants, with two strongest WTG OEMs left accounting for 85% of European market.

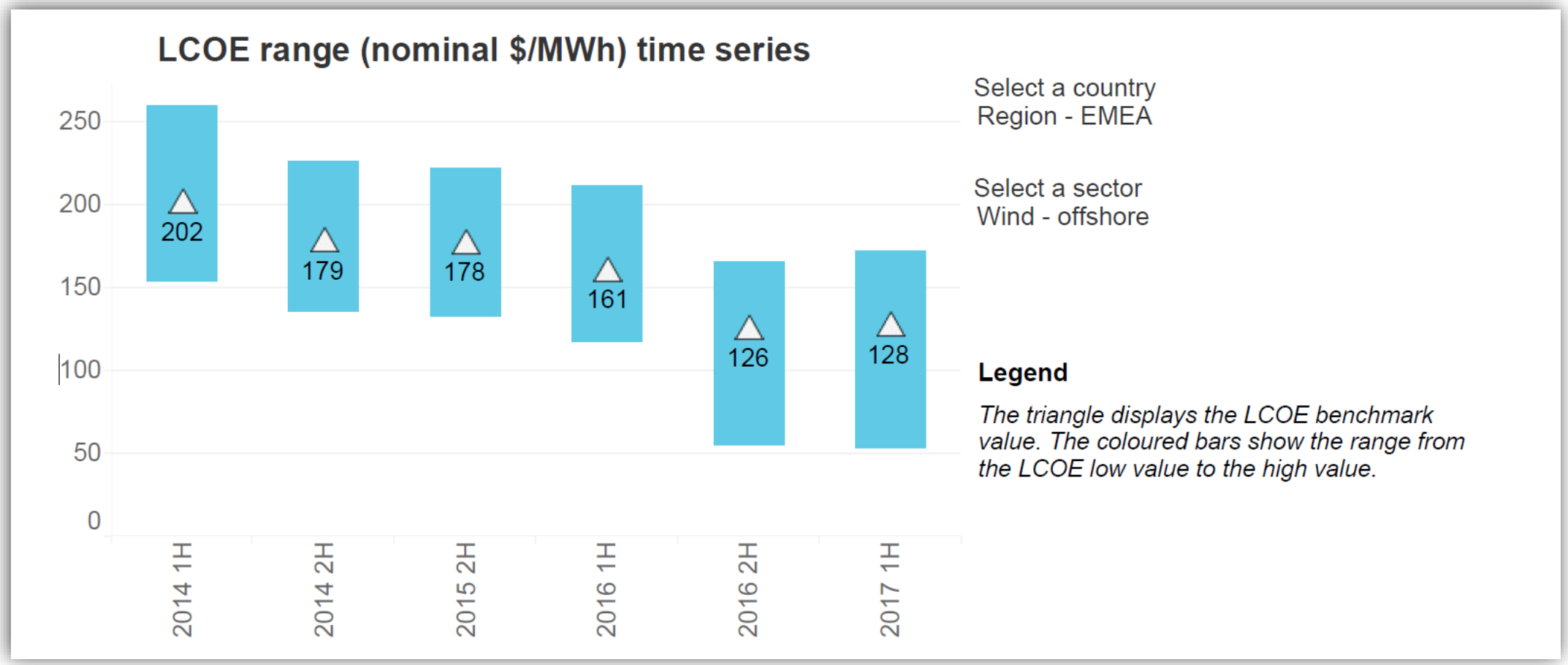




MHI VESTAS OFFSHORE WIND™

European Offshore Wind Market | Trajectory of LCOE

Along with the growth of the market, LCOE also reduced rapidly over the past few years. Latest, it marked $ 50/MWh.

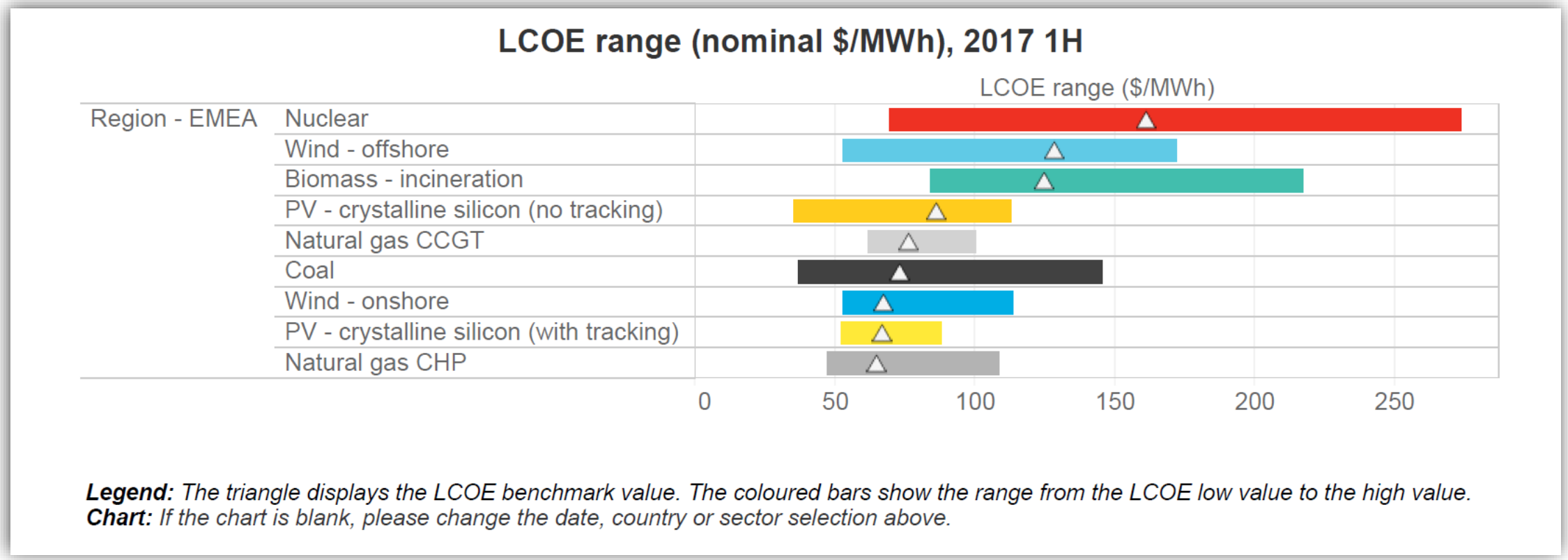


Source: Bloomberg New Energy Finance

MHI VESTAS OFFSHORE WIND™

European Offshore Wind Market | Comparison of LCOE

Due to drastic reduction in LCOE, offshore wind power is recognized as a large power supply comparable to other energy supply in Europe. Project owners such as Ørsted (former Dong Energy) and E.ON, are concentrating their management resources on Renewable energy.



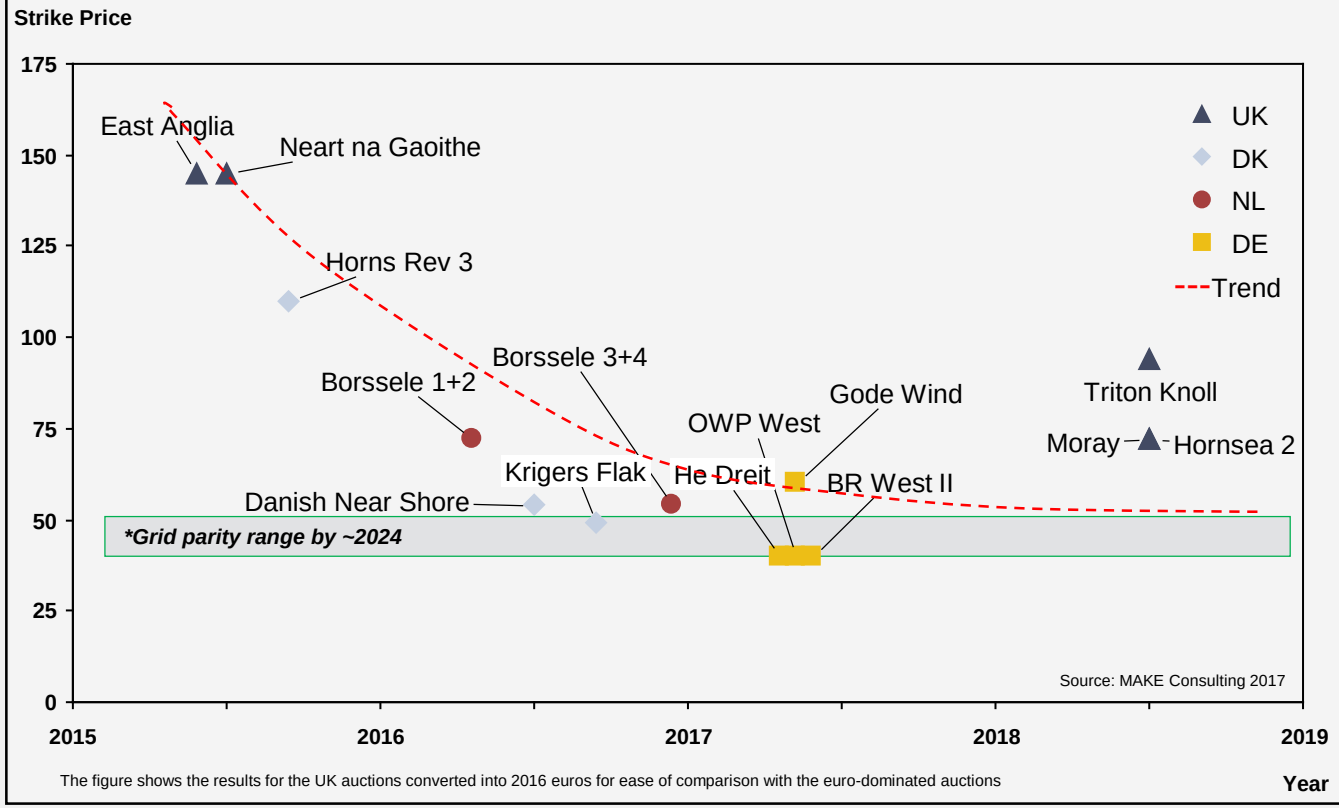
Source: Bloomberg New Energy Finance

Consequences of a market under rapid development.

Market design and strong regulatory framework are key elements.

Strike prices in Europe auctions are down to grid parity…

Recently awarded subsidies



The figure shows the results for the UK auctions converted into 2016 euros for ease of comparison with the euro-dominated auctions

… which requires policy makers and investors to review market design

Latest auctions have shown dramatic reductions in costs.

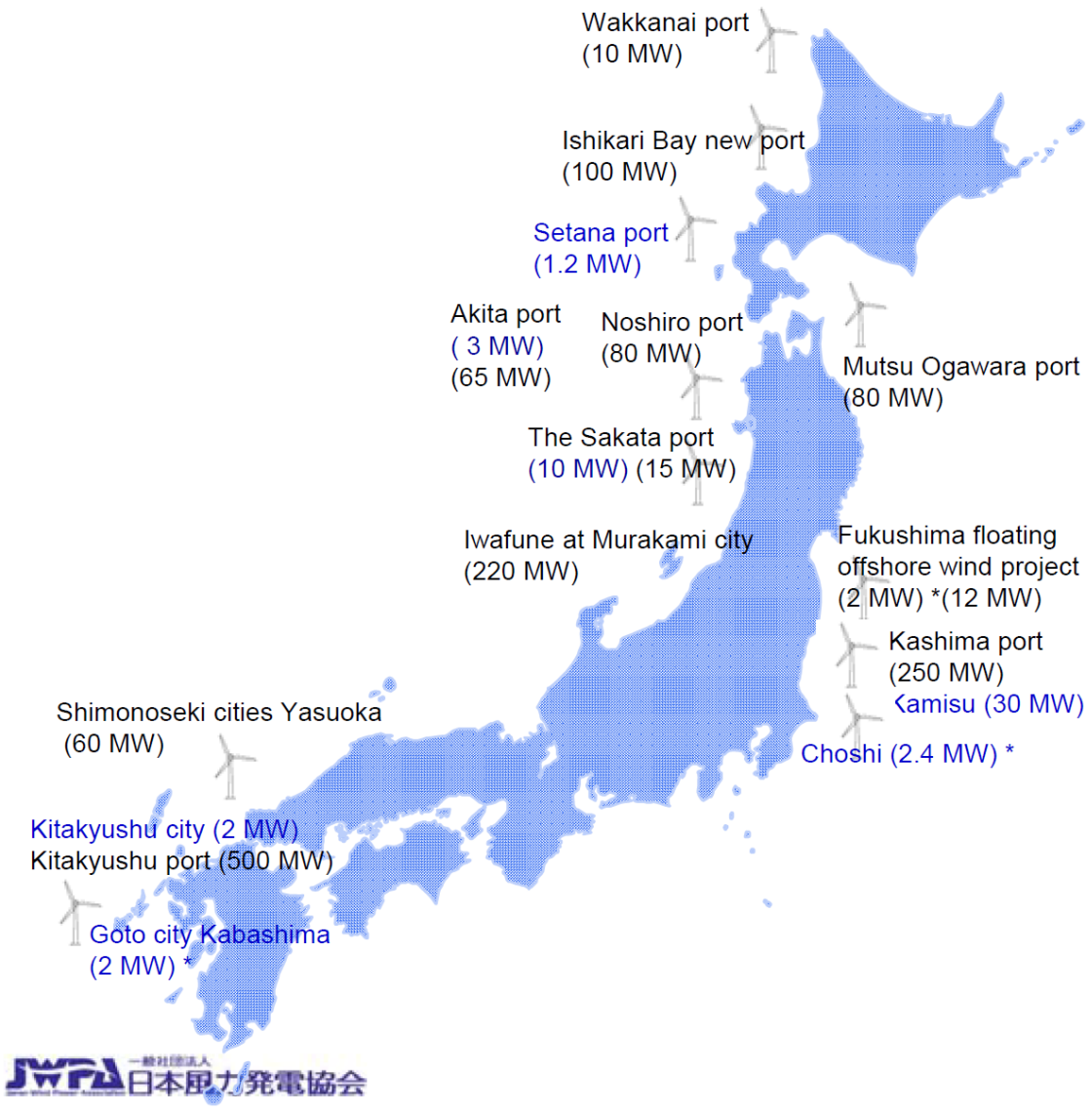
- How to ensure a visible and stable market?
- How to ensure continued innovation and investment?
- How to ensure the renewable energy build-out?

Collaboration and **partnerships** with **developers** and the **supply chain** is **paramount**, not just in **turbine technology**, but in **market design**, and **supply chain philosophy**

Agenda

- **Who we are**
- **Offshore Wind Market in Europe**
- **What we can deploy in Japan**

Offshore wind farm project in Japan



Experience: 52.6 MW
Planned: 1,392MW

Source: including the meeting small commission
term energy supply-demand projection (4th time)

Source: JWPA

MHI VESTAS OFFSHORE WIND™

Relationship with Japan | Transfer knowledge to Japan

MVOW has kept intense dialogue with policy makers of Japan

His Imperial Highness the Crown Prince

Members of the House of Representatives
(Economy, Trade and Industry Committee)

State Minister of Economy, Trade and Industry

State Minister of the Environment

Relationship with Japan | Collaboration with Japanese suppliers

Japanese manufacturers are providing key components for V164-8.0 MW

TORAY
Innovation by Chemistry
ZOLTEK

Carbon fibers for blade

YASKAWA
THE SWITCH
A YASKAWA COMPANY

Generator

MITSUBISHI ELECTRIC
Changes for the Better

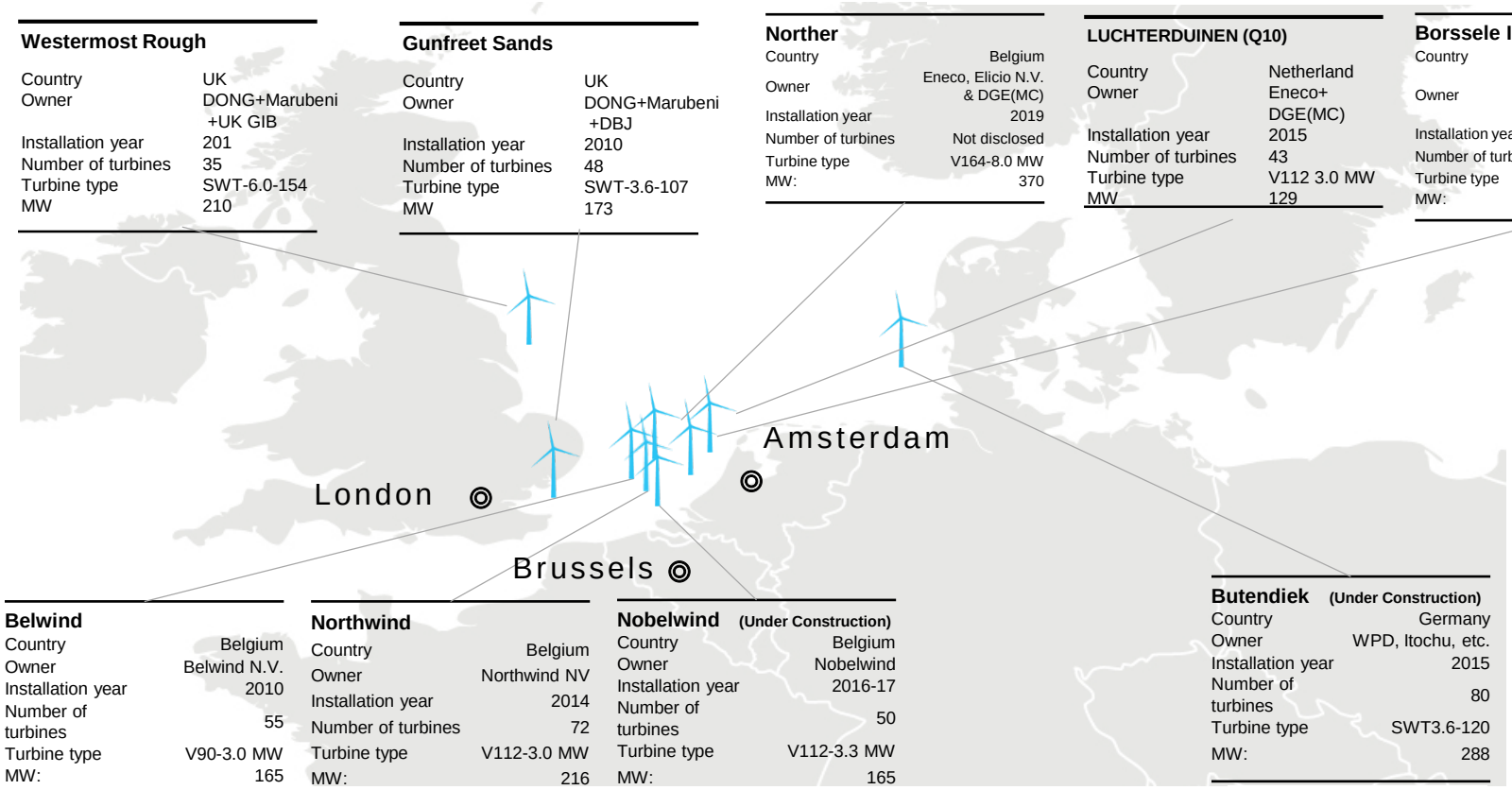
66kVA Switch gear

Relationship with Japan | Investment by Japanese trading company

Major Japanese trading companies have had significant footprint in offshore in Europe

Marubeni

Mitsubishi Corporation



Westermost Rough

Country	UK
Owner	DONG+Marubeni +UK GIB
Installation year	201
Number of turbines	35
Turbine type	SWT-6.0-154
MW	210

Gunfreet Sands

Country	UK
Owner	DONG+Marubeni +DBJ
Installation year	2010
Number of turbines	48
Turbine type	SWT-3.6-107
MW	173

Norther

Country	Belgium
Owner	Eneco, Elicio N.V. & DGE(MC)
Installation year	2019
Number of turbines	Not disclosed
Turbine type	V164-8.0 MW
MW:	370

LUCHTERDUINEN (Q10)

Country	Netherland
Owner	Eneco+ DGE(MC)
Installation year	2015
Number of turbines	43
Turbine type	V112 3.0 MW
MW	129

Borssele III & IV

Country	Netherlands
Owner	Shell, Van Oord, Eneco & DGE /Mitsubishi Corp.
Installation year	Not disclosed
Number of turbines	Not disclosed
Turbine type	V164-8.0 MW
MW:	2 x 340

Belwind

Country	Belgium
Owner	Belwind N.V.
Installation year	2010
Number of turbines	55
Turbine type	V90-3.0 MW
MW:	165

Northwind

Country	Belgium
Owner	Northwind NV
Installation year	2014
Number of turbines	72
Turbine type	V112-3.0 MW
MW:	216

Nobelwind (Under Construction)

Country	Belgium
Owner	Nobelwind
Installation year	2016-17
Number of turbines	50
Turbine type	V112-3.3 MW
MW:	165

Butendiek (Under Construction)

Country	Germany
Owner	WPD, Itochu, etc.
Installation year	2015
Number of turbines	80
Turbine type	SWT3.6-120
MW:	288

Sumitomo Corporation

ITOCHU

Key actions to make Offshore Wind fly in Japan

“Offshore wind power was not built in a day”. To transfer 25 years experience and know-how to Japan should be the best way to make offshore wind viable solution for sustainable energy mix in Japan

1. Strong commitment to offshore wind

- Long- term target of offshore wind deployment ensuring the visibility of market volume
- Stable but competitive support mechanism ensuring cost reduction

2. Clear roadblocks by provisioning the law and infrastructure

- Proper legislation framework and zoning by government
- Transparent and efficient authorization process
- Ensure grid connection
- Efficient environmental assessment procedure reflecting experience in Europe

3. Introduce the latest knowledge and experience of Europe

- Proven turbine technology, construction method and utilization of installation vessel
- Mature project management
- Contract / Risk Management Scheme, Finance structure
- O&M (Technical, operation method, ship operation etc.)

PRESENTER NAME
Presenter Title