附件 一

ClassNK 簡報資料

「Offshore wind turbine activities」

ClassNK

Offshore wind turbine activities

NIPPON KAIJI KYOKAI (ClassNK)
Renewable Energy Dept.

June 2016

ClassNK MISSION

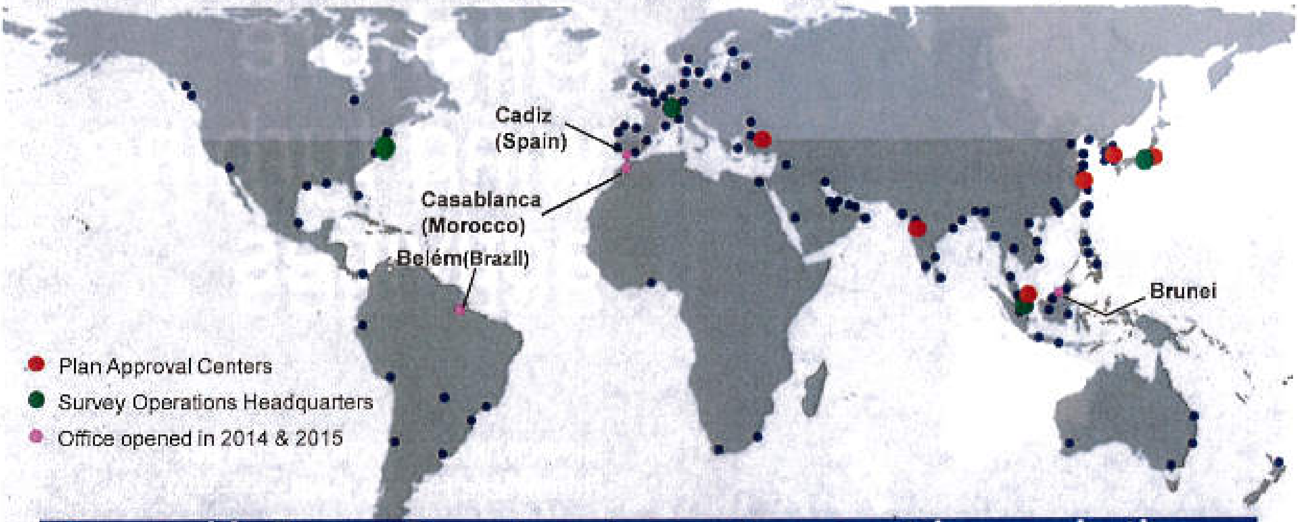
Devoting everything to safety and environmental protection

- ☐ Deliver the highest quality classification and certification services, by the highest quality personnel, while maintaining our totally independent third party, non-profit status.
- ☐ Develop relevant rules, guidances, and procedures, and conduct technical research and development to positively contribute to the maritime industry.
- ☐ Maintain and develop our global operations in line with the needs of our clients through our global service network of roughly 130 survey offices.

Introduction to Renewable Energy Technologies ClassNK

ClassNK has a global organization

- **129** Exclusive Survey Offices
- **6** Plan Approval Centers (Tokyo/Busan/Shanghai/Singapore/Mumbai/Istanbul)
- **4** Survey Operations Headquarters (Tokyo/Singapore/Hamburg/New York)



Renewable Energy Department operates as matrix organization across the global organization. Head office for Renewable Energy Technologies is in Tokyo, Japan.

Services for Renewable Energy Technologies ClassNK

Certification for large wind turbines

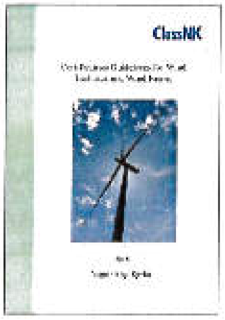
- ☐ Certification for wind power generators
- ☐ Project certification
- ☐ Site certification
- ☐ Certification for floating offshore wind turbine

Cooperation with organization for Renewables

Certification for large wind turbines

□Certification for wind power generators

- Design certification, type approval and prototype certification



□Project certification

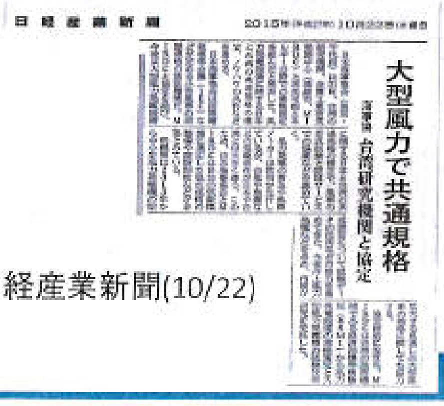
- Certification for wind farm projects

□Site certification

- Site certification is covered as a part of the project certification process and is carried out to ensure conformity with the safety regulations of the Electricity Business Act for business permits.

□Certification for floating offshore wind turbines

Cooperation with Taiwanese Organization


日経産業新聞

大型風力で共通規格

台湾研究機関と協定

日経産業新聞(10/22)

BSMI & MIRDC

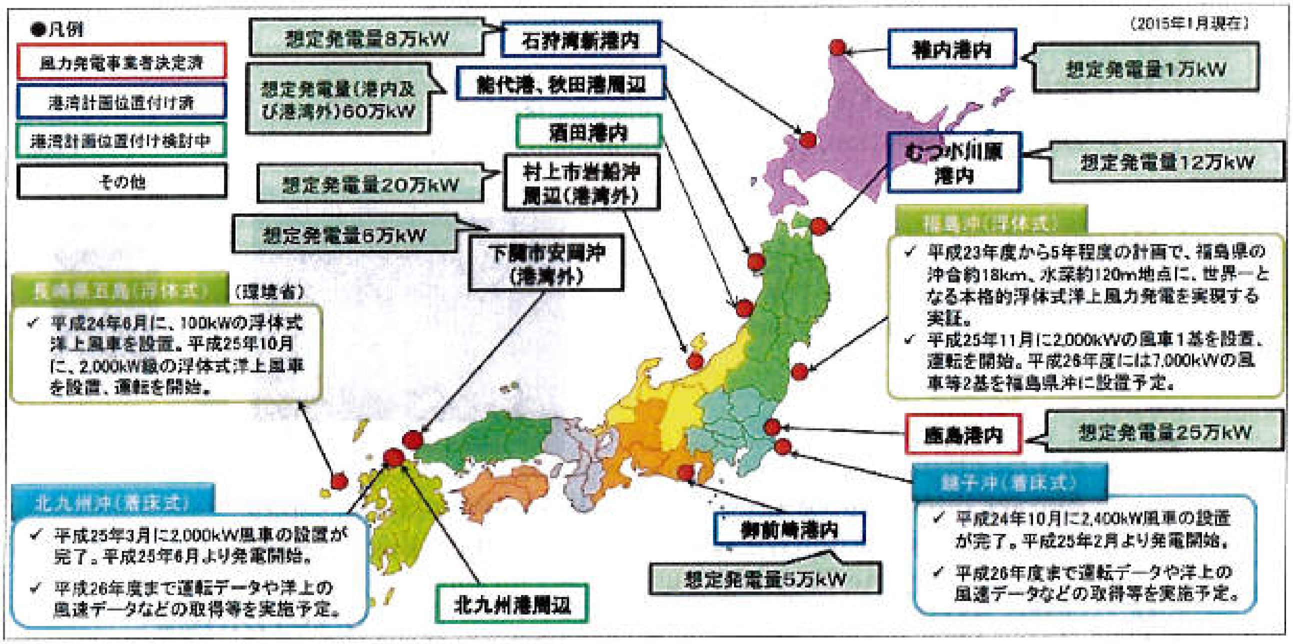
Establish a cooperative relationship especially type certification for wind turbine. (Oct 2015)

- ✓ Develop technical standard and guidelines in accordance with requirement within Taiwan and Japan
- ✓ Provide Services for type certification, prototype certification, component certification

etc.

Offshore Wind Farm Projects in Japan

ClassNK



出典:経済産業省

Track record of certification services

ClassNK

Fukushima FORWARD (HP: http://www.fukushima-forward.jp/english/index.html)

founded by the Ministry of Economy, Trade and Industry(METI)

Project Technical Leader is Prof. Ishihara

3 FOWT and 1 floating substation are all certified by ClassNK

Phase I (2011～2013) | Phase II (2014～2015)

Floating Substation | Compact Semi-Sub **Hitachi 2MW** | Advanced Spar **Hitachi 5MW** | V-shape Semi-Sub **MHI 7MW**

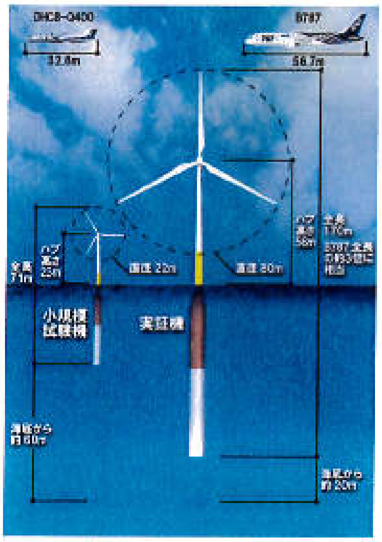
「Fukushima Kizuna」 「Fukushima Mirai」 「Fukushima Hamakaze」 「Fukushima Shinpu」

Image by Fukushima Consortium

GOTO FOWT (HP: http://goto-fowt.go.jp/english/)

founded by the Ministry of the Environment(MOE)

A FOWT and a floating observation tower are certified by ClassNK



GOTO FOWT
Floating Offshore Wind Turbine

Power generation has started operation since Oct. 2013

Floating Observation Tower, Hybrid Spar type 「Toki」

2MW FOWT, Hybrid Spar type 「Haenkaze」

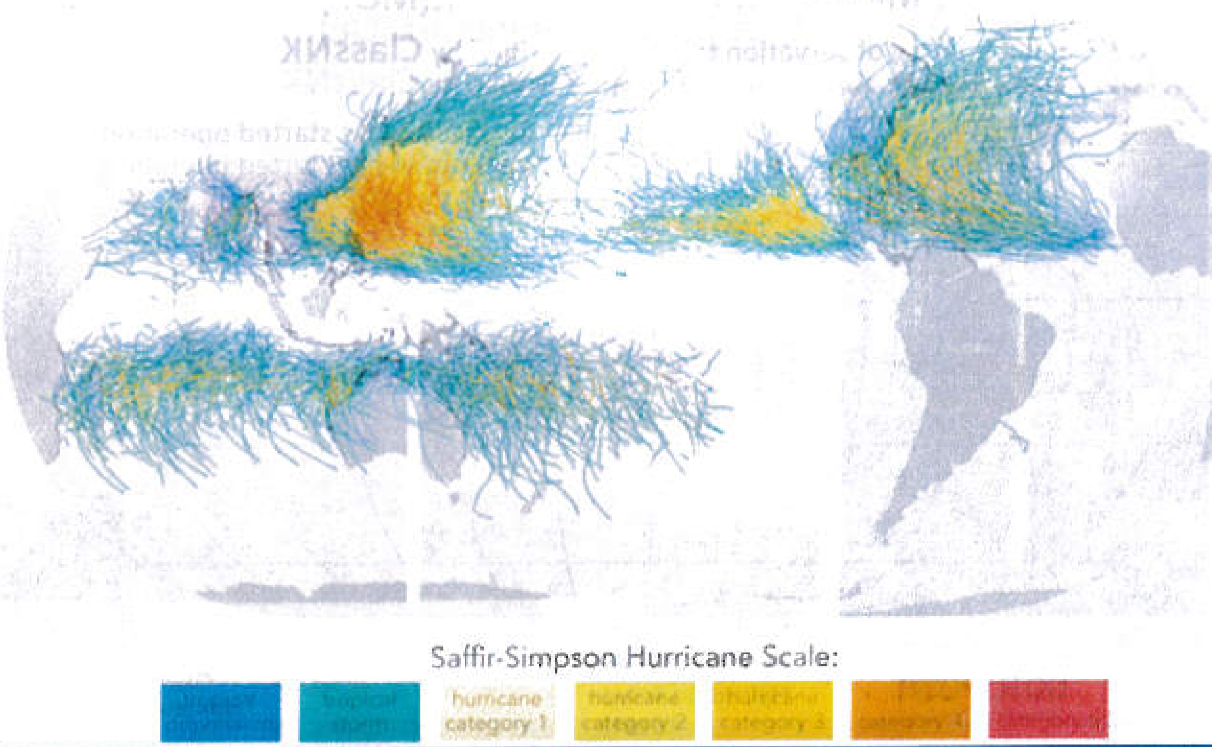
海底距50m以上才採浮体式

Severe environmental condition for WT in Taiwan and Japan

Severe environmental condition

ClassNK

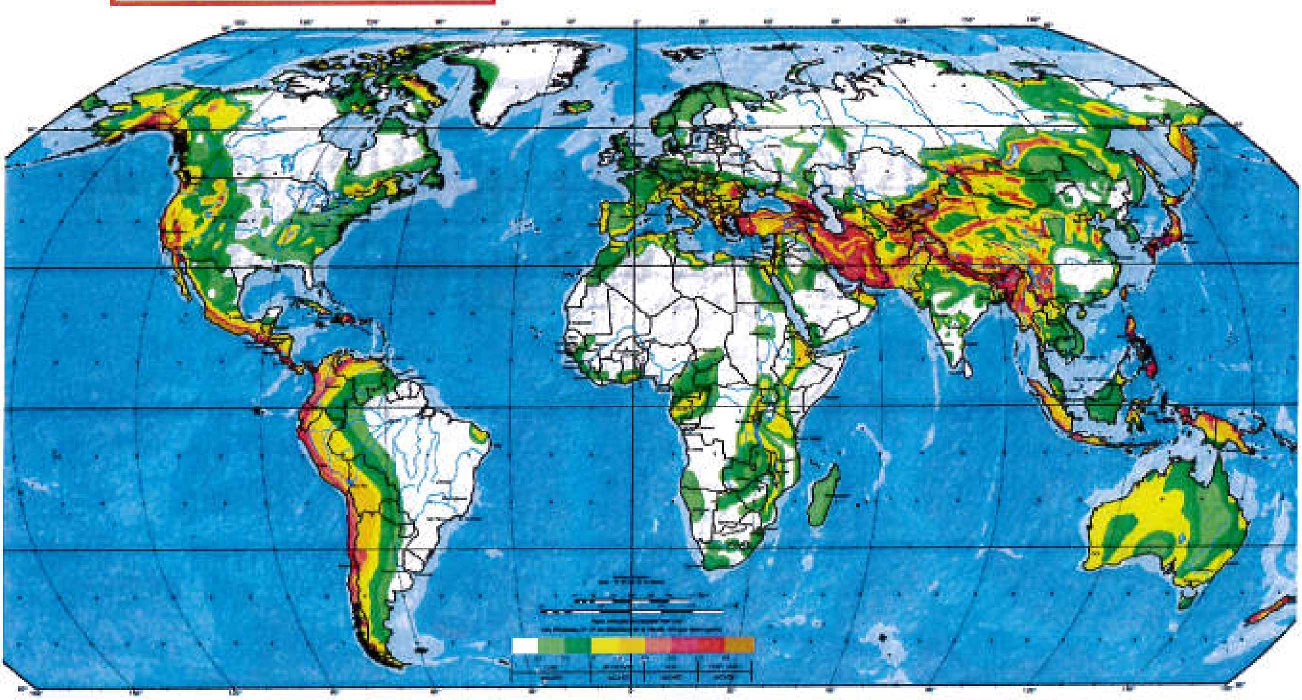
Tropical Cyclones, 1945–2006



Severe environmental condition

ClassNK

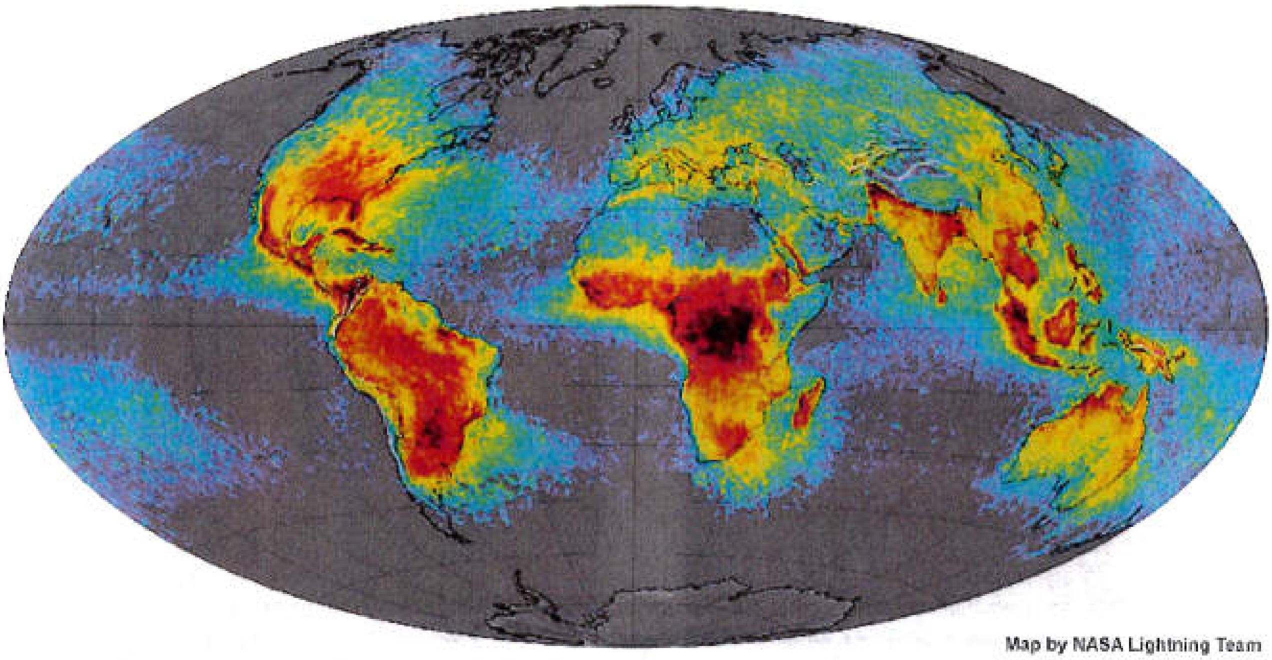
Earthquake



Severe environmental condition

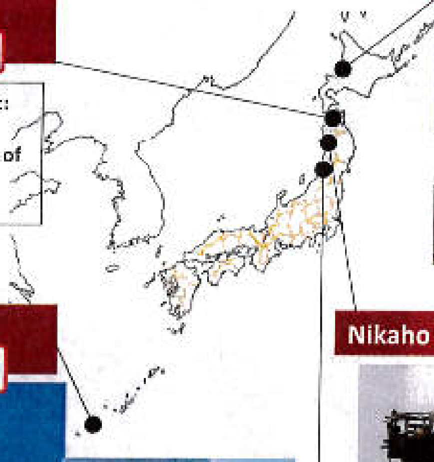
ClassNK

Lightning



Map by NASA Lightning Team

Severe Accidents of WT in Japan



Iwaya Wind Farm, Aomori, 8.Jan.2007

Turbulence

No.11A Bonus (Present: Siemens), Over speed caused by malfunction of pitch actuator made tower fall down.

Ororon Wind Power Plant, Hokkaido, 5.Dec.2013

No.1 NEG Micon, Blade Damage by Lighting Attack

http://www.hokkaido-np.co.jp/news/donai/508391.html

Karimata Wind Farm, Okinawa, 6.Sep.2003

Typhoon

No.3 Micon, Buckling of tower cross section

No.4 Micon, Damage of Nacelle

No.5 Micon, Buckling of tower cross section

No.4 Enercon, Damage of Blades

Damaged turbines at the Karimata site

Nikaho Wind Farm, Akita, 1.Oct.2003

Vestas, Lightning attack caused nacelle burnout.

Yuza Wind Power Plant, Yamagata, 22.Nov.2013

No.4 ENERCON, Blade Damage by Lighting Attack

http://www.okiden.co.jp/shared/pdf/corporate/r_and_d/04113002.pdf

Severe Accidents of WT in Taiwan

ClassNK

Wind turbine damaged by strong wind from Typhoon in Taichung on 8 Aug 2015

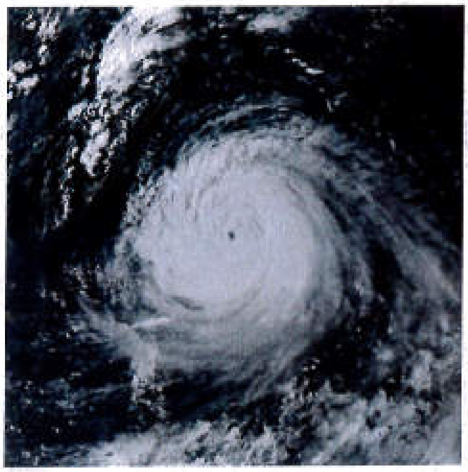
Common problem of WT

ClassNK

Common problem to be solved for wind turbine in Taiwan and Japan

- ☐ Evaluation of safety of wind turbine under storm in blackout condition

电网断电亦可能影响
风机控制



Thank you for your kind attention

ClassNK

Contact us: ClassNK Renewables
re@classnk.or.jp, +81-3-5226-2032

附件 二

日立公司簡報資料

「Development of Wind turbine System」

Meeting with Bureau of Standards, Metrology and Inspection

Development of Wind turbine System

Tailored to East Asian Environmental Conditions

June 22nd 2016

Renewable Energy Solutions Business Division
Hitachi Ltd.

FH-ES-16243

HITACHI
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Contents

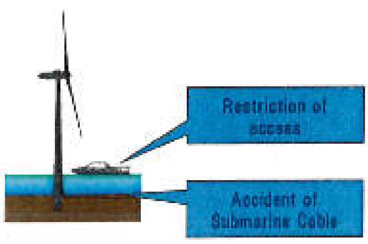
1.1. Solutions for TAIWAN Environmental Conditions

Environmental Conditions of Japan and East Asia	Hitachi Solutions
Tropical Cyclone	Downwind Weather Vane Principal
Lightning Attack	Lightning Protection Design
Earthquake, Sea Wave, etc.	Low Gravity Center, Low Overturning moment
Difficulty in Logistics and installation	Proper Modular Design

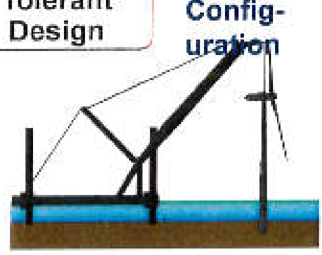
1.2. Design Concept of Hitachi Offshore turbines

Down Wind configuration meets offshore requirements.

Requirements	Solutions	Requirements	Solutions	Requirements	Solutions
System Cost Reduction		**Construction Cost Reduction**		**High Reliability**	
Larger sized turbine	Lineup •2MW •5MW	Simple Foundation	Low Over Turning Moment	Protection against salt and moisture	•Ventilation Design, •Gear Drive
Simple Wind Turbine System	Best-mixed Gear & Gene.	Low Installation Cost	Proper Modular Design	Preventive Maintenance	Service Net. Monitoring
				Fault Tolerant Design	Down Wind Config-uration



Hitachi 5MW windturbine, HTW5.0-126



1.3. Down Wind Solution

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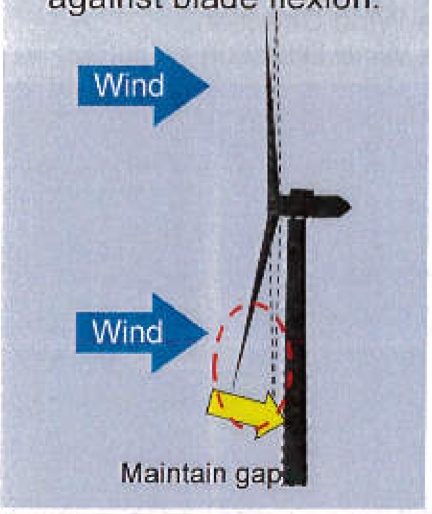
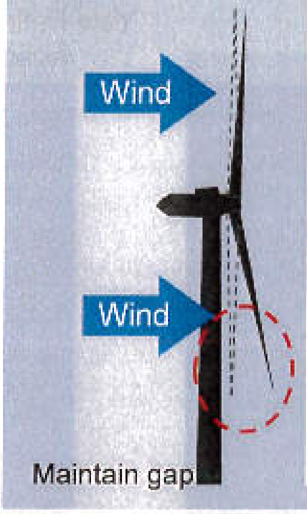
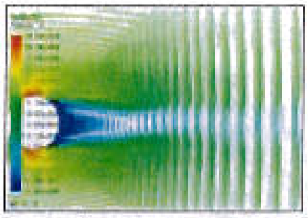
Upwind	Downwind
Gap between rotor and tower must be considered against blade flexion.	Need to Avoid tower shadow effects

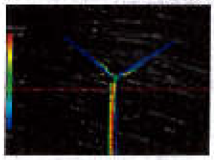
一旦在设计
就考虑到







Distance from tower and effect on air flow



Simulation

Experimental testing

Problems (incl. after tower turbulence) are overcome using analysis-based design techniques and then confirmed by demonstration test.

1.4. Merit of Downwind: Weathervane, Wind Sensor

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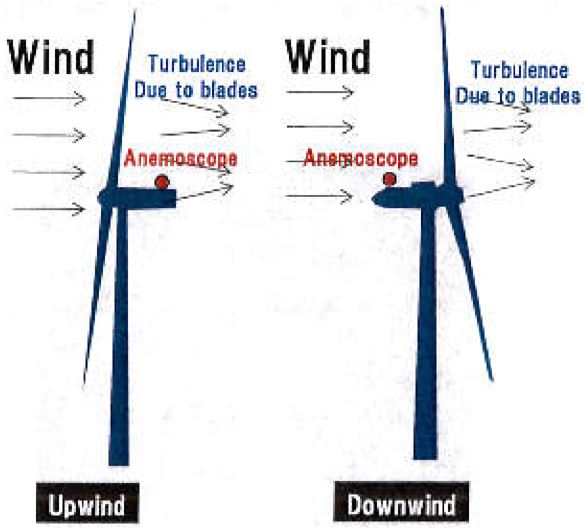
Vane Effect

Inherently following wind

・Free Yaw Operation

Downwind turbine can ride out the storm by free yaw operation without support of batteries with limited capacity in case of grid connection loss

Accurate Wind Detection



・Efficient Power Generation

Downwind configuration allows accurate wind detection with pre-wake flow

可准确测量
风速及风向

1.5. Normal Operation / Downwind, Upwind

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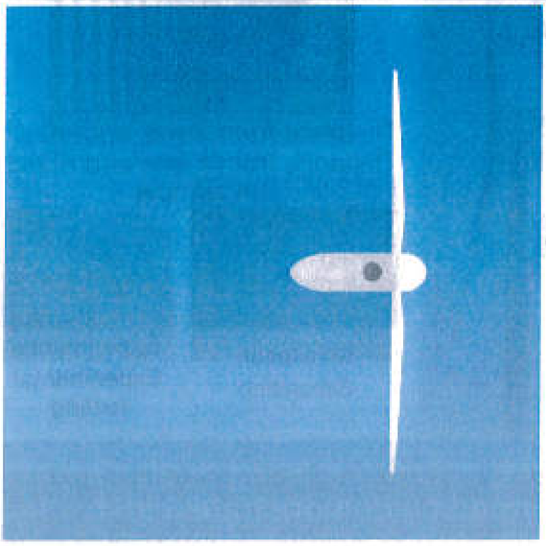
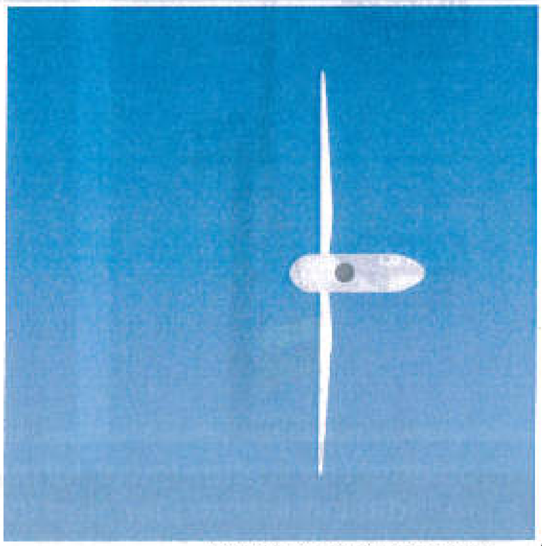
Both down wind and up wind configurations keep proper nacelle direction.

Down Wind	Up Wind
Active Yaw Control	Active Yaw Control
Yaw Follows Wind Direction	Yaw Follows Wind Direction





1.6. Standstill Mode without Electric Supply

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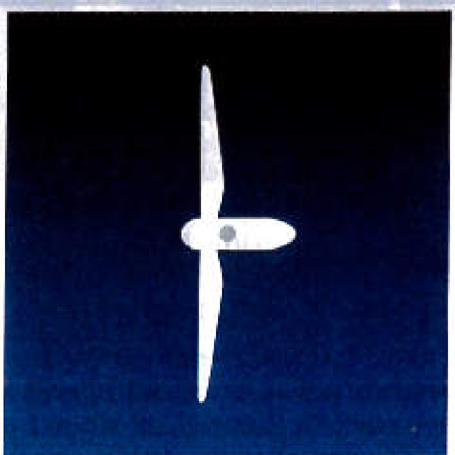
**Under storm in blackout condition
after exhaustion of battery, emergency power supply**

Down Wind	Up Wind
Free Yaw	Fixed Yaw
Yaw follows wind direction.	Yaw does not follow wind direction.



Down wind keeps right yaw angle not to receive cross wind.

Upwind has possibility to have cross wind.

1.7. Danger in Up-wind's Transit to Down-wind

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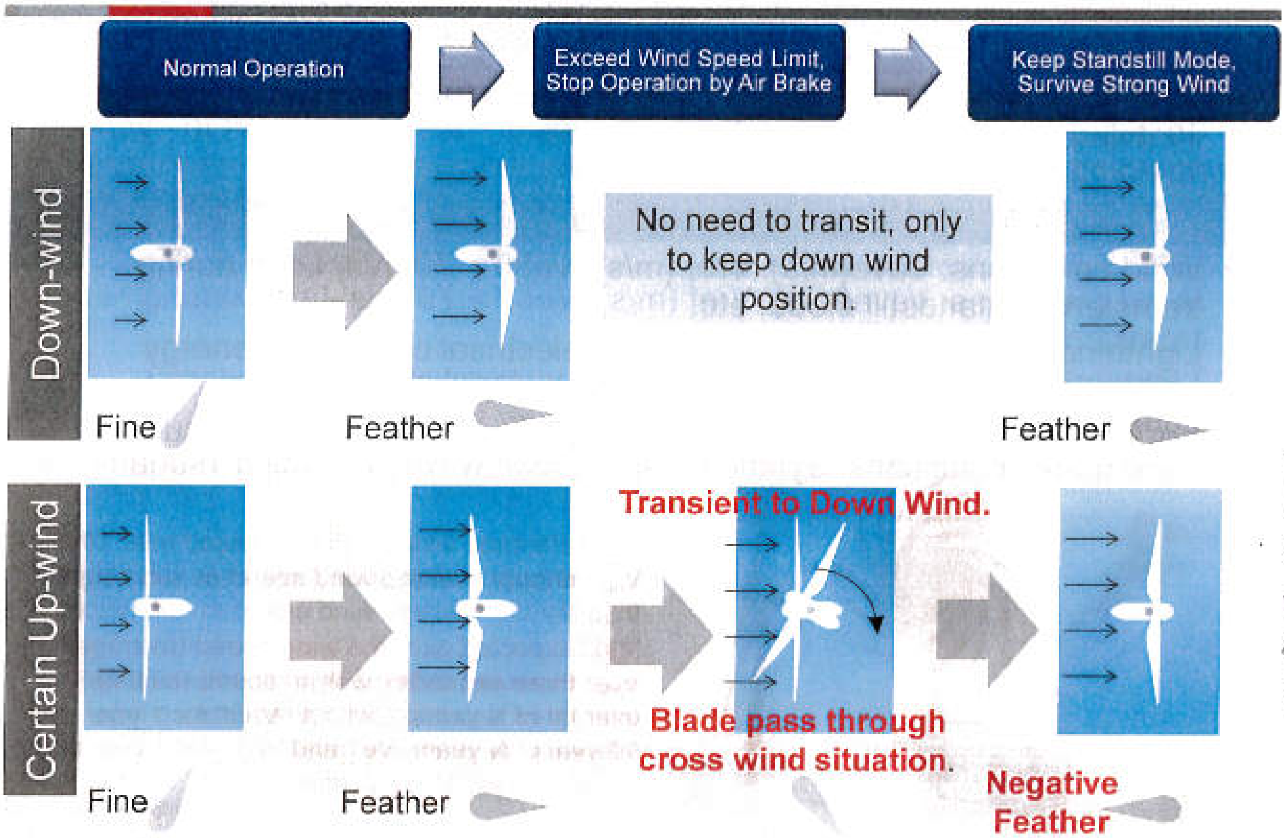

1.8. Lightning Protection

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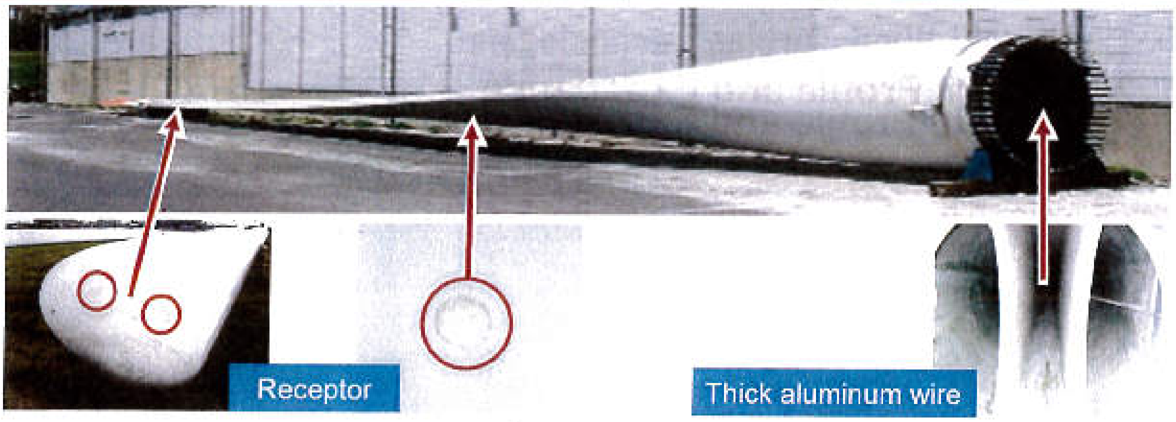
	Peak current(kA)	Electrical Charge(C)	Energy comparison (MJ/Ω)
International standard*	200	300	10
Hitachi's Wind Turbine	250	600	40
Comparison	1.25 times	Double	4 times



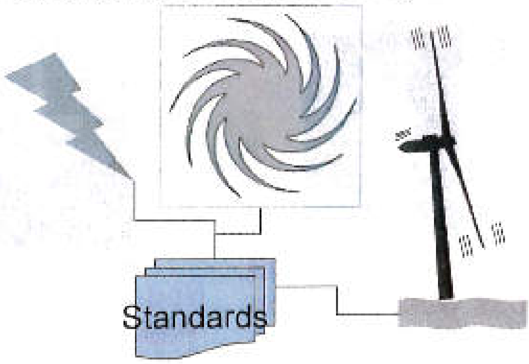
Secure lightning protection above international standard by using thicker aluminum wire

Need to evaluate conditions for Taiwanese Windturbines

- To assess what criteria are effective to design turbines tolerant to Typhoon, lightning attack, earthquake, Tsunami, etc.

Need to decide criteria

- Wind conditions: Vave(m/s), Vref (m/s), Ve50 > 70 m/s, Load during tramsient to standstill mode, etc.
- Lightning conditions; peak current(kA), electrical charge(C), energy comparison (MJ/Ω), etc.
- Earthquake conditions: Synthetic earthquake waves including Tsunami



V_{ref}: reference wind speed averaged over 10 min
V_{ave}: annual average wind speed at hub height [m/s]
V_{e50}: expected extreme wind speed (averaged over three seconds), with a recurrence time interval of N years. Ve1 and Ve50 for 1 year and 50 years, respectively [m/s]

HITACHI
Inspire the Next

Contents

2.1. Over 140 Hitachi Wind Turbines

HITACHI
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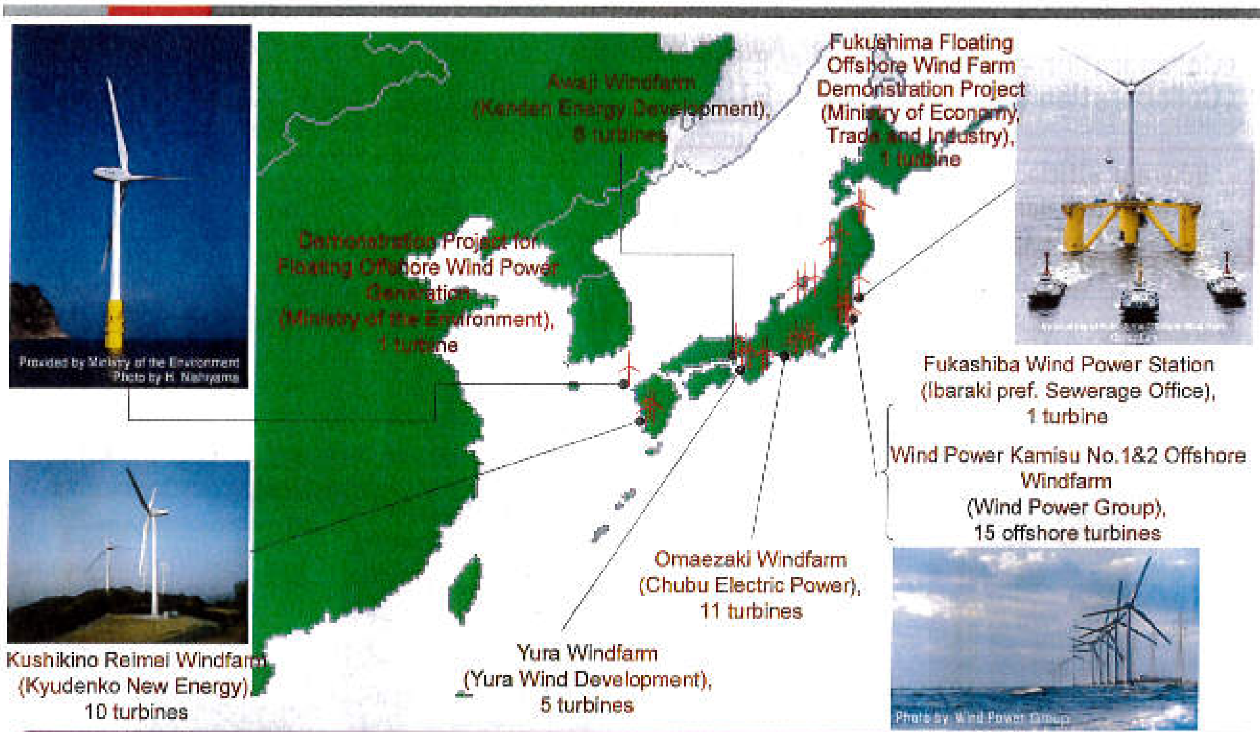

Top shares in Japan in 2012[*1], Cumulative orders received: 137 turbines(including 54 in operation)[*2]
The superiority of the downwind configuration has been recognized by selection for the government demonstration projects for floating offshore wind power

*1: Source: A BTM Wind Report: World Market Update 2012 *2: As of Feb.2014

2.2. Downwind Nacelle Effect

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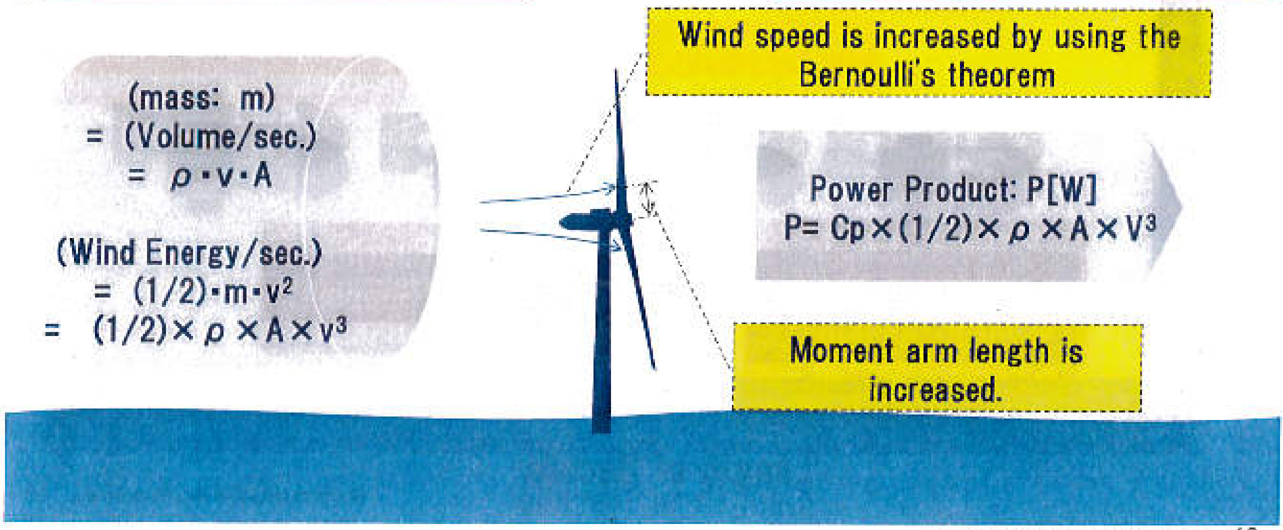
Downwind Nacelle increases wind speed and blades' moment arm.

Downwind power production is enhanced.



2.3. Nacelle Increases Inlet Wind Speed

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EWEA Offshore 2015 "Poster Award Winner"
(Collaboration between Hitachi & ETH)

OFFSHORE 2015 ORGANISED BY EWEA

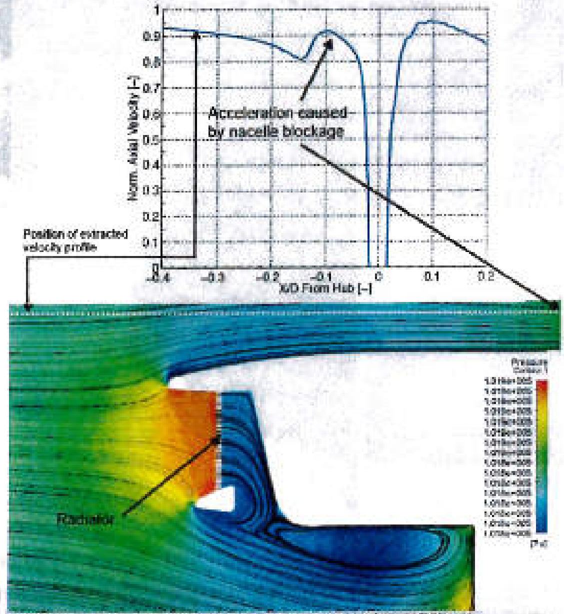
High efficiency of Downwind Rotor

Inherent efficiency of downwind rotor is shown not only theoretically but also experimentally

	Computation [2]	Experiment [3]
Downwind		
Power coefficient c_P	100%	100%
Thrust coefficient c_T	100%	100%
Upwind		
Power coefficient c_P	97%	95%
Thrust coefficient c_T	97%	97%

Experimental set at ETH Zürich

Wind Acceleration by Nacelle Shape



Top: Streamwise distribution of axial velocity 3.5m above hub height of Hitachi 5MW turbine
Bottom: Sectional view of upstream part of Hitachi 5MW turbine with pressure contour and streamlines

2.4. Rotor Bearing Design to reduce Nacelle weight

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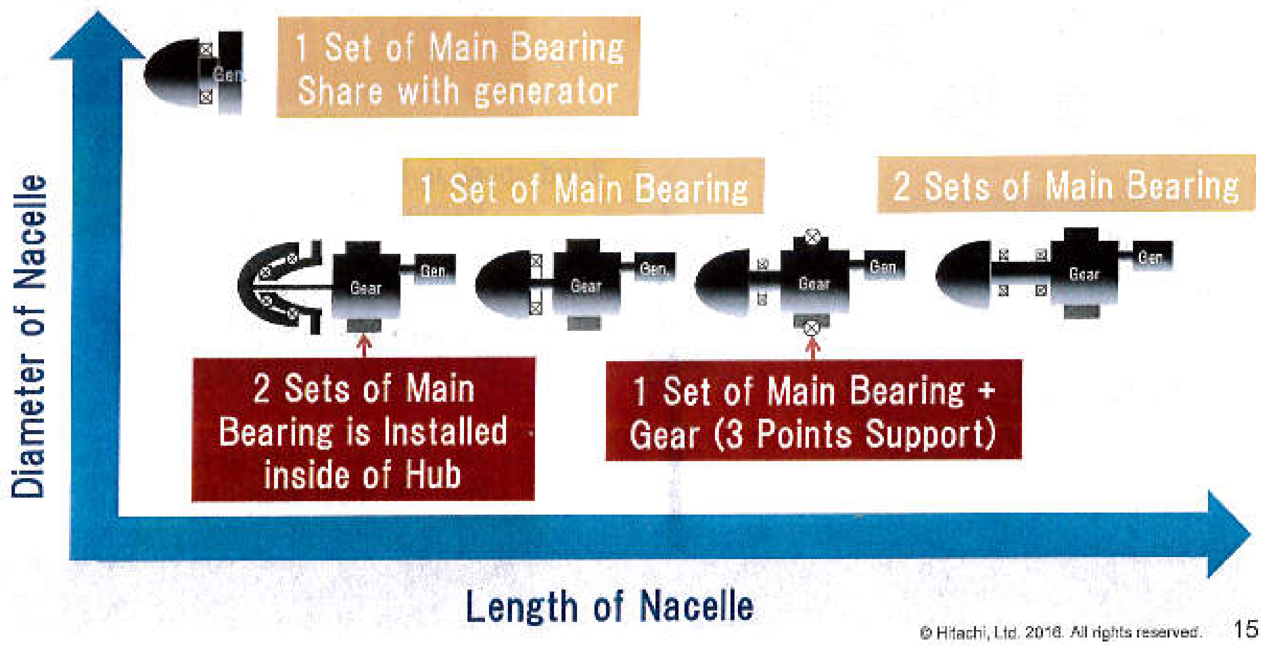
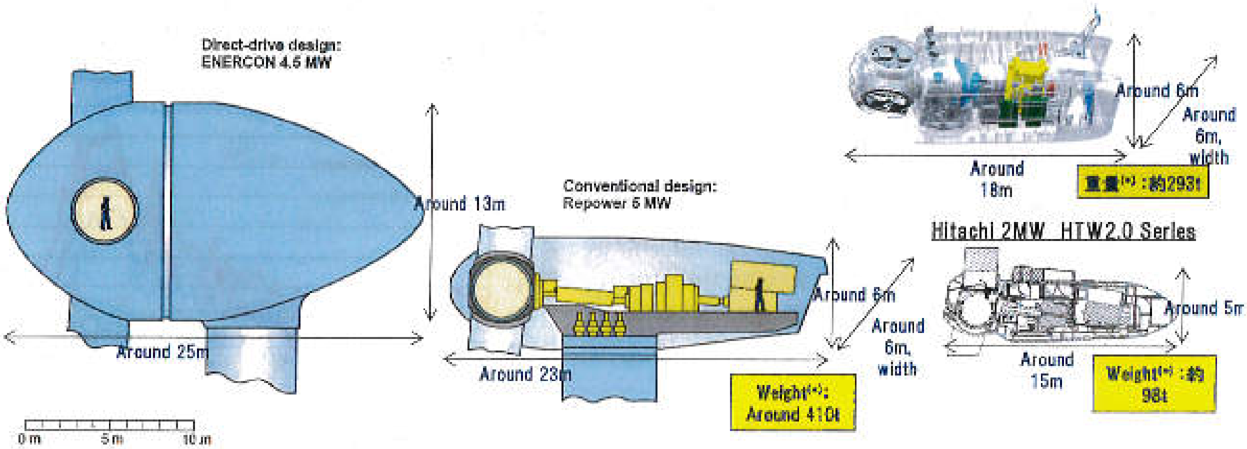
●Nacelle size and weight are reduced by rotor bearing concept.



2.5. Compact Nacelle

- Hitachi 5MW Turbines try to employ advanced design concepts to reduce nacelle dimensions and weight



Comparison between nacelle size

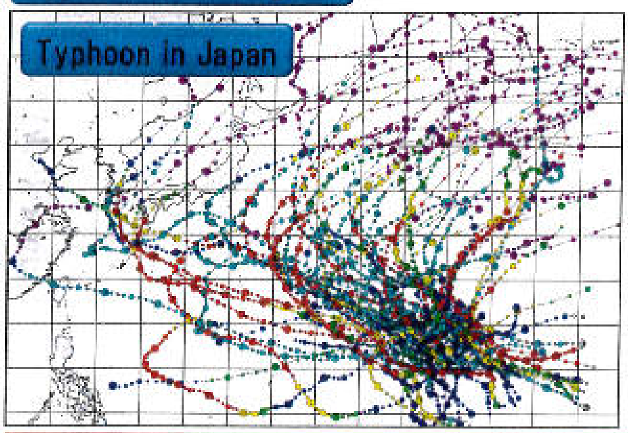
Source: de Vries, 2003/OPET Network, 2004

(＊)：重量はナセル本体及びハブの重量

2.6. Experiences on Severe Asia Environment

Wind Turbine has to be designed to adapt with severe typhoon

Typhoon Path Diagram



FY	Total in Japan	Total in Taiwan
2015	27	6
2014	23	3
2013	31	6
2012	25	7
2011	21	5

Hitachi's Wind Turbine → **No Fatal Accidents.**

2.7. Experiences on Severe Asia Environment

HITACHI
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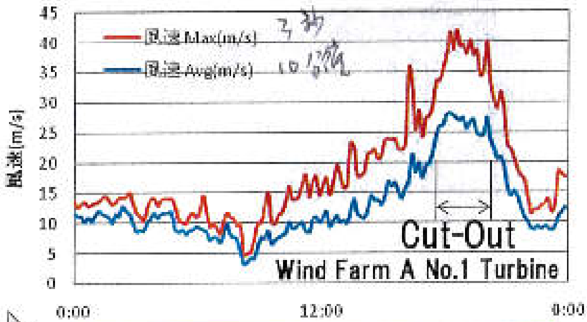
Safety in Stormy Wind (Typhoon)

Typhoon Attacked HTW2.0-80 on 21st Sep. 2011

Wind farm A
① 18:30, Max. wind speed 41.9m/s ② 17:30-20:00, Cut-out, No damage, Resumed operation after typhoon attack .
Wind farm B
① 12:10, Max. wind speed 42.2m/s ② 10:40-13:00, Cut-out, No damage, Resumed operation after typhoon attack .
Wind farm C
① Max. wind speed 61.7m/s, 10 min. average wind speed 46.1m/s, 1hour average 42.7m/s ② 11:00-21:00, Cut-out, No damage, Resumed operation after typhoon attack .



Hitachi's Wind Turbine → **No Fatal Accidents.**

2.8. Experiences on Severe Asia Environment

HITACHI
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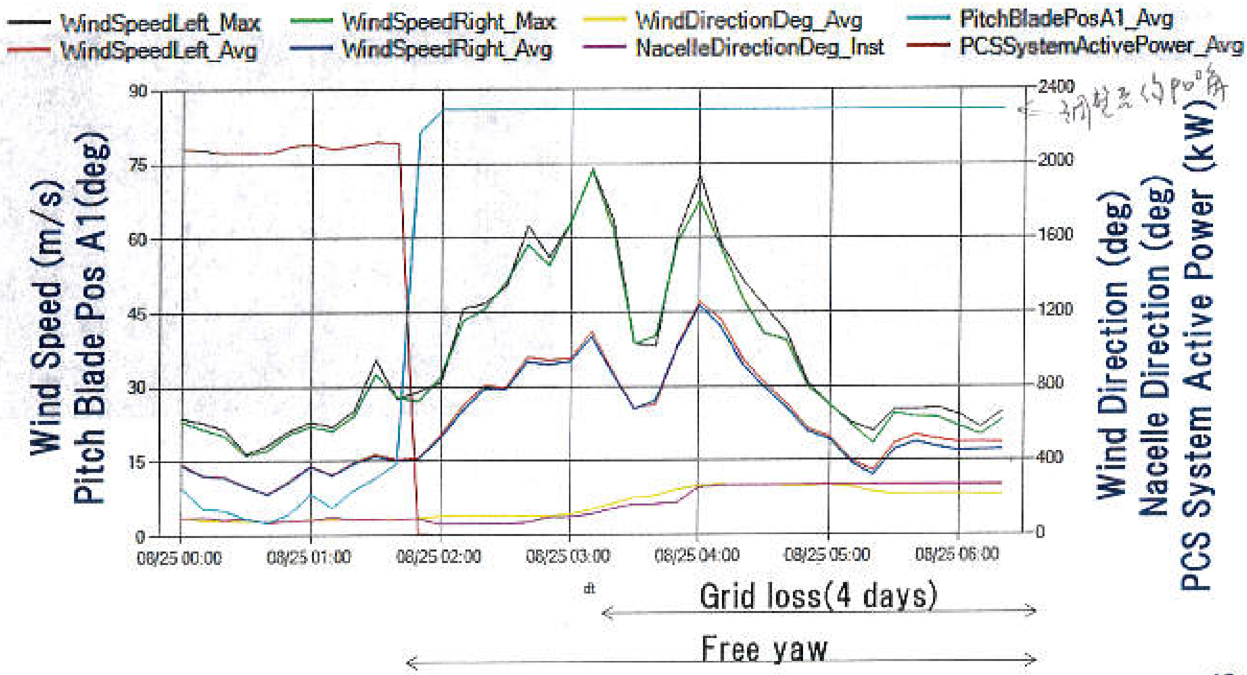
Typhoon passing experience on 25th Aug. 2015 (000hrs~0620hrs)

Recorded data from HTW2.0



2.9. Taiwan Offshore WTG / Hitachi Strategy

HITACHI
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- Partnering with A Leading Developer CSC(China Steel Corporation)
- HTC would like to cooperate not only WTG*1, but also total energy solution
- 【HTC WTG Advantages】
  ①Typhoon Class T ($V_{ref,T}$ = 57 m/s) Cert. with MIRDC*2 and NK*3,
  ②Support with Japan Alliance, ③Utilize METI (NEDO) Support

■Market

- Policy :
  Renewable Energy Development Plan(Offshore 3⇒4GW)

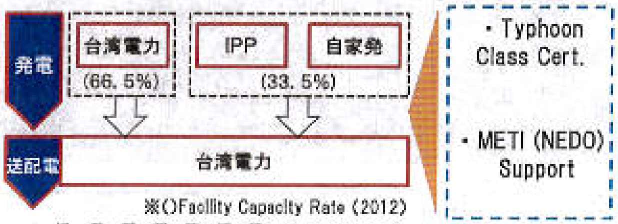
Target Plan (Acc.:GW)

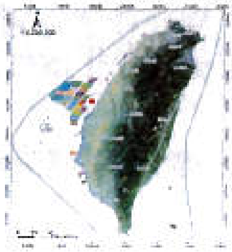
	'15	'20	'25	'30
On-Shore	0.9	1.2	1.2	1.2
Off-Shore	0.02	0.6	1.8 ⇒3.0	3.0 ⇒4.0
	Shallow 0.6GW		Large Scale 2.4⇒4GW	

✓ FIT :19JPY/kWh
✓ Wind Speed:>9.0m/s(台湾海峡)

*1:WTG(Wind Turbine Generator)
*2: MIRDC(Metal Industries Research & Development Centre)
*3: NK (Nippon Kaiji Kyokai)

- Power Utility Scheme
  <u>HTC to support not only WTG, but also Energy Solution (ex. Grid Stability, Micro Gird and IoT)</u>





・36 Potential Site
・OTPC 彰化 site

2.10. Seismic Design: Low Center of Gravity

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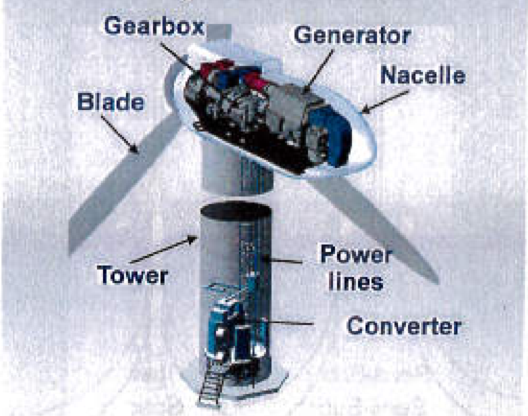
Lightweight nacelle allows low center of gravity design

■ Converter and transformer located at ground level
■ Easy maintenance



Kamisu 1 and 2 Offshore Wind Farms

Japan's largest offshore wind farm
30 MW (HTW2.0-80 turbines × 15)

■ Constructed on monopile foundations 40 to 50 m off seawall
■ Kamisu 1: 7 turbines (in operation during earthquake)
■ Kamisu 2: 8 turbines (started operation in March 2013)

The turbines kept integrity through the intensity 6+ earthquake and 5m tsunami

2.11. Tsunami Attack with 5 m Height, 8.5 m/s Speed

HITACHI
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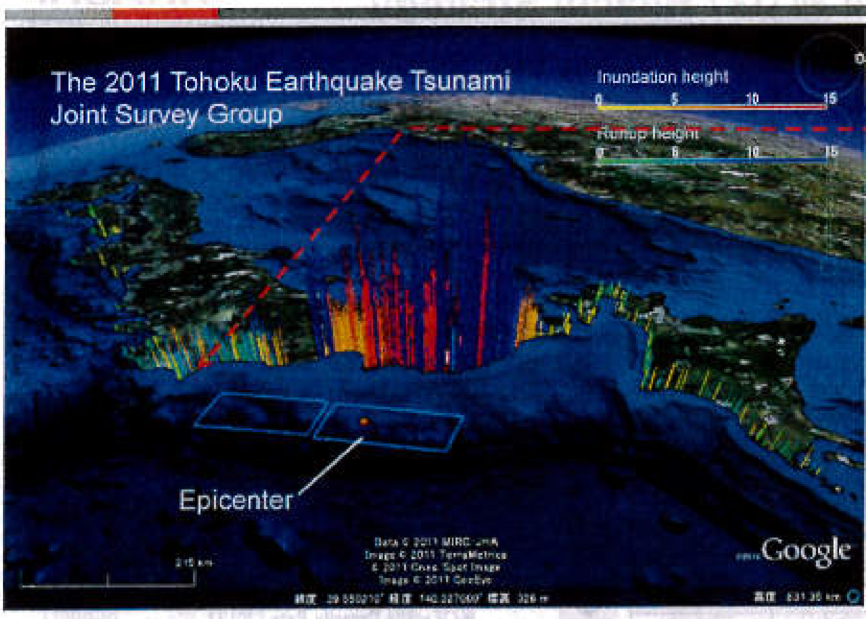

Kamisu Phase 1 was still "After the earthquake" and "5 m Height, 8.5 m/s Speed Tsunami".

Shallow water accelerated Tsunami speed.

2.12. Variety of Offshore Foundation

HITACHI
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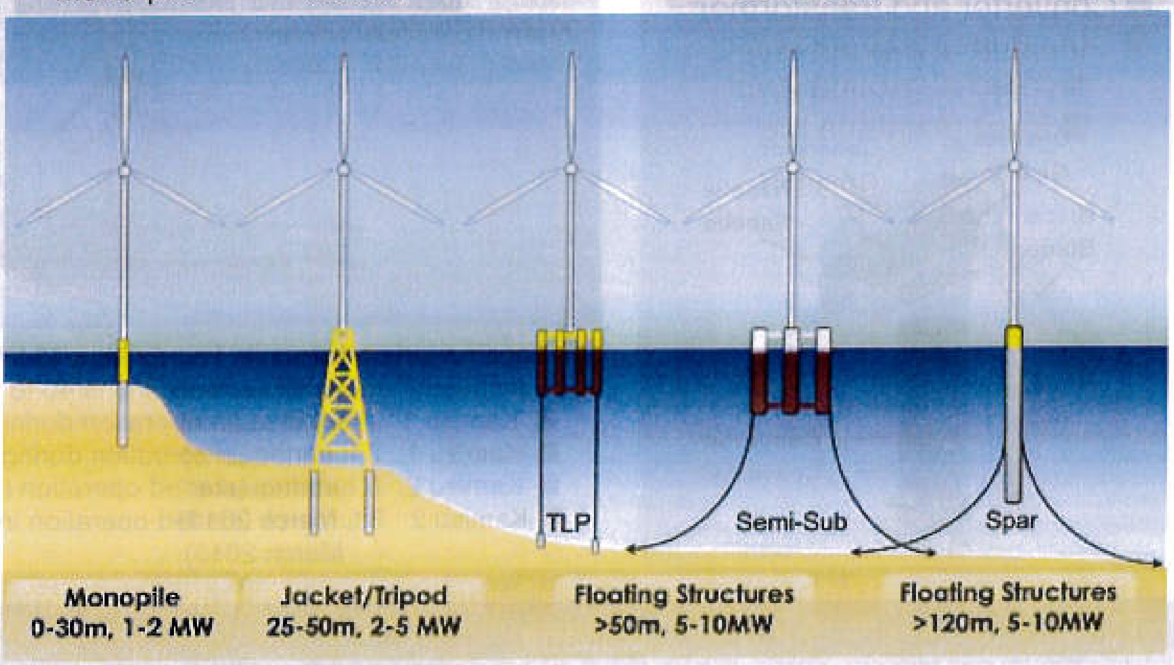
Fixed Base		Floating Base	
Kamisu	(A Certain)	Fukushima	Kabashima
Mono-pile	Jacket	Semi-Sub	Spar



Source: http://turbineel.net/offshore-wind-turbine-foundations/

附件 三

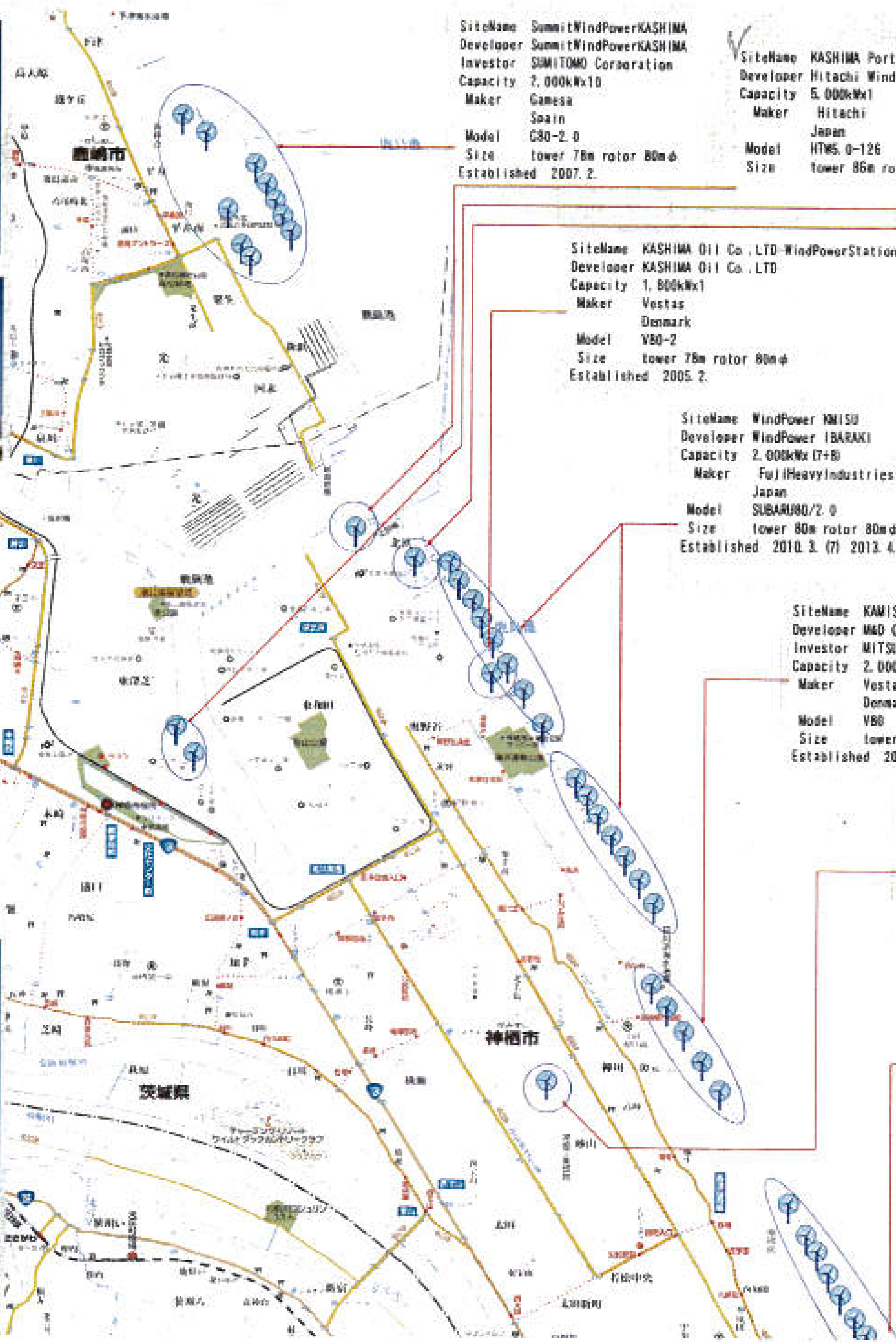
鹿島風力發電站設置圖

KAMISU·CHOSHI WindPowerStation MAP 2015. 7.

WindPower HITACHI-Chemical KASHIMA

WindPower HAZAKI

FUKASHIBA Sewage Treatment Plant



SiteName SummitWindPowerKASHIMA
Developer SummitWindPowerKASHIMA
Investor SUMITOMO Corporation
Capacity 2,000kWx10
Maker Gamesa
Spain
Model G80-2.0
Size tower 78m rotor 80mφ
Established 2007. 2.

SiteName KASHIMA Port FUKASHIBA
Developer Hitachi WindPower
Capacity 5,000kWx1
Maker Hitachi
Japan
Model HTW5.0-126
Size tower 86m rotor 126mφ

SiteName DIC corporation
Developer Hitachi
UFJCentralRease
Capacity 2,000kWx2
Maker Enercon
Germany
Model E82
Size tower 76m rotor 82mφ

SiteName FUKASHIBA-sewage plant
Developer IBARAKI Pref.
Capacity 2,000kWx1

SiteName KASHIMA Oil Co.,LTD-WindPowerStation
Developer KASHIMA Oil Co.,LTD
Capacity 1,800kWx1
Maker Vestas
Denmark
Model V80-2
Size tower 78m rotor 80mφ
Established 2005. 2.

SiteName WindPower KMISU
Developer WindPower IBARAKI
Capacity 2,000kWx (7+8)
Maker FujiHeavyIndustries-Hitachi
Japan
Model SUBARU80/2.0
Size tower 80m rotor 80mφ
Established 2010. 3. (7) 2013. 4. (8)

SiteName KAMISU-WindPowerStation
Developer M&D GreenEnergy
Investor MITSUUROKO-DAINEN Co.,LTD
Capacity 2,000kWx5
Maker Vestas
Denmark
Model V80
Size tower 78m rotor 80mφ
Established 2008. 1.

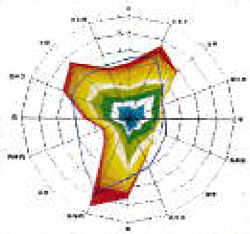
SiteName WindPower Hitachi-Chemical KASHIMA
Developer WindPower IBARAKI
Capacity 1,980kWx1
Maker FujiHeavyIndustries-Hitachi
Japan
Model SUBARU80/2.0
Size tower 80m rotor 80mφ
Established 2008. 2.
NacelleMark Hitachi Chemical

SiteName HAZAKI WindFarm
Developer HAZAKI WindFarm
Investor Eco Power Co.,LTD
Capacity 1,250kWx12
Maker DeWind
Germany
Model D6-62/1250
Size tower 64.5m rotor 62mφ
Established 2004. 3.

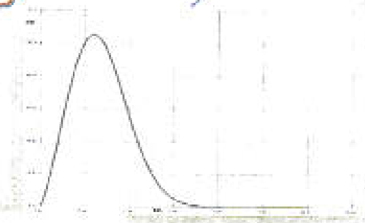
SiteName WindPower HAZAKI
Developer KOMATSUZAKI Urban Development
Capacity 1,980kWx1
Maker FujiHeavyIndustries-Hitachi
Japan
Model SUBARU80/2.0
Size tower 60m rotor 80mφ
Established 2006. 1.
NacelleMark SUBARU

WindPower KAMISU

WindPower KASHIMA



Windrose



Wind-Distribution

KASHIMA port FUKASHIBA 5MW

SiteName SHIISHIBA-WindPowerStation
Developer KUROSHIO-WindPowerGeneratorSystem
Investor Hitachi-Capital
Capacity 1,990kWx1, 1,990kWx5
Maker Enercon Germany
Model E70x1, E82x5
Size tower 64m rotor 71mφx1

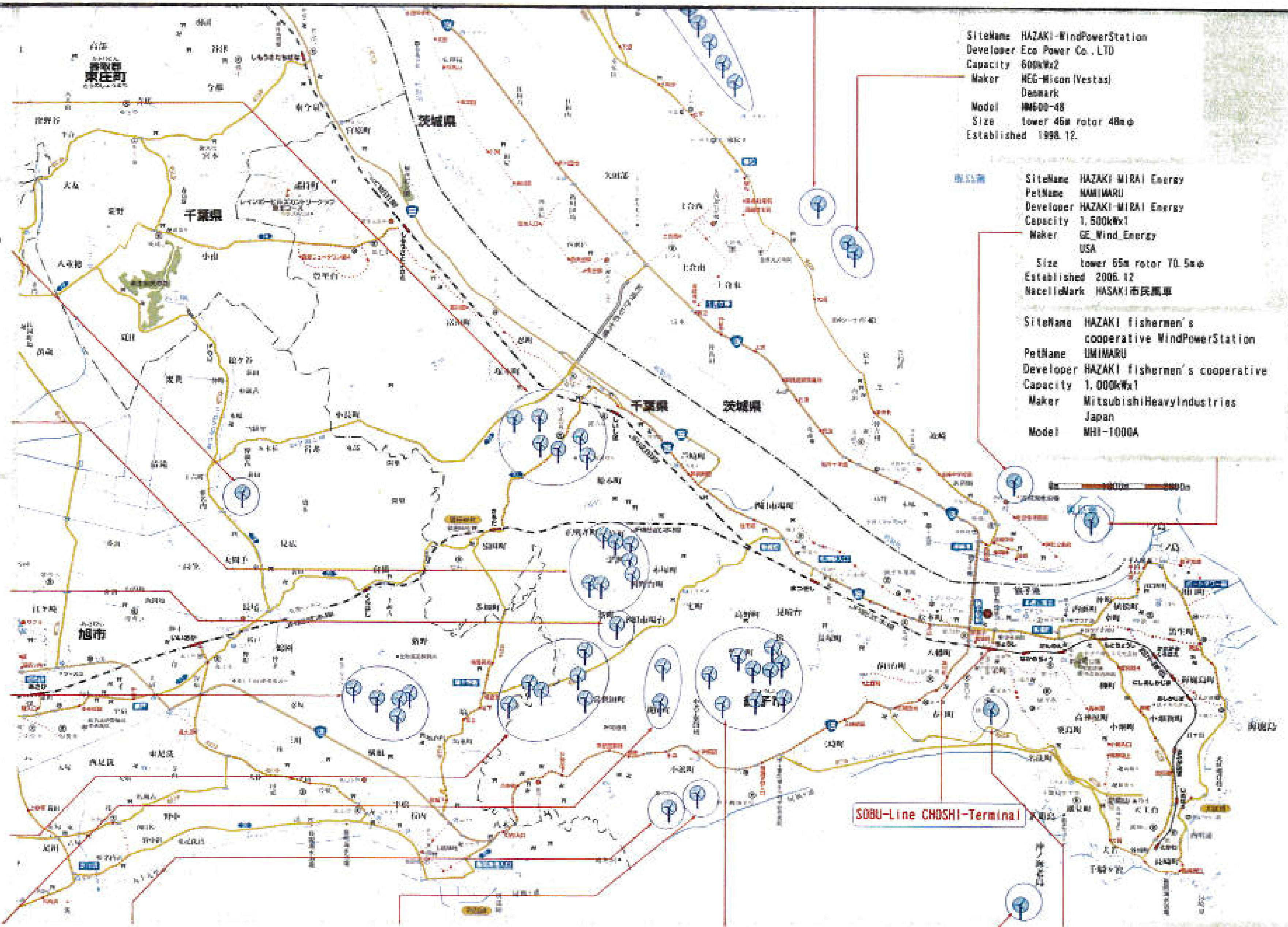
SiteName UNAKAMI-SHIMIN WindPowerStation
PetName KAZAMI
Developer UNAKAMI-SHIMIN-WindPowerStation
Capacity 1,500kWx1
Maker GE_Wind_Energy USA
Size tower 65m rotor 70.5mφ
Established 2006.9.

SiteName CHOSHI-WindPower
Developer Eco-Power
Capacity 1,500kWx7
Maker Ebara-Frideler Japan-Germany
Model EPW1570
Size tower 65m rotor 70mφ
Established 2007.2.

Developer HORIE-SHOTEN
Capacity 1,980kWx1
Maker Repower Germany
Model MM70
Size tower 64m rotor 70mφ
Established 2006.3.
NacelleMark HORIE

SiteName IIOKA-WindPowerStation
PetName KAZE-TARO
Developer MAD GreenEnergy
Investor MITSUUROKO-DAINEN
Capacity 850kWx5
Maker Vestas Denmark
Model V52
Size tower 65m rotor 52mφ
Established 2002.5.

SiteName YAGI-WindPowerStation
Developer CHOSHI WindPowerDevelopment
Investor Japan Wind Development Co.,LTD
Capacity 1,500kWx6
Maker GE_Wind_Energy USA
Size tower 65m rotor 70.5mφ
Established 2006.6.
NacelleMark CWD



SiteName HAZAKI-WindPowerStation
Developer Eco Power Co.,LTD
Capacity 600kWx2
Maker NEG-Micon (Vestas) Denmark
Model NM600-48
Size tower 46m rotor 48mφ
Established 1998.12.

SiteName HAZAKI MIRAI Energy
PetName NAMIMARU
Developer HAZAKI-MIRAI Energy
Capacity 1,500kWx1
Maker GE_Wind_Energy USA
Size tower 65m rotor 70.5mφ
Established 2006.12
NacelleMark HASAKI市民風車

SiteName HAZAKI fishermen's cooperative WindPowerStation
PetName UMIMARU
Developer HAZAKI fishermen's cooperative
Capacity 1,000kWx1
Maker MitsubishiHeavyIndustries Japan
Model MHI-1000A

SiteName CHOSHI-SHIOSAI WindPowerStation
Developer M-Winds
Investor MEIDENSHA Corporation
Capacity 1,500kWx2
Maker Repower Germany
Size tower 65m rotor 70mφ
Established 2003.12.

SiteName CHOSHI-OBAMA WindPowerStation
Developer CHOSHI-BYOBUGAURA WindPowerDevelopment
Investor Japan Wind Development Co.,LTD
Capacity 1,500kWx1
Maker TACKE (GE_Wind_Energy) Germany
Size tower 65m rotor 70.5mφ
Established 2003.11.

SiteName CHOSHI-BYOBUGAURA WindPowerStation
PetName CHOSHI-CHAN
Developer CHOSHI-BYOBUGAURA WindPowerDevelopment
Investor Japan Wind Development Co.,LTD
Capacity 1,500kWx1
Maker TACKE (GE_Wind_Energy) Germany

SiteName CHOSHI WindPowerStation
Developer CHOSHI WindPowerDevelopment
Investor Japan Wind Development Co.,LTD
Capacity 1,500kWx9
Maker TACKE (GE_Wind_Energy) Germany
Size tower 65m rotor 70.5mφ
Established 2004.11.
NacelleMark CWD

Developer NEDO
Investor Japan Wind Development Co.,LTD
Capacity 2,400kWx1
Maker MitsubishiHeavyIndustries Japan
Size tower 80m rotor 92mφ
Established 2013.4.
NacelleMark NEDO

SiteName DAIMACHI Natural Environment Energy Labolatory
Capacity 640kWx1
Maker Ecotechnia Spain
Size tower 45m rotor 44mφ
Established 2006.4.
NacelleMark Ecotechnia

附件 四

福島前進(Fukushima FORWARD)簡介資料

Fukushima Floating Offshore Wind Farm Demonstration Project
(Fukushima FORWARD)

Fukushima Offshore Wind Consortium

Fukushima FORWARD

Fukushima Floating Offshore Wind Farm Demonstration Project

Fukushima offshore wind consortium, which consists of Marubeni Corporation (Project integrator), the University of Tokyo(Technical advisor), Mitsubishi Corporation, Mitsubishi Heavy Industries, Japan Marine United Corporation, Mitsui Engineering & Shipbuilding, Nippon Steel & Sumitomo Metal Corporation, Ltd., Hitachi Ltd., Furukawa Electric Co., Ltd., Shimizu Corporation and Mizuho information & Research, is proceeding with Fukushima floating offshore wind farm demonstration project (Fukushima FORWARD) funded by the Ministry of Economy, Trade and Industry.

In this project, three floating wind turbines and one floating power sub-station will be installed off the coast of Fukushima. The first phase of the project consists of one 2MW floating wind turbine, the world first 25MVA floating substation and undersea cable, and will be completed in 2013. In the second phase two world largest 7MW wind turbines will be installed before 2015.

This project will establish the business-model of the floating wind farm and contribute to future commercial projects. The consortium members are also expected to learn know-how of floating offshore wind farm, which will be one of the major export industries in Japan.

The Fukushima FORWARD project believes to help Fukushima to become the center of new industry which will create new employment in this region to recover from the damage of the Great East Japan Earthquake in 2011.

Field view of FORWARD

Scope of FORWARD

Phase Ⅰ (2011～2013)		Phase Ⅱ (2014～2015)	
Floating Substation	Compact Semi-Sub (2MW)	Advanced Spar (7MW)	V-shape Semi-Sub (7MW)
			

Three key factors for success

Technical Challenge ／ Social Acceptance ／ Recovery of Fukushima

Design ／Test ／ Optimization

Cost efficiency ／ Standardization ／ Industrialization

Vision of Fukushima Floating Offshore Wind Farm

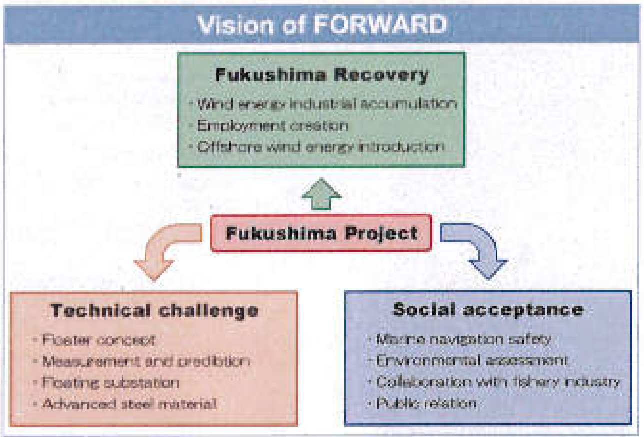
Two decades have passed since the first bottom-mounted offshore wind turbine was installed in Europe and many large scale commercial projects are in operation now. On the other hand, a few floating offshore wind turbine(FOWT) has been installed as a pilot project in Norway and Portugal. Several technical questions such as floater optimization and transmission system need to be solved for future large scale projects.

A V-Shape semi-sub floater with the world largest 7MW turbine, the world first 25MVA floating substation and the 66kV undersea cable will be implemented in Fukushima project and the economical feasibility will be studied.

A metocean measurement system considering the floater motion compensation will be developed in order to evaluate the performance and the motion of FOWT. Furthermore, the characteristics of each floater and the wind turbine, and the effect of control system on floater motion will be investigated.

In addition, the advanced steel material against corrosion and fatigue and construction technology under severe weather condition will be developed.

The project will not only focus on technical challenges but also on collaboration with fishery industry, marine navigation safety and environmental assessment, which are needed for the future large offshore floating wind farm. Public relations work will be carried out so that the status and results of this project will be open to public.



FORWARD member and Main role

FORWARD member	Main role
Marubeni Corporation [Project integrator]	Feasibility study, Approval and licensing, O & M, Collaboration with fishery industry
The University of Tokyo [Technical adviser]	Metocean measurement and prediction Technology, Marine navigation safety, Public relation
Mitsubishi Corporation	Coordination for grid integration, Environmental impact assessment
Mitsubishi Heavy industries, Ltd.	V-shape semi-sub(7MW)
Japan Marine United Corporation	Advanced Spar, Floating Substation
Mitsui Engineering & Shipbuilding Co., Ltd.	Compact Semi-sub(2MW)
Nippon Steel & Sumitomo Metal	Advanced steel material
Hitachi Ltd.	Floating Substation
Furukawa Electric Co., Ltd.	Large capacity undersea cable
Shimizu Corporation	Pre-survey of ocean area, Construction technology
Mizuho Information & Research institute, Inc	Documentation, Committee Operation

Metocean Measurement and Floater Motion Prediction

A metocean measurement system is developed by considering the floater motion compensation. Wind speed profile and wind direction are measured by anemometers on a met mast and a lider on the floater and are compared each othes. The motion of the floater is measured by using gyro, compass, accelerometer and GPS, and used for the motion compensation.

Also, in this project a dynamic analysis model of FOWT is developed. The model is improved by comparing the model results with water tank test and measurement data at the site.

1 Metocean and floater motion measurement

Items	Scopes
Metocean measurement	· Development of a metocean measurement system considering the floater motion compensation.
Floater motion measurement	· Development of accurate floater motion measurement system by combining gyro, compass, accelerometer and GPS.

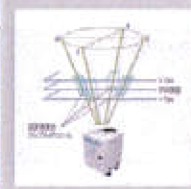
Measurement system on the floating substation


Advanced spar

●Measurement system

meteorology	cup anemometer, wind vane, thermometer, barometer, lider
oceanography	wave buoy, ADCP
motion	accelerometer, GPS, gyro, compass

●Lider

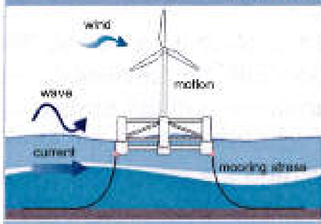


- Able to measure wind speed up to 200m above sea level.
- Ceonveenient and economical than conventional tower measurement.

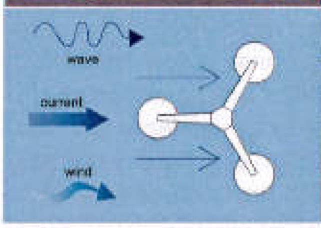
2 Prediction of floater motion

Items	Scopes
Dynamic analysis model	· Development of a coupled analysis model of wind turbine, floater and mooring. · Development of the wind turbine control model which takes the floater motion into account.
Refinement of the model	· Improvement of the analysis model by comparing with water tank test and on site measurements.

Water tank test



case	current	wave	wind
1	○		
2		○	
3	○	○	○




Water tank test

Floating Wind Turbine Technology

In the first phase of this project, minimization of floater motion, safety and power generation efficiency are attempted by using a compact semi-submersible floater with 2MW downwind wind turbine.

In the second phase, optimization and verification of the design is attempted by using V-Shape semi-submersible floater with the world largest 7MW wind turbine. These studies will establish technologies for a future large scale offshore floating wind farm.

1 Compact semi-sub floater with 2MW down wind turbine

Items	Scopes
Turbine	· Verification of 2MW down wind turbine.
Floating	· Development of compact semi-sub floater. · Minimization of floater motion and optimization of power generation by turbine control. · Minimization of floater motion by optimization of ballast.
Mooring	· 6 pieces catenary.

- Rotor diameter 80m
- Hub height 65m (ASL)
- Height of the floater 32m

2 V-Shape semi-sub floater with 7MW turbine

Items	Scopes
Turbine	· Verification of 7MW hydraulic turbine.
Floating	· Development of V-shape semi-sub floating. · Development of the reduction of floating motion by turbine control and O&M program.
Mooring	· 8 pieces catenary.

- Rotor diameter 164m
- Hub height 105m (ASL)
- Height of the floater 32m

Floating Grid Integration System

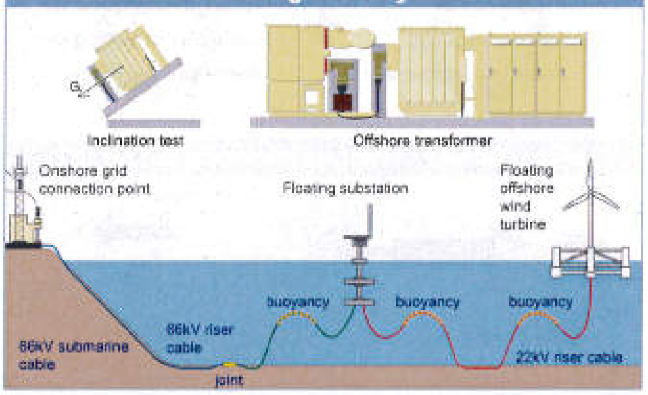
An offshore floating transformer system which is both durable and unsusceptible to motion is developed by evaluating its performance against vibration and inclination through the shaking table tests.

Furthermore, a large capacity water proof riser cable superior to fatigue is developed and optimized by motion analysis. The goal of these studies is to establish the world first floating offshore transformer system against severe metocean conditions.

1 Transmission system for floating offshore wind farm

Items	Scopes
Design and test	· Establishment of design criteria under motion. · Vibration test, inclination test.
Verification of GIS	· Comparison of two type. (GIS and Vacuum circuit breaker)
O & M	· Periodical cut on & off of equipment and continuous observation.

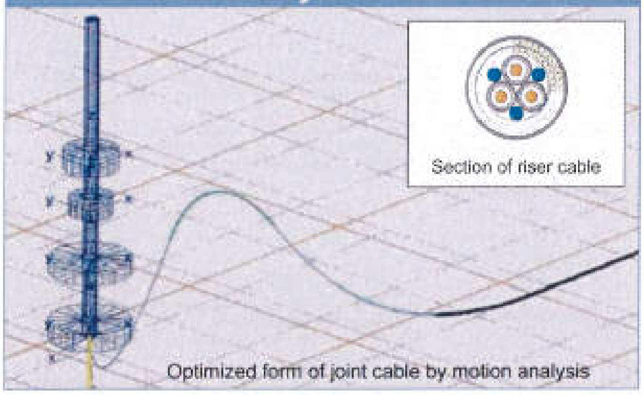
Grid integration system



2 Riser cable, cable joint and motion analysis

Items	Scopes
Riser cable	· Development of water proof cable superior to fatigue under high voltage(22/66kv) condition. · Design and optimization of dynamic cable by cable motion analysis.
Joint device for riser cable	· Development of joint device between different materials and development of anchor device. · Design of sub system (intermediate buoy, terminal reinforcement) by motion analysis.

Behavior analysis of riser cable



Pre-survey and Construction Technology for Floating Offshore Wind Farm

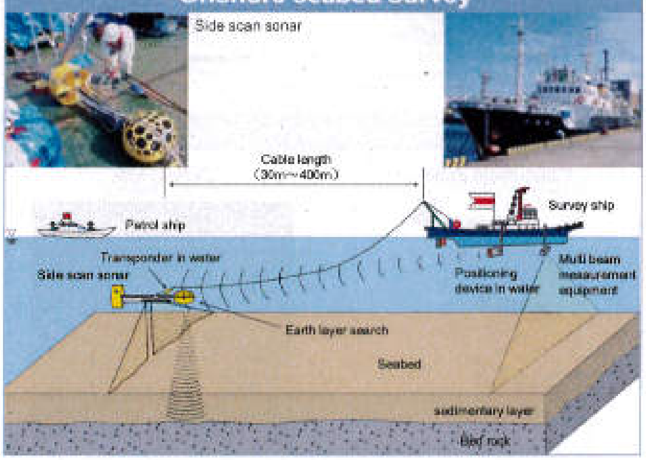
Optimal construction method which can be conducted under severe weather and minimize the impact on fishery environment is developed based on preliminary survey and estimation of meteocean condition.

Furthermore, optimal construction method for windfarm which consists of multiple floating wind turbines will be established.

1 Pre-survey and environmental evaluation

Items	Scopes	
Marine survey	Nearshore area	· Sounding survey. · Diving survey.
	Offshore area	· Sounding, seabed surface, core sampling.
Environmental condition for construction	· Estimation of wind velocity and wave height.	

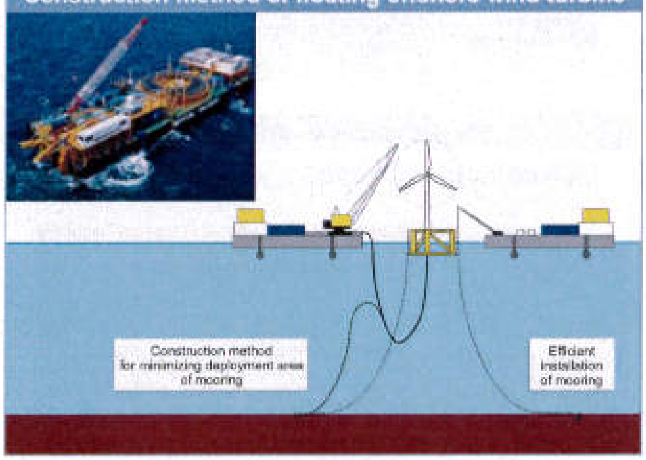
Offshore seabed survey



2 Development of construction technology

Items	Scopes
Construction technology for offshore floating wind turbine	· Optimization of construction method, workfleet and construction equipment. · Development of construction method minimizing deployment area of mooring for large scale of floating offshore wind farm.

Construction method of floating offshore wind turbine



Advanced Steel Material

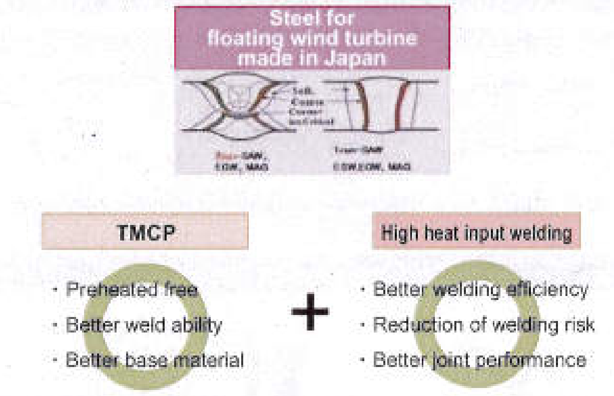
The TMCP and UIT developed in Japan are applied into steel material for the world first FOWT and the welding efficiency, corrosion resistance and fatigue for the long operation under the severe metocean condition are verified.

These studies will achieve shortening of the construction time and reduction of the construction cost.

1 Advanced steel material for floating offshore wind turbine

Items	Scopes
High tension steel for offshore wind turbine	· Application of TMCP to floating offshore wind turbine steel material and clarification of improvement of welding efficiency. TMCP（Thermo-mechanical Control Process） High heat input welding to be utilized for high tension steel among ship building and construction field and featured to be as high efficiency welding and easy construction control.
Fatigue solution	· Application of UIT technology into ultrasonic blow wave treatment and clarification. UIT（Ultrasonic Impact Treatment）: Promising technology which improve dramatically fatigue feature of welding joint.
Catenary chain	· Development of steel material for catenary superior to durability and corrosion.

Advanced steel material for tower, floater and catenary



Improvement of fatigue performance by UIT


Improvement of fatigue feature by UIT (cross welding connection)

Marine Navigation Safety

For floating offshore wind turbines, collisions between ships or collisions between ships and turbines might occur. Development of a collision risk model is carried out and the quantitative collision risk is assessed. Actual traffic data in the coast area along Fukushima are collected. The collision risk assessment makes it possible to take appropriate safety measures.

If mooring is failed by severe storms or accidents, drifting floaters may collide with other wind turbines and ships. A simulation method based on actual response of floating turbines is developed and the consequences of drifting of floating turbines is confirmed.

1 Assessment of collision risk

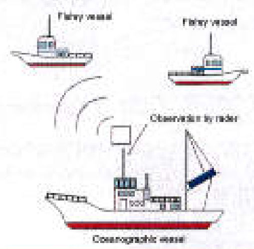
Items	Scopes
Collision risk analysis and risk control option	· Quantitative risk analysis for collision based on risk model and traffic data · Adoption of appropriate risk controloption (safety measures)
Collection of traffic data in the coast area	· Analysis of oceangoing vessels' traffic by AIS data. (past and daily data) · Observation for domestic and fishing vessels' traffic by Rader.

Observation of navigation

Oceangoing vessels' traffic


View of recorded data by Automatic identification system

Domestic and fishing wessels' traffic

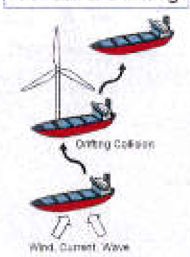


2 Assessment of drifting risk

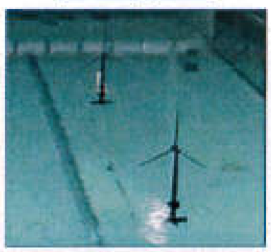
Items	Scopes
Response of moored floating offshore wind turbine	· Development of analysis method of low frequency, wave frequency and high frequency motion of moored floating offshore wind turbine.
Analysis method of drifting risk of floating wind turbine	· Development of a simulator for risk analysis of drifting floating offshore wind turbines considering coupled response of a floater, a wind turbine and a mooring system.

Safety verification by drifting risk

Concurrent drifting



Drifting test



Environmental Impact Assessment

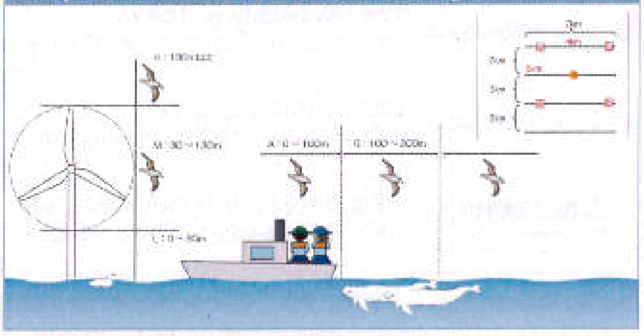
The environmental impact assessment is implemented around the sea where FOWT and seabed cable are installed.

The habits for seabirds, marine mammal and fish in addition to noise, scenery and radio disturbance will be surveyed and the environmental impact from the installation of the turbine and seabed cable will be clarified.

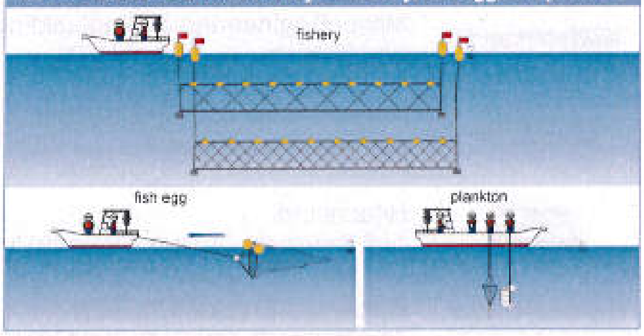
1 Survey area and item

Items	Detail (in habiting situation)	Survey area	
		turbine	cable
Bird	· Feedings, migrant of bird	●	
Marine mamma	· Whale, Dolphine	●	
Underwater sound	· Background noise and horizontal component in normal condition water	●	
Fish	· Fish, prawn/crab, squid octopus	●	●
Fish egg larval	· Fish, egg, young fish	●	●
Plankton	· Zooplankton & phytoplankton	●	●
Intertidal organism	· Attached organism and benthic living from seashore to 3m deep water.		●
Marine plant	· Brown algae such as sea grape and Ecklonia stolonifera.		●
Macrobentos	· Benthic activity such as bivalve, univalveshee and shell fish.		●
Attached Organism Megabenth	· Benthic activity such as sea chestnut, sea cucumber and sand star.		●
Others	· Sediment made of seawater, earth and sand.		●

Survey for seabird and marine mammal around the floating offshore wind turbine



Around the seabed cable survey for fishery, fish egg, and plankton



Collaboration with Fishery Industry

A committee formed by the government, Fukushima prefecture, local public entity and fishermen's union is organized. The impact on the sea and fishery operation around the project after installation of FOWT and a new fishing method are investigated working together with the special consultant of fishery industry.

After that, a proposal for fish gathering effect by marine farm, marine fertilization and culture raft and providing sea information will be discussed.

1 Proposal for new fishing method

Items	Scopes
Marine farm	· Construction of new fishery farm by automatic feeder, sound and fishing bank using floater and mooring
Marine fertilization and culture raft	· Cultivation of shellfish and seaweed by marine fertilization through water pumping of deep sea by density diffusion equipment and marine fertilizer
Fish gathering effect	· Observation of fish gathering around floater by ROV
Sea information	· Providing of real time sea information through observation equipment on floater to fisherman and disaster control center

Marine farm

Marine fertilization

Fukushima Offshore Wind Consortium

Marubeni Corporation
1-4-2 Otemachi, Chiyada-ku, Tokyo 100-8088

The University of Tokyo
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656

Mitsubishi Corporation
2-3-1 Marunouchi, Chiyoda-ku, Tokyo 100-8086

Mitsubishi Heavy industries, Ltd.
2-16-5 Konan, Minato-ku, Tokyo 108-8215

Japan Marine United Corporation
5-36-7 Shiba, Minato-ku, Tokyo 108-0014

Mitsui Engineering & Shipbuilding Co., Ltd.
5-6-4 Tsukiji Chuo-ku, Tokyo 104-8439

Nippon Steel & Sumitomo Metal
2-6-1 Marunouchi, Chiyoda-ku,Tokyp 100-8071

Hitachi Ltd.
1-6-6 Marunouchi, Chiyoda-ku, Tokyo 100-8280

Furukawa Electric Co., Ltd.
2-2-3 Marunouchi, Chiyoda-ku, Tokyo 100-8322

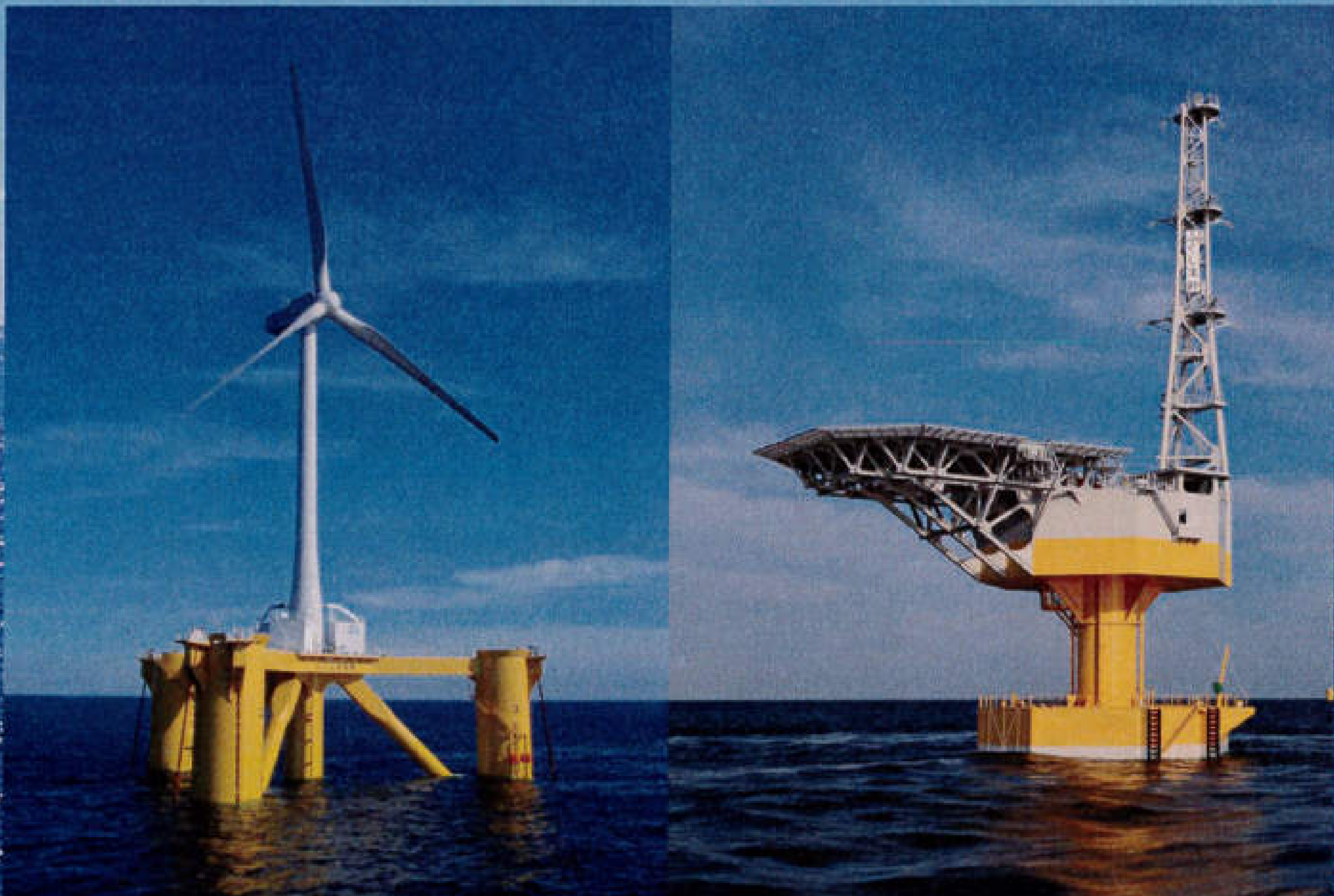
Shimizu Corporation
2-16-1 Kyobashi, Chuo-ku, Tokyo 104-8370

Mizuho Information & Research institute, Inc
2-3 Kandanishikicho, Chiyoda-ku, Tokyo 101-8443

Contacts:
The University of Tokyo
Department of Civil Engineering
School of Engineering
Prof. Dr. Takeshi Ishihara
Manager Shigeru Taki
2-11-16 Yayoi Bunkyo Tokyo 113-8656 Japan
Tel +81-3-5841-6145 fax +81-3-5841-0609

Fukushima Floating Offshore Wind Farm Demonstration Project
(Fukushima FORWARD)

- Construction of Phase I -



Fukushima Offshore Wind Consortium

Fukushima FORWARD

2MW Downwind-type Floating Wind Turbine "Fukushima Mirai"

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66kV Floating Substation "Fukushima Kizuna"

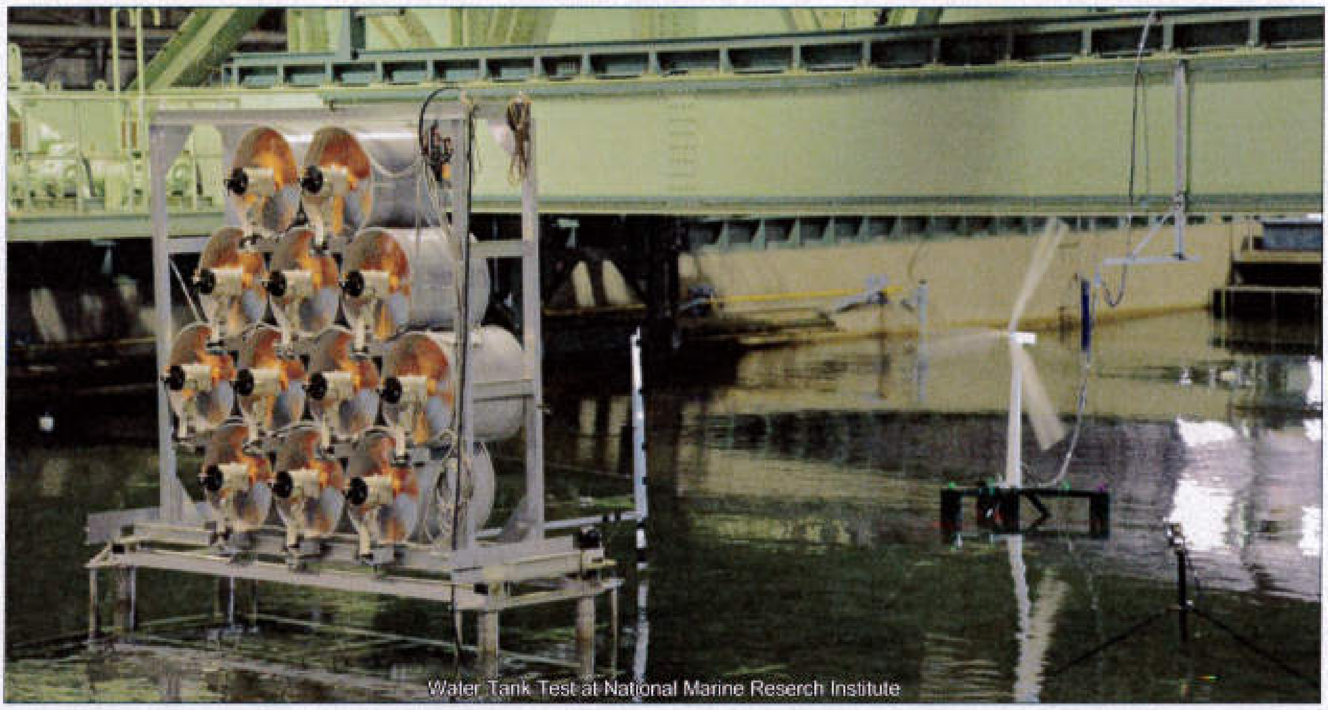
turbines will be installed before 2015.

This project will establish the business-model of the floating wind farm and contribute to future commercial projects. The consortium members are also expected to learn know-how of floating offshore wind farm, which will be one of the major export industries in Japan.

The Fukushima FORWARD project believes to help Fukushima to become the center of new industry which will create new employment in this region to recover from the damage of the Great East Japan Earthquake in 2011.

Water tank test

By using a scaled model of 2MW compact semi-submersible floater, water tank test was carried to clarify the response of the floater under design wind, wave and current conditions on April, 2013. The optimum control method during power production for floating wind turbine was also investigated. A dynamic analysis model of FOWT is validated by comparing with the water tank test and onsite mesurement data.



Water Tank Test at National Marine Reserch Institute

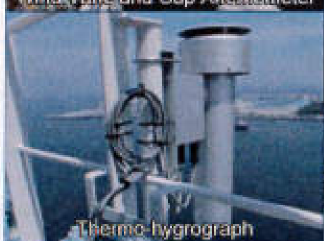
Metocean measurements

The floating substation is equipped with met-ocean measurement devices. Wind velocities are measured by using cup anemometers, wind vanes and sonic anemometers on the met mast, and the doppler lidar on the main deck. The wave and current are measured by using the wave meter and ADCP on the middle hull. The floater motion is also measured with accelerometers, GPS and gyros on the main deck, and a floater motion compensation algorithm is also developed.

Met-mast on the Substation

Wind Vane and Cup Anemometer

Meteorological Observation Instrument



Thermo-hygrograph

Doppler Lidar

Current meter

Wave Meter

Compact semi-sub floater for 2MW downwind turbine

The construction of compact semi-sub floater for 2MW downwind turbine was completed in May 2013. This floater consists of one center column, three side columns, three braces, the main deck beams and the pontoon beams which support the wind turbine. The compact semi-sub floater has advantages for construction and installation due to its shallow drought. The drought of the floater can be controlled by using the ballast tank located at the bottom of the side columns.


Full View of Compact Semi-sub

Deck Beams


Footing Ballast and Pontoon Beams

Installation of 2MW downwind turbine

The 2MW downwind offshore wind turbine was installed on the compact semi-sub floater in June, 2013. At first the three sectioned 48.5m tower and the nacelle were assembled and then 39m blades were installed. After receipt of commissioning test at Onahama, the 2MW downwind offshore wind turbine on the semi-sub floater was towed to the site and began to generate power in November.


Lifting of Blade


Installation of Blade


Installation of Tower


Installation of Nacel

Advanced spar floater for substation

The construction of the floating substations on the advanced spar floater was completed in June, 2013. On the main deck of the upper hull, a met mast and heliport are installed. Inside the upper hull, the world first floating substation is equipped. The bottom hull is filled with concrete to lower the center of gravity, which enabled the construction and towing in vertical position. The floater motion by waves is reduced by the unique hull shape with cob, middle hull and lower hull.


Upper Part of Substation
(Upper Hull, Cob, Midle Hull)


Heliport

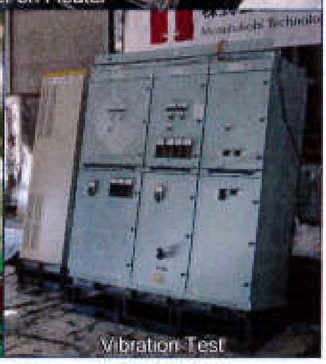

Roof of Transformer Station and Foundation of Tower

Floating grid integration system

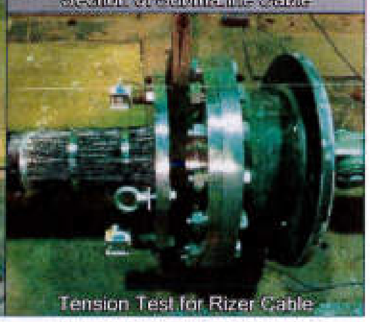
An offshore floating transformer system which is both durable and unsusceptible to floater motion is developed and the performance against vibration and inclination was evaluated through shaking table tests. Furthermore, a large capacity water proof riser cable superior to fatigue is developed and optimized by motion analysis. Based on these technology, the world first floating offshore transformer system was established against severe metocean conditions.


Transformer on Floater


Inclination Test


Vibration Test


Section of Submarine Cable


Tension Test for Rizer Cable

Installation of the compact semi-sub and advanced spar

The compact semi-sub floater with 2MW downwind turbine left Chiba dock of Mitsui Engineering & Shipbuidling on 27th of June, 2013. After testing at Onahama Port, it was towed to the site and installed. On 11th of June, 2013, the advanced spar floater for floating substation left Isogo dock of JMU and towed to the installation site directly. From the 16th of June, 2013, the anchoring for the substation began and finished in October.

Towing of Compact Semi-sub

Leaving Dock of Compact Semi-sub

Towing of Substation

Installation of anchor, chain and submarine cable

In May, 2013, the anchor and mooring chain for both compact semi-sub and substation floaters were installed. In June, at the coast of Hirono, where onshore substation is located, the installation of the submarine cable began by the cable layer ship. The grid connection of the floating offshore wind turbine and substation was completed on 31st of October.

Installation of Mooring Chain

Anchor on the Deck

Submarine Cable on the Cable Layer Ship

Installation of Submarine Cable

Fukushima Offshore Wind Consortium

Marubeni Corporation
1-4-2 Otemachi, Chiyada-ku, Tokyo 100-8088

The University of Tokyo
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656

Mitsubishi Corporation
2-3-1 Marunouchi, Chiyoda-ku, Tokyo 100-8086

Mitsubishi Heavy Industries, Ltd.
2-16-5 Konan, Minato-ku, Tokyo 108-8215

Japan Marine United Corporation
5-36-7 Shiba, Minato-ku, Tokyo 108-0014

Mitsui Engineering & Shipbuilding Co., Ltd.
5-6-4 Tsukiji Chuo-ku, Tokyo 104-8439

Nippon Steel & Sumitomo Metal Corporation
2-6-1 Marunouchi, Chiyoda-ku,Tokyo 100-8071

Hitachi, Ltd.
1-6-6 Marunouchi, Chiyoda-ku, Tokyo 100-8280

Furukawa Electric Co., Ltd.
2-2-3 Marunouchi, Chiyoda-ku, Tokyo 100-8322

Shimizu Corporation
2-16-1 Kyobashi, Chuo-ku, Tokyo 104-8370

Mizuho Information & Research institute, Inc.
2-3 Kandanishikicho, Chiyoda-ku, Tokyo 101-8443

Contacts:
The University of Tokyo
Department of Civil Engineering
School of Engineering
Prof. Dr. Takeshi Ishihara
Manager Shigeru Taki
2-11-16 Yayoi Bunkyo Tokyo 113-8656 Japan
Tel +81-3-5841-6145 fax +81-3-5841-0609

Fukushima Floating Offshore Wind Farm Demonstration Project (Fukushima FORWARD)

- Construction of Phase II -

Fukushima Offshore Wind Consortium

Fukushima FORWARD

http://www.fukushima-forward.jp

7MW floating wind turbine Fukushima Shimpuu

Fukushima offshore wind consortium is proceeding with Fukushima floating offshore wind farm demonstration project (Fukushima FORWARD) funded by the Ministry of Economy, Trade and Industry.

In this project, three floating wind turbines and one floating power sub-station have been installed off the coast of Fukushima. The first phase of the project consists of one 2MW floating wind turbine, the world first 25MVA floating substation and submarine cable, and had been completed in 2013. In the second phase the installation of 7MW floating wind turbine Fukushima Shimpuu was completed in

rotor diameter : 167m, hub height : 105m,the height of the top blade : 189m
depth : 32m, draft : 17m, length : 85m, width : 150m
no. of mooring chain : 8, chain diameter : 132mm

5MW floating wind turbine Fukushima Hamakaze

June of 2015 and 5MW floating wind turbine Fukushima Hamakaze will be installed in the summer of 2016.

This project will establish the business-model of the floating wind farm and contribute to future commercial projects. The consortium members are also expected to learn know-how of floating offshore wind farm, which will be one of the major export industries in Japan.

The Fukushima FORWARD project believes to help Fukushima to become the center of new industry which will create new employment in this region to recover from the damage of the Great East Japan Earthquake in 2011.

rotor diameter : 126m, hub height : 86m, the height of the top blade : 150m
depth : 48m,draft : 33m, length : 59m, width : 51m
no. of mooring chain : 6, chain diameter : 132mm

Installation of 7MW wind turbine on Fukushima Shimpuu

The nacelle of 7MW wind turbine by Mitsubishi Heavy Industries, Ltd was fabricated at Yokohama Dockyard & Machinery Works, the tower was manufactured at Kobe Shipyard & Machinery Works, and the blades over 80m were manufactured in Germany. All the above components were installed on the floater at Onahama port in Fukushima prefecture. The world's largest 7MW wind turbine installation was completed at the beginning of June, using one of the gigantic cranes which were only a few in the world. The height of the top blade is about 200m above the sea level.

Completion of installation of 7MW wind turbine on the floater

Blade

Installation of blade by special equipment

Nacelle

Construction of 5MW wind turbine and the floater for Fukushima Hamakaze

5MW down-wind turbine manufactured by Hitachi Ltd is now under construction and will be installed on Fukushima Hamakaze, which will be the second floating wind turbine facility in the second phase. Advanced spar floater for Fukushima Hamakaze is also under construction at Sakai Works of an affiliated company of JMU. The floater with 51m width and 33m draft is optimized for the construction and transport.

Upper hull under building

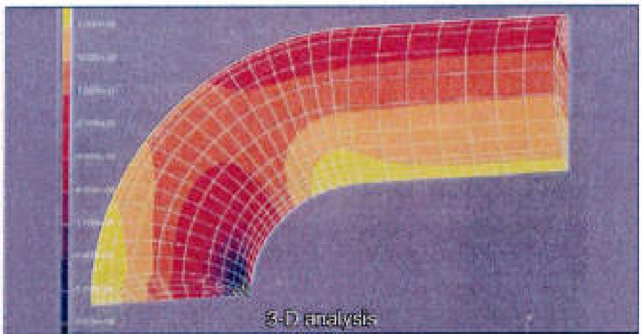
Floater under building

5MW down-wind turbine (the same type)

Mooring chain development

All mooring chain used for the four floaters, the material of which is made by Nippon Steel & Sumitomo Metal, are produced at Hamanaka factory. This material with lots of world track record is applicable to severe metocean condition in Japan and improves abrasion and fatigue resistances. By 3-D analysis and fatigue testing in the sea water, safety and reliability are validated. A dynamic analysis of the mooring lines by using measured floater motion, the lifetime of the mooring line was evaluated and the development of long life chain are also conducted.


Mooring chain for Fukushima Shimpuu

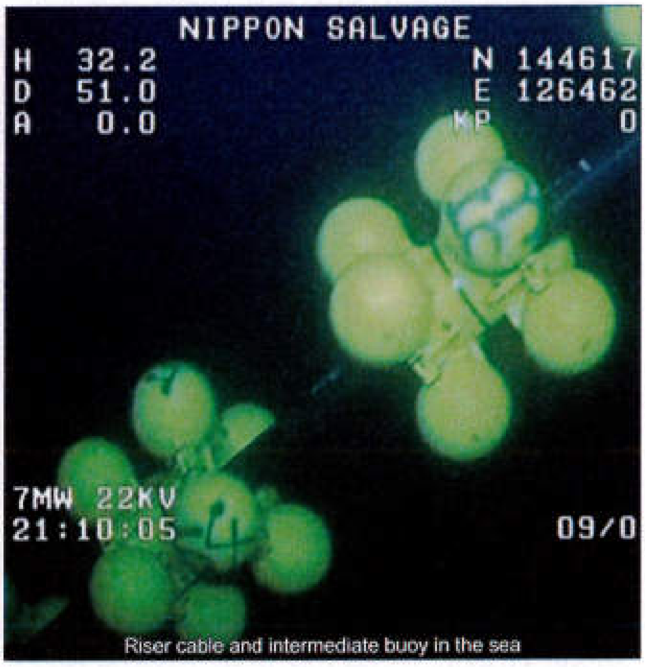

3-D analysis

Fatigue testing in the sea

Riser cable development

The world largest riser cable is used to connect the sub-marine cable and floating substation as well as floating wind turbines. The riser cable needs to be designed against fatigue load and water shielding is required while optimizing it against floater movement and wave effect. To keep the riser cable in planned shape, the intermediate buoy, developed by Furukawa Electric Co., Ltd and local UJK was used from the 2nd phase. Since the commissioning in November, 2013, there has been no major problem on power transmission. The data measured by the censors attached on the riser cable is useful for the estimation of the life time of the cables and the development of O&M method.

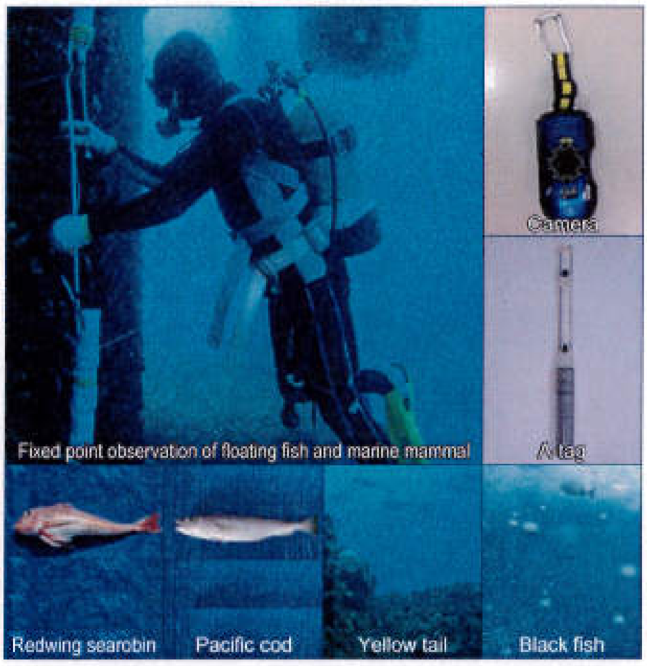

Installation of riser cable for Fukushima Shimpuu



Riser cable and intermediate buoy in the sea

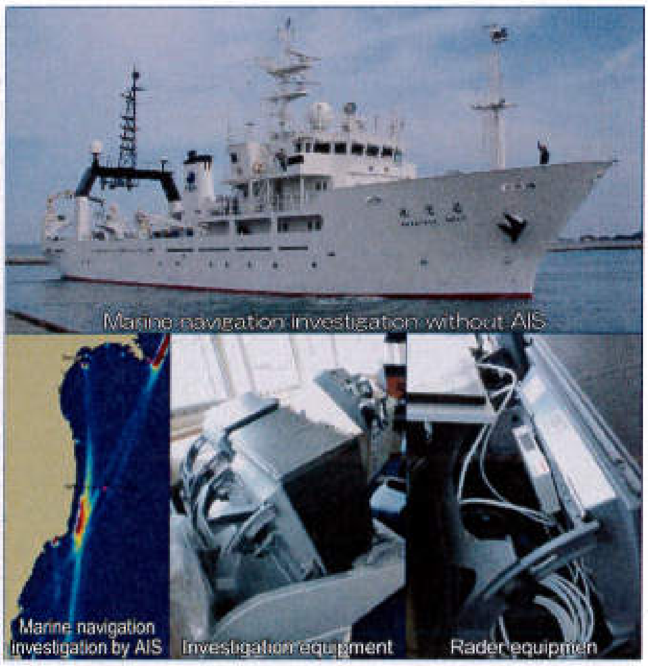
Environmental impact assessment

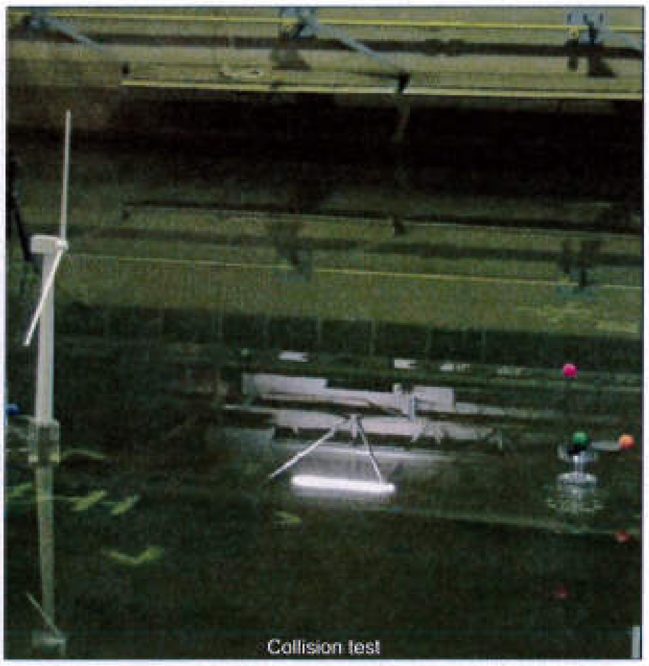
After installation of 2MW wind turbine Fukushima Mirai and world-first floating substation Fukushima Kizuna, environmental impact around the site has been investigated. By visual inspection which is conducted four times a year from ship, albatross and pelagic cormorant are found as valued sea bird species and by sea bed fish inspection redwing searobin and pacific cod are found. By the fixed point observation through the year, pacific white-side dolphin is found as marine mammal and yellow tail and large scale blackfish is found to be more than around adjacent sea.



Marine navigation safety

To assess the risks of collision of ships and moored floating wind turbines, maritime traffic was investigated using AIS and navigation radar at Fukushima site. The collision, initiation of drifting and drifting behavior of ships and wind turbines were investigated in wave basins. Analysis code of Rotor-Floater-Mooring coupled analysis code was improved to investigate the response of mooring line in shallow water. The risk evaluation procedure of the chain drift was developed based on the risk scenario combined with a chain drifting simulation method.





Collaboration with fishery industry

Not only the regular meeting with fisherman, but also the research on fishing environment, fish catch testing, fish research by ROV and provision of marine information data are proceeded. Through these activities, by developing a new fishing method and clarifying the effect of fishing bank and fish gathering, future direction of the collaboration between floating wind turbine and fishery industry was investigated.

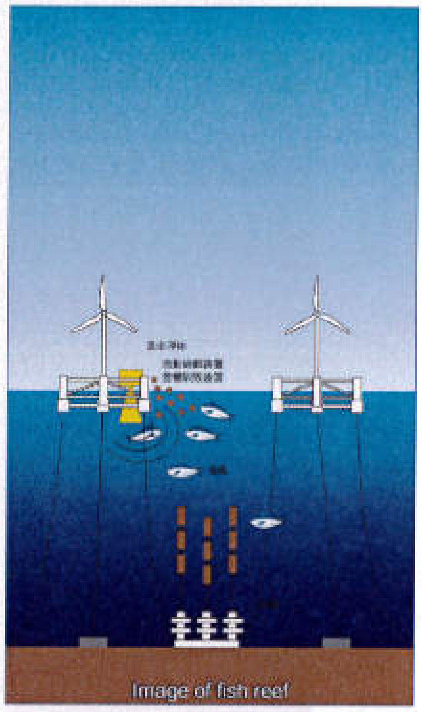


Image of fish reef


Testing by the model of sea bed net

Fish gathering around mooring chain

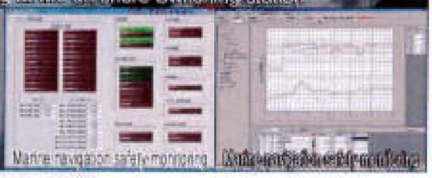
Fish gathering around Substation

Operating and maintenance

2MW wind turbine and world first substation are working well since the commissioning at the end of 2013. At the landing point of sub-marine cable, the onshore switching station is constructed and the four people are always managing the offshore wind turbine facility by remote monitoring. While the normal maintenance work for the power facility is done by boat, emergency response training by helicopter is also implemented to execute necessary behavior in the case of emergency and more effective access method and O&M method are developed.


Monitoring at the on shore Switching station


Monitoring camera


Marine navigation safety monitoring


Emergency response testing by helicopter


Access by boat

Fukushima Offshore Wind Consortium

Marubeni Corporation
1-4-2 Otemachi, Chiyoda-ku, Tokyo 100-8088

The University of Tokyo
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656

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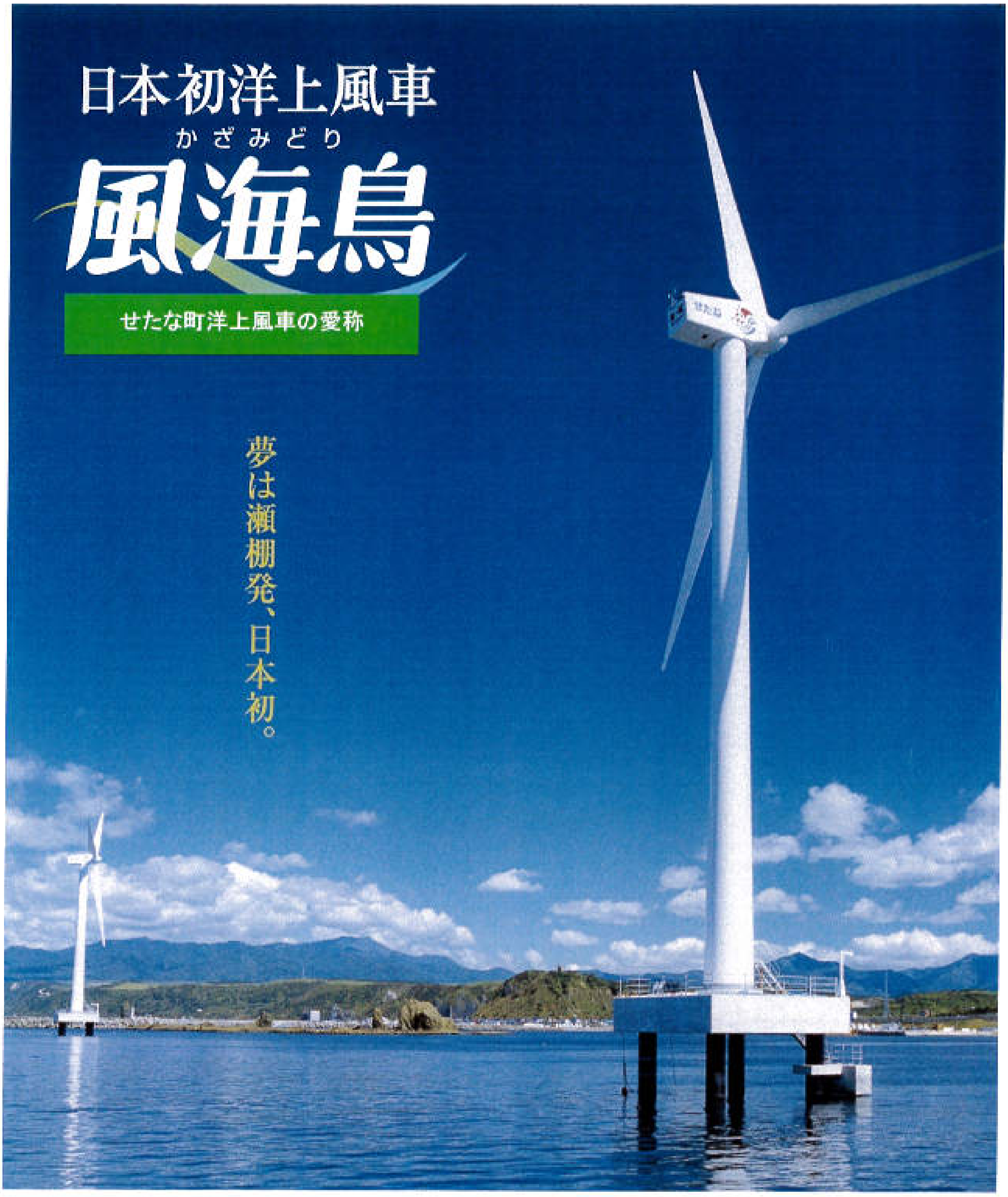
Contacts:
The University of Tokyo
Department of Civil Engineering
School of Engineering
Prof. Dr. Takeshi Ishihara
Manager Shigeru Taki
2-11-16 Yayoi Bunkyo-ku Tokyo 113-8656 Japan
Tel +81-3-5841-6145 fax +81-3-5841-0609

附件 五

瀬棚町產業建設課海上風力發電簡介資料



平成28年6月28日

・せたな町洋上風力発電所の建設経緯及び施設概要

せたな町

1．せたな町洋上風力発電所の建設経緯及び施設概要

●洋上風車建設の経緯

せたな町は平成17年9月1日に北海道南西部の日本海側に位置する3町（旧北檜山町・旧瀬棚町・旧大成町）が合併してできた新しい町です。特徴としては農業と水産業が共存する一次産業が盛んな自然に恵まれた町です。冬は北西の季節風が非常に強く、夏は北海道特有の「やませ」（東風）が強く吹き付ける、風が非常に強い町でもあります。

東日本大震災により電力供給のあり方や原子力発電の安全性について、現在さかんに議論が行われていますが、合併前の旧瀬棚町では、地方港湾「瀬棚港」の有効活用について検討を重ねており、その中で、厳しい自然環境を、むしろ恵まれた特色ある環境として活かそうという考えの下、"港湾の有効活用"と"当地特有の強い風を活かしたクリーンエネルギーの推進"という構想がうまく噛み合い、日本で初めての洋上風車建設をすすめることとなりました。

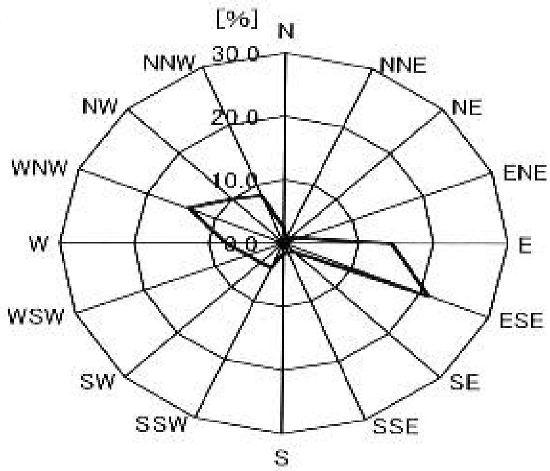
●せたな町の風

建設前に、風車の設置に適した風が吹いているかを確認するため、風況調査が瀬棚港湾内の建設予定地付近の外防波堤上で1年間にわたり(地上高20mと5m)行われ、冬場のオホーツク海からの季節風(西北西風)の並外れた強さに加え、夏場のやませ(東南東風, 噴火湾側からの陸風)も相当な強さで吹いていることが実証されました。風力発電事業が成り立つ数値として、平均風速5.8m/s以上とされておりましたが、1年間の調査結果は20mの高さで7.9m/sと極めて大きく(下図)、せたな町は風力発電に非常に適した環境であることがこの調査でわかりました。

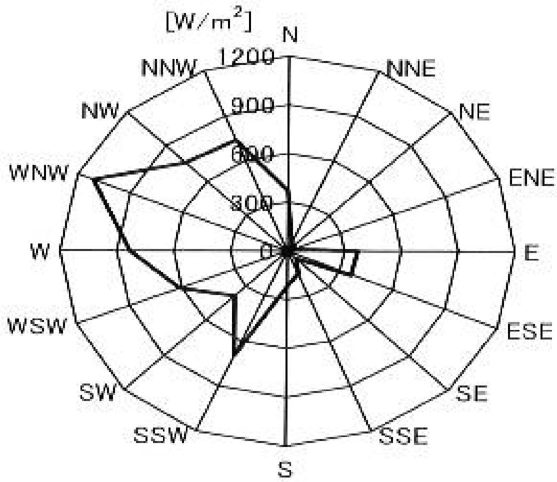
年	1999年（平成11年）					
月	7月	8月	9月	10月	11月	12月
平均風速（m/s）	7.3	5.7	6.4	7.6	8.4	9.7
卓越風向	ESE	ESE	ESE	ESE	WNW	WNW

2000年（平成12年）						年間平均風速	年間卓越風向
1月	2月	3月	4月	5月	6月		
9.0	8.2	9.9	9.1	7.4	6.1	7.9	ESE
E	WNW	WNW	ESE	ESE	NNW		

● 年間風配図
※ＥＳＥ（東南東）とＷＮＷ（西北西）の方向への風が吹く割合が高い。



● 風力エネルギー密度
※冬期間に吹く季節風　ＷＮＷ（西北西）のエネルギー密度が非常に高い。



●建設状況写真

※タワーは韓国で製作、瀬棚港へ陸揚げ

※ナセル(風車頂上の機械室)・ブレード(羽)はデンマークで製作

※風車の据付作業

● せたな町風力発電所の発電状況

地方港湾「瀬棚港」の有効活用と当地特有の強い風を活かしたクリーンエネルギーの推進という二つの構想が噛み合い、日本で初めての洋上風車（上記）がせたな町に建設されました。発電所の運営は町が行っており、発電した電力はすべて北海道電力へ売電し、町の収入となっています。

せたな町には、洋上風力発電所のほかにも、民間の風力発電所が2箇所（下記）あり、これら3つの発電所で作られる1年間の電力量の合計は約4,000万kwhで、これは約9,400世帯の1年分もの電力量になります。また、仮に同じ電力量を火力発電所で発電した場合は28,160t（東京ドーム22.7個分）もの Co2 が排出されるため、Co2の削減にも大きく貢献しています。