International Workshop on Marine Renewable Energy
Monday, 4 August 2014
Organizer: ClassNK
Venue: Kaiun Club, Tokyo, Japan

Outline of Offshore Renewable Energy

Takeshi Kinoshita
President, Ocean Energy Association, Japan (OEAJ)
Professor Emeritus, The University of Tokyo
Professor, Dpt. of Oceanic Architecture & Engineering,
Nihon University

Ocean Energy Association , Japan （OEAJ)

foundation：2008, March

objective：promotion of Ocean Energy in Japan by cooperating universities, Industries and governments （offshore wind, wave, tidal current, OTEC and marine bio）

members：59 companies（Heavy Industry, Venture business, banks, Investment companies, etc.)

196 individuals（university professors, researchers in institute, government officers, citizens, etc.)

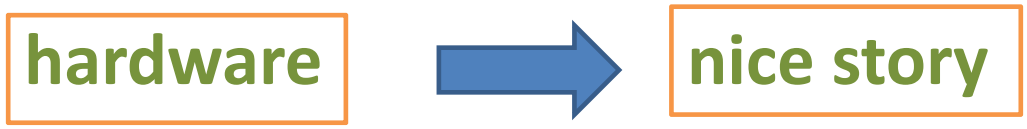
activities： Ocean Energy Forum(every year)

information exchange, international cooperation

propose for promotion of prototype tests

propose for promotion of test sites, etc.

Renewable energy is closely related to Rural vitalization & rebirth of declining town



- Nice stories for each peoples rather than hardware, namely road or building itself
- Design of communication between peoples

to share **CIVIC PRIDE**

- Key words of the stories are safety and environment
- Ocean energy is a very good example!
- Co-work with fishermen is not a headache, but a wonderful opportunity !

Why the renewable energy?

- Global warming
- National security (variety of energy sources)
- Self-supply
- Safe

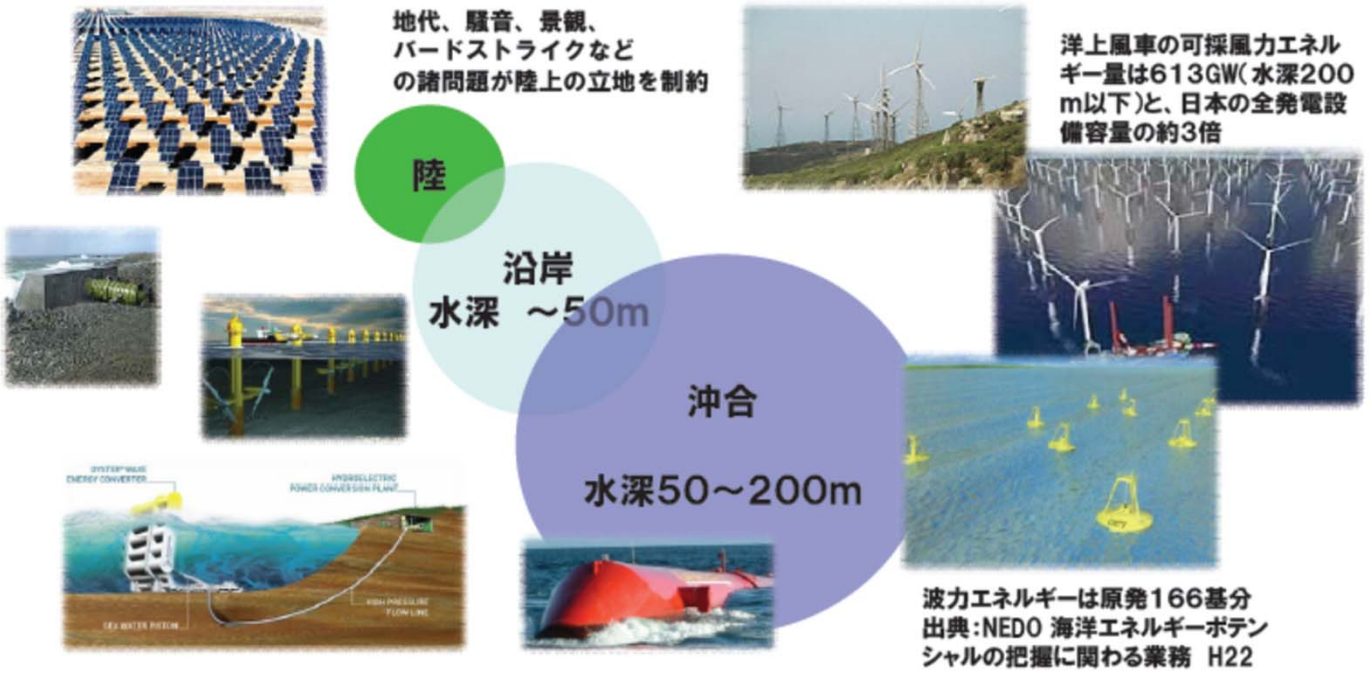
Ocean Energy one of the most possible one of renewable, when we consider 2050!

Renewable energy used to be generated on land,
but will be generated on the deserts and the oceans

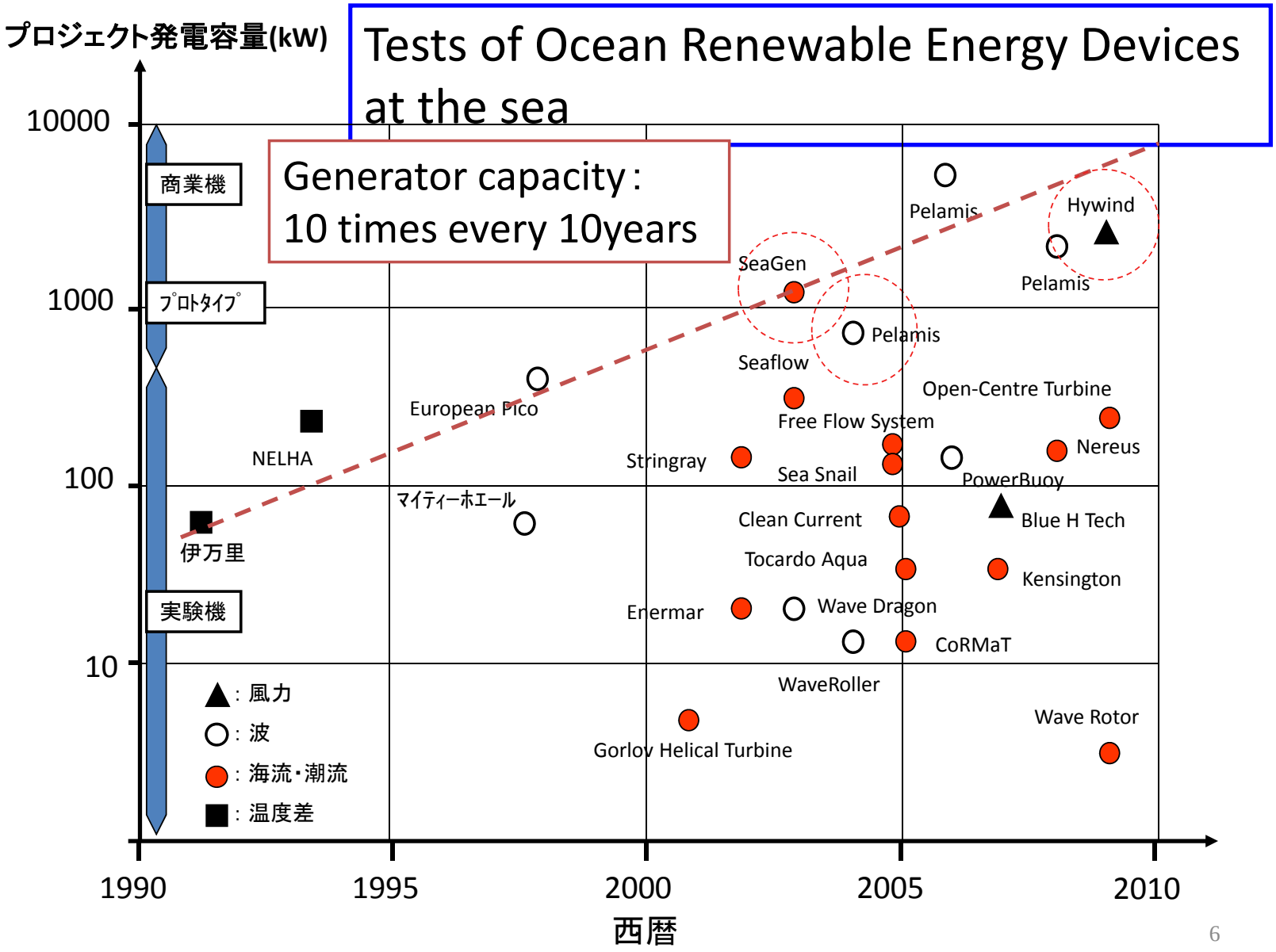
再生可能エネルギーは陸から海へ、沿岸から沖合へ

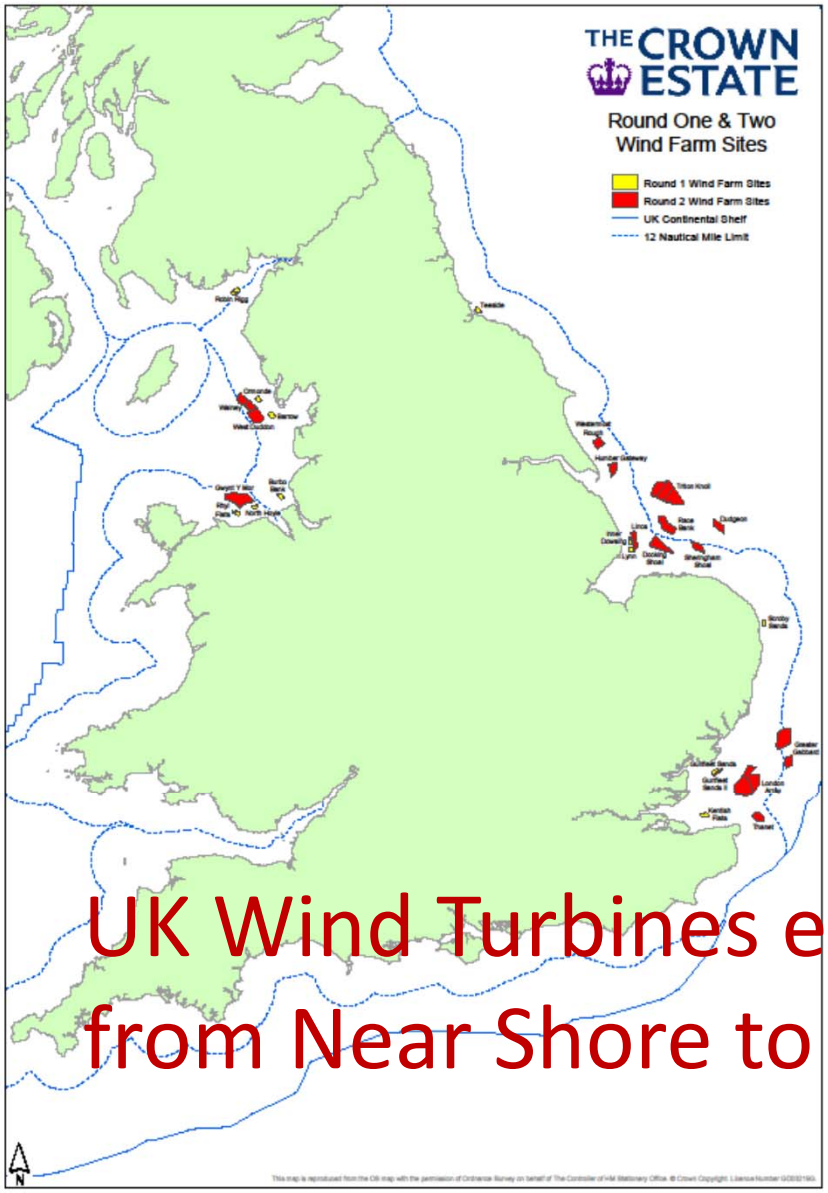
この度の東北地方太平洋沖地震により被災された皆様には心よりお見舞いを申し上げます。皆様の安全と一日も早い復旧を心よりお祈り申し上げます。

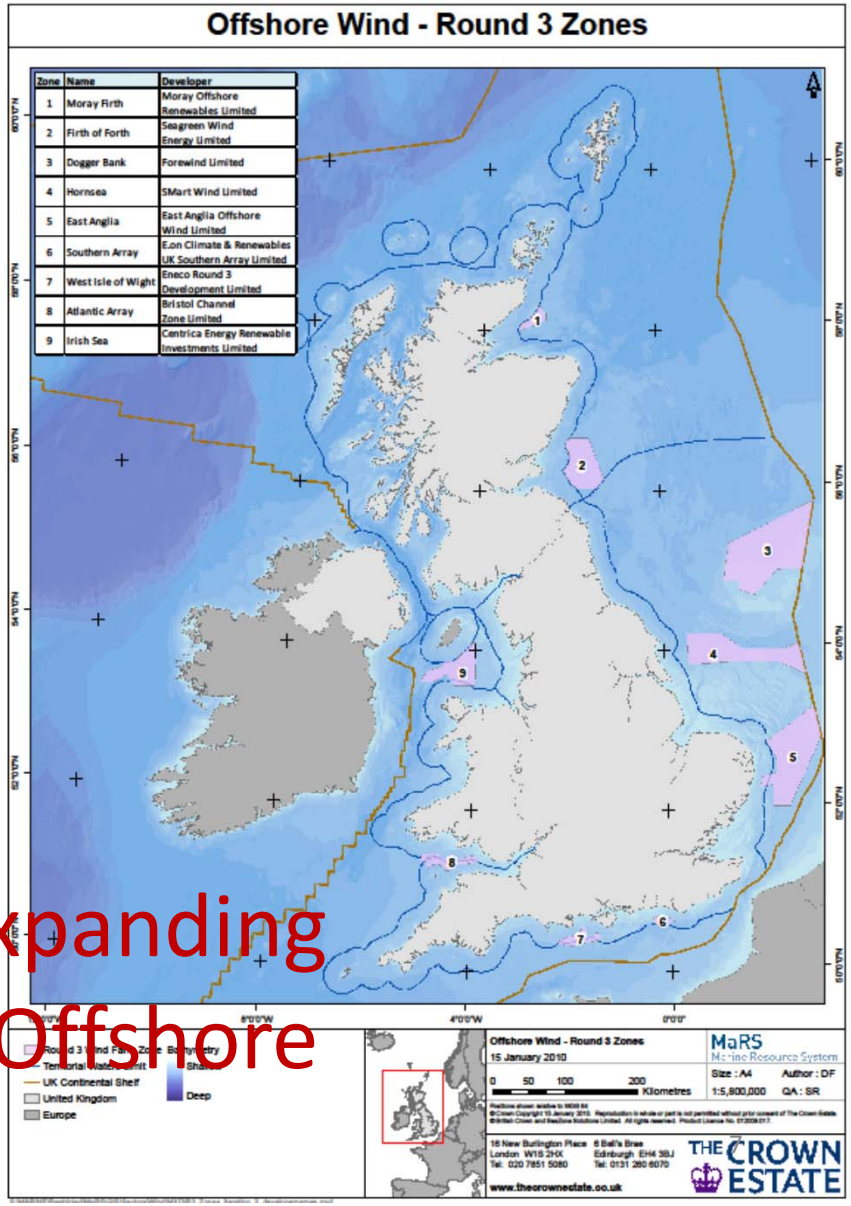
海洋エネルギー資源利用推進機構（OEAJ）は、海洋エネルギーによる東北再生について早くから政府に提言（4月1日、5月27日）、機構内に「海洋エネルギー東北再生協議会」を設置（6月21日）、盛岡でセミナー開催（7月23日予定）など、海洋エネルギーの普及促進を通じて被災地の復興に協力します。



Tests of Ocean Renewable Energy Devices at the sea





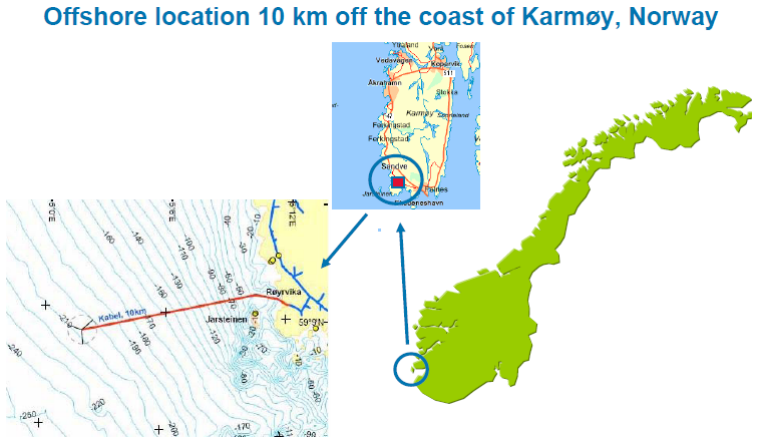


UK Wind Turbines expanding from Near Shore to Offshore

First Floating Wind Turbine of the world

Hywind demonstration
（Norway　StatoilHydro）

2007: planning of 3MW demo. Plant, tank test at Sintef Marintek
2008: design and construction
2009: start of demonstration



Principal particular
turbine：2.3MW
draft：100m
diameter of rotor：82.4m
water depth：120-700m
displacement：5300m³
mooring：3 lines

USA

Projects

（1）Wave Energy

・OPT（Oahu, New Jersey, Oregon）

・Finavera（Oregon, Washington, California）

・OceanLinx（Maui, Lahore）

（2）Tidal Current

・Verdant（East River/NYC, St Laurence River, Baguette Sound）

・OPRC（Marine）

R&D, supports

・OSU Wave Test Site(by Oregon State)

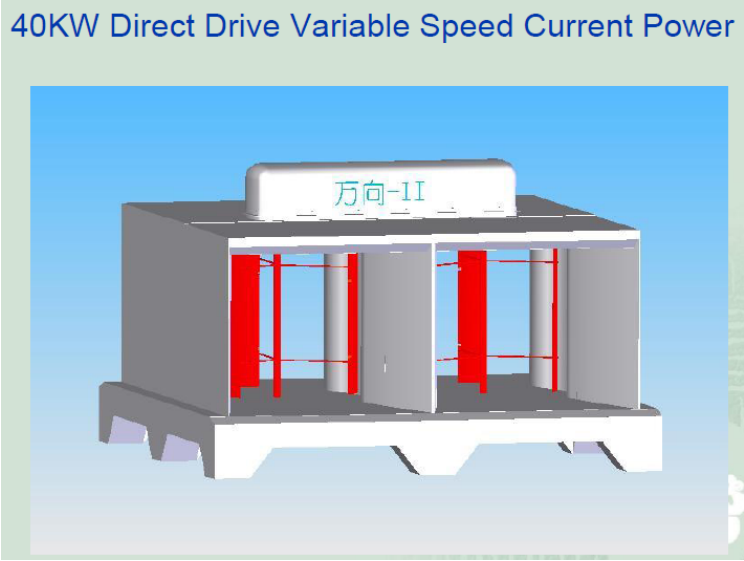
・EIS2007 1000milion$ to Research Institutions like University on Hydraulic R&D

・50% support to Ocean Energy R&D by DOE

China

- Coast line(main land) 18,000km, islands 14,000km
- Wave12,825MW, Tide1,255MW, Tidal Current 13,948MW
- 2x10**12 Yuen until 2020 to total renewable energy

白沙江潮汐発電所(運転中)
江厦湖潮汐発電所(浙江省建設中)
70kW潮流発電設備(浙江省建設中)
40kW潮流発電設備(計画中)
30kW波力発電設備(山東省運転中)
100kW波力発電設備(広州市運転中)



40kW潮流発電設備(計画中)

CE
CX windtech

Chinese Wind Power City

中国风电城

- The company has invested 6 billion yuan to build the large wind power generating equipments production base-"Chinese Wind Power City". At present the 850KW-2100KW large wind power generating equipments have reached the batch production capacity. The production capacity of multi-specification, multi-type large complete wind power generating equipments will reach 3 sets daily,1000 sets annually.
- Chinese Wind Power City has built ten large international advanced production lines of tower, main shaft, hub, gearbox, shaft block, yaw bearing, variable-pitch bearing, nacelle base, etc. It now owns the largest general assembly workshop in China with 60,000 ㎡ of large wind turbines. It is equipped with world first-level wind power experiment facilities and testing equipments, which can meet the general assembly commissioning of large wind power generating equipments with various models and various specifications. On the previous basis of electric automation production, the company has also invested large amount of money to build 40,000 ㎡ of large electric automation system production line.
- Chinese Wind Power City has solid technical research strength, owns national advanced large technology research center and provincial level lab, equipped with international advanced testing equipments and experiment devices. On the basis of solid technical strength and advanced experiment facilities, the company now is ready to build the national wind power generating laboratory.
- Chinese Wind Power City has installed over 1,000 sets of world advanced equipments such as large automatic computerized lathe, drilling machine with pivoted arm, gantry boring and milling machine, floor type boring machine, vertical lathe, large crane with 100 tons hoisting capacity, has realized the scale production capacity of complete wind power generating equipments. Some key parts such as hub, tower, main shaft, nacelle base, brake disc, yaw bearing, variable-pitch bearing, gearbox all adopt self-researched technology, and produced by itself, realized the localization of whole set equipment production.
- Chinese Wind Power City has also equipped with related casting and forging production workshop. The annual production capacity of mechanical semi-finished product, grey cast iron and ductile cast iron has reached 80,000 tons, the annual forging capacity of semi-finished gear, main axis and flange has exceeded 60,000 tons.
- In 2009, Chinese Wind Power City has been appraised as "the largest production base of complete wind power generating equipments in China" by China Wind Power Equipment.
- To satisfy the requirement of fast development of wind power generating industry, to cultivate more professional personnel of wind power generation, the company has also established the specialized teams of equipment transportation, installation, lifting and maintenance. It has also built the specialized personnel training institute and social practice basis in Chinese Wind Power City. Cooperated with Shandong University, Shandong University of Technology, Shanxi University of Technology, etc, the company has cultivated large batch of professional personnel of installation, commissioning and maintenance of wind power generating equipments.

- 公司投入资金60亿元打造大型风力发电设备生产基地——“中国风电城”，目前850KW—2100KW的大型风力发电设备都已达到批量生产能力，并将实现多规格、多型号大型成套风力发电设备的生产能力达到日产3台套，年产1000台套的目标。
- 中国风电城建有塔筒、主轴、轮毂、齿轮箱、轴承座、偏航轴承、变桨轴承、机舱底座等十条国际先进的大型流水生产线，拥有目前国内最大的6万平方米大型风力发电设备总装车间，配备了世界一流水平的风电实验设施和测试设备，可同时满足不同型号、不同规格的大型风力发电设备的总装调试。在原有电气自动化生产的基础上，还斥巨资建设了四万平方米的大型电气自动化系统生产线。
- 中国风电城拥有雄厚的科研力量，建有国内一流的大型科技研发中心和省级实验室，并配备有国际先进的检测设备和实验器材。在雄厚科研力量和先进实验设施的基础上，公司正在筹备建设国家级风力发电实验室。
- 中国风电城安装了世界一流的大型全自动数控机床，摇臂钻床、龙门镗铣、落地镗床、立式车床、100吨吊装能力的大型航车等设备1000余台套，实现了成套风力发电设备的规模生产能力。其中轮毂、塔筒、主轴、机舱底座、刹车盘、偏航轴承、变桨轴承、齿轮箱等关键部件均采用自主研发技术，完全自主生产，使整套设备的生产完全实现了国产化。
- 中国风电城还匹配有铸造、锻造等相关配套部件生产车间，机械毛坯、灰铸铁和球墨铸铁年生产能力达到8万吨，齿轮毛坯、主轴、法兰年锻打能力超过6万吨。
- 2009年，中国风电城被《中国风能设备》评为“目前国内最大的成套风力发电设备生产基地”。
- 为满足风力发电产业快速发展的需要，为社会培养更多的风力发电专业人才，公司还组建了专业的设备运输、安装、吊装、维修队伍，并在“中国风电城”成立专业人才培训机构和社会实践基地，与山东大学、山东理工大学、陕西科技大学等高等院校开展校企合作，为国家培养了大批风力发电设备安装、调试、维护等专业人才。

CE
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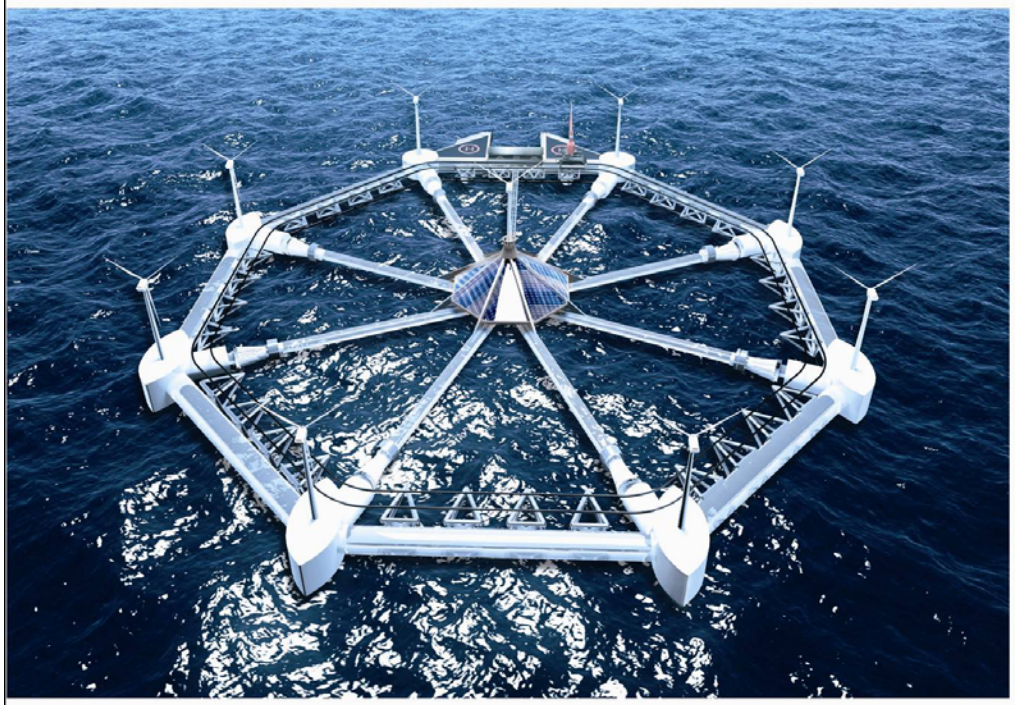
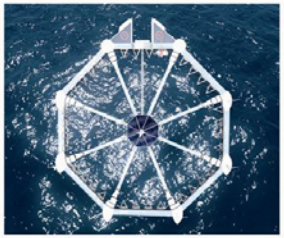
Offshore combined floating wind power generation technology

海上组合式漂浮风力发电专用技术





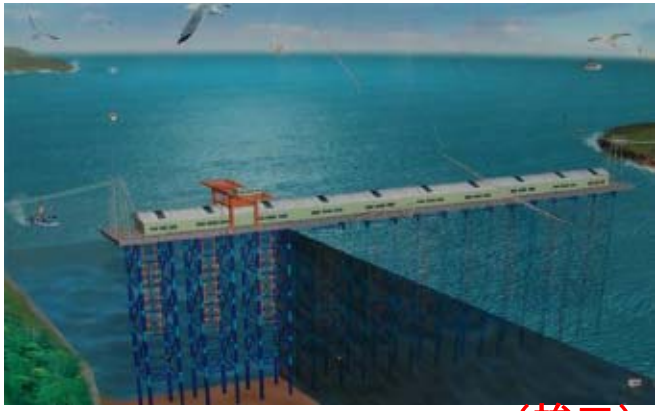
- Marine Combined Floating Platform employs an octagon architecture, comprising 9 floating wind generator bases, which constitute an integrated structure under support of cylinder columns and supporting components. This structure evenly scatters the load of entire system utilizing the principle of stability of triangle.Such a floating platform is a flexible supporting structure, whose octagon base is strong enough to endure hurricane occurring on the sea.It can be placed everywhere on the sea regardless of water depth and realize non-grid-connected wind power, thus supply energy to various ocean activities.The successful development "Offshore combined floating wind power generation technology " makes the human being's dream of deep-ocean wind power come true.
- 海上组合式漂浮平台为正八边形结构，由九个浮筒式风机底座组成，通过筒状支撑柱和支撑构件组成一个整体结构，利用三角形的稳定性将承受的载荷均匀分布，这种漂浮平台属于柔性支撑结构，正八边形底盘非常稳固，可经受海面上的12级风浪。它能够不受水深限制放置在海平面任何一个角落，实现非并网发电，为各种远洋活动提供能源。“海上组合式漂浮风力发电专用技术”的成功研制，使人类对深海风能的探索变为现实。

Korea

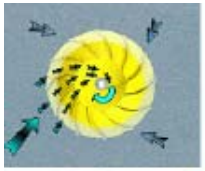
- very keen to renewable energy development
- huge potential of ocean energy

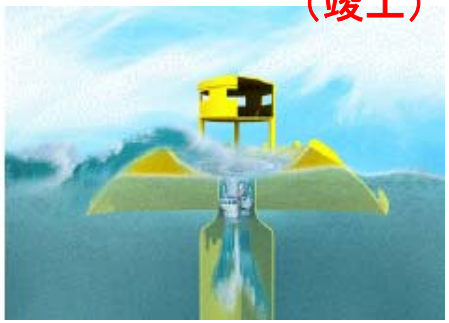
tidal : 6,500MW
tidal current : 1,000MW
wave : 6,500MW

Si-Hwa潮位差発電プロジェクト(竣工)



(竣工)





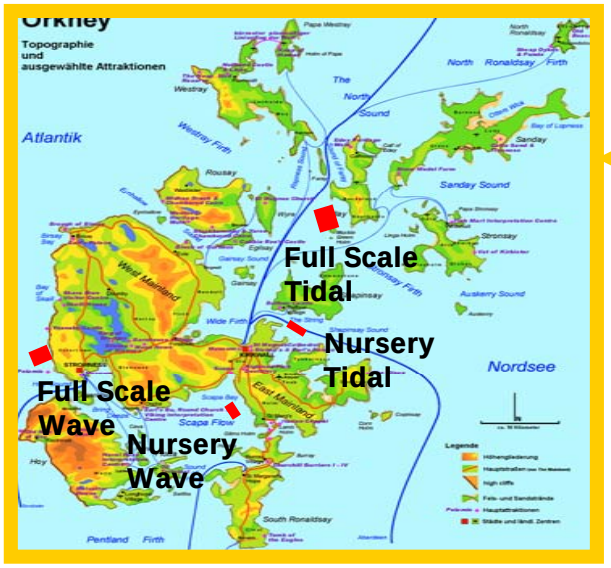
European Marine Energy Centre since 2003

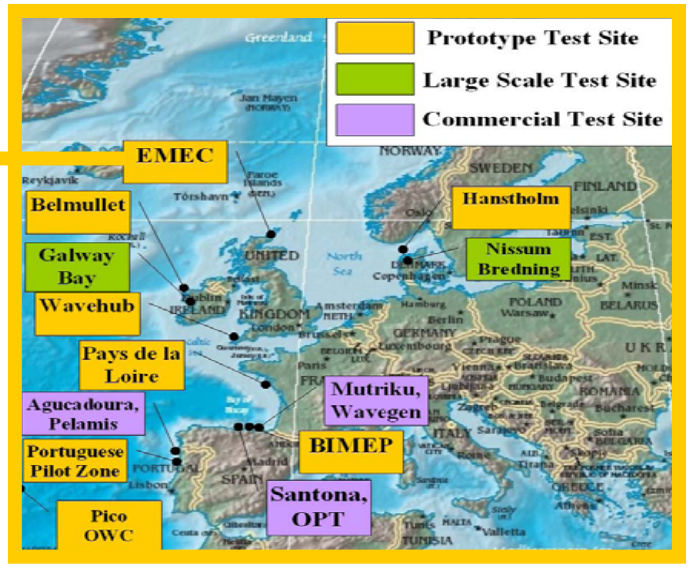
（出典）OETR岩手シンポジウムRichard Morris 資料より

Ocean energy test sites in Europe

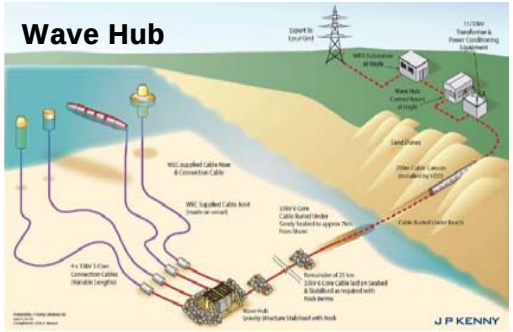
欧州では2005年以降に多くの実験サイトが稼動

多くはECの資金を含めて設置されている。

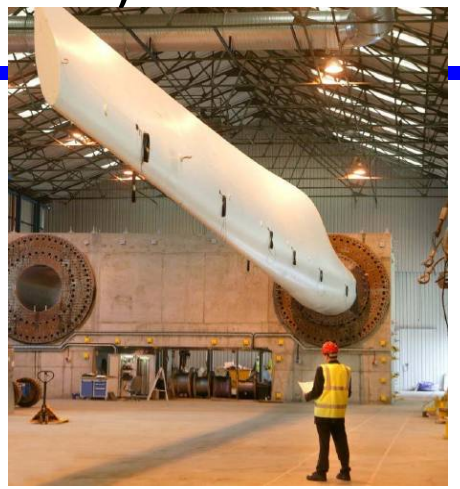




- **欧州で最初の良く整備された実験サイトの一つは、スコットランドのオークニー諸島に設置された European Marine Energy Centre（EMEC）であり、この海域は、大西洋の大波とスコットランドの諸島間に存在する潮流の両方を利用でき、波力発電と潮流発電の実証実験が可能。**
- **2011年内に開所予定の英国 Wave Hub は波力発電装置列を試験するサイトであり、同時に4機種が比較できる。**



NAREC(National Renewable Energy Centre)



Workshop of turbine blade（左：施設俯瞰図、右：試験風景）

●operation

number of employees is 115 in 2010

cooperate with local universities and institutes

back up from universities

education and research utilizing the facility

Budget for founding:30million£（約39億円）、

test site:22.85million£（約29.7億円）

Bench test of drive train for wind and tidal turbines

- Performance and endurance tests of gear box and generator
- for wind turbine（Fujin風神）: 15MW, for tidal : 3MW

Blade test fasility

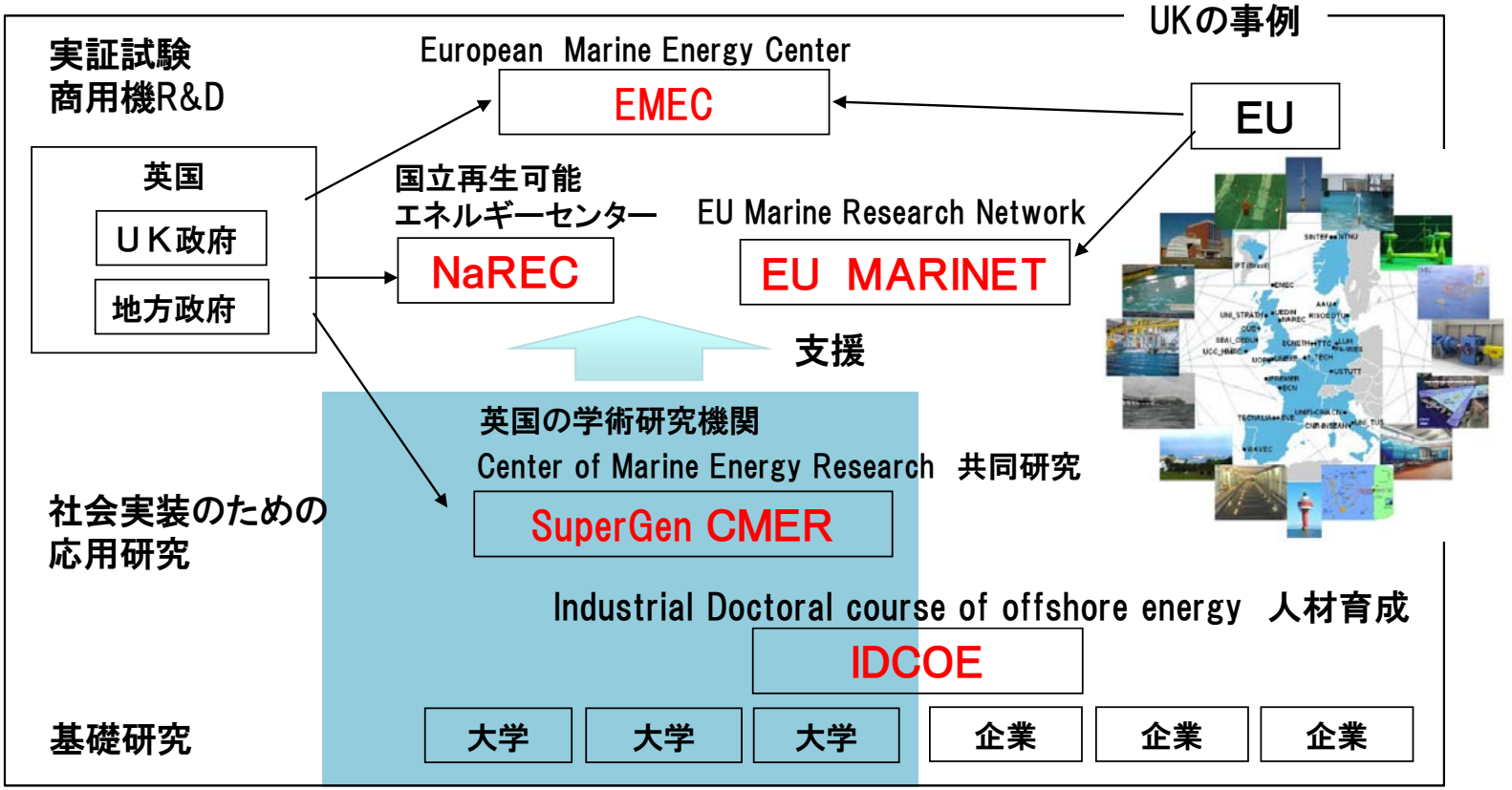
- strength test

  fatigue test, fracture test
- span 100m

  existing max span: about 80m

- Total system of R&D and Education
  - Industrial Doctoral course of offshore energy is important!

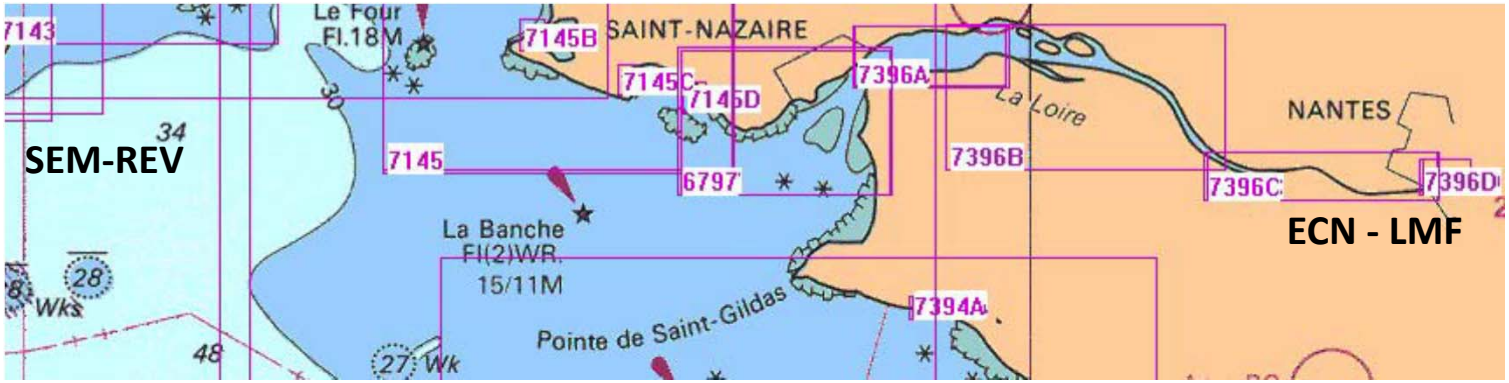
Japan should learn this total system!



Oyster
Aquamarine
set up in 2005
team now numbers
over 60 peoples

France

- France Energy Marines launched in 2011, center of R&D
- Ecole centrale de Nantes, SEM-REV



- Nuclear plant makers: AREVA etc.
- Heavy industry makers: ALSTOM etc.
- Low cost floating wind turbine（IDEOL): concrete float with moon pool etc.

ALSTOM's 7MW wind turbine

Now: training of maintenance on shore

Then: commercial bottom mounted
wind farm

Training of workers and quality control of
a production line at a tentative factory
that used to be for a ship building

Under construction of a huge manufacturing
plant that produces 100 turbines every year
at a port area

Renewable Energy contribution to total energy consumption of Japan in 2030 proposed by Government

2030年		環境省公表値 2012.8.31						エネ環会議2012.6.29			
エネルギー源		洋上風力	地熱	バイオマス	海洋エネルギー		小計	太陽光	陸上風力	水力	全電源中の再可エネのシェア
					潮流/波力	海流					
(稼働率)		(30%)	(80%)	(80%)	(40%)	(75%)		(12%)	(20%)		
15%シナリオ	①設備GW	8.0	3.9	6.0	1.5	—	19	63	38	48	168
	②電力量構成	2.1%	2.7%	4.2%	0.5%	—	9.5%	6.6%	6.6%	7%	30%
0%シナリオ	③設備GW	8.0	3.9	6.0	4.0	2.0	25	69	52	48	194
	④電力量構成	2.1%	2.7%	4.2%	1.4	1.3	11.7%	7.2%	9.0%	7%	35%

Floating wind turbine 2011～2015 at Goto islands

Univ. Kyoto, Toda const.,
Fuji H.I., Fuyo Ocean Develop.,
NMRI

- 2MW
- Evaluation method of a wind farm
- Research to reach consensus between local stakeholders
- Weather, Sea conditions, safety design, maintenance, environmental assessment

NEDO **Ocean energy R&D**

（1）On-site tests of commercial plants

- wave　Mitsui Ship Building
  point absorber, oil liquid transmission
  at Kozushima
- wave　MHI Bridge & Steel Str. Eng.
  Toa Const.
  in front of break water, OWC　at Sakata
- wave　Gyro Dynamics, Hitz
  Gyroscope type　at Shimizu
- Tidal current　Kawasaki H.I.
  construction & Maintenance, mooring
  at EMEC

(2) Technologies for next generation

- Tidal Current　University of Tokyo, IHI, Toshiba, Mitsui Glob.Strat.S.
  Single point mooring, horizontal axis turbine
- OTEC　Saga Uni., KOBELCO
  Thermal transfer, floating riser system

METI Wind Farm

Conditions of the site

Water depth 100～200m

Average wind speed more than 7m/s at the hub position

Max. significant wave height 7～14m

From the coast

more than 20km

Condition of the turbine

2 x 7MW + 2MW wind turbine

and floating substation

Turbine style: downwind and gearless

Type of floating structure:

spar and semi-sub

Transportation of compact semi 2MW

Transportation of floating sub-station

anker

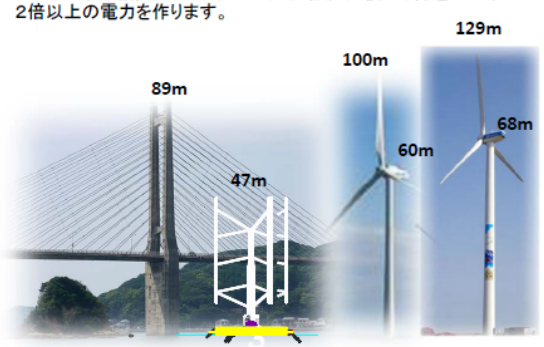
V-shape Semi
7MW

Hybrid wing & Tide:
NEDO　Ocean energy R&D

by MODEC

■　世界初の、潮流と風力の同時発電。

しかも風車は縦長タイプですので、同じ設置面積でも普通の風車の2倍以上の電力を作ります。



呼子大橋　三井海洋開発 500kw型　ウィンドパワー神栖2000kw型　海風丸 1000kw型

■　漁船のようにリースで購入、頭金なし。(事業化時)

そして魚を養殖するように、電気を養殖するビジネスをしませんか。
大きな船体の中をどのように使うか、アイデア次第です。

(写真は天地を逆にして建造中です)

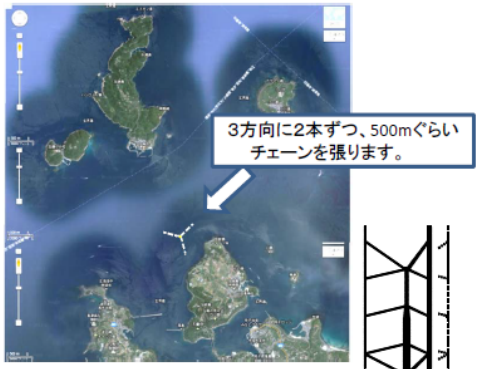
漁船と同じように、日常点検はお願いします。修理等は、三井海洋開発または関連会社が責任を持ってお応えします。

■　もちろん魚にやさしい水車、鳥にやさしい風車です。

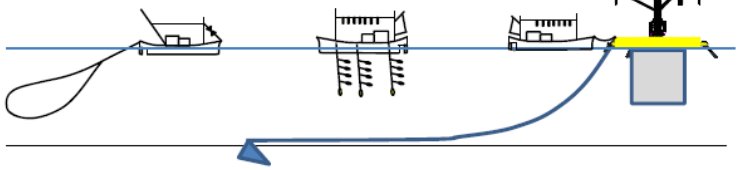
水車は潮流と同程度の速度でしか回らず、やさしく海を撹拌します。風車も、陸上型風車のおよそ半分のスピードで回ります。

■　底引きが難しいような潮流が速いところが得意です。

例えば加部島の北西。



係留範囲の内側でも一本釣りなどは問題ありません。
もちろん浮体に係留することも乗船することもできます。
みなさんの風車ですから。

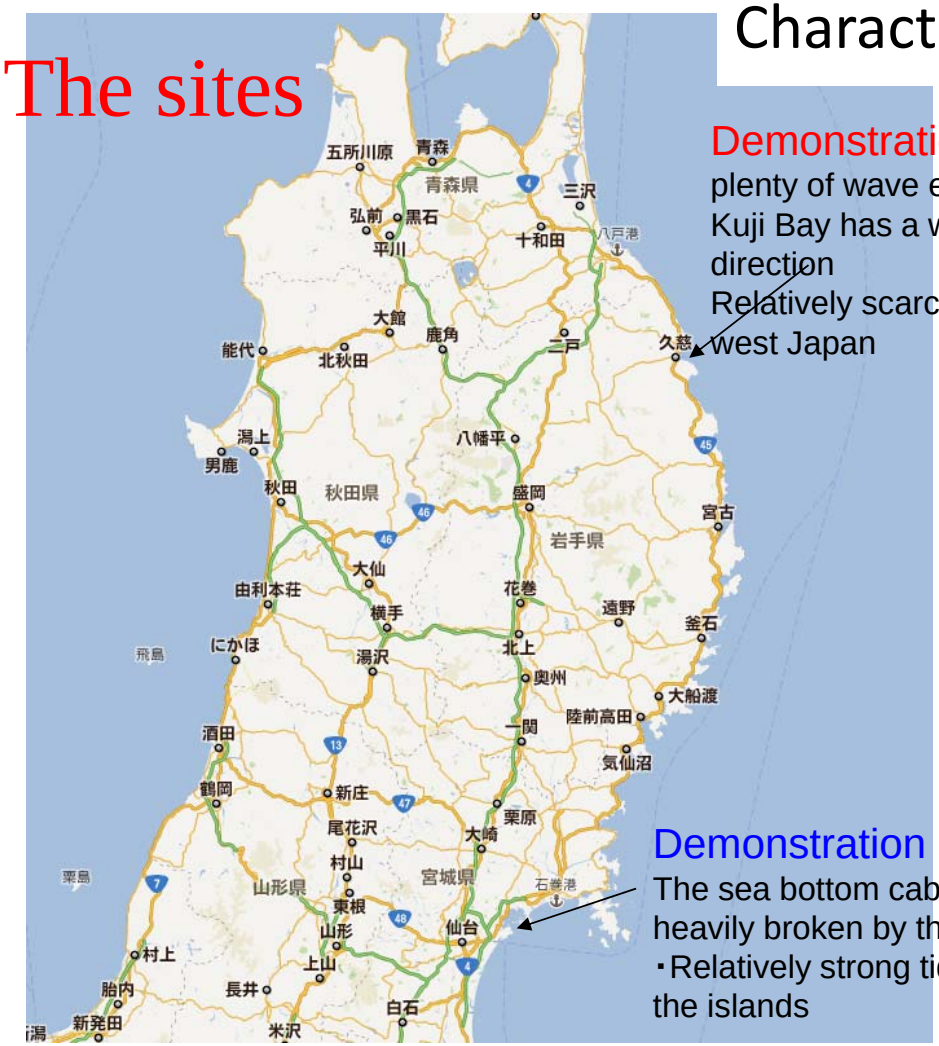


■　津波に耐え、そして停電時にこそ威力を発揮。

浮体型ですから波を乗り越えます。 そして少しでも潮流があれば風車を回してくれるので、風車の起動に九州電力の電気は要りません。停電時でも発電を続けるのはこの風車だけです。

R&D of Clean energy for Tohoku regeneration , 2012-2016 By MEXT

The sites



Characteristics of the demonstration sites

Demonstration site of WEC: Kuji

plenty of wave energy in coast of Iwate Prefecture

Kuji Bay has a wide mouth and accept waves from mult-direction

Relatively scarce attack of Typhoon compared with south west Japan

Wave

Tidal current

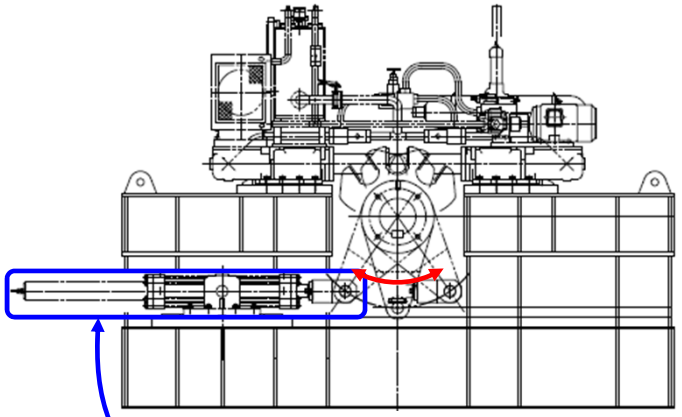
Demonstration site of Tidal current: Shiogama・

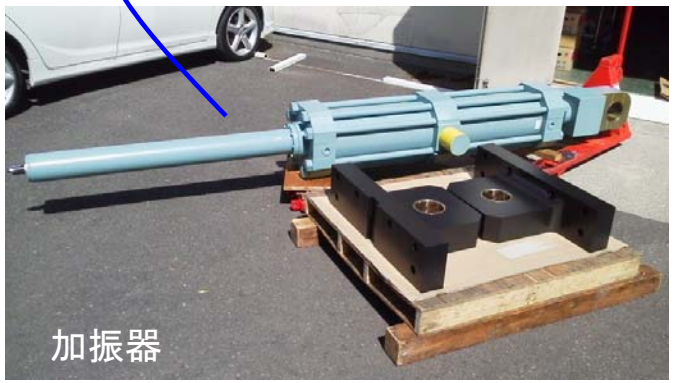
The sea bottom cable at Urado Islands, Matsushima Bay heavily broken by the Tsunami

・Relatively strong tidal current exists at the channel between the islands

Bench test of hydraulic drive train of wave power

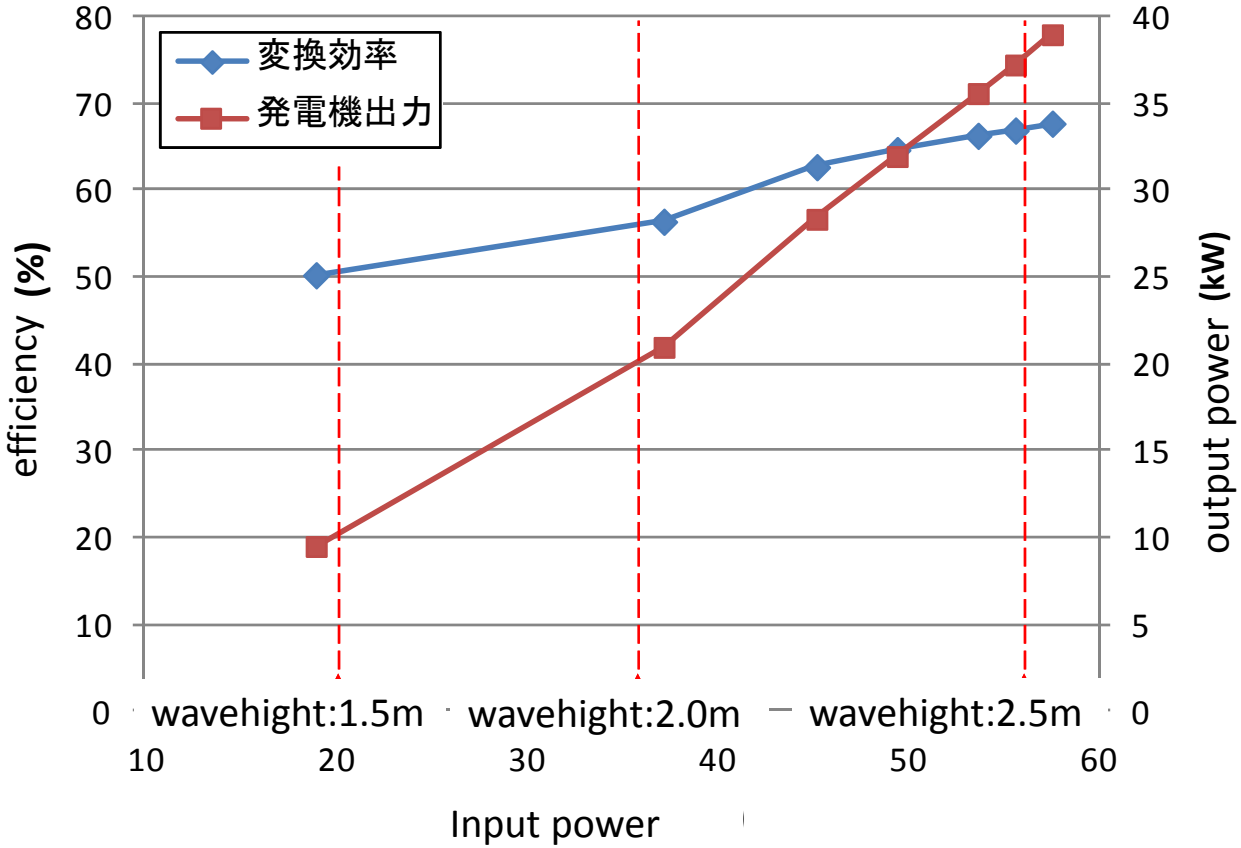
Forced-oscillates the hydraulic drive train by a hydraulic cylinder to obtain its efficiency (2014)





Drive train efficiency

Confirmed 40kW generated power for designed waveheight 2.0m and 70% efficiency for heavy seas



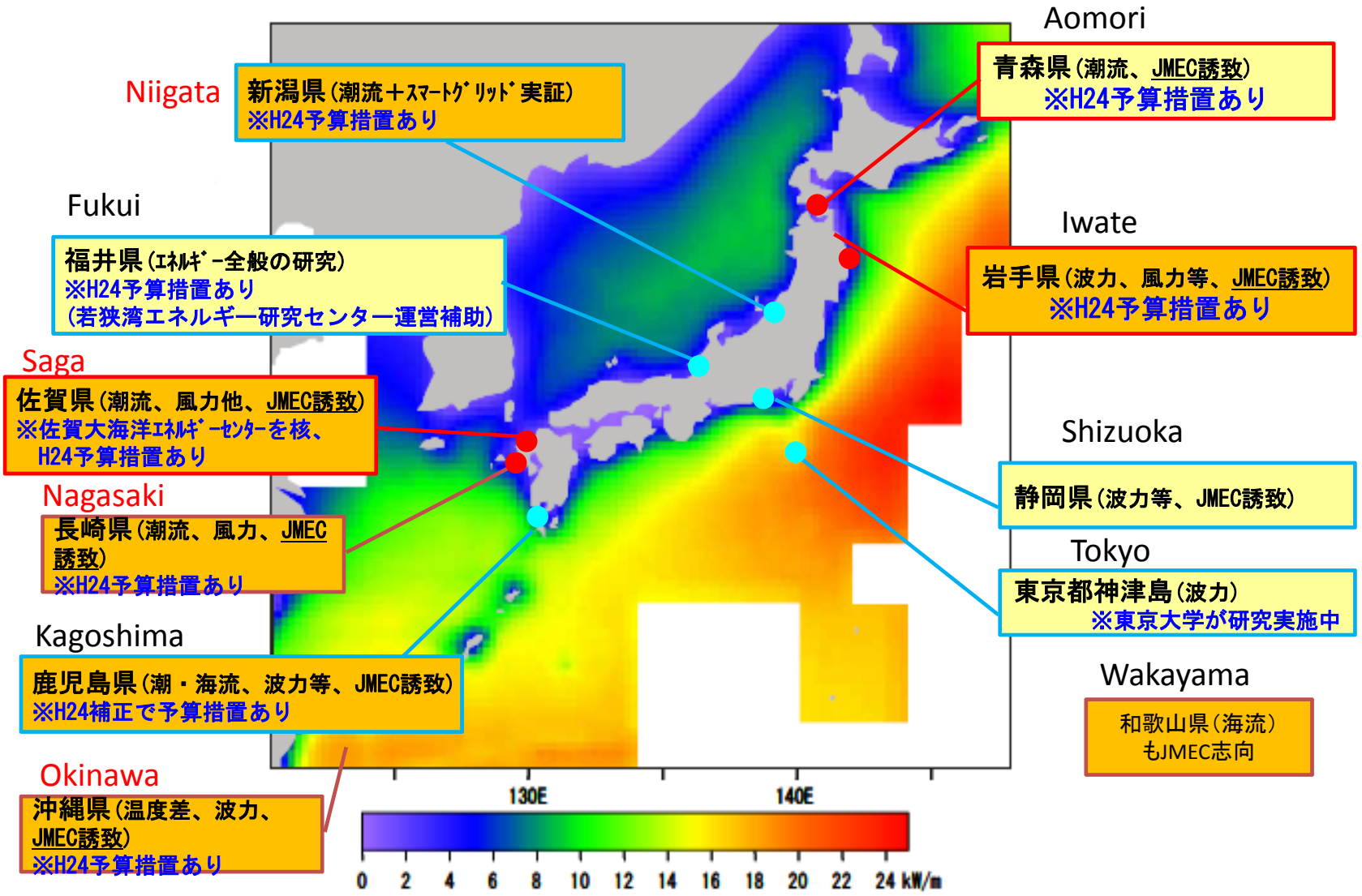
Tidal current turbine: CG picture for permission of Natural Heritage

Urgent issue for Japan

Research & Development: total system of multi-disciplinary education, public funded projects, drive train test facilities and scale & full scale test sites like UK

Commercialization: accelerate by packaging of national strategic approach

Ocean Energy Test Site applicants where local governments preparing



What should do in Japan?

- Political: Show the target of Marine Energy introduction, assuming a market & investment size, and then the road map
- Infrastructures: First of all, Test Sites, reduce the high cost factors (working ships, port facilities etc.)
- Prepare commercial sea areas: ocean space planning
- Create new simple regulation

Summary

- Japan has not decided yet the target of Marine Energy introduction
- The government will shortly make the road map, hopefully
- Japan can make 35% of total electricity by renewable in 2030
- Some of them should be marine energy
- Marine energy can contribute much more in 2050
- In order to do that, many problems remain. We have to do a lot cooperating with international colleagues.