Sea Horse Project
Ocean Energy Development at OIST

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1. Kuroshio Ocean Current power generation R&D.
2. Breaking Wave Energy converter R&D

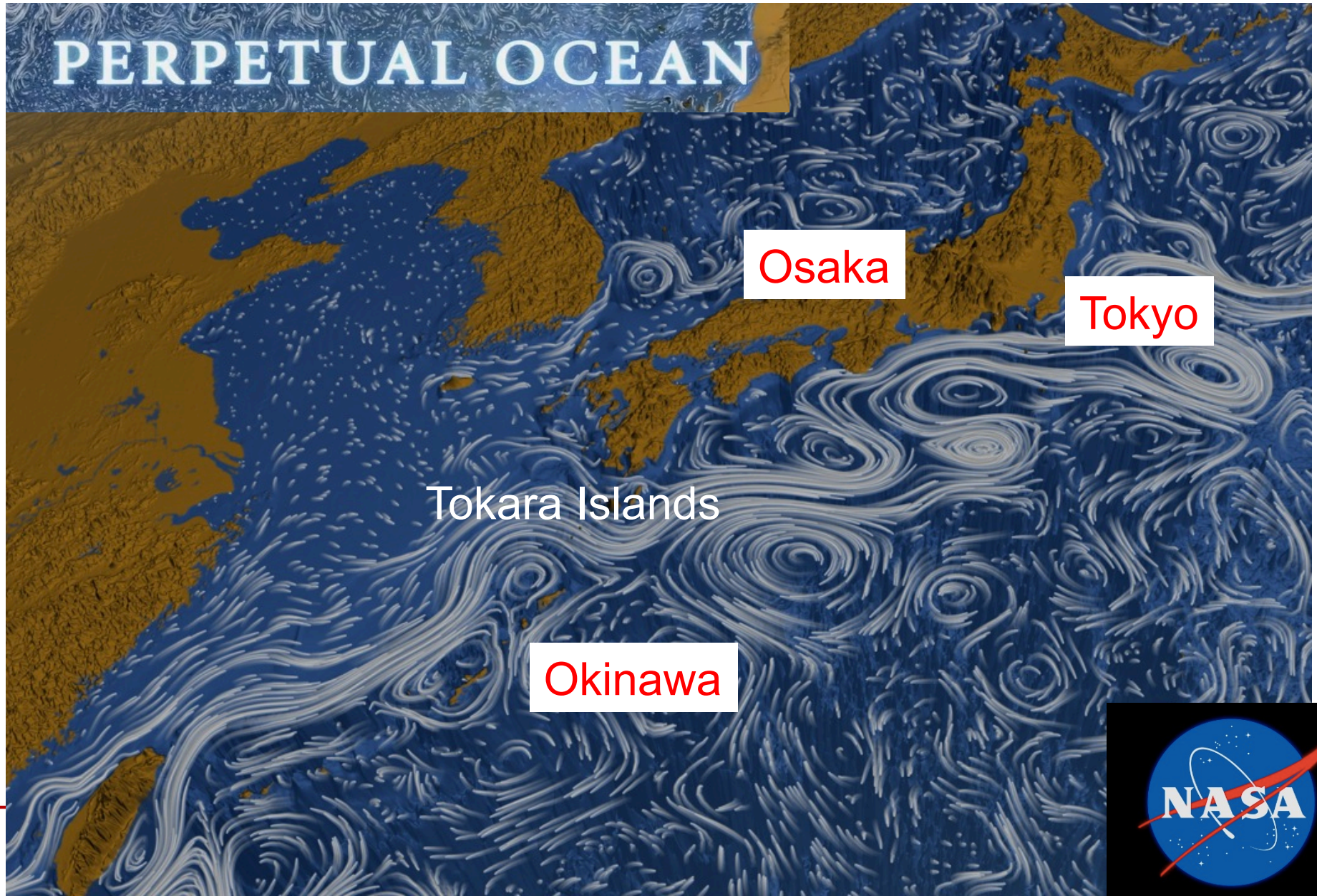
Why do we focus on Ocean Energy?

- There is a huge potential of sustainable energy source available from Ocean.
- Japan is surrounded by Ocean.

- .while, Tidal power might not contribute to major electricity resource in Japan, since good fishery points are mostly located at fast tidal current area.

- Ocean current will be a good candidate as sustainable energy source, i.e., Kuroshio current has wide (~100km width) water flow, and has less conflict of interest with fishing industry.

Ocean current is most reliable energy source.



Underwater Windmill

Seawater　1024 kg/m^3（820 times denser than air)

Fluid power $$P = \frac{1}{2}\rho A V^3$$

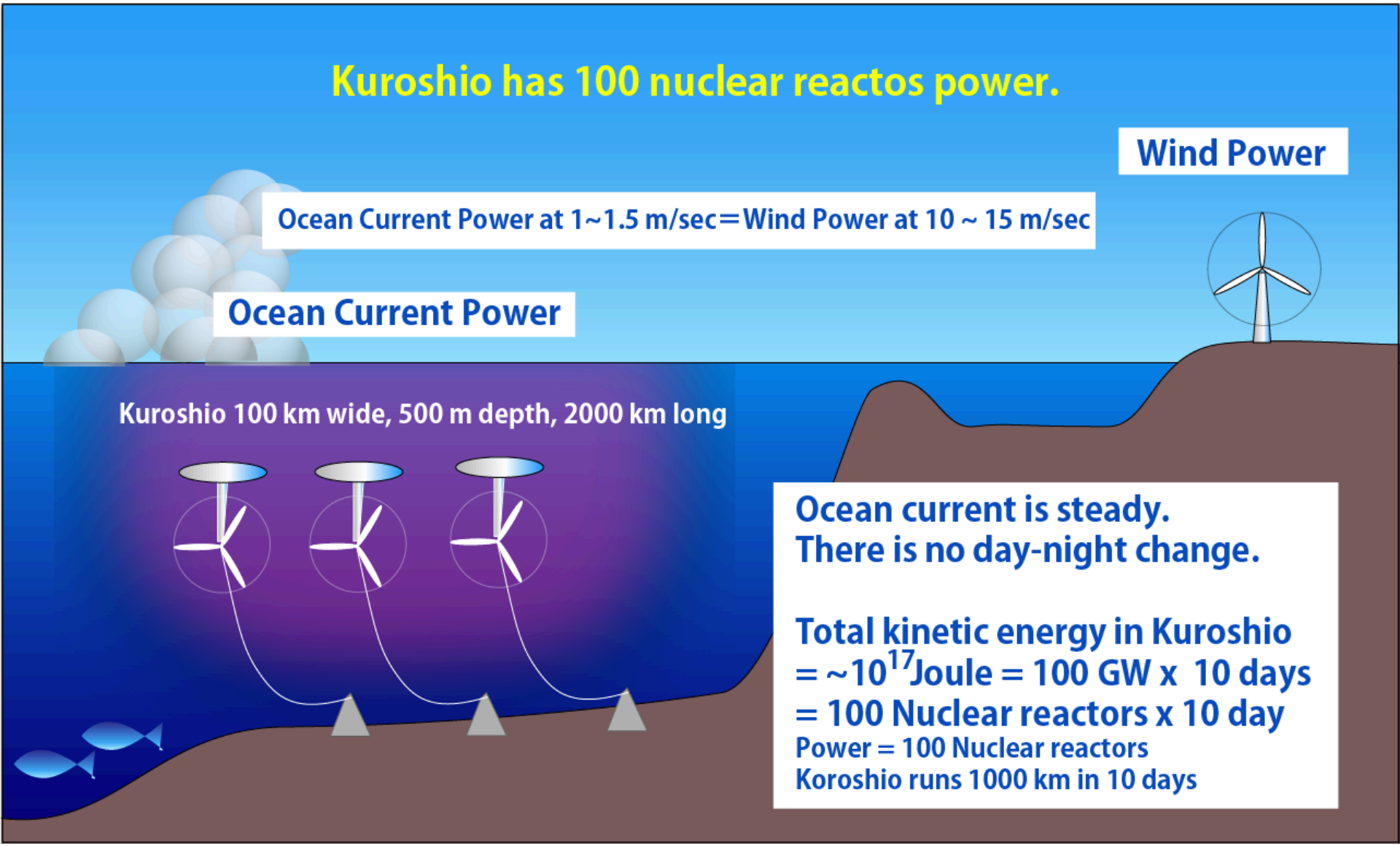
Ocean Current
1～1.5 m/s

=

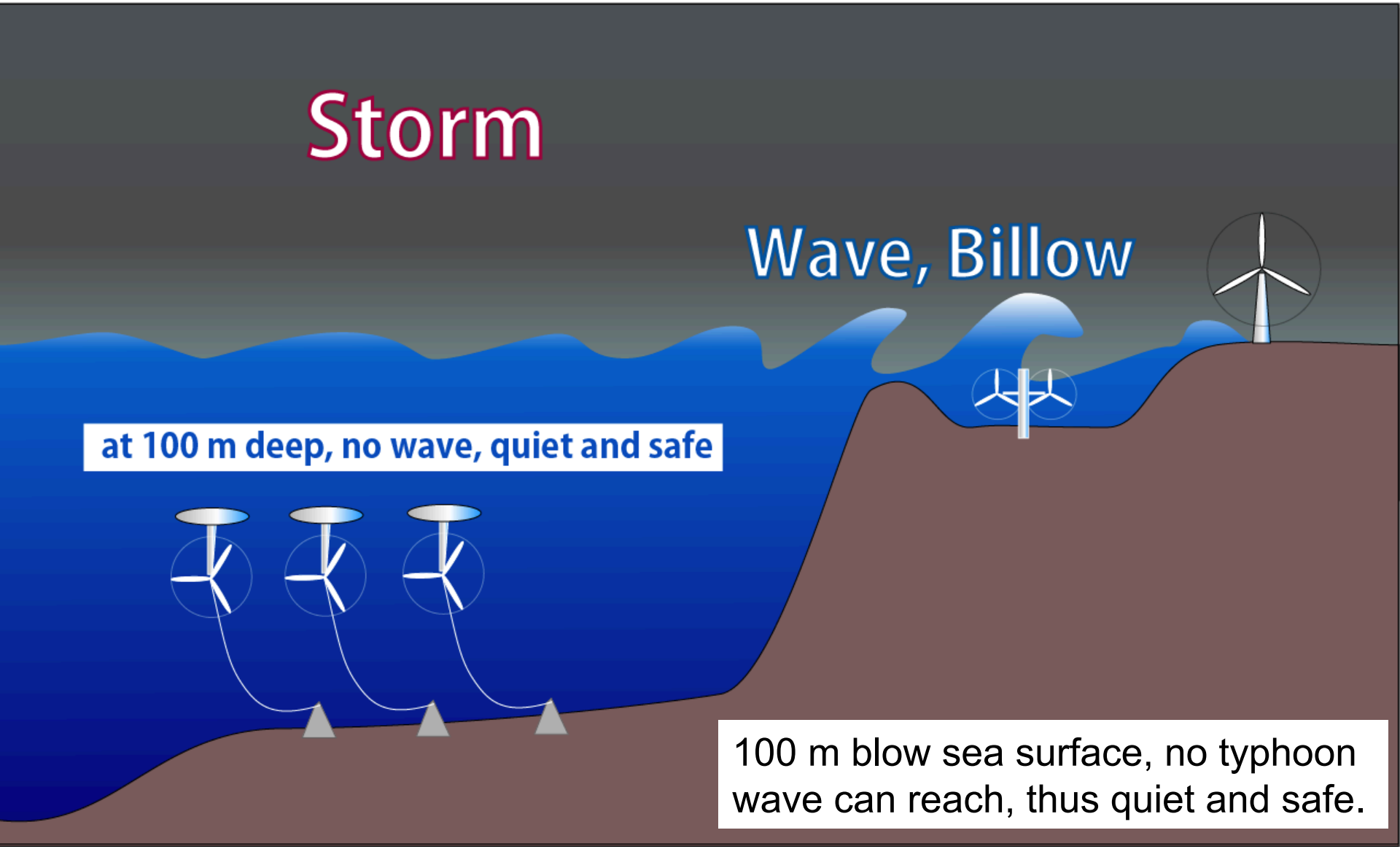
Wind
9～14 m/s

We build underwater “windmill”.

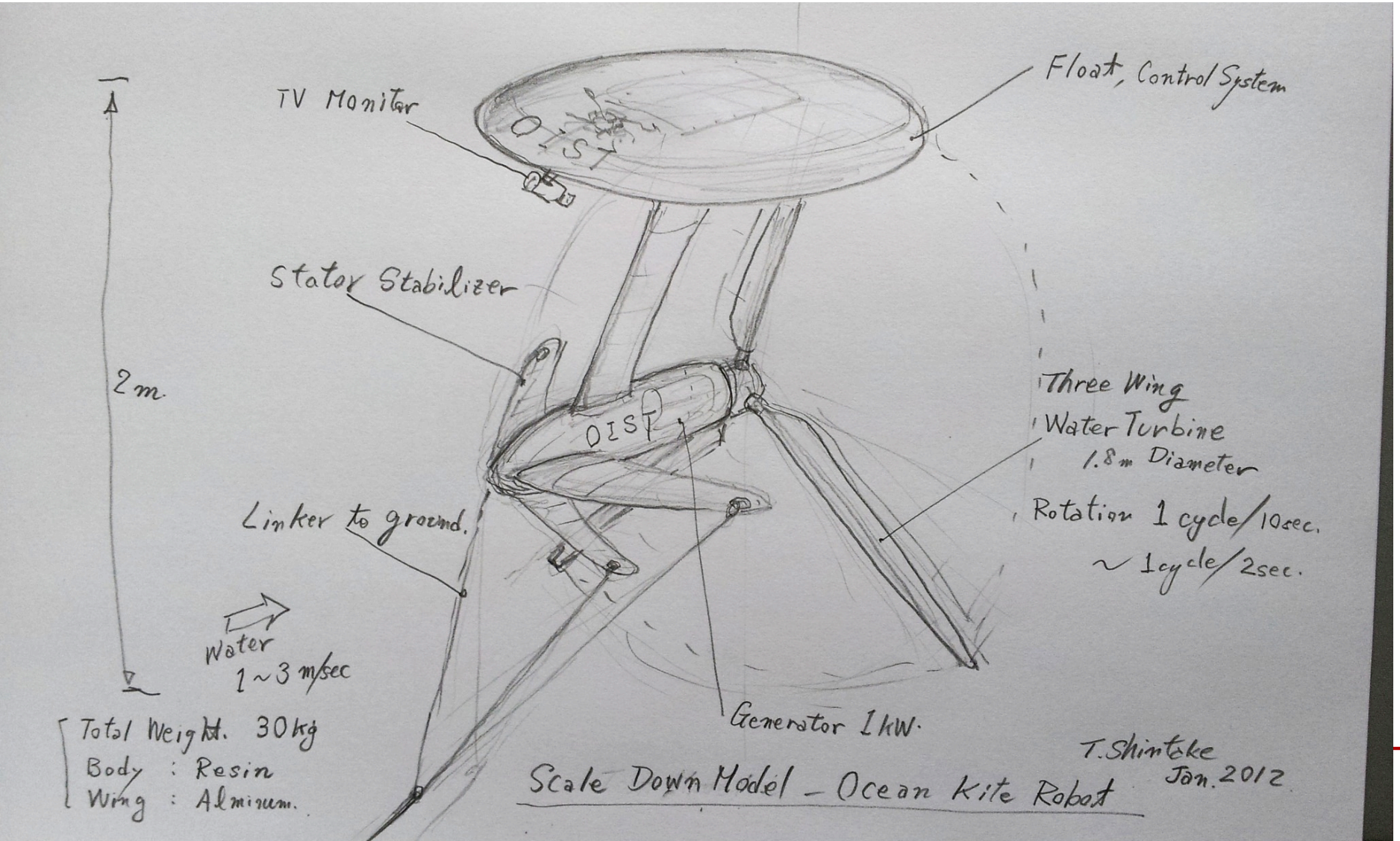
Seawater is 820 times denser than air.



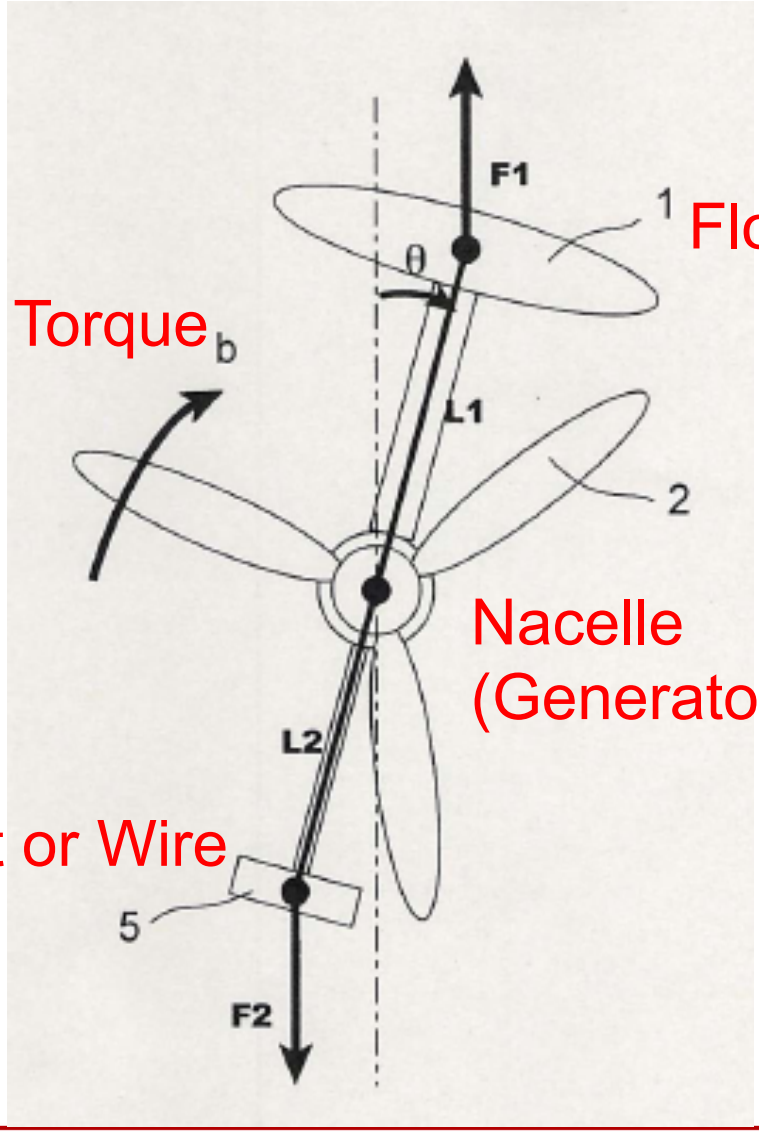
We have typhoons in summer season around Japan.



In 20th century, mankind started endeavor to the space. Thanks to the challenge, now we can use Google map, weather forecast, GPS, Hubble telescope, and etc. In 21th century, we start going down to deep sea. I make the space craft image on to our underwater windmill machine, wishes to save human life from CO2 emission or other high-risk energy source.



Why do we need the float?

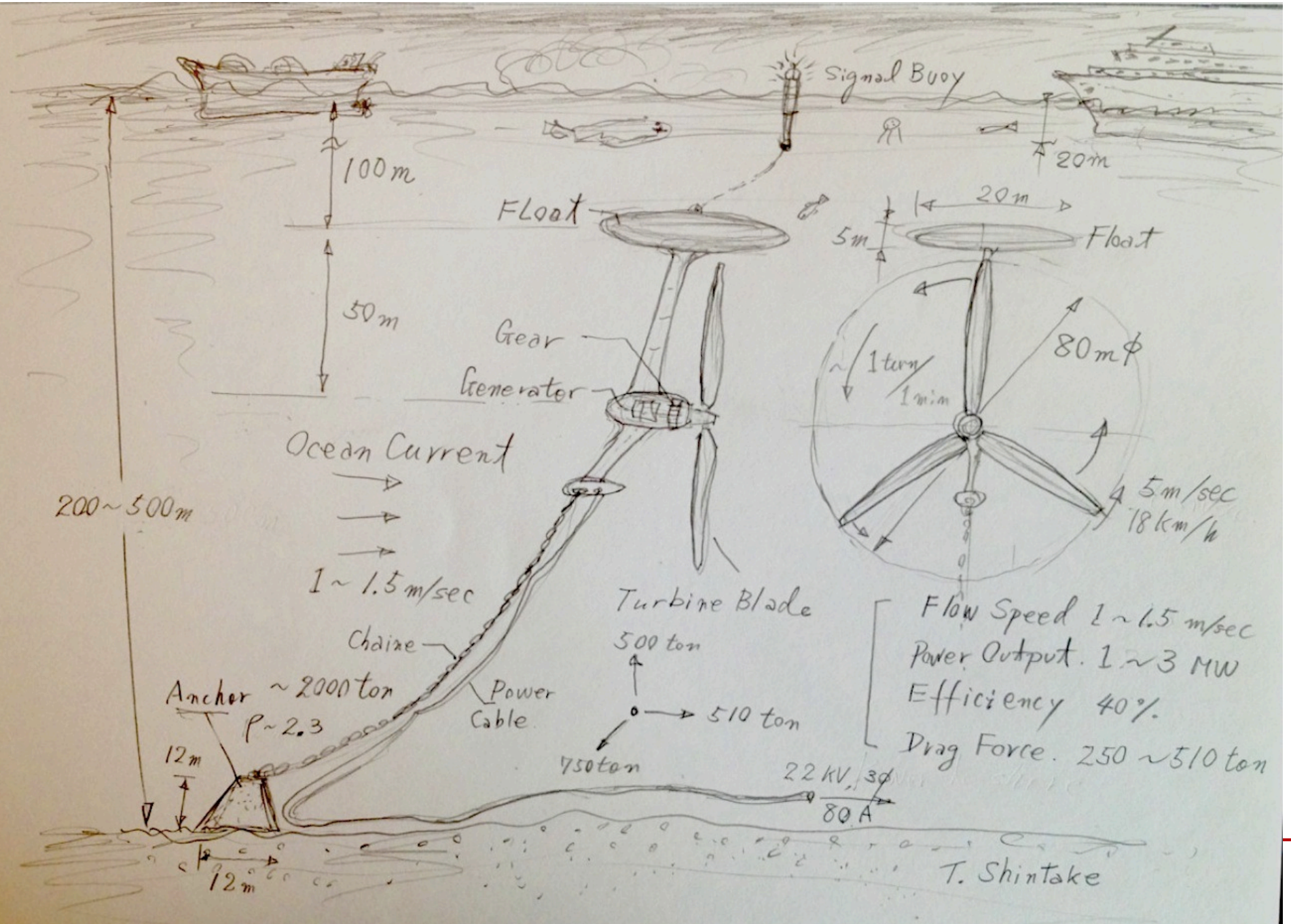


Float

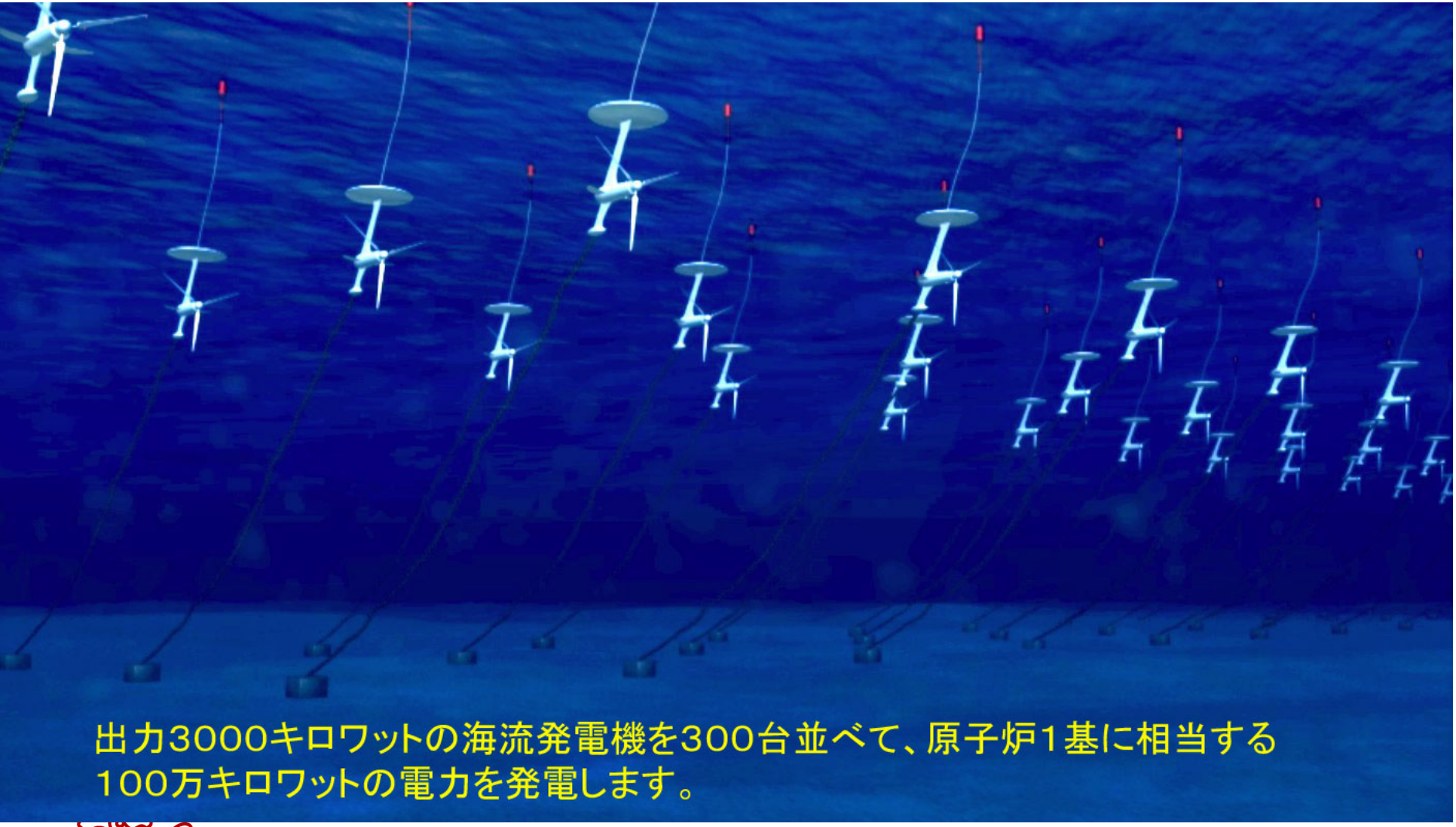
Blade Torque $_b$

Nacelle
(Generator)

Weight or Wire


Signal Buoy
100m
50m
20m
Float
20m
5m
Float
Gear
Generator
80mφ
1turn
1min
Ocean Current
200~500m
5m/sec
18km/h
1~1.5m/sec
Turbine Blade
500ton
510ton
750ton
Chaine
Power
Cable
Anchor ~2000ton
ρ~2.3
12m
12m
22KV, 3φ
80A
Flow Speed 1~1.5 m/sec
Power Output. 1~3 MW
Efficiency 40%
Drag Force. 250~510 ton
T. Shintake

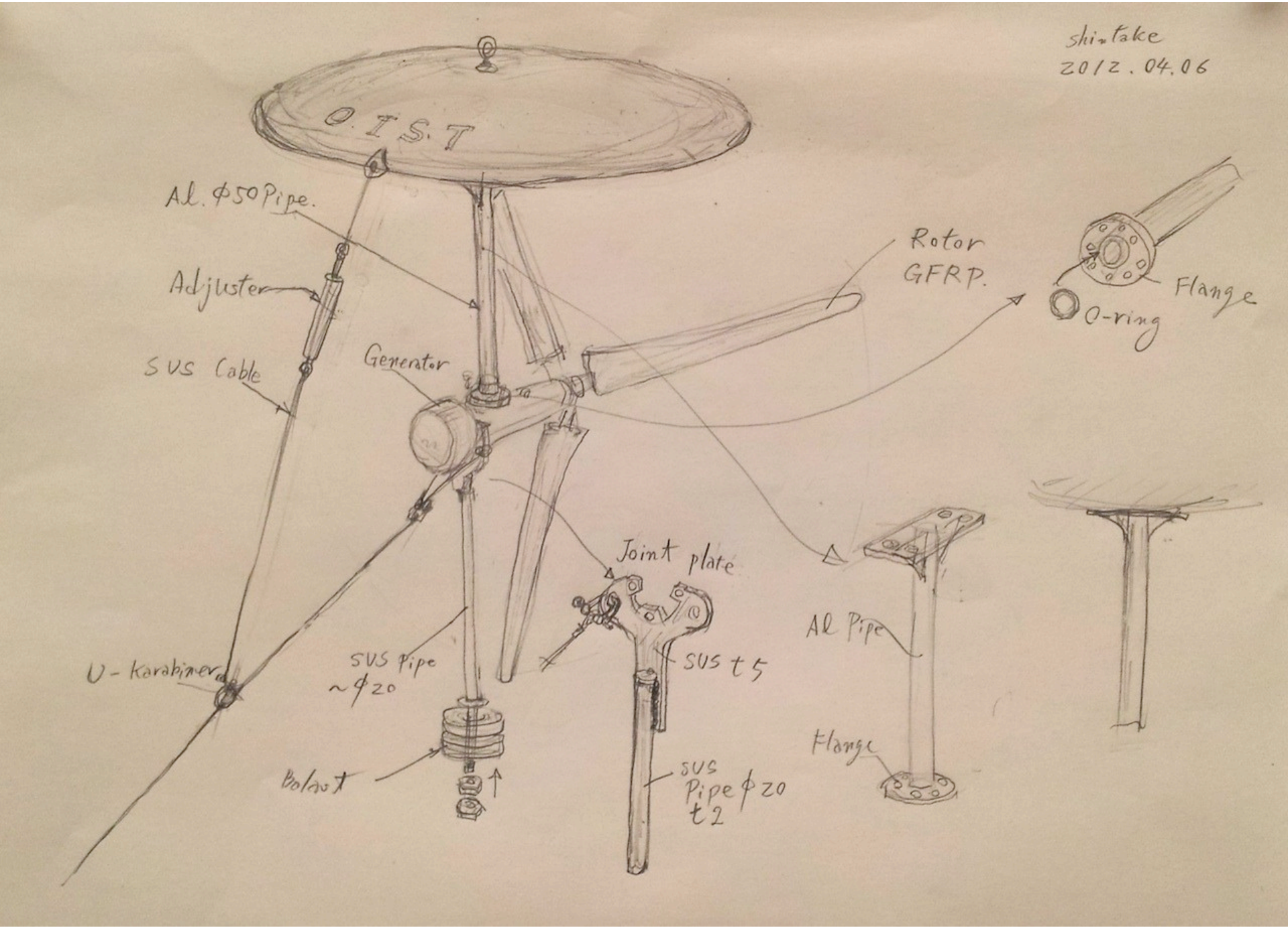
300 Turbines will generate 1 G-watt, equivalent to one nuclear power generator.



Parameters

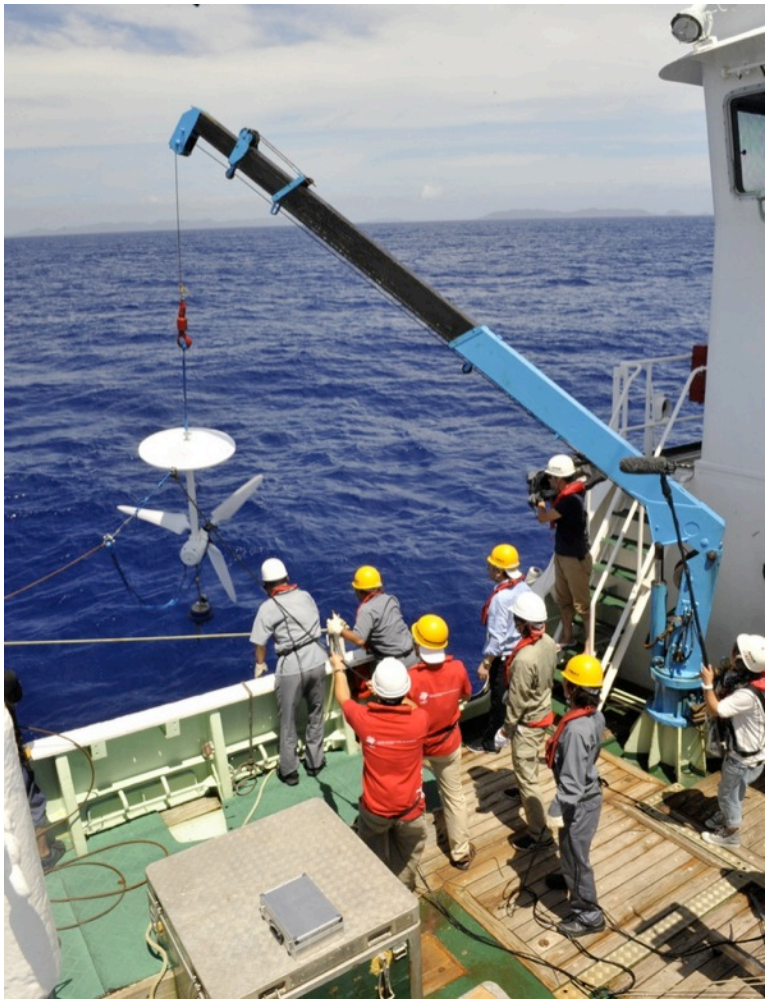
23. Mar. 2012 Shirasawa

	OIST Test Model (1 kW) (Design value)	NIKKO NWG-1K (1 kW) (Estimation from the catalog)
Flow	Seawater(ρ=1024 kg/m^3)	Air(ρ=1.29 kg/m^3)
Type	3 blades propeller	
Flow velocity	1 - 1.5 m/s	12 m/s (catalog)
Rotor diameter	2 m	2 m (catalog)
Swept area	3.14 m^2	3.14 m^2
Input power	1.6 - 5.4 kW	3.5 kW
Output power	1 kW	1 kW (catalog)
Total efficiency	--	29%
Tip speed ratio	6	6
Rotation	1 Hz	11.5 Hz
Torque	159 N･m	13.8 N･m
Drag	3200 N @ V=1.5 m/s	259 N

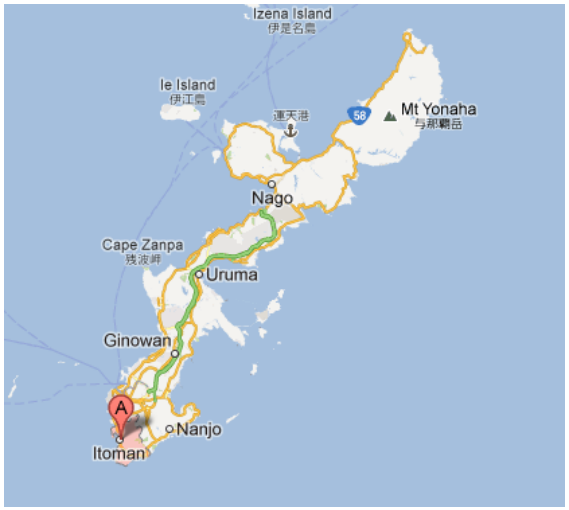

shintake
2012.04.06
O I S T
Al. φ50 Pipe.
Adjuster
SUS Cable
Generator
Rotor
GFRP.
Flange
O-ring
Joint plate
U-karabiner
SUS Pipe
~φ20
SUS t5
Bolt
SUS
Pipe φ20
t2
Al Pipe
Flange

Using a small windmill, we made prototype test model for Ocean current turbine.

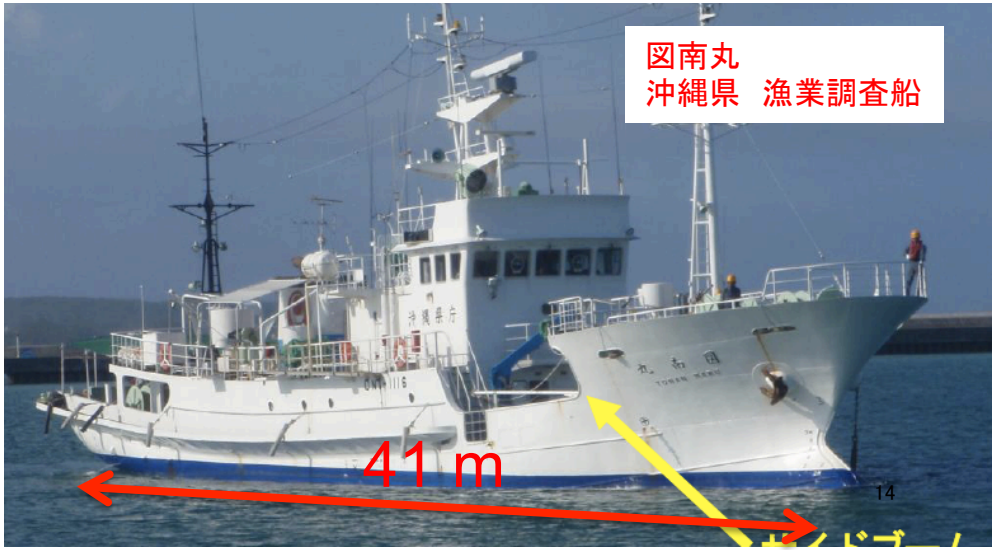
The first experiment in 2012, towed by a ship



2012/6/29

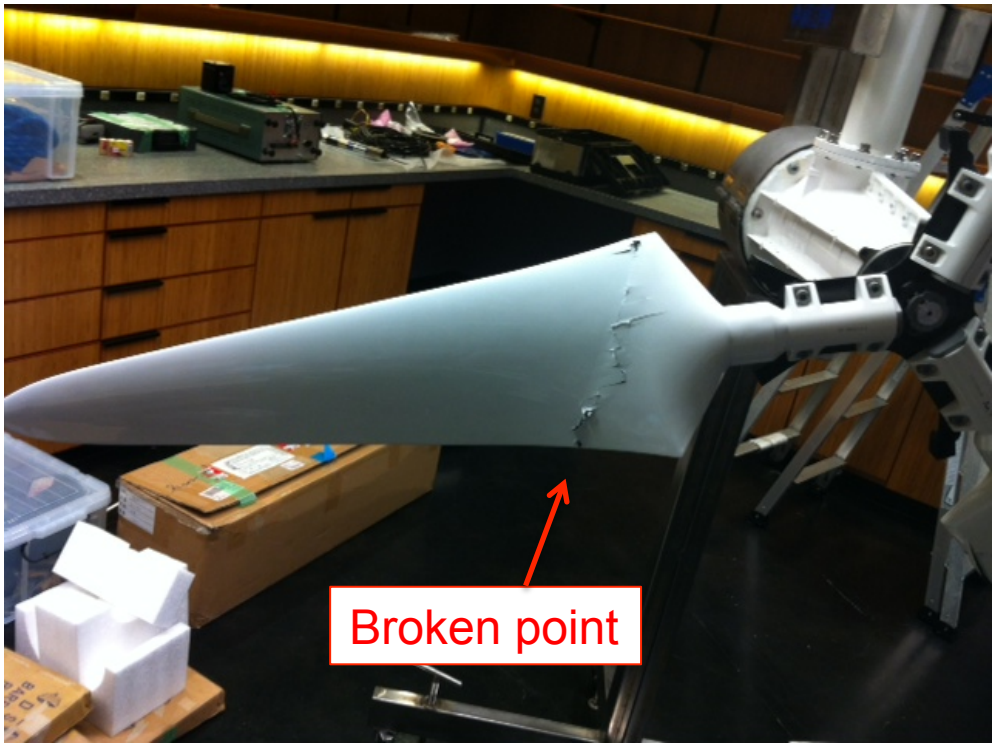


Place
Itoman Port,
Okinawa



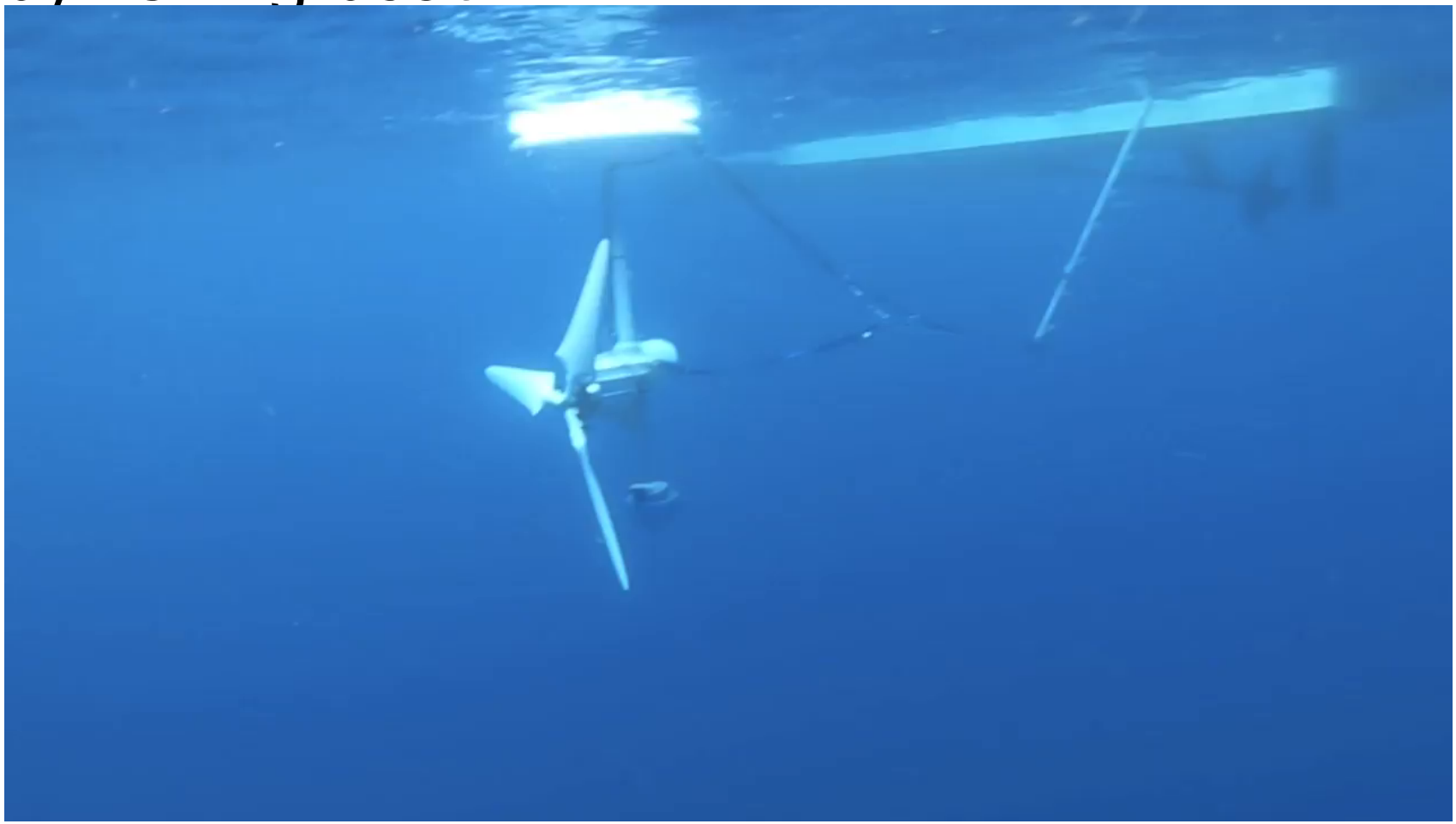
Windmill blades were broken due to strong force by sudden water flow.

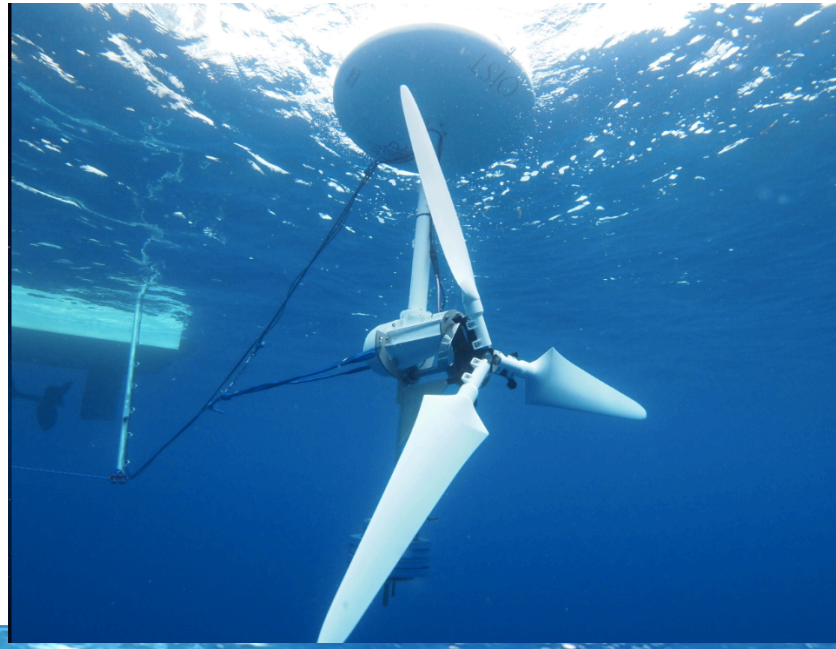
Wave

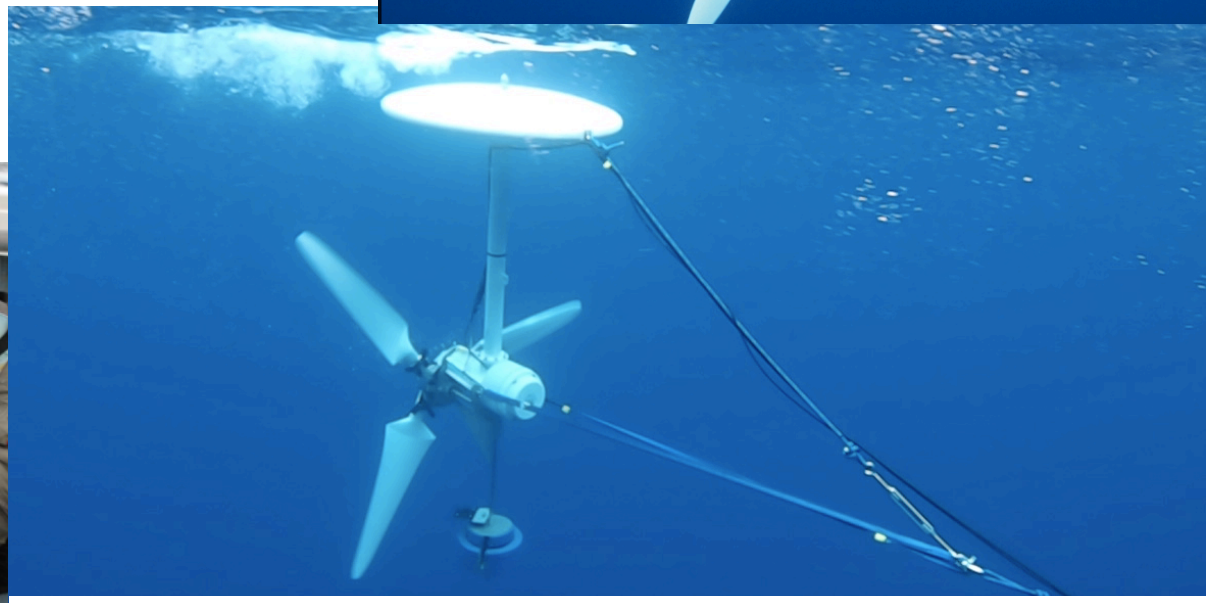


Reinforce by filling plastic Inside the blade.

2nd Field experiment at Maeda port, towing by fishing boat.

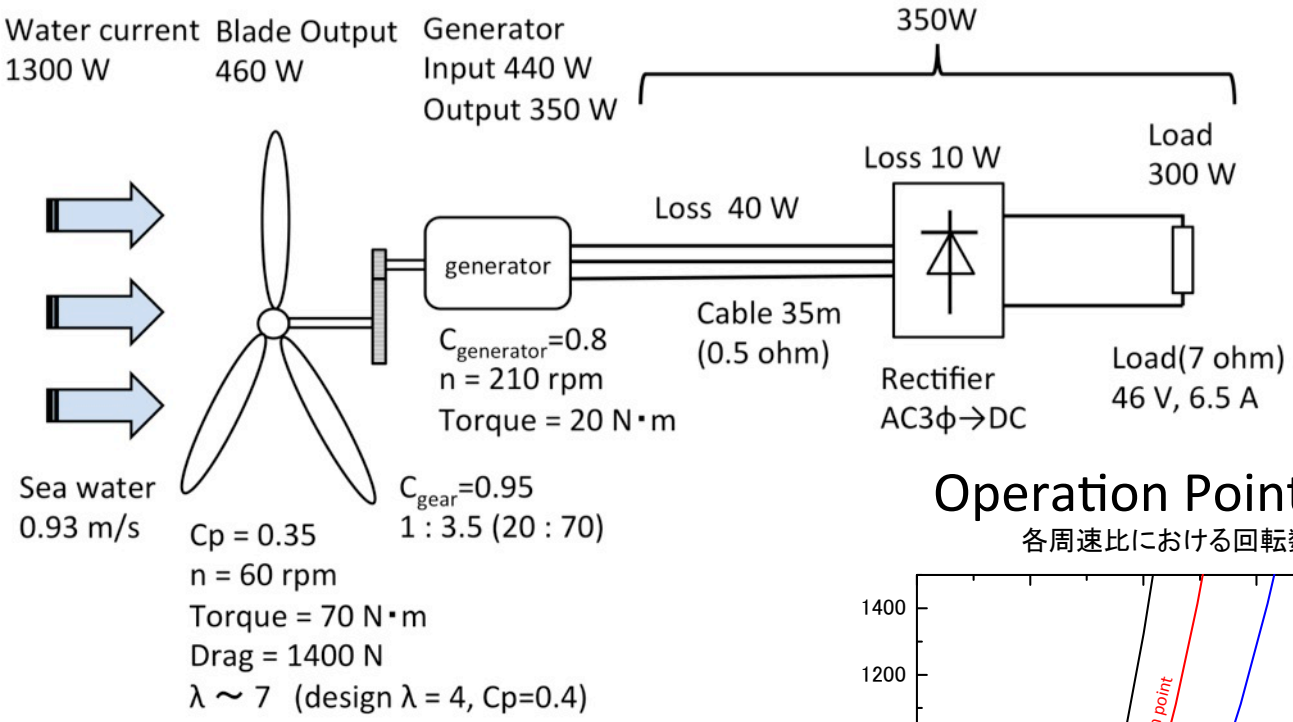






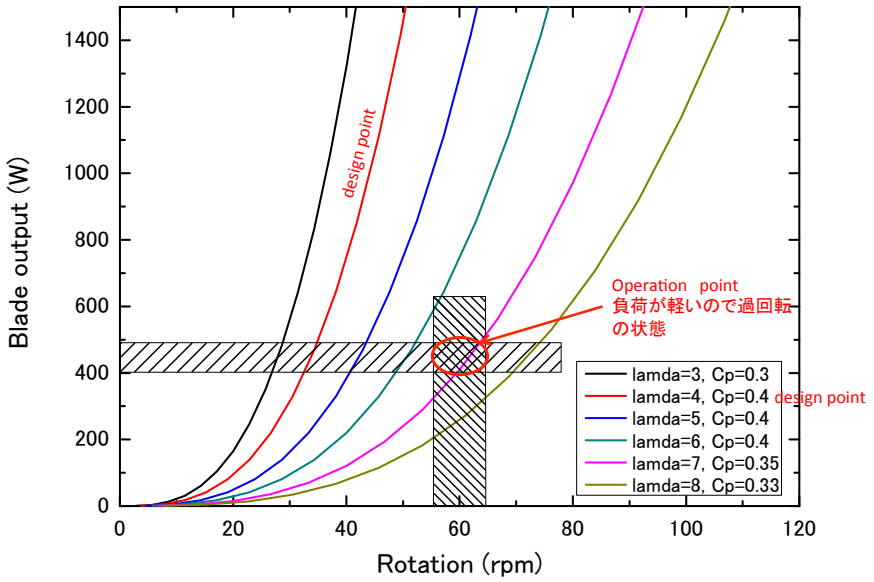
Towing at 1 m/sec, we obtained 400 Watt as expected.

Output power was measured carefully.



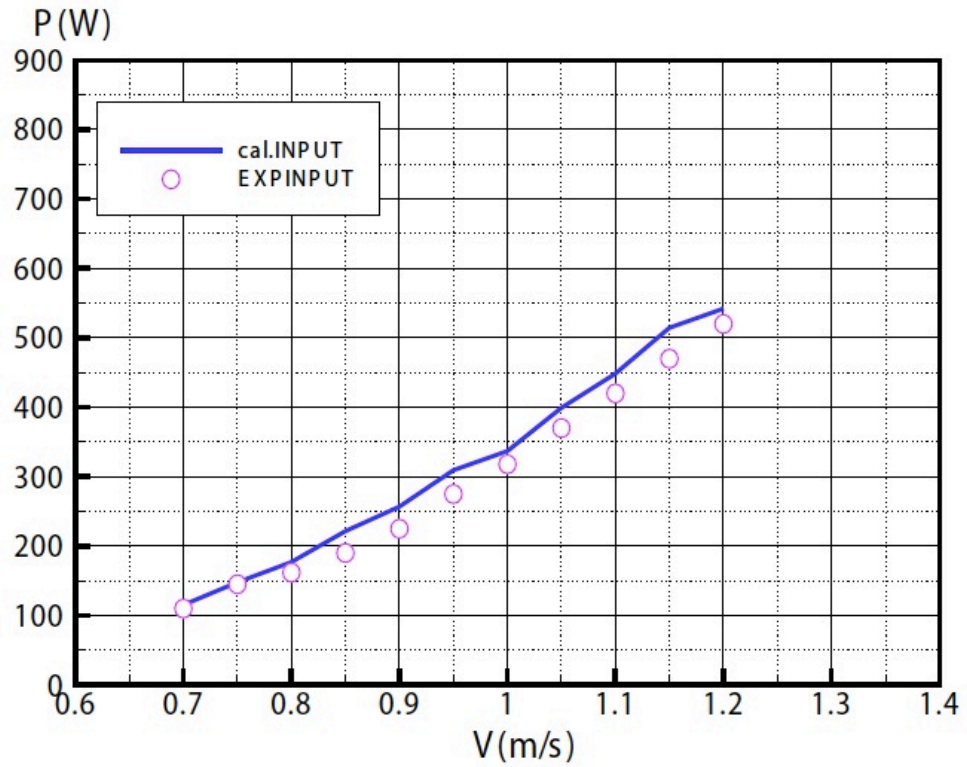
Operation Point(power)

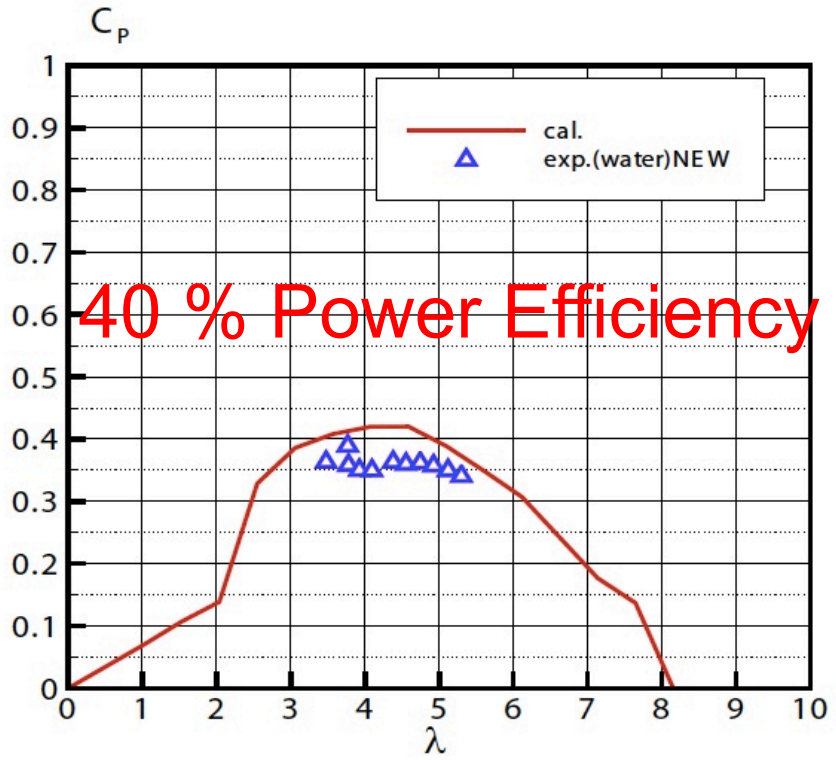
各周速比における回転数と発電量の関係



Testing in experimental pool.

Measured power and efficiency were good agreement with theory.





OIST Ocean Power R&D and HNK broadcasting team and local factory. 2012. Sept.

Collaboration with Hiroshima University for testing blades

Seahorse Project R&D Plan

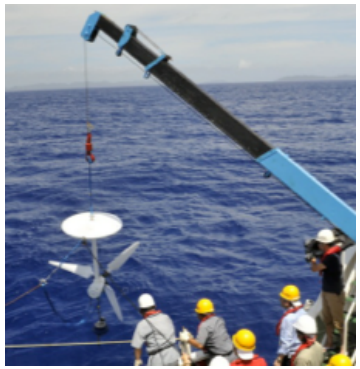
2012	2013	2014	2015	2016

2m Dia. Prototype Model
500 Watt

- Towing by boat
- Testing in pool

5 m Dia. Model
10 kW output

- Testing in field, at Churaumi Aquarium
- Fed into power grid.



Year 20XX

60m diameter, 1000kW
Tokawa island
H2 liquid hydrogen facility.

R&D Items → Target cost 1kWh ~ 10 Yen

- Protecting salt water leakage.
  Power generator, control and power cable.
- How to manage very high torque and drag force (~100 ton).
- Maintenance.
- Installation and restoration process.
- Protect blade surface from barnacle growing.

Wave Energy Converter (WEC) R&D

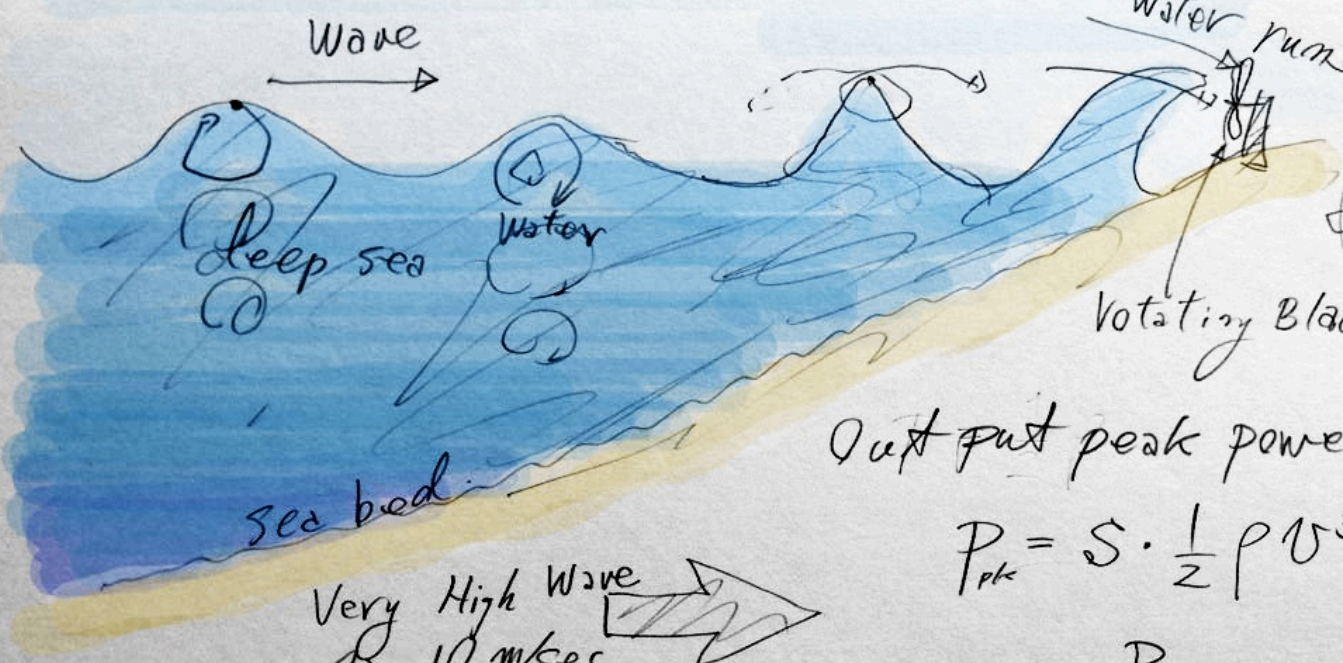
Laser speed meter

Chola Kalare
PhD Student at OIST
"Height is 3 m, speed is 15~30 km/h"

Strong water flow (~10m/sec) in the incoming wave rotate propeller shortly, generate pulse electric power.

T. Shintake
2013. Sept.

Wave Energy Plant using Rotating Propeller in Breaking Water



$S = \pi R^2$

$R \sim 1\,m$.

$S = 3\,m^2$

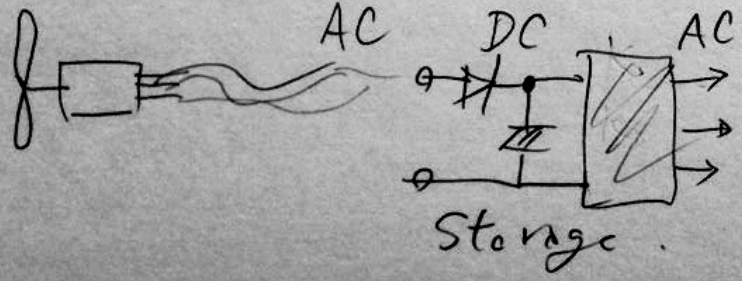
Very High Wave
$v \sim 10$ m/sec

Output peak power $v = 10$ m/sec

$$P_{pk} = S \cdot \frac{1}{2}\rho v^3 = 1.5 \times 10^3\,kg/m^3 \times 10^3\,(m/sec)^3$$

$$= 1.5\,MW$$

$$F = \frac{P}{v} = 1.5 \times 10^5\,N = 15\,ton!$$



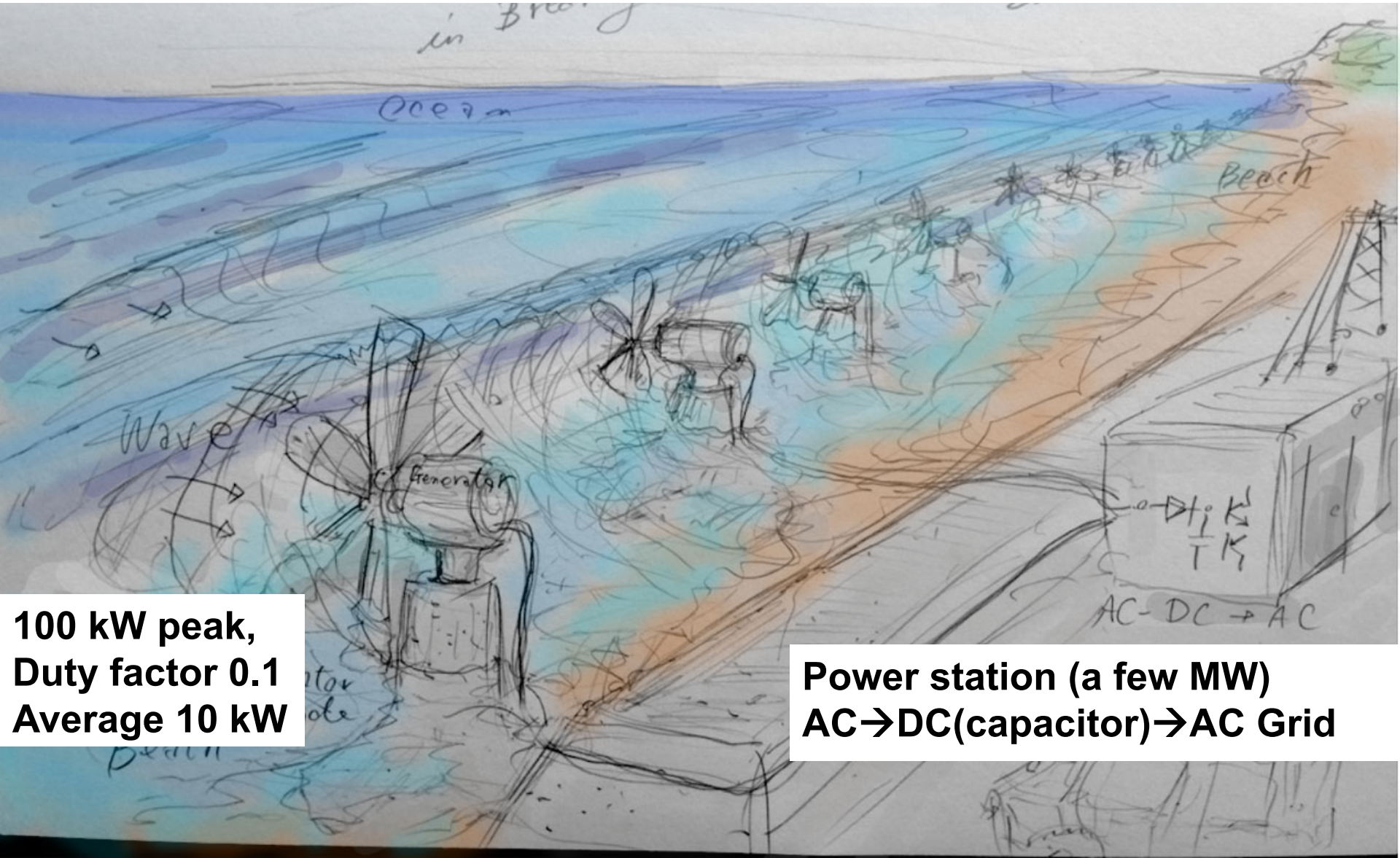
Time Average, 1 wave / 10 sec

$\langle P \rangle = 150$ kWatt.

If we have, 1000 unit,

$N\langle P \rangle = 150$ MW AC

Wave Energy Converter (WEC) acts as Tetrapod Wave Damper



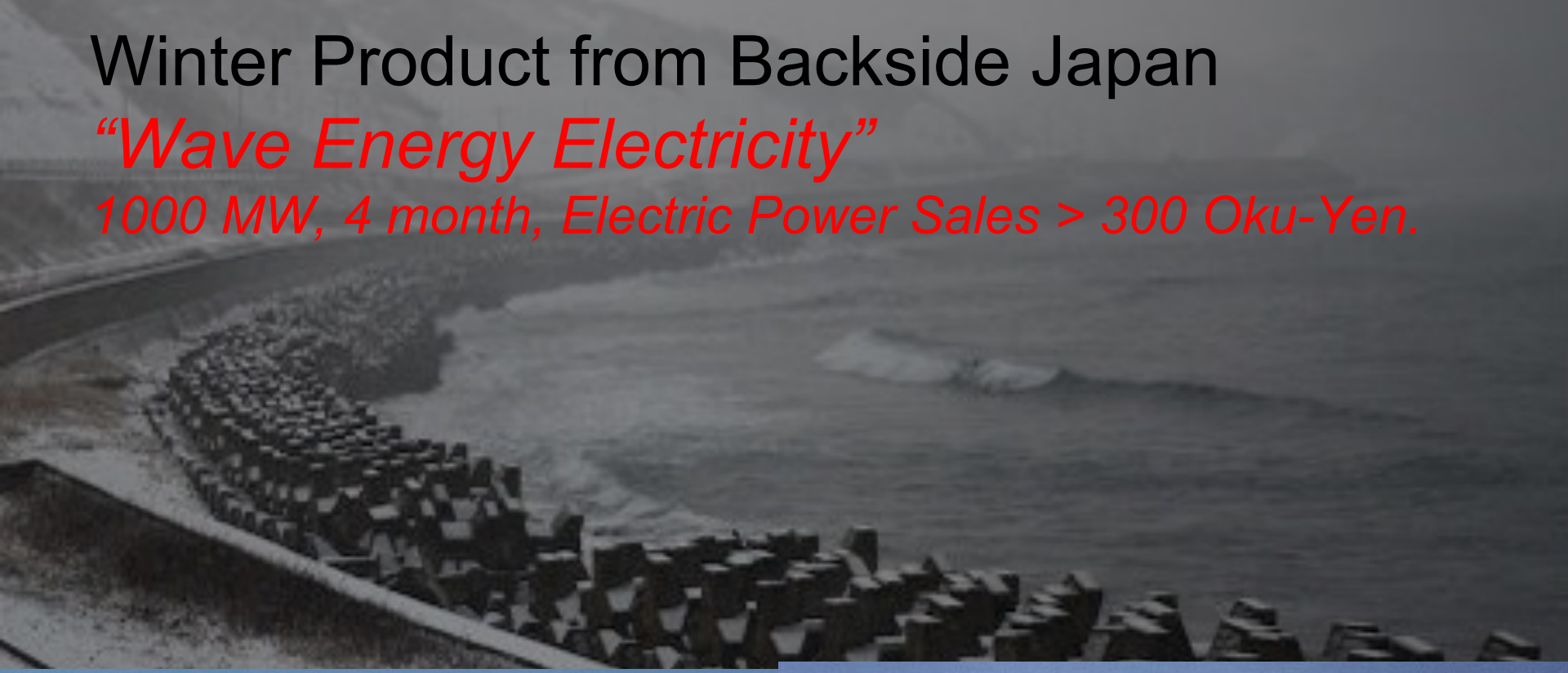
100 kW peak,
Duty factor 0.1
Average 10 kW

Power station (a few MW)
AC→DC(capacitor)→AC Grid

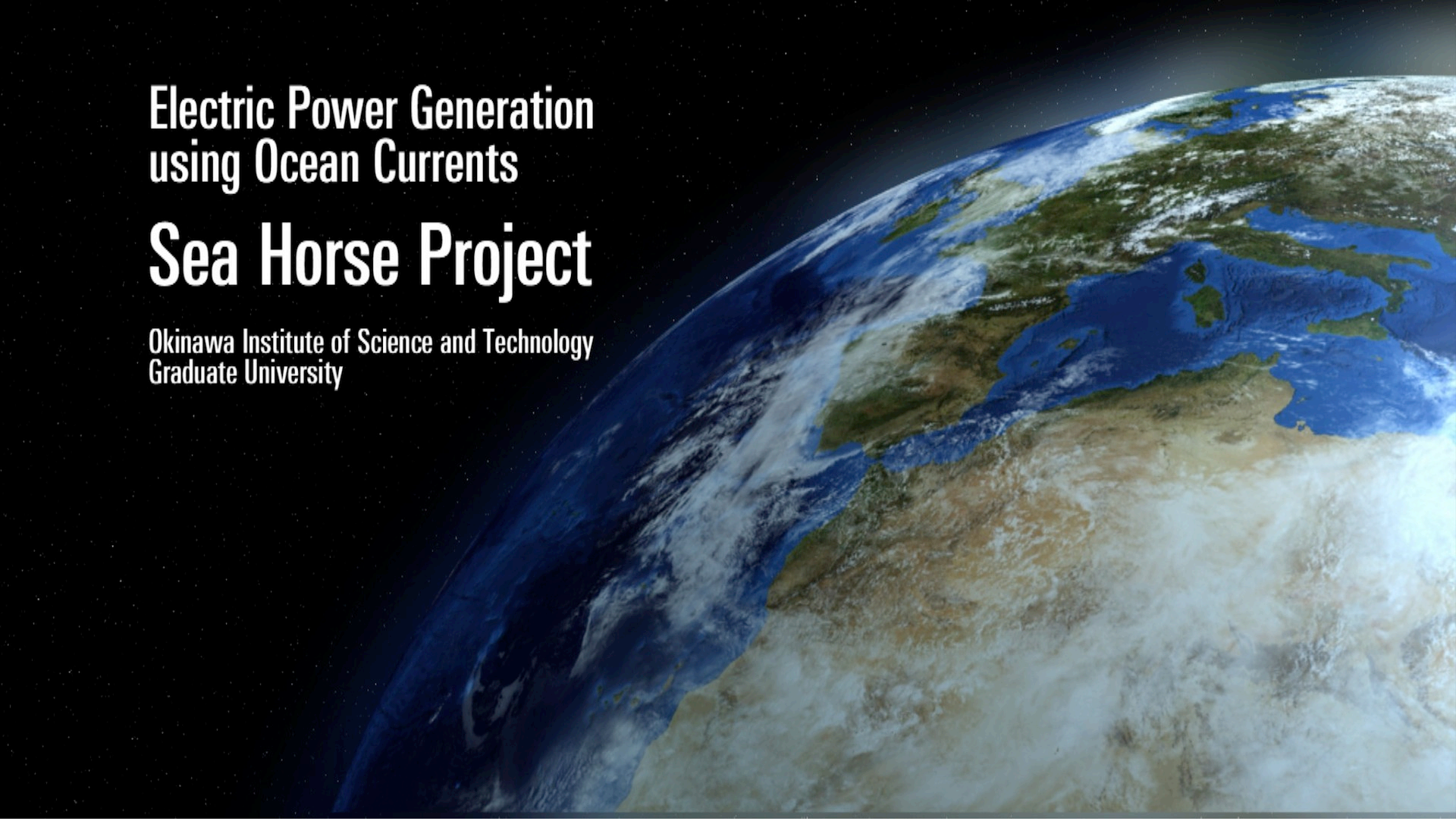
Winter Product from Backside Japan

"Wave Energy Electricity"

1000 MW, 4 month, Electric Power Sales > 300 Oku-Yen.



10,000 units generator x 100 kW
30 km site.



Welcome to the future.