



SAGA UNIVERSITY



International Joint Usage/Research Promotion Workshop

Mar. 9, 2026

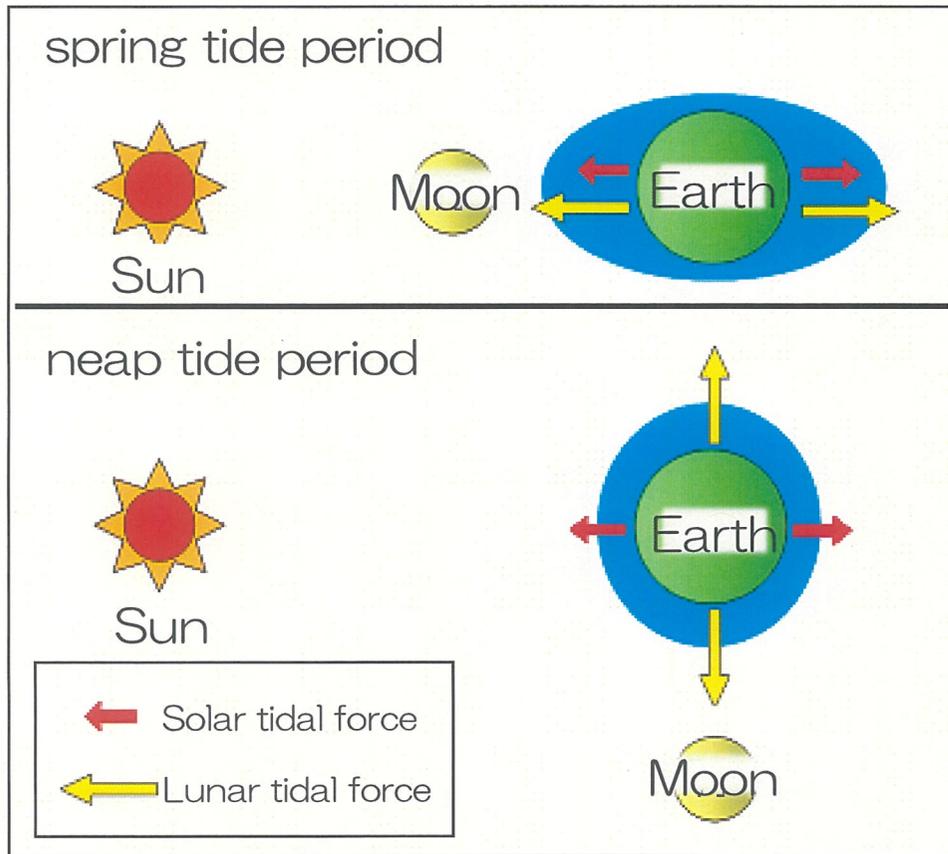
Activities and Research Overview in the Field of Tidal Current Energy Systems

Wakana Tsuru

Division of Tidal and Ocean Current Energy Systems

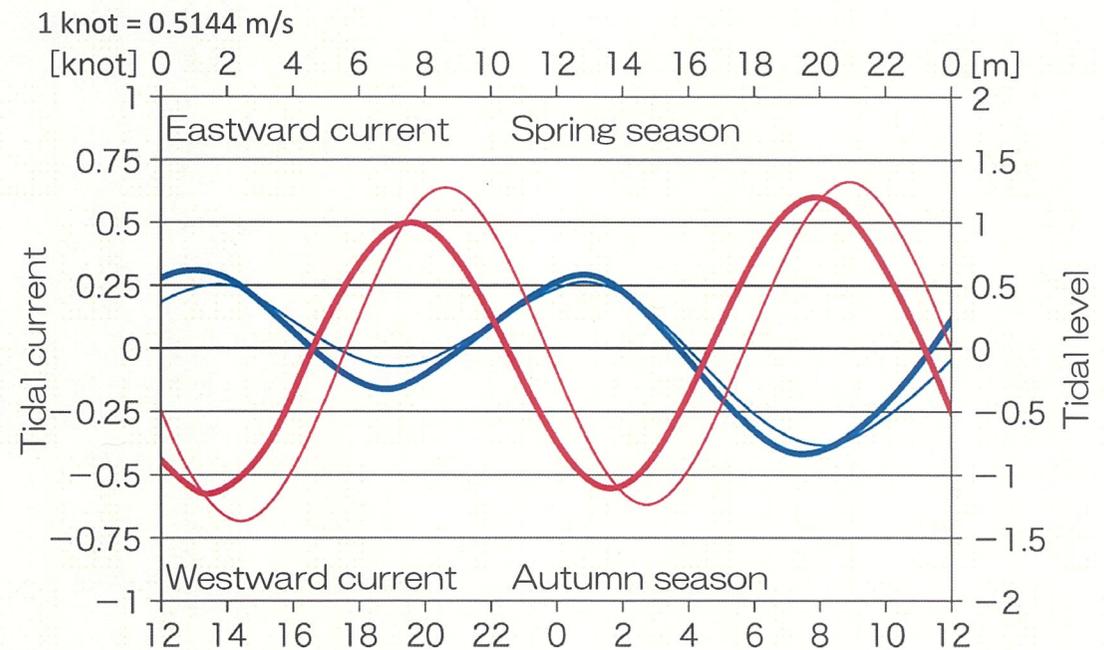
Institute of Ocean Energy, Saga University (IOES)

What is Tidal Current?



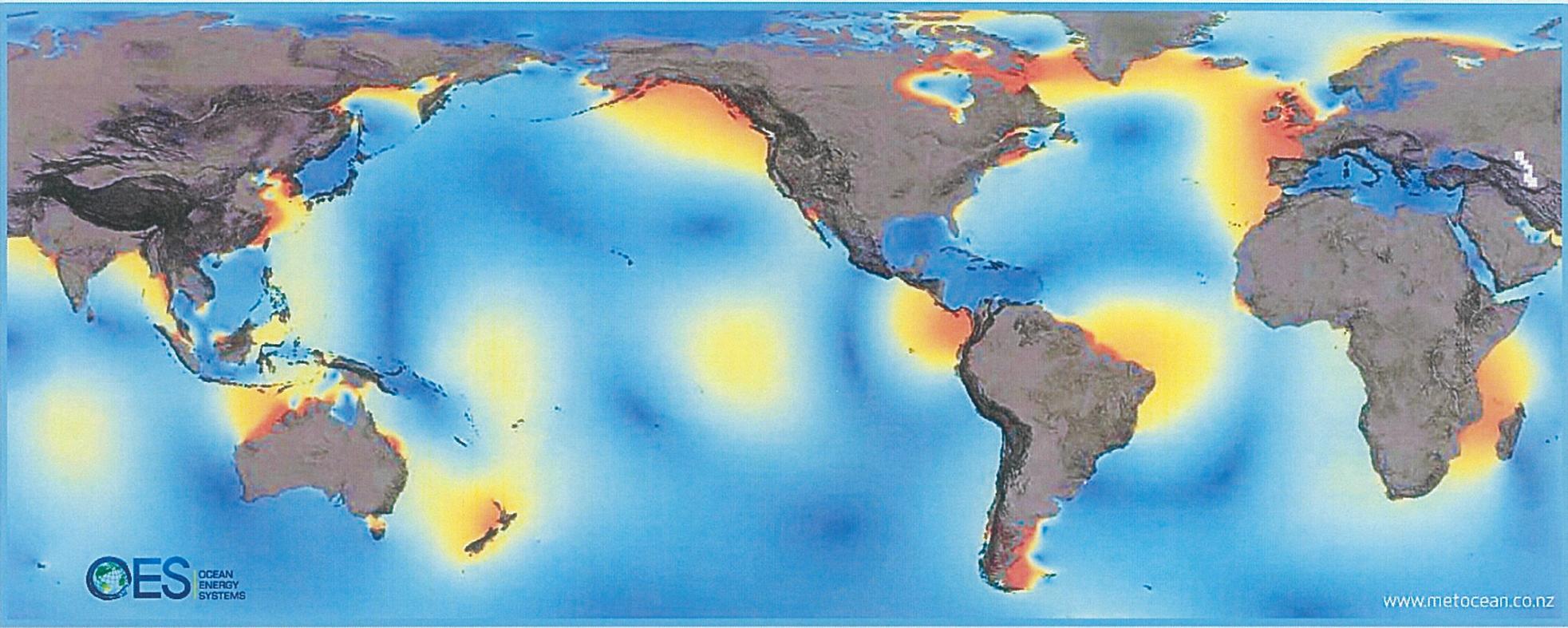
Characteristics

- ◆ Reversing flow (flood and ebb tides)
- ◆ Flow velocity can be predicted over long periods



Bold line : tidal current **thin line** : tide
red line : spring tide period **blue line** : neap tide period

Global Tidal Range Distribution

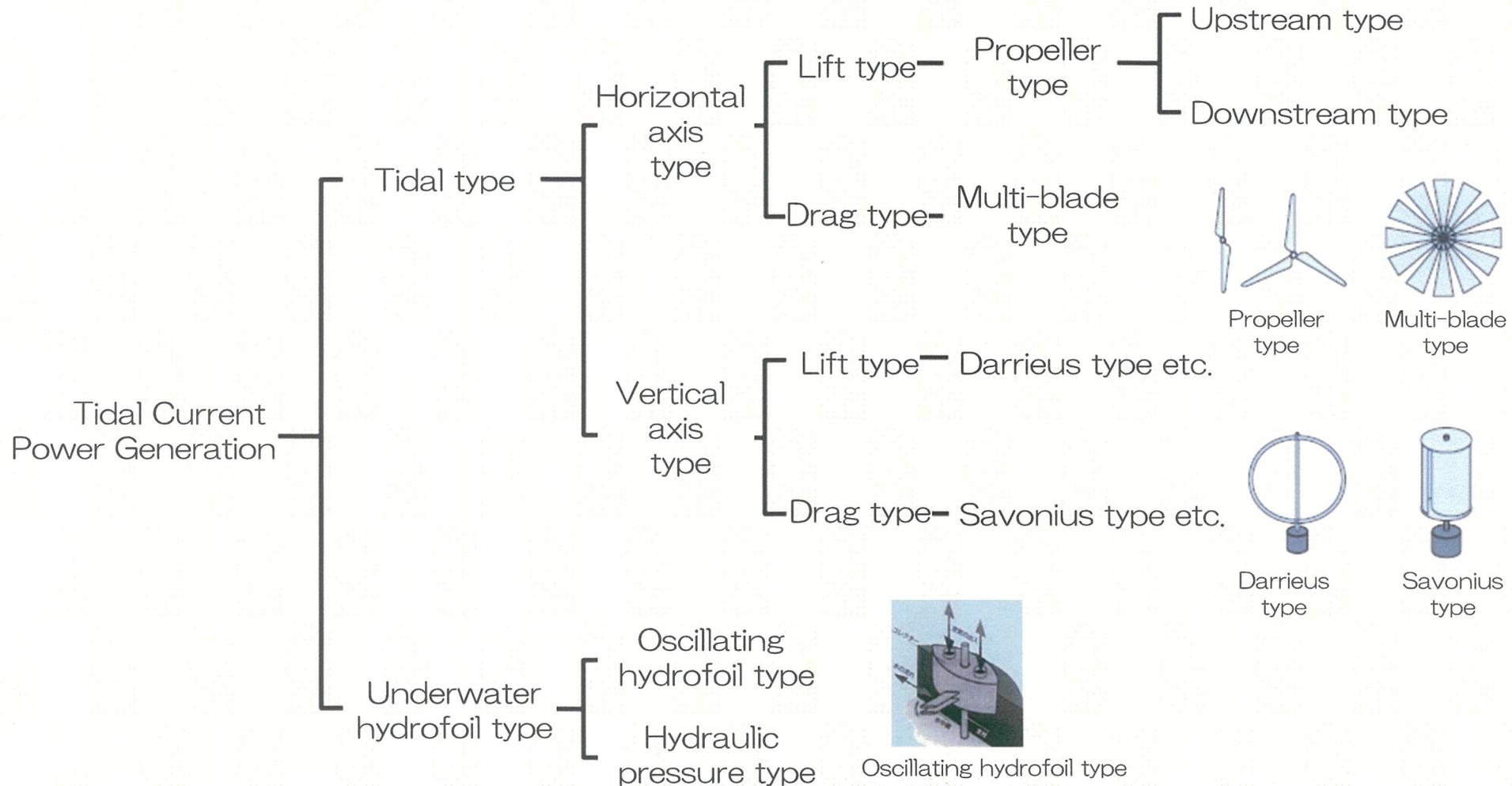


TIDAL RANGE (cm)

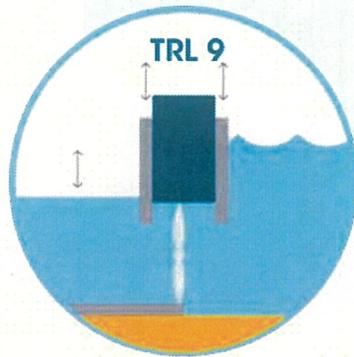


0 35 70 105 140

Types of Tidal Current Power Systems



Examples of Tidal Current Turbines (1)



Barrage

Water that entered an enclosed tidal basin with high tide is released in low tide and generates electricity by passing through turbines.



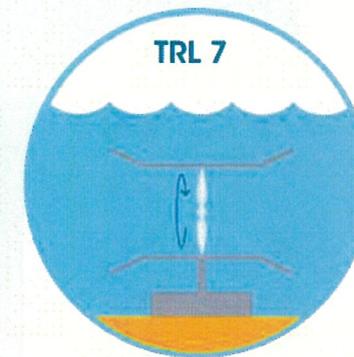
Horizontal-axis turbine

The tidal currents flow past blades that are radially attached to a horizontal shaft and cause rotation, thus generating power, much like a wind turbine underwater. Either the hub or blades need to turn 180 degrees to accommodate a reverse flow direction.



Vertical-axis turbine

The tidal currents flow through a set of blades parallel to a rotating shaft, generating power irrespective of the direction of the flow.



Enclosed tips (venturi)/ open-centre

The tidal stream's velocity is increased by concentrating it in a funnel or duct, in which a turbine is placed to generate energy.

Examples of Tidal Current Turbines (2)



TRL 5

Reciprocating device/ oscillating hydrofoil

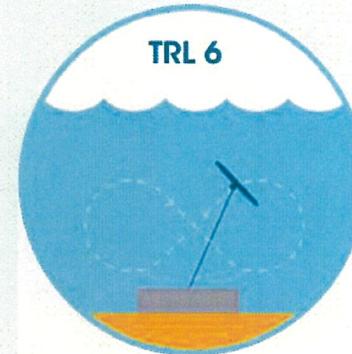
the tidal flow lifts an oscillating hydrofoil attached to an arm. This up-and-down movement drives a shaft or pistons to generate energy.



TRL 6

Archimedes screw/ spiral

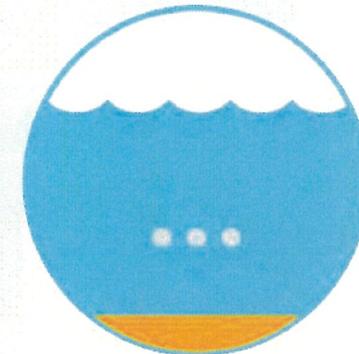
a tidal stream passes through the spiral of a helical-shaped impeller. The device starts to turn, and the rotation is converted into energy.



TRL 6

Tidal kite

A kite connected to the sea bed or to a floating platform moves through the tidal stream in an eight-shaped or linear trajectory. The relative velocity is increased and with it the electricity output.

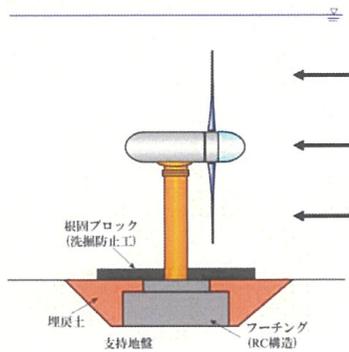


Other

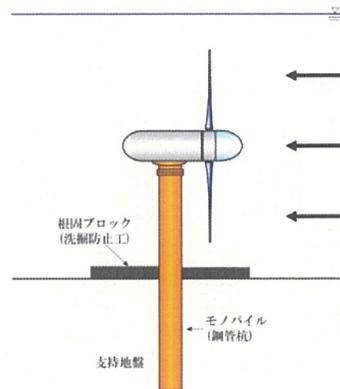
Other technologies have been investigated that either fit in none of the categories or incorporate various aforementioned characteristics.

Installation Methods for Tidal Turbines

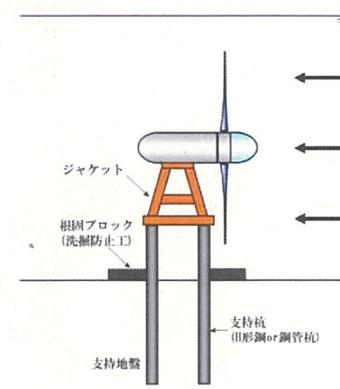
■ Fixed type



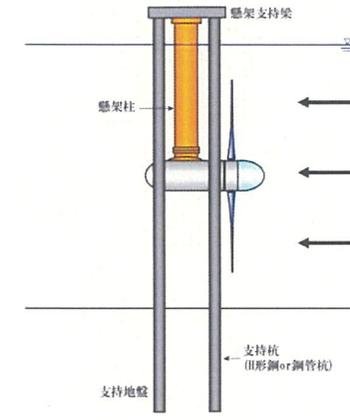
Gravity foundation



Monopile foundation

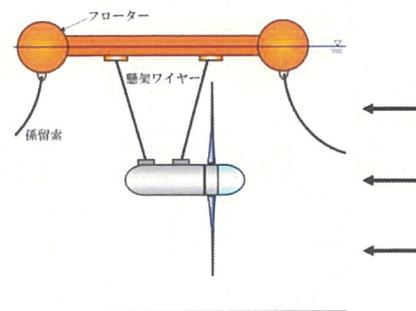


Jacket foundation

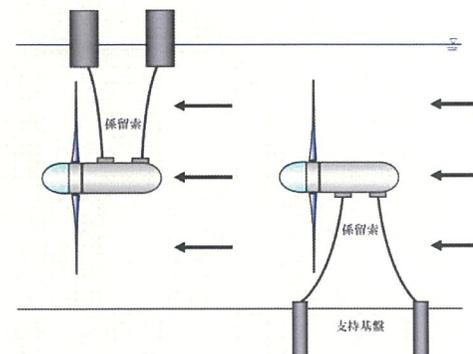


Suspended type

■ Floating and moored type

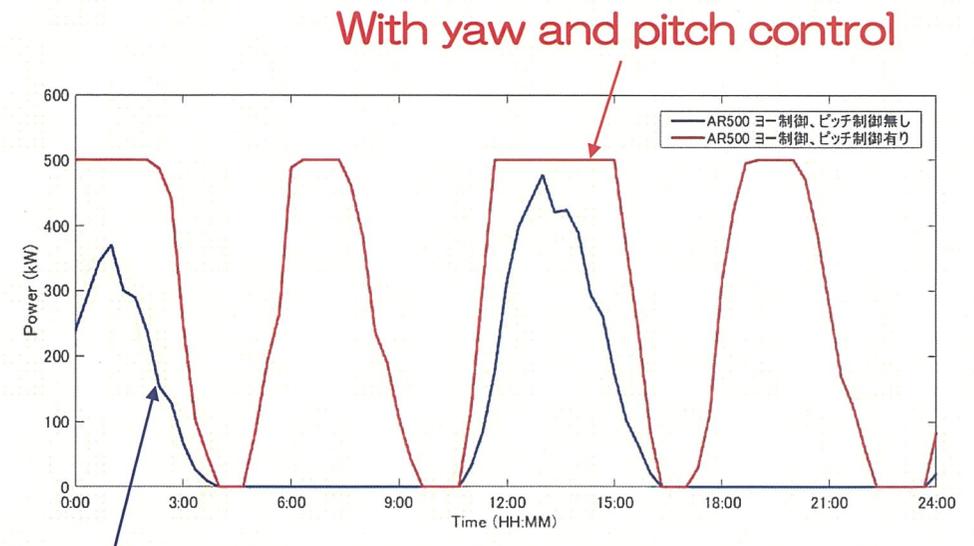
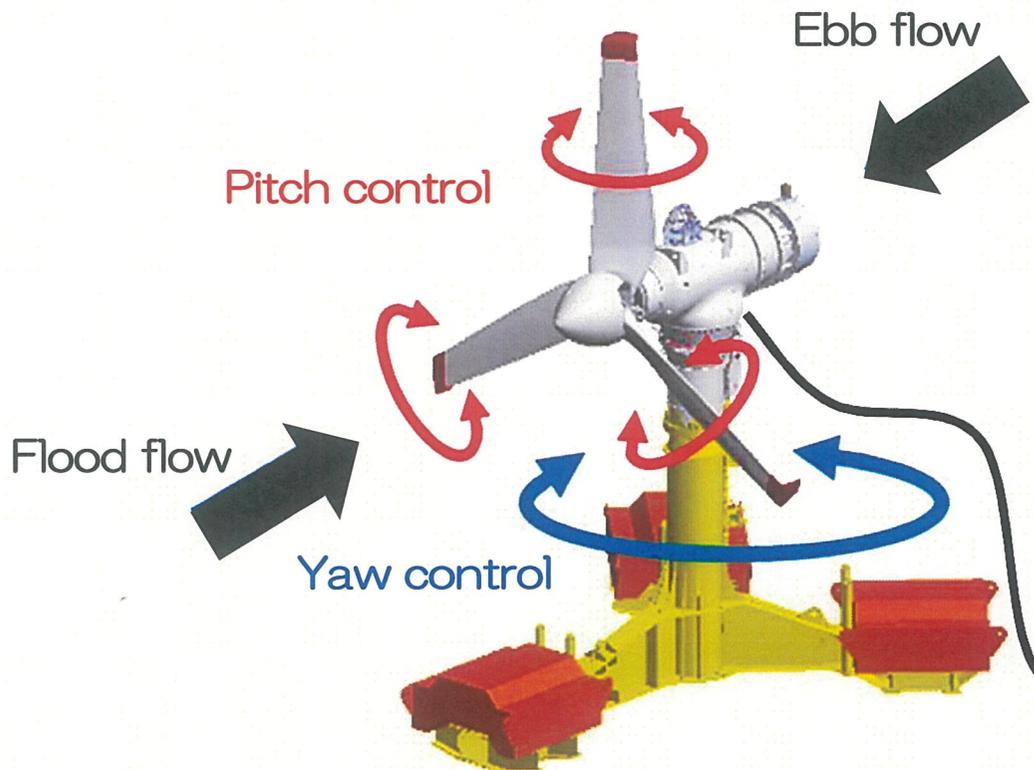


Floating type



Moored type

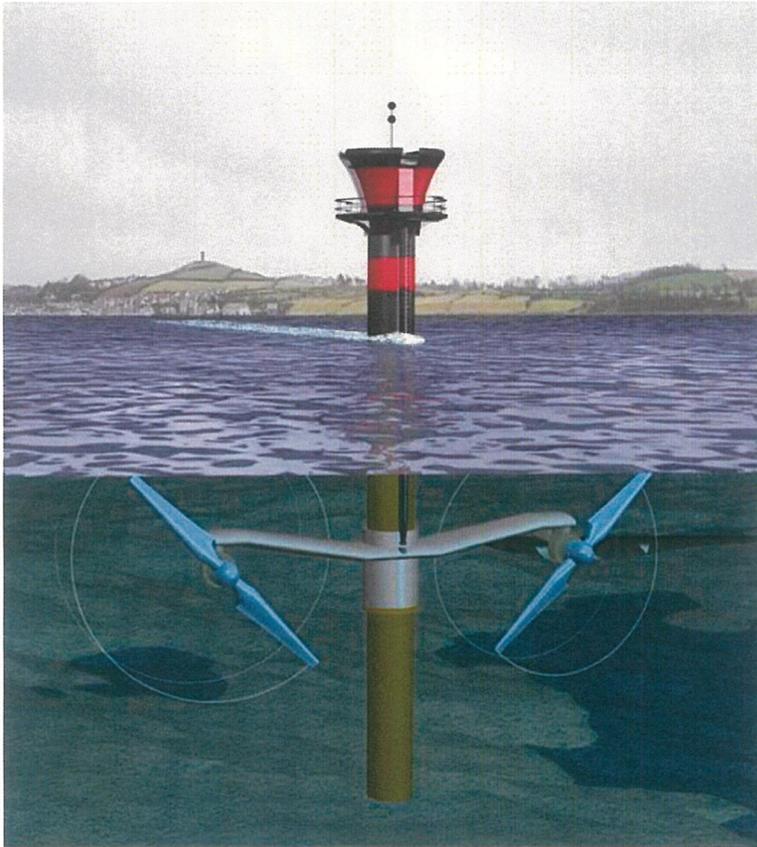
Adaptation to Reversing Flow (Fixed Type)



Without yaw and pitch control

Maintenance (Fixed Type)

- Special-purpose vessels are required for maintenance.

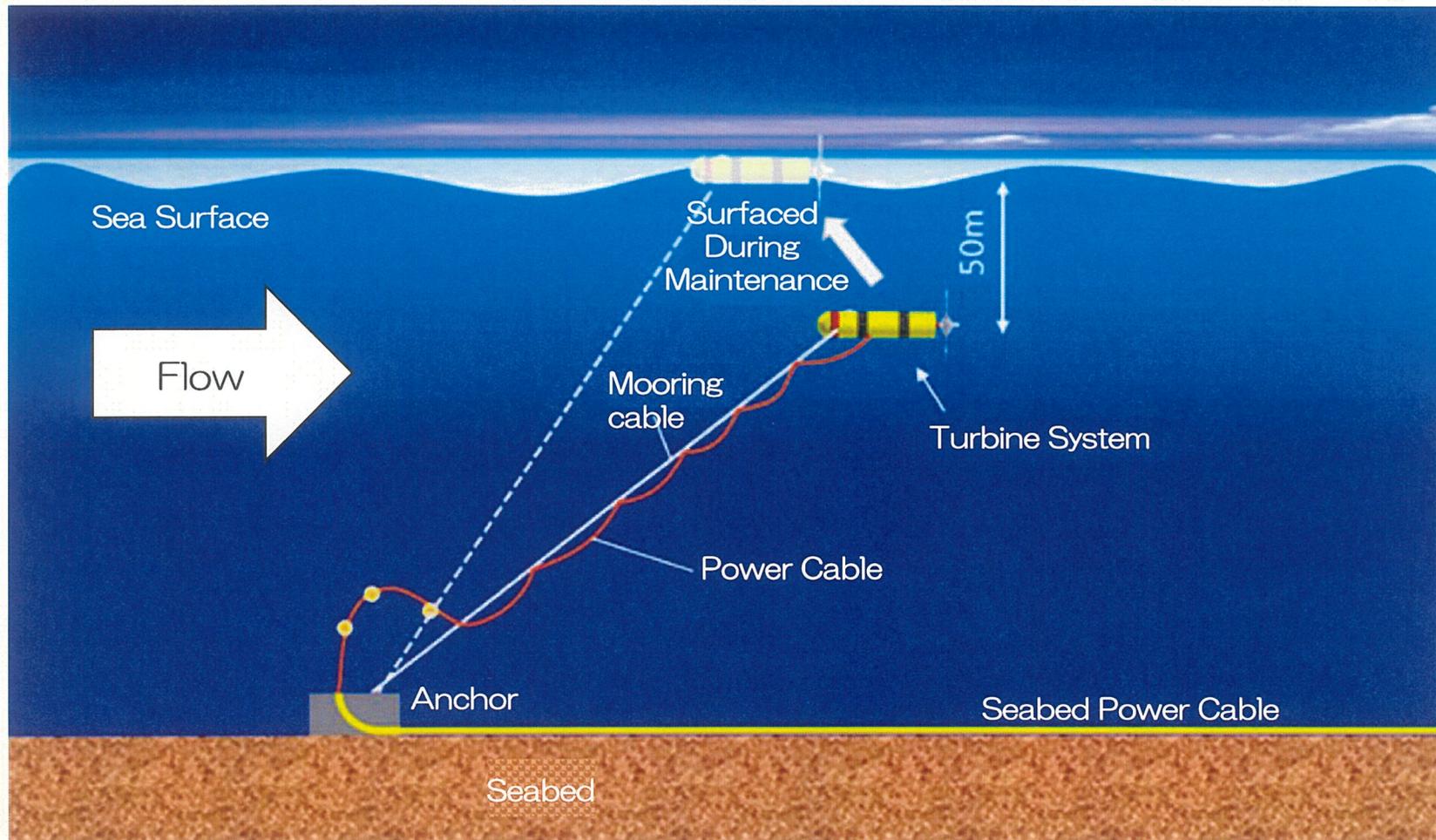


During Power Generation



During Maintenance

Adaptation to Bi-directional Flow (Floating and Moored Type)



Global Development and Demonstration of Tidal Current Turbines

Projects Highlights



2007~
Magallanes Renovables ATR © Magallanes Renovables



Orbital Marine Power's O2 turbine © Orbital Marine Power

5. Orbital Marine Power is already targeting the expansion of its project capacity, alongside the successful operation of the 2MW O2, the world's most powerful tidal turbine, at EMEC p. 10 2022~

12. 2020~
Minesto's tidal energy kite has been successfully operating at Faroe Islands and is progressing with the installation of a second device p. 17

6. Magallanes Renovables is progressing with its project in Wales after completion of a structured test programme at EMEC p. 11

2. Nova Innovation Tidal Array at Shetland Islands has accumulated years of operation p. 07 2016~



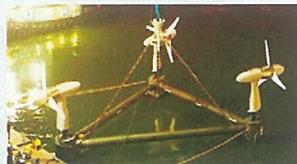
Nova M100-D tidal power turbine © Nova Innovation

13. 2019~
ORPC's RivGen Power System has been successfully delivering power to a remote Alaskan village p. 18



Sustainable Marine's PLAT-164 in Grand Passage, Nova Scotia © Sustainable Marine Energy

4. Sustainable Marine launched a new prototype at the Bay of Fundy harnessing the power of the world's largest tides p. 09 2022~



Verdant Power's project at East Channel of the East River © Verdant Power

3. Verdant Power completed its project in New York's East River with valuable insights on installation, operation, and maintenance p. 08 2020~

7. 2016~
Tocado's Oosterschelde Tidal Power Plant in the Netherlands resumed its full continuous operations p. 12



Tocado's Oosterschelde Tidal Power Plant © Tocado

11. 2021~
Uldolmok Tidal Power Pilot Plant in Korea completed two years of electricity generation p. 16



LHD Zhoushan tidal power station © LHD New Energy Corporation



SIMEC Atlantis deployed at MeyGen © SIMEC Atlantis

1. MeyGen, the world's largest tidal array has delivered over 50 GWh to the grid p. 06 2018~



Sabella D10 deployed at in the Fromveur Passage at Ushant Island © Sabella

8. Sabella's 1MW tidal turbine has been operating successfully off the Western coast of Britany, in one of the French hotspots for tidal resource p. 13 2015~

9. HydroQuest is designing the next generation turbine to be installed at the Raz-Blanchard, Normandy, integrating the learnings from the 1 MW pilot project p. 14 2019~

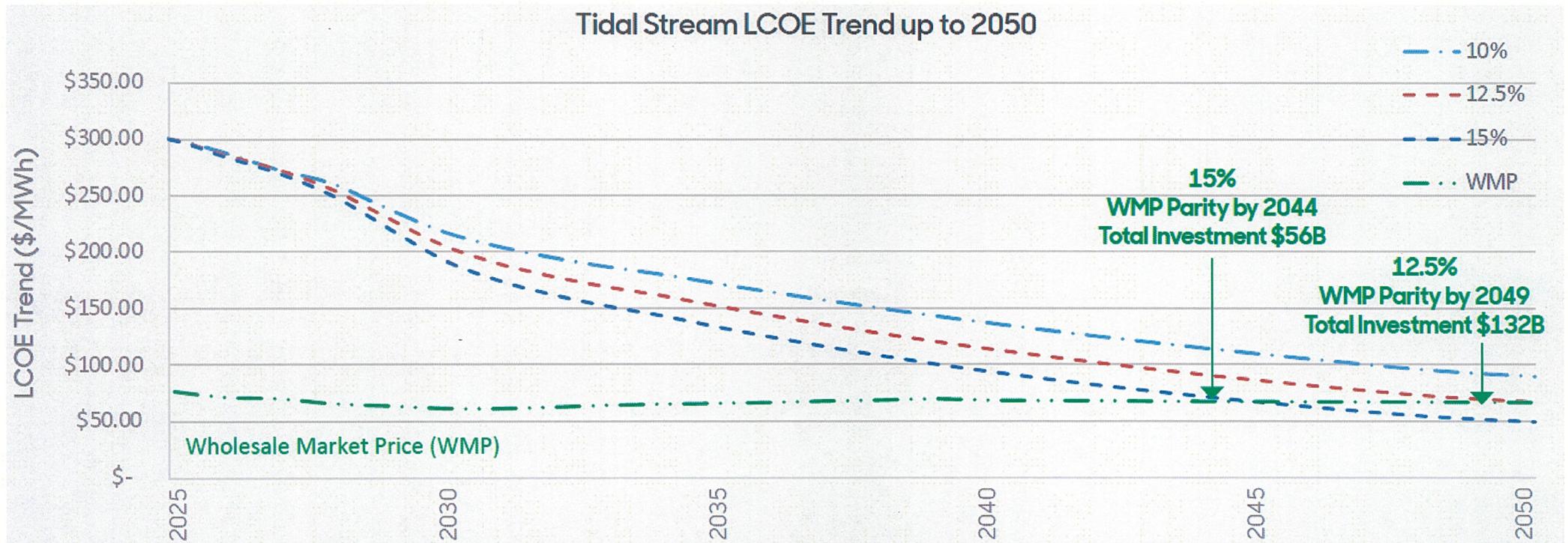


1 MW turbine deployed on Paimpol-Bréhat test site in Brittany © HydroQuest

Global Deployment Target for Tidal Current Energy



- Target: 120 GW by 2050
- ➔ cost reduction rate of about 12.5% is required
- ➔ Improvement of turbine performance, Increase in rated power output, Reduction of overall system cost



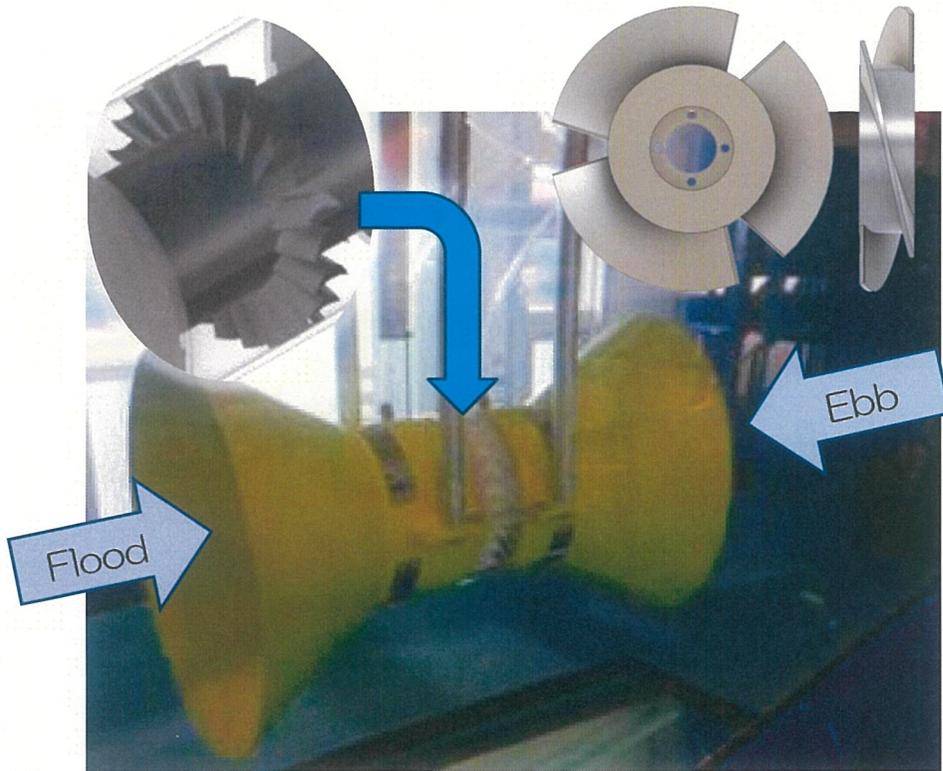
Objectives of IOES Tidal Current Power System Research

- First-stage target LCOE : 23 JPY/kWh (First Grid Parity)
 - ↳ Output equation $P = C_p \times \left(\frac{1}{2}\rho V_m^3 A\right)$ ⇒ Increasing A can enhance power output
- Larger turbines are cost-effective, but tidal sites have narrow channels
Maximum feasible diameter: ~30 m, maximum output: ~3 MW
(Frazer-Nash, Department for Energy Security & Net Zero, 2023)
 - ↳ Further enlargement is not practical for tidal sites
- ➔ Cost reduction must rely on other approaches
- Future Research Activities
 - Increase power output
 - Extend lifespan
 - Reduce weight
 - Improve rated capacity
 - Develop turbine farms
 - Standardization of domestic manufacturing lines→ Target LCOE: 23 JPY/kWh



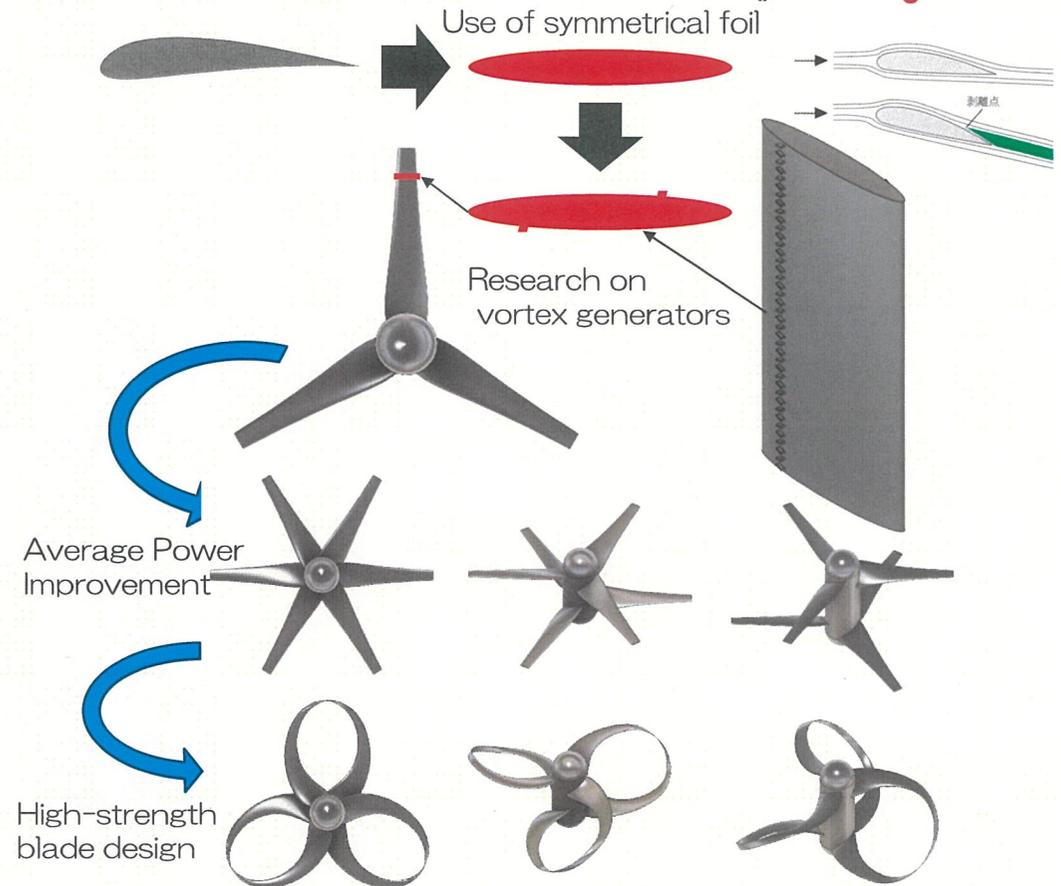
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https://www.q-mirai.co.jp/files/optionallink/00000285_file.pdf?1621647289

Approaches to Solving Technical Challenges



Ducted Turbine :

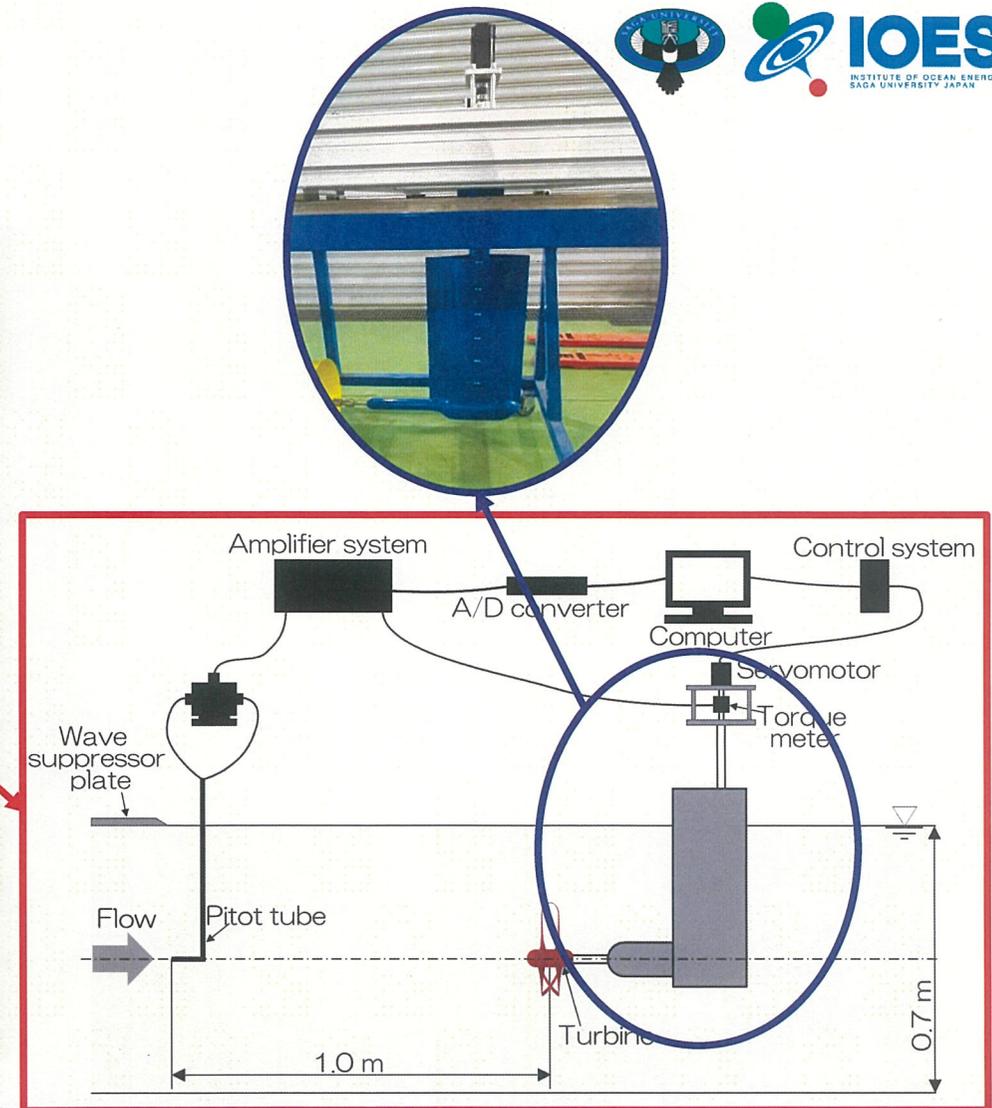
- ◆ Utilizes symmetrical ducts to capture more tidal energy
- ◆ Enables high power output without yaw control



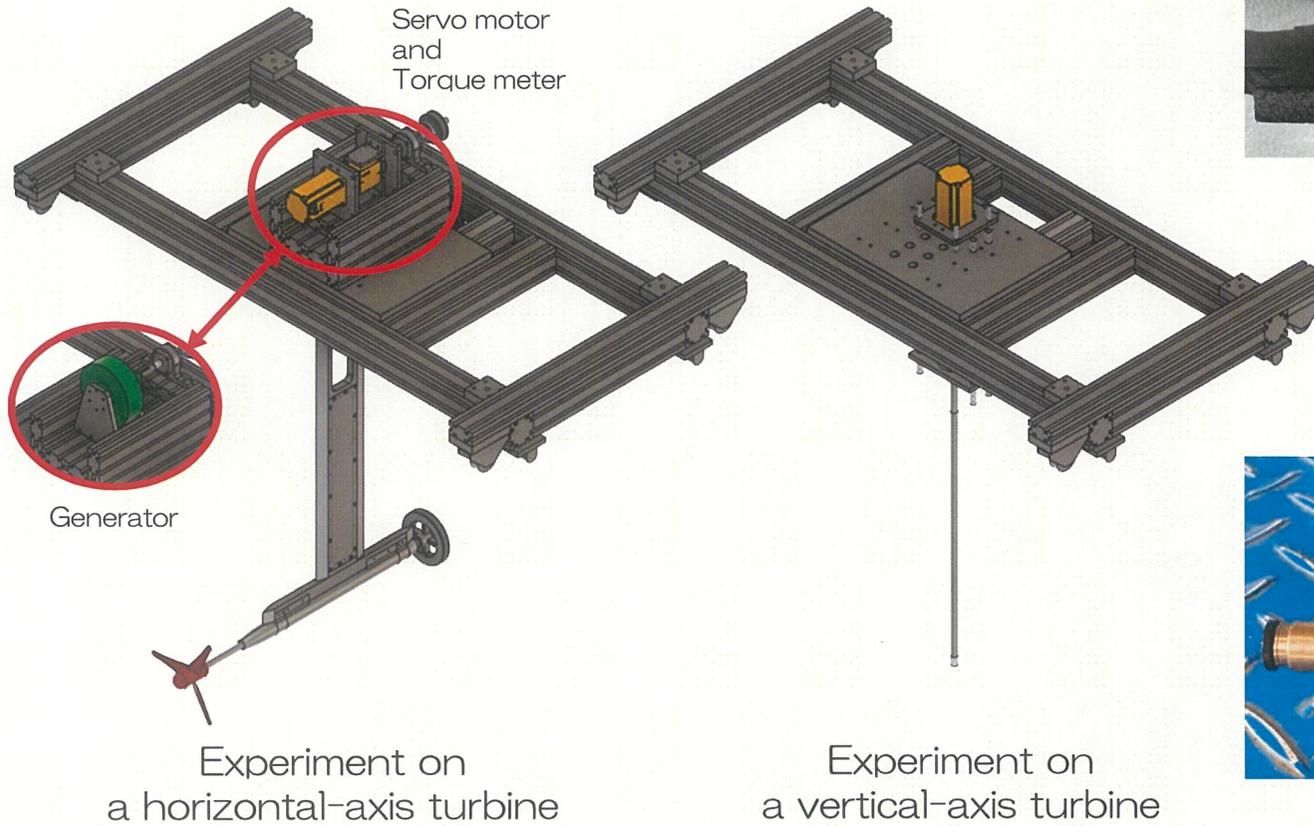
High-Strength Turbine without Yaw Control :

- ◆ Development high-output, high-strength turbine
- ◆ Development of a highly practical turbine.

Experimental Apparatus



Other Experimental Equipment and Instruments



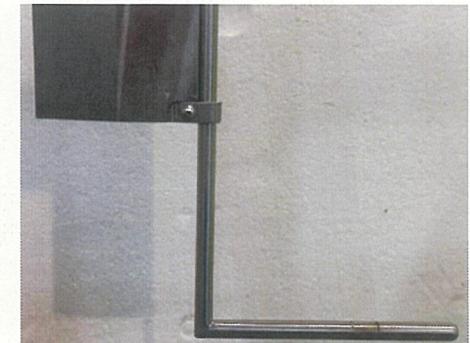
Tachometer



Three-component force sensor



Differential pressure gauge



Pitot tube

Thank you for your kind attention.

Wakana Tsuru
tsuruw@cc.saga-u.ac.jp