SAGA UNIVERSITY

IOES
INSTITUTE OF OCEAN ENERGY
SAGA UNIVERSITY JAPAN

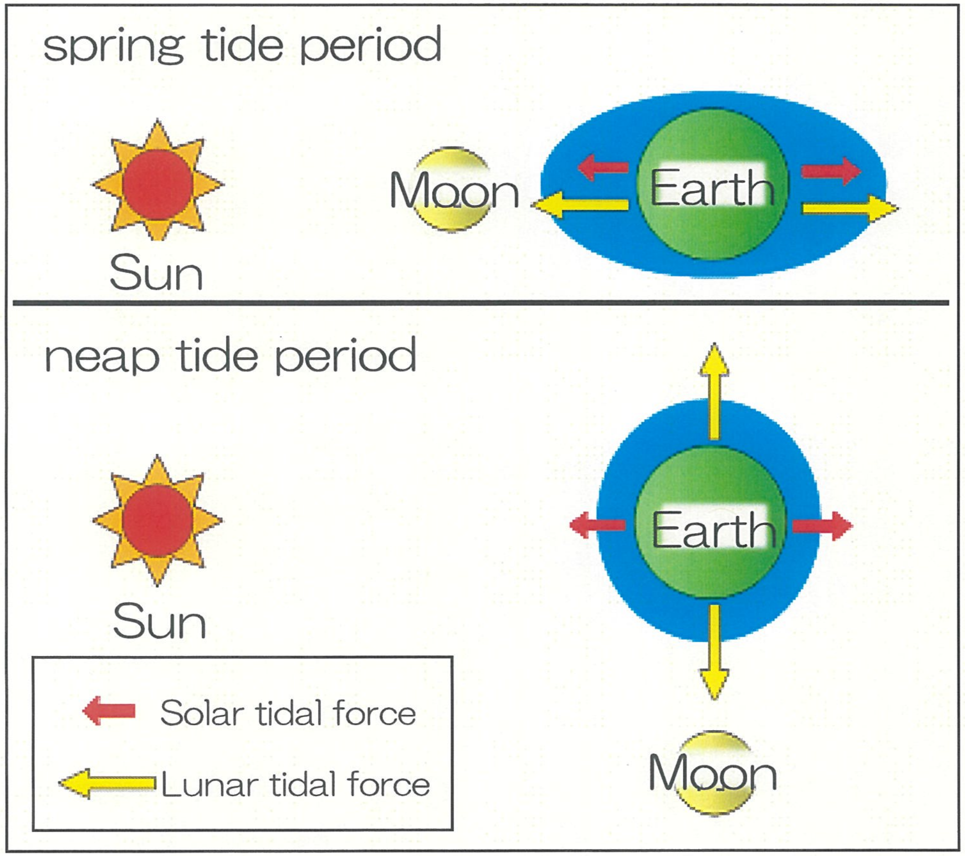
International Joint Usage/Research Promotion Workshop

Mar. 9, 2026

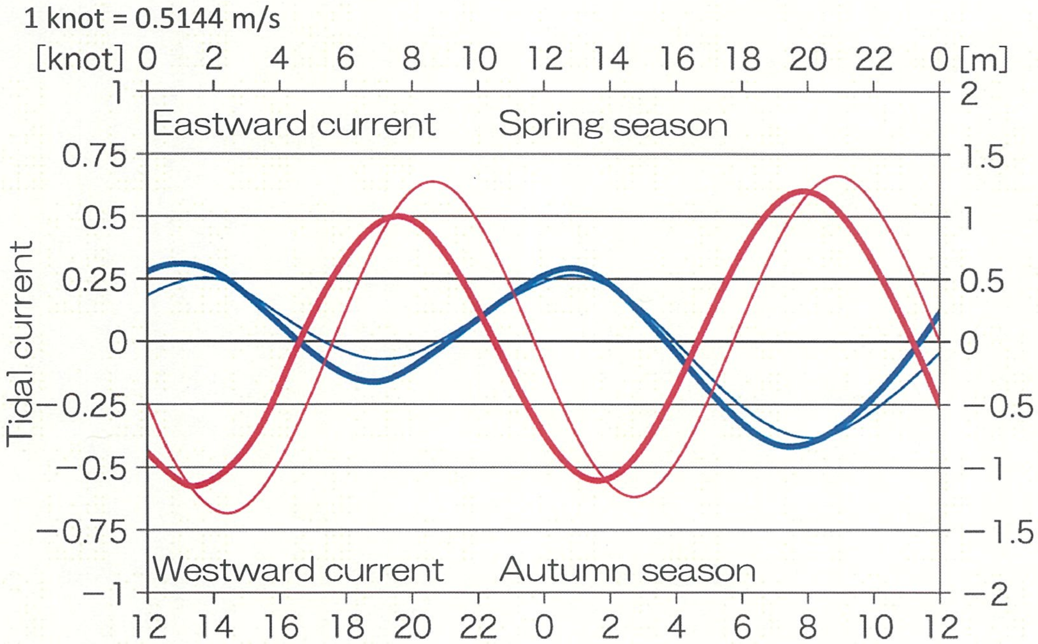
Activities and Research Overview in the Field of Tidal Current Energy Systems

Wakana Tsuru
Division of Tidal and Ocean Current Energy Systems
Institute of Ocean Energy, Saga University (IOES)

What is Tidal Current?



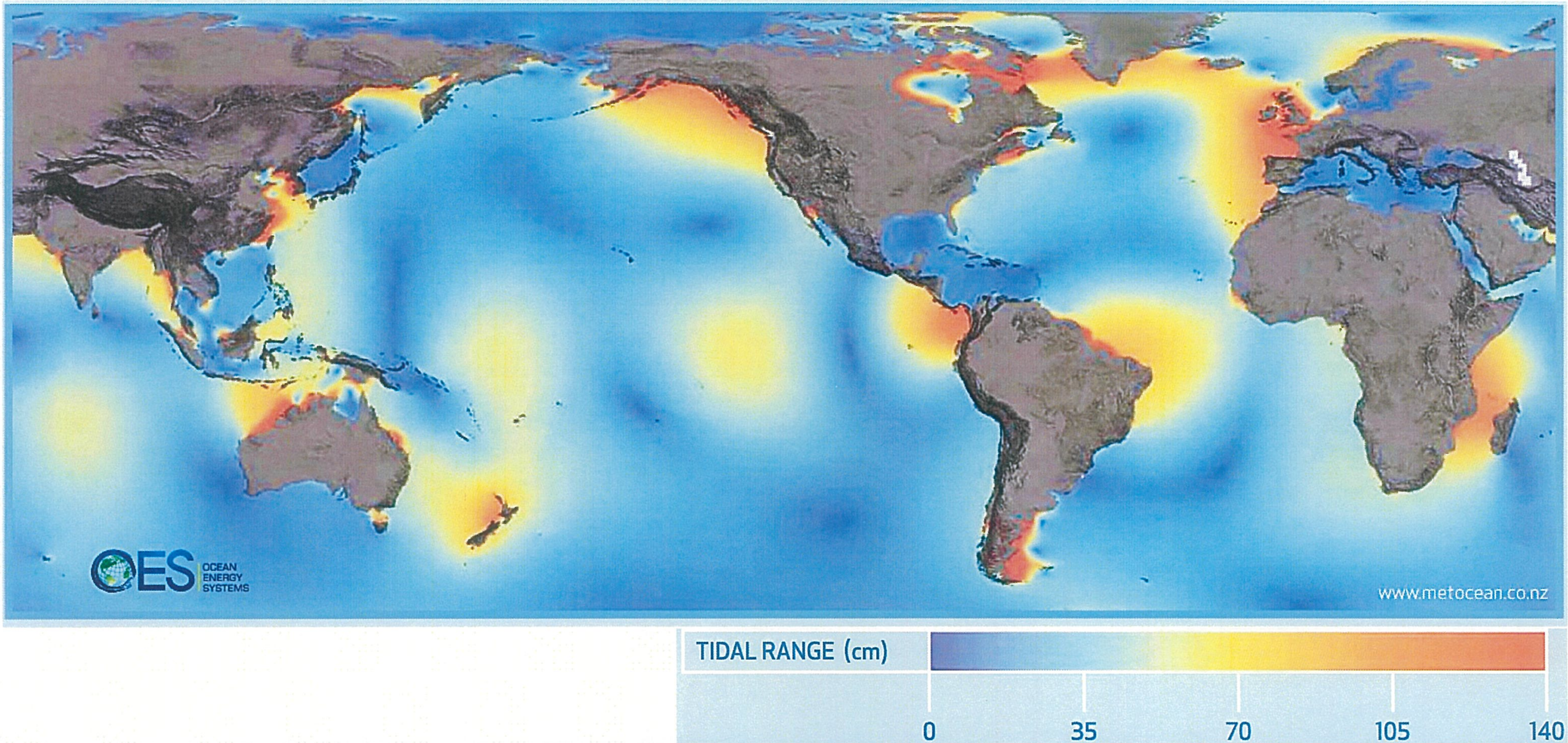
- Characteristics
  - Reversing flow (flood and ebb tides)
  - Flow velocity can be predicted over long periods



Bold line : tidal current thin line : tide

red line : spring tide period blue line : neap tide period

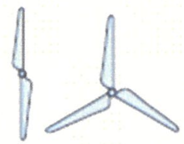
Global Tidal Range Distribution



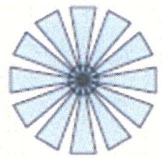
An International Vision for Ocean Energy (2012, IEA-OES)

Types of Tidal Current Power Systems

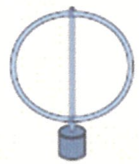
- Tidal Current Power Generation
  - Tidal type
    - Horizontal axis type
      - Lift type – Propeller type
        - Upstream type
        - Downstream type
      - Drag type – Multi-blade type
    - Vertical axis type
      - Lift type – Darrieus type etc.
      - Drag type – Savonius type etc.
  - Underwater hydrofoil type
    - Oscillating hydrofoil type
    - Hydraulic pressure type



Propeller type



Multi-blade type



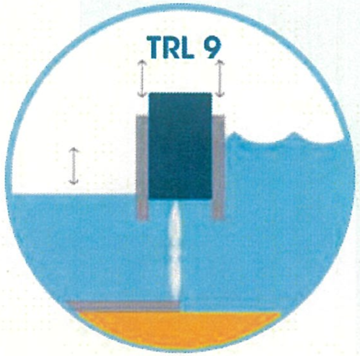
Darrieus type

Savonius type

Oscillating hydrofoil type

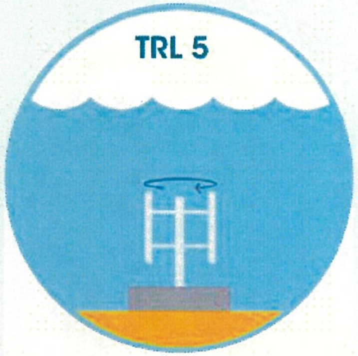
Japan Association of Marine Construction, Marine Energy Development Technology in the 21st Century (2006)
Usui, Ph.D. Thesis, Kyushu Institute of Technology (2015)

Examples of Tidal Current Turbines (1)

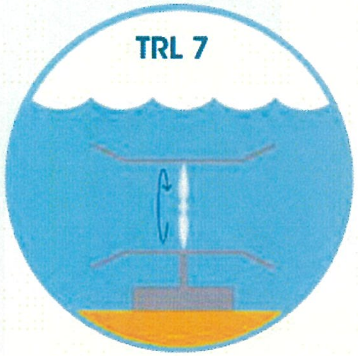


Barrage
Water that entered an enclosed tidal basin with high tide is released in low tide and generates electricity by passing through turbines.

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.

IRENA, 2020, Innovation outlook: Ocean energy technologies, International Renewable Energy Agency, Abu Dhabi

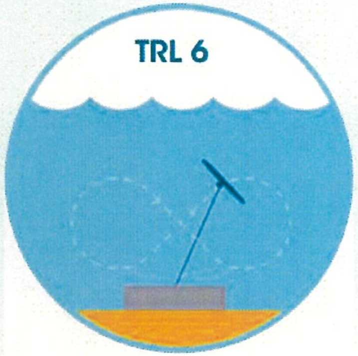
Examples of Tidal Current Turbines (2)

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.

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.



Tidal kite

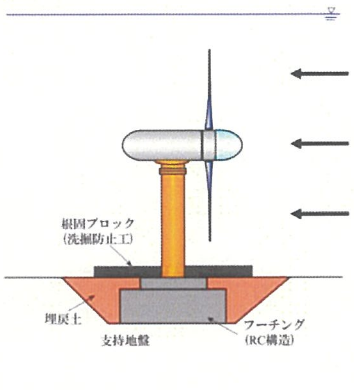
A kite connected to the sea bed or to a floating platform moves through the tidal stream in an eight-shaped or linear trajectory. The relative velocity is increased and with it the electricity output.

Other

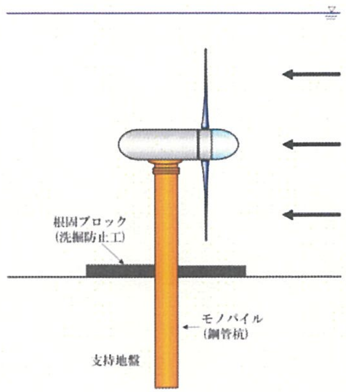
Other technologies have been investigated that either fit in none of the categories or incorporate various aforementioned characteristics.

Installation Methods for Tidal Turbines

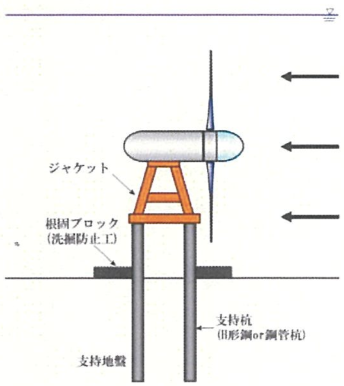
■Fixed type



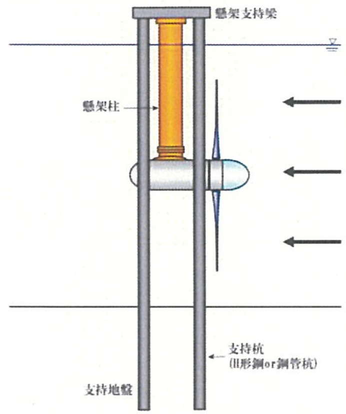
Gravity foundation



Monopile foundation

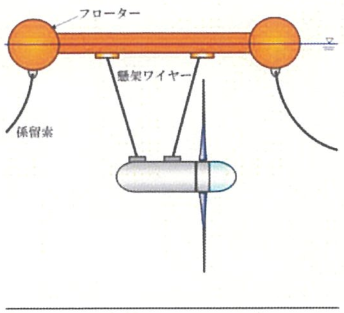


Jacket foundation

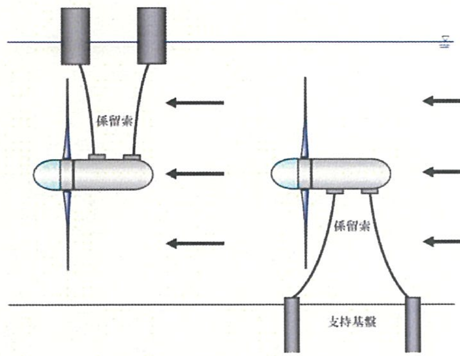


Suspended type

■Floating and moored type

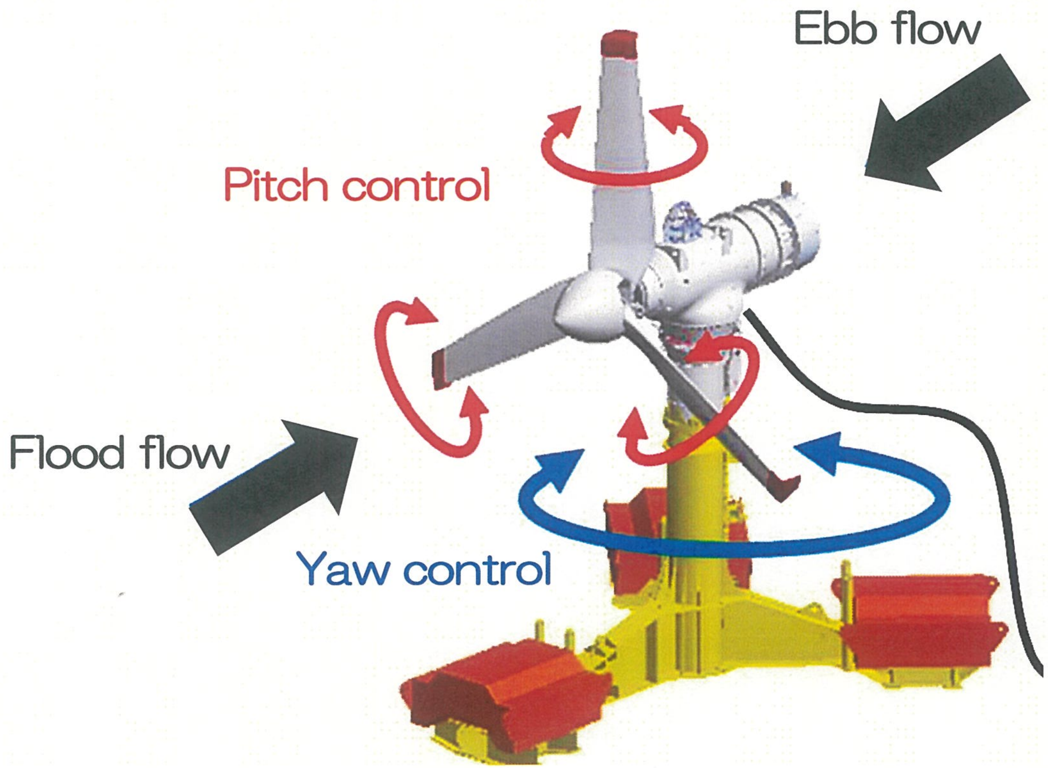


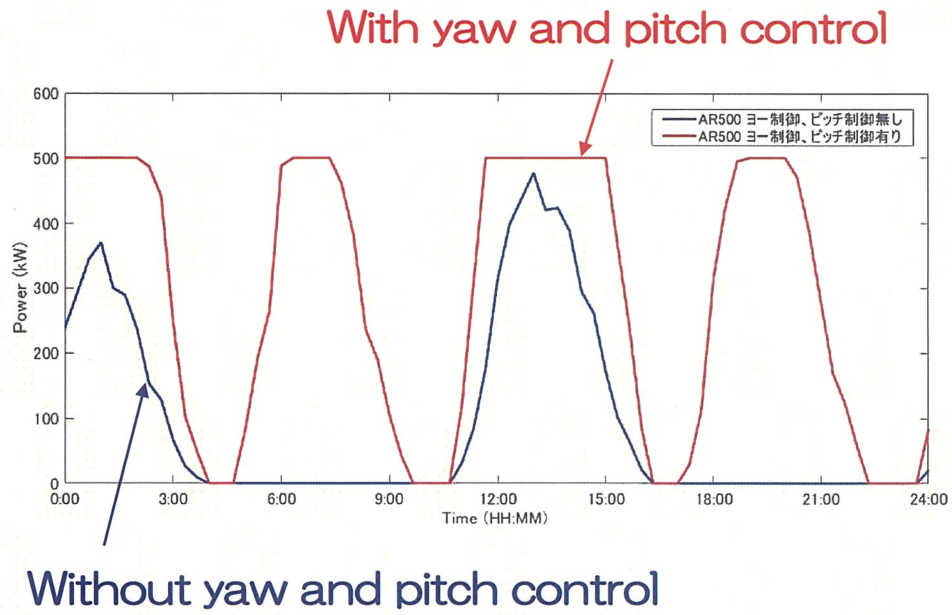
Floating type



Moored type

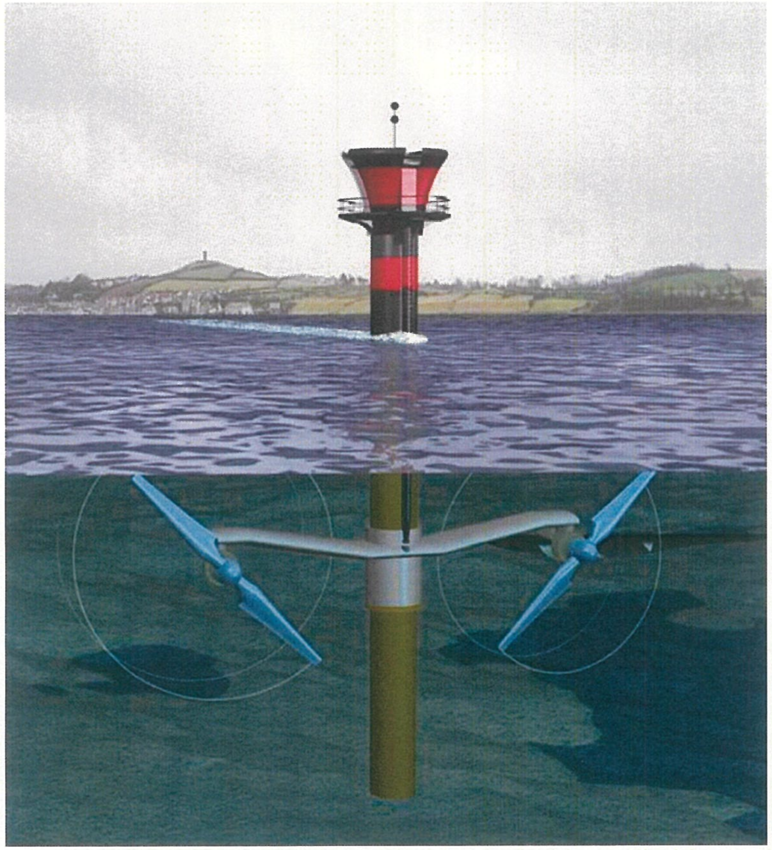
Adaptation to Reversing Flow (Fixed Type)





Maintenance (Fixed Type)

■Special-purpose vessels are required for maintenance.

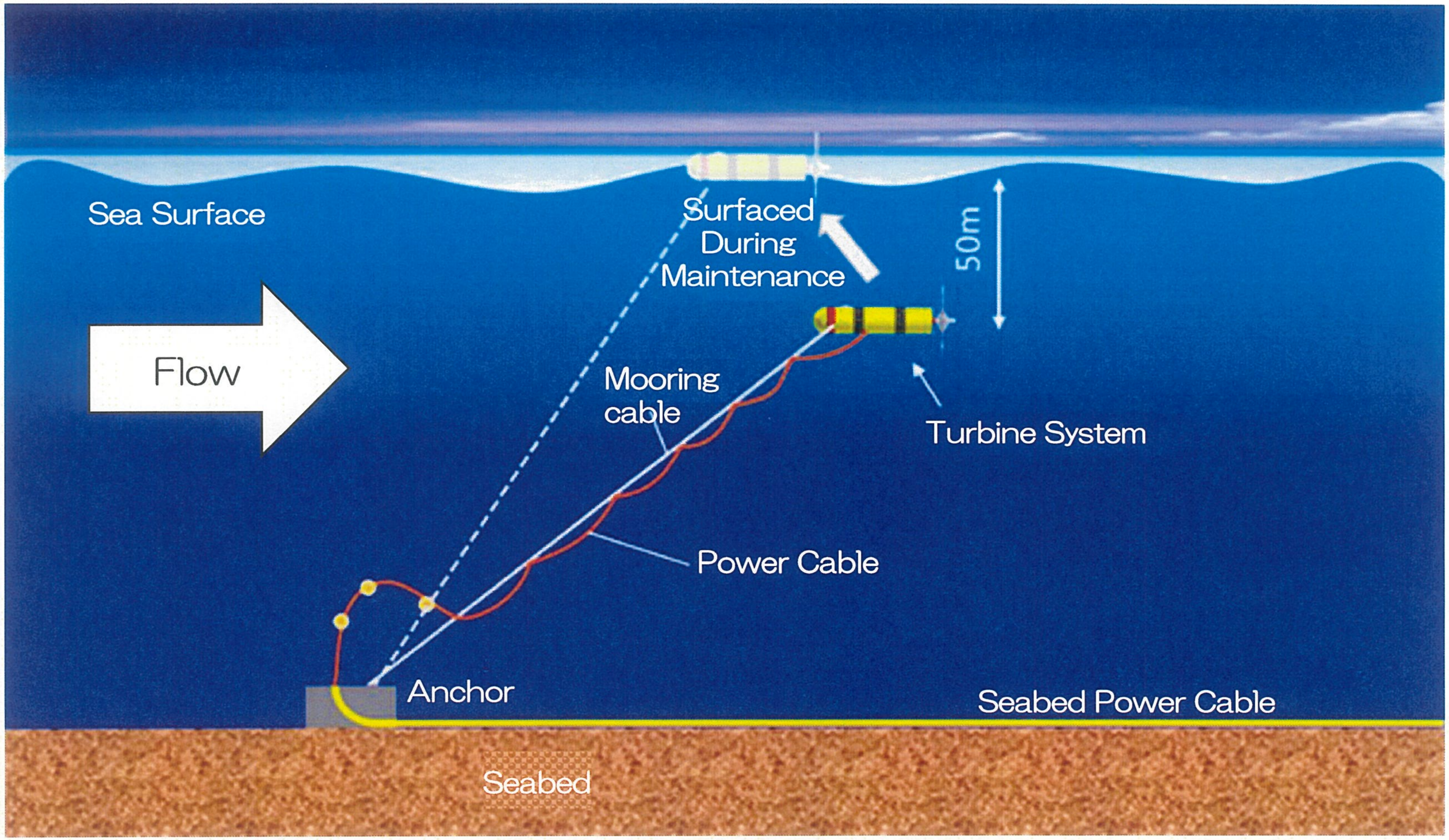


During Power Generation

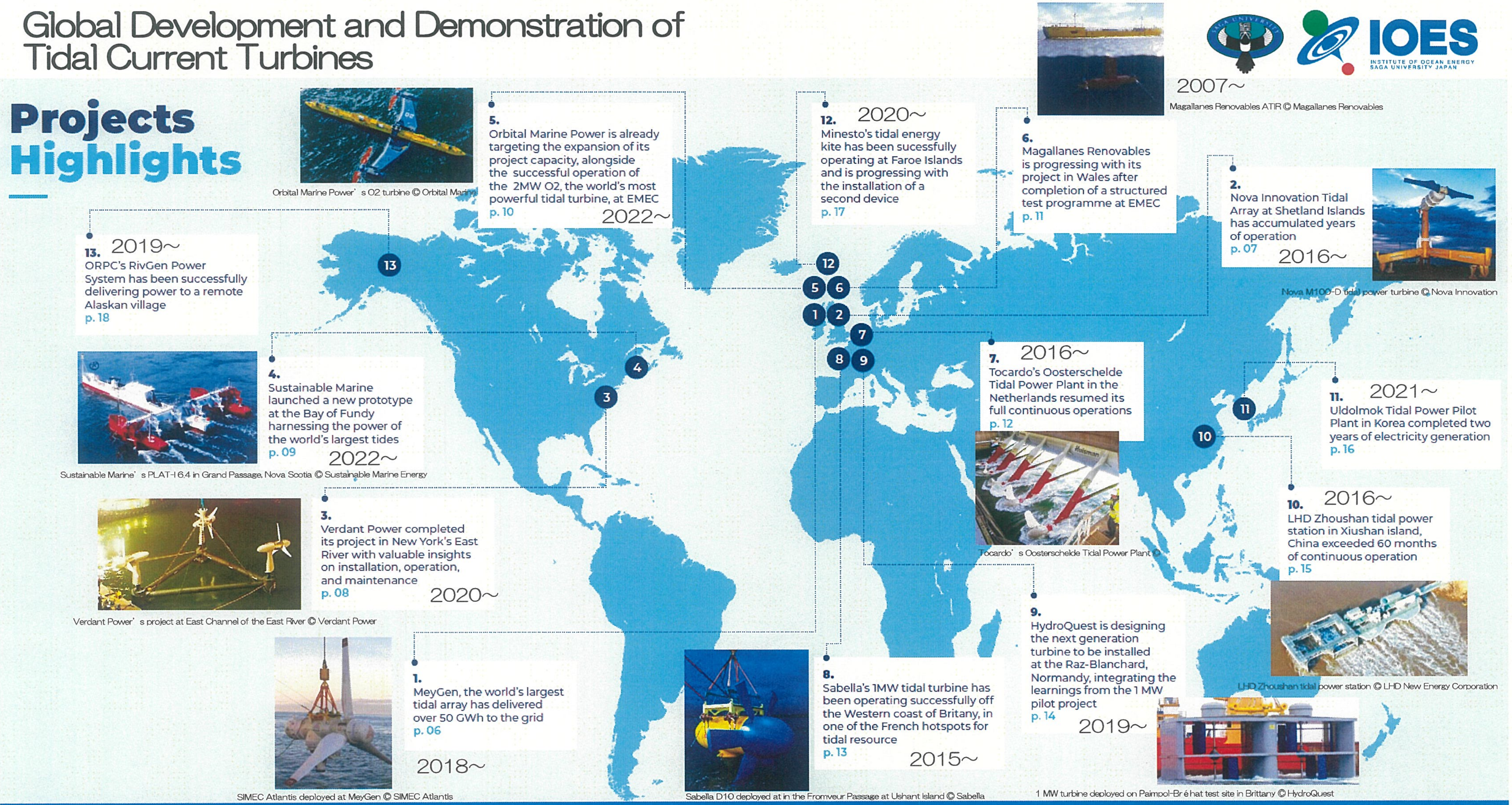
During Maintenance

SeaGen(https://www.power-technology.com/projects/strangford-lough/?cf-view)

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



Global Development and Demonstration of Tidal Current Turbines



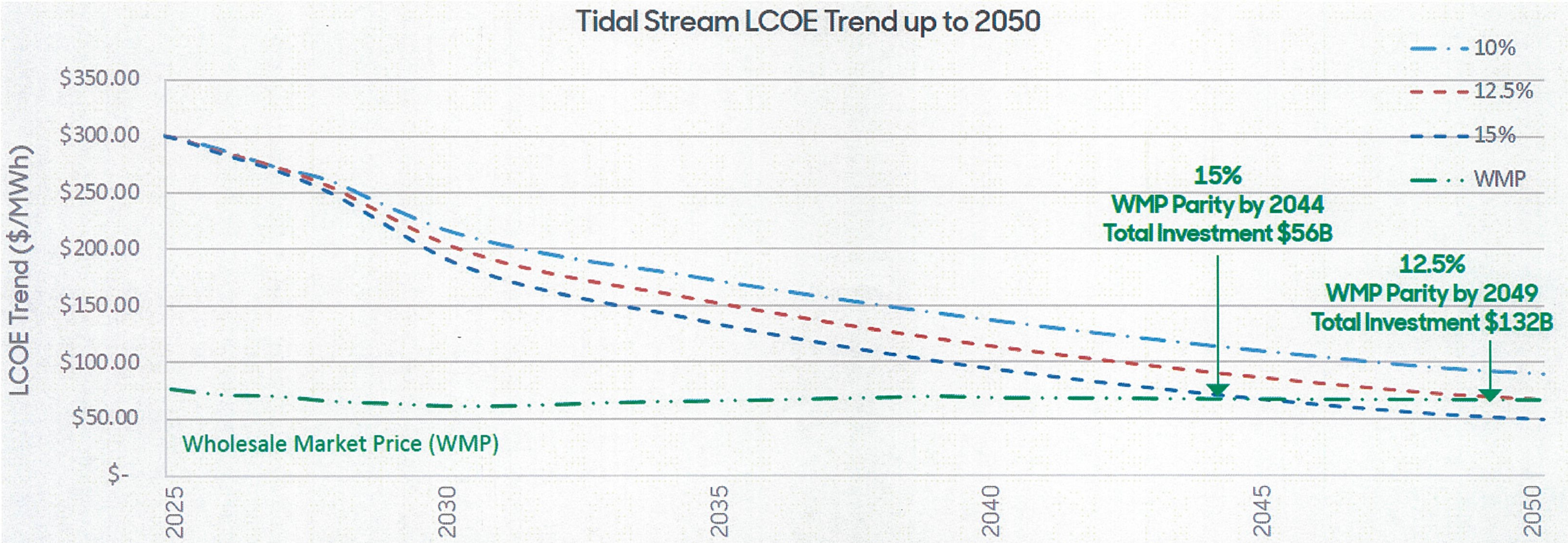
Tidal Current Energy Developments Highlights (2023, IEA-OES)

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 $P = C_{\mathrm{p}} \times \left(\frac{1}{2}\rho V_{\mathrm{m}}^{3} A\right)$ ⇒Increasing A can enhance power output

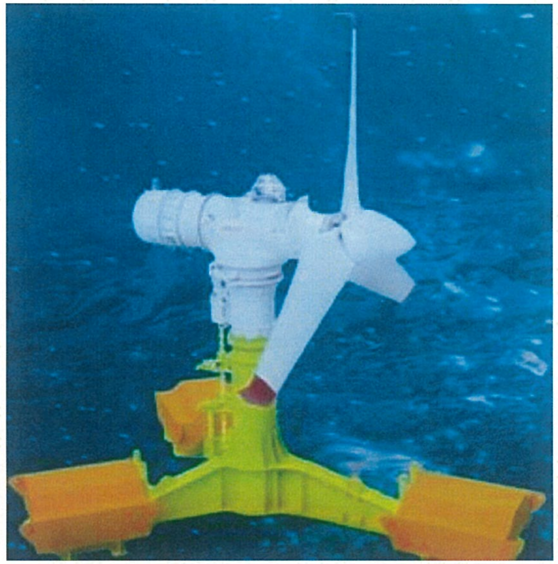
■ Larger turbines are cost-effective, **but tidal sites have narrow channels**
Maximum feasible diameter: ~30 m, maximum output: ~3 MW
(Frazer-Nash, Department for Energy Security & Net Zero, 2023)
➥Further enlargement is not practical for tidal sites

➡Cost reduction must rely on other approaches

■ Future Research Activities

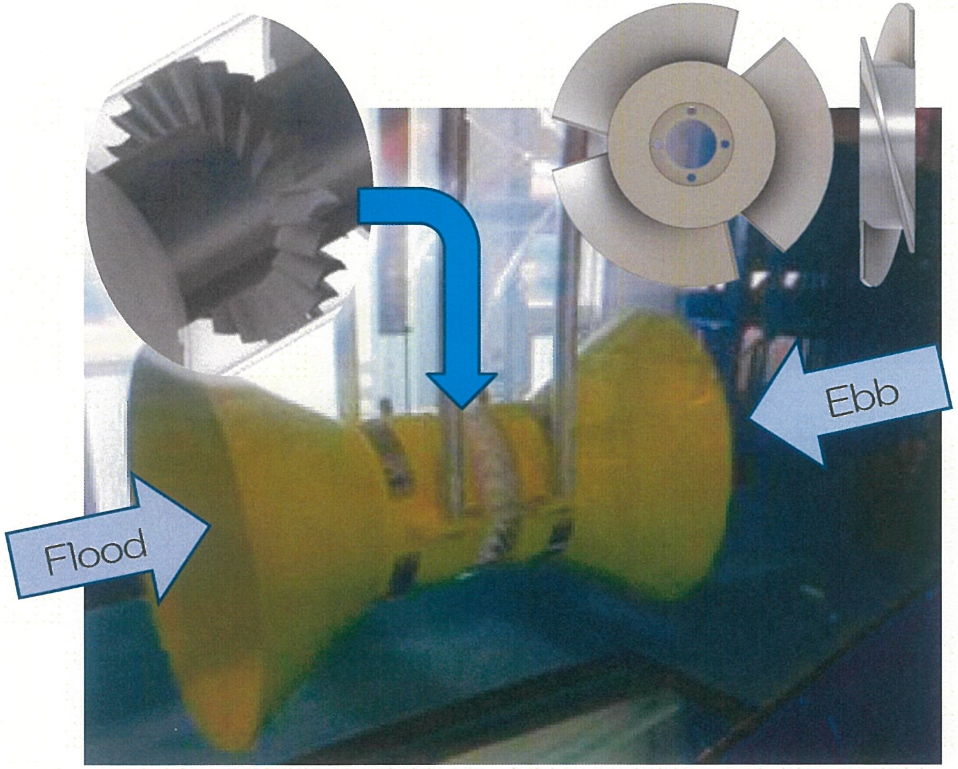
- Increase power output
- Extend lifespan
- Reduce weight
- Improve rated capacity
- Develop turbine farms
- Standardization of domestic manufacturing lines

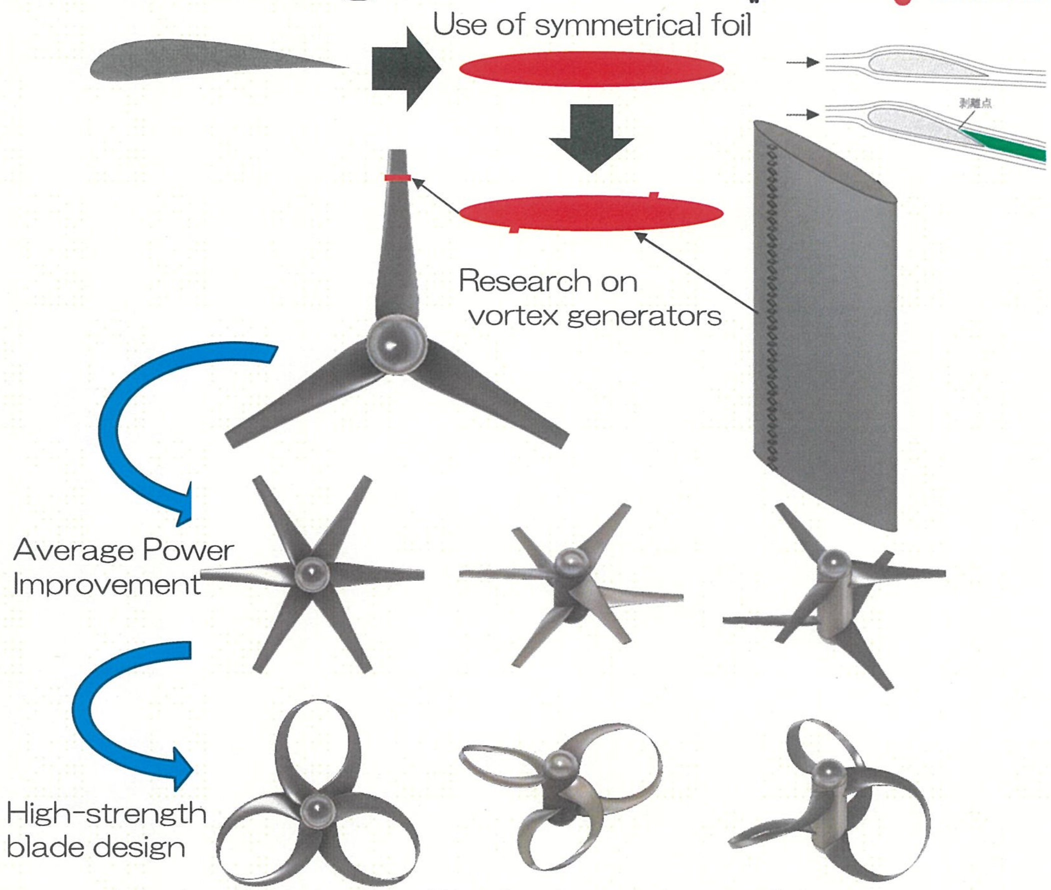
→Target LCOE: 23 JPY/kWh



九電みらいエナジー株式会社
https://www.q-mirai.co.jp/files/optionallink/00000285_file.pdf?1621647289

Approaches to Solving Technical Challenges





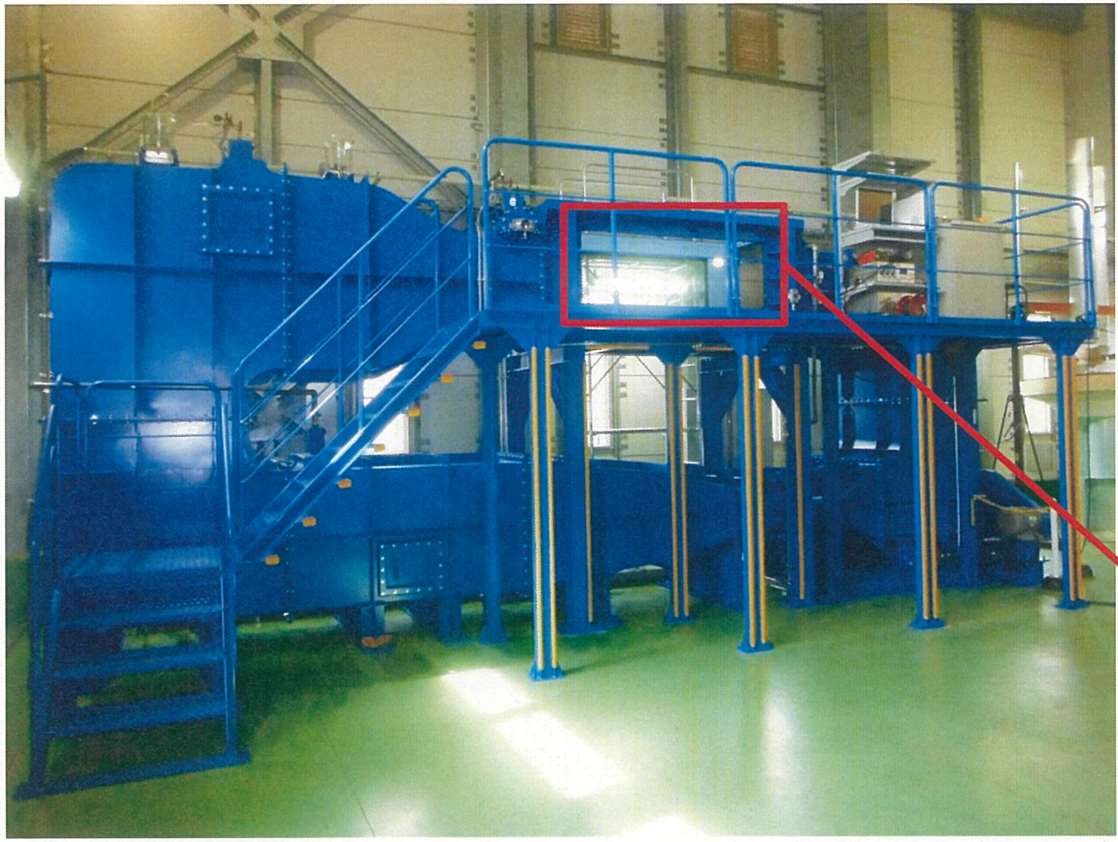
Ducted Turbine：

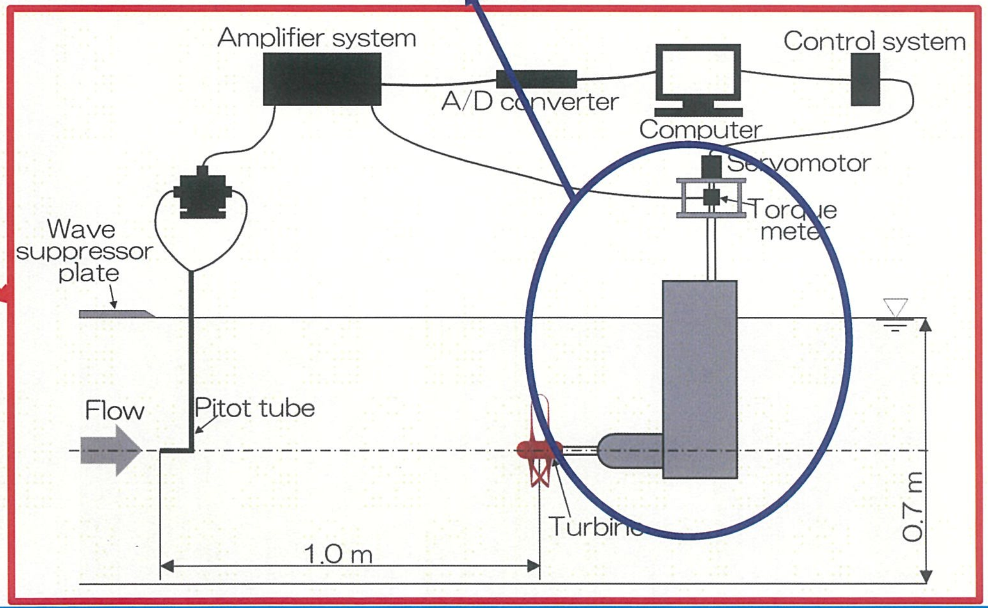
- ◆ Utilizes symmetrical ducts to capture more tidal energy
- ◆ Enables high power output without yaw control

High-Strength Turbine without Yaw Control：

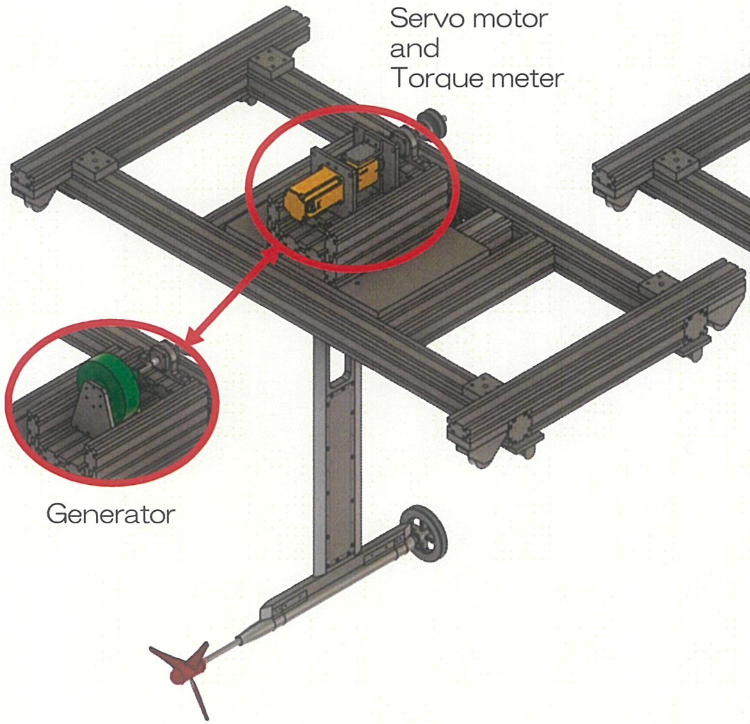
- ◆ Development high-output, high-strength turbine
- ◆ Development of a highly practical turbine.

Experimental Apparatus

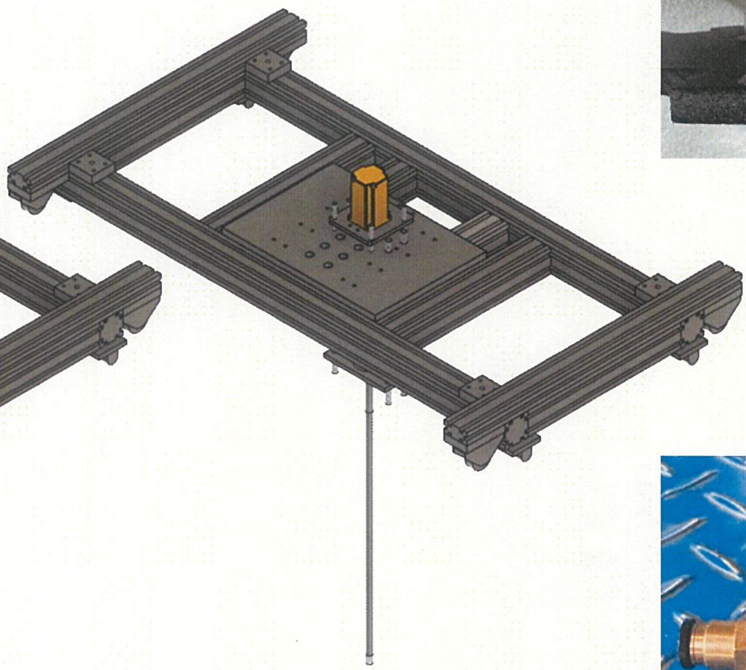




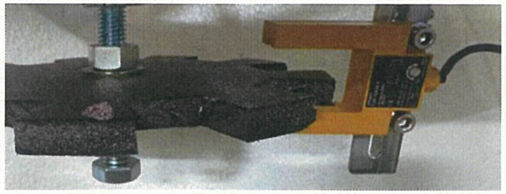
Other Experimental Equipment and Instruments



Experiment on
a horizontal-axis turbine



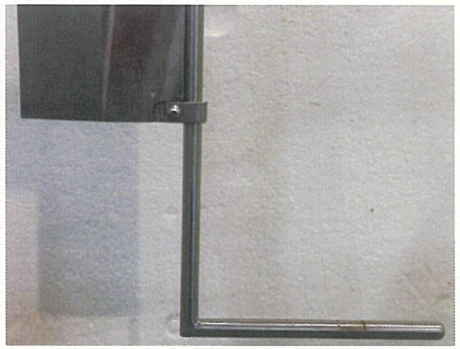
Experiment on
a vertical-axis turbine



Tachometer

Three-component
force sensor

Differential
pressure gauge



Pitot tube

Thank you for your kind attention.

Wakana Tsuru

tsuruw@cc.saga-u.ac.jp