Development of an ocean-current turbine for the Kuroshio current

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- towards a big picture

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Abstract

Ocean currents are a promising source of sustainable energy because the flow of water provides regular and predictable energy. Japan is in a suitable location for harnessing the power of ocean currents because the Kuroshio ocean current runs steadily near the Japanese seaside. The current flow is approximately 500 m deep and 100 km wide with a flow speed of 1-1.5 m/s. In order to harness the kinetic energy of marine currents, we propose a novel ocean-current turbine. The turbines are moored to the seabed and function like kites in the water flow. To operate such turbines in the middle layer of a marine current, it is necessary to cancel the resulting rotor torque. Therefore, our turbine is designed with a float at its top and a counterweight at its bottom. Owing to buoyancy and gravitational force, the turbine body maintains its attitude stably by canceling the rotor torque. In other words, buoyancy and gravity act together as a righting moment. Another advantage of working far from the sea surface is the lack of influence from waves and wind, especially in a typhoon. As a first step, we constructed a prototype turbine and conducted towing experiments in order to confirm the float and counterweight configuration.

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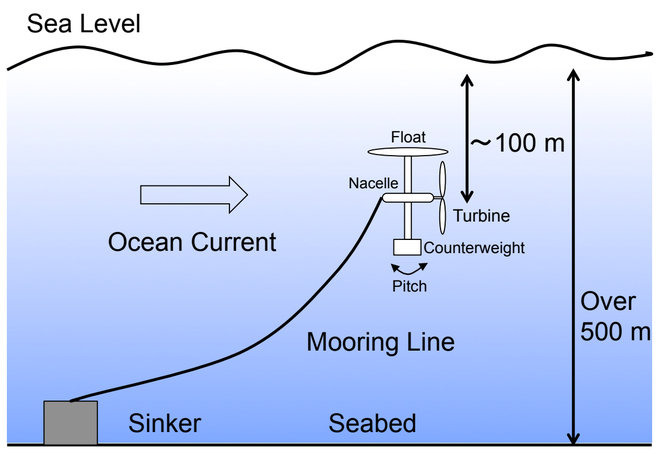
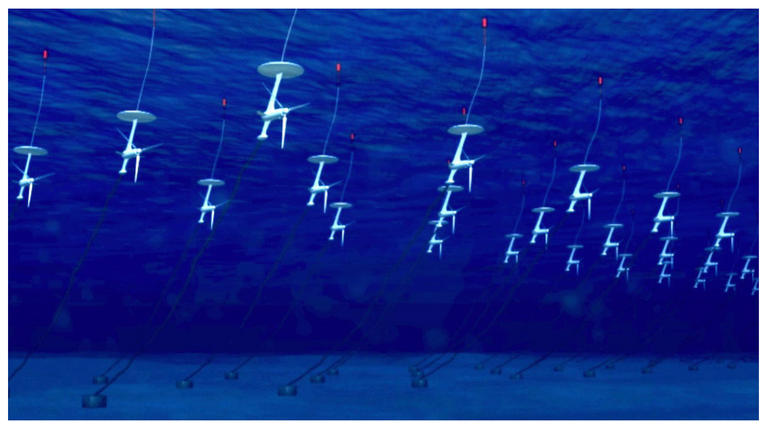
Motivation

- Japan is suitable to harness the power of the ocean current.
- Kuroshio Ocean Current runs steadily near Japan seaside.
- Technical issues
  - Stability of a floating body.
    - Cancel out a rotor torque.
- Proposal of new ocean-current turbine
  - We started R&D in 2012.

Ocean-current turbine system



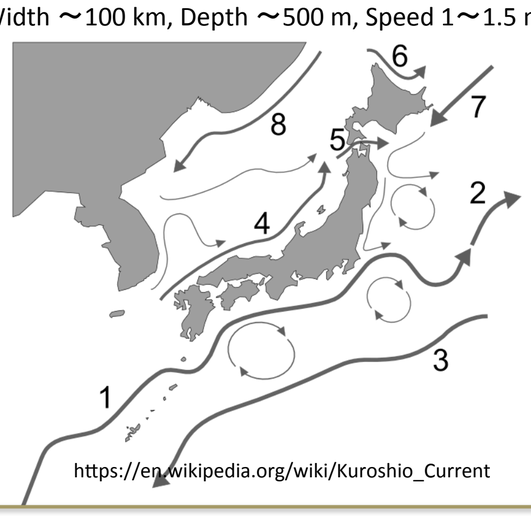
Energy Farm



Rotor diameter 80 m, 1 Turbine: Output 3 MW @ 1.5 m/s

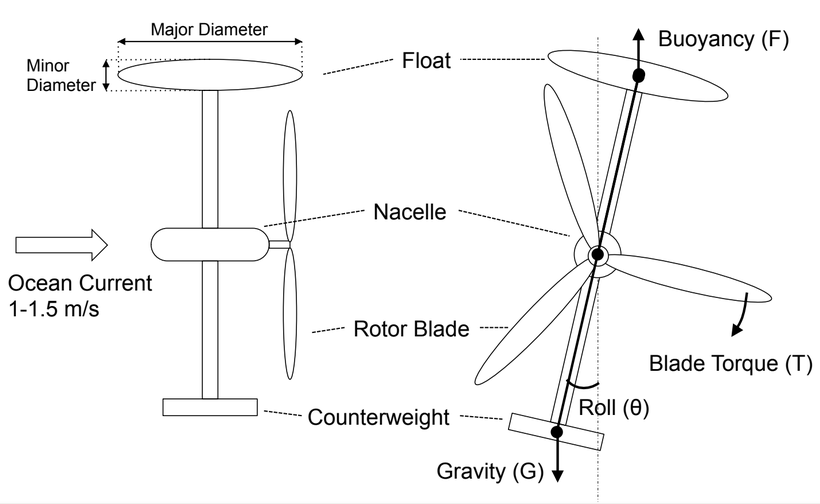
Kuroshio Current

Width ~100 km, Depth ~500 m, Speed 1~1.5 m/s



https://en.wikipedia.org/wiki/Kuroshio_Current

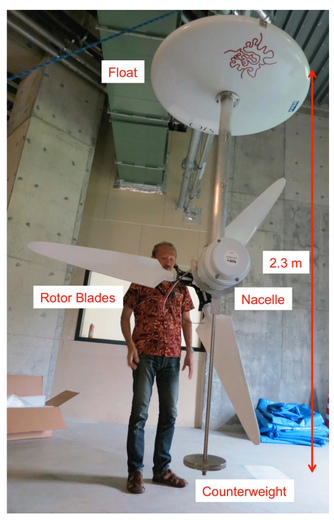
Principle



Advantages

- Stability
  - Ocean currents flow constantly.
- Availability
  - The volume of the water flow is very large.
- Predictability
  - The flow speeds and paths have been investigated thoroughly.
- No visual impact
  - The turbine operates beneath the water surface.

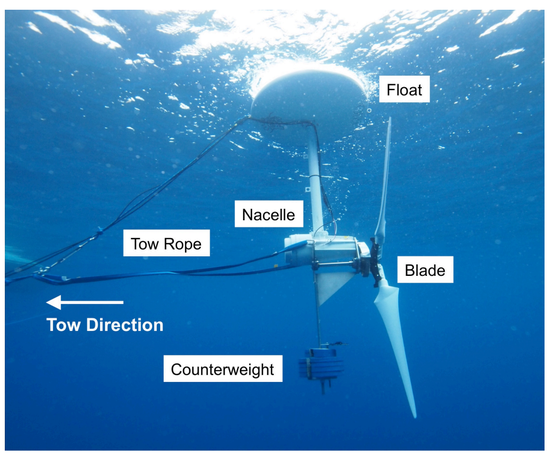
Prototype Turbine



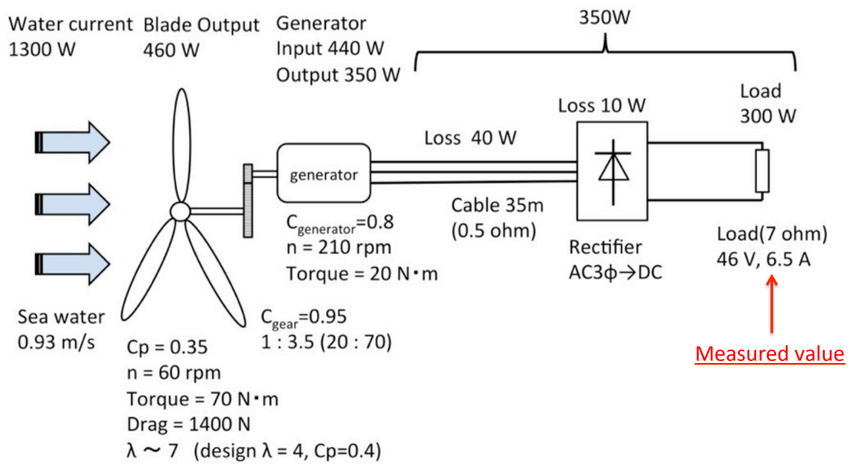
Parameters of the Prototype Turbine

Rotor diameter	2 m
Number of blades	3
Speed of flow	1~1.5 m/s
Rated generator output	1 kW
Cp (max.)	0.42 (TSR=4)
Float volume	0.1 m^3
Counterweight(in air)	50 kg

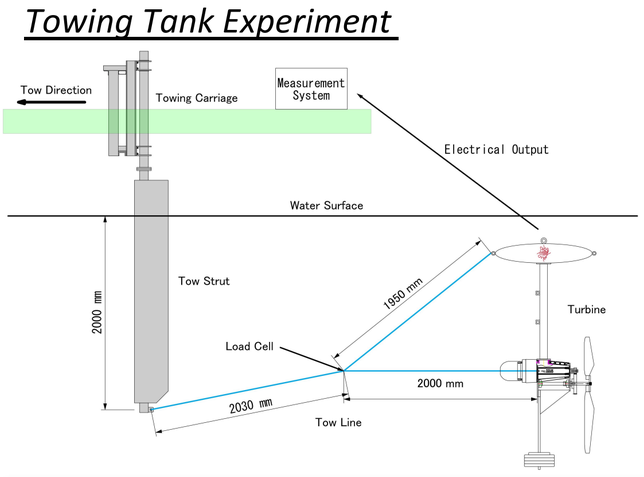
Towing Experiment at Sea



Measurement Result



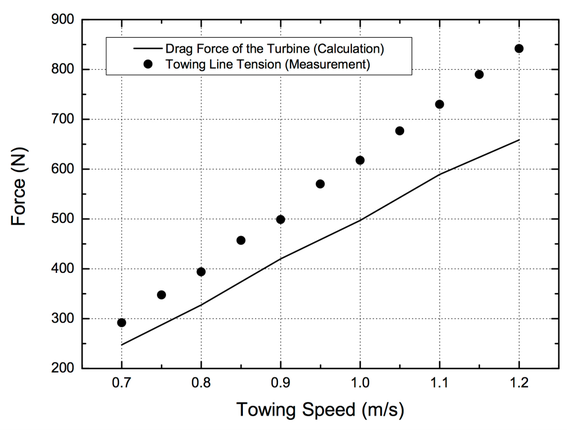
Towing Tank Experiment



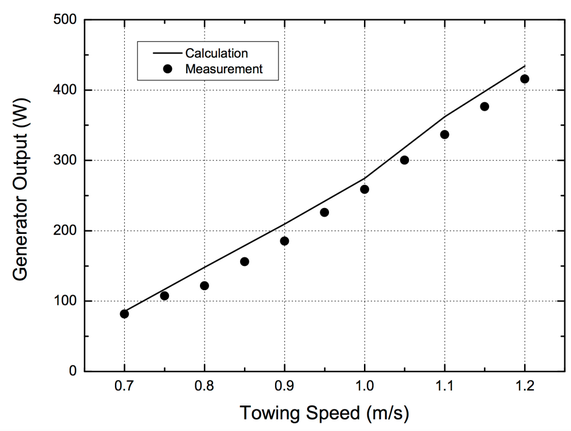
Turbine Design

Rotor diameter	1.46 m
Number of blades	3
Tip speed ratio	4
C_P (max.)	0.42
C_T (max.)	0.63
Airfoil	NACA642-415

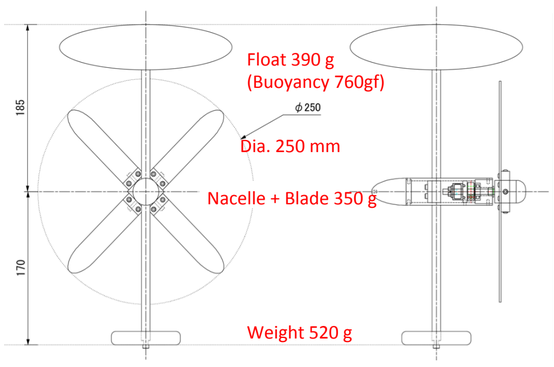
Thrust Force

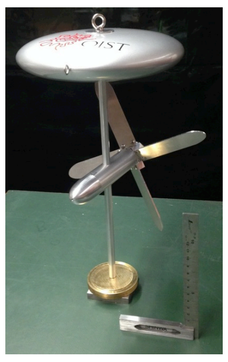


Output Power

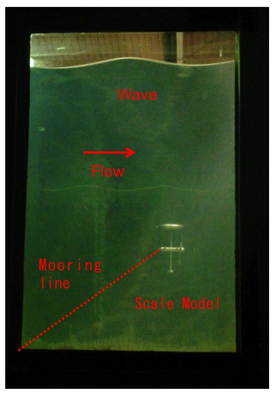


Scale-model Test at Circulation Water Channel





Scale model



Conclusion

- We have proposed a new ocean-current turbine.
  - Float and weight configuration has worked very well.
    - We have developed the prototype turbine and performed towing test in the sea.
    - Output Ave. 300W(Peak 400 W)
      - good agreement with the expected value.
  - Moored floating body has showed high body stability.
    - Mooring experiment using a scale model has been carried out with a circulating water channel.

Reference

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Experimental verification of a floating ocean-current turbine with a single rotor for use in Kuroshio currents☆

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ABSTRACT

Ocean currents have excellent potential as future renewable energy resources. In order to harness the kinetic energy of marine currents, we propose a new ocean-current turbine. In general, ocean currents

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