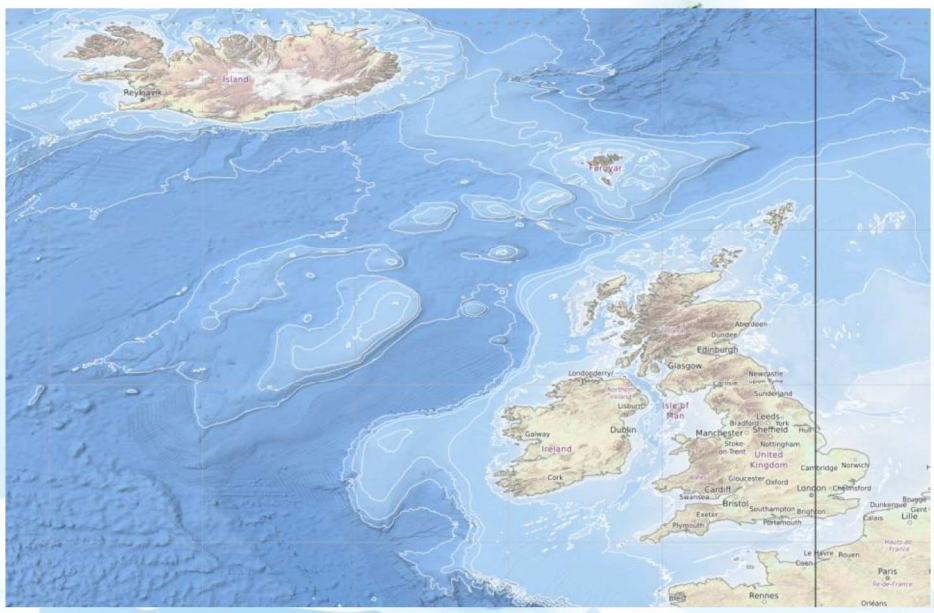
KUMANO

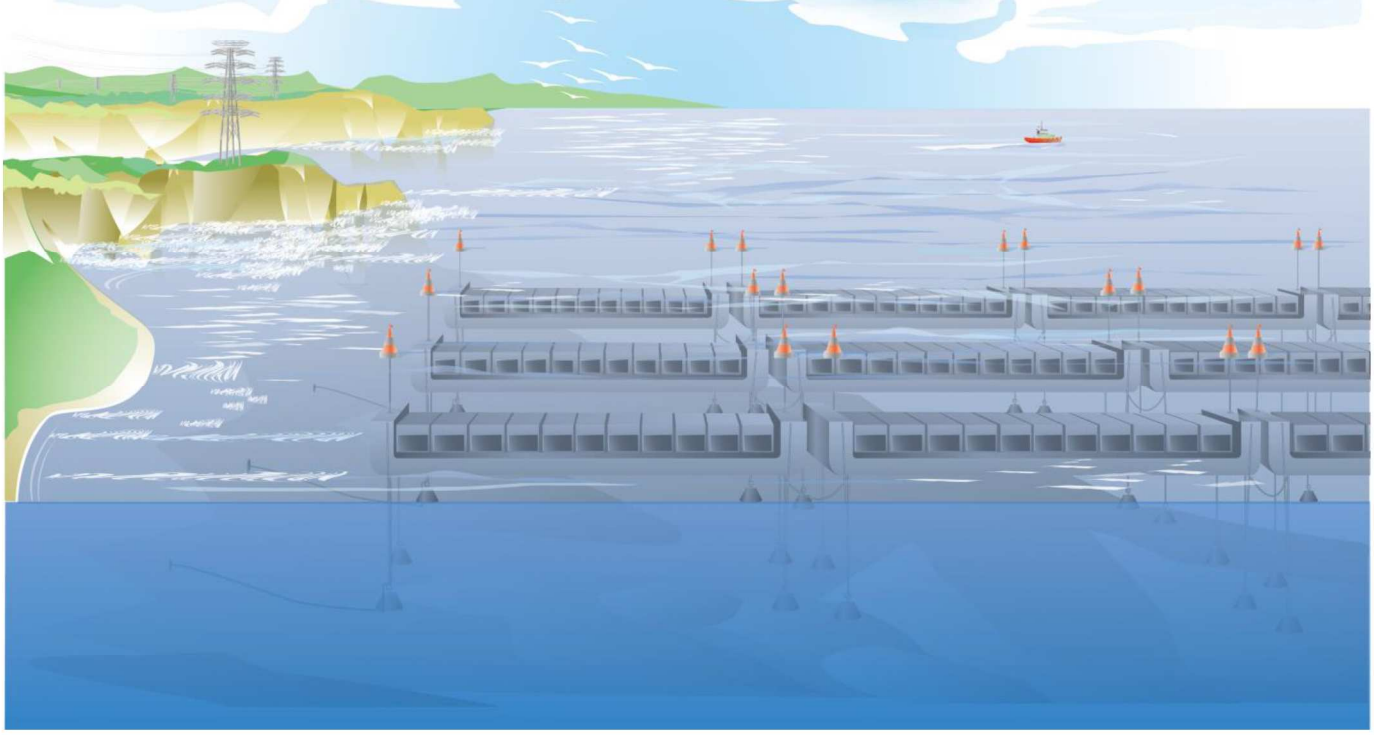
North Atlantic Current Power Generation

- Ocean power generation in the North Atlantic -

Creating a Hydrogen Production Industry (UK Clean Energy Plan)

May 23, 2019





Introduction – Why do we need ocean power generation now? –

Humanity has started an industrial revolution using coal from the 19th century. Coal is an accumulation of energy that solar energy has accumulated over millions of billions of years. In other words, coal is a bioaccumulation of organic matters (plants) grown through a process of photosynthesis: the combination reaction of carbon dioxide, water, and solar energy. The 19th century was the age of coal, which also used a long-term stock of solar energy. In the 20th century, humanity discovered oil and made significant progress in the industry using an oil-based internal-combustion engine. This oil, like coal, is a liquid made of organic matter that solar energy had accumulated over millions of billions of years. Thus, the 20th century was the age of oil as well as the age of using solar energy accumulated over many years.

In the 19th and 20th centuries, excessive use of long-term accumulation (stock) of solar energy increased concentration of CO_2 gas, resulting in global warming. It can therefore say that 21st century is a century that used only one year of solar energy (flow) without using this storage of solar energy. Meaning that it is required to transform into a renewable energy society: biomass energy that converts plants that grow by the energy, which the sun gives to the earth in a year, into fuel, solar power generation that converts solar energy itself into electric energy, wind power generation using the flow of air (wind) generated by the difference in heat distribution of the sun, and hydroelectric power generation using the energy of river generated by the process of the water cycle.

Despite the demanding need, approximately 30% of sunlight which reaches the ground had only been used as solar energy, and 70% of sunlight which hits the ocean is not being used at all. This energy is the movement of sea water generated by the difference in temperature distribution, which is marine energy.

Sea water can generate 500 times more power than wind power because the mass of sea water is 1000 times the mass of air, and there are more potential locations where ocean currents can be used.

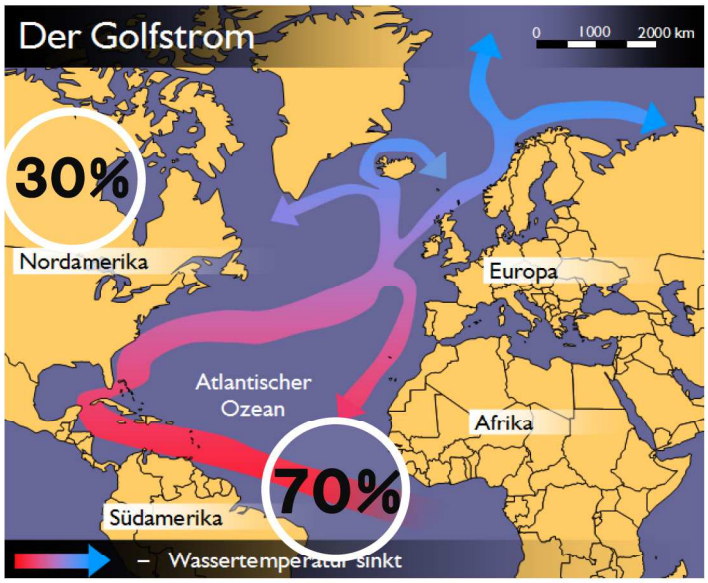


Figure 1: North Atlantic Current

1. Globally Significant Ocean Flow is coming to the United Kingdom

The North Atlantic Ocean Current, one of the world's largest ocean currents, is located off the coast of the United Kingdom, making it a country that can use marine energy.

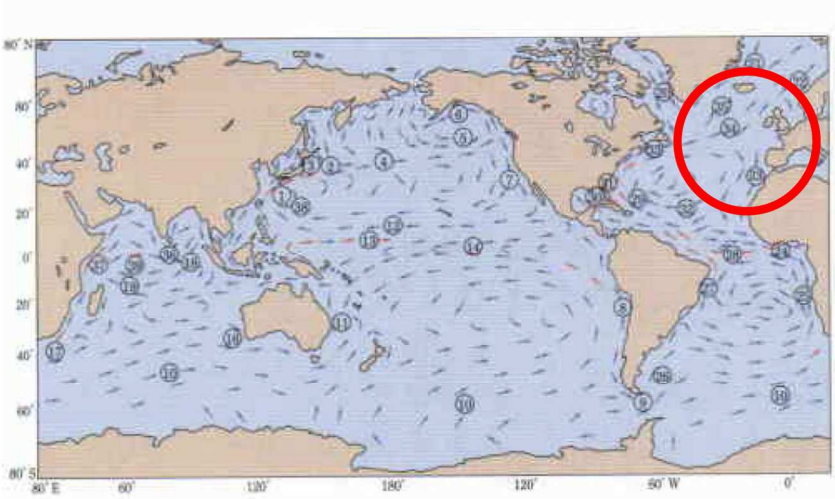


Figure 2: Current map of the world

1) 0.5 to 1.0 knot (about 0.25 to 0.5 m/sec)
   1.0 knot or more (about 0.5 m/sec or more)
2) 38 is a subtropical counter current that is said to exist as a weak eastward current.
3) 39 is an equatorial jet that exists as an eastward current of 3 knots or more in April and November.

2. Generate Electricity Cheaply using the North Atlantic Current

The important thing to carry out the Kuroshio Current Power Generation is to, first, generate electricity at low cost, and secondly to efficiently store and transport the generated energy. In order to reduce costs in the Kuroshio Current generation, it is necessary to install a generator with high generation efficiency at a low price at a place where the flow velocity of Kuroshio is the fastest since the amount of power generation increases in proportion to the cube of the flow velocity.

We developed a variable-wing type underwater generator with high power generation efficiency (PATENT No. 4808799), and also made use of the method of installing the generator at the fastest flow speed location at a low cost (PATENT No. 4422789). The next thing we need is to store and transport the generated energy.

We also acquired a patent for this "hydrogen energy supply system using ocean current power generation" (PATENT No. 6139594) last year.

3. History of development of KUMANO Ocean Current Generator

- Confirmation of the basics of the introduction channel, drainage channel and variable wing turbine.
  - Under the permission of Water Management Bureau (of Ministry of Land, Infrastructure, Transport and Tourism), tested at the upstream of Arakawa (2009, Fig. 3)
- Device position stabilization test in water (Our water tank experiment)
- Speed increase test by oblique plate in water channel
  - Test at Musashi canal under Incorporated Administrative Agency permission (2011, Fig. 4)
  - It is confirmed that the amount of water to the channel increases by adjusting the angle of the water conduit.
- Efficiency improvement test of water turbine rotation speed by adjusting the angle of variable wing.
  - Independent administrative agency National Maritime Research Institute (2012, Fig. 5)
- Test to improve power generation efficiency by changing the flow velocity
  - Akishima Laboratories (Mitsui Zosen) Inc. (2014, Fig. 6)
  - The power generation of 50.5W was recorded against the theoretical value 162.8W of the maximum power generation at a flow velocity of 1.7 m/s, achieving high power generation efficiency of 31% of the theoretical power generation.
- Submarine installation and power generation experiment using actual Kuroshio Current scheduled to be conducted by 2019.

Figure 3: Testing at the upstream of Arakawa (2009)

Figure 4: Testing at Musashi canal (2011)

Figure 5: Testing in a large tank at independent administrative agency National Maritime Research Institute (2012)

Figure 6: Testing in a tank at Akishima Laboratories (Mitsui Zosen) Inc. (2014)

Marine power system related patent list (in Japan)

Name / Patent No.	Registration Date
Installation structure of hydroelectric generator / PATENT No. 4422789	December 11, 2009
Method for preventing adhesion of shellfish and coating structure for preventing adhesion of shellfish / PATENT No. 4551963	July 16, 2010
Water turbine wing type generator / PATENT No. 4659917	January 7, 2011
Water turbine wing type generator / PATENT No. 4808799	August 26, 2011
Water turbine wing type generator / PATENT No. 5389082	October 18, 2013
Liquid activation, electrolysis apparatus and liquid activation, electrolysis method/ PATENT No. 5824122	October 16, 2015
Submersible water flow power generation system / PATENT No. 5905984	March 25, 2016
Water turbine wing type generator / PATENT No. 5918291	April 15, 2016
Hydrogen energy supply system using ocean current power generation / PATENT No. 6139594	May 12, 2017

(Overseas)

Name/ Patent No.	Country (Region)	Registration Date
Water turbine wing type generator / PATENT: ZL200910253950.4	China	October 3, 2012
Water turbine wing type generator / PATENT No. 2133557	EU (England, Ireland)	May 15, 2013
Installation structure of hydroelectric generator / PATENT: US 8,575,771B2	U.S.	November 5, 2013
Water turbine wing type generator / PATENT	U.S.	April 22, 2014

No. 8702392		
Water turbine wing type generator / PATENT: US8,794,904B2	U.S.	August 5, 2014
Installation structure of hydroelectric generator / PATENT No. I490405	Taiwan	July 1,2015
Water turbine wing type generator / PATENT No. I490406	Taiwan	July 1, 2015
Installation structure of hydroelectric generator / PATENT No. 2472499	UK	July 22, 2015
Water turbine wing type generator / PATENT: US9,103,314B2	U.S.	August 11, 2015
Water turbine wing type generator / PATENT No. 86657	Ireland	May 24, 2016
Water turbine wing type generator / PATENT: GB2480129	England	June 1, 2016
Water turbine wing type generator / PATENT: GB2531977	England	August 31, 2016
Water turbine wing type generator / PATENT No. I567297	Taiwan	January 21, 2017
Hydrogen energy supply system using ocean current power generation / PATENT No. 86785	Ireland	February 3, 2017
Water turbine wing type generator / PATENT: US9,587,621B2	U.S.	March 7, 2017

4. Installation of KUMANO Generators in the Sea

Figure 7: Image of transportation of KUMANO generator

Figure 8: KUMANO generator installation image in the sea

Characteristics of this device and technology

Our ocean current power generation device is a generator that moors a power generation device using a variable-wing-type turbine impeller from the sea floor (Fig. 10). The amount of power generation can be expressed by the following equation.

Amount of power generation = 1/2 × 1000 (specific gravity of seawater) × (flow velocity)^3 × area of wing × power generation efficiency

In summary, focusing on the fact that the amount of power generation is proportional to the cube of the flow velocity in the formula of fluid dynamics, by installing the generator at the place with the fastest flow velocity, high power generation efficiency is expected, and the cost-effectiveness is greatly improved. The features of this generator are as follows.

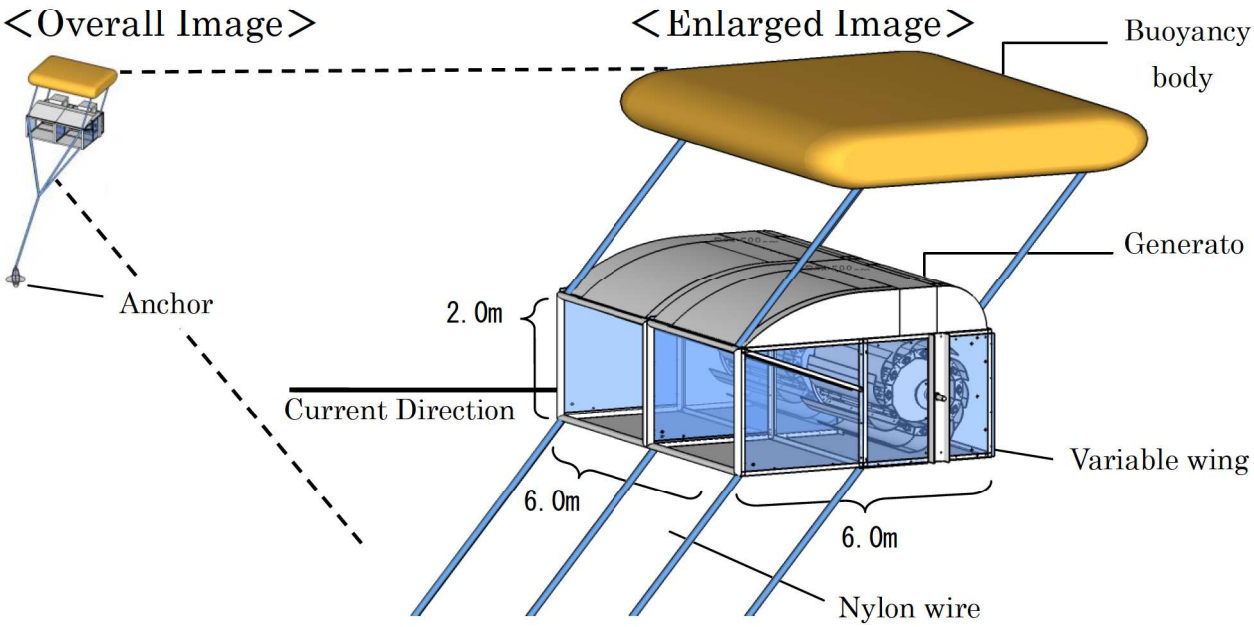


Figure 9: KUMANO variable-wing generator

- By turning the water wheel in the same direction as the flow of water, energy loss can be reduced.
- Due to the variable wing structure, the blades are unexpectedly folded when receiving flowing water, and rotation loss is minimized.
- It has a small exclusive area per unit and can be installed at high density (more efficient transmission)
- By using the anchor and the buoyant body, the device does not shake and is stable in water.
- It can be installed at the maximum current velocity of Kuroshio because it can be installed stably in water.
- It is a combination of single structures and has a low risk of breakdown.

There has never been a case of a water turbine-type power generation system in the ocean current, and the structure of the variable bladed impeller, the water flow increasing mechanism in the water conduit to the generator, the mooring method, etc. has been patented abroad. This power generation method is not only novelty, but also optimized in various points, such as power generation efficiency and installation method in the sea, so it can be said that it is an ideal power generation system in the sea.

5. Contributing to Economic Recovery in the UK

Today, despite having the world's 12th largest electricity consumption in the world, the energy self-sufficiency rate of the UK excluding nuclear power is 67.0% (2016), the highest among developed countries. The UK reported in the Paris Agreement, which came into effect in 2016, that it is "not likely to achieve" the goal of "getting 15 percent of total energy from renewable energy" by 2020. Throughout the EU, 20 percent of its energy is covered by renewable energy, and efforts are being made to reduce its dependence on fossil fuels.

In the UK, wind power (onshore and offshore) accounts for the majority of renewable energy, accounting for 36% (684 million kW) of the world's cumulative installed base. However, reducing the proportion of fossil fuels by including ocean current power generation in renewable energy is a pressing issue.

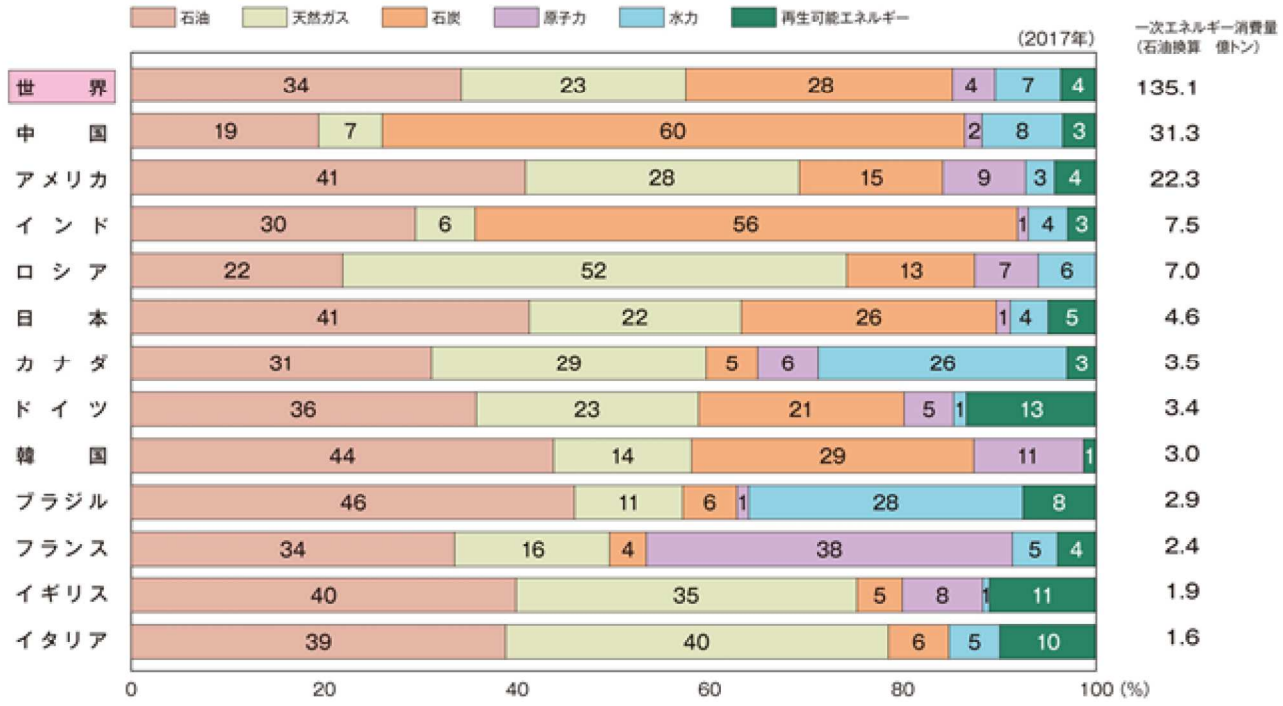


Figure 10: Amount of power generated by major countries and ratio of each power supply to generated power (2017)

The UK was originally rich in coal domestically, and coal-fired thermal power played a role of main power source. It is also a country with an exclusive economic zone that is 12th in the world, including foreign territory, and potentially a large ocean energy resource country. Among them, the North Atlantic Current, which flows on the Atlantic coast, is a current that flows in the West Coast of Europe, with the Gulf Stream moving north on the North Atlantic. This energy has the largest potential of UK renewable energy.

Seawater is about 1,000 times the mass of air, so the amount of power generated is larger than that of wind power in the case of the same installation area, and there is also the advantage that the available location is much larger than that of wind power. In addition, compared to solar power and wind power, etc., energy is always obtained, and stable power generation is possible 24/7 since it can generate power without interruption.

Our contribution to economic recovery brought by this research and development is shown below.

① Rising energy self-sufficiency rate

It is theoretically possible to install as many as 2 million KUMANO power generators if installed at intervals of 100m in the flow direction of 1000km×25km width of the North Atlantic Current, and the theoretical total power generation will be about 960 million kWh, which significantly exceeds the total power generation in Japan. It is thought that the use of the marine energy obtained constantly will reduce the import of fossil fuels and will greatly contribute to the rise of Japan's energy self-sufficiency rate.

② Reduce carbon dioxide emissions

The UK's dependence on fossil fuels is high, and carbon dioxide emissions are also high. In order to achieve 57% reduction of greenhouse gas (GHG) emissions in 2030, which is the target set in the Paris Agreement, is by increasing the production of renewable energy through ocean current power generation and reducing the ratio of thermal power generation, it can contribute to the reduction of carbon dioxide emissions.

③ Contribution to regional industry promotion

The basin that serves as the North Atlantic Current passage passes through the coast of the UK. Many cities rely on tourism as a major industry, making sustainable development difficult. If large-scale power generation facilities can be found in these prefectures, which are not rich in industry, it is possible to promote employment and contribute to regional development.