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2022年9月21日（水）
日中ChaoJi技術交流フォーラム

Technical trends in marine charging standards

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Technical trends in marine charging standards

1. Characteristics of Ships and Environmental Protection Measures
2. Offshore Power Supply system (OPS)
3. Battery-Propelled Boats Compatible with CHAdeMO and COMBO Quick Charging
4. Standardization

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Ship Characteristics and Environmental Protection Measures

Ships Run on the sea (long refueling intervals, salt damage)
Buoyant (large space to use)
Large engine output for running (approx. 0.1-100 MW)

1. Characteristics of the engine

(1) Electricity for general ships is AC only (440V AC is standard, no DC 12 lines like in automobiles)

2) Diesel engines are mainly used as propulsion engines, but are designed differently from land-based diesel engines due to their emphasis on high output, salt damage resistance, and constant output (response is not required).

(3) There is no redox catalyst like in automobiles (due to salt damage)

SOX is removed by scrubber (washing machine) Sulfur oxides are removed by reacting with washing water to form sulfuric acid (sulfuric acid is neutralized by the alkalinity of the secondary washing water)

NOX is controlled by controlling combustion temperature. NOX is suppressed by controlling combustion temperature.

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Ship Characteristics and Environmental Protection Measures

2. Tighter environmental regulations worldwide have led to

1) Ammonia-fueled engines, synthetic fuel-fueled engines, LNG, and hydrogen-fueled engines have been developed, and the number of ships equipped with LIBs (lithium-ion batteries) is increasing.

2) An increase in the number of ports requiring the shutdown of onboard generators while vessels are at anchor has promoted the development of Offshore Power Supply system (OPS) in ports.

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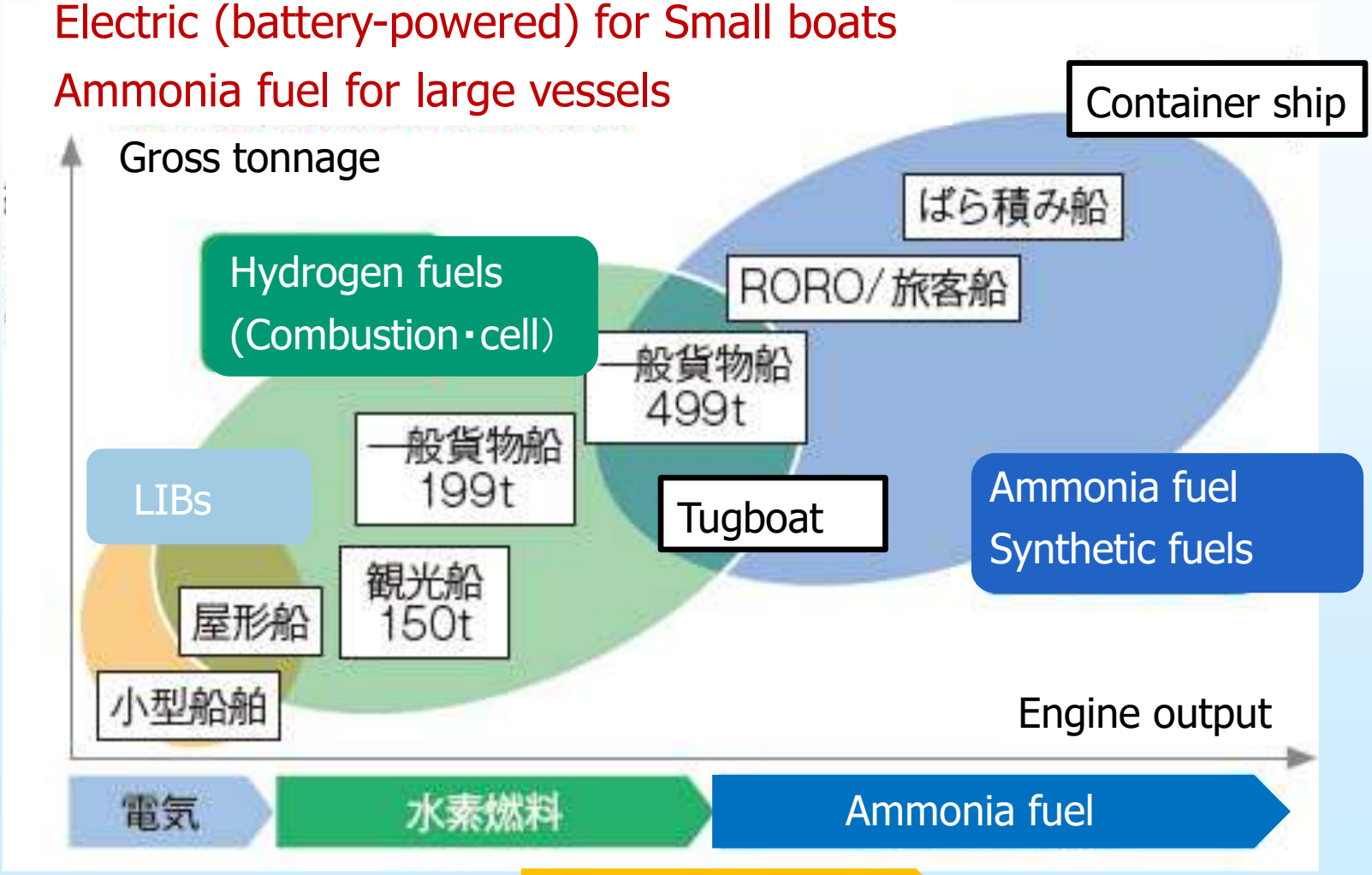
Future ship propulsion energy

Electric (battery-powered) for Small boats

Ammonia fuel for large vessels



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Exhaust gas from ships in bay area

Environmental Pollution

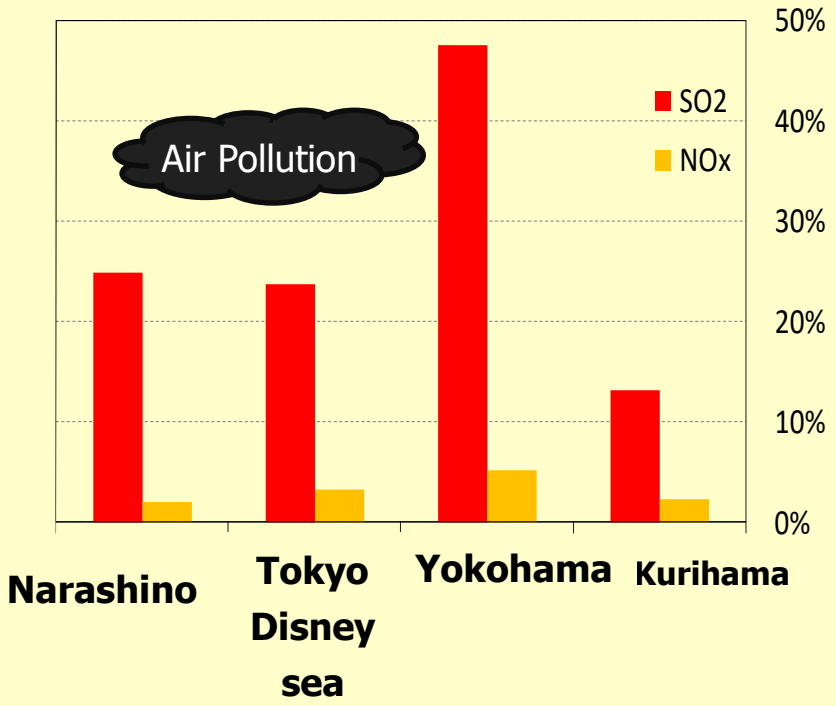
/ High proportion of exhaust gas from ships in bay area

/ Delayed adoption of environment-improving technologies in the field of sea transport, compared to land transport and automobiles

/ Preventing air and water pollution emission from conventional internal combustion engine-propelled ships

-- Zero emission ships or boats

/ Creating a low carbon society



Pollutant Gases in Tokyo Bay from Marine Engines

(Japan Institute of Marine Engineering (JIME) report in 2007)

Combustion engine in marine use

/ Corrosive sea air (wet and salty)

No catalyzer→SOx and NOx

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Emission Control Areas (ECA)

Area	Sulphur limit
Global	0.5% (MARPOL, 2020)
Emission control areas (ECAs)	0.1% (MARPOL)
EU Sulphur Directive	0.1% in all ports
China, Hong Kong*	0.5% selected areas, local limit
California	0.1% within 24 nm

* Hotel China and Hong Kong may go down to 0.1% earlier than 2020.

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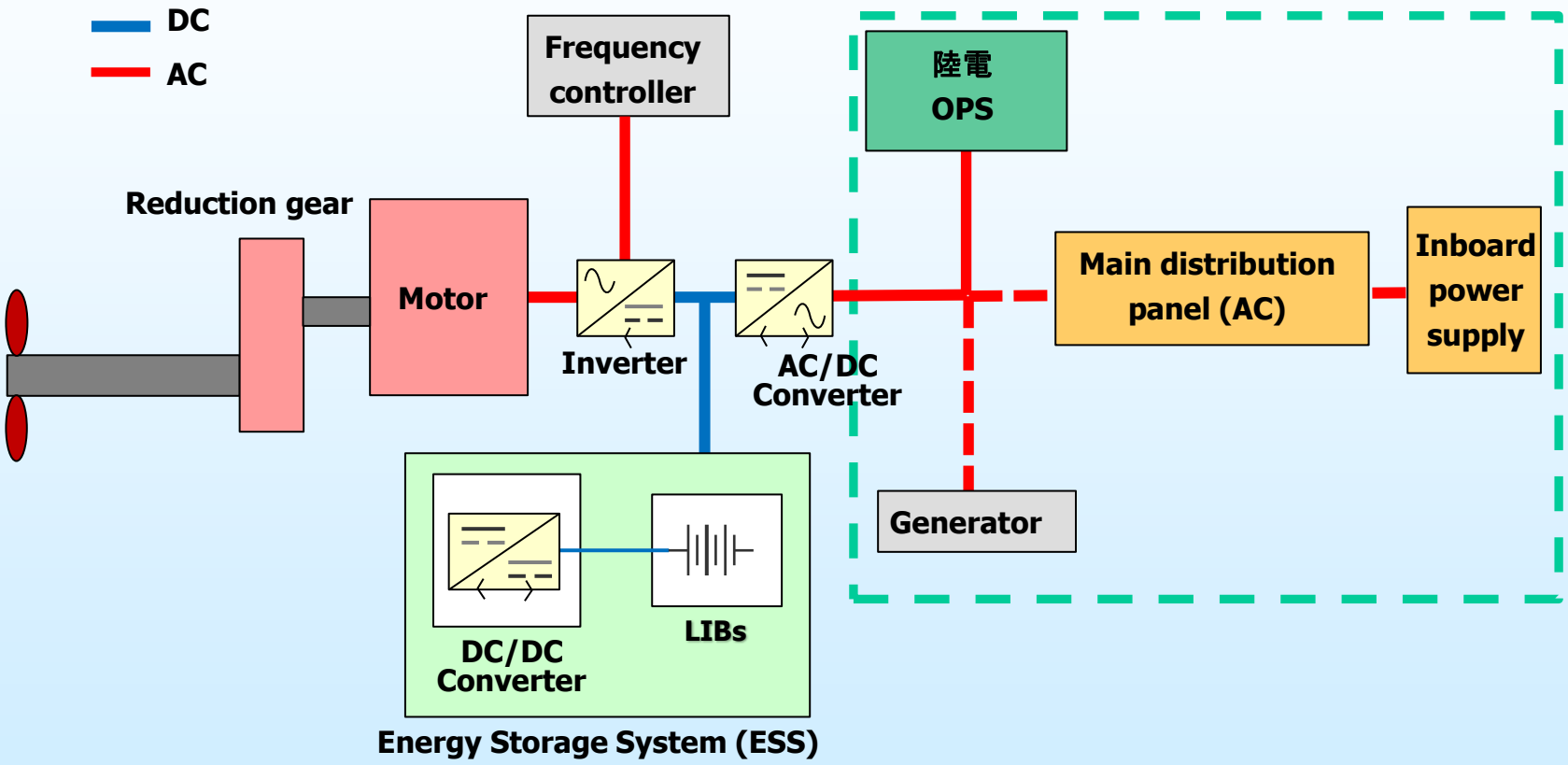
Typical system configuration diagram of a battery-propelled ship



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Standardization of OPS

The OPS is used to provide on-board power while the ship is at berth and to charge the LIBs. The main engines and engine generators can also be shut down in the bay, which is useful for reducing GHG emissions from ships and for complying with ECAs.

International standardization by IEC (International Electrotechnical Commission) and IEEE (Institute of Electrical and Electronics Engineers).

IEC PAS 80005-1:2019 Utility connections in port - Part 1: High voltage shore connection (HVSC) systems - General requirements (Part 1: High voltage shore connection systems - General requirements) specifies requirements for high voltage shore connection systems above 1,000 V AC.

IEC PAS 80005-3:2014 Utility connections in port - Part 3: Low Voltage Shore Connection (LVSC) Systems - General requirements for low-voltage shore power connection systems of 400 V AC to less than 1,000 V AC and 250 A or more are are under development.

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Application of LIBs to ships

In Europe, robotic (mechanical) OPSs are used and operated.

For example, ForSea Ferries in Sweden and Denmark uses a system that supplies power from a high-voltage OPS at 10 kV AC to the vessel, converts the power to 800 V DC onboard, and quickly recharges the battery in order to quickly recharge the LIBs (4,000 kWh) onboard the ferry in 10 minutes during the boarding and unloading time. The power is then converted to 800 VDC onboard for quick recharging.

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Battery-Propelled Boats Compatible with CHAdeMO Quick Charging

TUMSAT created new types of Battery-Propelled boats, "RAICHO-I" "RAICHO-S", and "RAICHO-N" in 2010, 2011, and 2014 respectively. These crafts utilize some special and unique features that set them apart from existing electric boats or battery-powered boats. They utilize a lithium-ion battery with a plug-in system or a CHAdeMO quick charging system (world first).

Raicho（雷鳥）: Japanese for "thunderbird" reflecting the expectation that it would be able to operate successfully even in adverse weather conditions

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Lithium-ion battery with plug-in system or rapid charging system

1. The dockside-mounted CHAdeMO charger can bring the battery up to 80% of full charge within 30 minutes, which is a much shorter time than is possible using conventional charging systems (usually taking 10 hours).
2. The boat can operate for 45 minutes at full speed and remain at berth for 30 minutes while recharging in a cyclic operation.
3. The powerful LIBs gives the boat a running speed of more than 12 knots, enabling it to navigate not only in calm waters but also open sea conditions where wind and waves prevent the operation of conventional battery-powered craft.

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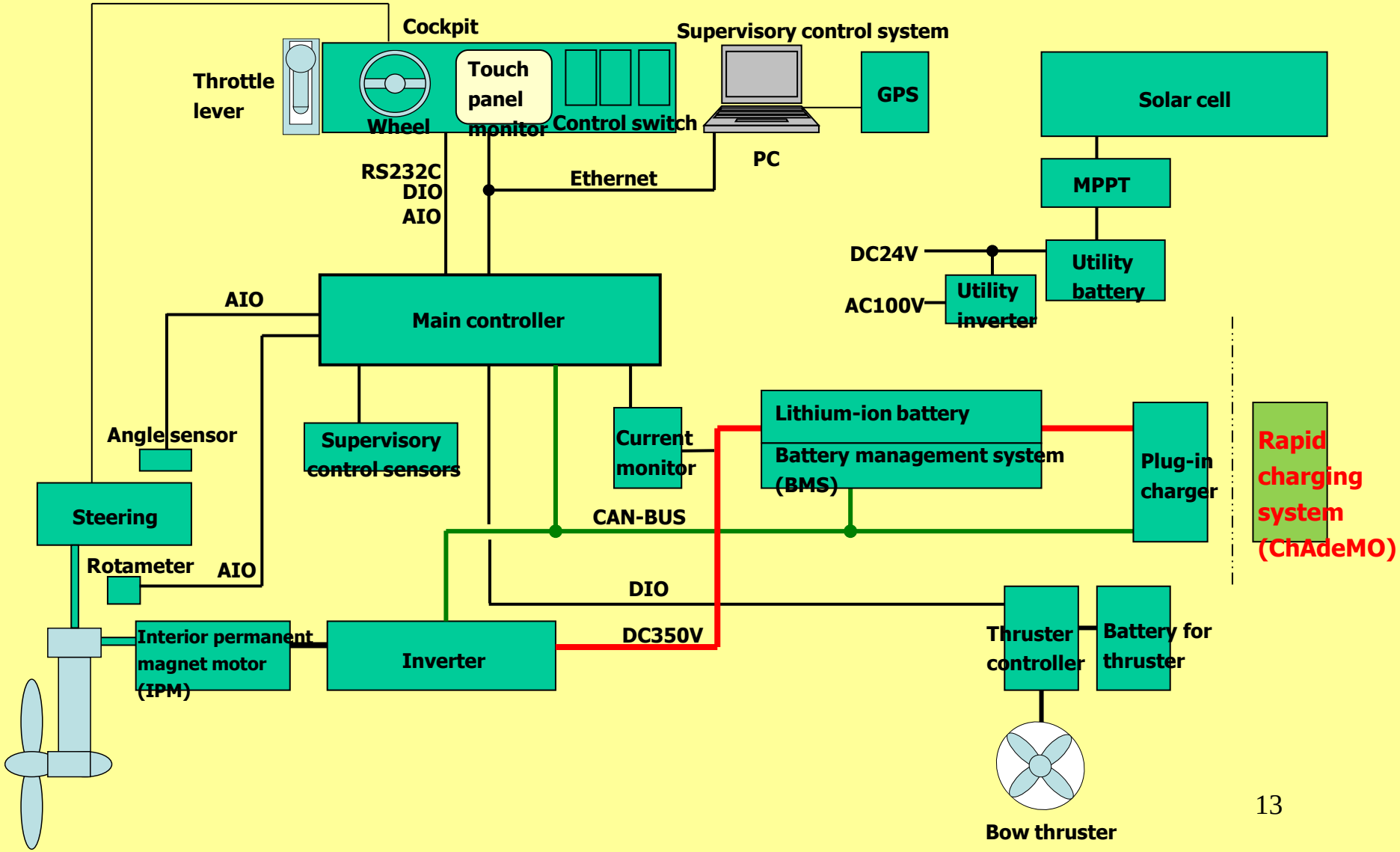
CHAdeMO for boat
（Basically the same as automobiles → no regenerative breaking）



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Battery-Propelled boat

1. Low environmental stress and low carbon society

/ Zero emission of NOx, SOx and CO_2 when running

/ Lakes and marshes where the use of combustion engine-propelled ships is prohibited in Europe and America.

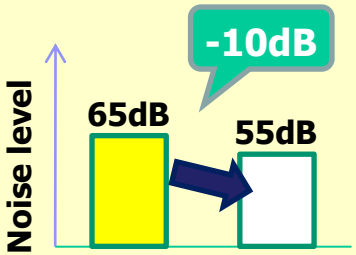
/ Reducing CO_2 levels by 50-70%

2. No-oil and no-gas, low noise and low vibration

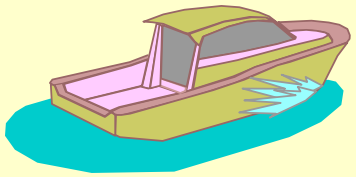
/ Sightseeing boat, traffic boat, ferry, research vessel, fishing boat, fisheries patrol boat

Engine noise and vibration
→easy insulating

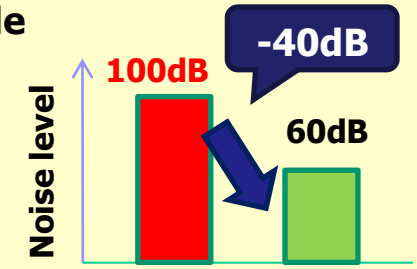
Automobile
→Suspension
→Versatile shaft



Engine noise and vibration
→easy transmittable



Boat
→Propeller
→Rigid shaft



RAICHO-I
in 2010

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2nd boat「RAICHO-S」2011

Water jet propulsion driven by electric motor

Advantage: Safety for the diver, Passing floating rope on Fish preserve, Environmental reservation (no-damage on leaf, fish, and ecosystem)

Disadvantage: Low efficiency and low maneuverability at low speed →improved by use of electric motor

「Ecosysytem of Fishing port 」Field test in 2013

Solar Panel (10kWh)

Electric Charger and Boat

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「RAICHO-S」

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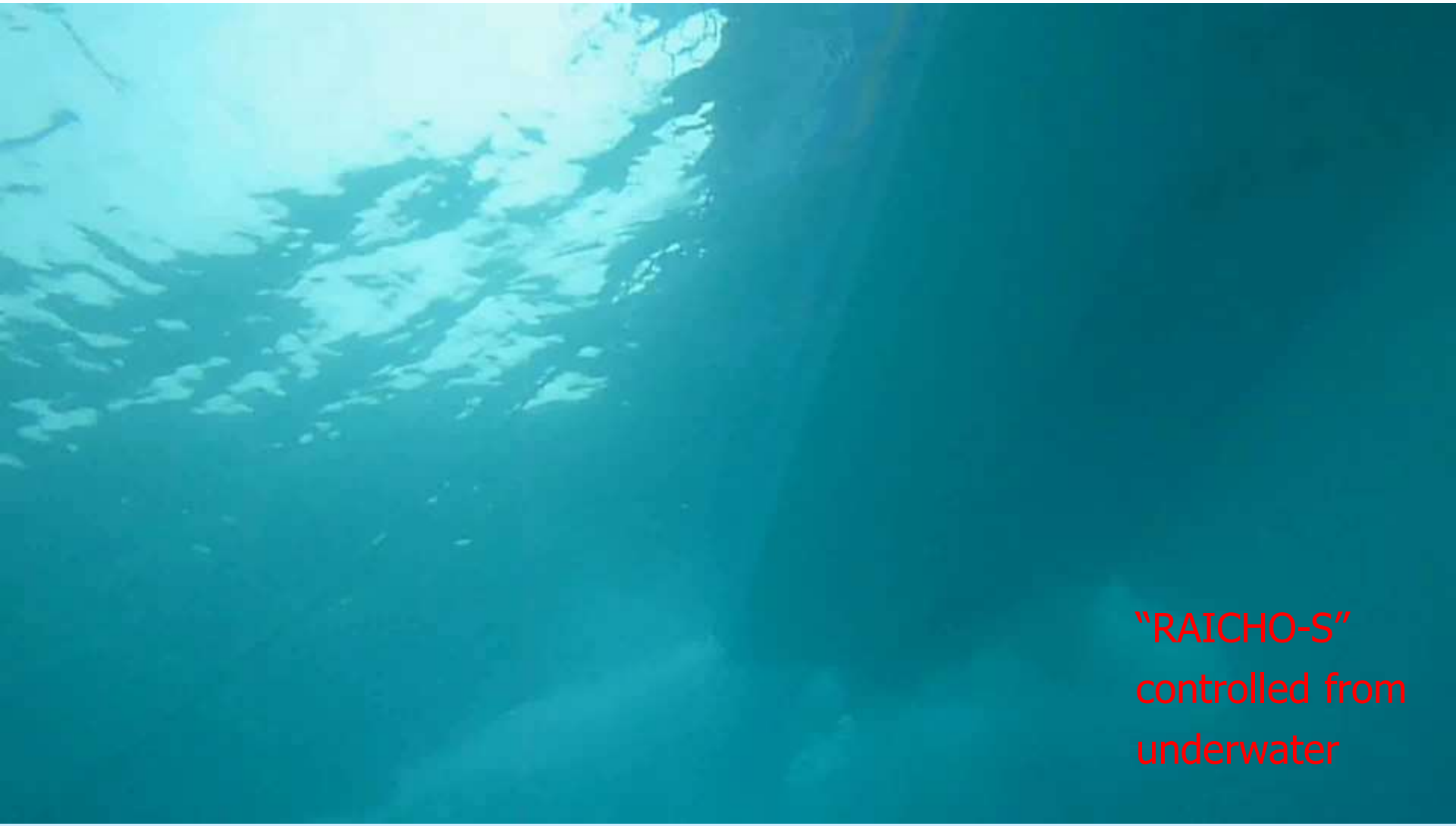
「RAICHO-S」
Cold test in Hokkaido

Even if the atmospheric temperature is −10℃, the seawater temperature is 4℃ at a depth of 1 m. The LIBs temperature does not drop below about 2℃, so there is no effect in cold regions.

Battery-propelled vessels do not need to be warmed up and can be easily cold-started.

Heat resistance Test
Most Southern City in Japan Ishigaki-jima



3rd boat「RAICHO-N」

Plugin Hybrid boat (World first) Fuel cell installed (Oct. 2016 ～)

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Ishigaki-jima Sightseeing boat (2015)

KABIRA-Marine #5
Sightseeing boat (Glass boat)
4.9ton Passengers 22 Crew1
Propulsion 45kW Battery 26kWh
6kt, 3hrs
I

CHAdeMO with 60 m long cable

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Mihama Mikatagoko Sightseeing Boat (2022)

The Japan Ship Technology Research Association (JSTRA) has started to study the domestic standardization of marine charging standards using CHAdeMO.

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Battery-Propelled Boats Compatible with COMBO Quick Charging

MINE Smart Ferry, where MINE is for "Mission No Emission“ in Bangkok, Thailand (2021)

800 kWh LIBs, 235 passengers, operating speed 11.0 knots (20 km/h), while the maximum 15.0 knots (28 km/h)

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Battery-Propelled Boats Compatible with COMBO Quick Charging

A total of **26 CCS2 DC fast charging inlets and plugs to conduct fast charging in 15-20 minutes**.

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Technical trends in marine charging standards (Summary)

1. Environmental protection measures for ships lag significantly behind those for land-based energy engines due to the characteristics of ships (long refueling intervals and salt damage).
2. In addition to exhaust emission regulations during ocean navigation, regulations on the use of diesel engines in bays are being tightened to protect the environment in coastal areas, and the number of vessels equipped with LIBs is rapidly increasing accordingly.
3. There is a global standard for AC power supply for onboard power supply when diesel engines are out of service and recharging of LIBs, and the wide application of this standard is under consideration.
4. Boats with DC power supply using CHAdeMO and CCS (COMBO) have been put into practical use by TUMSAT and , but the global standard for DC power supply has not yet been studied.
5. The Japan Ship Technology Research Association (JSTRA) has started to study the domestic standardization of marine charging standards using CHAdeMO.