



EUROMOT

The European Association of Internal
Combustion Engine and Alternative
Powertrain Manufacturers

The Role of Powertrains in Decarbonising Society

EUROMOT Guiding Principles to Decarbonise
Non-Road Mobile Machinery, Rail, Marine
and Power Plant Applications

**Summary Report:
Marine Recreational Craft**

March 2026

The Role of Powertrains in Decarbonising Society

EUROMOT Guiding Principles to Decarbonise Marine
Recreational Craft

This document is one of a portfolio of decarbonisation reports produced by EUROMOT, which are:

1. EUROMOT Guiding Principles
2. Executive Summary
3. Full Report
4. Sector-specific Summary Reports:
 - Non-road Mobile Machinery
 - Forestry, Lawn and Utility Machines
 - Marine Inland Waterways Transport
 - Marine Seagoing
 - Marine Recreational Craft
 - Rail Transport
 - Stationary Power Plants

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About EUROMOT

EUROMOT, the European Association of Internal Combustion Engine and Alternative Powertrain Manufacturers, represents the key manufacturers of internal combustion engines and alternative powertrains installed in Construction, Agriculture and Industrial; Forestry, Lawn and Utility; Marine; Rail; and Stationary power plant applications that are operating in Europe and globally.

Founded in 1991, we provide a recognised hub of expertise for businesses, authorities, regulators, and public stakeholders worldwide. In partnership with major sector associations and institutions, it is our mission to advocate better regulation, and to foster innovation that supports our sustainability and industry objectives.

Delivering reliable power for society at high energy conversion efficiency with low emissions remains a key objective of EUROMOT member companies. EUROMOT asserts internal combustion engines and alternative powertrains are a key enabler to address decarbonisation across multiple industry sectors. This can be achieved by continuing to advance the development of flexible highly efficient energy conversion systems capable of operating on various low and net zero greenhouse gas emissions energy carriers.

Our Members





EUROMOT Guiding Principles to Decarbonise Marine Recreational Craft

The sector comprises small boats predominantly less than 24m length that are used for recreational and leisure purposes. This includes sailing and motor yachts, motor cruisers, sports boats and some fishing boats.

Core Principles:

Technology neutrality:

- Facilitate a diversified energy mix and do not be tempted to force a single technology.
- Base overall GHG reduction objectives in each industry sector on Life Cycle Analysis (LCA) considering different end uses and do not focus solely on emissions at point of use.

Recognition of the needs of end users:

- Ensure the continued ability to deliver dependable power to perform the intended task wherever it is needed.
- Ensure the availability of new low or net zero greenhouse gas (GHG) energy carriers at competitive costs.
- Facilitate the availability and use of low and net zero GHG energy carriers suitable for existing in-use products.

Predictable global approach:

- Align activities and levels of ambition at international level recognising internal combustion engines, alternative powertrains and the applications in which they are installed are developed for global markets.

Key Factors that Determine Decarbonisation Pathways

The recreational craft sector accounts for 0.4% of transportation emissions in Europe. Recreational craft have an average lifecycle of 30-50 years with a high proportion of old vessels still in service. Most boats are owned for occasional leisure use and used on average between 35 and 48 hours per year.*

With such a low average use time, the environmental performance of the manufacturing process and choice of raw materials will play a significant role in the life cycle assessment of the recreational craft.

The decarbonisation of the recreational craft sector may result in a different usage pattern with respect to the distance travelled or performance, which customers need to be aware of.

To maintain the current range of the vessels, low carbon and net zero carbon fuels with equivalent energy density to diesel or gasoline will be needed.

Output of propulsion units ranges from <20kW to >1MW

Running times can vary from short periods to long, including running continuously for up to weeks at a time



Alternative propulsion systems must be of a size and weight that enables recreational craft to perform the tasks for which they are intended.

Decarbonisation pathways must also consider the many cases where electrification is not viable such as extended offshore voyages, and in remote locations.

Evaluation of these low emissions technologies also needs to factor in other key criteria including:

The largest motor vessels can consume up to several MWh of energy a day

Operating environments are rivers, lakes, inshore and offshore seas.

Fuel/energy is nearly always delivered to boats in harbours, marinas or moorings.



Facilitate adoption to ensure widespread use.

Availability of secure supply chains and material sources such as precious and rare-earth metals, and the technical feasibility and technological maturity of the powertrains

Cost-competitiveness to drive maximum market penetration and ensure mechanised industry products remain internationally competitive

Availability of the required energy carrier production, distribution, and storage networks across all operating environments

*RICARDO, ICOMIA (2023) Pathways to Propulsion Decarbonisation for the Recreational Marine Industry. Synopsis Report. © Ricardo plc 2023.

Powertrain Technologies

The powertrain technologies, that are available to support decarbonisation and their attributes, are shown here.

Internal combustion engines

<p>Efficiency</p> <p>Highly operationally efficient as the most compact powertrain technology with readily available, energy-dense fuel sources and fast refuelling times.</p> <p>Up to 55% energy conversion efficiency.</p>	<p>Emissions</p> <p>Potential for decarbonisation when using reduced carbon, low carbon, and renewable fuels (including non carbon fuels such as hydrogen and ammonia). Lower embedded GHG emissions* than fuel cells or electric powertrain technologies.</p>	<p>Technological maturity</p> <p>Proven technology across all industrial applications and use cases.</p> <p>Security, cost, and availability</p> <p>Secure, domestic supply chains and readily available material sources except some precious materials used in aftertreatment.</p>
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The technologies may be combined to improve system attributes - Hybrids

**Embedded GHG emissions* refer to the greenhouse gas emissions associated with the production, transportation, and disposal of a product or material, but not necessarily emitted during its use.

Hydrogen fuel cells with batteries and electric motors

<p>Efficiency</p> <p>Similar refuelling times to ICEs but hydrogen tanks need 4-8x onboard storage space of diesel tanks. Can achieve up to 60% energy conversion efficiency for some applications (efficiencies may reduce with use).</p>	<p>Emissions</p> <p>Zero air quality or GHG emissions at the point of use. Moderate embedded GHG emissions, usually higher than ICEs and lower than battery electric.</p>	<p>Technological maturity</p> <p>Technology already in use in on-road applications including cars and forklift trucks, but unproven in recreational craft.</p> <p>Security, cost, and availability</p> <p>Supply chain costs and risks around some components. Fuel cell systems for dynamic applications require a hybrid configuration with batteries.</p>
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Electric Motors - Continuous electric supply or with battery storage

<p>Efficiency</p> <p>The highest energy conversion efficiency technology giving 75-90% efficiency.</p> <p>The overall operational efficiency can be reduced by downtime due to charging, and the extra storage space needed for large onboard batteries.</p>	<p>Emissions</p> <p>Zero GHG emissions at the point of use. Usually higher embedded GHG emissions than ICEs or fuel cells.</p>	<p>Technological maturity</p> <p>Proven technology across some industrial applications.</p> <p>Security, cost, and availability</p> <p>Supply chain security risks, high costs and projected shortages for raw materials and components in batteries and motors.</p>
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Energy Carriers

Energy carriers are predominantly fuels or electricity. Their carbon intensity depends on their provenance.

Fuels

Fossil fuels

Derived from ancient organic matter, fossil fuels like coal, oil, and natural gas are burned for energy. Their combustion releases greenhouse gases, contributing to global warming. Unlike renewable fuels, fossil fuels are finite and environmentally impactful.

Reduced carbon fuels

Fuels where the carbon footprint (CF) is lower than the fossil fuels they replace, for example natural gas replacing diesel/fuel oil; B20 biodiesel; E50 gasoline.

Low carbon fuels

Fuels where the CF is >70% lower than their fossil equivalent.

Non carbon fuels

Fuels that do not contain carbon such as hydrogen and ammonia (not necessarily renewable).

Renewable fuels

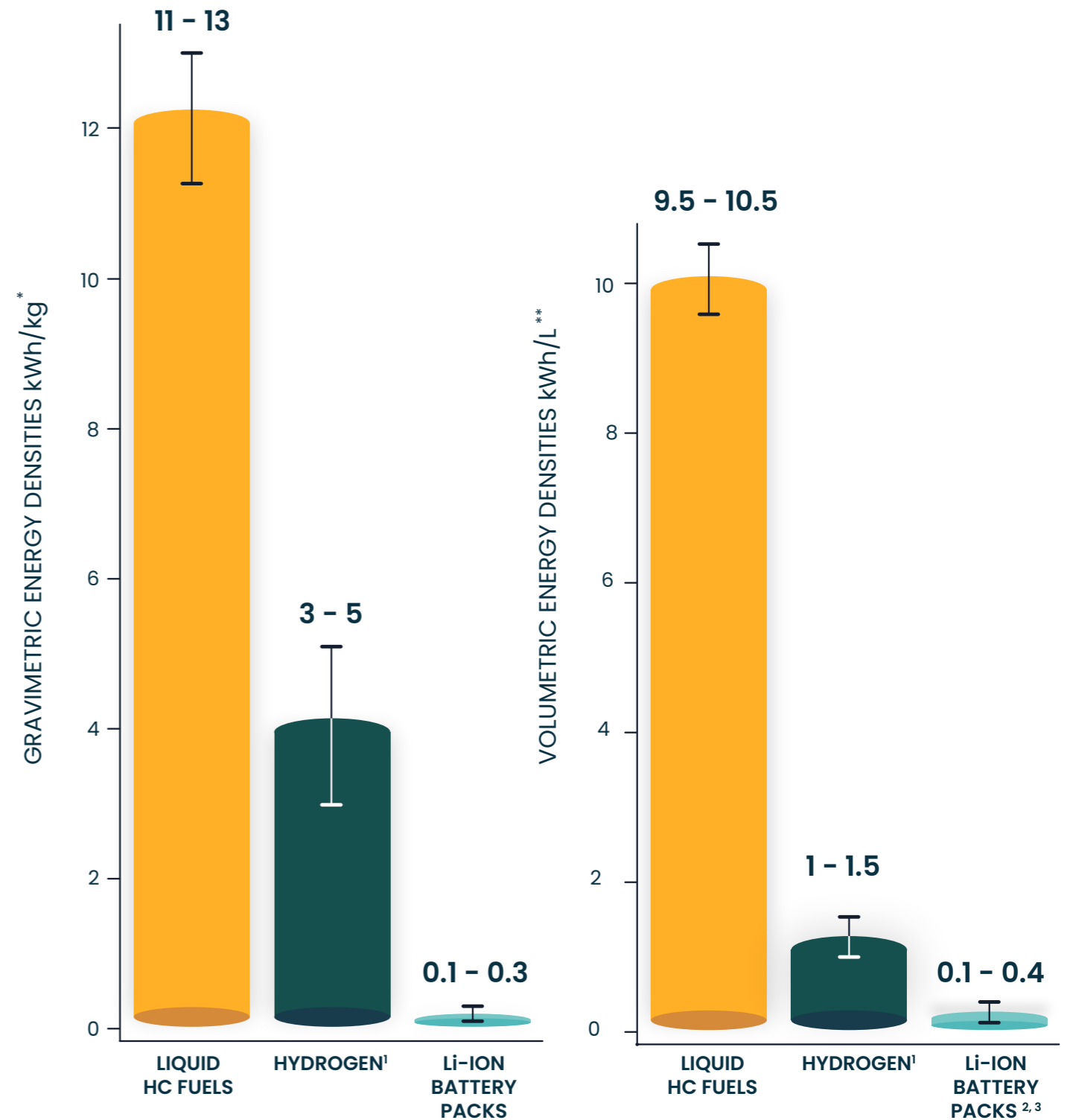
Fuels of biological or non-biological origin where the stored energy comes from renewable sources; either solar energy via photosynthesis or from renewable electricity. The EU Renewable Energy Directives (REDs) require the Carbon Footprint (CF) of renewable fuels to be >70% lower than their fossil equivalent.

Electricity

Generated from

- Fossil Fuels: coal, oil
- Natural Gas (RCF)
- Low carbon fuels
- Renewable fuels
- Non carbon fuels
- Renewable energy: solar, wind, hydro

Comparing energy densities for compressed hydrogen, liquid hydrocarbon (HC) fuels and lithium-ion (li-ion) batteries.



*Energy carriers with lower gravimetric energy density are heavier, which affects their feasibility for applications where weight is at a premium.

**Energy carriers with lower volumetric energy density need more onboard storage space, affecting their use in applications where space is at a premium.

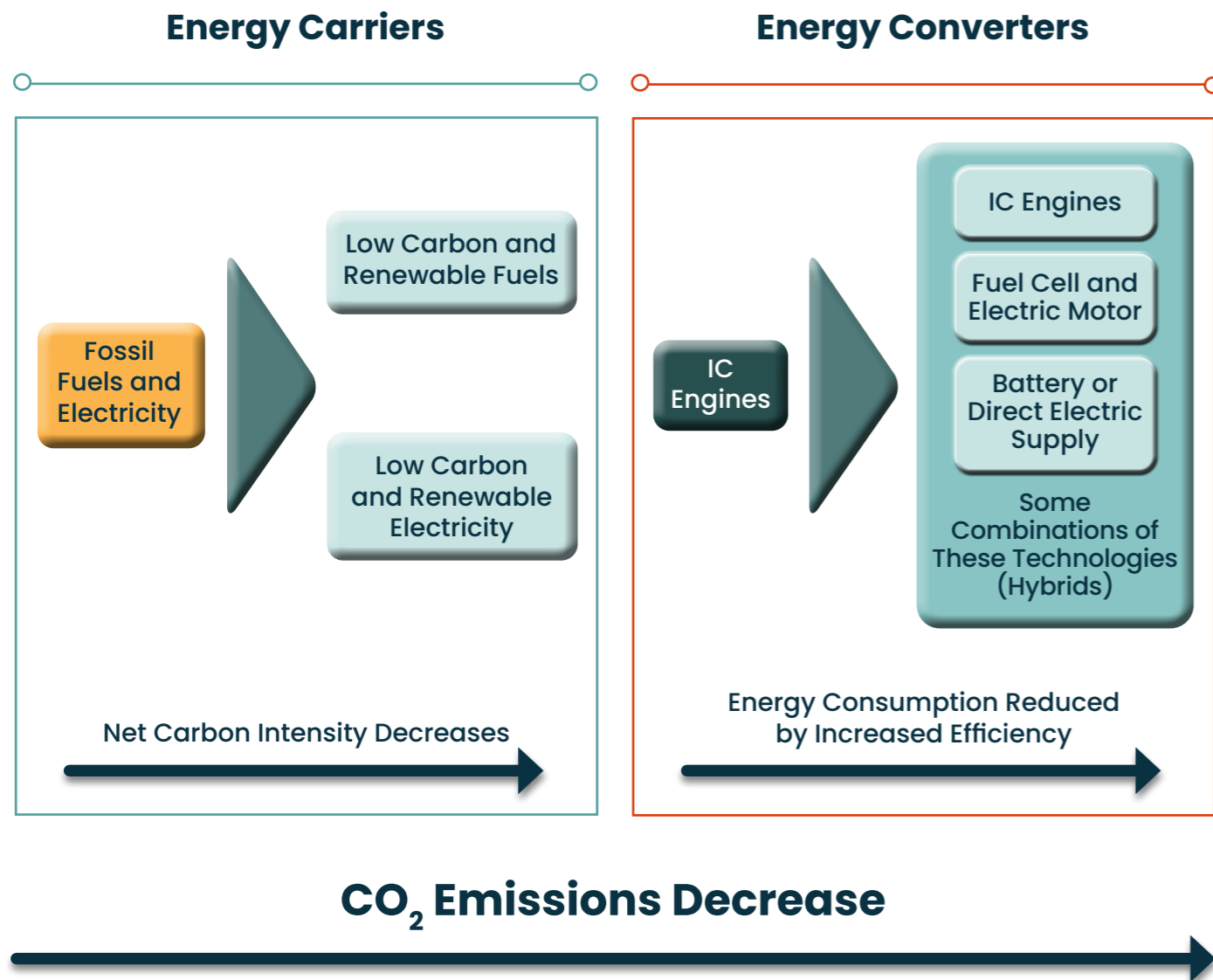
¹Compressed to 700 bar including the tank.

²STIHL. (2023). AP 300 S Battery.

³Husqvarna. (2025). Akku B330X.

Decarbonisation Journey

How sector decarbonisation will result by combining efficient energy converters with an increasing panel of low carbon and renewable energy.



Use Case Examples

The following section presents a selection of examples that demonstrate the fundamental principles of decarbonisation.

These examples are not exhaustive, and do not represent the only pathways to decarbonisation for each type of machine.

Each of these machines may require different powertrain technologies offering pathways to decarbonisation for different use cases.

The energy consumption numbers in the following examples include the efficiency of the ICE, i.e. they are comparable to the output of the electric motor of electric machines.



Important Criteria for Assessing Decarbonisation Pathways

Key Criteria*	Use Case Evaluation		
Energy use	Low	Is a large amount of energy used for the example task?	High
Work intensity	Low	Is the average power the machine is working at a high percentage of its maximum output power?	High
Type of use	Sporadic	Is the machine running for a high proportion of the task duration, or for a small portion?	Continuous
Availability of electricity on site	Available	Is electricity at a usable voltage and power available at the site of use of the machine?	Not available
Predictability of deployment	Pre-planned	Can the task be planned well in advance, or is it required to act urgently depending on circumstances?	Un-planned
Location of site	Adjacent to infrastructure	Is the machine being used in an area with infrastructure and service availability or any area without these?	Remote from infrastructure
Time on site	Extended	Is the time a machine is on site short i.e. days or weeks, or long i.e. months or years?	Short
Required machine mobility	Low	Does the machine used for the task move around the site (>100 m) or does it stay in one position?	High
Minimise refuelling/recharging	Infrequent	Is it important to complete task without significant downtime for refuelling/recharging	Fast

*Terms used to explain the use case evaluations found in the following examples.

Marine Recreational Craft

Example 1: Ocean-Going Sailing Yacht

Use description:

Used for ploughing, harrowing and planting on large arable farmland of over 100 hectares. The machine operates in remote rural environments at high intensities for periods exceeding 20 hours with usage dictated by the weather and crop cycles.

Machine employed:

Agricultural tractor with **200 kW** engine running on diesel. Fuel consumption is typically up to **500 L** diesel per day (equivalent to a battery capacity of **2 MWh**).

Decarbonisation pathways:

High density energy carriers are required that offer rapid refuelling and can be taken to the machine in the field. ICEs running on low carbon fuels, moving to renewable, gaseous and liquid fuels such as biomethane, synthetic diesel or renewable hydrogen. Fuels of biological origin may be favoured in the agricultural industry.



Evaluation Criteria

Use Case Evaluation

Energy use	Low	<input type="range" value="75"/>	High
Work intensity	Low	<input type="range" value="75"/>	High
Type of voyage	Stop-start	<input type="range" value="75"/>	Continuous
Predictability of voyage	Pre-planned	<input type="range" value="75"/>	Un-planned
Remoteness	Lake or river	<input type="range" value="75"/>	Open seas
Voyage duration	Low	<input type="range" value="75"/>	High

Marine Recreational Craft

Example 2: Motor Cruiser for Offshore Cruising

Use description:

Offshore cruising in the Mediterranean or other seas. Several days at sea per voyage leg. Shorter, inshore trips are also often undertaken.

Vessel employed:

12 metre motor cruiser with **2 x 250 kW** diesel engines. It has an **800 L** fuel tank (equivalent to a battery capacity of **3 MWh**) with a range of **1,000 km** and consumes an average of **250 L** of diesel per offshore journey (**1 MWh**).

Decarbonisation pathways:

Low carbon, moving to renewable, liquid fuels. The reduction in battery size needed due to weight, cost and space constraints would reduce vessel range by 80%.²⁰



²⁰RICARDO, ICOMIA (2023) Pathways to Propulsion Decarbonisation for the Recreational Marine Industry. Synopsis Report. © Ricardo plc 2023.

Evaluation Criteria

Use Case Evaluation

Energy use	Low		High
Work intensity	Low		High
Type of voyage	Stop-start		Continuous
Predictability of voyage	Pre-planned		Un-planned
Remoteness	Lake or river		Open seas
Voyage duration	Low		High

Marine Recreational Craft

Example 3: Roaming Tender for Short In-Harbour Journeys

Use description:

Short journeys to ferry passengers and goods between anchored boats in harbour and shore. Each journey is usually short (circa 15 minutes) with additional loading, unloading and idle time.

Vessel employed:

6 metre boat with 45 kW propulsion power. Energy used circa 15 L diesel (45 kWh) per day.

Decarbonisation pathways:

Internal Combustion Engine (ICE) with low carbon moving to renewable fuel. Battery electric or hydrogen fuel cells are also viable options.²¹



²¹RICARDO, ICOMIA (2023) Pathways to Propulsion Decarbonisation for the Recreational Marine Industry. Synopsis Report. © Ricardo plc 2023.

Evaluation Criteria

Use Case Evaluation

Energy use	Low	<input type="range" value="10"/>	High
Work intensity	Low	<input type="range" value="10"/>	High
Type of voyage	Stop-start	<input type="range" value="10"/>	Continuous
Predictability of voyage	Pre-planned	<input type="range" value="80"/>	Un-planned
Remoteness	Lake or river	<input type="range" value="10"/>	Open seas
Voyage duration	Low	<input type="range" value="10"/>	High



Conclusion

There is a wide range of boats in this sector, ranging from small vessels with low power propulsion systems to larger motor cruisers with high power engines.

The common factors, due to their recreational use, is very low annual use and long service life.

Weight and range are also critical factors which limits the applicability of battery electric solutions to uses where a substantially reduced range is acceptable.

Recommendations

Manufacturers are developing powertrains that support decarbonisation of all the sectors in which they are used. For successful deployment of these technologies, policy and regulation need to be technology neutral, recognising the need for the full array of decarbonisation pathways, and assessing them on life cycle basis (LCA method).

Policy also needs to enable supply and distribution of renewable electricity and low carbon and renewable fuels. This includes production of drop-in low carbon and net zero fuels for use in existing equipment. This will be critical to balance decarbonisation with the continuing need for dependable power across society.



Appendix: Definitions

Life Cycle Analysis (LCA) is a method of calculating the total CO₂e emissions from a product, including other emissions such as nitrous oxide (N₂O) and methane (CH₄), during its full lifecycle. That is throughout manufacture, use and disposal.

Well to Wheel, (or Well to Wake for marine) (WtW), or Well to X (WtX) emissions is the total (net) emissions generated when a fuel or energy carrier is created (such as when it is extracted from the ground or grown as a biological feedstock), when its energy has been converted in a machine and its end products emitted (e.g. CO₂ and water from burning a hydrocarbon fuel).

GHG Emissions CO₂ is the predominant Greenhouse Gas for this sector, but this also encompasses other GHGs such as nitrous oxide and methane, normally defined as CO₂ equivalent (CO₂e) when using the GWPI00 definition (the global warming potential of a specific greenhouse gas over 100 years).

Energy Carriers are fuels and electricity (including batteries) containing stored energy that can be converted to other forms of energy which can then be used to power machines and power plants.

Energy Converters are the devices that convert energy from stored chemical energy (fuels) or electricity to mechanical energy – generally engines or motors (such as internal combustion engines, electric motors, hydrogen fuel cells combined with electric motors, hydraulic pneumatic motors, and hybrid systems).

Conversion Efficiency is the energy out of a converter divided by the energy input. For example, the mechanical energy at the flywheel, divided by the stored energy available in the fuel used.

Operational Efficiency is a measure of the work a powertrain application can do compared to a theoretical maximum or to the incumbent powertrain's performance. For example, operational efficiency is reduced if a proposed powertrain reduces the payload of a goods carrying vehicle, or if the use time available is reduced by increased refuelling times.



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