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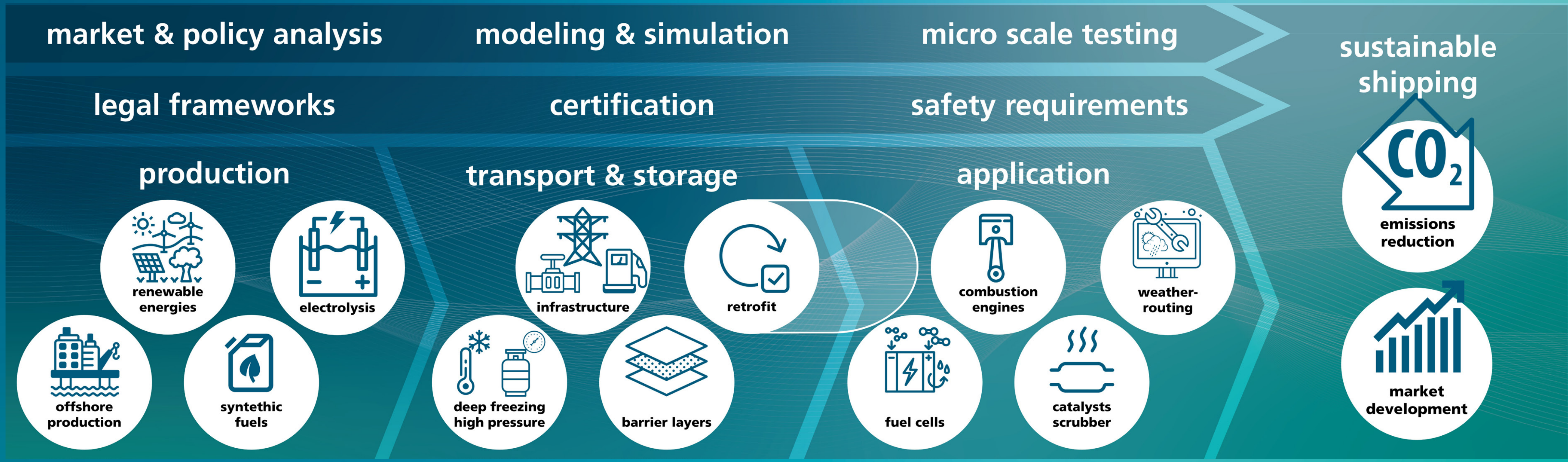
Hydrogen applications in maritime research

Fraunhofer-Waterborne

waterborne



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Introduction

The shipping industry is facing a transformation of propulsion technology and energy systems. The IMO Emission Control Areas, which set emission limits for sulfur oxides, nitrogen oxides and particulate matter, as well as a global limit of 0.5 percent sulfur in fuel for all ships over 100 GT, require new propulsion systems. Within the next few years, the maritime industry expects the introduction of effective measures for the mitigation of greenhouse gas emissions, both from the IMO and the EU. Fraunhofer-Waterborne analyzes the impact of maritime environmental policies and develops technologies to achieve the emission limits.

The reduction of greenhouse gas and other emissions requires climate-neutral and clean propulsion systems. Fuels such as LNG and hydrogen need complex cryogenic systems and new bunkering infrastructure. Catalysts or scrubbers can mitigate emissions from sulfur oxides, nitrogen oxides and particulate matter. Fraunhofer-Waterborne is researching new technologies and energy systems that can produce renewable energy and manufacture synthetic fuels. Systems and materials for hydrogen applications in engines and fuel cells are designed and technologies for safety and reliability developed. Wind propulsion systems, which have a high potential for mitigating greenhouse gas emissions, are also being considered.

Innovative approaches to emissions savings can be extended if, for example, the operation of ships is rethought. The development of software for weather routing and speed optimization is therefore a focus. Furthermore, market potential and transition paths for sustainable shipping are elaborated and analyzed.

Hydrogen logistics and supply chains

Transport and handling of »green« hydrogen, produced from renewable energies, e.g. in offshore wind farms, poses new challenges for planners, developers and operators of hydrogen supply chains.

The medium itself must be stored and transported in a liquefied or deep-frozen state under high pressure, thus placing new demands on vehicles. High permeation losses occur during gaseous handling and transport, so new materials must be developed for this form. Therefore, the less volatile derivatives ammonia and methanol are used as alternatives. Fraunhofer-Waterborne is developing innovative materials and hydrogen barrier layers for gas pipelines, tanks and pressure vessels, which can also be retrofitted into existing systems.

The special nature of hydrogen as an energy carrier and the large-scale conversion of industry requires the development of new end-to-end supply chains that connect production sources, e.g. at sea, with consumers., Logistics for the supply of large industrial plants are developed and validated with the help of simulation. Algorithms are used for the planning and control of smaller distribution systems, e.g. in ports.

Fuel cells for the conversion of hydrogen into propulsion energy is a growing technology. The use of this technology in the port environment is being pursued in the port of Hamburg, for example. There, handling equipment and tractors as well as the necessary filling station infrastructure for the use of hydrogen and its derivatives are being tested and prepared.

Hydrogen production

Fraunhofer-Waterborne is investigating open to all technologies the production of green hydrogen in the field of maritime shipping by means of electrolysis.

A particular focus is on the dynamic operation of electrolysers when using fluctuating renewable energy sources, as is characteristic for wind or solar energy. To this end, a cross-scale, comprehensive test infrastructure is being established to accompany the market ramp-up of green hydrogen technologies from microstructure to components to complete systems on an industrial scale. Large scale effects can be traced back to structure scale effects and vice versa.

Research includes the development of standardized tests for electrolysers, which investigate the behavior under realistically occurring load profiles and allow lifetime predictions. In addition, we pursue the goal of creating the prerequisites for the practical implementation of offshore hydrogen production by taking a holistic view of the topics of water treatment, heat management, island operation and grid forming, hydrogen logistics and storage.

Safety, reliability, service life

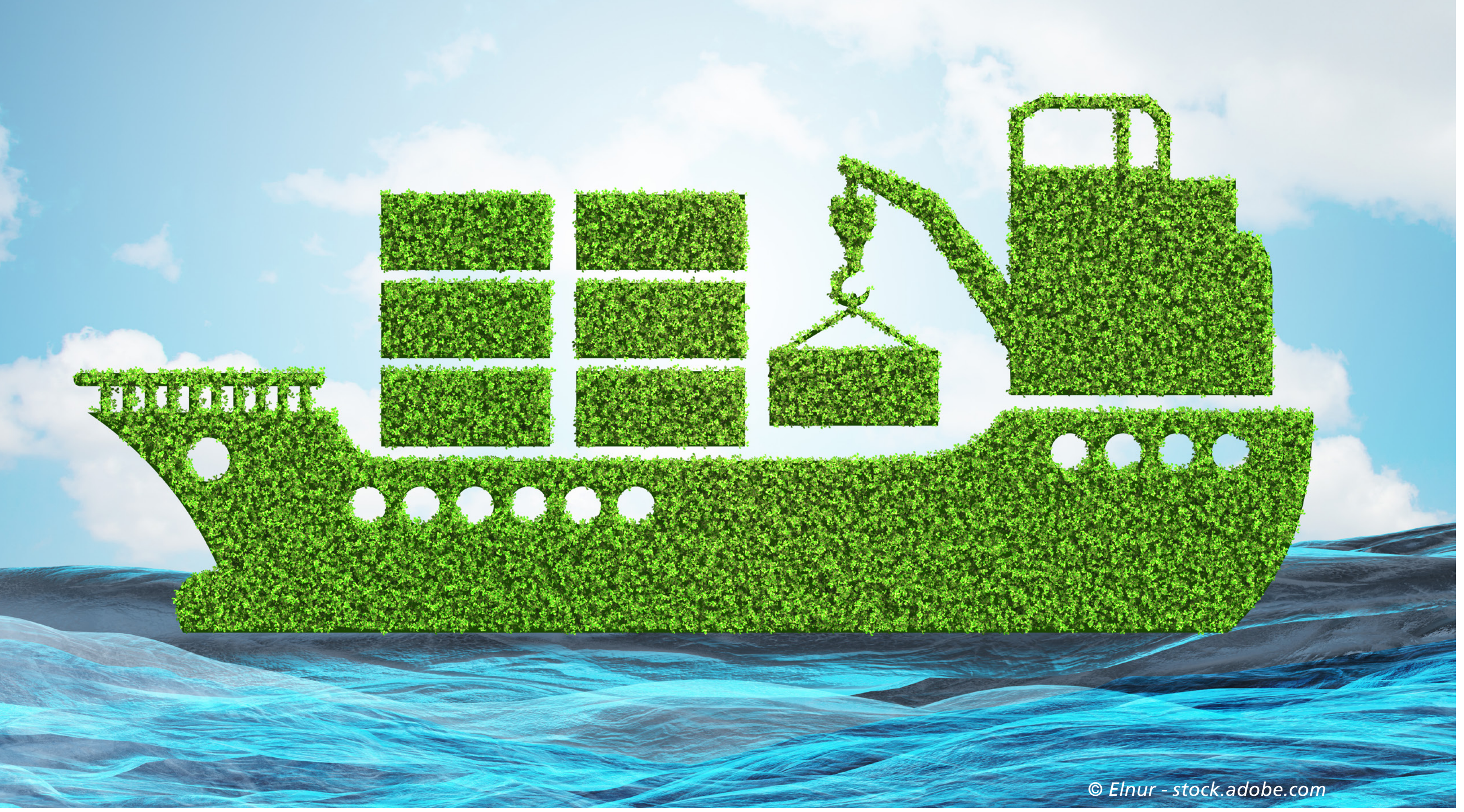
To anchor a broad acceptance of hydrogen in the maritime sector, the operational safety of the storage, the supply as well as the use of green hydrogen must be guaranteed. The entire infrastructure must not pose any safety risks or accident hazards, and a long service life and high reliability of the facilities must be guaranteed.

The safety, function, reliability and service life of components and systems are always limited by H^2-specific material damage resulting from mechanical, thermal, chemical and electromagnetic loads during operation. This can be countered on the one hand by selecting qualified materials with high H^2 corrosion resistance, but also by systematic and planned monitoring of all safety-relevant components and parts. Research is unertaken on material damage and damage detection by tailored non-destructive testing methods, the monitoring of hydrogen-bearing components, the acquisition of condition and process data, and the modeling and simulation of safety or reliability scenarios. The focus is on the safety, design and optimization of processes and components such as H^2 propulsion systems, fuel cells and storage systems. Intelligent sensor systems for non-destructive testing as well as lifetime models and methods are developed, which enable effective holistic system assessment and monitoring and evaluate system behavior down to the material level using digital sensor technology and sensor materials. This ensures high availability of systems and mobile applications.

Hydrogen propulsion systems

In the field of H_2-based propulsion, Fraunhofer-Waterborne offers extensive know-how, specialized infrastructure and a wide range of services. The analytical development of innovations for H^2 propulsion systems in maritime applications as well as different technological alternatives in the field of fuel cell and internal combustion engine technology are a central area of investigation. The R&D activities also cover hydrogen derivatives such as ammonia and methanol.

The service portfolio includes simulations to evaluate the performance and emissions of H_2 combustion engines as well



as the development and design of combustion processes and components. For this purpose, single-cylinder engines and, in the future, maritime full-scale engines, including high-performance measurement technology, are available. Fraunhofer-Waterborne can also carry out packaging studies and energy balancing of main propulsion systems and the associated subsystems. In addition, the simulative and economic evaluation of scenarios is an area of activity, as is the evaluation of H_2 technologies in terms of their impact on the environment, accompanied by simulations. Another field of activity is the conversion of the existing fleet to hydrogen-based propulsion solutions by means of suitable retrofit strategies.

Market analysis and policy

Fraunhofer-Waterborne has extensive competence and activities in market analysis of maritime H_2 systems and technologies as well as analysis of potential applications.

The transformation of the maritime industry towards a sustainable sector is driven by society and policy. Fraunhofer-Waterborne can provide an overview of German, European and further national policy orientations as well as insight into IMO and maritime R&D policies. Relationships with Classification Societies allow detailed knowledge and involvement in the regulation of H_2 systems on board, bunkering and in ports. Both joint projects and participation in industry networks such as the EU »Waterborne Technology Platform« and the »Maritimen Plattform e. V.« promote implementation of new technologies.

Fraunhofer-Waterborne provides industry-leading analyses of future markets for alternative fuels in shipping and inland navigation through computer simulations (including the MATISSE-SHIP model). Industry development scenarios are developed with industry through stakeholder processes and their application in combined qualitative and quantitative analyses. Drivers and barriers to market development are identified and used to develop policy ideas for both mitigation and innovation policies for market development.

The market and policy analysis includes the entire sustainable supply chain of H_2 and synthetic fuels. The analysis of the demand-driven, decentralized, modular solution for the production and distribution of green H_2 and the biological H^2 production are part of the development of H_2 systems in the marine and maritime industries.

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