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e-S1HyIPS ON THE WAVE OF HYDROGEN

NEWS LETTER 2

THE THREE E-SHYIPS SCENARIOS

During the first General Assembly, the e-SHyIPS consortium consolidated three functional concept scenarios, developed during the initial months of the project, and in agreement with the Advisory Board experts'.

The three chosen reference ships are as different as possible in terms of purpose, dimensions, and passengers' capacity. It may come naturally to think that vessels of similar size fulfil the same function. This is not always true, and e-SHyIPS vessels scenarios also deal with this crucial distinction. To be able to effectively compare the different features of each vessel scenario, they have been identified according to four criteria: i) operational profile and vessel typology; ii) potential hydrogen technology and systems; iii) bunkering strategy, and iv) safety engineering strategy. Each partner's field of study has set the involvement in the data gathering activity for each criterion. In relation to the methodology adopted to build the three scenarios, analysis of the market insights, case studies, and literature review were performed, dividing the results into different categories of interest, which then become the main scenarios "theme":

1) **SMALL VESSELS, WITH COASTAL/INLAND ROUTING.**
2) **MEDIUM VESSELS, WITH MARITIME COASTAL ROUTING WITH FREIGHT AND CARS ON-BOARD.**
3) **LARGE VESSELS, WITH MORE EXTENDED ROUTING.**

All three categories were deeply analysed to understand both challenges and potentialities for future on-board hydrogen-based systems adoption.

Going More Into Details, The Small Scenario Refers To Inland Waterways' Vessels. Also Known Under The Name Of "Water-bus", It Is A Widespread Means Of Transport In All The Geographical Areas Where People And Goods Are Daily Moved Along Canals. Throughout The Year, Due To The Morphology Of The Territory. This Vessel Typology Is Widely Used In Norther European Cities. The Maximum Length Of This Kind Of Vessel Is Supposed To Be Around 30 Meters, And The Reference Ship Studied Within The Project Is The Waterbus 2407, Built From Damen Shipyard, And Currently Under Operation For Many Shipping Companies.

The medium scenario is represented by roll-on/roll-off vessels used for freight and passenger transport. This category of vessel refers to the ones typically used by tourists to move among islands with or without their cars or even by locals to supply goods to the inhabitants during the year. For these reasons, the frequency of the route may be varied during the different periods of the year. The maximum length of this kind of vessel is supposed to be around 100 meters, and the reference ship studied within the project is the Fior di Levante ship, currently part of the Levante Ferries fleet.

Lastly, the large scenario refers to luxury cruise ships. According to the Global Demand Analysis and Opportunity Outlook, this market share is indeed estimated to grow significantly in 2021-2029, especially in Europe. In terms of shape, dimensionsand passengers' capacity, these vessels can be considered as mega-yacht rather than conventional cruise ships. Luxury cruise isdesigned to meet the needs of a limited number of passengers, which require a high level of comfort and services. The maximum length of this kind of vessel is supposed to be around 150 meters, and the reference ship studied within the project is the Flora Cruise, which is part of the fleet of Celebrity X cruise company.

DAMEN WATERBUS

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Damen is mainly working on the small scale scenario, the waterbus. The purpose of this vessel is to shift traffic from roads to the water. Usually there is plenty of space on waterways while roads are fully occupied. However, strict requirement are being set for public transport. The sailing schedules as presented to the public have to be reached, so reliability is a key factor. Also, customers will only make use of the service when traveling time stays limited. Therefor the sailing speed of the waterbus needs to high

This vessel is selected after exploration of state-of-the art vessels. Currently, the vessels are sailing mostly with conventional driveline due to the low weight. First steps are being made for full electric sailing, but also hydrogen seems a valuable solution. Since these vessels operatein urban areas, zero-e-missions for local and global emissions is expected to be required. The latest vessels in construction have electric propulsion with hybrid power supply, batteries in combination with a stage V diesel generator. This ensures a proper preparation to switch to battery-electric or hydrogen-fuel cell propulsion in the near future.

The smaller size vessel gives challenges in mainly volume and weight restrictions. Due to the high sailing speeds weight is a crucial parameter to limit resistance. Also the wash generated by the vessel has strict limitations which is also related to the displacement of the vessel. Therefor the latest vessels are constructed out of carbon fiber to limit weight as much as possible.

Within e-shyips an estimation is made for the average daily energy consumption of the waterbus. Therefor a route is selected which resulted in a daily consumption of about 400 kg hydrogen per day. Based on these numbers, various hydrogen storage solutions can be explored. The main focus is on compressed hydrogen because of the high technical maturity. Decisions have to be made about the pressure, cylinder type and refilling schedule. In parallel the footprint of a fuel cell is being studied, to estimate the impact on the ship design.

EFC21 - EUROPEAN FUEL CELLS AND HYDROGEN CONFERENCE

The European Fuel Cells and Hydrogen Piero Lunghi Conference - EFC21 took place as a virtual event in 15-17 December. The work "Hydrogen-based technologies in maritime sector: technical analysis and prospective" by some of the e-SHyIPS partners: ATENA, Politecnico di Milano, DAMEN and Proton Motor, was presented. This study will be published in the Conference Proceedings of the Conference.

HYDROGEN-BASED TECHNOLOGIES IN MARITIME SECTOR: TECHNICAL ANALYSIS AND PROSPECTIVE

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Abstract. The maritime transportation sector is one of the main contributors to global emissions of greenhouse gases (GHGs). The International Maritime Organization (IMO) has adopted a strategy to reduce these emissions from international shipping >50% by 2050, compared to 2008's emissions. Therefore, ship owners need to adopt solutions to bring emissions within these and other future limits by means of environmentally friendly fuels (hydrogen or hydrogen carriers) and high efficiency propulsion technologies (fuel cells). This paper focuses on the replacement of the conventional Diesel genset installed on a hybrid small-size ferry, with an innovative system based on PEMFC technology. A real case scenario is investigated: the total energy/power demand of the vessel is determined basing on a typical operational profile. Then, a preliminary redesign of its powertrain configuration is proposed along with an energy management strategy. The analysis has allowed to define the hydrogen consumption for a daily operation. Finally, different storage technologies involving both compressed and liquefied hydrogen have been considered and compared, in order to identify ship's weight and space requirements.