



WATERBORNE

STRATEGIC RESEARCH
AND INNOVATION AGENDA
FOR THE PARTNERSHIP ON
**ZERO-EMISSION
WATERBORNE
TRANSPORT**

June 2021





EXECUTIVE SUMMARY

Realizing zero-emission waterborne transport to the benefit of future generations

Amid growing global and European societal pressure to resolve issues related to **climate change, air pollution** and the **degradation of the world's oceans**, political and regulatory attention has been increasingly directed towards waterborne transport, due to its high environmental and climate impact. The European Green Deal, the Paris Agreement Objectives, the Initial IMO Strategy on the reduction of GHG emissions from ships and the CCNR Ministerial Mannheim Declaration are a number of key policy developments which provide a clear objective towards zero-emission waterborne transport.

The waterborne transport sector is committed to develop and demonstrate **disruptive** solutions to address the aforementioned challenges. Research, development and innovation are key to develop commercially viable solutions to **eliminate GHG emissions, air and water pollution**. These solutions should be applicable for both **new build and existing main maritime and inland navigation ship types and services**. Furthermore, the Partnership will develop solutions which will facilitate the **modal shift** of cargo from road to waterborne transport and, in doing so, will contribute to the achievement of the carbon neutrality goals envisaged by the European Green Deal.

The Partnership's objective is to **provide and demonstrate zero-emission solutions for all main ship types and services before 2030, which will enable zero-emission waterborne transport before 2050**

The Strategic Research and Innovation Agenda (SRIA) builds upon [the final draft Proposal for the Partnership](#), as published in May 2020. In order to achieve the objectives, the technical content of this SRIA is divided into six parallel activities. These activities are:

- use of sustainable alternative fuels,
- electrification,
- energy efficiency,
- design and retrofitting,
- digital green and
- ports.

In addition, the SRIA includes the monitoring and governance of the Partnership, as well as cooperation at EU and international level.



CONTENT

EXECUTIVE SUMMARY	3
PART 1: VISION 2050 AND OBJECTIVES 2030	6
Overall vision 2050 for the waterborne transport sector	15
Objectives of the Partnership	15
Operational objectives of the Partnership	16
Commitment of the Waterborne Transport Sector	18
PART 2: RESEARCH AND INNOVATION STRATEGY	23
R&I strategy	24
Implementation pathways	25
Achieving the operational objectives	33
Activities	40
PART 3: EXPECTED IMPACTS	70
Realizing zero-emission waterborne transport to the benefit of future generations	71
Impact by the specific objectives	72
Enablers and requirements to reach full impact of the Partnership	74
Proposed arrangements to monitor	75
Key Performance Indicators (KPIs)	77
PART 4: GOVERNANCE	87
Description of the governance of the Partnership	88
Openness and transparency	91
Update of the SRIA	92
Synergies with other Partnerships	94



PART 1: VISION 2050 AND OBJECTIVES 2030

The Strategic Research and Innovation Agenda (SRIA) is based on the Final Draft Proposal for a Co-Programmed Partnership Zero-Emission Waterborne Transport. Part 1 of the SRIA contains a summary of the [Final Draft Proposal](#).

This chapter describes the vision of the waterborne transport sector for 2050 and the objectives of the Candidate Co-Programmed Partnership for 2030. Part 1 describes the policies, new regulations and challenges the waterborne transport sector is facing. It also sets out the vision and objectives of the Partnership, including the commitment of the industrial stakeholders.

The COVID-19 pandemic has dramatically shown both the vulnerability of the global economic system and the relevance of waterborne transport. As a result of the COVID-19 pandemic, the market for cruising at sea and on inland waterways has collapsed, whilst other crucial waterborne transport segments, in particular inland waterway transport and maritime freight transport, have continued to provide their services as vital parts of the supply chains in Europe. For the maritime technology sector, the passenger vessel market and related activities has been one of Europe's most important waterborne transport sectors within both EU and global markets. However, the crisis has halted most activities, with the exception of some orders placed before the pandemic.

The socioeconomic impact of the COVID-19 crisis is, however, vast and continues to grow as a result of the effects on the waterborne transport sector, impacting crews, workers and the communities that benefit from waterborne tourism. As one of the essential and vital sectors for society and industry, waterborne transport has to remain safe and in operation. The transition to zero-emission waterborne transport offers the opportunity to grow markets in the longer term following the

COVID-19 crisis. To ensure preparedness in line with the European Green Deal, flexibility, creativity and financial effort from the sector will be required, backed by suitable policies and financial support.

The sector is committed to realize zero-emission waterborne transport to the benefit of future generations.

Policies and regulations

Amid growing global and European societal pressure to resolve issues related to climate change, air pollution and the degradation of the world's oceans, political and regulatory attention has been increasingly directed towards waterborne transport, due to this mode of transport's high environmental and climate impact. The most relevant recent developments are:

—**“The European Green Deal”** to ensure that Europe will be the first climate-neutral continent, thereby making Europe a prosperous, modern, competitive and climate-neutral economy, as envisaged in the Commission Communication **“A Clean Planet for All: A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy²”**;

—The International Maritime Organisation's (IMO) **Initial IMO Strategy on the reduction of GHG emissions** from ships³;

—The Central Commission for Navigation of the Rhine's (CCNR) Ministerial **Mannheim declaration**⁴.

Whilst the threats and risks of climate change and the harm from air pollution are known, policy actions have often failed to keep pace, despite increasing societal demand. To address this, the European Commission presented the **European Green Deal** in December 2019 with the objective for Europe to become the world's first climate-neutral continent by 2050, through the provision of a package of measures, to enable European citizens and businesses to benefit from a sustainable green transition. The Green Deal sets out the Commission's commitment to tackle climate and environmental challenges. To achieve climate neutrality, the European Green Deal envisages cutting transport emissions by 90% by 2050 at the latest. In addition, it sets out the ambition to reduce GHG emissions by at least 50% by 2030. This communication builds upon a clear strategic long-term vision for a prosperous, modern, competitive and climate-neutral economy (**A Clean Planet for All**), as communicated in November 2018. This strategy confirms Europe's commitment to lead in global climate action and to present a vision that can lead to achieving net-zero GHG by 2050 through a socially fair transition carried out in a cost-efficient manner. It defines pathways for the transition to a net-zero GHG economy and strategic priorities. Seven main strategic building blocks to achieve the objectives of this vision have been defined by the European Commission and **"clean, safe and connected mobility"** is one of these. In March 2020, the European Commission adopted a proposal to enshrine in legislation the EU's political commitment to be climate neutral by 2050, to protect the planet and EU citizens. This **European Climate Law** establishes a framework for the irreversible and

gradual reduction of greenhouse gas emissions and it sets out the pathway to achieve the 2050 target.

Furthermore, the European Commission's Communication, **"A Europe that protects: Clean air for all"**, provides the policy framework for the reduction of air pollutant emissions such as NO_x, SO_x and Particulate Matter. The 2018 Communication calls for further interventions to address the infringements of air quality limit values in many European countries.

At the international level, **IMO's Marine Environment Protection Committee (MEPC)** adopted an initial strategy for the reduction of GHG emissions from (seagoing) ships in April 2018, setting out a vision to reduce GHG emissions from international shipping by at least 50% compared to 2008 figures by 2050 and to phase them out as early as possible this century. When the strategy is **reviewed in 2023**, the level of ambition is expected to be considerably increased, not least of all in light of recent scientific reports, such as the IPPC "Global warming of 1.5°C" report⁶. In October 2016, the IMO MEPC also adopted the decision to reduce the sulphur content of marine fuels down to 0.50% as of 1 January 2020 in order to address the negative effects of related air pollution on health and the environment.

For inland waterway transport, the Council of Transport Ministers in December 2018, and the European Parliament in February 2019, called upon the inland waterway transport sector to improve the sector's sustainability with a view to contributing to the Paris agreement objectives (COP21⁷). In the Ministerial **Mannheim declaration** of October 2018,

CLIMATE CHANGE

Shipping emits approximately 1 billion tons of CO₂. Emissions are projected to increase by 20–50%² between 2008–2050. Ships entering EU ports emit 13% of the total EU transport emissions.

AIR POLLUTION

Current use of Heavy Fuel Oil pollutes air in port cities with Sulphur dioxide, Nitrogen oxide, particulate matter, and creates harmful effects on environment and human health.

DEGRADATION OF WATERS

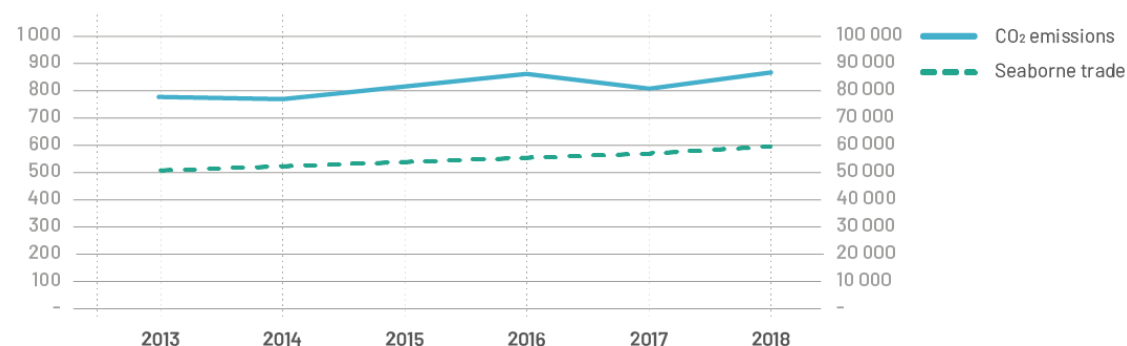
Waterborne transport is damaging seas and rivers: underwater noise, Sulphur-dioxide from scrubbers, ballast water transfers organisms, and hull coatings release chemicals.

Problems

CO₂ EMISSIONS FROM THE WORLD FLEET (THIS STUDY) AND SEABORNE TRADE (UNCTAD, 2019) FROM 2013 TO 2018

Units: CO₂ emissions (million tonnes)

Units: Seaborne trade (billion tonne-miles)



the CCNR stated its commitment to largely eliminate GHG and other pollutants by 2050 and to develop a roadmap for doing so and this was taken up by the Inland Waterway Agenda for Europe of the Naiades II implementation EC expert group in December 2019.

Problems

The main environmental challenges faced by waterborne transport sector, are:

- Impact on climate change;
- Air pollution from ships;
- Degradations of waters and oceans.

Climate change

European CO₂ emissions from waterborne shipping are a major challenge. In 2018, more than **130 million tons of CO₂**, or around **13% of total EU transport emissions**, were emitted from maritime ships over 5,000 gross tonnage visiting European ports⁸. International and domestic shipping dominates CO₂ emissions, whilst inland waterway transport cannot be ignored. The EU project PROMINENT calculated that inland waterway transport in the EU results in **3.8 million tons of CO₂ emissions per year**⁹.

The world is not on course to achieve a temperature increase of well below 2°C and therefore urgent action is needed. Even if the energy mix used for waterborne transport is changed in accordance with the objectives of limiting the temperature increase and the economic developments are commensurate with this goal, shipping emissions are projected to increase by 20-50% between 2008 and 2050¹⁰ (or by between 50%-250% according to the third IMO GHG study, to be updated in 2021).

Increasing the energy efficiency of ships has its limits and would not be sufficient to meet either the 2050 level of ambition of the European Green Deal or the targets of the Initial IMO Strategy on Reduction of GHG Emissions from Ships. Only a combination of low and zero-emission innovative solutions, fuels, operational approaches and technologies, initiated by ambitious regulations, can bring about the change needed.

Air pollution

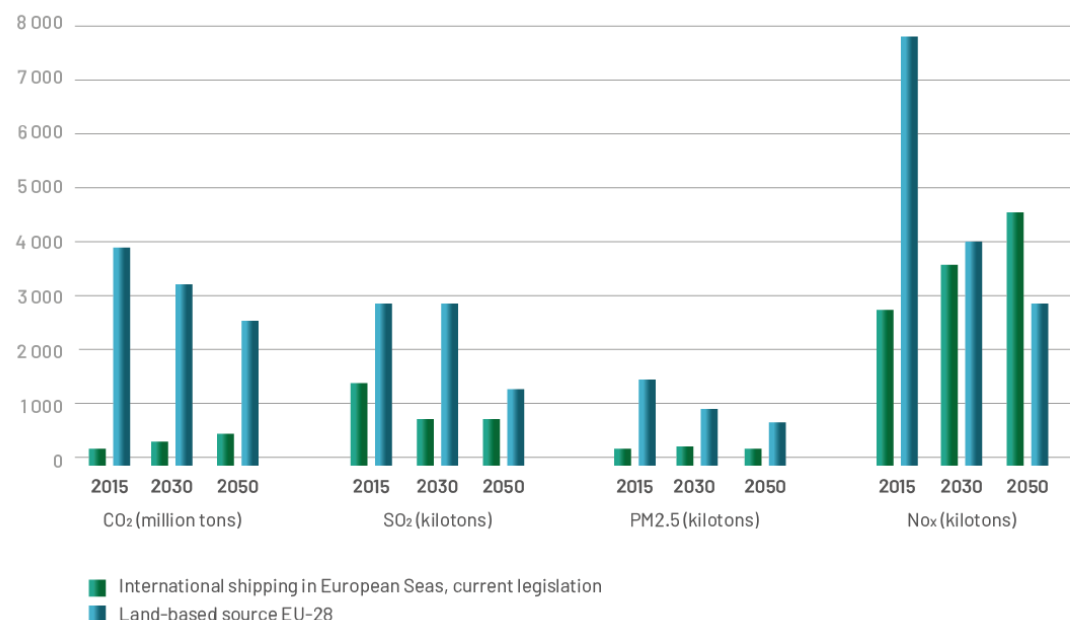
Emissions of sulphur oxides (SO_x) from maritime transport affect air quality in the EU and globally. SO_x emissions result from the onboard combustion of oil-based fuel products and are directly linked to the sulphur content in marine fuels used in maritime transport. SO_x emissions are a precursor of PM_{2.5} and a major cause of acid rain. According to the European Environment Agency, shipping is responsible for 11.05% of EU NO_x emissions and 11.05% of SO_x emissions¹¹. Nitrogen Oxides (NO_x) form smog, acid rain and eutrophication and are central to the formation of fine particles (PM_{2.5}) and ground level ozone, both of which are associated with adverse health effects. Air pollution from all sources causes 400,000¹²

premature deaths each year (2016). Concentrations of air pollutants from shipping can be much higher in coastal and port areas, where it can be the dominant source of air pollution, however as air pollution travels large distances it can contribute to concentrations up to 400 km from the coastlines.

While current IMO and EU legislation will reduce

SO_x emissions from international maritime shipping from 2020, emissions remain, however, much higher than other transport modes. After 2030, NO_x emissions from maritime shipping are set to exceed all EU land-based sources¹³.

The stricter sulphur in fuel requirements that have been agreed by the IMO will cut SO_x emissions by



Emissions from maritime shipping and projections¹⁴

50-80 percent up to 2030, but in the absence of additional regulations, emissions will rebound afterwards. Without introducing additional measures, CO₂ and NO_x emissions are expected to further increase¹⁵ the latter emissions becoming significantly higher than those emitted by land sources. SO_x Emission Control Areas have been established in the Baltic and North Sea in early 2000 following the request of the bordering states. Since 2015 ships sailing in these areas require an even higher level of SO_x reduction.

The IMO has designated the North Sea and the Baltic Sea also as a NO_x Emission Control Area (NECA) starting from January 1, 2021 which applies only to new ships. A period of at least 5 years for the fleet renewal is needed before the regulation will show its full effect, according to HELCOM (Baltic Marine Environment Protection Commission)¹⁶. This illustrated the need at the time for retrofittable technologies and alternative fuels as an essential tool to meet policy objectives. A further example is the establishment of an Emission Control Area in the Mediterranean Sea for sulphur oxides under IMO rules, which is being considered in the Barcelona Convention framework¹⁷ by the relevant riparian states in view of a possible decision by the end of 2021.

Inland waterway transport is not in the remit of the IMO and is covered by EU and regional legislation with different governance and legislation. It is a significant contributor to air pollution in cities along rivers. Passing through the centre of towns and cities, a large inland waterway vessel may produce approximately 11,000 kg of NO_x per year. Other

transport modes are becoming cleaner and inland waterway transport faces the risk of falling behind, e.g. a modern EURO VI truck emits approximately 10 times less NO_x per t/km than an inland waterway vessel. However, inland waterway transport has great potential both for long distance and urban logistics, free capacities can be mobilised, and in some regions new markets can be identified. This process shall go hand-in-hand with further greening the IWT vessel engines. The NRMM regulation¹⁸ addresses this topic and cuts these emissions significantly. The regulation has entered into force for new engines in inland vessels. However, these engines are not yet widely available and retrofittable technologies for the existing fleet are an essential tool to meet the policy objectives given the long lifetime of vessels and their engines.

Water pollution

Underwater noise from maritime shipping has a negative impact on the marine environment, in particular on marine life, including marine mammals. As such, levels of underwater noise are indicators of good environmental status within the scope of the European marine strategy framework directive¹⁹ and are also addressed within the non-mandatory guidelines on ship-quieting measures issued by the IMO in 2014. The characteristics of the underwater radiated noise from a vessel depend on multiple factors such as size, speed, horsepower, propeller depth, etc. Levels of noise vary within a ship class due to variability in design, maintenance and operational parameters, such as speed and displacement.

As an alternative to using cleaner low sulphur fuels to reduce SO_x emissions, regulations allow ships to be fitted with an **exhaust treatment device**, a so-called scrubber. A scrubber effectively captures the sulphur from the emissions and either stores the residue in a wash-water tank (closed loop) or dilutes and discharges this mixture into the sea (open loop). The use of open-loop scrubbers is less expensive and the ship owner is less reliant on port reception facilities to dispose of the scrubber residues. But discharge into the sea leads to secondary waste streams which may have harmful environmental impacts. With the introduction of lower sulphur limits applicable to fuels from 2020, more than 4,000 mainly open loop systems have been fitted to date, which is a source of environmental concern.

Ballast water is essential for the safe operation of ships, ensuring stability and structural integrity, as well as safe manoeuvring. However, ballast water can become a vector for the transfer of invasive organisms from one part of the world to another, causing damage and impacting natural ecosystems and the economy.

Ship hulls and marine structures attract sea life which attaches itself to the ship, thereby increasing friction, slowing down the ship and increasing fuel consumption. The fuel savings made by limiting the adhesion of marine organisms through the use of **hull coatings** has been estimated to reduce GHG emissions by 384 million and SO₂ by 3.6 million tons²⁰. However, the antifouling compounds used may leach harmful substances into the sea, damaging the environment and possibly entering the food chain.

Problem drivers

INTERNATIONAL SECTOR

The sector is global by nature, and subject to different international regulatory frameworks.

HIGH ENERGY NEED

Ships require large power over a long timeframe to be able to sail internationally.

LACK OF ALTERNATIVE FUELS

No alternative for fossil fuels in waterborne transport, leading to GHG emissions and other pollutants.

LACK OF INFRASTRUCTURE

Operational integration with ports and hinterland is not harmonised internationally.

DIVERSITY

The large diversity of ship types and operations hinders the deployment of standardised solutions.

AGE OF VESSELS

The lifetime of vessels is large, slowing down the uptake of new technologies.

Problem drivers

The contribution of shipping to the problems of climate change, air pollution and degradation of waters is difficult to tackle. Several factors contribute to a lack of change.

- Waterborne transport is an **international sector** by nature and solutions will have to be supported internationally;
- Large ships traveling over long distances require **large amounts of energy**;
- **Alternative fuels** have to be available and affordable in large amounts, and be **available in ports** around the world;
- The **diversity of the sector** and the **long lifetime of vessels** do not allow for standardised technologies and slows down the uptake of new solutions.

International sector

The maritime transport sector is an international sector. Maritime shipping transports nearly 90% of international trade and is therefore of crucial importance to the world economy. Not only do ships sail in international waters, but the entire maritime shipping sector is international. Maritime transport is therefore regulated on many different levels: international, European, regional and national. This incoherent landscape of policies, rules and regulations complicates the transition to zero-emission waterborne transport.

Agreements on new rules or on permission for using new technology has to be reached at these different levels. This contributes to the sector being cautious and aiming for incremental changes.

Example of the international character of the maritime transport sector

A container ship, built in China, equipped with European engines, might be sailing from Shanghai to Rotterdam. The ship is flagged in Panama, insured in London and sails with crew from the Philippines and officers from Russia. The ship is managed from Liberia, chartered from France, owned by a German shipowner and fuelled in Singapore

Inland waterway transport also plays a role within this international trade and holds an international character, as shown in particular by Rhine or Danube navigation. In addition, for inland waterway transport, large European maritime ports play a key role as an open door to trade outside the European hinterland, therefore offering a large and international transport market for inland waterway transport.

High energy need

Waterborne transport is the most energy-efficient mode of transport per ton-kilometre. This efficiency is partly achieved by the economy of scale compared to other transport means: ships are much larger and, as there are fewer size constraints compared to ground transport, are getting bigger and therefore increasingly efficient per ton-kilometre. For example, the largest maritime container vessel now carries almost 24,000 TEU, whereas five years ago this was still less than 20,000 TEU. One single large container vessel represents the equivalent of 10,000 to 12,000 trailer trucks. The largest inland container vessels also carry more than 600 TEU. Cruise ships have doubled the maximum number of passengers over the last 20 years, along with a steady growth of average ship capacity (+64%) in the same time-line. However, with this growth in vessel size, the total power needed to propel the ship inevitably increases. For the largest ships, engines of up to 70 MW are used. Given the long sailing distance from China to Europe, a ship may be at sea for 4 weeks before entering a port again. The total energy needed for such a trip would add up to almost 50 GWh. This very high energy need places requirements on the fuel that can be stored onboard the vessel.

The transition of the entire waterborne transport fleet to a zero-emission mode of transport is even more challenging. The energy need per ship is very high, but taking all vessels in the world's fleet into account would require the generation of a huge amount of energy from alternative fuels. This energy need has hindered initiatives to enable the transition

of the sector, as many feared that the renewable energy available would not be sufficient to sustain the waterborne transport mode on top of the societal need for green onshore power.

Lack of alternative fuel

At the moment, there is no cost effective and widely available alternative for the fossil fuels used in waterborne transport. Possible alternative fuels include biofuels (either bioliquids or biogases), as well as synthetic fuels based on hydrogen produced from renewable electricity and either captured carbon dioxide (to produce fuels such as synthetic diesel, synthetic methane or synthetic methanol) or captured atmospheric nitrogen (to produce ammonia).

Different fuels have different pros and cons: bio and synthetic carbon containing fuels have a higher energy density and are compatible with current bunkering infrastructure and safety rules, but generate carbon dioxide when used, even if their full lifecycle carbon emissions can be zero. Green Hydrogen and ammonia are zero carbon dioxide emission but have a much lower energy density and therefore require more space on board ships. Both hydrogen and ammonia also need new safety approaches and rules as well as a new bunkering infrastructure.

None of these fuels are currently available in large quantities around the world.

Another complicating factor is that fuel preference will likely be regional. Some countries, like Norway, are promoting hydrogen as fuel for short-sea shipping. In part, this is due to the large availability

of renewable electricity in Norway. Other regions have better access to sustainable biomass and favour biofuels or fuels derived from it. Having different fuels in different regions might require ships to be capable of sailing on several fuels depending on the expected area of operation of the vessel. Certain fuels require different fuel tanks which impacts the ships internal lay-out. This has hindered the transition to alternative fuels.

It is therefore likely that the ultimate choice of one or more alternative fuels in waterborne transport will boil down to the particular social, economic, technical and environmental implications linked to each fuel option.

Lack of infrastructure

Port facilities are essential in the operations of vessels. Dedicated bunker vessels supply new fuel to ships in ports or at anchor. With the transition to alternative fuels, new bunker vessels have to be developed for ports and new bunkering infrastructure is needed alongside European rivers. The bunkering technology has to be adapted to each specific alternative fuel. Cryogenic fuels such as hydrogen require specialised technologies and safety procedures, similar to those required for LNG. Other alternative fuels may be bunkered in similar processes to fossil fuels.

With the electrification of vessels, the need arises for high-power charging facilities, including battery swapping technology. At this moment, ports offer facilities for cold ironing: using shore-supplied electricity for operating the vessel while at quay.

But charging onboard batteries for operations at sea will require a much larger throughput of electricity. Technologies for this fast-charging of large amounts of power is being developed. Problems still exist with the safe and reliable integration of high capacity power charging with the electric grid in a port region.

Diversity of the sector

The **diversity of the sector** for waterborne transport is hindering the change towards zero-emission transport. The sector comprises shipyards, ship owners, maritime equipment manufacturers, flag states, waterway and port authorities and operators, river commissions, classification societies, energy companies, infrastructure companies, environmental non-profit organisations, research institutes, universities, citizens' associations, as well as various competent authorities, banks, insurance companies, etc. Many initiatives are currently being taken, but the solution found for one ship does not necessarily match the requirements for another ship. There is a lack of a common innovation agenda that takes into account the differentiated needs and possibilities of the waterborne transport sector.

Variations exist within each segment of the waterborne transport sector. Business models also show a wide variety both within and between segments. These need to be taken into account as drivers or inhibitors of the application and adoption of new technologies and concepts, sharing both the (investment) burden and the economic benefit of the adaptation of green technologies throughout the value chain. The most widely used

business model in shipping, chartering ships, can be an impediment to implementing new technical solutions due to split incentives between the ship owner and operator (user).

Age of vessels

Considering the average age of 21 years of a seagoing ship, the first radically changed new-build vessels need to be deployed within 10 years, with technology developed during the period of Horizon Europe. In addition, the relatively low turnover of the fleet requires zero-emission retrofit solutions to be deployed as soon as possible.

This need is even more urgent for inland navigation, since the average lifetime of inland vessels is even longer (40-60 years), leading to the existence of outdated and lower energy and environmental efficiencies on old vessels. Indeed, for inland waterway vessels, the western European market is characterised by a relatively old fleet. Half of the active fleet in Germany, the Netherlands and Belgium, as well as 80% of the French fleet, was built more than 50 years ago. 15% of the European fleet was built more than 75 years ago, in particular in the Netherlands. Switzerland is the country with the newest fleet (87% of the fleet was built in the last 35 years), which can be explained by the large share of inland cruise ships in their register²¹.

Overall vision 2050 for the waterborne transport sector

For Europe to lead and accelerate the transformation of the global waterborne transport sector into a zero-emission mode of transport which has eliminated all harmful environmental emissions (including greenhouse gas emissions, as well as air and water pollutants, including (underwater) noise through innovative ship technologies and operations which underpin european growth and employment.

Objectives of the Partnership

General objective of the Partnership on zero-emission waterborne transport is:

To provide and demonstrate zero-emission solutions for all main ship types and services before 2030, which will enable zero-emission waterborne transport before 2050.

Against this background, the specific **scientific** objective of the Partnership to be achieved **before 2030**, is:

To develop and demonstrate deployable technological solutions which will be applicable for the decarbonisation and the elimination of other harmful emissions of main ship types and services.

The specific **economic** objective:

By 2030, implementation of economically viable european new technologies and concepts regarding zero-emission waterborne transport, to strengthen the competitiveness of european industries in growing green ship technology markets and provide the capability to re-enter markets presently dominated by europe's competitors.

And the specific **societal** objectives are:

To facilitate the development and implementation of regulations and policies at national and international level, including the development of standards to enable the implementation of technological solutions for zero-emission waterborne transport by 2030 at the latest.

To facilitate the uptake of innovative zero-emission waterborne transport technologies and solutions within the european waterborne sector, supporting economic growth and european employment.

Operational objectives of the Partnership

The specific objectives have been broken down into a series of operational objectives that are dedicated to the operation of the Partnership. These operational objectives are organised with a view to the elimination of GHG emissions, air pollution and water pollution.

Elimination of GHG emissions

To develop and demonstrate solutions for the use of climate-neutral, sustainable alternative fuels applicable to ships with high energy demand (e.g. long distance shipping) before 2030;

To develop and demonstrate before 2030 solutions for the integration of high-capacity batteries solutions as single energy source for short-distance shipping (up to 150 to 200 nautical miles), as an additional energy source for all main ship types in environmentally sensitive areas, and to increase operational efficiency;

To develop and demonstrate solutions to be able to reduce the fuel consumption of waterborne transport, including by the use of non-fuel based propulsion (such as wind), by at least 55% before 2030, compared to 2008;

To develop and demonstrate solutions for port based supply infrastructure (i.e. infrastructure for bunkering of alternative fuels and electricity) needed to enable zero-emission waterborne transport, to be implemented by 2030 at the latest;

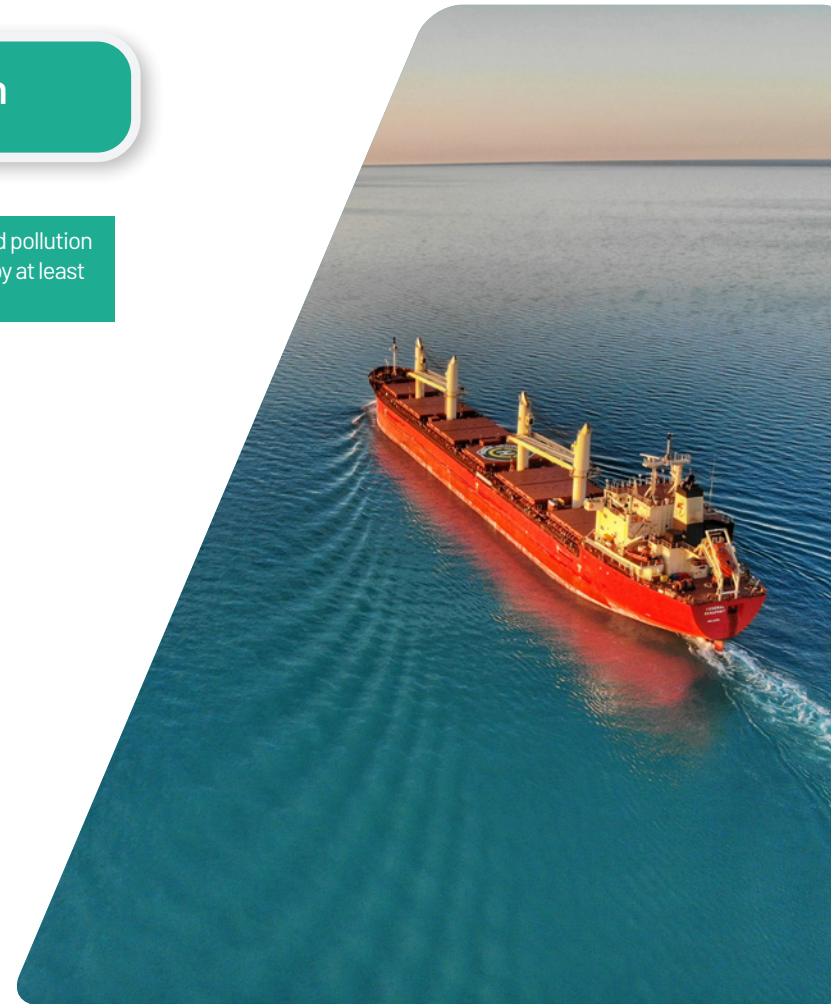
To develop solutions for clean and climate-neutral, climate-resilient inland waterway vessels before 2030.

Elimination of air pollution

To develop and demonstrate solutions to cut coastal and inland pollution to air from inland waterway transport and maritime shipping by at least 50% by 2030, compared to current levels

Elimination of water pollution

To develop and demonstrate solutions to eliminate pollution to water (including harmful underwater noise) from ships, by 2030.



Commitment of the Waterborne Transport Sector

In January 2019 the Waterborne Technology Platform launched its vision regarding zero-emission waterborne transport in 2050²², whilst – in addition – , an emerging number of maritime and inland shipowners have set net-zero CO₂ emissions in 2050 or earlier²³ as their target²⁴. The European waterborne transport sector welcomes the European Green Deal and is committed to reaching its objectives²⁵. An initial group of shipowners have indicated that their fleet will be emission free in 2050, stating that RD&I will be key to reaching this objective²⁶. The European maritime technology sector annually invests 8-9% of its turnover in RD&I²⁷ and is fully committed to develop the solutions needed and to invest accordingly²⁸.

Whilst putting forward clear environmental and climate-neutral targets, at the same time Europe needs to guarantee the waterborne transport sector's long-term economic resilience as global competition intensifies²⁹. Seizing opportunities to boost Europe's global competitiveness, as well as developments at home to become frontrunners in low-carbon and climate-proof technologies and embracing digitalisation, whilst also implementing market mechanisms to promote their take up, is key.

Scale of resources

The waterborne transport sector is fully committed to the objectives of the Partnership: zero-emission waterborne transport is a necessity for society, crucial for the sector to remain leading as a mode of transport, and an important driver for innovation and market opportunities.

The assesment of the Partnership is that the **achievement** of the Partnership's objectives is estimated to require an **overall mobilisation of resources of approximately € 3.8 Billion** (including Horizon Europe co-financing) towards research, innovation and other activities to achieve the objectives of the Partnership. This goal will be achieved **by leveraging the additional in kind contributions from the industry side of six to seven times**.

Resources contributed by the private side will include:

- Contributions from the members participating in projects funded by the Union contributions (on the basis of the non-reimbursed eligible costs);
- In-kind contributions to Additional Activities in the scope of the SRIA not covered by Union funding;
- Investments in **operational** activities that is spent beyond the work that is foreseen in the SRIA and aligned with the objectives of the Partnership.

Scope of Additional Activities

Additional in-kind contributions are envisaged to include:

- a) Upscaling of prototypical low emission systems in new-built ships or retrofitting of existing ones;
- b) Providing ships, test facilities, port and inland waterway facilities, GHG neutral fuels etc. necessary for the demonstration and development of the innovative technologies as referred to within the actions foreseen in the SRIA.
- c) Industrial RD&I programs of the members contributing to the objectives of the Partnership;
- d) Demonstrating that the results are achievable in a repetitive manner and thus qualifying the new solution;
- e) Implementing these new solutions in larger operational environments to prove their robustness;
- f) Developing proof of concept, novelty and feasibility studies and potential customer interviews to add value on the potential business case to ensure uptake of results from projects supported by the Partnership into products. Including for example: design, on-board configuration and integration of prototypical low emission systems aiming at developing economies of scale;

g) Training, education and other activities outside of the projects which support the uptake of the solutions developed;

h) Development and execution of the communication and dissemination plan (including social media, press releases, scientific publications, maritime pitching days, one-to-one meetings, fairs, workshops etc.);

i) Contribute to development of standards to ensure that they will be in line with the technological developments and to ensure Intellectual Property Rights protection;

j) Contributions to the development of new classification rules and regulations for design, constructions and operation necessary for the innovative technologies and actions referred to within the SRIA.

Investments in operational activities

Investments in operational activities may include:

a) Designing new training programs for amongst others crew managing new high tech zero-emission ships using new fuels/technologies;

b) Assessment of the market size dimension of innovative technologies for different operations;

c) Ensuring synergies with relevant initiatives, like the Pact for Skills and the Erasmus+ programme;

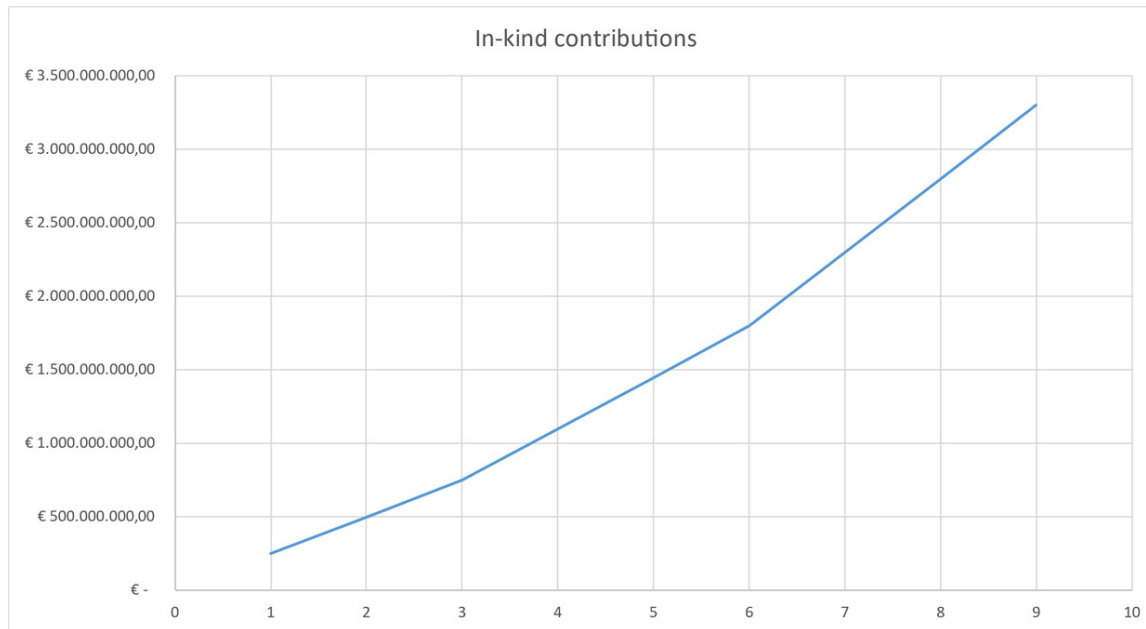
d) Commercial operations utilising solutions developed by the Partnership.

Contribution from industry partners

In total, the value of additional in-kind contributions from the Partners other than the union is expected to be approximately **€3.3. Billion** for the period 2021 - 2030.

These activities often include more than one additional activity as identified in aforementioned scope of activities, and range from: operational measures, exploratory research addressing ship concepts, propulsion systems, greening of engines, electrification, the development of rules and regulations, testing, upscaling, deployment, as well as the execution of internal RD&I programmes that are aligned with the objectives of the Partnership.

During the lifetime of the Partnership, these additional activities will be defined as an integral part of the SRIA within its regular updates. On average, the yearly contribution expected from industry is expected to be in the range of € 350 - € 375 M during the Partnership's lifetime. It is to be expected that larger contributions will take place towards the end of the programme, because of demonstration and upscaling activities.



This table includes an indicative estimate of the in kind contributions per type of activity. The actual breakdown will be included in the biennial update of the SRIA.

TYPE OF COST	INDICATIVE ESTIMATE
Contributions from partners to projects not funded by the EU	5%
Upscaling of prototypical low emission systems in new-built ships or retrofitting of existing ones	15%
Providing ships, test facilities, port and inland waterway facilities, GHG neutral fuels etc.	5%
Industrial RD&I programs of the members contributing to the objectives of the Partnership	20%
Demonstrating that the results are achievable in a repetitive manner and thus qualifying the new solution	20%
Implementing these new solutions in larger operational environments to prove their robustness	10%
Developing proof of concept, novelty and feasibility studies and potential customer interviews to add value on the potential business case to ensure uptake of results from projects supported by the Partnership into products	9%
Training, education and other activities outside of the projects which support the uptake of the solutions developed	5%
Development and execution of the communication and dissemination plan	1%
Contribute to the development of standards to ensure that the standards will be in line with the technological developments and to ensure IPR protection	5%
Contribute to the development of new classification rules and regulations for design, construction and operation	5%
TOTAL	€3,300 M: 100%

Additional investment

The Partnership also aims to mobilise additional investments through the use of finance investment mechanisms including, for example, any emerging climate change investment banks, innovation investment guarantees and performance based schemes where innovative technology is leased on the basis of assured performance guarantees.

In addition to this, the Partnership's activities will mobilise further resources within the Member States, several of which have indicated that they expect to orientate their national RD&I programmes to ensure complementarity with the Partnership and further increase leverage. Also, mechanisms supporting first of a kind deployment to provide market reassurance will be implemented to complement the outcomes from the Partnership. These include those available from private foundations, as well as European instruments such as CEF, Climate Innovation Fund, Regional Funds, etc.

Furthermore, members of the Partnership will provide resources to ensure a proper staffing of the Secretariat of the Partnership, as well as other bodies needed to execute the Partnership's tasks (contribution in kind or in cash).

Finally, the deployment of technologies and concepts requires a patchwork of regulatory and financial incentives in order to stimulate first movers. For this reason, it is vital that the Partnership establishes close links with competent administrations to ensure that the necessary rules and regulations are developed in order to ensure market introduction is facilitated. The partners in the Partnership will have an active role in providing support for the development of the required policies and regulations. In addition, synergies with regional, national and European funding schemes for first movers should be ensured.



PART 2: RESEARCH AND INNOVATION STRATEGY

R&I strategy

Strategic implementation approach

Europe's waterborne transport value chain is a frontrunner in the development of innovative technological solutions and is engaged in implementing technologies to reduce and ultimately eliminate GHG and air and water pollutant emissions from waterborne transport. New-build short-sea vessels and high-end complex ships (such as cruise/ferry passenger ships and other complex special ships), as well as retrofitting with energy efficiency solutions, offer Europe the most suitable and practical opportunity to develop, test and demonstrate the new emission reduction technologies which can also be applied to other market segments such as container ships, bulkers, tankers etc. Therefore, the Partnership will create a critical mass for the development and **demonstration** of innovative solutions and create a win-win scenario in which emissions are substantially reduced in European and global waterborne transport services, whilst reinforcing the competitiveness of the European technological industrial base in its competition on a global scale and helping to achieve the ambition of zero-emission waterborne transport by 2050.

Within the first two years of the Partnership, the intention is to foreseen to undertake a combination of lower TRL activities setting the foundation for later development, as well as potential "quick wins" with high short-term environmental impact, which will reinforce Europe's competitiveness as it emerges

from the consequence of the COVID-19 pandemic. These will be elaborated within the SRIA. Examples of lower TRL include proving the feasibility and safety of emerging, less market ready, alternative fuels such as ammonia, whilst higher TRL "quick wins" could include solutions which substantially improve energy efficiency. These are elaborated within this SRIA and will be chosen according to their capability to trigger the transformation of the sector in the short and long term.

The Strategic RD&I programme will provide scientific knowledge to enable informed choices concerning the optimal pathway to achieve zero-emission solutions that are climate neutral and which eliminate harmful pollution to air and water. **These will be appropriate for the main ship types and services which have the largest impacts on pollution and GHG emissions**, including large intercontinental merchant ships, short sea vessels, inland waterway transport and passenger vessels.

As the programme starts off with a mix of low and high TRL RD&I, some technologies can already be **demonstrated** during the mid-years of the programme. The developments starting off at a lower TRL will be developed and consolidated into smaller scale **demonstrations** in these mid-years. This could include smaller scale applications such as inland waterway vessels and other ship types, providing that the solutions can be a basis for a technology pathway for large scale deployment.

The programme will aim to conclude with **demonstrators** in the final two years, which will prove the viability of the developed solutions for all

This chapter describes how the objectives of the Partnership on Zero-Emission Waterborne Transport can be achieved. After outlining the overall strategy, a vision of what the future fleet could look like and the zero-emission technologies which are most likely to achieve this vision for the relevant ship types are described. Finally, the objectives described in Part 1 are linked to the research Activities being proposed in this SRIA, followed by a more detailed description of the Activities.

main ship types and services. Whilst some solutions may, for example, be applicable to large merchant ships such as container vessels, **demonstrations** could take place in the context of a different, but similarly relevant, ship type. For example, cruise ships have a long range and employ energy systems of similar scale to the large merchant ships.

In line with this strategy, detailed RD&I activities are developed in this SRIA on a rolling two-year basis and will be reviewed annually. The SRIA is developed in the Partnership jointly between the Partnership and the European Commission, in consultation with **EU Member States and Horizon Europe Associated Countries**. A transparent process will be deployed, including an opportunity for the general public to express their views, as well as stakeholders, industry, Member States and societal interests. Throughout this process, the Member States, Associated Countries and several European Commission services will be involved. This ensures avoiding unnecessary duplication with national programmes and enables synergies between national programmes, policy developments and Horizon Europe.

Implementation pathways

Greening the fleet has two aspects: while a certain part of the operational fleet will be converted through retrofitting, it is highly likely that another segment of the service provided by the industry will be replaced by new-builds. Close to 50,000 maritime ships and approximately 12,000 inland vessels are

in operation and will need to be converted into zero emission vessels, through retrofitting as well as replacement. At the same time, new-builds will need to be ready to become zero emission as soon as possible, meaning that they need to be compatible or adaptable so as to be used with a range of potential sustainable fuels, be optimised for efficiency (including digital), potentially deploy electric and/or battery drives, as well as renewable energy assistance. Onboard fuel storage should be suitable for alternative low to zero-carbon fuels, potentially based upon modular principles to facilitate conversion to full electric or hybrid powered units.

The best most relevant solution will need to be chosen according to ship size, the type of traffic it is in, its energy demand, required operating range, the regional energy carriers available and bunkering infrastructure, potentially emerging legislation, policies and governance. Integrated lighthouse projects will show best practice examples to be copied by early adopters.

An important factor in the selection and uptake of technologies in waterborne transport, (in addition to societal factors that also include aspects of health and education) is the service a vessel provides. A lot of focus is often put on larger vessels operating a liner service on long distance routes: transport cargo from port A to port B and back, sometimes including one or more stops. However, many ships are operating on a tramp service: with a varying schedule, collecting cargo in port A and delivering it to port B, collecting cargo there for port C, etc. For liner services, ports and vessels can more easily adapt

to each other; for instance, fuel choices, bunkering and recharging infrastructure can be aligned. With tramp services, a ship calls at many ports, often at short notice, meaning that the ship's next destination can change overnight and alignment within every port is not possible. If ports worldwide cannot ensure the availability of their fuels, these ships either have to be able to carry relatively large amounts of fuel or electricity or have to be equipped with multi-fuel flexible energy systems.



Examples of liner (first picture) and tramp (second picture) services: recent 3-month AIS data for two different vessels

At the same time, there are many other types of vessels, such as passenger vessels or high complex work vessels (e.g. dredging vessels, offshore construction vessels, windfarm service operation vessels). These vessel types often have a high energy demand while, in some cases, operating worldwide.

In the following sections, examples of potential pathways for the adoption of zero-emission technologies per ship category are provided. High-end complex ships offer Europe, given its expertise, the most suitable fit to develop, test and demonstrate new emission reduction technologies. Europe has a competitive advantage in these ship types over those built by other continents. Cruise ships, for example, are a large segment for Europe and are early adopters of green technologies, as well as having market forces for its adoption. Ferries are also important for Europe and they are more suited to 100% electrification technology between fixed points. Offshore vessels built in Europe facilitate the development of offshore renewable energy. They often need a larger amount of power, but for a shorter duration than long-distance shipping. Short-sea ships need less endurance than the intercontinental services where the volume and fuel capacity is more important. In addition, it is easier to provide specialist infrastructure.





For the majority of the existing **long-distance, intercontinental cargo fleet, which typically bunker 1,000 of tons of fuel with several weeks of autonomy**, future green propulsion is expected to be initially based on internal combustion engines operating on sustainable fuels, possibly assisted by wind-propulsion support, with a potential ultimate transition to fuel cells utilizing green hydrogen based fuels. These ships are delivering the biggest part of the world's transport provision and regardless of the fact that they are the most energy efficient in terms of ton kilometres, the sheer amount of cargo they transport and the fuel they burn makes them by far the largest waterborne

transport CO₂ producer and polluter and therefore the first target for greening.

The obvious shorter term solution for these existing ships is sustainable e-fuels and bio-fuels, in combination and separately, together with substantial operational and technical efficiency improvement and cleaner energy converters, as well as possibly renewable energies. The industry has already started to test the different options to be applied. Europe's supply industry is key to provide the technology for retrofitting, while the yards are preparing for the system integration and conversion work to come. This approach makes it possible to gradually grow into the green future by modifying existing engines and allowing for the co-combusting of existing fossil fuels with sustainable bio, hydrogen-based or e-fuels depending on availability, cost and performance, while reducing the proportions of fossil fuel. The experience from retrofits to dual-fuel systems will enable the industry to further improve the performance of dual-fuel engines. Newbuilds will benefit from these developments, considering multi-fuel tank systems, dual fuel engines, electric/hybrid drives and gen sets with hybridised energy storage, rather than large monolithic engines with direct mechanical drives which are typical today. In addition, more advanced efficiency measures are expected to find their place in long distance cargo fleets, e.g. waste heat recovery, smart energy grids/energy management, speed-adapted hydrodynamics, renewable energies such as wind and solar, as well as innovative solutions for reduction in hydrodynamic friction.

Inland Waterway Transport is characterised by vessels with modest power demands compared to maritime shipping, as well as being close to land-based infrastructures and operating within a regulatory regime which is less complex than international shipping. As a consequence, inland waterway transport offers valuable opportunities to more easily **demonstrate** innovative technologies.



The expected immediate focus will be on retrofitting and usage of drop-in bio-fuels such as HVO and Bio-LNG. Due to the age of the fleet and the comparable modest conversion costs the feasible options range from changing of fuel storage and engine modifications to enable the use of sustainable alternative fuels, to the replacement of the entire propulsion system to battery electric or fuel cells. Inland waterway transport could also benefit from containerised solutions for fuels and batteries.

The new builds do have similar options and in addition they will benefit from energy efficiency measures such as large diameter propellers, optimised hull design, air lubrication and arrangement of tank and cargo holds. IWT is also one of the candidates for the direct use of hydrogen in combination with a dedicated network of fuelling stations, which could be shared with the road fleet. The high variety of meaningful solutions, combined with the moderate cost of conversion using new innovations, make inland waterway transport implementations good examples for “marinizing” solutions from land or other modes of transport prior to later upscaling to, for example, short-sea-shipping and ferries.



Cruise ships are a high technology, high added value product which is key for the European waterborne manufacturing industry. They have been technology leaders for the industry, in particular for green waterborne transport, since their customers demand sustainable transport beyond the standards required by authorities and the vessels operate within the world's most environmentally sensitive regions.

Furthermore, cruise ships are characterised by requiring high amounts of energy, including large hotel loads which are present at all times and can be larger than the propulsive load. In the shorter term, retrofitting - to enable the use of a range of potential sustainable fuels, in combination and ultimately as a single fuel - as well as electrical supplies from shore, is a logical choice. Due to their electric drive system, the extension to electric energy storage, as well as energy harvesting for their hotel load, will need to be integrated into their energy grids. For the next generation of cruisers, the most complex combinations are on the agenda; fuel cells in combination with batteries and combustion engines, energy harvesting, electricity storage and propulsion support with wind assistance are the topics which will provide manifold input for innovation transfer into other ship-types. The development of smart interaction with ports for cold ironing and alternative fuel supply, for example, will deliver sustainable solutions as well as harmonisation among the ports of call for cruise ships.



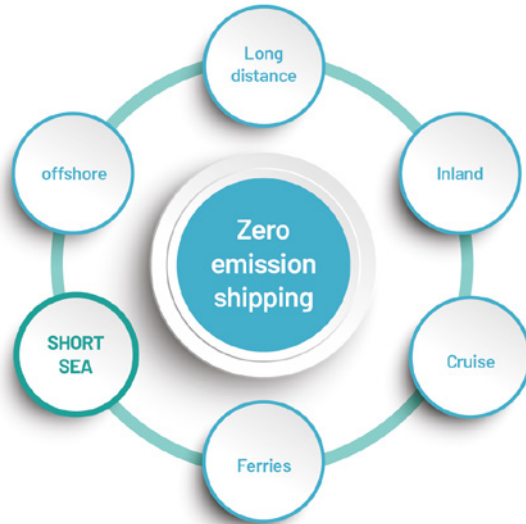
Ferries operate between fixed points and are the most suitable application to become fully electric with completely zero emissions. In this respect, they play a leading role when it comes to greening. Ferries operating in Europe covering a wide range of services, from urban/harbour passenger ferries with a range of a few miles, to large inter island RoPax ferries with ranges of 50 to 200 nautical miles with the longest ferry routes being as much as 500 nautical miles. For retrofitting, as well as newbuilds

and ferries with a range of up to 200 nautical miles the challenge will be between full battery electric, fuel cells and ICE powered with alternative fuels, with the regional conditions and their policy priorities pushing one or the other type of solution to the forefront. Ferries with significant hotel loads will be candidates to be early adopters of fuel cells. The requirements regarding zero emissions during approach and harbour stay will push hybrid solutions with battery capacities to allow full battery electric

transit for reduced noise and emissions. For the long-distance ferries, ICEs with alternative fuels will be the most competitive solution, supported by energy efficiency measures and smart power supply/buffer in port facilities.



The **Short Sea Shipping** fleet comprises all types of cargo vessels that operate coastal and shorter distance services which are typically up to two or three days.



Compared to long distance shipping, much less fuel is needed between port calls and the quantity of fuel which can be held on board is large compared to the needs for the voyage. As a consequence, the energy density of fuels is a secondary consideration and a wider range of sustainable alternative fuels can be more easily deployed. Many of these ships have been, and will be, built in Europe, making this segment particularly important for both the

development of tailored innovative solutions, as well as the introduction of fully fledged implementations from well to propeller. Upscaling of solutions from inland waterway transport to Short Sea Shipping (SSS) is an opportunity for European expertise to lead in design, production and operation and this has the potential to extend Europe's market share by technology leadership. SSS contains all of the ingredients for an entire European recipe, a zero-emission solution involving design, engineering, equipment production, shipbuilding, operation, ports and authorities to enable green shipping

to grow from vision to fact. In this context, the retrofitting solutions with the lowest OPEX, due to the initial investment, and highest environmental impact will also enable the use of alternative fuels. Ships which are being ordered now should consider readiness for a range of sustainable fuel options, both individual and in combination, electrification, energy storage, shore electric connections and efficiency. For some services, a combination of ICE/electric drive, fuel cells, battery packs and renewable energies can be more quickly deployed than others.



Offshore vessels are a wide category of vessels that facilitate offshore installations, operations and maintenance. Historically, this segment has focussed on oil and gas installations. But with the onset of offshore renewable energies and other Blue Growth activities, this fleet has transformed into an enabler of sustainable growth.

Many of the offshore vessels are complex work vessels, such as installation vessels, dredgers and cable-laying vessels, which are capable of executing very accurate work. These types of vessels typically have a high energy consumption at peak moments. The technologies used for power generation are the

same as those listed for transport vessels. As the offshore vessels are predominantly built in Europe, they are a suitable category for **demonstration** purposes.

The variety of operating profiles, as well as the size of ships, make Offshore vessels ideal candidates for innovative solutions. Their close shore activities allow for more frequent fuelling and thus low density energy carriers can be applied. Operating close to shore also means that it is necessary to reduce SO_x and PM emissions to the maximum extent possible.

Designs from full electric to hydrogen powered fuel cell hybrid solutions will make sense in this context. Today, hybrid battery systems are already being cost effectively deployed and some of the newest vessels can perform their operations at sea with zero-emission technologies, while transit is still covered with conventional diesel-electric systems using low-sulfur marine diesel oil. The latest announcements on new ship designs show an extended zero emission target range of up to two weeks operation time based on a hybrid concept with 2MW hydrogen powered PEM fuel cells combined with 5,5MW diesel ICE.



Achieving the operational objectives

In the following paragraphs, the three main objectives, i.e. the elimination of GHG emissions, air pollutants and water pollutants, are presented with their underlying specific operational objectives addressed by a combination of activities in the Partnership.

Elimination of GHG emissions

The first operational objective relating to the elimination of GHG emissions concerns the use of **sustainable alternative fuels** on board. The fuel transition is paramount to the elimination of GHG emissions. Using fuels other than fossil fuels will make shipping a (net) zero-emission mode of transport.

One of our Activities is therefore fully dedicated to enabling the use of these new fuels on board. This includes safe storage and usage on board ships and the conversion of the fuel into usable power through fuel cells, turbines or advanced internal combustion engines. As a safeguard for the transitional period, Carbon Capture and Storage (CCS) systems are part of the portfolio.

1. OPERATIONAL OBJECTIVE

To develop and demonstrate solutions for the use of climate-neutral, sustainable alternative fuels applicable to ships with high energy demand (e.g. long distance shipping)

Activities

- Use of sustainable alternative fuels
- Design & retrofitting
- Energy Efficiency
- Ports



- Use of alternative fuels on board
- Application to new and existing ships
- Range extension for new fuels
- Bunkering technologies

A crucial step for the fuel transition is the integration of all new technologies on board new and existing vessels. Especially for existing vessels, it is a challenge to integrate new fuels safely without completely overhauling the vessel and causing too much downtime. Modular approaches will be developed. These developments take place in the Activity on Design & Retrofitting.

The Activity on Energy Efficiency will facilitate the uptake of alternative fuels. It is expected that new alternative fuels will be (much) more expensive than the existing fossil fuels. Furthermore, storage of these new fuels on board will take up more space. Consequently, if the Energy Efficiency activity does not provide major breakthrough reduction steps in fuel consumption, either cargo load would have to be much decreased, or sailing range would be greatly limited. The need for energy from these fuels should therefore be limited as much as possible to facilitate the market uptake of alternative fuels.

The Activity on Ports is closely linked to reaching this objective. The safe bunkering of sustainable alternative fuels is, of course, crucial in developing and demonstrating these fuels on board.

Activity

Use of sustainable alternative fuels
Energy Efficiency
Design and Retrofitting
Ports

Read more on

[page 41](#)
[page 51](#)
[page 56](#)
[page 66](#)

The **Electrification** of ships is the second operational objective relating to the elimination of GHG emissions. Using electricity directly from a renewable source is more energy efficient than transferring the electricity into a fuel and carrying the fuel on board. But given the total amount of power needed on ships, it is envisaged that using batteries or other electricity storage cannot be the main power source for long-distance shipping. This will, however, be a solution for shorter ranges, from 150 to 200 nautical miles, for example. For longer ranges, it is envisaged that electrification will be used as an auxiliary power source, increasing the efficiency of the use of alternative fuels, for example, by supplying a portion of the electrical loads on board.

As with use of alternative fuels, a crucial step for the electrification of shipping is the integration of new technologies on board new and existing vessels. In new builds, the vessel's power train will be transformed into an electrical drive, instead of the conventional direct mechanical drive systems, to allow hybrid power architecture integrating different power production systems (ICE, fuel cell, battery). The electric drive systems will lead to higher controllability and higher dynamic performance, as well as higher efficiency. New internal lay-outs will mitigate the possible safety repercussions of using high-density batteries next to inflammable alternative fuels. For existing vessels, modular set-ups will be developed to retrofit with electrical auxiliary power.

2. OPERATIONAL OBJECTIVE

To develop and demonstrate solutions for the integration of high-capacity batteries solutions as single energy source for short-distance shipping, as an additional energy source for all main ship types in environmentally sensitive areas

Activities

- Electrification
- Design & retrofitting
- Energy Efficiency
- Ports

- Use of batteries on board
- Application to new and existing ships
- Range extension for new fuels
- Fast recharging

The Activity on Energy Efficiency will facilitate the uptake of electrification by increasing the sailing range of electric vessels. The Activity on Ports is closely linked to achieving this objective. For smaller vessels or for auxiliary power, containerised battery solutions will be applied. The safe recharging of large amounts of electricity in a short time period is, of course, crucial in developing and demonstrating electrification of ships.

Activity

Electrification
Design and Retrofitting
Energy Efficiency
Ports

Read more on

[page 46](#)
[page 56](#)
[page 51](#)
[page 66](#)

Increasing **Energy Efficiency** is the third operational objective relating to the elimination of GHG emissions. As explained above, the reduction of a ship's energy need is crucial in the implementation of alternative fuels or electrification. After all, the greenest form of energy is the energy that is not needed. Energy efficiency of ships will be improved by utilising renewable energy sources, such as wind and solar. We will also deliver solutions for the reduction of all energy needs (i.e. propulsion, equipment and hotel load) by means, for example, of optimisation of energy distribution, air lubrication, improved hydrodynamics, resistance-reducing coatings, recovering waste heat or thermal insulation. The new technologies will be integrated into designs of new vessels and by retrofitting in the Activity on Design & Retrofitting.

The energy efficiency of ships in a fleet will be optimized in Digital Green. By applying big-data analysis to new data coming from increased digitisation, energy performance predictions will guide crew and on-shore fleet managers in making operational decisions to cut emissions.

3. OPERATIONAL OBJECTIVE

To develop and demonstrate solutions to be able to reduce the (alternative) fuel consumption of waterborne transport, including by the use of renewable energy, by at least 55%

Activities

- Energy Efficiency
- Design & retrofitting
- Digital green



- Reduce energy need for operations
- Integrating on board
- Optimize operations

Activity

Energy Efficiency
Design and Retrofitting
Digital green

Read more on

[page 51](#)
[page 56](#)
[page 61](#)

The transition of waterborne transport into a net zero-emission mode of transport needs to be facilitated by ports and their infrastructure. The fourth operational objective is therefore related to the development and demonstration of **port-based supply infrastructure**.

In the Ports Activity we will develop and demonstrate standardized solutions for safe and efficient bunkering of new alternative fuels and for fast charging of high-power batteries. This is linked to the work in the Activity on the use of Sustainable Alternative Fuels on safe onboard storage of the fuels and to the work in the Activity on Electrification on the electrical grid and battery capacities on board.

4. OPERATIONAL OBJECTIVE

To develop and demonstrate solutions for port based supply infrastructure (i.e. infrastructure for bunkering of alternative fuels and electricity) needed to enable zero-emission waterborne transport

Activities

- Ports
- Use of sustainable alternative fuels
- Electrification

- Safe technologies
- On-board storage
- On-board grid

Activity

Ports
Use of sustainable alternative fuels
Electrification

Read more on

[page 66](#)
[page 41](#)
[page 46](#)

The fifth and final operational objective for the reduction of GHG emissions relates to the development of solutions for **clean and climate resilient inland waterway vessels**.

Many technologies that will be applicable to sea-going vessels are also applicable to inland vessels. However, the long lifetime of these vessels and the small fleet-size per owner mean that special attention must be given to the retrofitting of economically viable solutions. Given the relatively short range of many inland vessels, the electrification of the fleet is considered to be the most promising solution. The work in the Activity on Electrification will therefore pay special attention to the applicability of the solutions to this vessel type, e.g. containerised, exchangeable battery packs.

The Activity on Energy Efficiency will deliver solutions that are applicable to inland vessels similar to sea-going vessels. But the specific characteristics of inland navigation, such as extremely shallow water, continuous manoeuvring and lock operations, require special solutions.

Once again, retrofitting of new technologies into existing vessels is key in order to deliver this operational objective. The lengthy life span of inland vessels makes this an even greater challenge. Old ship designs and the integration of family living quarters require dedicated solutions with respect to safety and modularity.

5. OPERATIONAL OBJECTIVE

To develop solutions for clean and climate-neutral, climate-resilient inland waterway vessels.

Activities

- Use of sustainable alternative fuels
- Electrification
- Energy Efficiency
- Design and retrofitting



- Reduced emissions
- Zero emissions
- Reduced energy demand
- Retrofitting of existing fleet

Activity

Use of sustainable alternative fuels
Electrification
Energy Efficiency
Design and Retrofitting

Read more on

[page 41](#)
[page 46](#)
[page 51](#)
[page 56](#)

Elimination of air pollution

The operational objective regarding the **the elimination of waterborne transport air polluting emissions** is particularly important in coastal seas, in ports and on inland waterways.

6. OPERATIONAL OBJECTIVE

To develop solutions to cut coastal and inland pollution to air from inland waterway transport and maritime shipping by at least 50%

Activities

- Use of sustainable alternative fuels
- Electrification
- Energy Efficiency
- Design and retrofitting



- Reduced emissions
- Zero emissions
- Reduced energy demand
- Retrofitting of existing fleet

The Activity on the use of Sustainable Alternative Fuels will develop hydrogen-based solutions which will eliminate air pollution. The Activity on Electrification will deliver solutions to enable coastal ships to sail fully electrically, thereby eliminating all air pollution. For larger vessels, batteries as auxiliary power or fuel cells will allow electrical sailing into ports or around pristine areas and will allow for considerable energy savings by optimal use of hybrid power generation systems. Inland vessels will be battery electrified or will sail on hydrogen-based fuel cells to completely eliminate their negative affect on air quality in cities along rivers.

The Activity on Energy Efficiency will deliver solutions to reduce the energy required for operating a vessel, thereby directly reducing potential air pollution and extending the range of electric sailing. New solutions will be developed for emission reduction on existing vessels still operating on fossil fuels by using clean combustion engines and after-treatment systems. The possibilities of retrofitting will be demonstrated in the Activity on Design & Retrofitting.

Activity

Use of sustainable alternative fuels
Electrification
Energy Efficiency
Design and Retrofitting

Read more on

[page 41](#)
[page 46](#)
[page 51](#)
[page 56](#)

Elimination of water pollution

The operational objective to **eliminate pollution to water** from ships (including harmful underwater noise) is addressed by the Activities on the use of Sustainable Alternative Fuels, Electrification, Energy Efficiency and Design & Retrofitting.

7. OPERATIONAL OBJECTIVE

To develop and demonstrate solutions to eliminate pollution to water (including harmful underwater noise) from ships

Activities

- Use of sustainable alternative fuels
- Electrification
- Energy Efficiency
- Design & retrofitting



- Fuel cells eliminate lubricants
- Reduce engine noise
- Reduce noise / new coatings
- No waste streams

Within Alternative Fuels, fuel cells will be demonstrated which use no lubricants and therefore eliminate the emissions of these chemicals. Electrification contributes to the reduction of underwater noise by eliminating the engine noise. When smaller ships are fully electrified, the noisy internal combustion engine is removed from the noise sources. For larger vessels using electricity for auxiliary power, the internal combustion engine can be operated at lower power demand, or shut-down completely in sensitive marine environments, while still maintaining operational sailing speeds.

The Activity on Energy Efficiency will deliver solutions for new propulsion systems that will not only increase energy efficiency but also reduce noise. New solutions for air lubrication will be developed based on noise criteria. New coatings will not only lower the resistance but will also minimize the chemical release into water.

As with all new technologies being developed, it is crucial to integrate them into the design of new build vessels and into existing vessels by retrofitting. Solutions for the reduction of noise and for air lubrication will need to be applied to the existing fleet. Furthermore, new solutions could be developed to substantially remove pollution from scrubbers.

Activity

Use of sustainable alternative fuels
Electrification
Energy Efficiency
Design and Retrofitting

Read more on

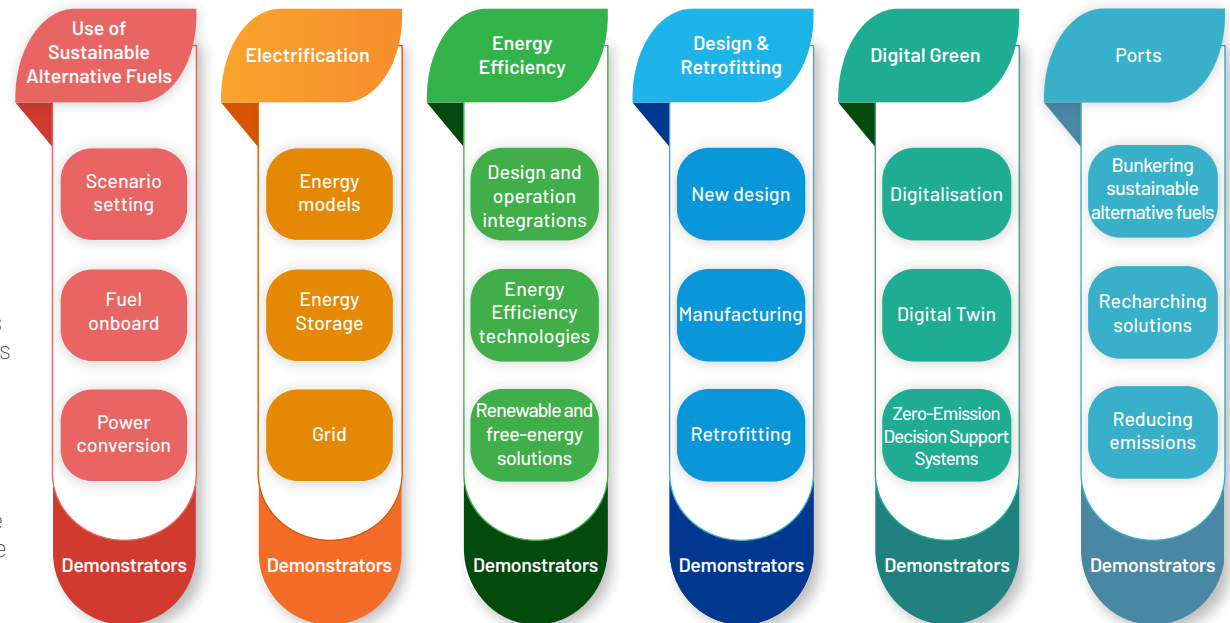
[page 41](#)
[page 46](#)
[page 51](#)
[page 56](#)

Activities

The technical content of this strategic research and innovation agenda is divided into six parallel activities. These activities are:

- Use of Sustainable Alternative Fuels³⁰
- Electrification
- Energy Efficiency
- Design and Retrofitting
- Digital green
- Ports

The relationship between the Partnership's objectives and these Activities has been explained in the previous sections. In the next section, a brief presentation of each of the 6 activities and related sub activities will be given, with a description including the relevance concerning the Partnership's operational objectives and the innovative aspects with respect to the current state-of-the-art. Moreover, an overview of the proposed topics for the first 2 years of Horizon Europe (short-term) is provided.



USE OF SUSTAINABLE ALTERNATIVE FUELS

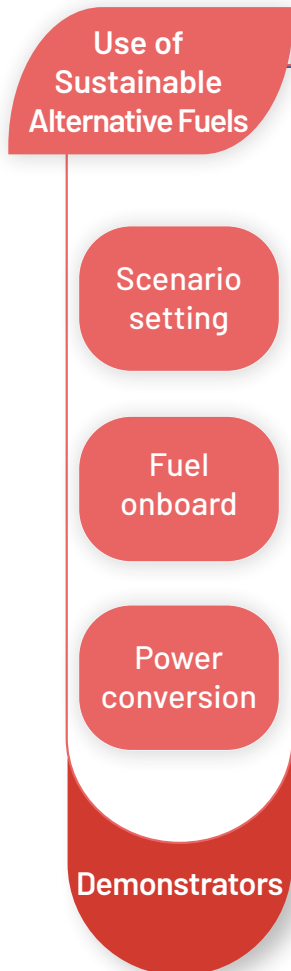
This activity concerns the development of ships with power generation systems based on the use of **Sustainable Alternative Fuels** that allow for reducing GHG and other emissions, coupled with engines, turbines and fuels cells and their integration on board.

Introduction

While significant GHG emission reductions can be enabled by increased energy efficiency, electrification, renewable energy and operational improvements, the aim of **achieving zero-emission waterborne operation** for the entire fleet can only be met by the **large-scale adoption of sustainable alternative fuels**. Depending on the fuel type, many external constraints exist, from fuel availability to distribution network and adequate bunkering capacity in ports. Overcoming some of these constraints requires developments outside of the domain of waterborne transport, as well as a market which is driven by demand for the sustainable fuel by the waterborne fleet.

Currently, a limited set of technologies exist to store, distribute and convert some sustainable alternative fuels into useful work and in this respect the low flash point fuels and gases (ammonia, methanol, hydrogen etc.) are more challenging, whilst sustainable bio diesel fuels for example, can be more easily deployed. Besides this, a regulatory framework needs to be developed. The output of this activity will be threefold:

- 1) An overall **sustainable alternative fuel scenario** for waterborne transport applications (including currently considered fuels based either on sustainable biomass or renewable electricity), monitoring the continuous ongoing developments in sustainable fuel supply and manufacture, taking into account the results of RD&I undertaken by the Partnership and allowing waterborne transport and other stakeholders to identify, compare and anticipate fuel availability, cost and benefits per waterborne transport segment and geographical area;
- 2) the technical capabilities needed to integrate the use of **sustainable alternative fuels on board**;
- 3) technologies for **power conversion** of these fuels in high-efficiency fuel flexible prime movers, including Internal Combustion Engines (reciprocal or continuous) and Fuel Cells.



Relevance

The introduction of the use of **Sustainable Alternative Fuels** in the waterborne transport domain will **enable the final step towards zero-emission operation**. In particular, this is true for ships that cannot be fully electrified, either because of their mission profile or of the legacy fleet and will therefore need retrofitting to meet the zero-emission target. Although sustainable alternative fuels are associated with a high cost per avoided ton of CO₂, they form an **instrumental and unavoidable part of decarbonizing the waterborne transport domain**. Since the waterborne transport sector has **committed itself to decarbonize** fully, a transition towards the use of **sustainable alternative fuels** is clearly required. At the same time, this opportunity should be taken to drastically reduce, or fully eradicate, air quality-related pollutant emissions (which are dominated by NO_x, SO_x and particulate matters) and fuel-use related water pollution.

Fuels which need no exhaust gas after-treatment equipment such as scrubbers and SCR would be beneficial to achieve this goal. This is related to the fact that they reduce the (additional) cost of their implementation, thereby leading to a possible faster transition towards zero-emission operation, due to possibly lower investment risks and complexity, which could be potentially offset by lower fuel costs and increased availability.

In this respect, it is also imperative that we not only focus on carbon-free fuels, but also carbon-neutral fuels. **Fuel pathways will be checked for regulatory acceptance in close dialogue with IMO and CESNI**

members³¹, as well as EU policies concerning both **maritime transport and inland waterway transport**.

We will develop the solutions with the overall lowest systemic cost for a healthier society with a green-skilled waterborne workforce, while keeping in mind the **need to decrease specific barriers for their implementation**. One example is a cross-link with Ports and their infrastructure for bunkering alternative fuels, as described in the activity dedicated to **Ports**.

Innovative aspect

Today, **very few sustainable alternative fuels are in use in significant quantities in the waterborne transport domain**. Small amounts of renewable diesel fuels are used. These are mostly waste cooking oil-based products that are limited in availability. Besides this, whilst the use of Liquefied Biogas is increasing, it is still extremely low. Trials with many other sustainable alternative fuels, such as ammonia and methanol, are emerging throughout the industry, but no single fuel has yet emerged to address all requirements and concerns.

Fuel scenario

We will follow an approach that starts from a range of potential **overall fuel scenario for waterborne transport applications** based on trends per waterborne transport segment and geographical area. Economic and safety requirements for onboard fuel storage, as well as handling and utilization technologies, will be based on this fuel scenario, taking into account the likely worldwide differences in fuel availability today and possibilities

for the future, potential costs, their potential evolution and level of decarbonization. The need for, and value of, fuel flexibility of vessels will be quantified. Given the complexity of the overall implementation of new fuels, which also implies infrastructure works in ports, roads, etc., it is of vital importance that collaboration with other Partnerships is established. This will enable us to take advantage of sectoral integration opportunities and satisfy common requirements. The waterborne transport sector's move away from the utilization of waste products as fuel (HFO) to tailor-made fuels (either Bio- or renewable electricity-based) which are available on a large scale, means that a **paradigm shift in the relationship between fuel producers and the waterborne transport sector will occur**. We will also take into account potential competition for similar sustainable alternative fuels from other sectors, such as aviation or domestic gas supplies. This will be addressed as a rolling scenario assessment which continues to monitor the evolution of potential sustainable fuels, their supply and manufacture, as well as the solutions needed to enable their end use on board, including those developed within the context of this Partnership.

Fuel on board

We will develop the technical capabilities and safety requirements to **store large quantities of sustainable Alternative Fuels on board** ships, taking into account the flexibility required due to the evolution of fuel types, local availability differences and cost scenarios. Most sustainable alternative fuels require additional storage space (i.e. low environmental impact liquid and gaseous fuels, such as hydrogen, etc.), which requires the operational profile requirements to be an integral part of these developments. This will be subject to the **highest standards of safety in design and operation**. Integration of the full alternative fuel-value chain through ports will be addressed to ensure the appropriate development of **bunkering and emergency response** procedures. As a safeguard for a transitional period, on-board carbon capture and storage (CCS) systems may potentially be part of the portfolio.

Power conversion

A third stream will address on-board **power conversion**, which will develop the most efficient way to transform the chemical energy of the Sustainable Alternative Fuel into propulsion power or into electrical energy to feed propellers and other ship equipment. Developments will be based on **multiple technology paths, including Internal Combustion Engines, Fuel Cells and Turbines**. The technology upgrade will take into account the efficiency of energy conversion and the scalability in size and power of the propulsion system, as well as system cost, power density, complexity, operability

and maintainability by the crew. Moreover, the robustness of the system, its loading capabilities (i.e. the possibilities to react quickly to changing energy demand) and operational safety (including, but not limited to, fire safety and bad weather condition response) will be considered. Given the very diverse makeup of the waterborne transport fleet and the technologies powering it today, we will need a broad palette of technologies and solutions to be developed. These will not only differ in power output and fuel compatibility, but also in the level of integration, acceptable complexity and cost. For example, it is unlikely that the most favourable combination of solutions for an inland vessel will be the most favourable one for a large container carrier or cruise vessel.

As well as the developments in these three areas, **the action on Sustainable Alternative Fuels will also support the further development of the regulatory framework** which, at the moment, either does not exist at all or is incomplete.

Short-term

For the Work Programme Horizon Europe 2021-2022, in order to pave the way for the overall development of the use of **Sustainable Alternative Fuels** (illustrated in the chart below), we will focus on the following issues:

- 11) Enabling the safe and efficient onboard storage and integration within ships of **large quantities of ammonia and hydrogen fuels** (2021);
- 12) Enabling the safe deployment of low-flashpoint GHG neutral shipping fuels underpinned by the necessary norms and regulations (2022);
- 13) Enabling the full integration of **very high-power fuel cells** in ship design using co-generation and combined cycle solutions for increased efficiency with multiple fuels (2021);
- 14) Ensuring clean, **efficient engines using new carbon neutral fuels** separately and in combination (2022);
- 15) Proving the feasibility of large clean **ammonia marine engine** (2021);
- 16) CSA Identifying waterborne sustainable fuel deployment scenarios (2021).

Use of Sus. Alt. Fuels	Electrification	Energy Efficiency	Design and Retrofitting	Digital Green	Ports
------------------------	-----------------	-------------------	-------------------------	---------------	-------

OPERATIONAL OBJECTIVES

Eliminating GHG emissions



To develop and demonstrate solutions for the use of climate-natural, sustainable alternative fuels applicable to ships with high energy demand (e.g. long distance shipping) before 2030;

To develop and demonstrate before 2030 solutions for the integration of high-capacity batteries solutions as single energy source for short distance shipping (up to 150 to 200 nautical miles);

To develop and demonstrate solutions to be able to reduce the fuel consumption of waterborne transport, including by the use of non-fuel based propulsion (such as wind), by at least 55% before 2030, compared to 2008;

To develop and demonstrate solutions for port based supply infrastructure (i.e. infrastructure for bunkering of alternative fuels and electricity) needed to enable zero-emission waterborn transport, to be implemented by 2030 at the latest;



To develop solutions for clean and climate-neutral, climate-resilient inland waterway vessels before 2030.

Eliminating air pollution

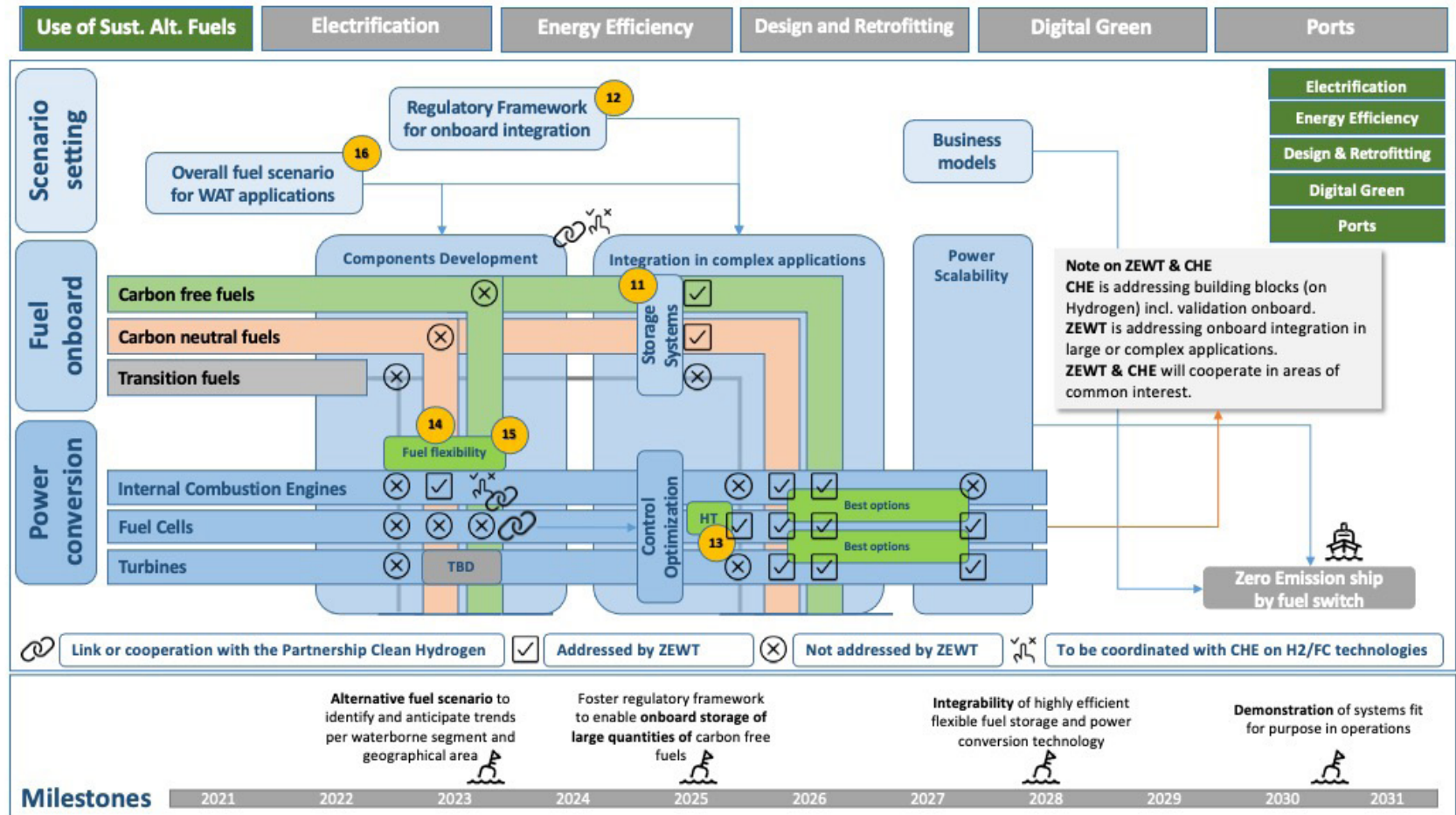


To develop and demonstrate solutions to cut coastal and inland pollution to air from inland waterway transport and maritime shipping by at least 50% by 2030, compared to current levels.

Eliminating water pollution



To develop and demonstrate solutions to eliminate pollution to water (including harmful underwater noise) from ships, by 2030.



ELECTRIFICATION

This activity concerns the development of ships with high-power energy storage systems and new DC distribution grids optimized for efficiency and operational profiles, new high performances, high efficiency variable speed electric generators and power trains.

Introduction

In some waterborne transport applications, the adoption of Alternative Fuels is not sufficient to meet with the ship's power demand. **Electrification** may represent a necessary complement to a power generation based on **Alternative Fuels** for long-range waterborne transport, as well as the unique solution for short-range, port calls and entry into environmental protected zones. Solutions must ensure the same level of performance of conventional vessels. This activity will be developed through three forward steps related to the state of the art: **Energy Models**, **Energy Storage Systems** (ESS), Electric Generators and Propulsion Drive Control and **Grid Architecture and Control**.

First of all, **Energy Models**, both static and dynamic if needed will be developed to allow a correct design and optimal management of the energy resources available (Alternative Fuels, batteries, renewables, fuel cells), taking into consideration different ship types and operational profiles. Secondly, in parallel with the development of the new energy models, the most appropriate and effective **Energy Storage System** technologies (e.g. lithium batteries, solid-state lithium batteries, super-/ultra-capacitors, etc.), for example utilising battery swapping or other configurations, will be chosen and modelled. Ground-breaking applications for batteries on

board will be implemented since they offer a form of power which can be immediately transformed into ship's power and motion. Moreover, studies on the feasibility of other options will be provided, including fast recharging systems at the port. The application of exchangeable batteries (which can be replaced by recharged batteries during the journey or when loading/unloading) will also be addressed. Finally, the development of **Innovative Grid Architecture and Control** will allow a smooth electrical integration of energy storage systems and renewables, together with traditional and non-conventional power generation plants (also allowing a switch to hybrid power architectures). The objective is to optimize the size of sources and switchboards (installed power, volume, weight and cost) and to be able to operate simultaneously with a different kind of electric source (DC or AC, having different dynamic responses) and electric storage devices, acting either as an energy buffer or back-up supply (battery, ultra-capacitors and others).

The onboard micro-grid should be integrated with a suitable control system, capable of regulating the electric variables of the micro-grid itself (voltage, frequency, active and reactive powers) with the desired dynamic performance, guaranteeing the overall stability. The onboard micro-grid should be further integrated with an energy management system (EMS), which is able to manage the power flows inside the micro-grid, suitably designed in order to pursue specific target functions (minimum fuel consumption, minimum polluting emissions, maximum efficiency of the energy conversion, minimum cost, etc.). A significant



part of the electric system to be modelled is the one constituted by the Electric Generators and Propulsion Drives, whose proper design and control present a significant impact on the dynamic performance, manoeuvrability, efficiency, fuel consumption and pollution of the entire ship.

By developing all of these sub-activities that integrate design, operative and controlling issues, a **technology demonstrator** of a large storage system installed on board a ship will be produced, taking into consideration the necessity of achieving the **highest standards of safety both in design and operation**.

Relevance

Electrification is one of the most promising options with a view to achieving Europe's aim of becoming the first continent with zero net emissions of greenhouse gases in 2050. New electrical power sources (i.e. batteries) will reduce greenhouse gas emissions from the transport of goods and passengers by ship (emissions of CO_x, SO_x and NO_x compounds and acoustic signature of the engine room, for instance), for both short sea and long route waterborne transport. The extensive **Electrification** of transportation systems (e.g. cars, trains, aeroplanes and ships) has today become an attractive technology, which offers the most efficient energy conversion in comparison to conventional concepts, even for waterborne transport applications. In this perspective, a fully electric ship could lead to more flexible, efficient and sustainable design and management of ships, geared towards the abatement of GHG emissions and the substantial decrease of the contribution to air/ water pollution from ships.

In this regard, it has to be noted that **Energy Storage Systems** are one of the best solutions to achieve zero GHG emission for several kinds of vessels, such as smaller in-land or near coastal vessels, ferries and platform supply vessels. The development of large scale **Energy Storage Systems** can also be useful to reduce both the GHG and pollutant emissions caused by modern passenger ships. Approaching the port in a "zero emissions condition" will be made possible through a power unit which can be fast-recharged while ships are at berth and connected to the onshore power facility (i.e. in "cold ironing"). Furthermore, considering the improvements promised by the next generation of solid-state battery technology that should be commercially available within the next 5 years, new prospects of a further reduction of GHG emissions are also expected for energy-intensive vessels. Finally, the development of **Innovative Grid Architecture and Control** systems will enable the reduction of overall emissions linked to energy waste, utilizing optimal management and control of electric energy on board, by both the generation and demand side, leveraging energy models able to provide the real operating conditions of the ship.

It is worth pointing out that a suitable grid architecture, partially or fully reliant on DC distribution, will make it possible to reduce the needed power conversion stages onboard and, therefore, the related electrical losses, with an increase in the overall system efficiency.

Innovative aspect

For an electric drive system to be "worthwhile" as the main power system, one crucial, challenging aspect which is highly dependent on ship power and operational profile constraints has to be overcome: high-power and compact electric storage solution on board (i.e. batteries). Moreover, the ports will need to have suitable charging infrastructures. This aspect is already an issue with shore-side electricity since, for instance, passenger ships need high electric power continuously for their hotel operations when at berth (in the 1-20 MW range). To address this issue, we will develop entirely new **Energy Models** to predict the required power load and devise more powerful **Energy Storage Systems**. Furthermore, innovative **Grid Architectures and Control Strategies** will be implemented and integrated into the **Port** ecosystem to achieve a more efficient, flexible and sustainable waterborne transport sector.

Energy Models

It has to be highlighted that a critical aspect of all of these technologies will be the development of the ability to predict the required power through **energy models**. The traditional methods used to calculate a ship's power demand and select the size of the generation system have become inadequate since they are based on very dated assumptions and do not take in account the possibility of innovative or alternative energy sources. Models will simulate electric load power demanded along the full ship operation time profile (anchor, manoeuvring, navigation, etc.) and the power generated by each power generation system, such as modern ESS

(batteries, super capacitors, etc.). New electric grid architectures (allowing comparison, for example, between AC/DC configurations) and environmental footprint abatement (GHG and pollutant emissions) will be integrated into the ship design process.

Energy Storage Systems (ESS)

For a full electric-drive ship power system, where both propulsion and other service loads are powered by electricity, the high variation in power demand typical of ships is even more significant than for traditional onshore power systems. In fact, in those conditions, power generation systems in most cases work far from their optimal point, resulting in an undesirable increase in costs, fuel consumption and emissions. Therefore, as happens in many land applications, characterized by uncertainties related to the power generation profile (e.g. wind and solar power generation plants), it may be advantageous to also install **Energy Storage Systems** on board many vessels. Such systems can be used to cover the fluctuating load variations and increase the efficiency, reliability and flexibility of the entire power system. In particular, they can be exploited by the vessel's Energy Management System to pursue specific objectives on the one hand, and to reduce the impact of fast load variation on the main generator set on the other. They can be further used to cover voltage fast variation and to cover power quality issues. They can even be devised to supply the energy needed by either the load or the propulsion system (if electric), in case of sudden failure of one of the main generators during the start-up of the auxiliary generators. Nowadays, **Energy Storage Systems** are not widespread and

are mostly limited to lead-acid batteries used for UPS in emergency conditions. The full Electrification of ships, including longer ranges, will be feasible thanks **new generation batteries and other innovative Energy Storage Systems. Among the solutions available, new generation batteries**, Super-/ultra-capacitors, or SMES (Superconductivity Magnetic Energy Storage) **will be** developed. Innovative approaches to ensure the safety of large Energy Storage Systems will be tested.

Grid Architecture and Control

Electrification will bring about another significant change. Today's standard for power system **Grid Architectures** is currently characterized by Alternative Current (AC) and radial configuration. However, priority has recently been given to the need for more complex power systems relying on Direct Current (DC), as well as radial/ring/decentralized configurations offering higher survivability, reliability and efficiency. With the advent of alternative forms of power, such as **Energy Storage Systems** (or fuel cells, see use of **Sustainable Alternative Fuels**), connected directly to the grid or via converters, **both AC and DC configurations will be possible (DC or hybrid AC-DC)**. The improvement of energy efficiency requires the development of **grid models**, the implementation of **control strategies** and smart energy management systems, optimizing energy flows and ensuring safe operations. Another critical issue to be tackled to properly address electrification and energy efficiency is the design and development of appropriate power electronic converters for interfacing electrical generators, storage systems and loads to the power grid. Such converters should comply with criteria required by the onboard application, i.e.,

modularity (designed according to the Power Electronic Building Blocks or PEBBs concept), high power density, redundancy, reliability and safety. When used in a storage system, they must provide bidirectional flow of power.

Moreover, specific control strategies of rotating electrical generators can be devised, according to a variable speed paradigm, to pursue the target of minimizing fuel consumption and related polluting emissions.

These innovations will result in weight and space savings, lower transmission losses, a faster and simpler connection of generators, enabling, overall, a more functional vessel layout and innovative operational principles.

Short-term

For the Horizon Europe Working Programme 2021-2022, in order to pave the way for the overall development of **Electrification** (illustrated in the chart below), we will focus on the following issues:

21) exploiting electrical energy storage systems and better optimising large battery electric power within fully battery electric and hybrid ships (2022);

22) Innovative electric energy storage systems for waterborne applications (2022);

23) Hyper powered vessel battery charging system (2021).

Use of Sus. Alt. Fuels

Electrification

Energy Efficiency

Design and Retrofitting

Digital Green

Ports

OPERATIONAL OBJECTIVES

Eliminating GHG emissions

To develop and demonstrate solutions for the use of climate-natural, sustainable alternative fuels applicable to ships with high energy demand (e.g. long distance shipping) before 2030;



To develop and demonstrate before 2030 solutions for the integration of high-capacity batteries solutions as single energy source for short distance shipping (up to 150 to 200 nautical miles);

To develop and demonstrate solutions to be able to reduce the fuel consumption of waterborne transport, including by the use of non-fuel based propulsion (such as wind), by at least 55% before 2030, compared to 2008;



To develop and demonstrate solutions for port based supply infrastructure (i.e. infrastructure for bunkering of alternative fuels and electricity) needed to enable zero-emission waterborn transport, to be implemented by 2030 at the latest;



To develop and demonstrate solutions for clean and climate-neutral, climate-resilient inland waterway vessels before 2030.

Eliminating air pollution

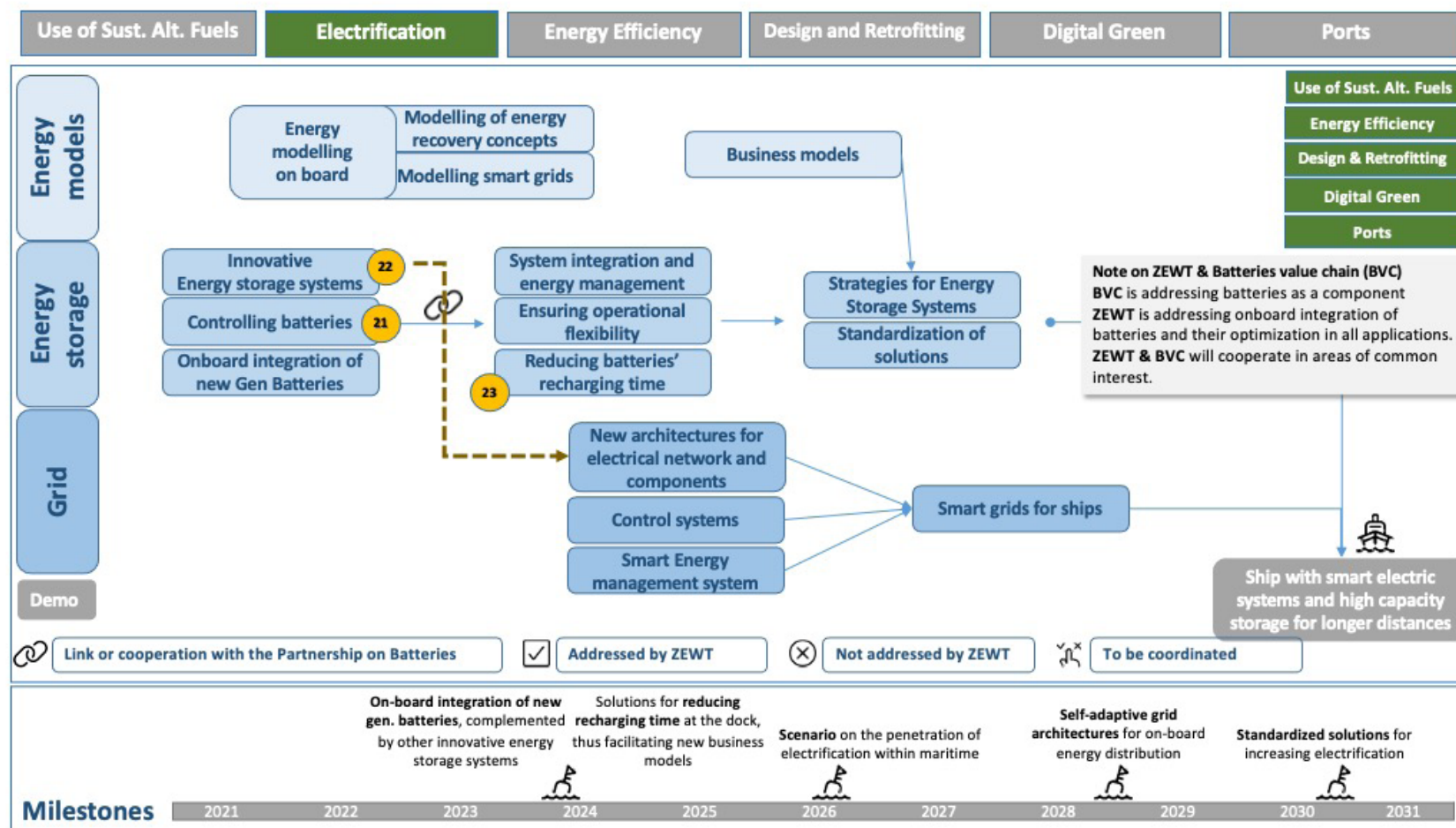


To develop and demonstrate solutions to cut coastal and inland pollution to air from inland waterway transport and maritime shipping by at least 50% by 2030, compared to current levels.

Eliminating water pollution



To develop and demonstrate solutions to eliminate pollution to water (including harmful underwater noise) from ships, by 2030.



ENERGY EFFICIENCY

This activity concerns the development of ships requiring significantly less power for operation thanks to power efficient solutions, the exploitation of renewable systems such as wind assisted navigation and the reconfiguration of the ship's architecture.

Introduction

The most environmental-friendly and cost-effective energy is energy that we do not need to produce, store and use. In this respect, the **Energy Efficiency** activity will contribute mainly to one major operational objective, which is **reducing the fuel consumption of waterborne transport by at least 55 % before 2030**. A new systemic and holistic approach can achieve such a breakthrough. **Energy efficiency optimization schemes need to be developed** beyond the current state-of-the-art with regards to single or limited design and operation points. This approach will tackle the full spectrum of ship energy needs and consumers, as well as operating profiles, to develop, demonstrate and select the most efficient technologies, ship design and operation solutions. As a result, the ship's energy needs will be reduced dramatically. Such an innovative approach and related solutions can be deployed along 3 main lines:

- **Ship design and operation optimization, integrating all solutions optimally** and taking into account the variability of ship operation profiles and corresponding dynamic energy needs,
- **Energy-efficient technologies**, to optimize the energy need for all consumers (technology bricks)

- **Renewable and free energy solutions**, to offer free additional energy sources, thereby further reducing the overall ship energy need from (alternative) fuels,

while taking full advantages of the new opportunities offered by electric power ship architecture, smart digital twin and technologies presented in the **Electrification** and **Digital Green** activities.

Relevance

Improving ship **Energy Efficiency** offers multi-dimensional advantages for this new paradigm of zero-emission waterborne transport, through reduction of fuel need and fuel storage volume on board, as well as down-sizing of ship power production systems. Therefore, the following benefits can be achieved:

- Direct reduction of the ship OPEX (fuel bill) and CAPEX (fuel tank and power system down-sizing) for the shipowner;
- Opening new grounds to develop innovative zero-emission ship architecture designs (through the free volume generated or as a consequence of the use of renewables), for designers;
- Counter-balancing of higher alternative fuel prices, lower alternative fuel energy density, or lower compactness of new fuel power conversion systems such as fuel cells (see “Sustainable Alternative Fuels” activity), for the market;

Energy
Efficiency

Design and
operation
integrations

Energy
Efficiency
technologies

Renewable and
free-energy
solutions

Demonstrators

– And even limitation of new infrastructures and operating constraints to supply alternative fuels to the ships safely and in the appropriate quantities, for the ports. (see “Ports” activity).

Since **Energy Efficiency is aiming to reduce the fuel consumption of waterborne transport dramatically** (by at least 55 % before 2030), the abovementioned gains will be tremendous, offering key leverage for zero-emission waterborne transport. In this regard, among renewables, wind propulsion can serve as a complementary and transformational energy source and a primary propulsion solution, thanks to the more advanced technology already available, with respect to the use of sustainable alternative fuels. Moreover, reducing the energy need by at least 55% before 2030 will directly impact the ship's GHG and air and water pollutant emissions by the same amount (through the ship's power production system exhausts and underwater noise), contributing 55% of the overall emission reduction objectives.

Innovative aspect

Today, ship energy efficiency optimization is conducted with regards to single or limited design and operation points (e.g. maximum ship speed required). However, these specific conditions represent a limited part of the full spectrum of ship operation profiles and corresponding energy needs. Furthermore, the technology solutions used to optimize these single or limited operation cases are mainly passive technologies (e.g. duct tail optimized to a specific ship speed) that can even offer lower performances in other ship operation conditions. Also, the use of renewable energy is

very scarce, mainly due to non-mature solutions (or lack of solutions compatible for high power/large-scale applications (e.g. wind powering, solar panels) beyond a low fuel price and the lack of an incentive to develop such solutions. In the context of zero-emission waterborne transport and to achieve this objective, especially the **55% reduction in energy consumption**, the current situation needs to change dramatically. A new paradigm will be developed here, based on 3 breakthroughs:

- A systemic and holistic approach to ship energy efficiency,
- A switch from passive technologies and single or limited design/operation point approach to active and adaptive, multi-parameter ship design and solutions,
- Large-scale, energy-efficient applications of renewable energies (i.e. upscaling of solutions for wind assisted propulsion).

Design and operation integrations

This **systemic, holistic and disruptive ship energy efficiency approach** will allow for a much better understanding, monitoring, prediction and real-time control of the full spectrum and complexity of ship energy needs, flows and operating profiles. In this way, it will make it possible, at the design stage, to conduct a full-scale multi-parameter optimization of ship energy efficiency for overall ship operation conditions. Selection and optimization for the integration of new energy power systems (i.e. fuel cells, batteries and renewable energies) and energy-

efficient technologies will also be supported. Moreover, it will open up new opportunities to develop **real-time adaptive optimization to take into account envisaged operating conditions, as well as new operating conditions under ship operation**. This approach will make full use of new capabilities offered by **breakthrough energy and ship data monitoring, analysis and prediction** (digitalization, Digital Twin, Big Data, Artificial Intelligence) and **hybrid energy power systems**, as presented in the **Digital Green and Electrification** activities. Small case applications of this complex approach on cruise ships have already shown considerably high energy savings and a full market up-take of such approach and methodologies should maximize these gains, thereby making a significant contribution to the overall 55% reduction of energy consumption objective.

Energy-efficient technologies

The **mastering of the full ship energy systems and operating profile** opens up a new paradigm for research and development of energy-efficient technologies by:

- **breakthrough assessment and optimized integration** of new innovative power conversion and storage systems (e.g. heat/steam energy recovery solutions, variable speed electric motors, centralized or modular energy architecture) and innovative and more energy-efficient consumers (e.g. HVAC new design/technology architecture/solutions, thermal insulation, ...). Solutions such as fuel cell technologies and advanced engine technology and combined cycles are expected to significantly reduce sustainable fuel consumption. This, in combination

with the use of alternative fuels and electrification, will make a substantial contribution to the efforts to optimize the energy need for all consumers (technology bricks) and significantly reduce fuel consumption, as well as emissions.

– enabling a disruptive switch from today's **mostly passive technologies to active/adaptive ship design and solutions, for energy-efficient operation conditions at all-times** (e.g. active deadweight and trim controls, active and bio-mimic appendages, innovative hull coatings...).

– Both areas will be developed here and fully **demonstrated**.

Renewable and free energy solutions

Renewable and free energy solutions are now attracting greater interest in the dramatic context of climate change. **Wind powering** (e.g. multi-MW wind turbines, automatic-controlled kites, large sails made of hinged composite panels,...), or **waste to energy solutions** (e.g. Hydrothermal Oxidation and alternatives) are also emerging as breakthrough solutions for larger ships propulsion. Most solutions are still under development on a small scale and **may not apply to all ship types**. Ship design and integration and full-scale demonstrators will be conducted to assess and select the most effective solution, depending on ship types and operations.

Significant potential market uptake is now expected by 2030, with progressively increasing energy savings depending on the ship application and operating profiles. **The combination of renewable and free sources** to power small-scale vessels (such as solar energy for an energy-autonomous drone) or provide off-shore fuel bunkering (see "Ports" activity), **will enable new energy-efficient waterborne applications**. The most promising applications will be assessed and **demonstrated**. For large-scale onboard ship applications, disruptive solutions in terms of power output and density, such as for wind (or solar) energy, still need to be developed.

Short-term

For the short-term Work Programme period of 2021-2022, in order to pave the way for the overall development of **Energy Efficiency** (illustrated in the chart below), we will focus on the following issues:

31) Exploiting renewable energy for shipping, in particular focusing on the potential of wind energy (2022);

32) Innovative onboard energy saving solutions (2021).

Use of Sus. Alt. Fuels	Electrification	Energy Efficiency	Design and Retrofitting	Digital Green	Ports
------------------------	-----------------	-------------------	-------------------------	---------------	-------

OPERATIONAL OBJECTIVES

Eliminating GHG emissions

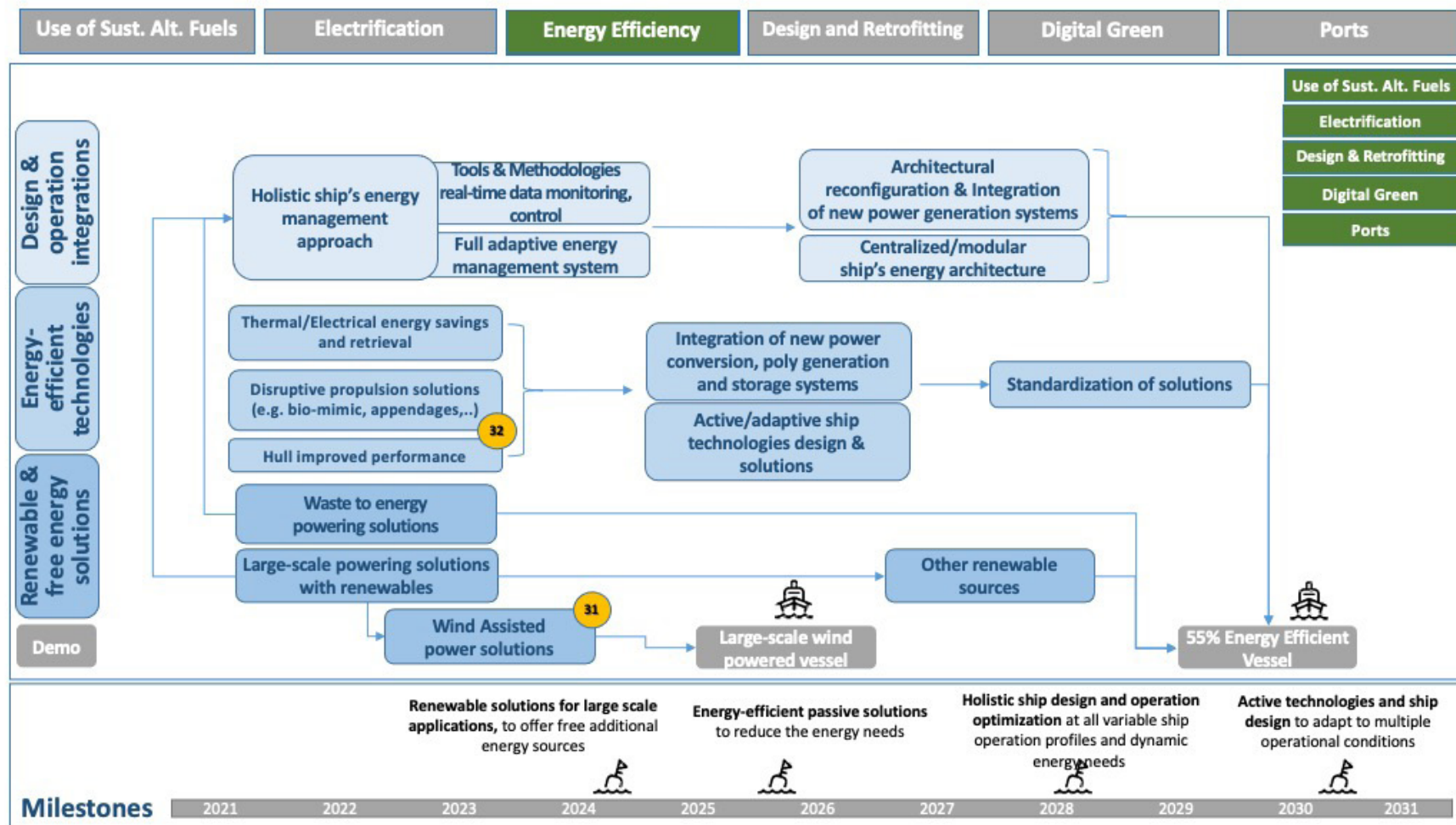
- ✓ To develop and demonstrate solutions for the use of climate-natural, sustainable alternative fuels applicable to ships with high energy demand (e.g. long distance shipping) before 2030;
- ✓ To develop and demonstrate before 2030 solutions for the integration of high-capacity batteries solutions as single energy source for short distance shipping (up to 150 to 200 nautical miles);
- ✓ To develop and demonstrate solutions to be able to reduce the fuel consumption of waterborne transport, including by the use of non-fuel based propulsion (such as wind), by at least 55% before 2030, compared to 2008;
- ✓ To develop and demonstrate solutions for port based supply infrastructure (i.e. infrastructure for bunkering of alternative fuels and electricity) needed to enable zero-emission waterborn transport, to be implemented by 2030 at the latest;
- ✓ To develop and demonstrate solutions for clean and climate-neutral, climate-resilient inland waterway vessels before 2030.

Eliminating air pollution

- ✓ To develop and demonstrate solutions to cut coastal and inland pollution to air from inland waterway transport and maritime shipping by at least 50% by 2030, compared to current levels.

Eliminating water pollution

- ✓ To develop and demonstrate solutions to eliminate pollution to water (including harmful underwater noise) from ships, by 2030.



DESIGN AND RETROFITTING

This activity concerns the development of methodologies for green design, manufacturing and retrofitting.

Introduction

To provide and **demonstrate** zero-emission solutions for all main ship types and services before 2030, which will enable zero-emission waterborne transport before 2050, requires **dealing with the existing fleet and with newbuilds**. The composition of the current fleet excludes a “one-size-fits-all” single zero-emission solution which may transform the sector. **Different technologies need to be developed and adapted** to the specific operational needs and business models of different ship types and these technologies also need to anticipate the continuous evolution of transport needs, ports infrastructures, technologies and regulations. All of these aspects require **new methodologies in Design, Manufacturing and Retrofitting**: these activities are the zero-emission target “enablers” throughout the entire life cycle of ships. A **new design approach** will integrate the latest and disruptive technologies in light, safe, clean and cost-effective ship solutions. At the same time, design methodologies will anticipate future needs to replace existing ship systems with new green systems, which will be demonstrated before 2030. Modular ship architectures will assure **cost-effective retrofitting** of low emission solutions throughout the ship’s lifetime. For ships-in-service, high priority will be given to the development and demonstration of easy to integrate green retrofitting solutions, such as electrification (batteries) or use of sustainable alternative fuels and power conversion

systems before 2030. Moreover, retrofitting of after-treatment systems for internal combustion engines, combined with climate-neutral drop-in fuels, will be considered.

Advanced assessment methodologies and full twinning of ship design and manufacturing processes will be developed to attain a high level of confidence regarding the environmental performance of ship designs, of ships in service before and after retrofitting and the environmental impact of manufacturing processes.

Relevance

A new business model is needed to achieve a reduction in GHG and other polluting emissions (NO_x, SO_x, PM, methane slip) towards zero values in 2050. At the same time, it is in the public interest to maintain the leading role of Europe’s shipyards and maritime equipment suppliers: fostering clean, safe and competitive European waterborne transport in a period of lower economic prosperity, also offers a way to meet both future market and societal needs.

The environmental performance of a ship is determined by her initial business model, her operational requirements, the energy management on board and the embedded technologies, which usually corresponds to the state of the art at the time of ship delivery. **Since the average life span of a ship is 30-40 years, specific measures for abating emissions on ships in service are needed.** The maintenance of ships must evolve from the current preservation of the initially designed environmental and operating performances



towards a process of minimising them by **retrofitting**. While retrofitting ships in use is bound by architectural constraints, **newbuilds replacing the older part of the fleet must anticipate future retrofitting options and employ appropriate measures in design and manufacturing**. Despite the differences between newly designed and in-service ships, a common strategy to greening, for GHG-elimination and pollution mitigation to air and water, can be applied in three consecutive steps:

- 1) minimise the ship energy needs,
- 2) minimise the share of onboard ICEs in power systems and
- 3) install alternative ship power systems and apply clean fuels on ICEs (fuel cells, alternative fuels, Energy Storage Systems, etc.).

Innovative aspect Design

Current ship design methods benefit from past experiences, either by copying or scaling of ship designs with comparable requirements or by creating a digital model based on pre-programmed rules derived from the analysis of existing designs (parametric design). Over the past decades, diesel engines and fuels have been more-or-less stable factors in ship design, production and CAPEX and OPEX. Once the ship powering demand was determined, power train and fuel weights, volumes and layouts followed well-established practices with the final details being set by the chosen brands.

The transition to other energy conversion technologies and fuels leads to different needs for weight, volumes and layouts. Moreover, potential retrofitting of the ship with newer green technologies and systems leads to **different needs for the ship architecture**. Similarly, introducing high strength and lightweight materials such as composites or intelligent materials with self-healing or self-cleaning properties to improve energy efficiency **cannot rely on current design, manufacture and end of life practices**.

Disruptive changes in power systems are envisaged and therefore new fuel storage systems, new materials and components will require ship design solutions to adapt to changed operational and environmental requirements, including legislation. Moreover, **cost-effective technology upgrades for greening will have to be foreseen throughout the life cycle with a view to maximising value, including end-of-life, supporting sustainability, and ensuring that the ships remain** competitive under varying market and mission requirements. Changes and uncertainties mean that future ship design methods will use probabilistic approaches to identify design solutions that will exhibit the smallest effects of random variability, e.g. those that are the most robust. A **new probabilistic design for greening** will make it possible to address uncertainties linked to totally new parameters, such as thrust from wind propulsion, use of different alternative fuels, etc., as well as operating and/or environmental conditions.

Fast design assessment methodologies capable of dealing with new technologies, their mutual impact, the overall impact on the ship, along with design robustness, flexibility and resilience over the entire life

cycle, will be developed and validated. The traceability of systems and components, as well as operational data obtained from remote monitoring and validated by the ship digital twin, will support the outlined greening strategy. The new opportunities offered by digital twin and technologies presented in the **Digital Green** activities will be fully leveraged to ensure a dual exploitation of results, both for the design of new vessels and their operational management.

Manufacturing

European shipbuilding and its highly relevant supply chain will continue to compete on a global level, with new business models employing the most advanced market leading green technologies which contribute to the 2050 zero-emission targets. The state-of-the-art manufacturing technology of European shipyards contains advanced CAD/CAE/CAM platforms with various levels of automation in parts of manufacturing, assembly and outfitting processes. **Modular ship architectures are now applied only on a limited scale**, with closer integration of the suppliers throughout the value chain, i.e. during design, engineering and assembly phases. To build green-to-zero emission ships, **European shipyards will deal with new technologies, new supply chain partners, harmonization of new technical rules and standards and new materials processed in shop floor processes**. Furthermore, the manufacturing of a zero-emission ship will fundamentally differ from current practices, thanks to **high reconfigurability for modular shipbuilding**.

Manufacturing is the “enabler” for building and retrofitting green ships at competitive costs in the

global shipbuilding and ship repair, maintenance and retrofitting industry. The research will address – in an LCPA context – new, low-polluting floor processes related to the building and retrofitting of green ships, e.g. with light alternative materials.

Retrofitting

Today, capturing and twinning an existing ship's architectural data by reverse engineering is not effective in lead time and cost, further reducing the efficiency of the retrofitting process. **The increased complexity of green technologies requires a better understanding of the ship systems' re-design and integration of old and new technologies and components.** A practical example is the electrification of the ship, including the installation of battery sets and relevant auxiliaries. Assessing the impact of retrofitting alternatives in terms of sustainability requires efficient methods and life cycle-oriented business models.

Two parallel retrofit tracks have been identified. First of all, the existing fleet and in particular the relatively younger fleet segments (< 10 years), thanks to more recent technologies, will allow for a fast assessment of retrofit options following the strategy of minimising energy needs, ICE's share and polluting emissions. Retrofit candidates are the ship systems for energy conversion, distribution and management, waste recovery, emissions reduction and capture, energy-saving devices (ESVs), ships' speed profiles review, propulsion train re-design and wind thrust-generating. The second track concerns fleet replacement and in particular the relatively older (> 25 years) fleet segments in Europe. New builds will be designed for

operational flexibility and robustness with structural measures for future retrofitting with progressively maturing green technologies, aligned with evolving port infrastructures (fuelling, waste disposal and shore supply). **Modular design for green retrofit as a new sub-discipline in ship design** will address all energy and emissions issues, enable efficient retrofit processes and provide LCA-tools for the assessment of retrofit scenarios. A wide variety of retrofit strategies and assessment methodologies for the entire waterborne sector will be developed.

Short-term

For the short-term Work Programme period of 2021-2022, in order to pave the way for the overall development of **Design & Retrofitting** (illustrated in the chart below), we will focus on the following issues:

41) Transformation of the existing fleet towards greener operations through retrofitting (2022);

42) assessing and preventing methane slip from LNG engines in all conditions within both existing and new vessels (2021).

Use of Sus. Alt. Fuels

Electrification

Energy Efficiency

Design and Retrofitting

Digital Green

Ports

OPERATIONAL OBJECTIVES

Eliminating GHG emissions



To develop and demonstrate solutions for the use of climate-natural, sustainable alternative fuels applicable to ships with high energy demand (e.g. long distance shipping) before 2030;



To develop and demonstrate before 2030 solutions for the integration of high-capacity batteries solutions as single energy source for short distance shipping (up to 150 to 200 nautical miles);

To develop and demonstrate solutions to be able to reduce the fuel consumption of waterborne transport, including by the use of non-fuel based propulsion (such as wind), by at least 55% before 2030, compared to 2008;



To develop and demonstrate solutions for port based supply infrastructure (i.e. infrastructure for bunkering of alternative fuels and electricity) needed to enable zero-emission waterborn transport, to be implemented by 2030 at the latest;



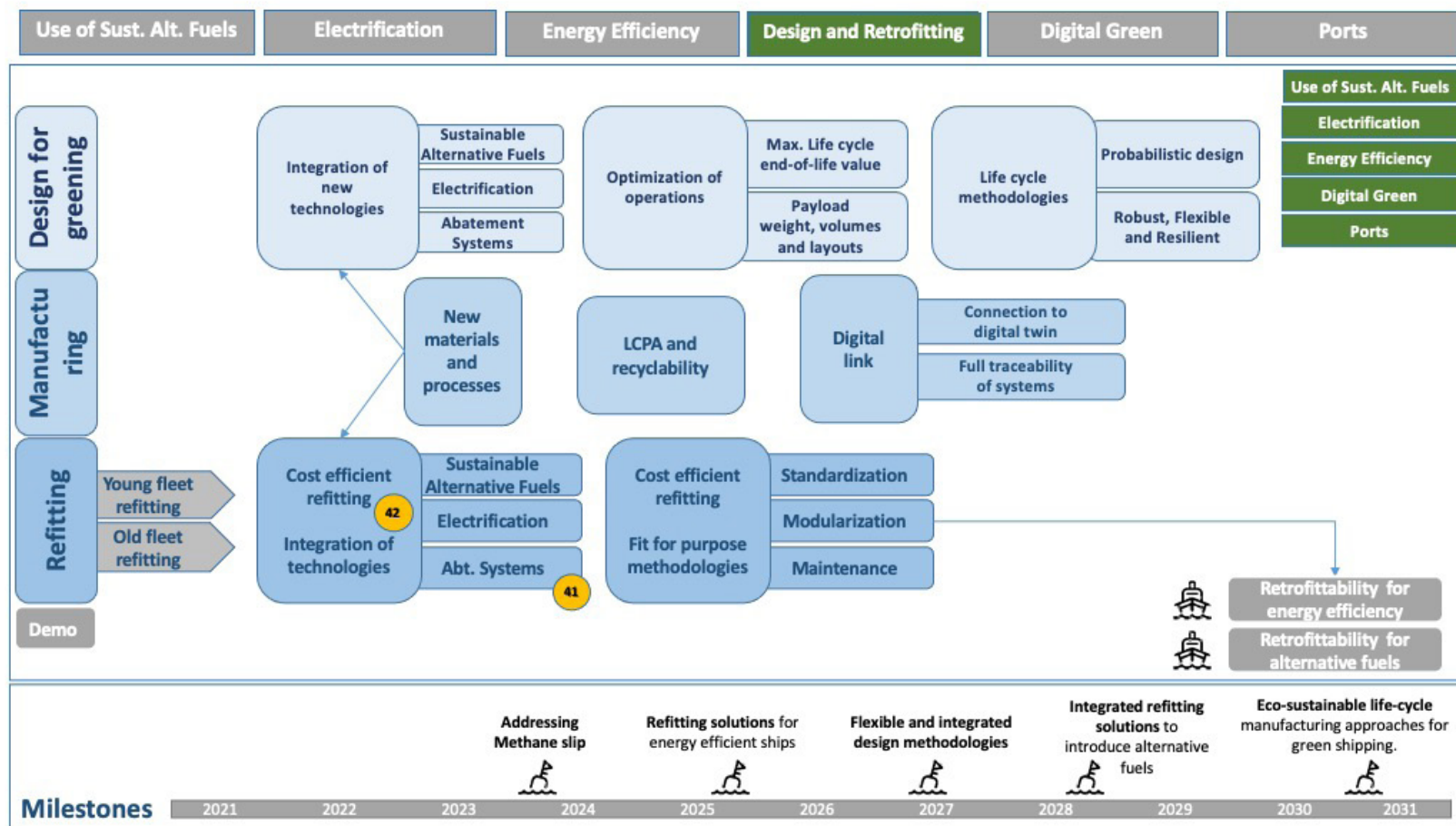
To develop and demonstrate solutions for clean and climate-neutral, climate-resilient inland waterway vessels before 2030.

Eliminating air pollution

To develop and demonstrate solutions to cut coastal and inland pollution to air from inland waterway transport and maritime shipping by at least 50% by 2030, compared to current levels.

Eliminating water pollution

To develop and demonstrate solutions to eliminate pollution to water (including harmful underwater noise) from ships, by 2030.



DIGITAL GREEN

This activity concerns the **broadest use of digitalisation to improve efficiency and reduce emissions through monitoring and big data collection**, the development of a secure and IPR-compatible **Digital Twin** and **Zero-Emission Energy Decision Support Systems**.

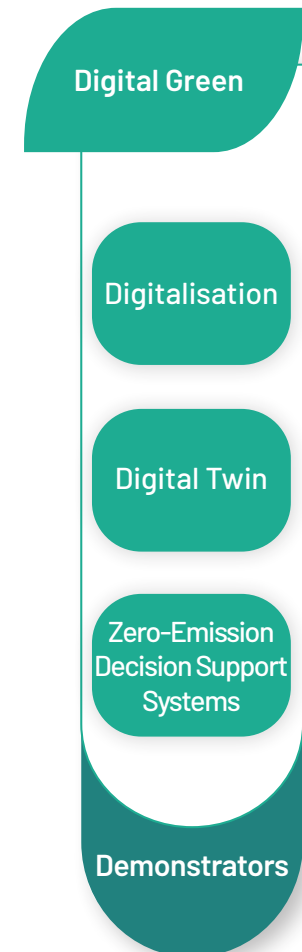
Introduction

Reducing GHG, air and water pollutions requires not only the integration of new digital technology in vessels, but also the effective use of these technologies in an operational context. The optimisation of fleets, traffic, port operations and individual ship operations as part of its function (e.g. a logistics chain, as currently discussed by the Digital Transport and Logistics Forum – DTLF with the proposed use of Corridor Information Systems) requires the availability of data, their analysis and guidance.

Managing and organising digitalisation towards the goals of this programme requires the development of three activities. These activities can be seen as the **three steps to the zero-emission epiphany**:

- 1) Monitoring and Big Data collection:** to look back by measuring, connecting, complying and making a diagnosis
- 2) Digital Twin:** to look ahead by predicting and improving predictions
- 3) Zero-Emission Decision Support Systems:** to act and create value, in terms of emission reductions, transcending the boundaries of individual ships and ship operations.

Monitoring and Big Data Collection cover sensing, data acquisition, including big data sourcing, connectivity, data management and sovereignty, data analytics and reporting. Some of the fundamental requirements to enable this are the availability of data standards, compliance, IPR agreements, configuration management and security management. These activities aim to enable the operational condition and ship health monitoring necessary to reduce emissions through a combination of increased vessel utilization, fleet efficiency, optimized traffic and port logistics, as well as to enable compliancy with rules and regulations. **The essence of the Digital Twin is a virtual representation of the ship and its relevant systems connected to the physical representation, the ship as it is built.** Providing predictive capabilities in addition to the historical and real-time data-based insights coming from **Monitoring and Big Data Collection** is not only an essential enabler for **Zero-Emission Decision Support Systems**, but also a prerequisite for a manageable and safe digitalized vessel. Nowadays, systems and subsystems increasingly come with advanced automation and software. **Digital integration onboard has therefore become a challenge in itself**, with necessary verification and validation through hardware in the loop testing and continuous software upgrades. Additionally, consistent configuration management is required throughout the lifecycle of the ship. In terms of energy consumption reduction, **managing digital integration through a Digital Twin is crucial for zero-emission ships.** On top of the combined Monitoring and Big Data Collection and Digital Twin sub-activities, a **Zero-Emission Decision Support System** will also be developed. A digital



twin can quantify vessel performances such as fuel consumption and emissions relative to speed, transit time or transfer of cargo or passengers. It may calculate multiple scenarios indicating the room for improvement to the captain, fleet manager, traffic controller or any other stakeholder. The combination of historical and real-time data with predictions based on alternative scenarios allows for the optimization of the condition of ship systems, the vessel performance (for emissions) and optimization of the vessel-, traffic and port and fleet operations. **The Zero Emission Decision Support System converts these insights into real-life** results by translating operator guidance into actions which are executed, in most cases, by the Decision Support System and supervised by the captain, cargo handler, traffic controller and any other operator.

Relevance

Fleet optimisation in the context of a single operator operating a fleet of ships, or multiple operators serving a single market or linked in a logistic chain, depends on accurate and real-time information regarding vessels, ship conditions, environmental conditions and operational plans. Digitalisation through **Monitoring and Big Data Collection** on board increases fleet utilisation, and as a result, lowers the energy need on a fleet or logistic chain level. Optimisation of fleet utilisation, ship operations and ship condition, based on **Monitoring and Big Data Collection**, offers a vast potential to achieve the Partnership's zero-emission goal. Measurements through appropriate sensors, analysis of data, control optimisation through predictive capabilities (the **Digital Twin**) and

operator guidance or automated actions (autonomy) will contribute to reducing energy consumption, air pollution and underwater radiated noise on multiple levels of maritime operations. The organisation of ship operations is also dependent on the availability of accurate and real-time information regarding the ship, the energy converters and consumers and environmental data, such as weather and sea state data, as well as water conditions on inland rivers (water depths and currents) and waiting times at inland locks and bridges. In combination with data shared by other vessels, ports and logistic chain data, **voyage optimisation will be raised to the level of the entire logistic chain**, thereby lowering the energy consumption and pollution of ship operations on a single ship level. Ship condition optimisation allows for the continuous monitoring of ship systems data concerning energy conversion and use, thereby ensuring the energy efficiency gains as described in **Energy Efficiency** activity. Increased energy demands caused by, for example, hull fouling, propeller damage or control deviations, can be monitored and analysed for deviations that require corrective action. Underwater radiated noise can be measured and monitored to allow for operator guidance depending on local rules and regulations or practices within particularly sensitive areas. Compliance with rules and regulations by individual ships and the obtention of accurate data from large numbers of ships are enabled by **Monitoring and Big Data Collection** for ships and shipping and allow for measured data-driven policies and enforcement of rules and regulation, as an additional societal benefit.

Innovative aspect

The innovative approach represented by monitoring and big data collection, digital twin and the subsequent implementation of **Zero-emission Decision Support Systems**, will be fully leveraged not only for the operational management of the new zero-emission vessels, but also for the related **Design & Retrofitting** activities (newbuilds & retrofits).

Monitoring and big data collection

State-of-the-art digitalisation and connectivity solutions are characterised by proprietary and (sets of) subsystem specific solutions. As such, the functionality required to monitor the condition of the vessel in terms of emissions requires a combination of connectivity solutions for each newly designed vessel. **Data standards** to facilitate the reusability of these solutions for other ship types or system designs are non-existent. **Data platforms** to exchange and share acquired data are emerging but offer **partial and often proprietary solutions**. Meeting the requirements concerning data sovereignty, IPR and security requirements on the one hand, and allowing access to stakeholders (equipment suppliers, shipyards, shipowners, cargo owners, classification societies, software application developers, flag states) on the other hand, is yet to be achieved. **The Partnership delivers the necessary standards for zero-emission relevant data exchange**, including a platform design for the monitoring, analysis and compliance of ship-related data and required data from sources other than the vessel. The data platform will allow interoperability with traffic, port and logistic operations.

Digital Twin

True digital twins, consisting of mutually and real-time interacting physical assets and digital representations, **are in an infant stage of development**. Combinations of simulation capabilities and operations do exist, most often in a semi-disconnected way and hampered by a lack of adequate configuration management of control systems applied in the physical vessel. **The addition of predictive capabilities in the operations of vessels to improve efficiency and eliminate emissions**, therefore, requires modelling standards, Verification, Validation and Accreditation (VV&A) procedural standards, configuration management, systems in the loop testing³² and distributed simulation architectural standards. These will be developed and **demonstrated** in the Partnership.

Zero-Emission Decision Support Systems

Zero-emission Decision Support Systems will subsequently be developed, combining sensor information, analytic and predictive capabilities and higher levels of automation, including AI. Ship condition monitoring, environment data, traffic data, port operations data and logistic chain data are **to be combined in Decision Support Systems or autonomous systems**. Nevertheless, the limitations of autonomous systems, as well as those of humans interacting with autonomous systems, have to be

taken into account. Consequently, a continuous and monitored maximum reduction of waterborne transport emissions in ship operations and **an essential contribution to the 55% reduction goal of fuel consumption of Waterborne Operations** will be achieved.

Short-term

For the Horizon Europe Work Programme 2021-2022, in order to pave the way for the overall development of **Digital Green** (as illustrated in the chart below), we will focus on the following issue:

51) Digital Twin models to enable green ship operations (2021).

Use of Sus. Alt. Fuels	Electrification	Energy Efficiency	Design and Retrofitting	Digital Green	Ports
------------------------	-----------------	-------------------	-------------------------	---------------	-------

OPERATIONAL OBJECTIVES

Eliminating GHG emissions

To develop and demonstrate solutions for the use of climate-natural, sustainable alternative fuels applicable to ships with high energy demand (e.g. long distance shipping) before 2030;

To develop and demonstrate before 2030 solutions for the integration of high-capacity batteries solutions as single energy source for short distance shipping (up to 150 to 200 nautical miles);



To develop and demonstrate solutions to be able to reduce the fuel consumption of waterborne transport, including by the use of non-fuel based propulsion (such as wind), by at least 55% before 2030, compared to 2008;



To develop and demonstrate solutions for port based supply infrastructure (i.e. infrastructure for bunkering of alternative fuels and electricity) needed to enable zero-emission waterborn transport, to be implemented by 2030 at the latest;

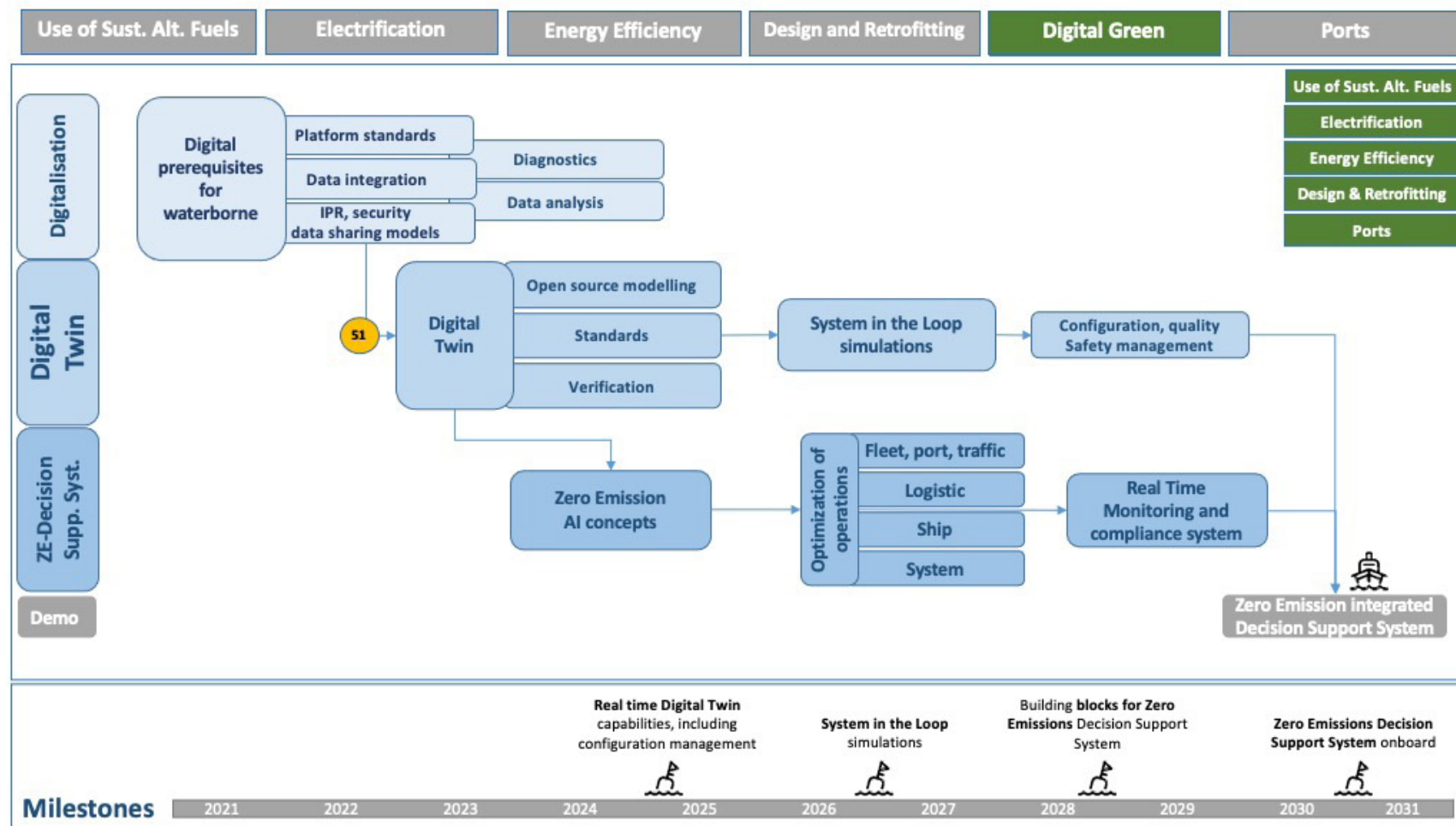
To develop and demonstrate solutions for clean and climate-neutral, climate-resilient inland waterway vessels before 2030.

Eliminating air pollution

To develop and demonstrate solutions to cut coastal and inland pollution to air from inland waterway transport and maritime shipping by at least 50% by 2030, compared to current levels.

Eliminating water pollution

To develop and demonstrate solutions to eliminate pollution to water (including harmful underwater noise) from ships, by 2030.



PORTS

This activity concerns the development of safe technologies and procedures for the **bunkering of sustainable fuels at inland and maritime ports, the supply of electricity to vessels**, taking into account new necessary systems for alternative energy solutions (i.e. recharging and transhipment points for exchangeable battery containers in the case of electrification) and **systems for reducing emissions** from waterborne transport within ports.

Introduction

Achieving net-zero emission waterborne transport, as well as broadly facilitating zero emission for the wider logistics network is one of the most critical challenges for port facilities.

Ports represent crucial hubs in the logistics network, linking maritime transport, to the hinterland, including inland waterway transport, and finally to customers. Net-zero emission waterborne transport, including related wastes within ports, are facilitated by this activity. **Therefore, ports have to develop their net-zero-emissions strategy adapting to the evolution of the different transport modalities**, starting with vessels, including port vessels such as tugboats. At the same time, **ports and waterways should adapt to climate change effects** by developing resilient solutions to minimise their impact on operations.

Ports and infrastructure solutions, including those located along inland waterways, for **flexible bunkering of sustainable fuel** will be developed within this activity to enable the transition of waterborne transport towards the use of alternative fuels. A **reduction of emissions** will be ensured by a

higher level of electrification and by increasing the abatement of the main water and air pollutants.

Relevance

Our proposed solutions in the **Ports** activity, are designed to enable the energy transition of maritime shipping and inland navigation and its interaction with ports and related infrastructures. These solutions are, therefore, strategic in facilitating **GHG reduction and reduction of other pollutants** for vessels. By taking actions to make the waterborne transport sector zero emission, it reinforces its position with respect to increasingly electrified road transport and reduces the risk of reverse modal shift towards road transport for both inland navigation and (short sea) maritime shipping. This approach is essential to ensure that European inland and maritime shipping meets the strategic objective of zero emission, as expressed in the EU Green Deal communication, and underpins its position as the cleanest and most energy-efficient modalities of transport. **Air pollution from waterborne transport** has a considerable impact on the environment of ports and the surrounding city areas. The activities of the Partnership will also tackle these emissions and address the issue of eliminating accidental water pollution, for example during bunkering operations. Technical standards and procedures for safe storage and bunkering of sustainable alternative energy providers, including fuels and preventing their spillage, will also be addressed. Hull coating management and noise reduction during the maintenance phase in port areas will be also reduced.

Ports

Bunkering
sustainable
alternative fuels

Recharging
solutions

Reducing
Emissions

Demonstrators

Innovative aspect

At present, there is no integrated vision and approach to the development of sustainable fuel supplies for alternative energy solutions.

Furthermore, there is a lack of technical standards for bunkering of these fuels, leading to a fragmentation of bunkering options throughout European ports. Finally, there is still much uncertainty on safe storage and bunkering for several alternative fuel options. By developing standards, creating flexible fuel storage and supply options for different energy suppliers and integrating them into the overall port energy grid, the fast adoption of bunkering different alternative fuels in European ports (seaports and inland ports) can be guaranteed.

This is also the case for inland waterway vessels sailing on inland waterways. Whilst cold ironing is already developed for the lower powers needed for inland navigation vessels and for some small-scale maritime vessels (such as short-distance ferries) **for larger vessels, there is a lack of standards** and there are no flexible solutions for providing enough power (for instance, for large passenger vessels).

Bunkering alternative energy solution

The lack of an established distribution and bunkering network in ports and along inland waterways across Europe is considered to be a major constraint for a large-scale roll-out of **new alternative sustainable energy solutions to provide a feasible service to both maritime shipping and inland navigation.** In this respect, special attention should be paid to hydrogen, whose bunkering and supply would be addressed by

the Clean Hydrogen Horizon Europe Partnership. By learning from the recent challenges related to the introduction of LNG as a fuel in ports, the Partnership will develop solutions and operational procedures with marine renewable energies and alternative fuels, given the varied range of fuels and a large assortment of engines technically possible. Safe, **flexible bunkering solutions** for different types of sustainable fuels for different waterborne transport segments, will be realized to facilitate their increased use.

The definition and development of proper and consistent **rules, regulations and procedures** will support the introduction of sustainable alternative shipping fuels in ports in the safest way possible for the infrastructure, the environment and the surrounding population. Furthermore, **technical standards** will be developed for transferring to ship, or recharging ships and the directly related facilities (i.e. nozzles and hoses) to ensure that ships can be serviced throughout Europe.

The Partnership may address solutions for **transfer and storage solutions for onboard Carbon Capture from ships, providing that these can be shown to be sufficiently energy efficient and feasible at scale.** The Partnership will develop solutions and strategies to link local energy streams (electricity, hydrogen, waste, ...) with the supply of alternative fuels for shipping, with a focus on the ship, whilst taking the **overall value chains** into consideration.

Reducing emissions

Once it is possible to move beyond the current state-of-the-art, innovative on-board monitoring, the use of (automated) drones, vessels and other detection methods will be used to enforce emission limits applicable to waterborne transport. As an innovative solution, different monitoring data may be combined and used to ensure compliance and enforcement of (new and emerging) environmental rules and regulations, ensuring a level playing field for ship owners. Supporting the Waterborne activities on the electrification of vessels and shipping-port operations, we shall develop **technical standards for recharging equipment** and power supply solutions, such as **integration with smart grids and mobile solutions.**

Use of Sus. Alt. Fuels	Electrification	Energy Efficiency	Design and Retrofitting	Digital Green	Ports
------------------------	-----------------	-------------------	-------------------------	---------------	-------

OPERATIONAL OBJECTIVES

Eliminating GHG emissions

To develop and demonstrate solutions for the use of climate-natural, sustainable alternative fuels applicable to ships with high energy demand (e.g. long distance shipping) before 2030;

To develop and demonstrate before 2030 solutions for the integration of high-capacity batteries solutions as single energy source for short distance shipping (up to 150 to 200 nautical miles);

To develop and demonstrate solutions to be able to reduce the fuel consumption of waterborne transport, including by the use of non-fuel based propulsion (such as wind), by at least 55% before 2030, compared to 2008;



To develop and demonstrate solutions for port based supply infrastructure (i.e. infrastructure for bunkering of alternative fuels and electricity) needed to enable zero-emission waterborn transport, to be implemented by 2030 at the latest;

To develop and demonstrate solutions for clean and climate-neutral, climate-resilient inland waterway vessels before 2030.

Eliminating air pollution

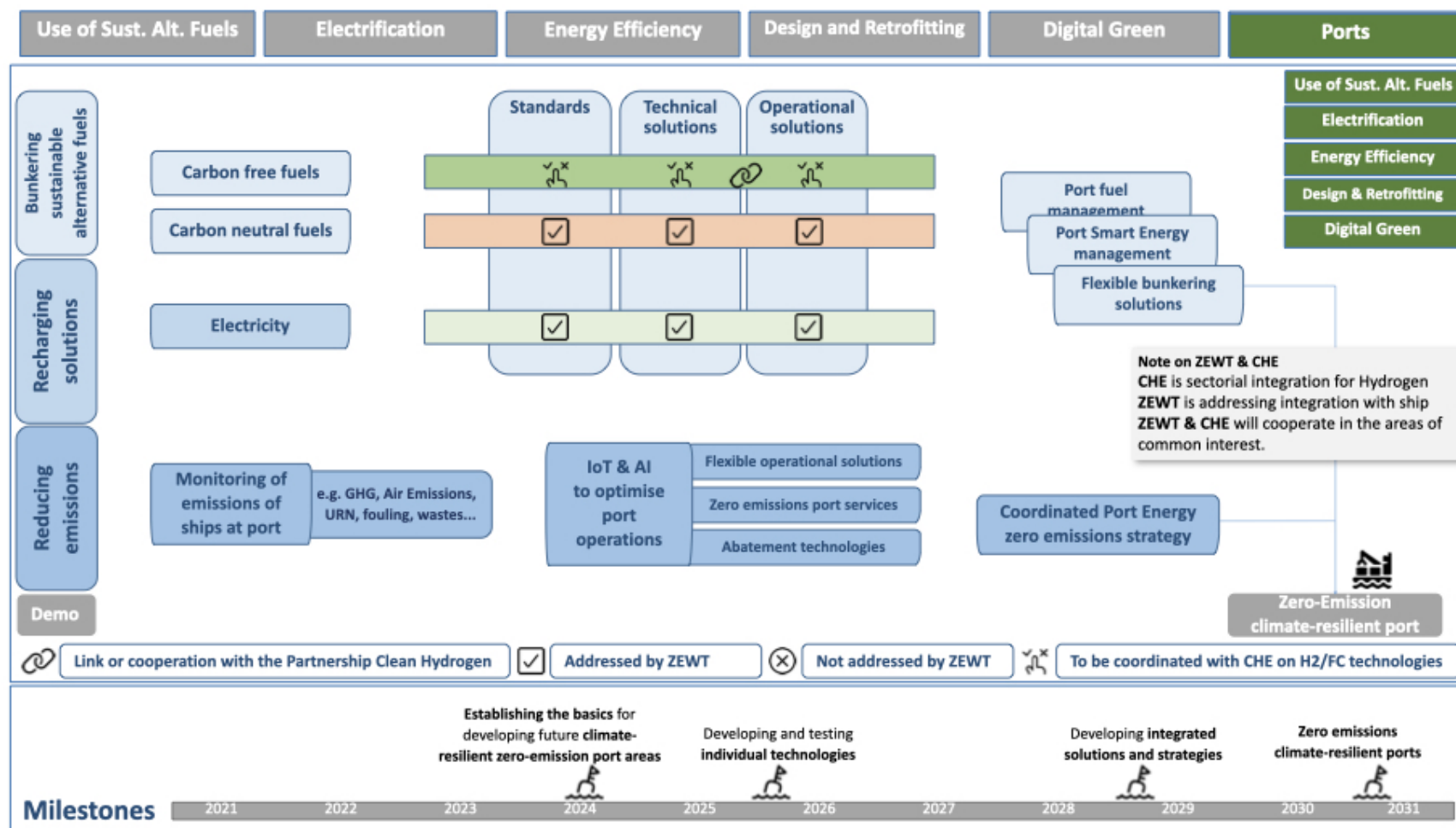


To develop and demonstrate solutions to cut coastal and inland pollution to air from inland waterway transport and maritime shipping by at least 50% by 2030, compared to current levels.

Eliminating water pollution



To develop and demonstrate solutions to eliminate pollution to water (including harmful underwater noise) from ships, by 2030.



The background of the slide features a photograph of a ship's deck. In the foreground, a thick, dark rope is coiled around a metal bollard. A metal railing is visible in the lower left. In the background, the blue sea stretches to the horizon, with a dark, silhouetted coastline on the left. The image is partially overlaid with large, white, stylized geometric shapes, including a large 'A' on the right and a triangle on the left.

PART 3: EXPECTED IMPACTS

Achieving zero-emission waterborne transport to the benefit of future generations

The Partnership on Zero-Emission Waterborne Transport is built upon the following vision:

“For Europe to lead and accelerate the transformation of the global waterborne transport sector into a zero-emission mode of transport which has eliminated all harmful environmental emissions **(including greenhouse gas emissions, as well as air and water pollutants, including (underwater) noise)** through innovative ship technologies and operations which underpin European growth and employment.”

The Partnership will therefore contribute to the three main impacts:

1) the significant reduction of GHG emissions from waterborne transport, in line with the EU's commitment to cut GHG emission by **at least 50% in 2030 compared to 1990 levels** and to achieve a 90% reduction in transport emissions by 2050. In addition, the deployment of solutions will **stimulate the modal shift** to waterborne transport;

2) cutting pollution, significantly improving the quality of the (European) environment and human health. The **external costs of the impact on human health** from maritime transport in the EU28 has been estimated to be €98 billion in 2016 and were €3 billion for inland waterway transport;

3) it will enable Europe's waterborne transport sector to **enhance its global competitiveness** in terms of innovative solutions, as well as its global technological leadership in green ship technologies and solutions over foreign competitors (in particular South Korea and China) which, in turn, will create higher added value and economic wealth, as well as innovative jobs. The Partnership has a number of objectives and the impact per objective is elaborated upon in this chapter.

Impact of the specific objectives

The Partnership is built upon specific scientific, economic and societal objectives. These objectives will have a major impact on European society and the waterborne transport sector, as well as EU and international policies. These impacts will be described in the following sections.

Specific scientific objective

To develop and demonstrate deployable technological solutions which will be applicable for the decarbonisation and the elimination of other emissions of relevant ships and services.

GHG emissions – European Green Deal

The European Green Deal aims to ensure that Europe will be the first climate-neutral continent, thereby making Europe a prosperous, modern, competitive and climate-neutral economy. Becoming the world's first climate-neutral continent is a great challenge and opportunity. The Partnership will ensure that the waterborne transport sector assumes its responsibility to contribute to this ambitious policy objective.

The Waterborne community is committed to provide and demonstrate technologies and solutions for all main ship types and services before 2030, which will enable zero-emission waterborne transport before 2050.

If no actions were to be taken, the GHG emissions from waterborne transport would be at least 5 to 10% of the world emissions in 2050. Therefore, the solutions developed in this Partnership will contribute significantly to the policy objectives of the European Green Deal to tackle climate and environmental-related challenges, thereby contributing to the preservation of human and animal life, as well as forests and oceans. Finally, the Partnership's solutions will contribute to the Green Recovery, as a key element to mitigate the economic effects of the COVID-19 Pandemic. Since the European waterborne transport sector is world leading in complex technologies, Europe can lead the world in the transformation of the waterborne transport sector.

The United Nations has formulated 17 Sustainable Development Goals (SDGs) which are at the heart of the 2030 Agenda for Sustainable Development, adopted by all UN Member States. Climate action is SDG13 and is fully in line with the European Green Deal. Therefore, achieving the objectives of the Partnership will significantly contribute to SDG13.



SDG 13 – Climate Action

- **Zero Emission Waterborne Transport** solutions (Sustainable Alternative Fuels, Electrification, Renewables, Abatement Systems)
- **Zero Emission Decision Support System**
- **Climate resilient port strategies & contingency plans**

Air pollution

Another **Sustainable Development Goal** defined by the United Nations is the Good health and well-being of citizens, SGD3.

The Partnership will develop and demonstrate solutions for the elimination of air pollution in port cities, coastal areas and along inland waterways. Waterborne transport into ports will be fully electrified; shipping along coastlines will be either electrified or based on clean, sustainable alternative fuels. Inland shipping will make use of batteries or hydrogen-based fuel cells, completely eliminating harmful effects.



SDG 3 – Good health and wellbeing

- **Reduction of air pollution in port cities and along inland waterways** (Use of alternative fuels, electrification, emission abatement systems)

Annual premature European deaths caused by air pollution are estimated at 430,000-800,000. A major cause of these deaths is nitrogen dioxide and other nitrogen oxides (NOx) emitted by transport. By switching to sustainable alternative fuels, the **waterborne sector is contributing significantly to the reduction of these premature deaths.**

Water pollution

Another Sustainable Development Goal defined by the United Nations is the protection of Life below water.



SDG 14 - Life Below Water

- Abatement systems for ship pollution
- New hull coatings with no release of chemicals
- Minimizing underwater noise of ships

The Partnership will contribute to the protection of the Ocean and Life below Water by developing and demonstrating technologies for the reduction of pollution from shipping. The use of open systems, such as scrubbers, will be drastically reduced. New hull coatings will be developed to reduce resistance of ships, whilst at the same time reducing the release of harmful chemicals into water. Furthermore, underwater noise will be mitigated by the development of quiet engines and quiet propulsion systems. Noise levels of individual ships will be significantly decreased.

Specific economic objectives

By 2030, implementation of economically viable European new technologies and concepts regarding zero-emission waterborne transport, to strengthen the competitiveness of European industries in growing green ship technology markets and provide the capability to re-enter markets presently dominated by Europe's competitors.

The European (EU 28+Norway+Turkey) waterborne technology industries, including shipbuilders, boatbuilders and 1st and 2nd tier equipment suppliers, are world leading in terms of aggregated production value of shipbuilding and ship-systems production, even though its physical level of shipbuilding production (in terms of gross tons (GT) and deadweight tons (dwt)) has decreased. With a calculated value of EUR 147 billion, the EU 28+2 countries represent 30,5% of the global production value for maritime technology of EUR 482,5 billion³³ (annual average for 2010-2014) and are securing more than 750.000 jobs in more than 40.000 enterprises in Europe³⁴.

Consolidating and further strengthening the EU's frontrunner role in RD&I and the implementation of greening technologies and concepts will be essential **to ensure the transition to a clean and competitive European waterborne transport sector and to enhance the competitiveness of the European waterborne transport sector across all market segments.**

The Partnership is a centre-piece of the European waterborne technology sector, underpinning the development of new ship concepts and system technologies and demonstrating radical onboard technologies. Innovation is seen as essential for gaining access to new markets, accessing high value niches (e.g. specialised vessels for offshore), or re-entering markets lost to competing continents.

Specific societal objective

To facilitate the development of regulations and policies at national and international level, including the development of standards to enable the implementation of technological solutions for zero-emission waterborne transport by 2030 at the latest.

The International Maritime Organization (IMO) is the United Nations specialized agency with responsibility for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships. IMO's work supports the UN SDGs and its work is therefore essential for the achievement of the policy objectives of the European Green Deal. The EU and its Member States discuss future regulations for the maritime transport sector at the IMO. The Partnership will provide the scientific and technical basis for discussion at the level of the IMO.

For inland waterway transport, the Partnership will present the progress and results of the Partnership during meetings of CESNI, as well as the relevant NAIADDES working groups.

The Partnership will therefore be a key instrument to provide the necessary input for the development of policies, rules and regulations to accelerate the transition towards zero-emission waterborne transport.

To facilitate the uptake of innovative zero-emission waterborne transport technologies and solutions within the European waterborne transport sector supporting economic growth and European employment.

The waterborne transport sector will benefit from the Partnership by developing new technologies, while boosting circularity and creating new markets. Therefore, the European waterborne transport sector will take a leading role in the transformation of the worldwide sector and will enhance its competitiveness at the same time, ensuring long-term employment, often in remote areas.

People, skills and knowledge are the backbone of the European waterborne transport sector. The waterborne transport sector is one of the most diversified sectors in terms of types of jobs and required skills, ranging from jobs in ports, forwarders, stevedores, designers, builders of thousands of systems to crew on board vessels, as well as office staff. Managing such a wide and diversified set of skills and tasks requires a coordinated approach in order to adapt skills along the entire value chain during the transformation. The waterborne transport sector will ensure that skills which are needed for deploying and using innovative technologies are embedded in education and training activities. In this context, a particular emphasis will be placed on nurturing Small and Medium-sized Enterprises which are an essential part of the European ecosystem. The waterborne transport sector will pay specific attention to the use of long term skills development strategies and

innovative educational and training methods to address the increasing diversity of the European workforce (which is comprised of people of all genders and ages, local and/or migrant origin) and also to attract more talented women and young people to the waterborne transport sector. Through the creation of the foundation to facilitate the shift to zero-emission waterborne transport, the Partnership will play a key role in the economic recovery following the COVID-19 pandemic through the creation of highly skilled jobs.

Enablers and requirements to reach the full impact of the Partnership

For the Partnership to reach its maximal impact, it is important that enablers are sufficiently developed and that requirements are met. Some examples are:

- Market demand for green products
- Infrastructure and fuel availability
- Regulations and international long-term governance
- Rules of classification societies

Market demand for green products

The most crucial factor to reach the full impact of the Partnership is the uptake of zero-emission technology by the sector. This can not only be achieved by technology push; there has to be a strong demand for green products and services. We are already seeing the first signs of shippers requesting green transport; or shippers awarding long-term contracts based on a transition to greener shipping. This is followed by some ship-owners pledging that, from 2030 onwards, they will only order zero-emission vessels. But this demand for green transport has to grow in the coming decade to stimulate the uptake of technologies. By developing and demonstrating deployable solutions and by supporting the development of rules and standards for green products, the Partnership will have an indirect impact on stimulating deployment, e.g. by ensuring synergies with deployment programmes like CEF, Innovation fund etc.

Infrastructure and fuel availability

Another important enabler or requirement to achieve the full impact of the Partnership is the availability of fuel and the necessary bunkering infrastructure. Here we are facing a Catch-22 situation: without demand for alternative fuels, availability of these fuels will be very limited and without availability of fuels along a route or in a sea region, the uptake of new technologies using these fuels will stop. Local, small scale cooperation may lead to small breakthroughs, but also to local solutions which limit wider applications. The international standardization of fuel availability and of bunkering technologies is necessary. This requires a coordinated approach outside the scope of the Partnership.

Regulations and international long-term governance

For ship owners making large investments or assuming long-term financial obligations, it is very important that their assets are future proof. On the one hand, this requires flexible ship designs and possibilities for retrofitting to adapt to new upcoming innovations. But a long-term perspective in international governance of the waterborne transport sector is also an important enabler of the transition. Regulations need to be known well in advance and should preferably be applicable world-wide. Given the lifetime of vessels of close to 30 years, a reliable framework of regulations has to be put in place to facilitate the transition to a zero-emission mode of transport. The Partnership will provide input to the European Commission and the Member States

regarding their position in regulatory discussions, with a special focus placed on long-term governance.

Rules of classification societies

Ships are being designed and built according to the rules of classification societies. Following these rules is necessary for guaranteeing a safe investment for financing institutions and for obtaining insurance of the vessel in operation. Classification rules are developed to establish standards for the structural strength of the ship's hull and its appendages and the safety of the propulsion and steering systems, power generation and those other features and auxiliary systems which have been built into the ship to assist in its operation. A vessel built in accordance with the applicable rules of a classification society may be assigned a class designation by that society upon satisfactory completion of the relevant surveys. For ships in service, classification societies carry out surveys to verify that the ship remains in compliance with those rules.

With the development of new technologies for propulsion, design, retrofitting and operations, the uptake of these innovations has to be facilitated with associated classification guidelines and rules. It is crucial that these guidelines and rules are developed alongside the development of the technology and in alignment with the IMO, to avoid their being a gap between demonstration and possible deployment. Timely development of rules will enable the Partnership to reach its full impact, but the Partnership will also have a role in supporting the development of these rules.

Proposed monitoring arrangements

An Objective oriented approach

The Partnership takes an objective driven approach, founded upon the ambition to achieve climate neutrality and eliminate harmful pollutants. From this general objective, specific and operational objectives follow and these objectives drive the Partnerships Intervention Logic.

The operational objectives are most closely linked to the implementation of the Partnership and are foundation for a set of KPI's (key performance indicators) which can be used to monitor the effectiveness of the action. In summary:

– **General or overall objectives** are the goals set at the EU level to which the initiative aims to contribute:

(To) provide and demonstrate zero-emission solutions for all main ship types and services before 2030, which will enable zero-emission waterborne transport before 2050.

– **Specific objectives** are those setting out what the initiative aims at achieving at the scientific, economic and societal level. In this respect the Partnership aims at developing and demonstrating new technological solutions, strengthening the competitiveness of the EU industries and facilitating the uptake of innovative technologies and the development of new policies and regulations.

– **Operational objectives** are the specific focuses of the activities of the initiative.

From objectives to Results

As a research and innovation action the final impacts towards the widespread implementation of zero-emission waterborne transport will only be achieved in the long term. However, the direct activities of the partnership will achieve 3 types of Results:

– **Outputs** are the solutions directly developed within the Partnerships activities in the short term, which will contribute to meeting the **Operational objectives**;

– **Outcomes** are the medium term results of the actions of the initiative, meeting **Specific objectives**;

– **Impacts** are the long term indirect result of the action, i.e. **General objectives**, expected to be achieved in the social, economic and scientific spheres.

DATA COLLECTION

The primary means of collecting information for some of the reporting elements will be through European Commission's reporting systems for management of the Horizon Europe programme. For the private side, the necessary data needed to monitor the implementation of the Partnership will be compiled by means of a questionnaire circulated by the Secretariat every second year to the membership. The questionnaire will obtain:

- Details of the value of the additional in kind resources mobilised, broken down by broad category;
- The outcomes, solutions, commercialisations and patents arising out of the Partnership activities;
- Any scientific publications and participation within policy and regulatory forums linked to the Partnership;
- Any other relevant data necessary for the monitoring framework

Similarly Member States and Associated States within the cooperation group will be asked to provide information on any alignment between their programs and the Partnership.

The Partnership will also formulate a framework to enable the projects supported to report towards the Secretariat on their activities without substantial additional efforts. Reporting data will be aggregated so as to maintain the reasonable commercial confidentialities of the members.

The Partnership expects that the European Commission will provide reasonable support to provide the necessary quantified statistical data needed for annual reporting whilst respecting its confidentiality obligation.

Key Performance Indicators (KPIs)

The following KPI's will be used to support the monitoring of partnership implementation



Key Performance Indicators (KPIs)

European Partnership on Zero-Emission Waterborne Transport

Monitoring and evaluation framework

General objectives

G01 To provide and demonstrate zero-emission solutions for all main ship types and services before 2030, which will enable zero-emission waterborne transport before 2050.

Measure of success

- a) Value of contribution (EU and additional resources) mobilised towards the achievement of the European Green Deal objectives (total in 2030, monitored every year)
- b) Total value of the private contribution and EU contribution and its percentage of the EU contribution mobilised to date, dedicated to decarbonisation (total in 2030, monitored every 2 years)
- c) Total value of private contribution and its percentage of EU contribution mobilised to date, dedicated to reducing air pollution (total in 2030, monitored every 2 years)
- d) Total value of private contribution and its percentage of EU contribution mobilised to date, dedicated to water pollution (total in 2030, monitored every 2 years)

Data source and methodology

- a) HE budget, and information from the Partnership secretariat on in-kind contribution following questionnaire to members
- b, c and d budget for the partnership and for total value including additional activities (biannual WPs)

Responsible for monitoring and timing

- a) b) c) and d) RTD, INEA, Partnership Secretariat (monitored and reported every 2 years, target measured at the end of the program)

Baseline and targets

- Baseline: start of the Partnership
- a) Total resources deployed in the context of the the partnership (EU contribution defined in MoU +3.3 bn Eur private additional in kind resources) by 2030
- b) Target: billion €2.3 of private contribution (additional resources) & 70% of EU contribution
- c) Target: 660 million € of private contribution (additional resources) & 20% of EU contribution
- d) Target: 330 million € of private contribution (additional resources) & 10% of EU contribution

Key Performance Indicators (KPIs)

European Partnership on Zero-Emission Waterborne Transport

Monitoring and evaluation framework

Program level objectives

Measure of success

Data source and methodology

Responsible for monitoring and timing

Baseline and targets

Partnership leveraging the EU's investment

e) Commitment deployed compared to planning, % of value of additional resources mobilised compared to EU contribution to date.

e) Partnership secretariat (response to questionnaire to partners), Cordis data (funding per project), INEA.

e) To be monitored on yearly basis compared to planning at start of partnership and additional activities described within MoU. Target measured at the end of the program

Final target 600% (by 2030) 3Bn€/500€M

Achieving a critical mass to increase impact.

f) Number of MSs and Horizon Europe associated states who have adapted R&I programs to increase synergies with ZEWT.

g) Number of companies, research bodies and universities who have adapted R&I programs to increase synergies with ZEWT.

f) Partnership's States Representative Group, questionnaire, Partnership secretariat, g) Partnership secretariat (response to members questionnaire),

f, g) To be measured every second year. Targets: intermediate (y+3) and final - end of the program (2030)

f) Intermediate (after Y+3) at least 3 states, 2030 at least 5 states g) Intermediate (after y+3) 30 members, 2030 50 members.

Key Performance Indicators (KPIs)

European Partnership on Zero-Emission Waterborne Transport

Monitoring and evaluation framework

Program level objectives

Broadening Participation in European Research Programmes.

Measure of success

h) Number of different MSs and Horizon Europe associated states industries represented within the membership of ZEWT.

i) Percentage of projects including participants from the MSs and Horizon Europe associated states who are within the lower quartile of Horizon 2020 activity.

j) Percentage of projects including SME participation

Data source and methodology

h, i, j) CORDIS, INEA, Partnership secretariat.

Responsible for monitoring and timing

h, i, j) To be calculated on yearly basis

Baseline and targets

h) 20 states
i) 30%
j) 80%

Key Performance Indicators (KPIs)

European Partnership on Zero-Emission Waterborne Transport

Monitoring and evaluation framework

Specific objectives

S01 (scientific) To develop and demonstrate deployable technological solutions which will be applicable for the decarbonisation and the elimination of other harmful emissions of main ship types and services.

Measure of success

- a) Number of scientific papers and journal citations arising from the partnership including projects (from year +3)
- b) Number of patents and solutions placed on the market for outcomes resulting from ZEWT supported activities, projects (from y+3).
- c) Impact studies, examples that provide evidence for significant impacts from the partnership.

Data source and methodology

- a) Project questionnaire, citation index, Monitoring mechanisms of the industry
- b) Projects, Monitoring mechanisms of the industry etc.
- c) Secretariat, membership questionnaire, INEA, feedback from the projects, expert interviews.

Responsible for monitoring and timing

- a) Projects, Partnership secretariat and members; Every second year
- b) Projects, partnership secretariat; Every second year, starting y+3
- c) Case studies included within reporting every second year, illustrating contribution to specific objectives and added value from partnership. Every second year

Baseline and targets

- Baseline: start of the Partnership
- a) Target: min 50 after y+3, min. 300, in 2027, min. 450 in 2030
- b) Baseline: by 2030 minimum 50 patents and/or solutions commercialised
- c) At least four successful impact studies included in reporting every second year (except for the first biennial report).

Key Performance Indicators (KPIs)

European Partnership on Zero-Emission Waterborne Transport

Monitoring and evaluation framework

Specific objectives

S02 (economic) By 2030, implementation of economically viable European new technologies and concepts regarding zero-emission waterborne transport, to strengthen the competitiveness of European industries in growing green ship technology markets and provide the capability to re-enter markets, presently dominated by Europe's competitors.

Measure of success

Number of solutions arising from the outcomes of the projects supported by the partnership

Data source and methodology

Projects, monitoring mechanisms of the industry etc.

Responsible for monitoring and timing

Partnership Secretariat, Industry; On yearly basis, starting y+3

Baseline and targets

Baseline: start of the Partnership
Target: min. 12 after y+3, min. 50 after 2027 and 70 solutions at the end of the program (2030)

Key Performance Indicators (KPIs)

European Partnership on Zero-Emission Waterborne Transport

Monitoring and evaluation framework

Specific objectives

Measure of success

Data source and methodology

Responsible for monitoring and timing

Baseline and targets

S03 (societal) To facilitate the development and implementation of regulations and policies at national and international level including the development of standards to enable the implementation of technological solutions for zero-emission waterborne transport by 2030 at the latest;

Number of contributions from projects forming basis towards the development of guidelines, standards and rules provided directly to the relevant standards and rule setting bodies (IMO, Member States, legislative expert groups, Classification Societies, etc.)

Projects, partnership secretariat questionnaire to members

Partnership secretariat, INEA, COM (RTD), To be monitored every second year, starting y+2 until 2030

Baseline: start of the Partnership

Target: minimum 20 contributions to developments of standards from ZEWT projects by 2030

S04 (societal) To facilitate the uptake of innovative zero-emission waterborne transport technologies and solutions within the European waterborne transport sector supporting economic growth and European employment.

Number of solutions resulting from the projects supported by ZEWT, whose uptake has been facilitated by CEF, Climate Innovation Fund, Regional Funds, national deployment schemes and other relevant programs and/or private investments (commercialised)

Secretariat questionnaire to members, own industry's monitoring mechanisms, CEF yearly reports, Climate Innovation Fund reports etc.

Partnership Secretariat, INEA, RTD, CLIMA (starting from y+3 and in 2030)

Target: minimum 50 solutions by 2030

Key Performance Indicators (KPIs)

European Partnership on Zero-Emission Waterborne Transport

Monitoring and evaluation framework

Operational objectives

Measure of success

Data source and methodology

Responsible for monitoring and timing

Baseline and targets

001 (GHG) To develop and demonstrate solutions for the use of climate-neutral, sustainable alternative fuels applicable to ships with high energy demand (e.g. long distance shipping) before 2030

Number of directly deployable solutions developed using climate-neutral, sustainable alternative fuels applicable to ships with high energy demand, e.g. long distance shipping;

Projects results

INEA, Partnership secretariat (can be monitored after first results, y+3, and then throughout the program, the final result will be known at the end of the program 2030), every second year

Target: 20 solutions by 2030

002 (GHG) To develop and demonstrate before 2030 solutions for the integration of high-capacity batteries solutions as single energy source for short distance shipping (up to 150 to 200 nautical miles)

% of target electrified autonomy (150nm-200nm) achieved for commercially scaled shipping using electrical energy storage systems

Projects, INEA, Partnership secretariat, Progress reported every second year from Y+3.

Target: of 150nm 100% electric autonomy demonstrated by 2030

Key Performance Indicators (KPIs)

European Partnership on Zero-Emission Waterborne Transport

Monitoring and evaluation framework

Operational objectives

Measure of success

Data source and methodology

Responsible for monitoring and timing

Baseline and targets

003 (GHG) To develop and demonstrate solutions to be able to reduce the fuel consumption of waterborne transport, including by the use of non-fuel based propulsion (such as wind), by at least 55 % before 2030, compared to 2008

% of fuel consumption reduction target (55%) achieved applicable to large scale shipping as a result of innovations supported by the partnership.

Projects results

Projects, INEA, Partnership secretariat. Progress reported every second year from Y+3.

Target: 100% of target 55% reduction in fuel consumption demonstrated applicable to large scale shipping by 2030

004 (GHG) To develop and demonstrate solutions for port based supply infrastructure (i.e. infrastructure for bunkering of alternative fuels and electricity) needed to enable zero-emission waterborne transport, to be implemented by 2030 at the latest

Number of projects which demonstrates innovative solutions enabling deployable cost-effective bunkering of different sustainable alternative fuels and electricity supplied to ships.

Projects

Projects, INEA, Partnership secretariat measured at the end of the program and monitoring cycle. Reported every second year.

Target 004: 5 projects by 2030.

Key Performance Indicators (KPIs)

European Partnership on Zero-Emission Waterborne Transport

Monitoring and evaluation framework

Operational objectives

Measure of success

Data source and methodology

Responsible for monitoring and timing

Baseline and targets

005 (GHG) To develop solutions for clean and climate-neutral, climate-resilient inland waterway vessels before 2030.

005 Number of solutions demonstrating clean and climate-neutral, climate-resilient inland waterway vessels

Projects

Projects, INEA, Partnership secretariat, measured at the end of the program and monitoring cycle. From Y+3 reported every second year.

Target 005: 15 number of solutions demonstrated by 2030.

006 (Air) To develop and demonstrate solutions to cut coastal and inland pollution to air from inland waterway transport and maritime shipping by at least 50% by 2030, compared to current levels.

006 Number of solutions demonstrated contributing to cutting coastal and inland pollution to air from inland waterway transport and maritime shipping by at least 50% by 2030.

Projects, INEA, Partnership secretariat, measured at the end of the program and monitoring cycle. From Y+3 reported every second year


Target 006: 25 solutions demonstrated by 2030.

007 (water) To develop and demonstrate solutions to eliminate pollution to water (including harmful underwater noise) from ships, by 2030.

Number of projects demonstrating solutions to eliminate pollution to water (including harmful underwater noise) from ships

Projects, INEA, Partnership secretariat, measured at the end of the program and monitoring cycle From Y+3 reported every second year.

Target: 5 number of projects

The background of the slide features a photograph of a large yellow ship docked at a pier, with several blue and red shipping containers stacked in the foreground. A large, white, abstract, organic-shaped cutout is positioned on the right side of the image, revealing a different scene of industrial structures and more containers behind it. The entire image has a warm, golden-yellow color cast.

PART 4: GOVERNANCE

Description of the governance of the Partnership

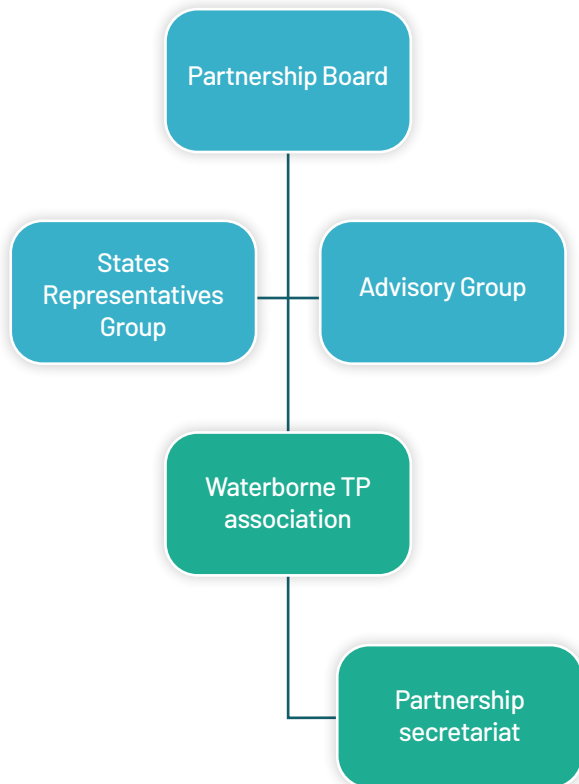
The Partnership will be concluded between the European Commission and the Waterborne TP Association (hereinafter referred to as Partners), representing the entire waterborne transport community. The Waterborne TP is established as an Association under Belgian law with the role of representing its members with regards to RD&I strategies defined within its statutes. It is a membership-based organisation; it is open to newcomers, on the basis of a paid subscription (€3,000 annually as of 2020). Other parties can also participate as observers at no cost, subject to board approval; these may include civil society organisations and representatives of national administrations.

Partnership Board

The Partnership will be governed by a Partnership Board. This board will steer the Partnership towards achieving its SRIA, supervise the process of interaction with industry and Member States, approve the research programme as set out in the SRIA and the specific topics to be addressed in Horizon Europe calls. The actual decision on the calls to be published is taken following comitology procedure.

The Partnership Board will consist of representatives of the European Commission Services, together with representatives of the Partnership. The European Commission will co-chair and may include several participants, such as from DG RTD, DG MOVE, DG CLIMA, DG GROW and DG ENV, and potentially other DGs as necessary. The Partnership's representatives will be approximately 15 high-level representatives of the stakeholders in the transition to zero-emission waterborne transport. The Waterborne TP representatives will be proposed by the association following a vote in its General Assembly and be appointed by the European Commission. Participation in the Partnership Board from the industry side will be on a rotating basis, every second year.

The Partnership Board will lay down its Rules of Procedure, based on a harmonised proposal provided by the European Commission, covering inter alia rules on confidentiality, transparency and avoidance of conflicts of interests.



States Representatives Group

EU Member States and Associated Countries will be involved in the Partnership through the States Representatives Group. All Member States and associated countries are invited to participate. The aim is to ensure a two-way information flow between the updates of the SRIA and research proposals from industry and national priorities, policies and programmes. This is seen as a crucial step in the priority-setting process and will facilitate discussions in the Transport Programme Committee. In addition, it will facilitate the take-up of results and the development of necessary policies and regulations.

Partners will agree on the composition of the Advisory Committee. The Partnership Board convenes both the meetings of the Advisory Committee as well as the States Representatives Group and endorses their membership.

Advisory committee members from the waterborne transport sector and research community, shall be members of the Partnership; those members from missing categories such as NGOs and public bodies are not required to be also Partnership members.

The advisory committee chair will be selected from the relevant bodies of the Partnership.

Advisory Committee

In addition, the Partners will form an Advisory Committee. The members of the Advisory Committee will reflect a balanced representation of experts and stakeholders from across Europe within the scope of the priorities of the Partnership, representing academia, industry and SMEs as well as end-users, non-governmental and civil society organisations, stakeholder associations and regulatory bodies. It will include representatives of the existing relevant bodies of the Waterborne TP and whilst operational the chair of the Steerer CSA Green Shipping Expert Group. The Advisory Committee will advise on the priorities to be addressed, in line with the SRIA and the Horizon Europe strategic planning, and suggest, in view of the progress of the Partnership or wider developments corrective measures or re-orientations to the Partnership Board, where necessary. The

Secretariat

The Partnership will be assisted by a Secretariat which will be provided by the Waterborne TP association. The private side of the Partnership will be organised within the Waterborne TP association. Within the Partnership's working groups, members of the Partnership will discuss the technical requirements and research progress for the Partnership. Representatives of EU Member States, Association Countries and European Commission services will be invited to participate in the technical meetings of the working groups.

Managing crosscutting issues

The research requirements and associated research activities for the Partnership are a subset of the activities of the existing Waterborne TP association. There is a close link between topics in the Partnership's research agenda and topics that, although outside the scope of the Partnership, are addressed by collaborative research activities of Horizon Europe. Examples of cross cutting issues include digitalization for greening within the Partnership vs digitalization for safety, or fire/explosion/toxity risks and passenger safety on vessels in general and the safety associated with using new sustainable alternative fuels and the required ship layouts which would be covered within the Partnership. In addition, to address the synergies described below, ensuring the coordination of needs and activities linked to these issues is important and will be ensured by the Waterborne TP Coordination Group and Board.

Dissemination and Horizon scanning

Furthermore, the Waterborne TP will organise activities to maintain an overview of ongoing relevant research and developments in the waterborne sector and more broadly. It will also ensure the appropriate communication and dissemination of the findings of the results of the Partnership as well as ensuring high visibility of the Partnership and its activities. For example, this might be undertaken through brochures, maintaining a website, social media activities and organising events. Such activities will also be coordinated together with the activities of the "Lasting" CSA and the related dissemination activities of the European Commission.

The Partnership will establish a visual identity to stimulate participation in its activities by organising conferences, workshops, social media accounts e.g. Twitter, newsletters and press releases. As the main European branch organisations will be taking part in the Partnership, the broader waterborne transport community will be informed through them, thereby ensuring an appropriate level of visibility for the Partnership, including its visual identity.

Openness and transparency

The waterborne transport sector is, by its very nature, a highly diversified sector and an objective of the Partnership is to bring together the sector's diverse activities and focus efforts more efficiently on zero-emission waterborne transport. As a consequence of this diversity, the Partnership will have a broad composition and will be open to new members. From the beginning, the Partnership will include all members of the Waterborne TP which, in turn, includes relevant European associations representing, for example, ship owners and operators, as well as industrial representatives within the maritime and inland navigation sectors. Furthermore, leading companies from all stakeholders will sign the Partnership agreement.

As the Partnership is for co-programming, participation in calls for proposals is open to all by definition.

Participation

Stakeholders in the waterborne transport sector and in zero-emission transport can participate in the Partnership in two ways:

- Associations, companies, academia and research institutes can join the Waterborne TP Association. There is a low annual membership fee for this association (3,000 EUR for 2020) which allows as broad a participation in the association as possible. Benefits of being a member of the Waterborne TP Association include:
 - Direct involvement in in-depth discussions on all technical issues;
 - Participation in other relevant waterborne issues, such as safety of ships, digitization and automation, production processes, Blue Growth and logistics;
 - Automatic membership of the Partnership;
 - Networking and collaboration;
 - Direct access to the additional activities performed by the Partnership related to establishing synergies with relevant initiatives/programmes as well as information on applicable financial instruments.
- Non-members can participate in events organised by the Partnership and/or the Waterborne TP Association. Events may include conferences to present the latest RD&I results or open discussions on the technical research agenda.

Governmental and non-governmental organisations can join the Partnership at all levels as observers, without having to pay a fee. Observers will be invited to strategic and detailed programming workshops.

It is understood that many stakeholders in the waterborne transport sector are small companies and travel to and from Brussels may hinder their on site participation in the Partnership, and physical meetings with direct interaction with European Commission Services and Member State representatives which usual takes place in Brussels. Consequently, the Partnership will facilitate remote access and tele presence for most events as well as organising outreach events towards remoter maritime and inland navigation regions (such as Bulgaria, Romania, Ireland) to allow a balanced participation from all Member States.

Furthermore, meetings of the Partnership will be live-streamed and live feedback to the participants in the meeting will be possible. In addition, a number of Associations involved in the Partnership represent a broad base of SMEs. These SMEs will be involved via discussions in their relevant associations, online consultations and national outreach events and will be able to represent their umbrella organisations during meetings.

Access to information

The Partnership will launch a dedicated website which will give an overview of its research agenda and of ongoing and finished projects. For finished projects, the website will detail the main results and deliverables for everyone to use. The website will also offer the possibility to provide feedback on the Strategic Research and Innovation Agenda and the rolling detailed activity plans through surveys and will show what feedback has (or has not) been taken up and why.

The Partnership will undertake actions that will increase the impact of its activities and the supported RD&I, including ensuring broad awareness within key bodies such as IMO and relevant Commission expert groups, like the European Sustainable Shipping Forum.

Recruitment policy

The Partnership will actively recruit new participation by analysing the evolving waterborne transport stakeholders and the representation of relevant sectors. We will invite new members or industrial sectors through our European and national branch organisations. The Partnership will also be open to direct expressions of interest and, in this respect, membership will only be rejected for exceptional reasons, such as lack of European added value or applications from non-European competitors.

Update of the SRIA

For the update of the SRIA and the input to multi-annual calls, we envisage applying an open, but manageable, process.

- 1) The Partnership will undertake a **broad assessment of the current state-of-the-art** and challenges for the different ship types and services. On this basis, an SRIA will be developed for 7 years, addressing the main **objectives and activities**. **Each year**, the SRIA will be updated taking into consideration the results achieved (within or outside the Partnership), the technological developments available in the market and the immediate priorities of the sector;
- 2) The Partnership will create and maintain an overview of **ongoing projects and research outcomes (including policy recommendations)**. This overview will not be limited to EU funded research, but through its members and its contact with the Member States, the Partnership will acquire information on relevant national or industrial projects, as well as assess reports within the wider press and journals. A summary of this overview and the main trends will be published each year;
- 3) The Partnership will continuously liaise with relevant bodies and working groups and integrate the work being done in the framework of the Strategic Research Agenda for inland waterways

and ports³⁵. Following the execution of research projects, the policy recommendations will be discussed during dedicated meetings with EU Member States and Associated Countries (see governance) and/or during the relevant meetings of the bodies and working groups identified;

4) The Partnership will organise conferences on a yearly basis to present the research outcomes as mentioned above and to discuss necessary updates to the SRIA. These conferences will target dedicated audiences, such as European Commission Services, MEPs, Representatives of EU Member States and Associated Countries, as well as representatives of the waterborne transport sector;

5) The proposed updates to the SRIA for the Partnership will be put forward in an **open consultation** through the Partnership's website. Discussions on the topics will be facilitated on this website. **EU Member States, Associated Countries, NGOs and civil-society organisations** will be invited to participate in the discussions and to encourage their local stakeholders to participate in the consultation;

6) On the basis of the SRIA, and taking into account emerging developments, **each year experts** from the Partnership's members will evaluate the portfolio of activities, taking into account the most recent developments and consultations for new RD&I topics, as well as types of research (e.g. TRL levels may need to be revised), actions needed to facilitate

deployment, actions concerning dissemination and communication etc., in order to ensure the maximum impact of results. Following this update, the portfolio of activities for the following two years will be drawn up in order to ensure the maximum impact of results. These proposed actions will be discussed with the European Commission Services, representatives of EU Member States and Associated Countries.

The EU Member States, Associated Countries and the European Commission will be involved throughout this process. This ensures avoiding unnecessary duplication and enables synergies between national programmes, policy developments and Horizon Europe.

Cooperation with Member States and Countries Associated to Horizon Europe

In order to align the developments of the Partnership with relevant national (sectoral) policies, programmes and activities, close cooperation with EU Member States and Associated Countries will be established from the start of the Partnership. For inland waterway transport, close cooperation will be established with the River Commissions which play an important role in coordination with their Member States on technical and legislative matters for inland navigation. There are a number of areas of attention which are of importance to streamline the Partnership's developments with relevant policy developments, as well as research initiatives:

- Create synergies between the Partnership and national **research and implementation** strategies and programmes and vice versa, which will be discussed in the States Representatives Group;
- Coordinate between the Partnership (including research outcomes) and regulatory actions at regional, national and international level.

For this reason, the Member States and Associated Countries will be involved in the governance of the Partnership through the States Representative Group and through observer status in the Waterborne TP association.

Synergies with other Partnerships

In preparation for the Partnership, the Waterborne TP will **nominate interlocutors** who will act on behalf of the Partnership to liaise on the developments of the Partnership with other relevant initiatives in order to **avoid duplication of efforts**, as well as to discuss **necessary prioritization**. Finally, the **representatives of the Partnerships, Missions, Technology Platforms and other relevant initiatives** will be invited to attend meetings with the Waterborne TP on a regular basis to discuss the **issues at stake**, the creation of **possible synergies**, to **develop joint work plans** and **common calls** (where possible) and any other issues relevant to the execution of the tasks of the Partnership.



Synergies with other Partnerships foreseen include:

- **“Towards a competitive European industrial battery value chain for stationary and mobile applications”,** which addresses battery development, with automotive as the largest target and biggest market. The Batteries Partnership will also address development for other markets, including for waterborne transport. In this respect, **it focusses on specialist battery technology, material and manufacturing,** including battery safety, whilst the Zero-emission waterborne transport Partnership will address **integration of a battery within the ship systems and enable pre-deployment in maritime and inland applications** (addressing, for example, charging infrastructure, certification process, etc.). This is reflected in the proposal for Batteries and cooperation between the two Partnerships will be maintained to ensure relevance and to generate synergies;
- **“Clean Hydrogen”** Partnership focuses on **green hydrogen fuel production, storage and supply, as demand side technologies and the development of high-power fuel cells.** The Waterborne Partnership will address **technology integration, implementation and validation, for both maritime and inland shipping.** This includes safety of **bunkering and integration of onboard storage of non-hydrogen alternative fuels.**

The “Clean Hydrogen” Partnership will ensure close coordination with a view to exploit the role hydrogen can have as a candidate fuel towards the achievement of zero-emission waterborne transport. The Partnership will focus on onboard technology and on board standards, whilst CHE will focus on onshore and important technology building blocks such as multi MW fuel cells for ship propulsion and the related fuel technology. Whilst one or the other Partnership will lead on these linked activities, there are inevitably grey areas where close cooperation will be undertaken to ensure complementarity and to enable the possibility of developing linked actions. An example of information sharing is Partnerships projects linked to hydrogen may be asked to contribute non confidential project data within a hydrogen projects data base;

- Connected, Cooperative and Automated Mobility Partnership **“CCAM”,** addresses mobility and safety for automated road transport. CCAM also mentions potential interfaces with other transport modes. In this context, within a zero-emission waterborne transport Partnership, **any efficiency improvements achieved through automated shipping and maritime/river traffic management** may be leveraged through synergies with CCAM for the efficiency of the wider multimodal mobility system as a whole;

- **“A climate neutral, sustainable and productive Blue Economy”** is focused upon resilient marine ecosystems and marine resources, contributing to the realisation of a sustainable economy for

maritime and inland waters. Waterborne transport is one of several influencers on the marine environment and, in this respect, cooperation between the Partnerships will be ensured. It is noted, however, that the ‘Blue Economy’ Partnership is not expected, as such, to develop the solutions enabling zero-emission waterborne transport itself (e.g. new technologies, fuels, or any relevant bunkering infrastructure).

- **“Made in Europe”,** which will be the driving force for sustainable manufacturing in Europe. It will contribute to a competitive and resilient manufacturing industry in Europe and affects many value chains. Another priority is circular economy and following a circular by design approach. The Partnership will serve as a platform for aligning national and regional manufacturing technology initiatives. Synergies and cooperation with this Partnership are essential to ensure the alignment of the production process in the context of the ZEWT Partnership, in order to be able to reach its objectives.

In the area of logistics, Waterborne TP will remain its strong link with the ALICE TP.

To maximise synergies and impact, memorandums of understanding will be established with all of the above linked Partnerships and regular meetings will be held to share information, identify complementarities and potential linked actions which could maximize leverage from the EU's investment ³⁶.

Links with missions

- The Mission on Healthy Oceans, Seas, Coastal and Inland Waters. The mission's focus is yet to be fully developed. Although the main focus of the mission is not on the greening of transport, our targets for the reduction of water pollution, including underwater radiated noise, contribute to a healthier ocean;

- The Mission on Climate Neutral and Smart Cities. The mission's focus is yet to be fully developed. Although the main focus of the mission is not centred on greening of transport, our targets for reduction of harmful air pollution will contribute to a clean living environment in port cities and their surroundings;

-The Mission on Adaptation to Climate Change including Societal Transformation. The focus for this mission is also yet to be fully developed. Although the mission will not focus on greening of (waterborne) transport, it may have influence on shipping through the protection of port cities from rising sea levels. The results of both the Partnership, as well as the Mission, might cross-fertilize each other.

Communications with these missions will be maintained so as to ensure complementarities between the programs as well as flagging any potential overlaps. As the scope becomes clearer, cooperation agreements will be made, to ensure clarity with respect to the linked activities.

Synergies with other EU financial instruments

A number of European programmes have synergies with the implementation of the technologies developed in the framework of the Partnership, notably:

- Innovation Fund (DG CLIMA): The Innovation Fund focuses on: 1) innovative low-carbon technologies and processes in energy intensive industries, including products substituting carbon intensive products; 2) carbon capture and utilisation (CCU); 3) construction and operation of carbon capture and storage (CCS); 4) Innovative renewable energy generation; 5) Energy storage. This fund is essential to support the implementation of solutions developed by the Partnership;

- Modernisation Fund (DG CLIMA): support for modernisation of energy systems and transition in 10 beneficiary Member States. This fund is essential to support the implementation of solutions developed by the Partnership;

- Connecting Europe Facility – Transport (DG MOVE): which supports the roll-out of innovation in the transport system in order to improve the use of infrastructure, reduce the environmental impact of transport, enhance energy efficiency and increase safety;

- Connecting Europe Facility Transport Blending Facility (European Commission and EIB): It is currently envisaged that, via **InvestEU**, the CEF Transport Blending Facility will co-finance greening of maritime and inland waterway transport fleets in the period 2021 - 2027;

- European Fund for Regional Development (DG REGIO): The current ERDF focuses its investments on several key priority areas. This is known as 'thematic concentration'. This fund is essential to support RD&I in line with the Partnership at the regional/national level.

- **LIFE** (DG ENV): the LIFE Programme has four objectives:

- Help the move towards a resource-efficient, low carbon and climate resilient economy, improve the quality of the environment and halt and reverse biodiversity loss;
- Improve the development, implementation and enforcement of EU environmental and climate policy and legislation, and act as a catalyst for, and promote, the mainstreaming of environmental and climate objectives into other policies and practices;
- Support better environmental and climate governance at all levels, including better involvement of civil society, NGOs and local actors;
- Support the implementation of the 7th environmental action plan.

Through close interaction with the European Commission Services, as well as the EU Member States, the Partnership will discuss the possible alignment of its activities with other relevant EU financial instruments.

This is expected to take place within the context of an annual coordination meeting held with each of the linked programmes.

International cooperation

To support identification of the most important knowledge, regulatory, standardisation and technological gaps, the Partnership will monitor the discussions and developments of international organisations such as the IMO (in particular its Marine Environment Protection Committee), HELCOM, OSPAR etc. In addition, the Partnership will follow the process of establishment of the International Maritime Research and Development Board (IMRB), as recently proposed in the context of the IMO, with a view to avoiding duplication of effort and to stimulate the development of necessary rules and regulations.

The members of the Partnership will also actively participate within and present the results of the Partnership and projects supported to the European Sustainable Shipping Forum (ESSF). Although, the ESSF is a Commission Expert Group, which provides advice to the Commission and the Member States on matters related to sustainability of shipping, these activities are important with respect to the formulation of the EU and Member States contribution to the discussion at the IMO level.

The Partnership will also establish links with governing bodies in Inland Waterway Transport, in particular the Central Commission for the Navigation on the Rhine, the Danube Commission and, if relevant, other river commissions as well as UNECE. In this context, the study regarding financing of the energy transition in inland waterway transport as currently conducted by the CCNR is an important initiative to explore synergies with.

Cooperation with regions will also be pursued. The international nature of the waterborne transport sector requires cooperation with other non-EU research-oriented countries and flag states as well. Of course, cooperation is subject to requirements on IPR protection, as well as the fair processing of investments and public procurement.

NOTES

¹https://ec.europa.eu/commission/presscorner/detail/en/ip_19_6691

²<https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0773&from=EN>

³<http://www.imo.org/en/MediaCentre/PressBriefings/Pages/06GHGinitialstrategy.aspx>

⁴https://www.ccr-zkr.org/files/documents/dmannheim/Mannheimer_Erklaerung_en.pdf

⁵COM(2013) 918 final 'Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - a Clean Air Programme for Europe'

⁶<https://www.ipcc.ch/sr15/>

⁷<https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement>

⁸https://ec.europa.eu/clima/news/commission-publishes-information-co2-emissions-maritime-transport_en

⁹Source PROMINENT Deliverable D6.3&D6.5

¹⁰CE Delft, Update of Maritime Greenhouse Gas Emission Projections, 2019

¹¹<https://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-air-pollutants-8/transport-emissions-of-air-pollutants-8>

¹²<https://www.eea.europa.eu/highlights/cutting-air-pollution-in-europe>

¹³https://www.iiasa.ac.at/web/home/research/researchPrograms/air/Shipping_emissions_reductions_main.pdf

¹⁴https://iiasa.ac.at/web/home/research/researchPrograms/air/Shipping_emissions_reductions_main.pdf

¹⁵https://www.iiasa.ac.at/web/home/research/researchPrograms/air/Shipping_emissions_reductions_main.pdf

¹⁶<https://worldmaritimenews.com/archives/205936/imo-designates-north-sea-baltic-sea-as-neca/>

¹⁷The contracting parties to the Barcelona Convention agreed in December 2019 to finalise a joint and coordinated proposal to the IMO in 2022 requesting the possible designation of an ECA for sulphur oxides in the Mediterranean Sea. <http://web.unep.org/unepmap/barcelona-convention-cop21-naples-2-5-december-2019>

¹⁸<https://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=9732>

¹⁹https://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy-framework-directive/index_en.htm

²⁰https://www.researchgate.net/publication/271179593_Marine_Fouling_An_Overview

²¹<https://inland-navigation-market.org/>

²²http://www.waterborne.eu/media/35860/190121-waterborne_sra_web_final.pdf

²³<https://www.maersk.com/news/2018/12/04/maersk-sets-net-zero-co2-emission-target-by-2050>

²⁴<http://www.inlandnavigation.eu/media/92406/Future-proof-shipping-presentation-191016.pdf>

²⁵<https://www.ecsa.eu/news/european-shipping-industry-welcomes-european-green-deal>

²⁶<https://worldmaritimenews.com/archives/290006/cmb-to-operate-zero-emission-fleet-by-2050/>

²⁷SEA Europe, White Paper, Maritime Technology in Europe: A Strategic Solution Provider for Major Societal Challenges, 2019

²⁸<http://www.seaeurope.eu/>

²⁹https://ec.europa.eu/epsc/sites/epsc/files/epsc_clean-transport-at-sea.pdf

³⁰Wherever Alternative Fuels are mentioned in the following (e.g. charts, etc.), please note that reference is made to the use of **Sustainable Alternative Fuels**.

³¹Including National Maritime and Inland waterways Authorities

³² The “system-in-the-loop” approach (modern evolution of “hardware-in-the-loop”), meaning the feedback backward to design processes and the feedback forward to future operational conditions by means of a virtual framework coupled with the physical system.

³³ Average annual value for the period 2010-2014 acc. BALance Analytics for “Study on New Trends in Globalization in Shipbuilding and Marine Supplies”, Study for EU COM 2017

³⁴ Average annual value for the period 2012-2016 acc. BALance Analytics and “European Shipbuilding Supply Chain Statistics”, Study for SeaEurope 2019

³⁵ <http://www.inlandnavigation.eu/news/policy/towards-a-strategic-research-agenda-for-inland-waterways-transport/>

³⁶ As of February 2021 an MoU has been concluded with Hydrogen Europe and Hydrogen Europe Research, the remaining are expected to be concluded over the course of 2021.



WATERBORNE

WATERBORNE TP
Rue de la Loi, 67 (4th floor)
B-1000, Belgium

+32 2 230 2791
info@waterborne.eu
www.waterborne.eu

