Work package number [9]	WP5	Lead beneficiary [10]	11 - ZCS
Work package title	Maritime and Inland Waterway Transport		
Start month	1	End month	53

Objectives

This work package will demonstrate several maritime technologies in the Port of Rotterdam, proving the feasibility and confirming the effectiveness of the design, procedures, safety measures and systems developed to facilitate the practical execution. Four demonstrations (demo 4, 5, 6 & 7) will be deployed to test a series of zero carbon energy technologies, providing both increased insight into the technical and commercial viability as well as input for the impact evaluation and roll-out in work packages 8 and 9.
Demo 4consists of a demonstration of ammonia bunkering, making use of a retrofitted / equipped inland ammonia barge and an ammonia powered vessel as the receiver. This demo will also include a concept design of a scalable green ammonia storage terminal with cracking capabilities.
Demo 5 consists of a refuelling buoy demonstration, allowing for offshore single point mooring and refuelling for ammonia/HV electrical power supply. This will be demonstrated in a model basin mimicking the North Sea extreme environments and at full-scale at the offshore anchorage area of the Port of Rotterdam.
Demo 6 consists of an Autonomous shipping demonstration at model and pilot scale, to prove the feasibility and safety of intra-port container transhipment using an autonomous barge, while integrating the process into actual container-terminal operations. The vessel will be used on designated routes, with autonomous mooring/unmooring/loading/unloading demonstrated in an actual port-setting, to develop a complete fully integrated and automated logistical process. Importantly, safe autonomous-navigation of the vessel will depend on prior successful demonstrations of key digital tools (specifically, the digital twin in WP 4). This same vessel will also be used in demo 7.
Demo 7 will show the application of containerised li-ion batteries and gaseous hydrogen at low pressure (300 bar) in real life port operations. The demonstration will further test shore-based infrastructure for handling the energy container as is used for normal containers, as well as a concept design of a swapping station. This demo will work in conjunction with the RH2INE project, wherefore demand, safety framework and design studies are conducted for hydrogen propelled Inland Waterway Transport.
The demos will draw on and feed back into the supply chain analysis performed under WP3 and the digital tools from WP4. The monitoring requirements and KPIs for the demonstration and roll-out plan will be aligned and agreed with WP8 and the outputs shared with WP9 for the Master Plan.

Description of work and role of partners

WP5 - Maritime and Inland Waterway Transport [Months: 1-53]
ZCS, POR, HARPOR, DeltaPort, APS, S.A., TNO, EUR, TU Delft, SPB, MARIN, ZES, PROTON, NMTF, Chemgas, VOM, BES, Van Oord, WTI
Task 5.1: Demo 4: Ammonia bunkering (M1 – M47) [ZCS (PM), TNO, CHEM, VOM, PV, TUD, POR]
Subtask 5.1.1 Safety and operational procedures for bunkering scenarios Description of ammonia bunkering scenarios addressing the different fuel tank types, primary ship types (container, bulk, tanker, passenger, offshore/ special purpose) and simultaneous operations scenarios. Lead by ZCS and supported by CHEM, VOM, PV and POR. Input will be taken from WP3 regarding the ammonia supply chain requirements. A standard QRA for ammonia ship-to-shp (STS) bunkering and an additional assessment and risk mitigation plan for identified key risk scenarios. Lead by TNO with support from VOM, ZCS (and third parties APMM and ABS), POR and CHEM. Operational procedures for STS ammonia bunkering addressing the primary ship types and bunkering scenarios. A gap analysis of the rules, procedures and regulations required for ammonia bunkering in the EU. Lead by ZCS (and third parties APMM and ABS) with input from CHEM and the POR. Actions will be shared with WP7 and WP9.
Subtask 5.1.2 Retrofitting / equipping of the ammonia bunker barge and STS bunkering demonstration A general requirement specification for an ammonia bunkering vessel and a specific requirement specification for the retrofit / equipping of the selected inland ammonia barge. Retrofitting / equipping of the barge based on the specific specification. ZCS will create the specifications and any design package. CHEM will provide the barge and equipment. TUD, PV and POR will support with input and needs analysis. WP3 analysis will support the design scoping. Demonstration of STS ammonia bunkering in Rotterdam between the ammonia bunker barge and an ammonia powered vessel provided by APMM as the receiver. The receiver will be found from one of the first ammonia powered vessel demos and a letter of support to participate is included in this application. ZCS will align with WP8 on the test program and demo KPIs and coordinate with WP10 on the receiver. The results will be shared with WP3 and WP9.

Subtask 5.1.3 Concept design and scaling of an innovative green ammonia storage terminal Concept design for a scalable green ammonia storage terminal with an ammonia cracking facility to produce hydrogen. The scalability and optimisation of the terminal will be analysed for Rotterdam and the fellow ports as part of the roll-out of ammonia as an energy carrier. A basic safety assessment will be done along with an assessment of the permit application process and stakeholders. Demand scenarios from WP3 will be used by TUD to evaluate the terminal design / logistic requirements. PV will lead the concept design with support by TNO, POR and ZCS.

Task 5.2: Demo 5: Offshore charging buoy (M1- M24) [BES (PM), MARIN, VOO, POR)
Subtask 5.2.1 Buoy demonstration and feasibility study: Design and numerical evaluation for an electrical refuelling buoy in the range of 1-20+MW. The demonstration is based on two test cases: one application at the anchorage for large vessels and the other for charging small O&M vessels in an offshore environment. First the test cases are demonstrated in a model basin to mimic realistic North Sea extreme environments. Software–in-the-loop is used to allow large scale models for the buoy. Results are validated with CFD simulations, as basis for the full-scale demonstration focussed on the mechanical integrity of a buoy for O&M vessels during period of 3-4 months offshore Rotterdam. In this period several marine operations will be executed in different sea states using a crew transfer vessel (or equivalent). Feasibility assessments are made on the technical and commercial viability of the buoy designs. The lessons learned from the demonstrations are used to review the operability of the buoy designs and to serve as basis for standards. Lead & design by BES, support by MARIN, installation/operation by VOO. Input on the electrical and ammonia supply chains will come from WP3.
Subtask 5.2.2 Business case report and roadmap to offshore recharging: The business case study defines the commercial viability and requirements of recharging buoys using energy demand scenario analysis from WP3. Input of CAPEX/ OPEX calculations are based on the experiences gained from the demos. The roadmap provides an overview of the remaining technical and non-technical challenges for the different stakeholders such as future owners, EPCI operators, vessel operators, governmental organisations and regulators. Lead by BES, support by VOO and POR. The output will be shared with WP8 and WP9.

Task 5.3 Demo 6: Autonomous e-barge and transhipment (M6-M51) [POR (PM), WAR, ZES, TUD, EUR, KRA]
Subtask 5.3.1 Design of collaborative planning and execution concept for inter-terminal barge operations: Develop collaborative planning and execution concepts, including centralised/decentralised communication protocol, to coordinate terminal approach, kiss-and-ride transhipment design, terminal operations, and in-port VTS communication. EUR will lead supported by TUD, KRA, POR and WAR.
Subtask 5.3.2 Algorithm development for autonomous docking, collision avoidance and risk prediction methods: Design and simulation-based assessment, allowing mooring/unmooring in the kiss-and-ride concept under realistic conditions such as unforeseen events, weather conditions, presence of other waterway traffic, etc. TUD will lead this task with input from WAR and PoR. Align with digital tools WP4.
Subtask 5.3.3 Demonstrating autonomous barge transhipment and autonomous barge fleet operations: model-scale: Assessment of proposed algorithms of Task 5.3.2 using vessel-models in controlled lab environments of the Researchlab Autonomous Shipping. Lead by TUD with supporting input from WAR and PoR.
Subtask 5.3.4 Demonstrating autonomous inter terminal barge concept: pilot-scale: Pilot for demonstrator execution for the Kiss-and-Ride including: pilot-project planning together with terminal, integration of barge systems into terminal systems, data acquisition and analyses, functionality testing of all blocks in the concept (equipment, hardware, communication, etc.). Demonstration of the concept by transporting containers between port location (on pre-designated routes varying between 0.5 and 30km in distance). The design of experiment will ensure successful execution and repeatability of the demonstrator, leading to validation of the concept. Lead by WAR with input from POR, KRA, TUD. Output will feed into WP8.
Subtask 5.3.5. Autonomous transhipment roll-out report: Impact evaluation and roll-out report of autonomous inter-terminal barge concept detailing specific impact on terminals, port operations and waterways. Lead EUR, support by TUD, POR and fellow ports. Key impacts shared with WP8 and outputs fed into WP9.

Task 5.4 Demo 7: Green Energy Container (M6-M53) [SPB (PM), WAR, TUD, POR, EUR]
Subtask 5.4.1 Green Energy Container demonstration: Analysis of the main tasks, KPI's, rules procedures and regulations for hydrogen sailing and swapping, resulting in a design specification for the vessel and demonstration. Led by SPB, supported by WAR, TUD and POR. Subcontracting and acquisition for: (a) vessel in conjunction with demo 6, , (b) logistic services providers (e.g. Danser, ProLog, HTS), (c) hydrogen containers (gaseous 350 bar/green H2 for 3 months, e.g. Air Liquide, Air Products), (d) terminal operator city and deep sea terminal (e.g Waalhaven Group; Kramer Group), (e) electricity charging (e.g. S4Energy) UWT, (f) hydrogen supply (e.g. , Air Liquide, Air Products and (g) fuel cell suppliers/system integrators (e.g. Nedstack/Koedood). Lead by POR, supported by WAR, TUD and SPB. Refitting ship and setting up swapping/charging and fuelling arrangements with terminal operators (linked to demo 6). Lead by WAR, support by POR, SPB, TUD. Running the pilot, demonstrating the capabilities of li-ion

batteries and hydrogen at low pressure, including safety assessments, technical requirements, technical standardisation and digitalization requirements for the new logistic supply chains and to implement a certification process for green H2 (linked to WP7). ZES will supply the required battery container for 6 months. The usage will be coordinated with container rental in WP 3 top optimise container usage. The demo will demonstrate the interoperability of both energy sources. Output in the form of a performance dashboard. Lead by ZES.
Task 5.4.2 Rollout plan for green containers: Overview of logistics requirements, monitoring requirements and KPI's for green container handling in Port of Rotterdam. Led by TUD, input by other demo partners. Hydrogen supply input will be taken from WP3 and aligned with Demo 4 concept terminal design. Basic safety assessments for container handling and analysis of the technical requirements to swap containers. Conducted by SPB with input from demo partners on the safety and technical aspects for the terminal, bunkering vessel and port. Assess and validate results and potential by project team fellow inland port (Deltaport). The key measurements and impact will be aligned with WP8 for monitoring and evaluation. Assessment of the operations, permits and stakeholder management required to gain the approvals required in the POR. Also, process variations for the fellow ports will be assessed as part of the upscaling plan. This will be performed by TUD with support from the partners and input from the fellow ports where required. The key measurements and impact will be aligned with WP8 for monitoring and evaluation and outputs shared with WP9.

Participation per Partner

Partner number and short name	WP5 effort
1 - POR	45.00
2 - HARPOR	2.00
3 - DeltaPort	2.00
4 - APS, S.A.	2.00
5 - TNO	15.00
6 - EUR	38.00
7 - TU Delft	90.50
10 - SPB	4.50
11 - ZCS	38.00
13 - MARIN	31.40
14 - ZES	11.00
15 - PROTON	54.80
16 - NMTF	0.50
19 - Chemgas	2.15
28 - VOM	4.00
32 - BES	45.30
39 - Van Oord	4.70
43 - WTI	40.10
Total	430.95

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D5.1	Ammonia bunkering demonstration report	11 - ZCS	Report	Public	47
D5.2	Ammonia fuel roll-out plan	15 - PROTON	Report	Public	53
D5.3	Buoy demonstration and feasibility report 3	32 - BES	Report	Confidential, only for members of the consortium (including the Commission Services)	19
D5.4	Business case report and roll-out plan to offshore recharging	1 - POR	Report	Confidential, only for members of the consortium (including the Commission Services)	24
D5.5	Autonomous barge and transhipment evaluation report	7 - TU Delft	Report	Public	39
D5.6	Autonomous e-barge demonstration report	43 - WTI	Report	Public	49
D5.7	Port logistics impact report and roll-out plan	1 - POR	Report	Public	51
D5.8	Green Energy Container evaluation report	14 - ZES	Report	Confidential, only for members of the consortium (including the Commission Services)	47
D5.9	Roll-out plan for Green Energy Containers	7 - TU Delft	Report	Public	53

Description of deliverables

D5.1 Ammonia bunkering demonstration report (M47) [ZCS]
D5.2 Ammonia fuel roll-out plan (M53) [PV]
D5.3 Buoy demonstration and feasibility report (M14) [BES]
D5.4 Business case report and roll-out plan to offshore recharging (M17) [POR]
D5.5 Autonomous barge and transhipment evaluation report (M39) [TUD]
D5.6 Autonomous e-barge demonstration report (M49) [WAR]
D5.7 Port logistics impact report and roll-out plan (M51) [POR]
D5.8 Green Energy Container evaluation report (M50) [ZES]
D5.9 Roll-out plan for Green Energy Containers (M53) [TUD]

D5.1 : Ammonia bunkering demonstration report [47]

Report describing the approach, setup, execution and results of the ammonia bunkering demonstration.

D5.2 : Ammonia fuel roll-out plan [53]

Report describing the large scale roll-out potential of ammonia bunkering barges and ammonia as a fuel for maritime transport.

D5.3 : Buoy demonstration and feasibility report 3 [19]

Report studying the feasibility of an offshore electricity charging buoy demonstrator

D5.4 : Business case report and roll-out plan to offshore recharging [24]

Resport describing the business case and the large scale roll out potential of floating charging buoys for the port of Rotterdam, Fellow ports and other European ports considering the boundary conditions of these ports.

D5.5 : Autonomous barge and transhipment evaluation report [39]

Report describing the demonstration plan, execution, results and conclusions for the autonomous port barge and autonomous transshipment demonstration.

D5.6 : Autonomous e-barge demonstration report [49]

Reporting giving the demonstrator results for the autonomous e-barge.

D5.7 : Port logistics impact report and roll-out plan [51]

Report giving the large scale roll out potential of the autonomous in port barge and autonomous transshipment technologies demonstrated in MAGPIE.

D5.8 : Green Energy Container evaluation report [47]

Report describing the design, execution, results and conclusions of the green energy container demonstration

D5.9 : Roll-out plan for Green Energy Containers [53]

Report giving the large scale roll out plan for the green energy container for the port of Rotterdam, Fellow ports and other European ports.

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS13	Demo input to Master Plan	1 - POR	54	All demos have supplied (preliminary) conclusions on results with WP 9