



Portable Innovation Open Network for
Efficiency and Emissions Reduction Solutions

Deliverable 2.15:

PIONEERS' Best Practise Master Plan and Handbook

Disclaimer

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1 Your Roadmap

1.1 Introduction

The roadmap is a collection of initiatives that a port will implement to achieve the decarbonization goals set forth. They are a collection of niches that, after careful consideration through the port readiness assessment, are deemed to be the best-fitting solutions for the specific port environment.

A timeline is used to plan the initiative according to when they will be implemented in the port. This roadmap is constantly updated and challenged due to the nature of the initiatives that are constantly pressuring the port environment.

1.2 Best practise example: Roadmap development in the Port of Barcelona

The Port of Barcelona developed its roadmap to translate the Green Port Master Plan into a practical implementation framework for the transition towards a Smart Energy Hub. The roadmap establishes a structured pathway that aligns strategic objectives, investments and governance mechanisms over time. Intermediate milestones for 2025 and 2030 support a phased transition towards the long-term vision for 2040 while considering technology maturity, regulatory developments and investment capacity.

1.2.1 Roadmap methodology

The roadmap is organised around three structural axes that guide the energy transition: the shift from fossil to renewable energy sources, the reduction of energy carbon intensity, and improvements in energy and operational efficiency. Together, these axes provide the technical foundation for achieving the port's decarbonisation objectives.

Building on these structural axes, the roadmap defines six strategic objectives covering decarbonisation, sustainability, resilience, innovation, ecosystem integration and harmonious cohabitation. Each objective is implemented through one or more Development Lines that include a main milestone, programmes, expected results and a portfolio of prioritised actions scheduled across different implementation horizons. technological developments, regulatory changes and evolving strategic priorities. Figure 1 provides an example of how a Development Line is translated into concrete programmes, milestones and implementation targets.

To support implementation, the roadmap is complemented by a monitoring framework that assigns Key Performance Indicators (KPIs) to each strategic objective and Development Line. Annual monitoring enables progress to be tracked against defined targets, while a comprehensive review every five years ensures that the roadmap remains aligned with technological developments, regulatory changes and evolving strategic priorities.

ETODC-1	Emissions management
Active management of the emissions generated in the port is essential to move towards a more sustainable future. This means measuring emissions accurately, ensuring that the measurements are reliable, incorporating digital technologies and integrating them into decision-making.	
Main objective: 50%/85%/100% GHG emission reduction by 2030/2040/2050	
Programmes	Expected results
• Mainstreaming environmental sustainability • Digitalisation of consumption, emissions and calculations • Port energy management system • Low-emission certificate systems	• Sustainability guidelines integrated into decision-making processes • Platform to centralise energy and emission data • Port GHG emissions monitoring system • Adoption of certified low-emission electricity and natural gas (GO)

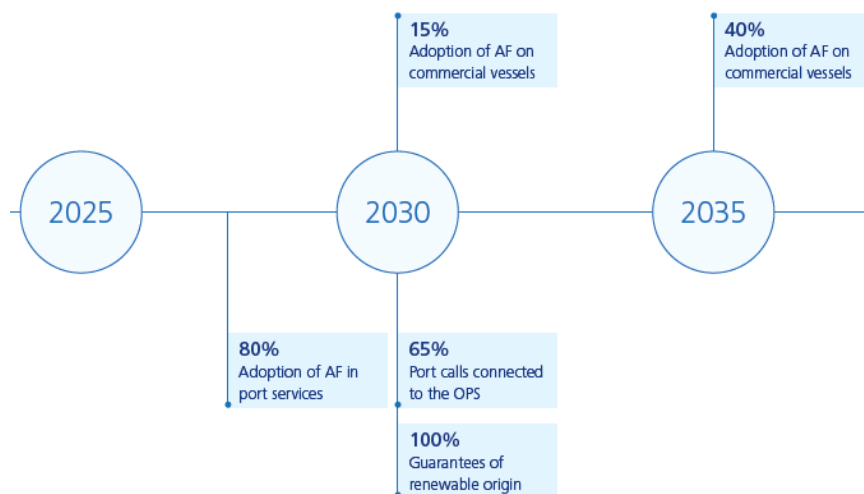


Figure 1: Example of a Development Line from the Port of Barcelona Roadmap

1.2.2 Prioritisation and implementation

Actions are prioritised using a multi-criteria assessment based on impact, implementation effort and implementation period. Additional factors such as greenhouse gas mitigation potential, technology readiness, investment requirements, stakeholder complexity and strategic alignment ensure that resources are allocated to actions with the greatest overall value. Implementation is phased across four planning horizons (2025, 2030, 2035 and 2040), allowing the roadmap to combine early actions with long-term investments.

1.2.3 Best practices

- Start with a clear strategic vision and translate it into a structured roadmap.
- Combine short-, medium- and long-term planning to balance immediate actions with long-term transformation.
- Apply transparent prioritisation criteria to support objective decision-making and resource allocation.
- Integrate monitoring through KPIs and regular roadmap reviews.
- Review the roadmap periodically to adapt to technological, regulatory and market changes.

1.3 Co-Transferability

What is it?

The co-transferability workstream of the PIONEERS project set in place a process to ‘...drive accelerated transfer and deployment of green port solutions amongst the PIONEERS ports, resulting in measurable progress and commitments during and beyond the project timeframe.’ By sharing the transferability framework and methods applied by the partners of the PIONEERS project, as well as the main lessons learned, we hope to inspire and inform future similar innovation transfer processes – whether these are implemented by similar multi-party consortia, or independently by port authorities.

Based on our experience, the transferability of green port technologies is dependent on a wide range of factors, and the different PIONEERS Work Packages for co-transferability (WP8), commercial exploitation (WP1) and impact assessment (WP9) methodologies approached this from different perspectives. The two main elements comprised:

- **Co-transferability process** –the main framework of transfer steps undertaken by the PIONEERS ports, to assess the *transfer potential* of multiple demos, and to define specific *transfer activities* to be undertaken during the project.
- **Port-related conditions and readiness** – a series of physical, infrastructural and organisational conditions that need to be in place for a transfer to succeed,

These different elements of the approach are explained further below, together with examples from the project, to support the design of future transfer approaches.

How to use it

The co-transferability process outlined below represents a simplified version of that applied by PIONEERS, taking into account lessons learned:



Figure 2: The Co-transferability process

Step 1: Identify transfer stakeholders – The relevant transfer organisation for some port technologies will be the port authority, but in many cases one or more additional stakeholders (such as terminal operators, inland waterway authorities and energy utilities etc.) will need to be convinced of the operational, commercial and environmental benefits etc. Others may play supporting roles for the implementation and subsequent operation (universities providing training and innovation services, logistic operators providing data, emergency services, etc.)

For the PIONEERS Container Handling Equipment demos, it was important to reach out to terminal operators at each port to understand their ambitions for electrification, hydrogen fuelling and automation of terminal operations.

Step 2: Screen transfer potential – Transfer screening involves the presentation of green port technologies to gain an initial understanding of whether: key port-related conditions are fulfilled; whether other related and

equivalent technologies are already planned or deployed; and an initial view on the environmental, social, operational and commercial value of transfer. A decision could be taken to focus on the most promising green port technologies at this stage.

For the PIONEERS Vessel Traffic Optimisation demo, conversations with Port of Constanta revealed that the scale and complexity of maritime vessel movements would not warrant implementation of a new system. Through discussions, it was learned that vessel congestion can occur where the Danube-Black Sea Canal enters the port. An adapted transfer pilot was therefore arranged in liaison with the inland waterway authority.

Step 3: Transfer scope and activities planning – Where good potential for technology transfer has been identified through the screening process, this step provides the basis for transfer implementation and involves a combination of:

- **Identifying technology components to be transferred** – technologies can be divided into different components and service levels, only some of which may be transferred. There may be value in transferring a data transfer process; a regulatory approach; or a specific technical component of a technology.

The hydrogen dual-fuelled straddle carrier tested at the Port of Antwerp-Bruges involves engine technology that could be used in other types of port equipment, and knowledge gained on the safe handling of hydrogen could also be shared. To provide another example, the electric propulsion of barges using modular battery container relies on a number of demo components being implemented simultaneously: retrofit/procurement of barges with electric motors; installation of charging stations at a network of ports; potential deployment of renewable energy generation.

- **Planning of transfer activities and timescales** – It is typically not possible to move immediately to implementation of a technology transfer, as it is necessary to work through the process of clarifying the business case, considering what the alternative options would be, and then undertake detailed design and procurement of the preferred solution. For this reason, PIONEERS defined transfer stages and activities based on the categories shown below,

Knowledge & Strategy Transfer Activities				Feasibility & Implementation Transfer Activities		
			Commitment to Transfer 			
Training & Knowledge Exchange	Data & surveys	Process & Options appraisal	Port policy, strategy & roadmap	Feasibility study	Technical design	Pilot or operational implementation

Figure 3: Transfer stages and transfer activities

To provide an example, transfer activities for the Modal Shift in the Commute of Port Employees have involved two knowledge exchange sessions involving all four ports, to build understanding of the demo aims and approach. Materials provided by Port of Antwerp-Bruges were used to undertake employer and employee mobility surveys at the Ports of Barcelona and Constanta, helping to inform options appraisal of the best sustainable mobility measures to pursue. Both ports have included sustainable mobility objectives and measures in their GPMPs, providing the basis for the design and implementation of mobility measures in the future, such as improved public transport links or creation of cycle lanes to and within the port area.

Step 4: Transfer implementation, monitoring and review – In many cases the transfer process is iterative, requiring completion of the knowledge exchange, research and options appraisal stages to help generate a clear picture of the technical solution required and define next steps. The timescales for working through the stages could vary from a few months (e.g. for a digital solution) to several years, if regulatory changes, feasibility

studies and/or complex procurement procedures are necessary. A process for monitoring progress and reviewing transfer aims on a regular basis is therefore recommended, to provide a series of decision-point gateways.

Within PIONEERS, the transfer process was divided into three main waves, originally with the intention that partners would focus on different demos at different times over a period of ~4 years.. During the project it became clear that related transfer activities would need to continue from one period to the next, and the wave structure allowed for monitoring of overall progress.

Port-related conditions and readiness

Drawing also on work undertaken in WPs1 and 9, it is recommended that the following factors are used to support screening of transfer potential (Stage 2) and definition of transfer scope, activities and timescales (Stage 3).

Port-related conditions & readiness		Demo examples
Physical factors	Some of the demo technologies require specific physical port characteristics to be in place, or to create sufficient value. Considerations include the scale and complexity of operations, geographic setting (e.g. tidal or deep water, space constraints), and natural resources (materials and renewable energy).	<i>Energy from water currents – this hydropower demo has been implemented at a tidal lock at the PoAB. A limited number of other ports have similar infrastructure, so opportunities with inland waterways were also explored.</i> <i>Green, circular concrete – the demo involves upcycling of find sands excavated on-site at PoAB for use in new quay walls. Many ports undertake land reclamation using dredged materials (rather than needing to excavate land to create port area), which represents a different form of material recycling.</i>
Operational factors	Presence of existing equivalent or related technical systems (requiring integration), Technical readiness of ports to implement technologies, including (where relevant): - availability of renewable energy and hydrogen supply networks. - status of enabling digital infrastructure (e.g. 5G network) and systems (e.g. Port Community System).	<i>Hydrogen heating and dual-fuelled straddle carriers – cost and availability of hydrogen is a major hurdle for the transfer of these demos. Some ports are positioning themselves as hydrogen import and storage hubs, while for others there are no detailed plans and timescales for making the fuel available.</i> <i>Vessel tracking using a camera network, 5G and artificial intelligence – the availability of a fibre optic or 5G network at a port is a necessary pre-condition for the transfer of this demo. PoC have plans to install a 5G network and introduce a Port Community System, which would provide the foundations for introducing further digital technologies.</i>
Organisational factors	Readiness of regulatory framework to enable technology implementation (e.g. in relation to automation). Capacity of port authority and/or other stakeholders to implement and operate technology (e.g. overall resource levels and completion of training) Commercial readiness and financial capacity of technology provider to expand to new Member States	<i>Autonomous/remote control of inland vessels – demo activities at PoAB and across Flanders are helping to inform the creation of a regulatory framework for the inland waterway networks linking to the Rhine (Belgium, Germany, the Netherlands). Once this framework is set, this could provide the model for other regions across Europe.</i> <i>Port Digital Twins – digital twin systems such as PoAB's APICA have been developed by large IT departments, which could not be sustained at all ports. Different levels of service (e.g. basic, intermediate and advanced) and prioritisation of uses cases need to be considered during transfer discussions.</i>

Table 1: Port-related conditions & readiness

Throughout PIONEERS it has been necessary to adapt the type and sequence of transfer activities, depending on the characteristics and readiness level of the port and the nature of the green port technology (i.e. vehicle, infrastructure or digital). The transfer process set out here is intended to provide guidelines and pointers, based on the experience of the project, to support the design of future co-transferability processes.

2 Conclusions

The development of the Green Port Masterplans within PIONEERS demonstrates that the transition towards climate-neutral ports cannot be addressed through a single blueprint. Ports differ significantly in their governance structures, infrastructure, economic activities, stakeholder ecosystems, environmental impacts and strategic priorities. Consequently, the value of the GPMP lies in providing a common transition framework while keeping sufficient flexibility for each port to develop its own pathway towards 2050.

A key lesson from PIONEERS is that the green transition needs to be approached as a systemic transformation rather than a collection of individual technological projects. Technologies and innovations remain essential, but their successful implementation depends on the wider port system, including infrastructure, regulation, market conditions, stakeholder acceptance, financing and organisational capacities. Applying the Multi-Level Perspective helps ports connect these dimensions and understand how innovations interact with existing port structures and broader developments such as climate change, energy transition, digitalisation and changing transport and trade patterns.

The experience of the PIONEERS ports further highlights the importance of establishing a robust understanding of the status quo. Port characteristics, governance structures, stakeholder relationships and environmental impacts form the foundation for subsequent strategic decisions. In particular, developing a comprehensive greenhouse gas inventory – including Scope 1, 2 and, where feasible, Scope 3 emissions – is important for identifying major emission sources, defining priorities and measuring progress. However, differences in data availability, responsibilities and organisational boundaries remain significant challenges and need to be considered when applying the approach in different ports.

Stakeholder engagement emerged as a continuous key element of the transition process. Ports depend on numerous public and private actors whose decisions influence infrastructure, energy systems, transport operations and investment. Effective engagement therefore goes beyond consultation. Stakeholders should progressively become involved in problem definition, development of the future vision, identification of solutions and implementation. At the same time, the appropriate form and intensity of engagement depend on the governance structure and stakeholder ecosystem of each port.

The GPMP experience also confirms the importance of looking beyond current port operations. Landscape analysis, scenario development and long-term visioning help ports prepare for uncertainty and understand how external developments may affect their transition. Rather than attempting to predict one future, scenarios allow ports to explore alternative developments and identify strategies that remain relevant under different conditions. Backcasting then provides the connection between the desired future and today's decisions by identifying the milestones, actions and enabling conditions required to move towards the long-term vision.

Another important conclusion concerns the role of innovation assessment. The availability of a technology alone does not determine whether it is suitable for implementation in a specific port. Technical maturity needs to be considered alongside environmental and economic impact, feasibility, scalability, stakeholder support and the specific conditions of the receiving port. The PIONEERS Innovation Radar and assessment approach provide a structured basis for identifying and comparing innovations while recognising that final investment and implementation decisions remain context-specific.

The roadmap brings these different elements together and converts strategic ambition into concrete initiatives and implementation pathways. However, a roadmap towards 2050 cannot be treated as a fixed plan. Technologies, regulations, energy markets, infrastructure requirements and stakeholder priorities will continue

to evolve. The GPMP should therefore be understood as a living strategic process that is periodically reviewed and updated while maintaining its long-term direction.

Experiences within PIONEERS also demonstrate that transferability does not mean replication. Solutions demonstrated successfully in one port cannot automatically be transferred unchanged to another. Differences in infrastructure, physical conditions, regulation, governance, operations and stakeholder structures need to be assessed first. Transfer may therefore range from replication of a complete solution to the transfer of individual components, knowledge, operational practices, data approaches or lessons learned. The co-transferability approach developed in PIONEERS provides a structured way of identifying what can be transferred, under which conditions and with which adaptations.

Overall, PIONEERS demonstrates that developing a green port requires the integration of system understanding, environmental awareness, stakeholder collaboration, innovation, long-term visioning and implementation planning. The GPMP provides a structured framework for combining these elements without prescribing identical solutions for fundamentally different ports.

The central lesson is therefore that there is no single Green Port Masterplan, but there is a common process for developing one. By understanding where a port stands today, anticipating how its environment may change, identifying suitable innovations, defining a shared long-term vision and translating this vision into an adaptive roadmap, ports can establish credible and actionable pathways towards climate neutrality. The methodologies, tools, experiences and best practices consolidated in this handbook provide a basis for other European ports to initiate, strengthen or reassess their own green transition.