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Green Energy Transition Tool for SMSPs Methodology

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Executive Summary

Small and Medium-Sized Sea Ports (SMSPs) face increasing pressure to reduce emissions, comply with evolving EU and international regulations, and remain competitive, often with limited financial and organisational capacity. This Deliverable presents the Methodology for the Green Energy Transition Tool for SMSPs, which provides a structured, practical, and scalable approach to support port administrations in planning and implementing their green energy transition.

The methodology builds on the results of previous project activities and integrates three core dimensions: technological solutions, human and organisational capacity building, and strategic roadmap development. It explains how ports can collect and use operational, energy, and emissions data as inputs to the tool, how these data are processed through transparent decision logic, and how the tool supports prioritisation of actions based on environmental impact, feasibility, and cost-effectiveness.

A curated set of green technologies applicable to SMSPs is embedded in the methodology, including shore power systems, electrification of port equipment, renewable energy integration, digital and smart port solutions, and readiness for alternative fuels. These technologies are assessed in line with relevant regulatory frameworks such as IMO MARPOL Annex VI and the EU Fit for 55 package.

Recognising that green transition is not solely a technical challenge, the methodology places strong emphasis on human factors. Capacity-building measures, including online seminars for port staff at different levels, are integrated to ensure organisational readiness and reduce implementation risks.

The methodology translates analysis into action through a step-by-step application pathway for port administrations, guiding ports from self-assessment and value identification to prioritisation, roadmap implementation, and continuous improvement. A practical use case demonstrates how a typical SMSP can apply the tool to achieve realistic and measurable decarbonisation outcomes.

Overall, this methodology serves as a practical manual for the piloting phase, enabling SMSPs to move from regulatory pressure and strategic uncertainty towards informed decision-making, targeted investments, and a structured transition towards greener port operations.

1. Introduction

Small and Medium-Sized Sea Ports (SMSPs) play an important role in South Baltic Regional supply chains and maritime connectivity, yet they face increasing regulatory, economic, and environmental pressures to decarbonise their operations. Compared to large hub ports, SMSPs often operate with limited financial resources, lower technological readiness, and reduced internal capacities for strategic planning. These constraints make the

green energy transition particularly challenging, but also underline the importance of tailored, practical, and scalable solutions.

This Deliverable presents the Methodology for the development and application of the Green Energy Transition Tool for SMSPs. The methodology builds directly on the results of previous project DigiTechPort2030 activities which focused on integrating technological, organisational, and strategic elements into a coherent roadmap for the green transition of SMSPs.

The methodology document serves as a theoretical and practical manual that explains how the Green Energy Transition Tool is structured, which data inputs it requires, which decision-making logic and algorithms operate in the background, and how the tool supports SMSPs in developing realistic and effective decarbonisation roadmaps. It is designed to guide the practical setup and implementation of the solution during the piloting phase.

Value Creation Logic for Port Authorities

REGULATORY PRESSURE

Fit for 55, IMO, FuelEU

↓

STRUCTURED DECISION SUPPORT

Green Transition Tool

↓

PRIORITISED ACTIONS

Realistic & affordable

↓

BENEFITS FOR THE PORT

Lower risks
Cost savings
Better funding access
Higher competitiveness

2. Overview of the Methodological Framework

The Green Energy Transition Tool is based on a modular and stepwise methodological framework that reflects the specific context and constraints of SMSPs. The framework integrates technical, economic, regulatory, and human dimensions of the green transition.

At a conceptual level, the methodology follows five main stages: 1. Baseline definition and data collection for port operations, infrastructure, and energy use; 2. Identification and selection of applicable green technologies tailored to SMSP characteristics; 3. Assessment of human factors and capacity-building needs, including skills, organisational readiness, and awareness; 4. Analytical processing and scenario evaluation through embedded decision logic and algorithms; 5. Development of a strategic roadmap for short-, medium-, and long-term green transition actions.

These stages are fully integrated into the Green Energy Transition Tool, enabling SMSPs to move from data input to actionable strategic outputs in a structured and transparent manner.

3. Input Data Requirements for the Tool

A key element of the methodology is the clear definition of data inputs required to ensure reliable and meaningful results. The Green Energy Transition Tool is designed to work with both basic and advanced data sets, allowing flexibility depending on the maturity level of the port.

3.1 Port Operational Data

- Annual vessel calls by type (cargo, passenger, service vessels)
- Berth occupancy and average time at berth
- Cargo handling volumes and equipment usage

3.2 Energy Consumption Data

- Electricity consumption (kWh/year)
- Fuel consumption by type (diesel, LNG, etc.)
- Energy use by operational segment (cargo handling, buildings, lighting, vessels at berth)

3.3 Infrastructure and Asset Data

- Existing electrical infrastructure capacity
- Availability of shore power (OPS)
- Renewable energy installations (if any)
- Age and type of port equipment

3.4 Environmental and Emissions Data

- Baseline CO_2 emissions
- Local air pollutants (NOx, SOx, PM where available)
- Waste and water management indicators

3.5 Economic and Market Data

- Energy prices (electricity, fuels)
- Investment and operational cost estimates (CAPEX, OPEX)
- Access to funding schemes and incentives

Where available, the methodology allows the integration of real-time or near-real-time market data, particularly for energy prices, to improve economic accuracy.

GREEN ENERGY TRANSITION TOOL – PORT ACTION PATHWAY

STEP 1

PORT SELF-ASSESSMENT
Baseline & Identity

↓

STEP 2

VALUE DEFINITION
Why this matters for my port

↓

STEP 3

PRIORITISATION
What to do first?

↓

STEP 4

CAPACITY BUILDING
People & organisation

↓

STEP 5

ROADMAP IMPLEMENTATION
Short / Mid / Long-term actions

↓

STEP 6

MONITORING & FEEDBACK
Adjust – improve – scale up

4. Green Technologies Applicable to SMSPs

Based on the outcomes of Activity 2.6, the methodology incorporates a curated set of green technologies that are considered most relevant, feasible, and scalable for SMSPs.

4.1 Shore Power Systems (OPS)

OPS enables vessels to switch off auxiliary engines while at berth, significantly reducing emissions. For SMSPs, the methodology promotes modular and scalable OPS solutions, including shared infrastructure models between neighbouring ports.

4.2 Electrification of Port Equipment

Electrification of cargo-handling equipment, vehicles, and auxiliary machinery is prioritised based on emission intensity and operational criticality. Leasing and phased replacement strategies are included to reduce financial barriers.

4.3 Renewable Energy Integration

The methodology supports the integration of small-scale renewable energy sources such as photovoltaic panels, small wind turbines, and hybrid systems to supply port buildings, lighting, and electrified equipment.

4.4 Digitalisation and Smart Port Technologies

Digital solutions such as sensors, energy management systems, and data analytics are included as enabling technologies to optimise energy use and reduce inefficiencies.

4.5 Alternative Fuels Infrastructure

The tool considers readiness for alternative fuels such as LNG, hydrogen, and biofuels, with a focus on shared infrastructure and long-term transition pathways aligned with EU and IMO regulations.

5. Decision Logic and Algorithms Behind the Tool

The Green Energy Transition Tool applies a multi-criteria decision-making logic to evaluate and prioritise green transition options. The methodology defines the following core analytical functions:

- **Baseline assessment**: calculation of current emissions and energy performance;
- **Technology impact estimation**: potential CO_2 reduction per technology;

- **Economic evaluation**: investment costs, operational savings, and indicative payback periods;
- **Scenario analysis**: comparison of short-, medium-, and long-term implementation pathways;
- **Prioritisation logic**: ranking of measures based on environmental impact, feasibility, and cost-effectiveness.

The algorithms are designed to remain transparent and adaptable, allowing ports to understand the rationale behind recommended actions.

6. Human Factors and Capacity Building

The methodology recognises that technological solutions alone are insufficient to achieve a successful green transition. Human factors and organisational capacities are therefore embedded as a core component of the tool.

6.1 Competence Requirements

- Strategic and managerial skills for green transition planning
- Technical skills related to energy systems and digital tools
- Operational skills for new equipment and procedures

6.2 Capacity-Building Measures

The project foresees online seminars and training activities targeted at port employees at different levels, including management, technical staff, and operational personnel. These activities aim to raise awareness, increase knowledge, and support behavioural change.

6.3 Organisational Readiness

The methodology includes a qualitative assessment of organisational readiness, identifying gaps in governance, processes, and internal coordination.

7. Market Prices and Regulatory Context

Economic evaluation within the tool is supported by market price data for energy and technologies, combined with an overview of the relevant regulatory framework.

The methodology aligns with key international and European regulations, including: - IMO MARPOL Annex VI and the IMO GHG Strategy; - EU Fit for 55 package, including EU ETS, FuelEU Maritime, and AFIR; - Renewable Energy Directive (RED) and related energy taxation frameworks.

This ensures that recommended measures are both economically and regulatorily viable.

8. Roadmap for Strategic Positioning of SMSPs

All methodological elements are integrated into a strategic roadmap that supports SMSPs in positioning themselves within the green transition of their regional ecosystems. The roadmap is not only a planning output, but a practical action pathway for port administrations.

The roadmap is structured across three time horizons: - Short-term (0–2 years): low-cost, high-impact measures and capacity building; - Medium-term (3–5 years): infrastructure upgrades and technology deployment; - Long-term (beyond 5 years): advanced technologies and systemic transformation.

To ensure usability for port administrations, the roadmap is complemented by a step-by-step operational pathway, described in Section 9.

9. Practical Application Pathway for Port Administrations

This section explains how a port administration can practically use the Green Energy Transition Tool, step by step. It is written for non-technical users and decision-makers.

Port Administrator Action Pathway
Practical application of the Green Energy Transition Tool

PORT SELF-ASSESSMENT
Where are we today?
↓
VALUE IDENTIFICATION
Why does this matter?
↓
PRIORITISATION
What do we do first?
↓
CAPACITY BUILDING
Are our people ready?
↓
ROADMAP IMPLEMENTATION
Short – Medium – Long term
↓

MONITORING & REVIEW
Adjust and improve

Step 1 – Understand Your Starting Point. The port administration uses the tool to answer one simple question: "Where are we today?"
The tool helps the port to: - identify how much energy it uses; - understand where emissions come from; - assess how ready the organisation is for change.
Output**:** a clear profile of the port (starting level, main challenges, realistic potential).

Step 2 – Understand the Value for the Port. Once the starting point is clear, the tool helps answer: "Why should we act?"
The port administration can clearly see: - how upcoming regulations affect the port; - where operational costs could be reduced; - how green actions improve competitiveness and reputation; - how the port becomes more attractive for funding and partners.
Output**:** a shared understanding inside the organisation that green transition creates value.

Step 3 – Decide What to Do First. The tool does not overload the port with options. Instead, it answers: "What should we do first?"
Actions are prioritised based on: - environmental impact; - cost and complexity; - current organisational capacity.
Output**:** a short list of realistic priority actions (no more than 3–5).

Step 4 – Prepare People and Organisation. Before investing in technology, the port prepares its people.
This includes: - short online trainings and seminars; - internal coordination and role assignment; - awareness raising across departments.
Output**:** higher internal readiness and lower risk of implementation failure.

Step 5 – Implement the Roadmap. The tool supports monitoring and updates when conditions change.
The port follows a clear roadmap: - short-term actions (quick wins); - medium-term investments; - long-term strategic transformation.
Output**:** structured and manageable implementation.

Step 6 – Review, Learn, Improve. Green transition is not a one-time action.
The port periodically: - updates data; - reviews results; - adjusts priorities.

Output**:** continuous improvement and growing ambition.

10. Port Administrator Use Case

Profile of the Port

A small-to-medium-sized port located in the South Baltic Sea region, handling mixed cargo and short-sea shipping. The port has limited investment capacity, ageing infrastructure, and no dedicated sustainability department.

Step 1 – Using the Tool for Self-Assessment. The port administration enters basic data into the Green Energy Transition Tool (energy use, vessel calls, infrastructure). The tool generates a baseline profile showing that emissions mainly come from vessels at berth and diesel-powered cargo equipment.
Key insight: the port is classified as a "transition-ready SMSP" with high potential for quick improvements.

Step 2 – Understanding the Value. The tool shows that installing shore power and electrifying key equipment could: - reduce emissions significantly; - lower exposure to future EU regulations; - improve eligibility for EU and national funding.
Decision: green transition is framed as a strategic investment, not a cost.

Step 3 – Prioritising Actions. Based on impact and feasibility, the tool recommends: 1. Modular shore power installation at one berth; 2. Replacement of two diesel vehicles with electric alternatives; 3. Staff training through online seminars.
Decision: focus on achievable actions within the next two years.

Step 4 – Capacity Building. Port management and technical staff participate in targeted online training sessions. Internal responsibilities for energy and sustainability are clearly assigned.
Result: increased confidence and organisational readiness.

Step 5 – Roadmap Implementation. The port adopts a roadmap with: - short-term actions (OPS pilot, training); - medium-term actions (renewable energy for port buildings); - long-term vision (alternative fuels readiness).

Step 6 – Monitoring and Improvement. After two years, the port reassesses its data using the tool. Emissions are reduced, and the port updates its roadmap with higher ambition.
Outcome: a realistic, step-by-step green transition aligned with port capacities.

11. Expected Decarbonisation Impact

Using scenario-based analysis, the methodology enables SMSPs to estimate the potential decarbonisation impact of different transition pathways. While results depend on local conditions, the tool provides indicative CO_2 reduction ranges linked to technology adoption levels and investment intensity.

12. Conclusions and Recommendations for Port Authorities

Conclusions

Small and Medium-Sized Sea Ports are entering a period of profound transformation driven by regulatory pressure, rising energy costs, and increasing expectations from port users and society. For SMSPs, the green energy transition is not a question of *if*, but *how* and *at what pace*. This methodology demonstrates that, despite limited resources, SMSPs can engage in the green transition in a realistic, structured, and value-driven manner.

The Green Energy Transition Tool, as defined by this methodology, provides port administrations with more than analytical outputs. It offers a decision-support framework that connects data, technology choices, organisational readiness, and strategic planning. By integrating technological assessment with human factors and capacity building, the methodology reduces the risk of fragmented or ad-hoc investments and supports coherent long-term positioning of ports within their regional ecosystems.

Importantly, the methodology shifts the narrative from compliance-driven action to strategic opportunity. It enables ports to understand their current position, identify realistic priorities, and gradually scale ambition as capacities grow. Through iterative use, the tool supports continuous improvement rather than one-off planning exercises.

Recommendations for Port Authorities

Based on the methodological framework and its intended application, the following key recommendations are addressed to port administrations:

1. **Start with self-awareness, not technology**
   Port authorities are encouraged to begin with a clear understanding of their baseline situation, including energy use, emissions, organisational readiness, and regulatory exposure. Realistic self-identification is a prerequisite for effective decision-making.

2. **Frame green transition as a strategic investment**
   Rather than treating decarbonisation solely as a regulatory obligation, ports should use the tool to articulate internal value propositions, such as cost reduction, risk mitigation, funding eligibility, and increased attractiveness for port users.

3. **Prioritise achievable actions and build momentum**
   Early focus should be placed on a limited number of high-impact and feasible measures. Demonstrating early success strengthens internal support and builds confidence for more ambitious actions.

4. **Invest in people and organisational capacity**
   Technological solutions must be supported by adequate skills, awareness, and internal coordination. Participation in targeted training and capacity-building activities is essential for successful implementation.

5. **Adopt a phased and flexible roadmap**
   Port authorities should use the roadmap to balance short-term actions with medium- and long-term investments, while remaining flexible to market, technological, and regulatory changes.

6. **Use the tool as a living instrument**
   The Green Energy Transition Tool should be applied iteratively. Regular updates of data and reassessment of priorities allow ports to track progress, adjust strategies, and progressively increase their level of ambition.

In conclusion, this methodology equips SMSPs with a **practical, accessible, and future-oriented framework** to navigate the green energy transition. When applied consistently, it supports informed decision-making, targeted investments, and a credible pathway towards decarbonised port operations aligned with European and international objectives.