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COURSE NAME: Sustainable Maritime Operations and Green Ports

Module 14 (Week 14)

Faculty of Maritime Studies, University of Rijeka

DEVELOPMENT AND IMPLEMENTATION OF SUSTAINABLE PORT AND SHIPPING STRATEGIES



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1. Introduction

- Port operations and shipping are at the heart of global trade and represent a significant source of greenhouse gas emissions and air pollution.
- The **European Union Green Deal** sets ambitious targets:
 - 55% reduction in transport emissions by 2030
 - Net-zero emissions by 2050
- To meet these goals, **ports must adopt** comprehensive sustainable strategies including:
 - Planning
 - Operational efficiency
 - Impact measurement
 - Investment in innovation

2. Planning and implementation of sustainability strategies

- Planning and Implementation of Sustainability Strategies in Ports begins with **alignment to international and EU regulations**, including the Green Deal targets and the Directive on Alternative Fuels Infrastructure.
- Key legislative documents define the **ultimate emission reduction goals** and conditions for the use of renewable energy sources within the port system.
- Ports must establish **specific, measurable, achievable, relevant, and time-bound (SMART) targets** (e.g., reducing CO₂ emissions by 30% within the next five years).

- **The first step** in strategic planning involves a detailed analysis of relevant legal and institutional frameworks at the international, European, and national levels:
 - Includes reviewing regulations set by the International Maritime Organization, EU regulations on ship engine emissions, legislative initiatives like the “Fit for 55” package, and national strategies for sustainable transport development.
 - Legal alignment ensures that port authorities and shipping service operators meet minimum standards and secure incentives, including subsidies for adopting low-carbon technologies.
- The port authority should then **formulate a clear sustainability vision and mission** that encompass environmental, economic, and social aspects of development, based on transforming the port into a green energy hub for integrated systems of electricity, hydrogen, and other low-carbon fuels.

- **Engaging key stakeholders** - government bodies, ancillary service operators, the local community, and academia - is crucial for developing a cohesive strategy and securing support and funding.
- The implementation of the sustainability strategy proceeds through four phases:
 - **Conceptualization Phase:** Define the strategic framework; prepare the Port Energy Transition Master Plan.
 - **Detailed Planning Phase:** Develop technical and financial plans for low-carbon infrastructure projects, such as shore-side electricity supply and hydrogen storage.
 - **Execution Phase:** Construct alternative fuel refueling stations, modernize loading and unloading machinery, and digitize emission monitoring systems.
 - **Evaluation and Adjustment Phase:** Regularly review achieved results against key performance indicators and adapt plans according to new technologies and changes in the regulatory framework.

3. Operational efficiency in ports and optimizing port logistics.

- Increasing operational efficiency in ports relies on the digitization and automation of key processes such as berth scheduling, truck traffic control, and inventory management.
- The application of intelligent transport systems enables real-time tracking of vessel arrivals and departures, reducing waiting times and avoiding unnecessary fluctuations in turbine operations.
- Digital platforms for managing cargo flows connect the port with its logistics hinterland, optimize vehicle routing, and contribute to reducing emissions from inefficient operations.
- Auxiliary vessels, such as tugboats and pilot boats, are often excluded from national emission targets, even though their collective fuel consumption significantly impacts local air quality.

- Slow steaming strategies; optimizing speed and route planning within the port; reduce fuel consumption by up to 15% per operation.
- Establishing standardized maneuvering procedures and using digital seabed maps increase safety, allow more precise vessel movements, and reduce unnecessary turns.

Best practice examples:

- **The Port of Rotterdam's** shore power project enables ships to turn off auxiliary engines in port, reducing nitrogen oxide and carbon dioxide emissions by up to 20% within one year.
- **The Port of Málaga's Green Port Initiative** combines local renewable energy with digital air quality monitoring, achieving a 25% reduction in particulate matter emissions.
- **EmissionInsider Carbon Insight Suite** offers real-time emission monitoring for ports such as Houston and Rotterdam, enabling rapid management responses and continual operational optimization to better protect the environment.

4. Measuring impact and continuous improvement

- Multidimensional KPIs: economic, environmental, social, governance
- Important indicators: CO₂, NO_x, SO_x emissions; fuel use
- Social focus: safety incidents, air quality
- Digital platforms enable automatic data collection (IoT sensors)
- Integration: meteorological and sea condition data
- Dashboards support fast, informed decisions
- Regular audits allow strategy updates

5. The role of innovation and new technologies in port development

- Digital twins: virtual replicas of port infrastructure, created using sensor data, GIS, and BIM.
- With the iTwin® platform, simulate terminal load scenarios, test logistics solutions, and enable predictive maintenance for cranes and vehicles.
- IoT and automation modernize port operations; projects like NON-STOP show that green digital investments improve efficiency and reduce ecological footprints.

- Customized IoT and AI optimize truck movements, cutting waiting times by up to 30% and CO₂ emissions by 10%.
- Energy storage, automated monitoring, and machine learning allow real-time, efficient resource management.
- Hydrogen dual-fuel technology in Antwerp: up to 70% less diesel use, paving the way for hydrogen fleets.
- Solar panels and wind turbines provide renewable energy for ships and logistics.
- Simulation models (Docks-the-Future) allow virtual supply chain testing, improving response to disruptions and speeding up protocol implementation.

Case Study: Implementing a training program for sustainable navigation.



- Initiative at the Port of Aveiro (Portugal) aims to cut emissions and fuel use by changing ship personnel behavior.
- Focus: Structured training and awareness for pilot boat and tugboat skippers to promote slow steaming (lower sailing speeds) without affecting safety or efficiency.
- Program components: theoretical and practical workshops, simulations, digital tools, real-time performance monitoring.
- Expected results: less fuel consumption, lower CO₂ emissions, higher awareness among workers, better EU/IMO compliance.
- Key stakeholders: port authority, pilots, tug operators, regulatory agencies, European associations.
- Scalable for expansion to other ports, with a long-term goal to foster environmental responsibility and support global shipping decarbonization.



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