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Environmental Management in a Life Cycle Perspective. Study case: Shipping Industry and Shipyards Activities

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Abstract

The paper addresses the environmental standards, especially the standards on environmental management, life cycle assessment and environmental performance evaluation. It presents examples of how ISO 14000 was implemented in Romanian shipping and shipbuilding. The holistic view and life cycle approach were essential to this research program. The environmental effects related to construction, operation and maintenance of ships were evaluated, and the results were presented by means of environmental performance indicators. The indicators were placed in a three-tier informational structure. Finally, it was demonstrated how the use of ISO 14000 as a complement to ISM can focus the shipping companies, strategic efforts on areas which may yield the biggest economic returns for the future.

Key words: *environmental management, Romanian shipping industry, LCA.*

Foreword

During the past four decades, industrial environmental management views have shifted focus from the dilution of waste discharges to a focus on the environmental characteristics of the product itself. An increasing number of consumers demand environmentally friendly products and services that have little or no detrimental impact on the environment. The environmental impact of a product accumulates throughout its life cycle, with transport representing a major contribution to the total environmental load of a product.

Environmentally friendly means of transport have therefore become an important element of competition and a new challenge to the entire transport industry. "Good operational practice" is not sufficient to demonstrate a satisfactory environmental profile. The means of transport must (within practical and economic limitations) be made from environmentally friendly materials. Designing, building, maintaining and scrapping the transport means must be made with consideration to sustainability in every aspect of its life cycle. Environmental management has become a challenge to Romanian shipping and shipbuilding. Results from environmental management and life cycle projects in these industries are presented in this paper.

Life Cycle of a Ship

The life cycle of a ship consists of four main phases: planning, construction, operation, maintenance and scrapping (see Figure 1). Traditionally, the term shipbuilding encompasses the construction phase in the ship's life cycle. Rebuilding is performed in the operational maintenance phase. However, construction, maintenance and scrapping are all included in the business of shipbuilding. Shipping is a very comprehensive business. Shipping is a complex international business involving international trade, multinational finance, insurance and investment, shipbroking and the management and operation of ships. It is debatable whether design activities belong to shipping or shipbuilding. Other parties belong more or less to both shipping and shipbuilding, such as insurance companies, financial institutions, and governments. ISO 14000 will be of consequence to them all.

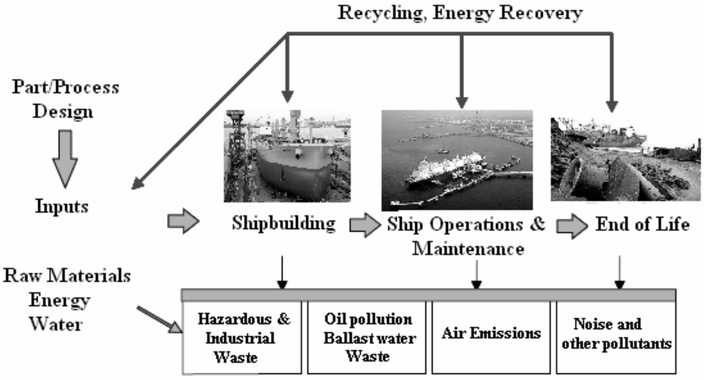


Fig. 1. Life cycle of a ship

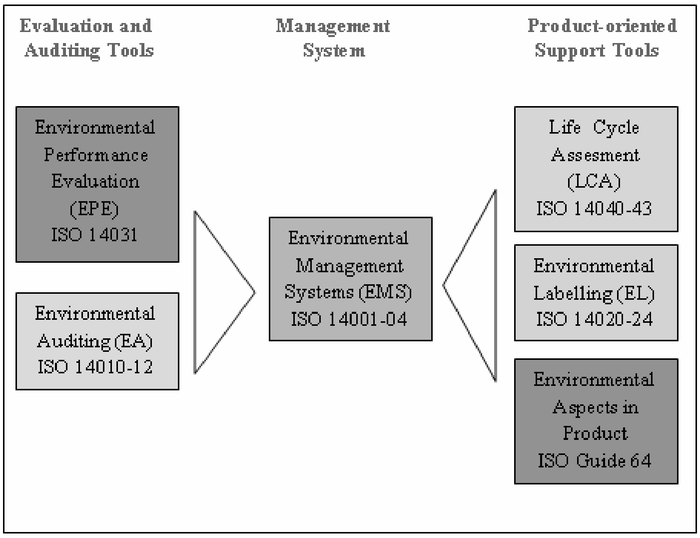


Fig. 2. ISO 14000- phases

The ISO 14000 standards family

ISO 14000 represents a new consensus position for the business and the environmental communities. It is a "package" tying the mandatory requirements of environmental performance to a management system. The standards have been designed for application by all organizations regardless of their size, process, economic situation or regulatory requirements.

The relationship between different ISO 14000 standards is shown in Figure 2. The most important ones for shipping and shipbuilding are the standards for Environmental Management

Systems (EMS), Environmental Performance Evaluation (EPE) and Life Cycle Assessment (LCA). EMS and EPE are mainly oriented towards organizations or single companies. LCA, however, is product oriented and will therefore involve several companies.

ISO 14001-04 are the specifications of Environmental Management Systems (EMS) with guidance for use. The methodology for implementation of EMS consists of three main phases: planning (with identification of regulatory requirements), implementation (with commitment to continuous improvement), and regular evaluation of environmental performance. Implementation of EMS can be based on other management systems [5].

Environmental Performance Evaluation (EPE) provides for measuring environmental impacts that can be controlled by the organization. EPE is the process that organizations can use to measure, analyze, and assess their environmental performance against a set of criteria, and establish objectives and targets for improvements. EPE can be used by all organizations, with or without an EMS in place. EPE is an ongoing internal management process that uses environmental indicators to compare an organization’s past and present environmental performance with its performance criteria [3].

There are two basic evaluation areas to consider in selecting Environmental Performance Indicators (EPIs): the management area and the operational area. In addition, the condition of the environment is an evaluation area described by Environmental Condition Indicators (ECIs), see Figure 3. The condition of the environment covers the quality of air, water, soil, flora, fauna and human health, [1].

The operational area includes physical facilities and equipment, operation, and material and energy flows. Environmental related inputs and outputs to the management area include requirements, views of interested parties, information from the operational system, and information about the condition of the environment. EPE allows organizations to benchmark their performance against other similar organizations. The EPE process consists of several steps including commitment, planning, application, review and improvement.

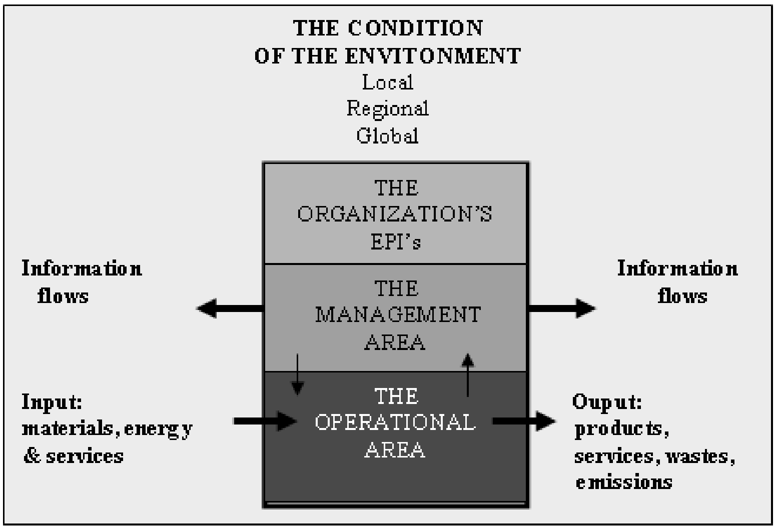


Fig. 3 Environmental performance evaluation areas to consider in selecting EPIs and ECIs.

Life Cycle Assessment (LCA) is a tool for evaluating the environmental impacts along the entire chain of a product's life (from raw material extraction, through manufacture, distribution and transportation, use, recycling, and final disposition). The methodology includes the following: goal and scope definition; inventory analysis; impact assessment; interpretation.

During goal and scope definition, the application, depth and subject of the study must be defined. The functional unit and the system boundaries should also be specified. Inventory analysis is the stage in which emissions and raw material consumption from each process are identified. Impact assessment involves analyzing and assessing the effects of the environmental burdens identified in the inventory analysis. Finally, interpretation is the phase of an LCA in which a synthesis is drawn from the findings of either the inventory analysis, the impact assessment, or both. The findings of this interpretation phase may lead to conclusions and recommendations valuable to decision makers, [4].

Most ocean regulations pertaining to ships' safety and environmental protection, are established by international conventions and protocols. The International Maritime Organization (IMO) is responsible for most requirements within international shipping. The most important conventions and codes are: Safety of Life at Sea (SOLAS); Prevention of Pollution from Ships (MARPOL); The International Safety Management Code (ISM); Safety and Environmental Protection (SEP). For shipping and shipbuilding in Romania environmental problem is an important issue. The program "Environmental Management in a Life Cycle Perspective". is divided into three parts:

- The implementation of EMS at Romanian shipyards.
- Development of EPIs and EPE appropriate for shipyards.
- LCA and Life Cycle Costing (LCC) for selected parts of a ship.

Five companies (three construction yards, one maintenance and repair yard, and one shipping company) have collaborated with the foundation Anconav Romania.

Environmental Management System in Shipping and Shipbuilding

The shipyards involved in the program have partly implemented an EMS, mainly the three first steps in the ISO 14001 procedures:

1. Environmental policies are described.

2. Environmental aspects are identified relative to external material protection, waste treatment and section mounting.

3. Objectives and targets are established, e.g. better utilization of available „surplus energy"; reducing the percentage of wastes; assessing environmental effects by covering up the ship during painting and sandblasting; routine improvement in treating special wastes; and developing action plans.

Even though the EMS was not fully implemented by the shipyards, good environmental performance has already provided economic gains and positive environmental effects. Today there are no shipping companies in Romania with an implemented EMS according to the ISO-14001 standard. In fact, the Romanian Ship-owners Association and some ship-owners hope that ISO 14000 will have no significant consequences for shipping, as most of those having involved themselves in ISO 9000 still struggle with this (Schmidt &Marin, 2008). However, some shipping companies focus on good environmental management practice such as: coating systems without organotin; cooling water systems to prevent growing of hull instead of using antigrowing paint system; waste handling systems on board their ships; educating employees on ships in environmental issues and attitudes.

Environmental Performance Evaluation (EPE) in Romanian Shipbuilding

The use of EPIs and ECIs is a new method for the Romanian shipbuilding industry. A method for identifying and implementing EPIs was tested for the first time in several Romanian companies in the shipping industry [6]. The main focus when selecting EPIs was production, even though one yard focused also on the distribution of the steel prior to hull assembly. A good structure of EPIs is based on 3 levels of information.

Table 1. Environmental performance indicators for shipbuilding.

Corporate Level	
Index	**Index**
Material use	**External material protection**
Local management	
Indicators	**Indicators**
• Material utilization • Enegy use per unity of material	• Emission of noise • Emission of dust • Emission of solvent • Use of paint per unit area
Reporting parameters	**Reporting parameters**
• Percentage excess material • Purchase of cut steel plates • Purchase of complete hulls • Transport of material (t·km) • Means of transportation from steelworks to the yard	• Number of complaints on noise from neighbors • Degree of covering when sand blasting or painting occurs • Amount of generated dust per spent blasting sand • Recycling of thinner • Number of accidentally painted cars

Each of the shipyards involved in the research program is a part of a conglomerate comprising other shipyards. This makes a three-tier informational structure appropriate.

The reporting parameters at the lowest level are used for measuring the environmental standings on a short term basis, and are management tools for every day issues. This information is meant to be used for communication both within the company and to the stakeholders. The reporting parameters might be further aggregated to EPIs and indices in order to compare the company's real environmental performance with the environmental targets set for the period.

A set of indices, EPIs, and reporting parameters for main shipyard activities were suggested as illustrated in Table 1. They were developed for validity within defined system boundaries. With a standard way of calculating environmental performance scores, it is possible to benchmark companies within a trade. However, such comparisons must be carried out carefully; it is important that companies use the same basis for these calculations.

Examples of EPIs:

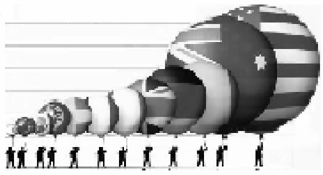
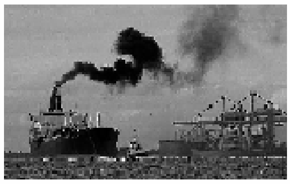
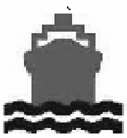
$$Material\_utilization = 1 - \frac{Weight\_of\_excess\_material}{Total\_weight\_of\_steel\_product} \qquad (1)$$

Emission of noise (or dust) = Measured emissions (dB or g/m^3) 100 m from the site of sand blasting.

EPIs may be selected for each subsystem of a ship. For example, for the main engine systems, EPIs can be structured as illustrated in Table 2. Similarly, EPIs can be developed for other subsystems like the hull, the equipment, the waste handling systems, etc. By means of target levels for different types of emissions, the ship's true emission performance can be measured by

EPIs, [8]. So far, this paper has discussed EPIs related to the operational area in an organization or to the ship system. Suggested indicators for performance evaluation within the management area and for the condition of the environment are: management area (financial performance; community relations; implementation of policies and programs; conformance with legislation), condition of the environment (local, regional, global: quality of air, water, soil, number of species in flora or fauna)

Table 2. EPIs for main engine system.

Indices	
• contribution to global warming potential • contribution to acidification • contribution to eutrophication • contribution to smog formation • material efficiency	
Indicators	
• Emission of CO_2 • Emissions of No_x • Emissions of SO_x • Emissions of CO • Emissions of HC • Fuel consumption	 
System alternatives	
Suggestion 1: Fuel consumption reduction	**Suggestion 2: Exhaust treatment**
Adjustable parameters	
• Cylinder dimensions, • Injection pressure, • Combustion pressure, • Expansion ratio, • Air flow • Charge temperature 	• Selective Catalytic Reduction (SCR) • Selective Non Catalytic Reduction (SNCR) • Sea-water treatment GREEN SHIPS

An interesting issue is to find adequate EPIs for communication between the shipbuilding industry and the shipping industry. Since the designer/consulting companies, the scrapping yards, and recycling plants are not clearly defined as a part of either the shipping industry or the shipbuilding industry, it is important to find EPIs also for communication among them. The group of stakeholders within the maritime industry is illustrated in Figure 4.

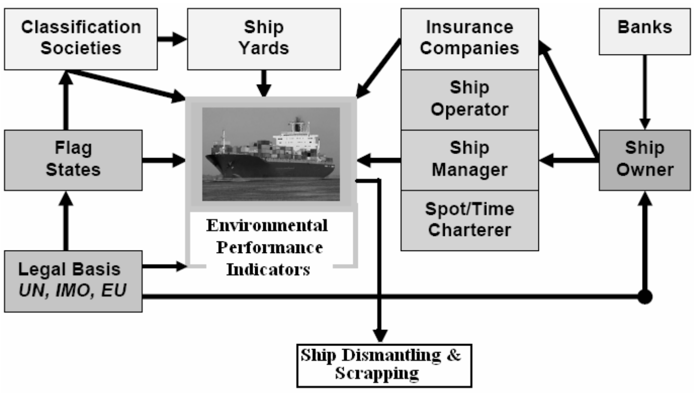


Fig. 4. The maritime industry- stakeholders.

LCA- Shipbuilding and Shipping

In most LCA-studies, the life cycle starts with raw material extraction, and culminates with the final disposal or recycled material, i.e. the "cradle to grave" approach. Within shipping, the life cycle concept is often understood as the period from the time the ship is contracted until the time it is sold. Assessment of the economic life cycle focuses on the trading profit. Since the under-standing of the life cycle within shipping is mainly restricted to the operational phase, it is in conflict with what is defined as the life cycle of a product according to the LCA-standard.

For example, the life cycle of the steel part of a ship is emphasized in Figure 5. Steel enters the system life cycle of the ship in the construction phase.

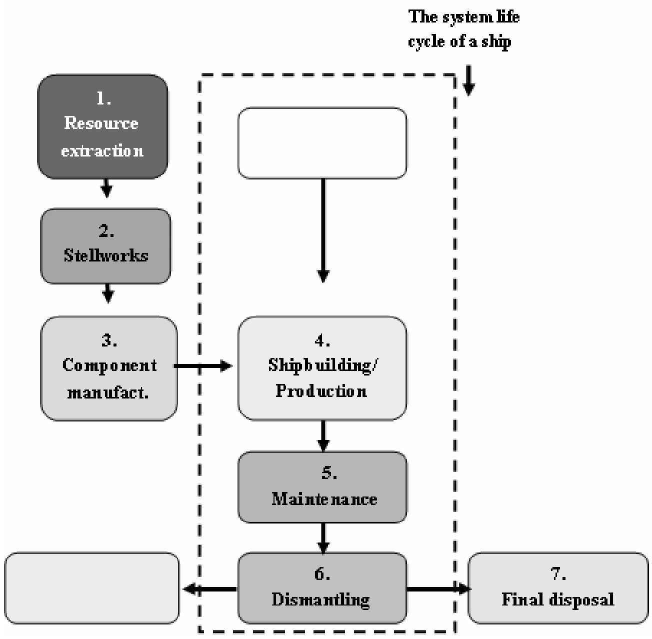


Fig. 5. The life cycle of the steel part of a ship.

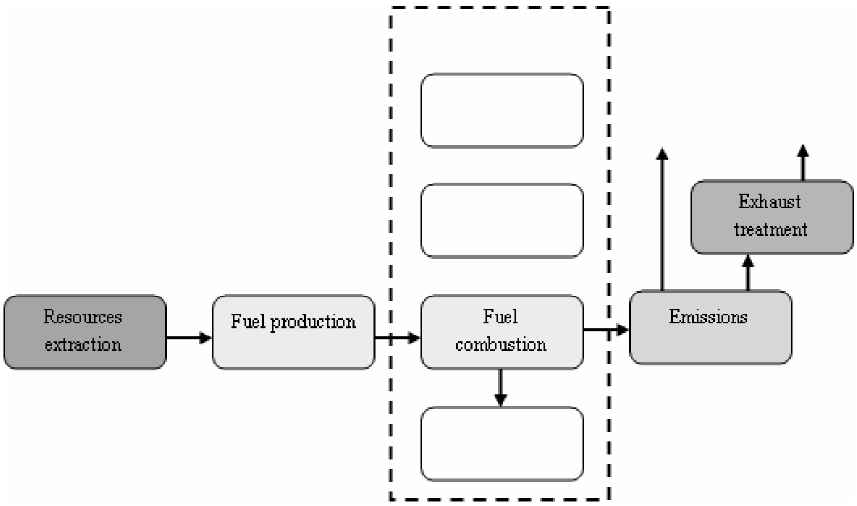


Fig. 6. Interaction between fuel system and the system life cycle of the ship.

The environmental impact caused by steel parts depends on the raw material extraction, processes cutting and fitting of steel plates and profiles, mounting of plates to sections by welding, grinding, sand blasting and painting, and transportation of steel components and sections. In the research program carried out at the Romanian shipyards, the flow of materials was determined quantitatively, and the data were related to a functional unit such as “1 ton steel”. Different patterns of steel flows from steelworks to shipyard were evaluated. By using today’s practice with several vendors and transportation between the steelworks, suppliers and the shipyards, the environmental impacts were evaluated by means of the LCA software tool [10]. The SimaPro software evaluates data to demonstrate how different substances contribute to global warming, ozone depletion, acidification, eutrophication, smog formation and pollution caused by heavy metal discharges to the environment. For an alternative scenario, in which cut steel plates were transported directly from the steelworks to the shipyard, the environmental impacts were reduced due to less transportation and material consumption. The results showed lower emissions of greenhouse gasses, lower regional acidification and eutrophication effects and lower emissions of substances causing smog formation [7]. Similarly, the fuel system’s entrance into the system life cycle of the ship may be as illustrated by Figure 6. By a calculated average fuel consumption of 15 g/t·km and emission factors given in Table 3, the environmental impact from a ten year period of a platform supply vessel operating in the Black Sea were evaluated. The results show that acidification effects dominate as the most serious. The study is combined with an LCC analysis.

Table 3 Exhaust emissions calculation.

Relative emissions for platform supply vessel, based on 15 (g fuel/t·km)	
CO_2	64.90
NO_X	1.31
SO2 (1% Sulphur Content in fuel)	0.46
CO	0.16
HC	0.05

The environmental impacts related to hull assembly and fuel consumption are illustrated in Figure 8. The effects are measured using Eco-points 2 [10], and the effects are approximately 100 times more serious caused by emissions during 10 years operation of ships.

The results of the LCA/LCC conducted in the research program have shown the following:

• Emissions to air from fuel combustion during operation normally represent the major contribution to environmental impact over the entire life cycle, Figure 7 [2].

• The conventional coatings have a higher impact on the environment than self polishing antifouling due to increased docking frequency and higher fuel consumption during the operational period of the ship. However, the impact on marine organisms caused by polluted flush down water from bottom hull cleaning of ship with self polishing antifouling is more serious because of heavy metal content.

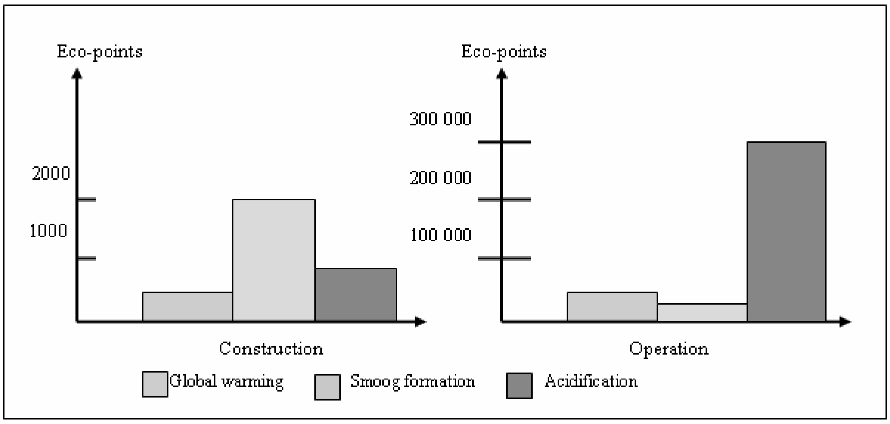


Fig. 7. Pattern of environmental impact from construction and operation of ships.

• Change from Marine Gas Oil (MGO) to Heavy Fuel Oil (HFO) leads to increased emissions of acidifying gasses. The change from MGO to HFO also increased fuel consumption and maintenance costs, but reduced operational costs. MGO is found to be a better fuel alternative than HFO, both from an economic and environmental point of view. The information the LCA provides will be an important input to the ship designer. However, software is needed to analyze and evaluate multivariable environmental issues.

Conclusions

ISO 14001 is a supplement to the ISM-code. The intention of ISO 14001 is to promote proactive attitudes towards environmental improvement actions within companies. So far ISO 14001 has resulted in models for EMS at shipyards. Shipyards with a good environmental management practice have reduced their environmental loads through better planning. They have achieved economic return from increased efficiency of resource use and waste treatment practice. Shipyards have also realized benefits in credit approval. However, they have also incurred higher management costs in the planning stage. Some consequences of ISO 14001 for shipbuilding in the future may be: Increased knowledge about environmental issues and performance; Better conditions for loans and insurance; Cost savings through better resource utilization; Better reputation in the local community; Procedures for continuous improvement and a code of practice for shipyards; Better health and safety conditions at yards resulting in better recruiting of labor to the industry.

ISO 14031 and EPIs will be important tools for communicating environmental performance among interested parties and groups within industrial clusters such as the maritime cluster. EPIs will also be of importance for benchmarking, but probably not in the near future. ISO 14040-standards have already provided data input to ship design and improvement of maintenance routines. It has contributed to optimization of fuel consumption and bottom hull coating and to cost/environmental optimizations for the vessel taken under study. Today there are still no examples of complete LCAs for ships.

However, some examples are available for parts of ships. The results from an LCA/LCC should be a strategic tool for policy- and decision making, and a tool for highlighting important connections between materials, environment and costs throughout the life cycle of a ship. The results must be addressed to ship owners, shipbuilders, ship designers, and suppliers in order to improve and optimize design, maintenance routines, and fuel consumption and machinery performance. The information will aid the planning of the ship owners environmental and economical goals, aid subcontractors in setting new requirements, and enable better compliance with legislation. Examples of the positive effects caused by correct environmental measures, are reduced maintenance, service and fuel costs, and hopefully longer life-cycle and higher second hand or decommissioning value. The results of an LCA/LCC will be important in the achievement of sufficient information for setting the right priorities.

Note however, that the lack of information on scrapping activities throughout the world makes it difficult to measure total environmental impact. To gather sufficient information on these activities is a challenge. Another important challenge is to develop weighting models and specific environmental performance evaluation criteria for selected oceans areas.

To get ISO 14000 implemented in the Romanian shipbuilding and shipping industry there will be a need for closer cooperation and communication between the different parties involved in the different phases of the ship's life cycle (designers, construction yards, ship operators, maintenance and repair yards, supporters and suppliers, financial institutions, scrapping yards and waste handling and recycling companies, etc.). ISO 14000 can be used to develop the industry standard for environmental performance evaluation within the maritime industry. Networks will strengthen by setting forward mutual requirements among the involved parties within the industry. That will be an additional important competitive factor for shipping and shipbuilding in the transport market.

References

1. Berrien, P., Gomez-Mejia, L. - *Environmental Performance and Executive Compensation: An Integrated Agency-Institutional Perspective,* The Academy of Management Journal (AMJ), Volume 52, Number 1 / February 2009, pages 103 – 126, 2009
2. GLOBE - *Influence of geo-climatic changes on global and regional sustainable development in Dobrogea*, Control: 3-PC-3535 Partnerships program in priority areas, 2009
3. Hyunkee B., Yong-Woo, K. - *Survey on indicators in environmental performance evaluation for small and medium sized companies*, International Journal of Environment and Sustainable Development, Volume 8, No.2/2009, pages 151-172.
4. Hutchins, M., Sutherland, J.W - *The Role of the Social Dimension in Life Cycle Engineering*, International Journal of Sustainable Manufacturing, Volume 1, Number 3 / 2009, pages 238-250, 2009.
5. Marimba, A., Farinha, J.T., Ferreira, L. - *International standards integration for ecologic asset management*, Energy and Environmental Engineering Series, Proceedings of the 5th IASME/WSEAS International Conference on Energy & Environment, UK, pages 54-61, 2010.
6. Nicolae, F., Bosneagu R - *Risk factors associated transport system and their influence on Climate Change*. Geo-climatic changes on land and sea Dobrogea, GLOBE Symposium 2009.
7. Nicolae, F. - *A mathematical method to determine the energy consumption and pollutant emissions from maritime transport*. Conference NAV-MAR-EDU 2007. ISBN 978-973-8303-84-3, Constantza, 2009
8. Saengsupavanich, *C.*, Coowanitwong, N, Wenresti G., Lertsuchatavanich, C. - *Environmental performance evaluation of an industrial port and estate: ISO14001, port state control-derived indicators.* Journal of Cleaner Production 17 (2009) 154-161, Elsevier, 2009
9. Schmidt, V.; Marin, D. - *Shipbuilding Industry in Romania – Continuity and competitiveness. The changing structure of the world shipbuilding industry*, Paris, 2008
10. SimaPro - *Software, Product Ecology Consultants, SimaPro 7.2.* Amersfort, Netherlands, 2008.

Management de mediu din perspectiva ciclului de viaţă. Studiu de caz: Activităţile din transportul maritim şi din şantierele navale

Rezumat

Lucrarea abordează problema standardelor de mediu şi în special pe cea a standardelor de management de mediu, de evaluare a ciclului de viaţă şi de evaluare a performanţei de mediu. Lucrarea prezintă modalitatea de implementare a standardului ISO 14000 în transporturile maritime şi construcţiile navale româneşti. Viziunea holistică şi abordarea din perspectiva ciclului de viaţă au fost esenţiale pentru acest program de cercetare. În lucrare sunt evaluate efectele asupra mediului referitoare la construcţia, exploatarea şi întreţinerea navelor, iar rezultatele sunt prezentate prin intermediul indicatorilor de performanţă. Indicatorii au fost ierarhizaţi într-o structură informaţională pe trei nivele. În cele din urmă este demonstrat că utilizarea standardului ISO 14000, ca o completare a codului ISM, conduce, în cazul companiilor de transport maritim, prin eforturi strategice susţinute, la rentabilitate economică.