Science for Environment Policy

Environmental impact of recycling metals from ships: a life cycle assessment

Life cycle assessment (LCA) can measure the environmental impact of the different stages of a ship's life cycle, from design to dismantling. This assessment focused on the impact of recycling the metal parts of a ship and did not consider the crucial impact of the hazardous materials present on board. The results showed that re-use of metals had environmental benefits, but overall these were small compared to the environmental impact of other life cycle stages, such as operation.

Global trade is dependent on seaborne transport — over two thirds of goods worldwide are carried by ships. However, the amount of seaborne transport has decreased recently. Following the 2008 financial crisis, demand for the transport of goods fell and ships on the world's oceans reached over-capacity. Many older vessels were decommissioned and scrapped, generating business for the ship recycling industry.

Most of this business went to Asia, where over 90% of ships are scrapped[1]. In countries such as India and Bangladesh, ships are often dismantled under harsh working conditions and with few environmental protection measures. Many 'scrapyards' are simply beaches, where ships are pulled ashore and manually disassembled.

Due to the human and environmental cost of such practices, international agreements have been launched to improve management of ships at the end of their useful life, including the Basel Convention, Hong Kong Convention and the more recent EU Ship Recycling Regulation.

This study aimed to estimate the environmental impact of the end-of-life phase compared to the overall life cycle of a ship. The researchers first performed a literature review of existing ship LCA studies. They found that many studies have been published in the past 15 years, but few focused on end-of-life. A number of assessment tools have also been developed, such as the 'Tool for Environmentally Efficient Ship Design', developed as part of the Energy Efficient Ship project[2]. This tool aids decision-making during design to reduce energy consumption and environmental impact, and was used by the authors of this study.

Based on the findings of the literature review, the researchers developed their own end-of-life assessment approach, using a simplified model that takes into account all three phases of the ship life cycle (building, operation and scrapping). The model was created with the product sustainability software GaBi and assessment was performed based on ISO 14040 guidelines.

The model was based on one ship with a mass of 5000 tonnes (without cargo). The impact assessment focused on the metal components of the ship (mainly steel), which were assumed to contribute 75% of its overall mass. The authors describe this as a 'first screening' of the environmental impacts of ship recycling and did not assess the impact of environmental contamination with hazardous substances, but say they hope to do so in future work.

Two scenarios for scrapping were evaluated, with different approaches to recycling. The first scenario represented *general recycling* of the metals, separated into ship body and machinery. This assumes general recycling of steel for other industries. In the second scenario, the researchers looked at the impact of *re-using metals*, for example, putting machinery in a new ship. Any materials that cannot be re-used are recycled as in the first scenario.

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June 2016
Thematic Issue 55

Ship Recycling: Reducing Human and Environmental Impacts

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Source: Ko, N., Gantner, J. & Wehner, D. (2015). Life cycle assessment of ships with special consideration of ship scrapping. *Matériaux & Techniques*, 103(1): 101. DOI: 10.1051/mattech/2015002.

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To cite this article/service: "Science for Environment Policy": European Commission DG Environment News Alert Service, edited by SCU, The University of the West of England, Bristol.

1.M. Sarraf, F. Stuer-Lauridsen, M. Dyoulgerov, R. Bloch, S. Wingfield, R. Watkinson, The Ship Breaking and Recycling Industry in Bangladesh and Pakistan, The World Bank. Washington, DC, 2010.

2.The Energy Efficient Ship (TEES) project was funded by the European Commission under a cooperative research contract. See: http://cordis.europa.eu/project/rcn/46334_en.html

European Commission

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(continued)

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The contribution of the end-of-life phase to the overall environmental impact of the ship (in each scenario) was evaluated using five categories: impacts on climate (global warming potential), impacts on plants and soil (acidification potential), impacts on soil and water (eutrophication potential), impacts on the lower atmosphere (photochemical ozone creation potential) and energy use (primary energy demand). The researchers used the CML impact assessment methodology[3], developed by Leiden University.

Scenario two (re-use) had greater environmental benefits compared to general recycling, at least 23% (in terms of impacts on soil and plants through acidification, based on a re-use rate of 20%), and up to 101% (for impacts on the lower atmosphere, based on a 60% re-use rate). However, when the researchers compared the environmental impact of all the life stages, they found that the ship's working life (operation stage) has the greatest impact.

End-of-life causes the least environmental damage of all stages, but, at best, could only compensate for half of the environmental damage caused by ship building. Overall, it had less than 1% influence on environmental impact, suggesting that other stages of the life cycle may be more important for making environmental gains. However, the researchers say recycling may have a more significant impact via categories not measured in this study, such as resource efficiency.

The scenarios assessed here show that ship recycling is environmentally beneficial. However, this study did not consider economic and social factors, such as the economic value of ship recycling for developing countries, or the impacts of exposure to hazardous materials. As the project develops, the researchers hope to use their model to evaluate the environmental, economic *and* social impacts of ship designs, in order to optimise sustainability in the ship building industry.

3. http://www.universiteitleiden.nl/onderzoek/onderzoeksoutput/wiskunde-en-natuurwetenschappen/cml-cml-ia-characterisation-factors