ODFJELL

NTNU
Norwegian University of Science and Technology

LIFE CYCLE AND RISK ASSESSMENT OF IMPLEMENTATION OF ROTOR SAILS ON EXISTING CHEMICAL TANKER

M.Sc. by Frida Volden Tiller(fridavt@stud.ntnu.no) and Siri Trige(siritri@stud.ntnu.no)

Supervisor: Bjørn Egil Asbjørnslett
Contributors: Dr. Dražen Polić and Odfjell Tankers

INTRODUCTION

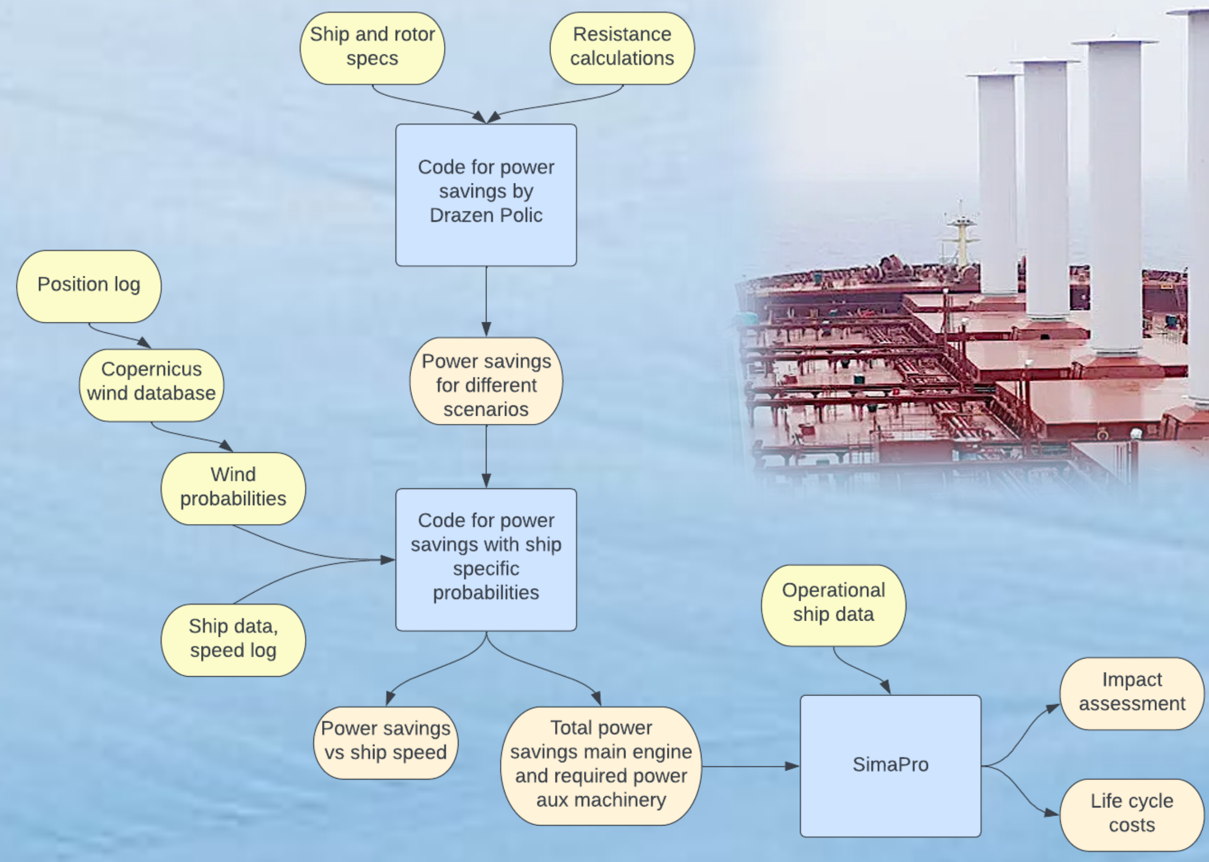
Wind-assisted ship propulsion (WASP) is a method of reducing emissions on ships, being explored as a means for a more sustainable shipping industry. However, if the industry shall embrace such a solution, it must be shown to be financially sustainable, that it attains actual results, and that it is safe.

Much effort is being put into exploring the best options for new ships and how these can be constructed for zero- or low-emission operation. However, in the meantime, thousands of ships are still planned to operate for another 5-30 years. Therefore, if the shipping industry is going to succeed in lowering its emissions altogether, lowering emissions from these existing ships must also be considered.

For this reason, it is interesting to explore quantitatively the life cycle effects and risks for an existing ship when implementing an energy-saving device. Rotor sails is a technology established on the market, with several providers, but has yet to be implemented on many ships. This is likely due to the high cost without the promise of significant savings.

The study's results should be helpful to decision-makers considering rotor sails. The study will include an analysis of changes in emissions, costs, and risk factors. Ultimately, we should clearly see the differences between the ship in continued regular operation and the ship with rotor sails implemented.

[1]



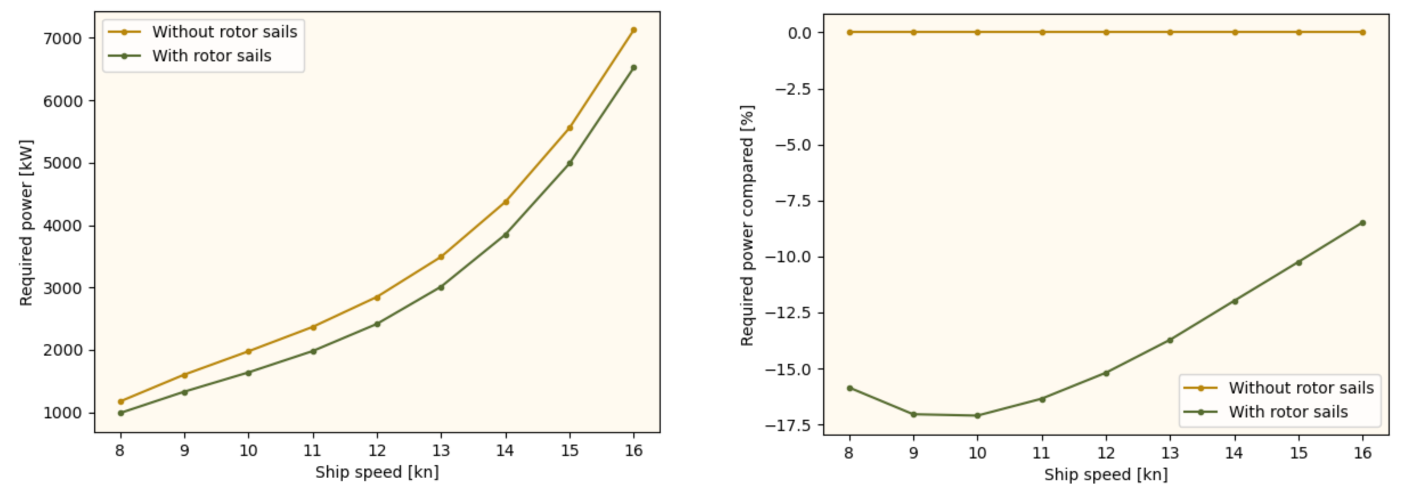
LIFE CYCLE ASSESSMENT

An LCA consists of four phases; goal and scope definition, inventory analysis, impact assessment, and interpretation [2]. The main goal of the LCA is to find out if it is environmentally and financially beneficial to implement rotor sails on a specific ship. As the expected remaining lifetime of the ship is 20 years, the functional unit is ship operation for 20 years.

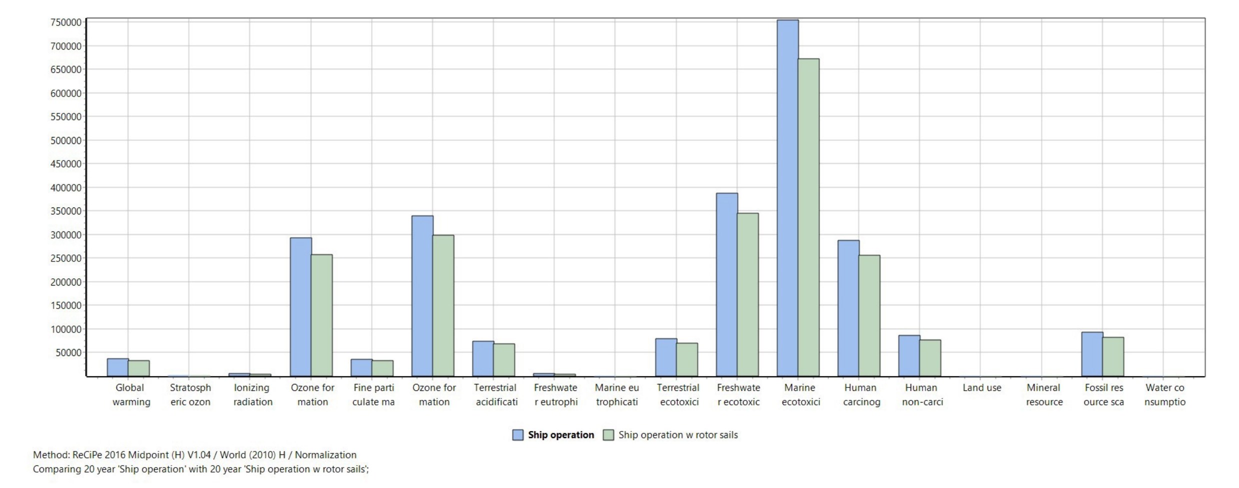
After defining the scope and goals, the inventory analysis consists of finding the data needed to do the analysis. A simplified flowchart for calculating the data is shown to the right. Post doc. researcher Dražen Polić has calculated the estimated power savings for different scenarios. These results are further used to calculate the total power savings for the specific fleet with a specific route. Finally, the total power savings are used with historical operational ship data in the software SimaPro to calculate the environmental impacts and costs based on the functional unit.

The required power for the ships in the fleet with and without rotor sails is presented in the graph to the right, and the total power savings for the historical route is calculated to be 15%. The environmental impacts for the ship with and without rotor sails are presented as midpoint indicators from the ReCiPe method in graph at the right [3].

REQUIRED POWER FOR SHIP WITH AND WITHOUT ROTOR SAILS



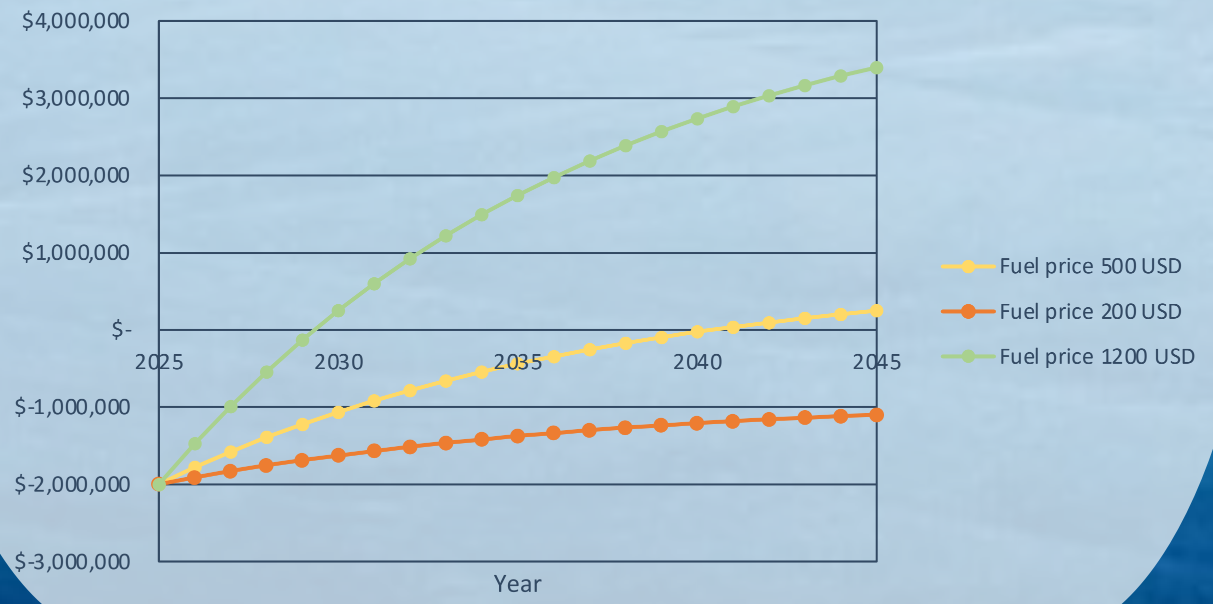
ENVIRONMENTAL IMPACTS BASED ON RECIPE MIDPOINT INDICATORS



COST ANALYSIS

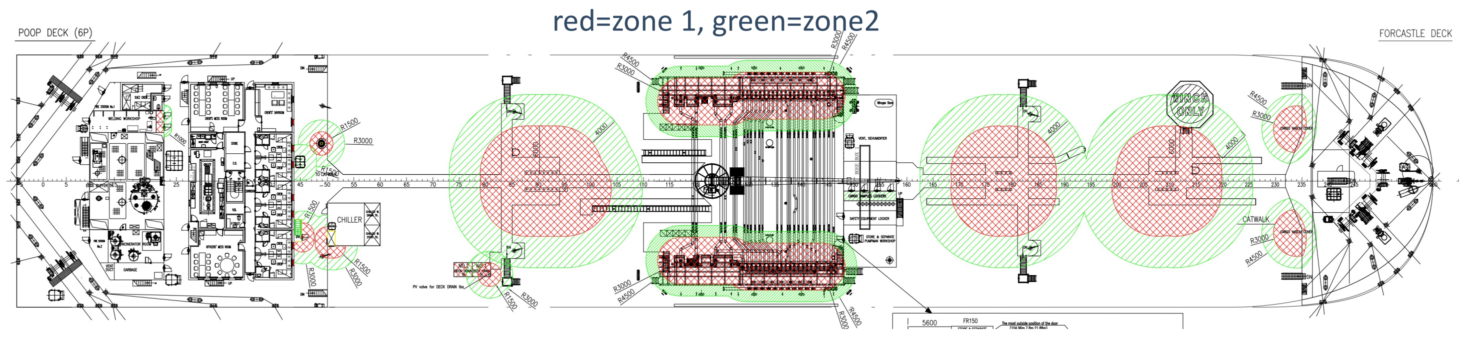
As the software SimaPro doesn't include discount rate, interest rate or NPV, the costs from SimaPro are exported and used to do further calculations on the costs. The graph on the right shows the profit in todays value of implementing rotor sails for different fuel prices. If the fuel price is above todays price, about 500 USD/t, it will be financially benficial to implement the rotor sails.

PROFIT AFTER IMPLEMENTING ROTOR SAILS



EXPLOSION ZONES AT HEIGHT OF ROTOR SAIL FOUNDATIONS

red=zone 1, green=zone2

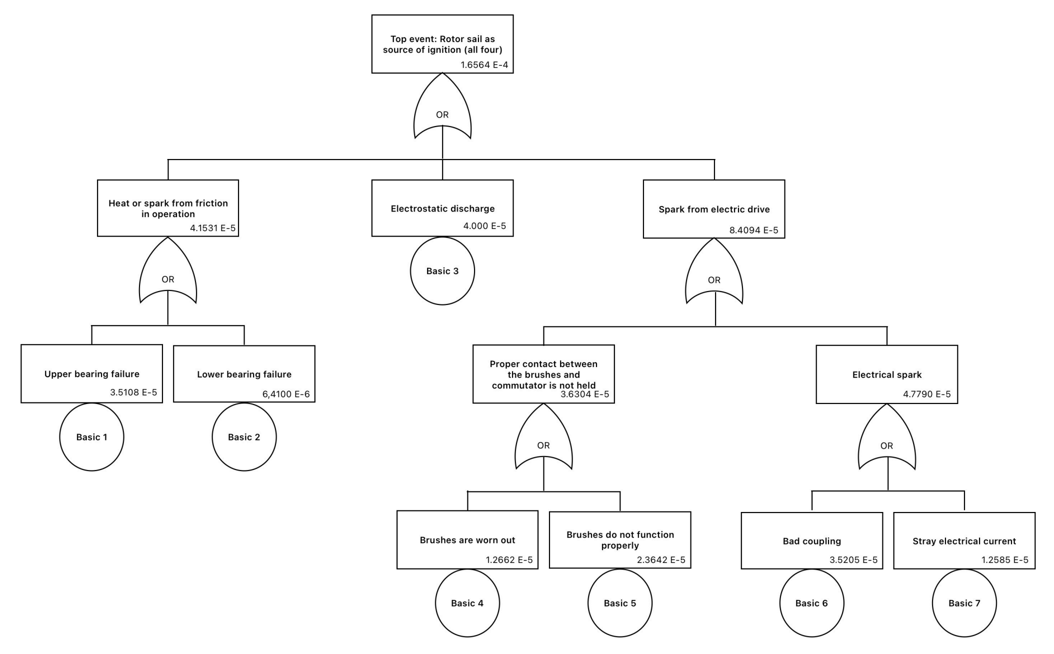


RISK ASSESSMENT

Installing the rotor sails on a ship will entail changing the already established system onboard. The ship is a chemical tanker, so it is at heightened risk of fire and explosion accidents. All parts of the ship are divided into explosion zones 0, 1, and 2. Zone 0 continuously has an explosive atmosphere, and zone 2 environments only have an explosive atmosphere for short periods. The explosion zones at the height we plan to place the rotor sails are shown in the figure to the right.

The explosion risk assessment found through the use of Fault Tree Analysis (FTA) and Event Tree Analysis (ETA) that the explosion risk increase after introducing the rotor sails was 0.0054% when the Rotor Sail is not ATEX compliant and 0.0027% when the rotor sail is ATEX compliant. The increase in explosion risk is not sufficient to add additional barriers.

FAULT TREE WITHOUT ATEX COMPLIANCY



REFERENCES
[1] NorsepowerNorsepower. Technology. url: https://www.norsepower.com/technology. (accessed:15.09.2022)
[2] International Organization for Standardization. "ISO 14040:2006, Environmental management - Life cycle assessment - Principles and framework". In: (2006)
[3] M. A. J. Huijbregts and et.al. ReCiPe 2016 : A harmonized life cycle impact assessment method at midpoint and endpoint level Report I: Characterization. Rijksinstituut voor Volksgezondheid en Milieu RIVM, 2017. url: http://hdl.handle.net/10029/620793