Assessing costs for new Swedish icebreakers: a 25-year perspective

Renewing Sweden's icebreaker fleet is a major infrastructure initiative. The existing icebreakers have been in operation for almost 50 years and the new icebreakers are expected to have a similar lifetime. Operational costs for such a long lifetime have a huge impact on the vessels' total life cycle costs. Based on a number of investigations of key features for a new icebreaker, SSPA has conducted life cycle cost (LCC) assessment of a new Swedish icebreaker.

The icebreakers and their activities are an essential feature of the Swedish infrastructure, allowing it to function in the winter and enabling the ports to be open all year round. Icebreakers provide merchant ship assistance by monitoring, directing, leading and towing. The Swedish Maritime Administration (SMA) is responsible for the Swedish icebreaking service and has conducted a prestudy on how the current icebreakers can be replaced. The study, which was submitted to the Swedish Government and the Board of the Swedish Maritime Administration, concludes that the design process of the first new icebreaker should begin shortly and by 2030 the five state-owned icebreakers currently in service will either be replaced or undergo a lifetime extension.

To support SMA's conclusions in the prestudy, SSPA conducted investigations of different aspects, including:

- Forecast of future tonnage in the Gulf of Bothnia
- Evaluation of alternative fuels
- Alternatives for hybrid solutions
- Evaluation of different propulsion concepts
- Overall feasibility studies of different options' capabilities

To support the decisions in an economic perspective, the life cycle costs of different propulsion concepts were assessed.

The Swedish Maritime Administration (SMA) is responsible for the Swedish icebreaking service. Their icebreaker fleet consists of Ale, Atle, Frej, Oden and Ymer.
Read more at www.sjofartsverket.se. Photo of the Swedish icebreaker Ymer. Courtesy of SMA.

LCC for different propulsion concepts

Life cycle cost analyses were conducted for different aspects; one aspect having a significant impact on the total cost is the propulsion solution. Several feasible solutions for the new icebreaker were investigated. The table presents the estimated costs over a period of 25 years for two of the investigated propulsion concepts. Since the costs are estimated to reflect the differences between alternatives, the figures below should not be considered to represent actual total costs.

Both concepts are diesel electric. Concept A consists of twin rudder and shaft propellers in the aft and twin shaft propellers in the fore, while concept B uses POD propulsion, two in the fore and two in the aft. Of the investigated concepts, concept B is assumed to yield the highest performance, whereas concept A will have weaker icebreaking and manoeuvring capabilities. Concept B will, however, impose additional costs of about SEK 200 million, corresponding to about 10% of the life cycle cost (LCC). The analysis thereby puts a price on the higher performance, which is crucial as a basis for decision-making in the design evaluation process.

Acquisition costs versus operational and service costs

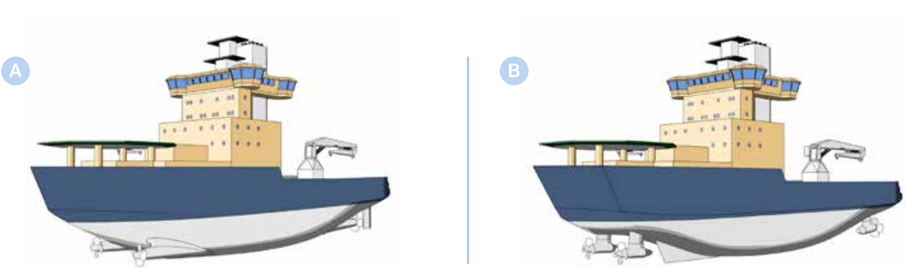
POD propulsion generally generates significantly higher acquisition costs as it includes more advanced technology and systems compared to shaft propellers. POD propulsion also generates significantly higher support costs. Concept A requires rudders, a factor which slightly increases fuel consumption and thus means higher operational costs. For 25 years of operation, the fuel savings using POD propulsion are not sufficient to compensate for the higher acquisition and service costs related to POD propulsion, and the total life cycle cost is thus higher for POD propulsion. However, as the difference in operational costs mainly relates to the fuel costs, the expected fuel price will have a major impact on the result.

Predicting future fuel prices

The fuel price development in a 25 years perspective is difficult to predict. Predicting the

Life cycle costs over a 25-year period for alternative propulsion concept, figures are normalised where Support Cost concept A is set to 1.

	Concept A 4 shaft propellers and 2 rudders	Concept B 4 POD
Acquisition Cost	9.3	13.2
Support Cost	1.0	3.0
Operational Cost low	19	18
Operational Cost medium	28	27
Operational Cost high	42	40
Life Cycle Cost low	29	34
Life Cycle Cost medium	38	43
Life Cycle Cost high	53	57



Concept A consists of twin rudder and shaft propellers in the aft and twin shaft propellers in the fore, while concept B uses POD propulsion (integrated electric motor/propeller unit mounted on the same shaft), two in the fore and two in the aft.

prices on a 50-year horizon, which is the actual expected time of operation for the icebreakers, would be associated with even greater uncertainty that would have made the analysis less valuable. It is also reasonable to believe that the icebreakers' operation will change within a 50-year period and they will probably have to be upgraded and re-built before that. A 25-year horizon was therefore assumed to be an appropriate time for analysis.

The analysis includes three fuel price scenarios. Probably none of the scenarios will correspond to reality and the figures are wrong. The scenarios do, however, serve as part of a sensitivity analysis, which must always be a central component of an LCC analysis.

Valuable despite high level of uncertainty

All costs are only estimates and based on available information. The analysis is thus associated with a high level of uncertainty for all sub-costs. Even though the accuracy might be low, the analysis has a high value since the process of performing the analysis can reveal future risks as well as potential costs. The sensitivity analysis may also facilitate the decision-making process as it may give a price for different risks. The uncertainty is thus not a reason to not conduct the analysis. Clearly, substantial costs will occur during all phases of the lifetime. Disregarding any of those, and not conducting an LCC, will lead to an even higher level of uncertainty as decisions are made based on unstructured guesses.

In the current analysis, not all costs are included. The main purpose of the analysis is to be able to compare alternative solutions. Common structures are omitted as the assumed costs for these may just increase the uncertainty and not add extra value to the analysis. The LCC analysis is just one tool for design decision-making. In this case, it enables monetary valuations of performance; is the higher performance with concept B worth additional costs of about 10%?

Strategies for low LCC for the entire process

For the yard building the vessel, the focus is generally on keeping the building and construction cost as low as possible. For the shipowner and operator, SMA in this case, the life cycle cost is of the utmost importance. To get the best result, the LCC aspects have to permeate the entire process of design, construction and building new icebreakers. With several parties involved in the process, including design company and yard, finding ways to get all parties to focus on LCC instead of low investment costs is essential.

The figures presented are a simplified example produced from several comprehensive investigations. The LCC conducted for project IB 2020 (Icebreaker 2020) involves a number of aspects and the outcome is used for comparisons of different design parameters, of which propulsion is one. The results of the LCC analysis are just one tool for decision-making in this matter.

All illustrations by SSPA.

Nelly Forsman

Project Manager

Nelly has an MSc in Sustainable Energy Systems, majoring in Mechanical Engineering. She graduated from Chalmers University of Technology in 2012. Since joining SSPA in 2014, Nelly has mainly worked on studies of alternative fuels for shipping, LNG bunkering, AIS analysis and maritime risk analysis. Nelly is also currently involved in research projects on winter navigation and ice-related projects. Prior to joining SSPA, Nelly also gained experience of numerous different permit processes.

Contact information

E-mail: nelly.forsman@sspa.se

Mikael Razola

Project Manager

Mikael received his PhD in the field of Study Maritime and Vehicle Engineering. He graduated from the Royal Institute of Technology (KTH) in Stockholm in 2016 and was employed at SSPA in 2017. He has mainly worked with optimising future ships and boats in several perspectives e.g. hull weight, cost, performance, environment and autonomy (unmanned ships).

Contact information

E-mail: mikael.razola@sspa.se