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Life cycle cost (LCC) as a tool for improving sustainability in the Norwegian fishing fleet

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ABSTRACT

Systems engineering principles in fisheries management may structure and improve the decision-making process. Sustainability in the fishing fleet is comprised of economic, environmental, and social dimensions. Even though the total system value may be constituted by economic factors and technical factors, non-market issues, such as environmental and social issues, have an increasingly important impact on the economic performance of a system or company. Life cycle cost (LCC) is related to the systems engineering process, because economic considerations are very important in the process of creating systems. LCC involves evaluation of all future costs related to the life cycle of a system. The main objective of this article is to discuss the usefulness of LCC as a method to enhance sustainable designs of fishing vessels for ship owners, and to improve the decision-bases for fisheries management.

1. Introduction

Overcapacity is a major threat to sustainable fisheries [1]. More effective fishing vessels and catching gear contribute to increased catch capacity, which causes problems such as overexploitation and pressures to enlarge the quotas. The problem of overcapacity implies a stronger integration of technological aspects into fisheries management [2,3]. Technical and social systems increase in their complexity and vulnerability, and human-made systems, such as the fisheries, are not in conformance with carrying capacities of natural systems.

The technological perspective on fisheries management is facilitated through systems engineering, which is a multi-disciplinary approach that enables the realization of successful systems. Systems engineering has been introduced as an interdisciplinary, systematic, and holistic approach to problem solving in fisheries management, rooted in the engineering disciplines [3,4]. The systems engineering process expands on the common sense strategy of understanding a problem before seeking to solve it, examining alternative solutions, and verifying that the chosen solution is correct before implementing it. Use of the systems engineering process in fisheries management may give increased visibility of the system alternatives and trade-offs; therefore it can reduce the risks associated with the decision-making processes [3].

Life cycle cost (LCC) is related to the systems engineering process, because economic considerations are very important in the process of creating systems. Life cycle economic analyses should be done early in the system or product life cycle, because the outcome of the systems engineering process cannot be influenced very much when the design is completed. Use of procurement costs is an easy criterion for decisions of acquisition, but it may result in bad financial decisions as the major costs may appear during system operation and maintenance. Thus, LCC involves evaluation of all future costs related to design, construction and/or production, distribution, operation, maintenance and support, retirement, and material disposal; that means all of the phases in the system life cycle [5]. The process of systems engineering and the system life cycle are illustrated in Fig. 1.

The main objective of this article is to discuss the usefulness of the LCC approach for ship owners in making sustainable fishing vessel investment decisions, and for fisheries management to improve their decision-bases. The total system value is constituted by economic factors (benefits/costs) and technical factors (operating characteristics) [6]. However, non-market issues, such as environmental and social issues, may have important impacts on the economic performance of a system or company [7]. LCC has been proposed as an environmental accounting tool useful in environmental decision-making or to be used in parallel with a Life Cycle Assessment (LCA), see e.g. Refs. [8–10].

In most projects regarding the design of fishing vessels, financial issues are the limiting factor. However, there is a growing focus on other sustainability issues, such as energy efficiency due to increasing fuel prices [11,12], safety due to the high accident risk in the fisheries [13–15], and emissions of greenhouse gases and acidification due to Norwegian commitments to the Kyoto Agreement and the Gothenburgh Protocol [16,17]. The following discussion attempts to include such costs in the LCC analysis.

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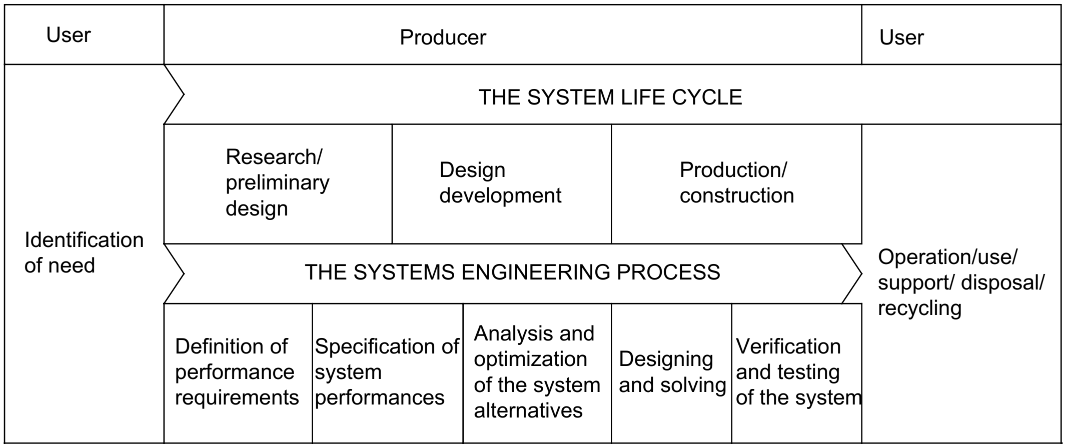

Fig. 1. The relationship between the systems engineering process and the system life cycle. Based on Refs. [3,5].

In a former study, five different Norwegian cod-fishing vessel groups were assessed on six attributes within three sustainability dimensions; the economic, environmental, and social. The former evaluation is used as a basis for the discussion about LCC in this article. The sustainability attributes of the Norwegian fishing fleet are shown in Fig. 2. Six of them have been evaluated in Ref. [4], and all seven have been further discussed in Ref. [18]. The attributes were identified based on objectives of the Norwegian fisheries management, and may be used to evaluate sustainability of a specific fishing vessel as well. The article is structured according to the steps of the LCC method.

2. The LCC analysis method – from a perspective of sustainable development

LCC has been applied since the 1960s when the United States' Department of Defense stimulated the development and application of LCC to enhance its cost effectiveness. Defense systems, such as an aircraft or a special land vehicle, are ideal for LCC analyses since the Department of Defense mainly controls the entire life cycle [19]. LCC has moved from defense systems to industrial and consumer product areas, where each user controls only a portion of the actual life cycle of the system.

LCC may be defined as "the cost of acquisition, ownership, and disposal of a product over a defined period of its life cycle" [20,21]. LCC is a standard engineering economic approach to be used for choosing among alternative products or designs that provide approximately the same service to the customer [22]. In many cases it may not be necessary to perform a complete LCC analysis, but rather to estimate the differences between the alternatives for the major cost elements [23]. The LCC process may also provide information, for example, in the assessment of the economic viability of products and projects, in the identification of the cost drivers and cost efficiency improvements, in evaluations of different strategies for product operation, maintenance, inspection, and so on [24].

Cost models may range from simple to complex, and are essentially predictive in nature. Parameters, such as the system's physical environment, usage demand, reliability, maintainability, labour, energy, taxes, inflation, and the time value of money, may have a great impact on the life cycle costs [19]. There are various ways of doing LCC, for example analogy models, parametric models, and engineering cost models [20]. Choice of model is dependent on available resources, time, data, and the need for accuracy. An LCC through an analogy model identifies a similar product and adjusts the differences in costs between the products. This is a common way of doing LCC in shipbuilding, where costs are related to mass factor [25]. Parametric models utilize statistical methods, where the objective is to establish a functional relationship between changes in cost and the dependent factor(s) such as weight, lot size etc. [5]. A parametric model is thus more advanced than an analogy model, which is only dependent on one single, dominant cost driver, with a linear relationship [25]. The engineering cost model estimates capital and operational cost data when more detailed information is needed than found in an analogy or parametric model, however, complexity is increasing because costs are assigned to each system element at the lowest level of detail [5].

2.1. LCC and the environmental dimension of sustainability

According to "Our Common Future", the report of the World Commission on Environment and Development (WCED) [26], sustainable development requires high economic growth rates in developing countries and moderate to low growth rates in developed countries. However, sustainable development also requires a change in the content of growth, to make it less material – and energy – intensive and more equitable in its impact. Ecological problems caused by exploitation of natural resources have to be taken into consideration, and maintenance has to be prioritized. This means that economic growth cannot be the only priority at the sacrifice of the environment. A lot of criticism has been raised on the possible contradiction between the drive towards higher profits and sustainability [27,28].

Following the publication of the WCED report [26], increased emphasis has been put on the use of economic instruments to modify the behavior of actors towards the environment. Environmental objectives are merged with economic policies, e.g., through economic valuation of the environment [29]. Measuring environmental improvements in monetary may be done by estimating the costs of the improvements and the extra benefits. Benefit measurements may be interpreted in different ways, depending on stakeholders' preferences reflected in their "willingness to pay" (WTP). Sometimes WTP may excess the market prices, and this excess is known as consumer surplus. A complimentary concept is "willingness to accept" (WTA), which asks how much money should be paid to compensate for an environmental loss. Stakeholders may view gains and losses differently, and consequently WTP and WTA may differ. A significant difference may create problems difficult to resolve [30]. Economic valuation is normally a part of cost-benefit analysis, multi-criteria analysis, and natural resource damage assessments [29].

Environmental issues and consequences should be considered in LCC calculations [20]. LCC has been suggested as a cost-accounting