

# Discrete-event simulation application for integrated energy efficient shipping

Onder Canbulat – University of Strathclyde

Umran Kaya – University of Strathclyde

Osman Turan – University of Strathclyde

Evangelos Boulougouris – University of Strathclyde

Energy is a strength and one of the most indispensable resources for maritime transport activities. Efficient utilising of energy is crucial to protect the limited sources and marine environment. The energy usage in shipping is generally port and fleet operations oriented. Therefore, minimisation of this consumption added significant value to the maritime supply chain system. Energy efficiency and port operation are widely mentioned in the current literature. However, there is still a research gap on the ship-port interface regarding energy efficiency. These complex logistic chains ought to comprise port performance to reduce certain delays to make a better energy-efficient system. This examination aims to improve our understanding of port and ship operations based on energy efficiency. A modelling framework is developed to investigate how ports and ships could work together to reduce energy consumption and maximise the efficient operation time. According to the integrated concept of shipping, the system is analysed to create a case study application of a container port discrete-event simulation application (DES) with ARENA software, which aims to support the fleet and port optimisation as well. In this research, one of the primary container ports in Europe was taken as a case study to analyse the operation of the port. ARENA application on a case study showed that considering the integrated system's energy efficiency instead of only port energy efficiency, the whole system's energy consumption and CO<sub>2</sub> pollution have around 6% improvement in the port area. The case study also clearly demonstrates that ship operation is the main contributor and has a more significant effect on the integrated system. This research may assist in understanding the whole model of the maritime transportation of container shipping. This research creates a solution to analyse the energy efficiency of the ship and port integration which is a gap in the literature.

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