A REVIEW OF ENERGY EFFICIENCY IMPLEMENTATION BARRIERS IN THE MARITIME SHIPPING SECTOR

Mohamed E. Elbawab [(1)i], Fawzy F. Dekinesh [(2)]

(1) Engineering Department, Sea Training Institute, Arab Academy for Science, Technology and Maritime Transport, Alexandria, Egypt, mohamedelbawab111@yahoo.com

(2) Natural Gas & Petrochemical Department, Integrated Simulator Complex, Arab Academy for Science, Technology and Maritime Transport, Alexandria, Egypt, fawzydekinesh1977@gmail.com

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ABSTRACT: United Nations Sustainable Development Goals (UNSDGs), climate change, International Maritime Organization (IMO) initial strategy on the reduction of greenhouse gas (GHG) emissions from ships, environmental impact, carbon footprint, carbon price, competitive advantage and Corporate Social Responsibility (CSR) have driven the maritime shipping sector to consider and enhance energy efficiency. However, a significant number of barriers prevent cost-effective energy-saving technologies/measures. This study aims to identify and addresses the recently existed barriers by conducting literature review for the most recent research articles in the maritime energy efficiency domain. The outcomes of this study would help the shipping companies, maritime energy manager to overcome most of the maritime energy efficiency implementation barriers while acting the energy efficiency management plan. Researcher and policymaker also can get the benefit of this study as they can discover a new area for future research related to energy efficiency in the shipping sector.

INTRODUCTION

The increasing growth of the international sea born trade gives significant importance to maritime transport, in fact, more than 90% in volume of world cargo is transported by ships, between 2000-2015 the energy demand of the international shipping and ports has increased in annual average rate by 1.6% [1]. As a result of increasing energy demand the energy cost, air pollutant and GHG emission have increased. Energy cost directly increasing operational cost therefor every shipping company endeavour to reduce energy consumption (economic benefit) consequently became energy efficient which directly contribute to sustainability, green shipping and emission reduction (environment benefit). The global awareness adopted by the United Nations Framework Convention on Climate Change (UNFCCC) towards air emissions issues under international agreement called Kyoto protocol. Led the IMO to adopt long term strategies and set of rules in The International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI, which came into force 2005. In 2013 a new chapter on energy efficiency entered into force with Energy Efficiency Design Index requirements (EEDI) for new ships and Energy Efficiency Operational Index (EEOI) for all ships was associated with the concerns in the shipping sector to find an efficient approach to comply with IMO requirements for both technological and operational measures. Moreover, IMO set a GHG emission reduction target to at least 40 % by 2030 and 70 % by 2050 compared to 2008 level [2]. International shipping accounted for 3.1 % (CO_2), 13 % (NOx) and 12 % (SOx) of the annual global emissions for the 2007-2014 period [3]. The shipping sector is currently facing stringent environmental legislation to improve their energy performance; Besides the legislation, some shipping companies are embracing sustainable operations for a positive social image such as the adoption of CSR programs hence, improves their competitive advantages [4]. Although energy efficiency is the cost-effective energy-saving technologies/measures, still a significant number of barriers prevent energy efficiency implementation. This study aims to review the latest research articles to stand on the current maritime energy efficiency implementation barriers and categorize/gather them in one document to help the maritime energy manager to overcome barriers and undertake most optimum decision while implementing energy efficiency measures in their organization.

LITERATURE REVIEW/ BACKGROUND

The energy efficiency definitions are varied in literature linguistically but have the same goal, such as "using less energy to handle the required work at the same standard" as per [5]. While Rehmatulla and smith, are defining energy efficiency as "increase production at the same level of power consumption" [6]. The same scenario has repeated while defining the "barrier" but the most appropriate definition adopted by the authors that a barrier can be described as an alleged process preventing investment in energy-efficient, economically efficient technology [7].

Many maritime experts believe that shipping has a high untapped potential to reduce energy consumption. Part of this potential so-called "low hanging fruit" is easy to achieve at zero or minimum cost, but the other part refers to energy-saving measures requiring a feasibility study, cost-benefit analysis and prudent investment. Based on the literature review it has been proved that energy efficiency gap is visible. The current energy efficiency deficit (gap) has been established as a consequence of barriers to energy efficiency [8]. Energy efficiency gap may also define as the difference between the ideal and actual implementation of energy efficiency measures Figure 1[6].

Johnson and Anderson stated that although cost-effective energy efficiency measures in shipping, but it has not been implemented significantly in the maritime sector [9]. Furthermore, it can be clearly seen from overviewing the literature that the complexity in the maritime sector due to the wide range of stakeholders regarding energy efficiency implementation measures are contributing negatively. Every stakeholder is seeking his favour regardless of the more extensive energy-efficient goal. Jafarzadeh and Utne are categorizing the stakeholders into the main three groups, firstly, external parties which subcategorized to authorities, costumer, class/insurance, suppliers and banks.

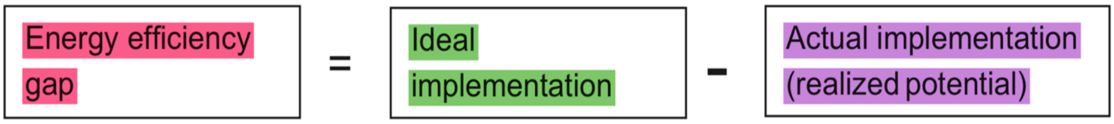

Figure:1 Energy Efficiency Gap source: [6]

Secondly, shipowner which subcategorized to the maritime department, shipowner, economy department, technical supervisor, new building and manning/personnel. Lastly, "ship" which also subcategorized to captain, chief mate, navigation mate, bosun, Steward, chief engineer and engineers [10]. Jafarzadeh and Utne aimed from the proposed categorization to create a framework for visualizing the barriers to stakeholders and help them identifying and prioritize the barriers to find optimum solutions easer [10]. However, the most detailed categorizing for energy efficiency barriers in the maritime sector founded in literature was the one carried out by Rehmatulla in his PhD Thesis Figure 2 [11].

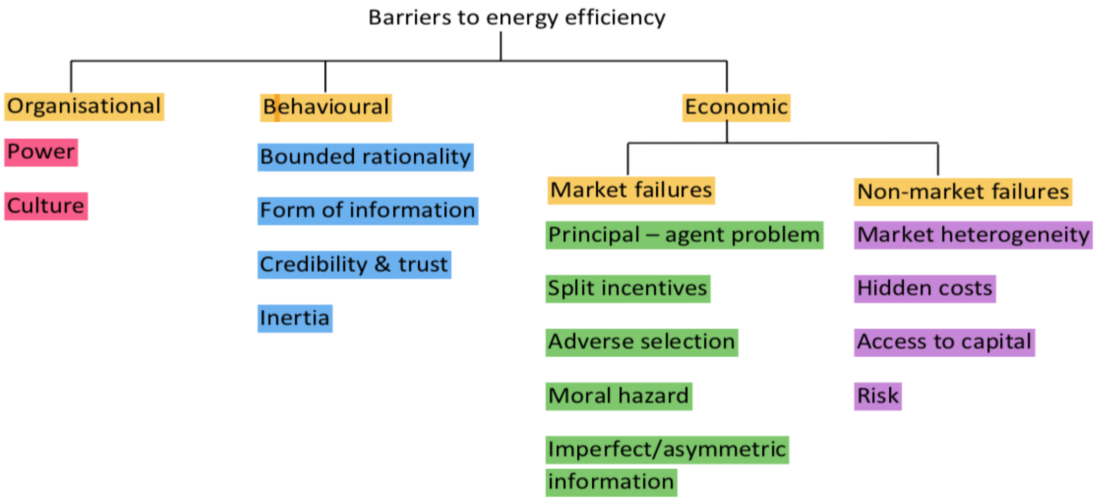

Figure: 2 Energy efficiency barriers Taxonomy, adopted from source: [11]

Although the barriers to energy efficiency in shipping are not widely discussed in the published literature, more recently, shipping experts concentrate on this subject as a key activity in recognizing and alleviating these barriers. Various approaches to the definition and classification of barriers could be clarified by dissecting and reviewing the literature. Jafarzadeh and Utne are stated that the barriers are grouped into seven main categories as followed. (i) Information barriers, (ii) Economic barriers,

(iii) Intra-organizational barriers, (iv) Inter-organizational barriers, (v) Technological barriers, (vi) Policy barriers, and (vii) Geographical barriers [10].

Dewan, Yaakob and Suzana, after detailed scrutiny, they got very similar conclusions in compare with Jafarzadeh and Utne result [12]. With a focus on decision-making challenges in selecting the best emission reduction measure, Olcer and Ballini interpret this as a barrier [13]. Rehmatulla and Smith while defining the energy paradox they focused mainly in economic barriers in shipping sector to end with two categories market failure and non-market failure. They believe that non-market failures include: heterogeneity, risk, hidden costs and access to capital and market failures includes: information problems, split incentives, bounded rationality, inertia, values, credibility and trust [6,11].

Kitada and Olcer advocated that the barriers could be categorized as follows: safety and reliability, technical uncertainty, behavioural barriers, market constraints, financial and economic constraints and finally complexity. In addition, they interpret the managerial difficulties in auditing the work done by the subsidiary or outsourced firms as a barrier [14]. Thus, the on-hand research will handle the energy efficiency barriers in maritime shipping sector as categorized at the global level under the auspices of International Maritime Organization referring the existence of barriers in one or more of the three main areas: human element, policy and regulation and finally technical and innovation.

HUMAN ELEMENT BARRIERS

When new technology is introduced to the human element, the way he/she responds to it often varies depending on the situation and condition affecting the human or the technology, which appears in the form of a special relationship dependent on many factors [15]. In 2000 Dobie called this interaction by "Human-technological". Also, stated that human element plays a crucial role either in ship design or in ship operation. Human-technological interaction is extended to routine operation and controlling during emergencies [16]. Onboard vessels, there are several technologies and energy efficiency measures. The selection of those options and how it will be handled professionally are essential at the decision-making phase. Decision making in the design process such as the optimization of hull form to lower the wave making resistance and fractional resistance.

Moreover, to attain the EEDI formula by naval architectures they need a full overview of analysis from the different perspectives in the design process. In ship operation, trim optimization as an example challenges the decision-making onboard vessels while finding optimum voyage performance due to various ship types and voyages. Moreover, decision makers face challenge to analyse multiple attributes along with their trade-offs [13].

In energy efficiency matters that includes a new technology or/and a new software that will requires training the ship's crew to enhance their competences is associated with a major concern to achieve the targeted energy efficient operational skill. Otherwise, the main objective of fuel saving will not be attained [15]. Human resource management cannot be separated from discussion about training. Considering the fact that manning expense represents half of the operational cost, maintaining the efficiency of manning is related to cost and energy saving. The management of shipping companies responsible for this matter for the sake of sustainable competitive advantage [17].

POLICY AND REGULATION BARRIERS

Several studies were concluded to show that the shipping industry could achieve energy efficiency gains through the implementation of a comprehensive energy management system like Ship Energy Efficiency Management Plan (SEEMP), with considerable reductions of fuel costs and emissions. Even though the economic and social benefits of this management system are well known, businesses are still reluctant to adopt it because of the so-called energy efficiency gap. Dewan stated that policy and legislation affairs are a vital barrier to energy efficiency implementation [12]. The policy barriers are illustrated as follow:

Policy formation barriers

These barriers originated due to the following reasons:

(1) Government involvement.
(2) Diverse incentives by different stakeholders.
(3) Nonunified interpretation of incoming policy.
(4) Compliance with local, national, and international environmental requirements [18].

Government participation in making policy may hinder the small companies to achieve the decided ambitious standards in the developed countries. In contrast, the government involvement in developing countries with a limited vision towards energy efficiency may limit future benefits due to slack tracking. The difference in motivation between stakeholders may affect the policymaking, the best example time charter contract which govern the relationship between shipowner and charter regarding fuel consumption.

Policy implementation barriers

These barriers originated due to the following reasons:

(1) Lack of awareness and training.
(2) Low motivation and commitment.
(3) Policy intersection.
(4) Not implementing at multiple levels.
(5) Management structure [12].

The shortage in providing training in some companies will lead consequently to incompetent crew hinder the effectiveness of energy efficiency measure, for example, trim optimization it was always taken by the rule of thumb, sailing with ship trimmed by aft will have the minimum exerted resistance on the hull. Still, the modern Computational Fluid Dynamics (CFD) modelling has proved the falseness of trim by aft hypothesis.

TECHNICAL AND INNOVATION BARRIERS

The shipping industry is the very energy-intense industry, like 50% of the total of the tanker company cost is the energy cost [9]. Therefore, implementing energy efficiency onboard is essential, and there are already exists measures such as bow optimization, ducted propeller, waste heat recovery [19], but the technical barrier still exists as a gap for implementation. As stated by Utne and Jafarzadeh, technological barriers include technical risk, immatureness, the complexity of measures, improvement likeliness and mutually exclusive energy-saving measures [10]. Barriers accord to technology concern includes lack of or limited technology supply chain in some states, lack of technology base for Research and Development (R&D) in some states and lack of trust in the ability to reduce emission as well as operational costs [19]. Besides, the lack of trained human power, high initial cost and lack of awareness of technology are the barriers for the technology concern. There also a lack of awareness with renewable energy towards better energy efficiency enhancement due to the barrier of its price [20]. Although the availability of several innovative technologies in energy efficiency, the implementation still at an inconsiderable level that may be attributed to the absence of energy efficiency concept awareness [12].

Statistical data analysis carried out by Dewan on a sample group of vessels and shipping companies regarding innovative energy efficiency measures implementing percentages, the results found to be supporting for the claim of the energy efficiency gap and showed that approximately one-third of the sample are applying energy efficiency devices through retrofitting, while, propeller polishing and hull cleaning were represented by 12% and 11% respectively [12].

DISCUSSION

Referring to barriers mentioned above, it could be realized that some links somehow interconnect the barriers against energy efficiency, and they cannot be separated indeed. Enacting new regulation is dependent on technology maturity and human element ability and level of knowledge. The footprint of cost barrier could be observed at the other barriers; for instance, the cost of research in technology and innovation, cost of compliance with new regulations and cost of training for human resources.

After reviewing the literature, it can be seen that the human element as a barrier is the most critical energy efficiency implementation hinder due to the crucial human role in all the process steps starting from understanding, finding, planning, enacting, investing, auditing, learning, teaching, innovating, developing and implementing. the complexity of the human emotion and moods, understanding the different psychological conditions for human, for example, the relation between productivity and loyalty which may sustained through adoption of CSR program.

Moreover, the novelty of the topic led to a shortage of specialized expertise in the field of maritime energy management, World Maritime University (WMU) founded by the IMO in 1983 aiming to promote capacity building and provide marine expertise with the required up to date skills. Recently, WMU established the master degree in Maritime Energy Management (MEM) to fulfil the current maritime energy domain needs [21]. Thus, the above statement supports the author claim that the shortage of maritime energy management expertise considered a significant barrier to energy-efficient implementation. Further, Arab Academy for Science, Technology and Maritime Transport (AASTMT) as a leading maritime institution in the middle-east region and Africa, the member of International Association of Maritime Universities (IAMU) has realized this issue, in response AASTMT has signed Memorandum of Understanding (MoU) with WMU regarding knowledge transfer in the maritime sector through scholarships in maritime energy management.

United Nations 2030 agenda issued in 2015, climate change, 2020 Sulphur cap, GHG periodical reduction targets and NOx tire III are a rapid set of rules and guidelines have driven the maritime stakeholders to act rashly toward implementation through hiring maritime energy experts who are in scarcity and insufficient for worldwide implementation. Thus, it may explain the significant gap in well understanding the IMO regulations, policies, and measures regarding energy efficiency and illustrates the cause of defected implementation in some cases within the international maritime sector.

After an intensive analysis of the literature, have proven certainty that the technology currently used has not reached the maturity needed to support the requirements of the stage. The maritime sector faces the inevitability of change towards clean energy sources as an essential prerequisite for sustainable development and an effective tool to limit the phenomenon of climate change. However, some barriers limit reaching the desired goal, for instance, the limited spaces available on ships to accommodate and install clean and renewable energy systems along with the low rates of energy harvesting from sources to the form that energy used in it, to illustrate, converting solar energy or wind energy into electricity. A further new challenge is a limited ability to store the energy produced. As an example, high capital cost batteries with limited capacities.

CONCLUSION

To conclude, maritime transport is the most cost-efficient mode of transportation, which explains the steady growth in seaborne trade. As a consequence, emissions from the marine sector predicted to increase. The environmental awareness improvement has driven the specialists in the maritime field to keep pace with international environmental requirements and the efforts of the United Nations towards reducing air emissions and their impacts. The United Nations assigned the International Maritime Organization, through the Kyoto protocol, to control and mitigate GHG emissions from the maritime sector. IMO has adopted a set of studies to identify and address the causes, shipping sector share of air emissions and the possible remedies. As a result of the effort made, the International Maritime Organization has adopted some regulatory measures to improve the energy efficiency of ships by adding Chapter 4 to Annex VI of the MARPOL convention.

Since then, ship owners have obliged to comply with this new energy efficiency measures, either technical or operational. Such as the initiation of EEDI within the new build ships and the introduction of SEEMP to all ships. Although the proposed energy efficiency measures are cost-effective, the current energy efficiency implementation level is not yet matured attributed to several barriers claimed to be hinder implementing efficiently causing what called the energy efficiency gap. The barriers were traced and categorized and prioritized differently in the literature. The IMO introduced one of the presented categories. Authors have adopted the IMO approach, which covers three main areas of barriers; human element barriers; policy and regulation barriers and technical & innovation barriers.

The finding of this study indicated as follow: firstly, the human element is the most critical energy efficiency implementation hinder since he is a member of all the stakeholder's parties and involving in all the process levels such as enacting, learning, teaching, auditing, innovating, implementing, Secondly, the misleading approach to the policy and regulations due to the shortage of maritime energy management experts to manage the implementation process, the novelty of the topic, rapid set of rules and guidelines adopted has driven the maritime stakeholders to act rashly.Thirdly, immaturity of the technical and innovative measures, for instance, limited harvesting and storage capacity for renewable energy resources and their converters productivity rates.

RECOMMENDATIONS

(1) Corporate Social Responsibility to be adopted by shipping companies in order to obtain a high level of productivity and gain crew loyalty.
(2) Establishing an energy efficiency training program for building capacity at all levels from managerial to vocational.
(3) Promoting education at the university level through including energy efficiency topics to the curriculum.
(4) Promote more investment on research and development to well understand the potential of renewable energy sources implementation onboard vessels.

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[i] Chief Eng. Mohamed Elbawab, BSc in Marine Engineering 2002 (AASTMT) Alexandria, master degree in the Maritime Affairs (Maritime Energy Management) (WMU) Malmo, Sweden Nov.2018. Postgraduate Diploma in Marine Engineering (AASTMT) Oct.2019, works as Lecturer in the Sea Training Institute, Arab Academy for Science, Technology and Maritime Transport.