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The Insurance Business Perspective on the Risk of Transporting Electric Vehicles by Sea

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Magdalena Klopott[1], Ilona Urbanyi-Popiolek[2]

Abstract:

Purpose: *The primary objective of this article is to explore insurers' perspectives on the risks associated with the maritime transport of electric vehicles (EVs), whose production and sales have been rising steadily in recent years, introducing new challenges and potential hazards to maritime shipping.*
Design/Methodology/Approach: *To achieve the study's objective, a combined approach of desk research and open-ended interviews was chosen. The desk research relied on secondary data, including analysis of the EV sales market, data on ship and cargo losses due to EV-related fires, shipowner regulations on EV carriage, and industry reports from reputable sources (e.g., IUMI, IMO, EMSA). To capture insurers' perspectives, a qualitative method using open-ended interviews was selected as the most suitable approach.*
Findings: *The research reveals that the maritime transport of electric vehicles presents specific risks primarily due to the presence of lithium-ion batteries. Insurance policies must address these risks; however, uncertainties regarding EV-related incidents and firefighting limitations have led insurers to impose strict coverage limits or, in some cases, deny comprehensive coverage. These concerns also extend to hull insurance and shipowners' liability, as marine insurers exercise caution due to the evolving nature of these risks. Developing standardized procedures for transport and firefighting is essential, with standards endorsed by insurers, insurance associations, and regulatory bodies like the IMO.*
Practical Implications: *With the rising presence of electric vehicles on board the vessels the risks are growing. Recognising and mitigating these risks is essential to protect the safety and security of all parties involved in maritime transport. This research underscores the need for insurers to re-evaluate policy coverage for EV shipments, including specific protections for lithium-ion battery hazards.*
Originality/Value: *This issue is both recent and crucial for marine insurers, cargo owners (e.g., EV manufacturers) and shipowners. Given its evolving nature, there is minimal literature on the topic, with only limited industry reports available. Existing literature mainly covers the technical challenges of lithium-ion battery construction, operation, and fire suppression, but it does so exclusively from a safety engineering perspective.*

Keywords: *Maritime transport, electric vehicles risk, insurance.*

JEL Classification: *G22, K29, L91.*
Paper type: *Research paper.*

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[1]*Dr., Gdynia Maritime University, Faculty of Management and Quality Science, Poland, e-mail: m.klopott@wznj.umg.edu.pl;*
[2]*Dr., the same as in 1, e-mail: i.urbanyi@wznj.umg.edu.pl;*

1. Introduction

Transport responsible for 24% of global greenhouse gas emissions (approximately 8 Gt CO_2 in 2022) and accounts for 27% of emissions from European Union countries. In the EU, road transport alone is responsible for 72% of all transport emissions (IEA, 2021; Aminzadegan *et al.,* 2022).

From a climate change perspective, emissions from the transport sector are a significant and increasingly visible contributor to global warming. This fact, together with the depletion of non-renewable energy sources, has led to a pronounced trend in recent years towards the search for alternative sources of this energy to conventional fuels.

These efforts are based on a variety of environmental policy instruments, both economic and regulatory (existing or planned), which impose, directly or indirectly, an obligation to reduce pollutants (SOx, NOx, CO_2) from fuel combustion on those operating means of transport (e.g., shipowners, airlines, road carriers). Such initiatives include include, for example, the "2023 IMO Strategy on Reduction of GHG Emission from Ships", which aims to decarbonise shipping, or the EU's landmark "FIT for 55" programme designed to reduce the EU's GHG emissions by 55% by 2030.

These ambitious policies play a pivotal role in driving global interest in alternative sources of energy. One such source is electricity, currently considered essential primarily for decarbonising road transport. Consequently, it is electric vehicles (EVs), including hybrid electric vehicle (HEV) and pure battery electric vehicle (BEV), that are now considered particularly critical in this transition.

It is important to acknowledge that the long-term viability of electricity as a source of energy for vehicles is a topic of ongoing debate. The environmental impact of electric vehicles is dependent on the manner in which electricity is generated in different geographical regions. Furthermore, the manufacture of electric vehicles (EVs) has considerable environmental consequences.

Consequently, electric vehicles are not universally regarded as environmentally friendly (Pipitone *et al.,* 2021). Notwithstanding the controversy, production and sales of EVs continue to grow, reflecting the effectiveness of forward-looking policies in expanding the electric car market, even in the face of some reluctance.

The growing demand for electric vehicles has been accompanied by an increase in the sea transport of this type of cargo, as well as the emergence of a new face of a long-known risk in maritime transport, namely fire. Reports of maritime accidents involving this specific cargo have led to the formulation of research questions: a) What are the new risks and challenges associated with the maritime transport of electric vehicles? b) What measures would need to be taken to ensure that the transport of electric vehicles does not present greater risks than those previously known for the transport of internal combustion vehicles? c) What is the impact of these risks on the underwriting of insurance contracts and the settlement of potential claims?

The main objective of this article is therefore to examine the insurers' perspective on the risk associated with the maritime transport of electric vehicles. This is a very recent and important issue and from the point of view of both the owners of the cargo (EVs) and the owners of the ships carrying them. Given the relatively new and evolving nature of this topic there is no literature on the subject, apart from for some limited industry reports.

The existing literature on this topic is extensive and addresses the technical and technological challenges associated with the construction and operation of lithium-ion batteries, as well as the procedures for extinguishing fires originating from such batteries. However, it is presented purely from a safety engineering perspective.

2. Methodology and Literature Review

In order to respond to the research questions and achieve the objective set forth in the Introduction, it was determined that a combination of two methods would be most effective: desk research and open-ended interviews. The desk research was based on secondary data, including an analysis of the EV sales market, a search for information on losses and damage to ships and cargo related to fires and the carriage of EVs, an analysis of the regulations of selected shipowners regarding the carriage of EVs, and an analysis of industry reports published on reliable websites and by reputable industry bodies (e.g., IUMI, IMO, EMSA).

In order to gain insight into the perspective of insurers, a qualitative research method was selected as the most appropriate for this study. Given the nature of the topic, it was deemed appropriate to adopt an open-ended interview approach. The interviews were conducted during the final week of May 2024.

A total of five respondents from the insurance industry were invited to participate in the interview. These included three insurance brokers specialising in risk analysis and two employees of insurers operating in the transport insurance market, offering a range of services including cargo insurance. Only these individuals expressed willingness to participate in the study, indicating that they possessed sufficient knowledge of the topic to contribute meaningfully to the interview.

2.1 Global Market of Electric Vehicles

As documented in the International Energy Agency's (IEA) "Global EV Outlook 2023" (IEA, 2023) that the electric vehicle (EV) market experienced significant growth in 2022, with over 10 million units sold, representing about 14% of all new cars sold globally (from just 5% in 20200. The report predicted continued growth, which was subsequently confirmed by data from 2023, which showed that nearly 14 million new EVs had been registered worldwide.

As a result, the total number of electric vehicles in operation approached 40 million by the end of 2023. (IEA, 2023). This represents a remarkable 35% year-on-year increase, with 3.5 million more electric vehicles sold in 2023 compared to 2022. This is six times the number sold just five years earlier in 2018.

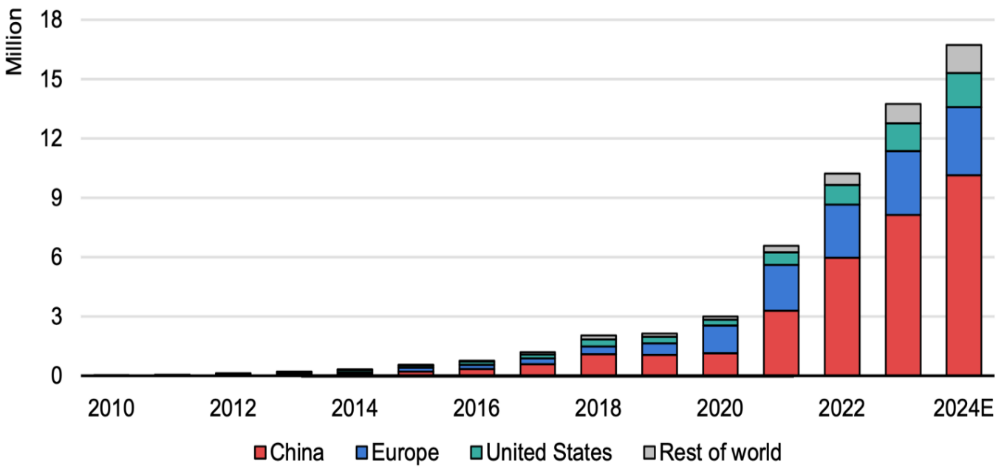
The upward trajectory persisted into the initial quarter of 2024, with sales surpassing 3 million units, representing a 25% surge compared to the corresponding period in 2023. It is projected that by the end of 2024, the annual sales figure will reach approximately 17 million units (IEA, 2024).

The global market for electric vehicles is currently dominated by three key markets: (IEA, 2024):

- China accounts for approximately 60% of global electric vehicle (EV) sales, having already exceeded its target for 2025.
- Europe – sales of electric vehicles (EVs) increased by over 15% in 2022 and by approximately 25% in 2023.
- United States – the EV market share reached 8% in 2022, representing a 55% increase, and rose to 10% in 2023.

It is anticipated that these trends will persist as the electric vehicle market matures and technological advancements drive further growth.

Figure 1. *Global electric cars sales 2010-2024*



Source: *IEA, Global EV Outlook 2024.*

Analogous growth trends are evident in the sales of electric vehicles extending beyond passenger cars, including heavy-duty trucks, buses, electric light commercial vehicles (LCVs), and two- and three-wheelers. In 2023, global sales of these vehicles increased by over 50%, with Europe experiencing a notable 60% growth in electric LCVs. In the two- and three-wheeler segment, China, India, and the Association of Southeast Asian Nations (ASEAN) collectively account for 95% of global sales, representing a 30% increase compared to 2022. These countries continue to be significant exporters to Latin America, North America, and Europe.

With regard to the production of electric vehicles, China is the dominant player in the global automotive industry, significantly outpacing manufacturers from the United States and Europe. In 2023, the Chinese company BYD produced 3,014,692 electric cars, with Tesla and Volkswagen producing 1,811,088 and 1,010,263 units, respectively. In Germany, of the 4.1 million cars produced in 2023, 1.27 million were equipped with electric engines, including both battery electric and plug-in hybrid vehicles, with 955,000 of these being purely electric (Wehrman, 2024)

The production and sales of electric vehicles are set to continue growing, driven by the implementation of ambitious environmental policies in many countries. In Europe, for instance, governments have established a goal for the transportation sector to achieve zero emissions by 2050. Similarly, countries such as China are providing significant government support with the objective of accelerating the transition to electric mobility. These policies, in conjunction with an increase in consumer demand and advancements in electric vehicle technology, are anticipated to drive sustained growth in the EV market (Virta, 2024).

2.2 Electric Vehicles in Shipping – the New Face of an Old Risk

As global demand for electric vehicles (EVs) continues to increase, the necessity for their maritime transportation will concomitantly expand, thereby intensifying the risk exposure for shipowners. It is important to note that the maritime transport of EVs occurs primarily in two forms. Firstly, substantial quantities of EVs are frequently transported as cargo on dedicated vessels, such as Pure Car and Truck Carriers (PCTC) or Pure Car Carriers (PCC), which are specifically designed to accommodate significant volumes, up to 6,000 cars and trucks per voyage. The transportation of smaller consignments of EVs may also be undertaken in standard containers aboard containerships.

Additionally, the rising number of EVs on the road translates into a growing demand for ferry transport, as some EV owners - such as individual passengers or road carriers - require ferry crossings. Although EVs travelling with passengers on ferries are legally classified as personal vehicles rather than cargo, they are transported on roll-on/roll-off (ro-ro) vessels, such as ro-pax or passenger ferries, which raises specific safety considerations.

The primary safety concern associated with transporting electric vehicles by sea arises from the lithium-ion (Li-ion) batteries they use, which can be classified as hazardous materials.

The transport of hazardous goods by sea is governed by stringent international regulations, notably the International Maritime Dangerous Goods (IMDG) Code. This code functions as an extension of the safety standards outlined in Chapter VII of the International Convention for the Safety of Life at Sea (SOLAS) and is based on the United Nations Recommendations on the Transport of Dangerous Goods, which set foundational safety requirements across all modes of transport (IMO, 2018)

Currently, Li-ion batteries are classified under Class 9 (Miscellaneous Dangerous Goods) in the IMDG Code under UN numbers 3480 and UN 3481, due to their dual chemical and electrical hazards. Vehicles powered by Li-ion batteries are specifically classified as "UN3171 battery-powered vehicle" under the same code. The IMDG Code's Special Provision 961 offers potential exemptions for EVs from classification as hazardous goods, provided they meet the criteria established in this provision. However, EVs that do not fulfill these criteria must be declared as dangerous goods. Furthermore, electric vehicles transported on container ships must be declared as hazardous goods without exception. (IMO IMDG Code, n.d.)

It is important to point out that in May 2024, the International Maritime Organization's (IMO) Maritime Safety Committee adopted significant amendments to the IMDG Code provided in Resolution MSC.556(108) "Amendments to the International Maritime Dangerous Goods (IMDG) Code" (IMO MSC, 2024), in which much attention was paid specifically to the carriage of lithium batteries.

Among the key updates, the amendments stipulate that lithium batteries must meet the testing requirements outlined in the Manual of Tests and Criteria, including pre-production prototypes being transported for testing purposes. Vehicles containing such batteries will be required to adhere to Special Provisions (SP376).

Additionally, the amendments introduce new entries within Class 9 to distinguish between different types of lithium-powered vehicles:

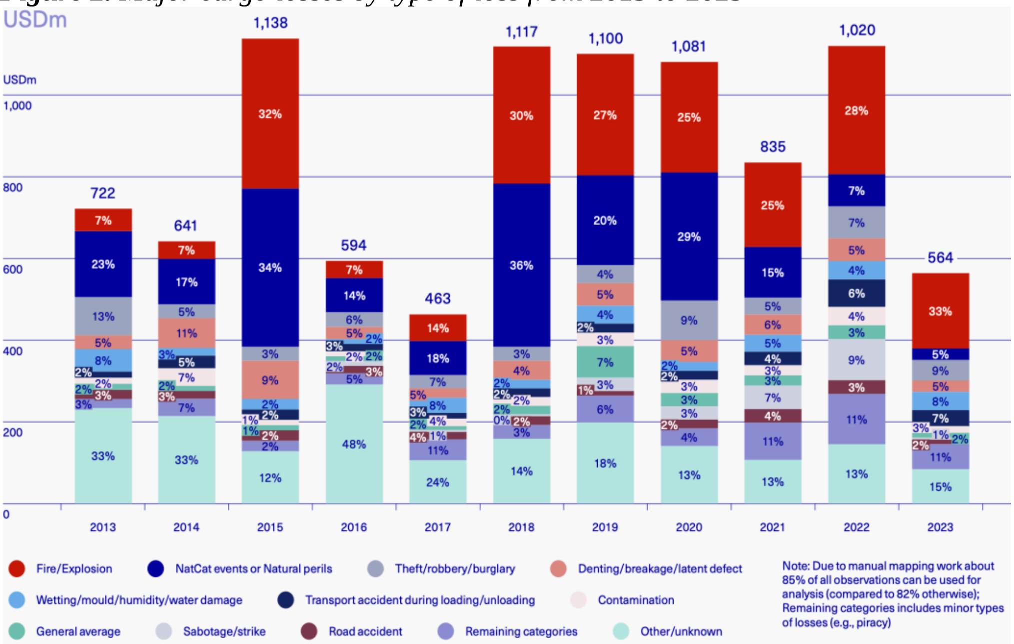
- 3556 vehicle, lithium ion battery powered
- 3557 vehicle, lithium metal battery powered.

With these changes, lithium batteries are now removed from the previously used classification "UN3171 lithium battery-powered vehicle." Implementation of these updated requirements, in part or in full, will begin on a voluntary basis from 1 January 2025, with full compliance becoming mandatory on 1 January 2026 (IMO, 2018).

One of the biggest safety concerns while transporting EVs is a risk of fire ignition. Fire as a risk have long been one of the greatest threats to seagoing vessels, and despite technological advancements over the centuries, this risk, as the statistics prove, remains significant.

According to Allianz Global Corporate & Specialty (AGCS), between January 1, 2017, and December 31, 2021, fires accounted for approximately €9.2 billion in claims, making them the most costly cause of loss, responsible for 18% of the total value of all claims during that period (AGCS, 2022). The same trend is also supported by data from the International Union of Marine Insurance (IUMI), which confirms in its report that cargo fires on shipping vessels are becoming an increasingly frequent problem and are responsible for numerous fatalities and significant damage. From 2021 onwards, it is the risk of fire on ships that ranks first in terms of the value of claims paid out due to loss and damage to cargo (IUMI, 2024).

Figure 2. *Major cargo losses by type of loss from 2013 to 2023*



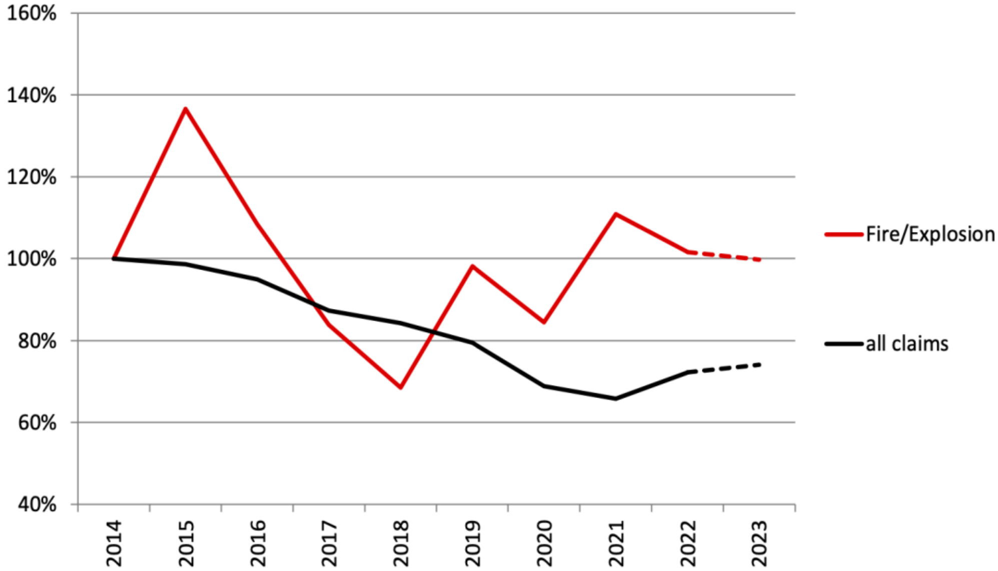
Source: *IUMI's 2024 Analysis of the Global Marine Insurance Market.*

Fires on ships have become the predominant risk, not only in terms of the severity of the losses suffered (the amount of compensation paid out), but also in terms of their frequency of occurrence, which differs significantly from other risks, far outweighing them.

This is confirmed by the data provided in the report "Ocean Hull Trends" of the Nordic Association of Marine Insurers (CEFOR, 2024).

As reported by CEFOR (2024), the year 2023 marked the first occasion in over a decade that individual hull insurance claims following ship fires have exceeded US$50 million. The data provided by CEFOR, which covers 46% of the global fleet of vessels larger than 20,000 GT, clearly demonstrates the ongoing concern regarding ship fires and the subsequent significant claims, which are in part a consequence of the trend towards larger and higher-value vessels, but also driven by the growing share of hazardous cargoes, including lithium-ion batteries and EVs.

Figure 3. *Index of fire and explosion claims against all claims (2014 = 100%)*



Source: *CEFOR, Ocean Hull Trends, 2024.*

Recent high-profile fires on car carriers have sparked speculation that EVs were the source of ignition, intensifying concerns about the safety of transporting these vehicles by sea. In light of these incidents, some shipping companies have begun refusing to transport electric vehicles, citing the increased risk after several ships either caught fire or sank while carrying them. Fires on ships in European waters in recent years further underscore the dangers associated with electric generators and batteries on board.

One notable incident occurred in February 2022, when the m/s “Felicity Ace”, a vessel owned by Mitsui OSK Lines (MOL), caught fire off the coast of the Portuguese Azores. The blaze, which started on the car decks, quickly spread throughout the 656-meter vessel. Despite attempts to salvage the ship, it was lost after drifting for two weeks in the Atlantic.

Fortunately, the crew was safely evacuated, but the ship and its cargo of about 4,000 luxury cars, primarily Porsches, Bentleys, Audis, and Volkswagens, were unsalvageable, resulting in losses valued at $400 million (The Maritime Executive, 2022). According to ship's cargo manifest there were 281 EVs (EV FireSafe, 2022).

Another widely publicized incident is the fire aboard the PCTC vessel "Fremantle Highway" which occurred in July 2023. The ship, transporting over 3,800 vehicles from Europe to the U.S. - including around 500 electric vehicles - caught fire off the Dutch coast, tragically resulting in the loss of a seafarer (Lloyds's List, 2023). The fire caused the death of one crew member as well as significant economic damage and it is almost certain that the vessel will be written off as a constructive total loss.

While the precise cause of the fire may never be determined, it is widely believed that the presence of lithium-ion (Li-ion) batteries on board significantly worsened the fire conditions. Indeed, the sea transport of electric vehicles gives rise to a distinct set of risks that differ from those associated with the transportation of vehicles powered by internal combustion engines (ICEVs). The most significant risks and issues associated with electric vehicle fires are outlined below:

1. Risk of fire in the event of a thermal runaway of a battery cell.

Thermal runaway in lithium-ion batteries is the phenomenon of exothermic chain reactions within the battery. These reactions typically result in a rapid elevation of the internal temperature of the battery, which can potentially lead to combustion or even an explosion (Shahid and Agelin-Chaab, 2022). This is also the main cause, along with mechanical and electrical failures, of total battery failure. The most common feature of all abusive condition is an internal short circuit. Thermal runaway represents a significant scientific challenge in the field of battery safety research. (Feng *et al.,* 2018).

2. Difficult to stop/extinguish thermal runway.

A thermal runway is difficult to extinguish unless fire-fighting agent (e.g. water) is directly injected into the battery to enable efficient cooling of the battery cells (Lashifire, 2022). In the absence of intervention (cooling), the internal temperature of the battery will continue to rise, thereby increasing the risk of fire spreading and explosion if the resulting gases accumulate. Most modern EVs are equipped with internal cooling system to maintain the battery temperature. Modern batteries are designed to vent rather than explode, but vented gases must be removed from any enclosed spaces to avoid pressure build-up and explosion (AMSA, 2023). The sheer amount of water needed presents a challenge on board, as it may compromise ship stability. Extinguishing an electric car fire may require a large amount of water, as much as 10 m^3 (flow rate of 200 litres per minute). It should be noted, however, that approximately two cubic metres of water are required to extinguish a fire in a combustion car (Węglarz *et al.,* 2024).

3. Long lasting re-ignition risk.

Another issue associated with EV battery fires is the significantly elevated probability of the vehicle reigniting. It is possible for a fire to be reignited weeks or even months after the initial incident that caused it. It is not sufficient to rely on water cooling alone to prevent the chemical chain reaction that causes a fire; it merely slows down the process. Once the cooling process is halted, the heat generated by the chemical chain reaction will increase significantly, thereby increasing the likelihood of re-ignition. To illustrate, the fire on the "Felicity Ace" burned for more than a week, whereas a fire on her sister ship, the "Sincerity Ace", took between nine and ten days to extinguish.

4. Toxic gases and gas explosion.

The release of toxic gases in the presence of an ignition source can result in a gas explosion (EMSA, 2023). The combustion of an electric vehicle (EV) is characterised by a more dynamic development and significantly faster smoke emission in the initial phase of the fire than that observed in the combustion of a conventional internal combustion engine (ICE) vehicle (IUMI, 2023). For each kilowatt hour (kWh) of battery power, approximately 6,000 litres of gases are produced. For instance, a single 55 kWh battery can generate up to 330,000 litres of these gases (AMSA, 2023). The presence of these gases presents a significant hazard to crew members attempting to extinguish the fire in an enclosed space, such as a ship's cargo hold.

5. Jet flames.

One of the principal dangers faced by firefighting team members is the hazard of a jet fire, coupled with the potential of electrocution. In hybrid vehicles, the risks of battery and hydrocarbon fires occur simultaneously (Węglarz *et al.*, 2024). Jet flames can reach a maximum length of 7-10 m and persist for approximately 1-2 minutes. Additionally, they frequently contribute to the spread of fires on ships (EMSA, 2022).

3. Research Results and Discussion

All interviewees concur that safety concerns pertaining to the maritime transportation of electric vehicles have recently given rise to considerable emotional responses and uncertainty within the market. The issue is multifaceted and can be examined from the perspectives of the shipper (the cargo owner of EVs), the shipowner, the cargo or casco insurer, and the shipowner's liability insurer. Each of these parties may possess a distinct and disparate perspective.

An increasing number of shipping companies are either declining or limiting the transportation of electric vehicles in the wake of a series of high-profile incidents, including fires and the sinking of vessels carrying EV cargo. To illustrate, the Norwegian ferry owner Havila Kystruten has ceased transporting EVs and hybrid vehicles.

This decision was reached following comprehensive risk assessments that identified a number of potential hazards associated with carrying non-fossil-fuel vehicles, limited fire-fighting capabilities, the dangers of water-based fire suppression to a vessel's stability, and the significant number of passengers at risk from Li-ion battery fires (Havila Voyages, nd.) In particular, shipping operators are increasingly electing to refrain from transporting used electric vehicles that present an elevated risk.

Wallenius Wilhelmsen, a market leader in roll-on/roll-off (roro) shipping and vehicle logistics, has introduced restrictions and curtailed carriage of used electric vehicles due to the "unpredictability" of such vehicles. In accordance with the company's "Customer Guide," used electric buses and vehicles must be certified as having not been involved in any form of incident (crash) and may only be transported if the battery is free of leakage and protected from short-circuiting (Wallenius Wilhelmsen, n.d.). The Japanese company Mitsui OSK Lines (MOL) has recently announced its intention to phase out the transportation of used battery-powered cars (MOL, 2022).

According to respondents, this shift is primarily driven by difficulties in securing adequate insurance coverage, as insurers are often reluctant to fully cover EV shipments or impose stringent limitations on coverage. These issues also extend to hull (casco) insurance and shipowners' liability insurance when transporting EVs, reflecting a cautious stance by marine insurers due to the relatively new and evolving risks associated with EV transport. It is crucial to consider that insurers rely on substantial data to assess and price premiums accurately.

This necessitates information on both the frequency and severity of potential losses posed by a given risk. However, the paucity of data pertaining to EV-related maritime risks has resulted in a reluctance to provide coverage or a tendency to impose higher premiums, in accordance with industry norms for emerging risks.

The respondents indicated that the insurance market for electric vehicles during maritime transport is currently characterised by a high degree of uncertainty. This uncertainty pertains to the insurance of EVs during maritime transport and to the insurance of the maritime carrier responsible for transporting this cargo.

The current situation may be described as a state of stalemate. There is considerable concern about the potential for litigation against shipowners in relation to damage to cargo or their civil liability. Moreover, shippers (e.g., exporters) of electric vehicles may also be held legally liable in the event that these vehicles are transferred for transport.

To illustrate, Allianz, the insurer of m/v "Felicity Ace", and the shipowner (MOL) have initiated separate legal proceedings against Volkswagen Group, holding the automaker accountable for the fire and subsequent sinking of the car carrier (e.g., by MOL sued for 30 million euros). The plaintiffs allege that the fire originated in the lithium-ion battery of the Porsche model and accuse VW of failing to inform them of the inherent dangers and the necessary precautions needed to transport such vehicles.

It seems probable that the legal proceedings initiated by Allianz and Mitsui OSK Lines will continue over a period of several years. (Lloyd's List, 2024) As respondents have highlighted, there are already significant challenges ahead for insurers who are underwriting cargo of EVs, ship hulls and machinery, containers, and storage facilities handling damaged EVs.

It was observed by respondents that in the context of cargo damage, it is crucial to recognise the exemption of maritime carriers from liability for damage and loss of cargo resulting from fire. This is the case, for example, when the carriage takes place under a bill of lading that refers to the Hague-Visby Rules (HVR) or when the terms of the charterparty also refer to such. In accordance with Article IV, Rule 2(b) of the Hague-Visby Rules (HVR), the fire exception states that "neither the carrier nor the ship shall be responsible for loss or damage arising or resulting from fire, unless caused by the actual fault or privity of the carrier."

However, respondents highlighted a crucial legal point, namely the shipowner's obligation to exercise due diligence in ensuring the vessel's seaworthiness at the commencement of the voyage and its suitability for carrying specific cargo (cargoworthiness), as outlined in Article III, Rule 1 of the Hague-Visby Rules.

In light of the court rulings, two of the interviewees questioned whether a vessel could be considered seaworthy if it lacked the requisite equipment and crew training to address electric vehicle fires, which differ significantly from fires involving traditional internal combustion engine vehicles. The consequences of such shortcomings can be significant, and failure to address these issues could prevent a shipowner from claiming exemption from liability due to fire.

In the course of the interview, the interviewee made reference to the 2021 CMA CGM Libra case, in which the issues of the seaworthiness of the vessel, as well as the 'prudent owner test', were subjected to rigorous examination. The ruling of this court also made reference to the carriage of dangerous cargo on a ship, despite the fact that the case in question pertained to a different incident. In essence, the Court resolved a long-standing controversy regarding the potential for dangerous cargo (including EVs or Li-ion batteries) to render a ship unseaworthy.

The Court acknowledged that the presence of a dangerous cargo could result in unseaworthiness, thereby establishing liability for carriers who fail to demonstrate due diligence in managing these risks. To substantiate this assertion, one interviewee presented a court ruling from the case (ruling UKSC 51, available at Russel and Coffer, 2021).

The question of whether the vessel was seaworthy or not is measured against the prudent owner test, which is a precedent established in English maritime law in the early nineteenth century[i]. In light of the specific hazards associated with the transportation of EVs and Li-ion batteries, questions remain regarding the potential breach of the duty of due diligence that may result from accepting these cargoes, and the subsequent risk of rendering the vessel unseaworthy from the outset. Conversely, the insurer will not be held liable for the loss of the EV cargo, as it can invoke the standard exclusion of its liability as outlined in the cargo policy, in the event of a latent defect or "inherent vice or nature of the cargo".

The key question arises as to whether the fire risk associated with the carriage of EVs is genuinely greater compared to internal combustion engine (ICE) vehicles? Respondents noted the absence of consensus within the insurance industry on this point: while some blame EVs and lithium-ion batteries for major ship fires, others find no substantial evidence that EV fires pose greater danger. However, insurers remain cautious and resist underestimating the risk.

As mentioned above, the insurance sector still lack data to develop meaningful and precise insurance statistics on EV fires. One interviewee noted that the lack of data is actually a positive sign, indicating that there are not that many incidents occurring. Nonetheless, incomplete data and ongoing investigations of recent cases mean that comprehensive conclusions are not yet possible. Another interviewee emphasized that the relatively low number of current incidents does not necessarily indicate a low risk level, as limited data makes it challenging to accurately assess risk from a mathematical standpoint.

Notwithstanding the above dilemmas, reports of a high risk of electric vehicle fires have not been supported by research. It appears that fires involving BEVs are less likely than fires involving internal combustion engine (ICE) vehicles in relation to the total number of vehicles (ICE vehicles are 60 times more likely to catch fire). (AMSA, 2023; Hynynen *et al.*, 2023).

On the other hand, it is a fact that EVs fires can escalate more quickly, and have significant consequences due to their unique characteristics that prolong firefighting efforts. Even if one were to agree that EV fires are no more probable than fires in conventional combustion engine vehicles, they require different preventive and control measures.

However, Decades of experience and established protocols exist for managing fires in fuel-powered vehicles, whereas the marine industry currently lacks similar protocols for EVs. Therefore, developing such procedures as soon as possible is essential for effective risk management in EV transport.

Respondents emphasized the urgent need for consistent and uniform regulations to reduce uncertainty, mitigate litigation risks, and enhance safety for crews, cargo, vessels, and the environment. Unified recommendations and regulatory frameworks are essential, as current guidelines, such as for example, to name a few, EMSA’s guidance, the UK Government’s Marine Guidance Note (MGN) 653 (M), the Polish

Registry of Shipping, and the U.S. National Safety Board guidelines - are fragmented, incomplete, and lack legal enforceability.

One significant document in this area is the position paper released by the International Union of Marine Insurance (IUMI) in August 2023, titled "Best Practice & Recommendations for the Safe Carriage of Electric Vehicles (EVs)" (IUMI, 2023). Respondents had high expectations that this document would alleviate many of the uncertainties surrounding insurance for EV cargo and the vessels carrying them, but it fell short of this goal.

It is worth noting that IUMI is a prominent organization within the insurance market, comprising 42 national and marine insurance and reinsurance associations. Despite its influential role, the IUMI position paper, only eight pages long, added little to existing guidance. According to respondents, it did not clarify the pressing doubts that plague theinsurance industry in relation to insuring maritime transport of EVs.

Instead, they viewed the paper as a recognition of the industry's own uncertainties and a brief outline of the primary safety principles for EV transport and fire suppression methods. Additionally, it signaled IUMI's anticipation of forthcoming outcomes from the IMO's work on safety standards, specifically amendments to SOLAS and Fire Safety Systems.

Indeed, the International Maritime Organization (IMO) Sub-Committee on Ship Systems and Equipment (SSE) began work in March 2024 on the "Evaluation of Adequacy of Fire Protection, Detection, and Extinction Arrangements in Vehicle, Special Category, and Ro-Ro Spaces to Reduce the Fire Risk of Ships Carrying New Energy Vehicles." By May 2024, the IMO had already adopted amendments to the IMDG Code, reflecting the urgency of addressing fire risks associated with transporting new energy vehicles on vessels.

Respondents acknowledged that they are waiting for consistent and comprehensive loss prevention and risk reduction measures to be developed. In particular, they have high hopes for the work of the IMO. In the absence of generally applicable guidelines, the current fire precautions and procedures in the event of an EV fire, although clearly inadequate for fire protection on a ro-ro ship, are of great importance and should be taken into account when carrying EV cargoes. These loss prevention and risk reduction measures include, but are not limited to, the basic procedures outlined below:

- The early detection of fires is of critical importance in reducing the response time for firefighting. This can be achieved through the use of advanced technologies such as thermal imaging and AI-enhanced systems, which can enhance the capabilities of traditional firefighting techniques. In November 2023, MOL announced plans to install security cameras powered by artificial intelligence on 10 new LNG-fuelled car carriers currently under construction. The company also indicated its intention to retrofit existing in-service vessels with the same system. (MOL, 2023) The prompt detection and response to fires are of the utmost importance for effective fire management, with fixed systems being given precedence over manual firefighting on PCTCs.

- The deployment of firefighting methods, including drencher systems, rapidly deployed CO_2 systems supported by video monitoring, dry powder extinguishers, foam suppression systems, and aqueous film-forming foam, has been demonstrated to be an effective approach for the mitigation of fires on ro-ro and ro-pax vessels carrying both electric and internal combustion engine vehicles. It should be noted, however, that some of these methods are not designed for use in the event of a fire involving lithium-ion batteries. While these methods can undoubtedly assist in preventing the spread of fires, they do not address the fundamental issue of thermal runaway in EV batteries. Furthermore, they may have limitations in extinguishing an EV fire that has been self-sustaining for an extended period. Furthermore, the supply of foam and CO_2 is limited, and once these extinguishing agents have been deployed, they are no longer available for use on the ship (Solum and Nielsen, 2023).

- A clear cargo acceptance policy is crucial, particularly for screening used vehicles for hidden damage (EMSA, 2022).

- It is of the utmost importance to consider the knowledge and skills of individuals in this context. It is imperative that employees receive comprehensive training on the correct procedures for EV packaging and handling. Similarly, the ship's crew must undergo rigorous training to ensure they are able to extinguish lithium-ion battery fires before EVs are permitted on board. Furthermore, it is essential that the crew is well-versed in the safety data outlining the process and precautions to be taken in the event of an accident (EMSA, 2022).

- Guidance should be prepared on the state of charge (SoC) of the battery, which is at the optimum level for transport. The SoC of the battery is important and ideally should be kept to a minimum to mitigate against risks of overheating and short-circuits. Some regulations and some manufacturers may have specific guidelines on SoC. This varies from 30% to 50%, depending on the manufacturer's recommendations and the length of the journey (Steamship Mutual, 2023; EMSA, 2022).

The IUMI document additionally indicates that the charging of electric vehicles (EVs) on ropax vessels may be permitted if a comprehensive risk assessment is conducted, as EV safety features are usually active during charging. (IUMI, 2023) It is reasonable to conclude that passengers would appreciate the availability of charging stations on board ropax and ferries, particularly given the extended travel times (up to 10 hours).

Nevertheless, all respondents concurred that such a possibility is currently untenable. One insurer explicitly stated that the vessel in question would not be insured if onboard charging facilities were introduced.

One noteworthy and unanticipated theme emerged throughout the course of the interview. One interviewee referenced the perspective of an insurance company loss prevention manager who asserted that ships designed to transport vehicles powered by internal combustion engines are not suitable to accommodate vehicles powered by lithium-ion batteries. It was also recommended that a new car carrier vessel be designed or that existing ones be retrofitted to address the firefighting issues that arise when carrying EVS at sea.

However, it is likely that this recommendation will be met with significant opposition from shipowners, who would be responsible for bearing the financial burden of extensive retrofitting of their PCTC fleet to reconfigure deck spacing and firefighting systems.

4. Conclusions, Proposals, Recommendations

Maritime transport of electric vehicles presents unique risks, primarily due to the presence of lithium-ion batteries, which bring heightened hazards of battery damage, fire and explosions, as well as increased liability in the event of accidents. To address these risks, insurance policies must provide specific protections, yet uncertainties about EV-related incidents and firefighting limitations have led insurers to impose stringent coverage limits or, in some cases, to refuse comprehensive coverage for EV shipments.

These concerns are also affecting hull (casco) insurance and shipowners' liability insurance, as marine insurers exercise caution given the relatively new and evolving nature of these risks.

A comprehensive understanding of the risks posed by EV cargoes to vessels and crew is critical. A recent study highlighted a significant knowledge gap among stakeholders, revealing that many do not fully understand the challenges associated with transporting EVs by sea (Kirkels *et al.*, 2022). This gap underscores the urgent need for better education and risk assessment to effectively manage these complexities.

While the maritime industry has long managed the transport of dangerous goods, it is unrealistic to expect shipowners to avoid EV shipments altogether in the long term. Instead, the development of standardized transport and fire-fighting procedures is essential. These standards must be accepted by insurers, insurance associations, and regulatory bodies as e.g., the International Maritime Organisation (IMO) to protect crews, vessels, and the environment.

Adapting existing regulatory frameworks, including the IMDG Code, SOLAS Convention, and fire training protocols, to address the unique challenges of EV shipping is also crucial.

In addition, shippers should collaborate with experienced insurers and shipping companies that understand the unique challenges posed by EV transport. Ongoing work at the IMO is promising, and the amendments to the IMDG Code in 2024 through the resolution of IMO's Maritime Safety Committee represent a significant step in making these regulations more targeted and responsive to the emerging environment.

With the rising presence of lithium-ion batteries on board roro vessels and ferries, the risks are growing. Recognising and mitigating these risks is essential to protect the safety and security of all parties involved in maritime transport.

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[i] *„(…) the duty to supply a seaworthy ship is not equivalent to a duty to provide of that is perfect, and such as cannot break down except under extraordinary peril. What is meant is that she must have that degree of fitness, which an ordinary careful and prudent owner would require his vessel to have at the commencement of her voyage, having regard to all the probable circumstances of it. To that extent the shipowner, as we have seen, undertakes absolutely, that she is fit; and ignorance is no excuse. If the defect existed, the question to put is, would a prudent shipowner have required that it should be made good before sending his ship to sea had he known of it? If he would, the ship is not seaworthy within the meaning of the undertaking" (Carver, 1900).*