IMDG Code for

Lithium-Ion Battery Reverse Logistics

Proposals for the Development of New UN Code Provisions for the Maritime Transportation of Used Lithium Ion Batteries for Reuse & Recycling Purpose

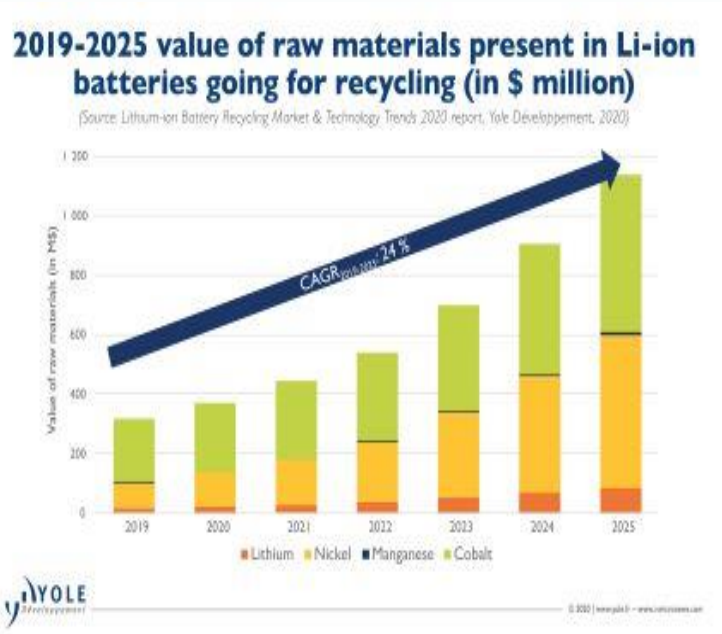
Team **Love ReLiB**

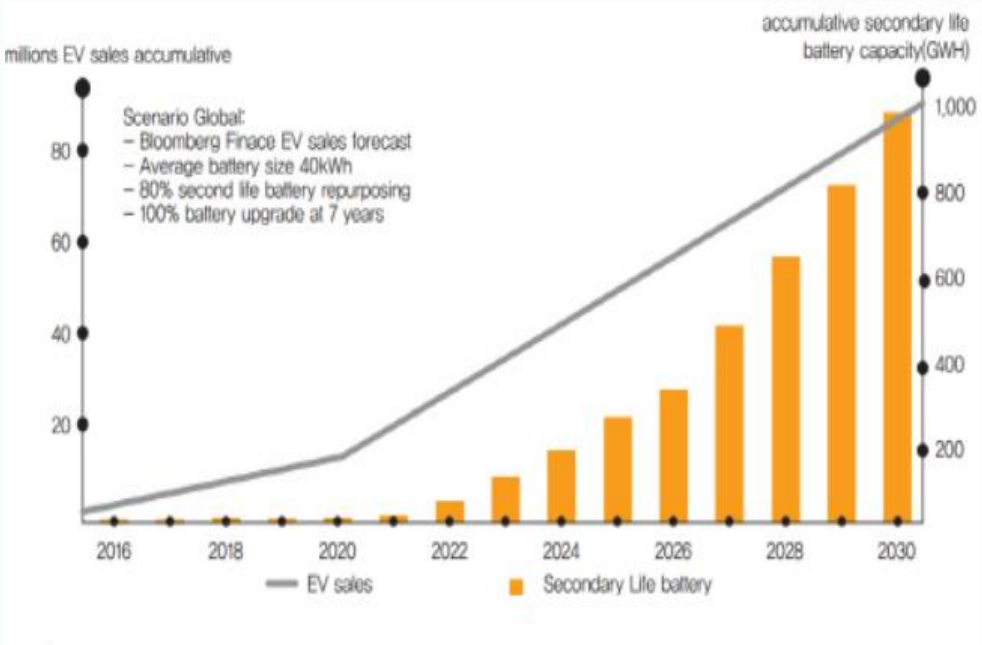
Index

1. IMO's Objectives and Expected Benefits

[Background] Growing Usage of Reused and Recycled Lithium-Ion Batteries

CURRENTLY 3~5% ► More than 50% Increase in Near Future





Source: Lithium-ion Battery Recycling Market & Technology Trends 2020 report, (Yole Development,2020)

IMO's Objectives

Our Proposal and IMO

Understanding the International Maritime Organization (IMO)

The International Maritime Organization's objectives can be best summed up by its slogan—"Safe, secure and efficient shipping on clean oceans." Basically, the IMO sets policy for international shipping, discouraging shippers from compromising on safety, security and environmental performance to address financial concerns, and encouraging innovation and efficiency.

IMO's Strategic Plan	Indicators
SD1	**Improve implementation**- Assessing the effectiveness of IMO, Uniform Implementation
SD6	**Ensure regulatory effectiveness** (IMO,IMSAS)- Development and review of IMO regulations

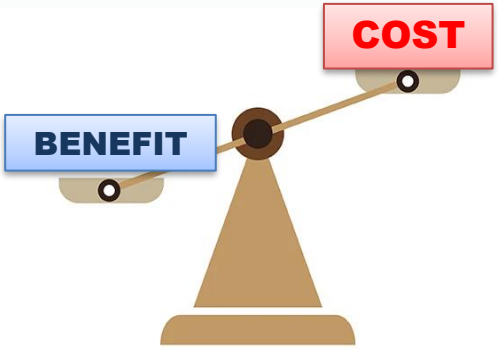
SAFE and SUSTAINABLE shipping by adopting the highest practicable standards of MARITIME SAFETY

Benefits & Importance of Reuse and Recycling

Why Need to Discuss Reuse & Recycling?

Savings from recycling cathode materials from the end-of-life LIB relative to the use of virgin materials

	Cost				Energy		$CO_{2\text{-Eq}}$			
	LCO	NMC333	NMC811	LFP	LCO	LMO	LCO	NMC333	LMO	LCO
Pyrometallurgy	38%	6%	5% more		35%		70%	78%		70%
Hydrometallurgy	41%	13%	1%		38%	18%			5%	
Direct Recycling	43%	27%	16%	15%	5%	76%		94%	10%	
Virgin Raw Materials	$ 62	$ 45	$ 40	$ 32	77 MJ/kg	34 MJ/kg	200 kWh/kg material	9 kg $CO_{2\text{-Eq}}$/ kg cell	5 kg $CO_{2\text{-Eq}}$/ kg cell	11 kg CO_2/kg material
Source	[23]				[22]	[22]	[24]	[25]	[23]	[24]



- ✓ **Economic Benefits : Lowers Manufacturing Cost ► Cost-Benefit Analysis**
- ✓ **Environmental Benefits : Mining, Manufacturing, & Disposal;**
  Disposal – Reduces Quantity of Materials going into Landfills
- ✓ **Policy Compliance : Green New Deal Policy;**
  Renewable Energy needs Lots of Storage

Source: Elsevier B.V 2019, DW.B Glabler,Pitaka,Lily;2018

2. Needs and Urgency

- Features of Li-Ion Batteries
- Potential Hazards of Li-Ion Battery Maritime Transportation
- Failure and Causes
- Urgency

Features of Lithium Ion Batteries

Alkali metals

Sodium, Potassium, Lithium, Cesium, and Rubidium

Alkali Metals + **Water**

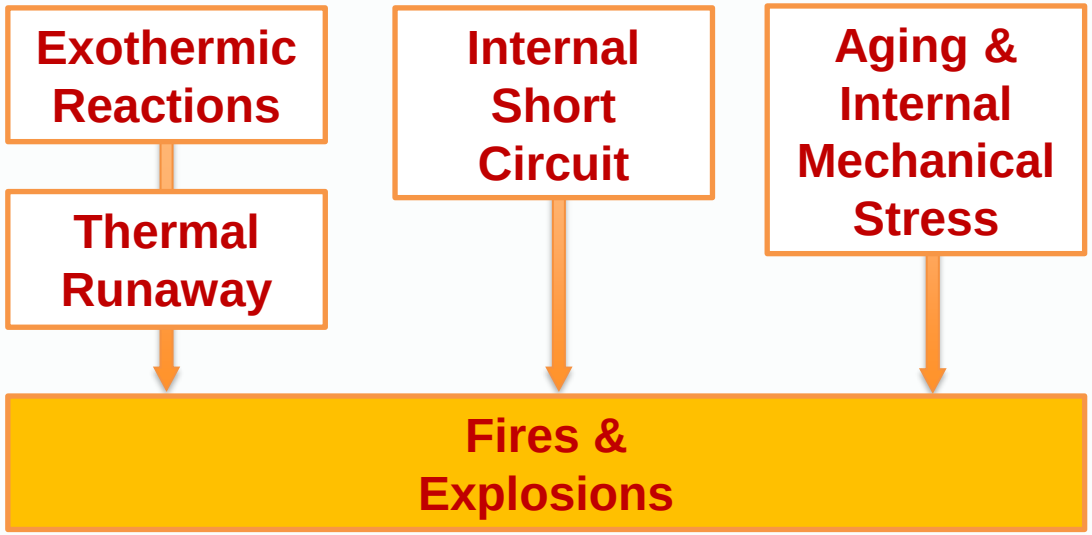
4 Components of Lithium Ion Battery

- **Cathode**
- **Anode**
- **Electrolyte**
- **Separator**

Source: “Information on Alkali Metals.” Stanford Environmental Health Safety iCal. Accessed September 01, 2020. https://ehs.stanford.edu/reference/information-alkali-metals.

Potential Hazards of Lithium Ion Battery Maritime Transportation

<Mechanism>



Source: Nur, Ahmet. “An Overview Of Battery Electric Vehicles And Plug-In Hybrid Electric Vehicles.” International Journal Of Advances On Automotive And Technology, 2017. https://doi.org/10.15659/ijaat.17.04.527.

Lithium Ion Battery related maritime accidents; CASES

Norwegian Li-ion battery powered Ferry Fire; 2019

Container Ship 'Hyundai Fortune caught fire in 2006

Russian Nuclear submarine caught fire and explosion

Source: "Battery Fire Safety Marine : the Rising Risk of Lithium Batteries." LithiumSafe. Accessed September 01, 2020. http://www.lithiumsafe.com/battery-fire-safety-marine.

Li-Ion Battery Failure Causes

- External electrical causes such as external electrical short, overcharging, or overdischarging → **Electrical**
- External thermal causes such as exposure to high temperatures or charging at cold temperatures → **Thermal**
- External mechanical causes, which include excessive shock, impact, compression (crush), or penetration → **Mechanical**
- External chemical contamination, including packaging penetration by corrosive and aggressive agents and contamination of internal components by water, saltwater, or corrosive agents → **Chemical**
- Service-induced stress and aging causes such as excess cycling that cause electrochemical component breakdown, fracture, and crack growth → **History Tracking**
- Cumulative abuse and service causes, in which sequences of electrical, mechanical, and thermal abuse, summarized above, with charge/discharge duty cycles cause damage to initiate and grow to the point of failure → **History Tracking**

Source: Nur, Ahmet. “An Overview Of Battery Electric Vehicles And Plug-In Hybrid Electric Vehicles.” International Journal Of Advances On Automotive And Technology, 2017. https://doi.org/10.15659/ijaat.17.04.527.

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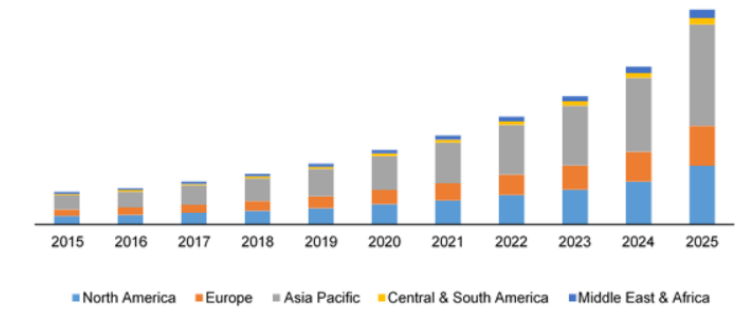
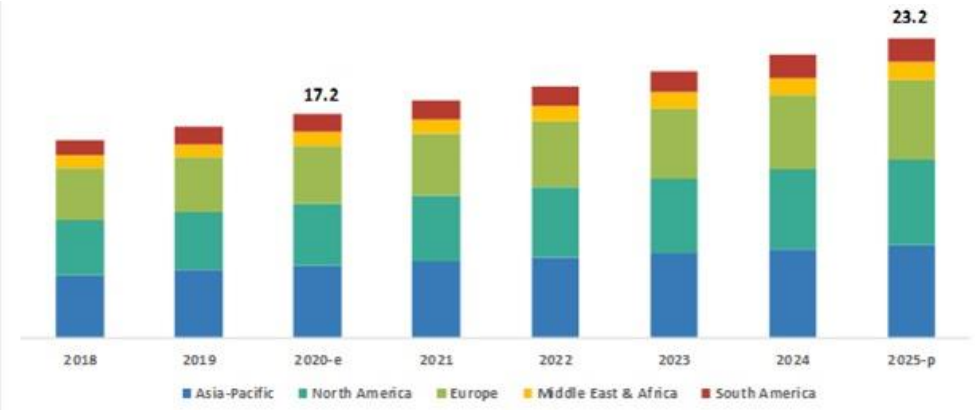
[Urgency] Maritime Transportation of Used Batteries for Reuse & Recycling IN NEAR FUTURE

Global Lithium-ion Battery Market, 2015 ~ 2025 (MWh)

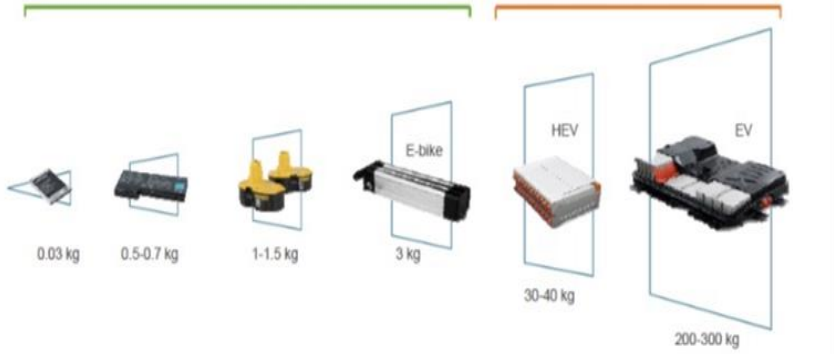


Adroit Market Research © 2019

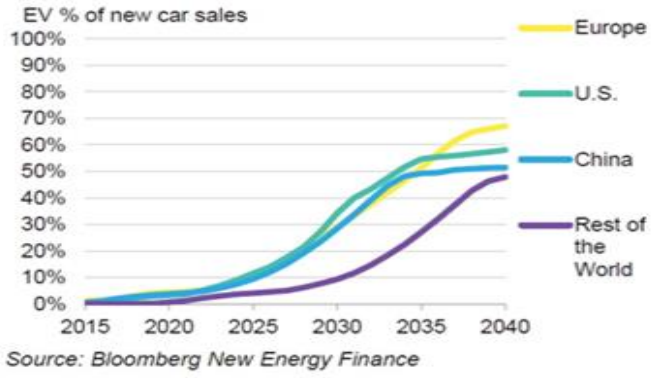
BATTERY RECYCLING MARKET, BY REGION (USD BILLION)



No Pre-treatment Necessary **Pre-treatment Necessary**



Long-term EV sales penetration by country



Source: Bloomberg New Energy Finance

Source: "Procedia Manufacturing-sustainable Manufacturing for Global Circular Economy", Bloomberg New Energy Finance, Adroit Market Research 2019

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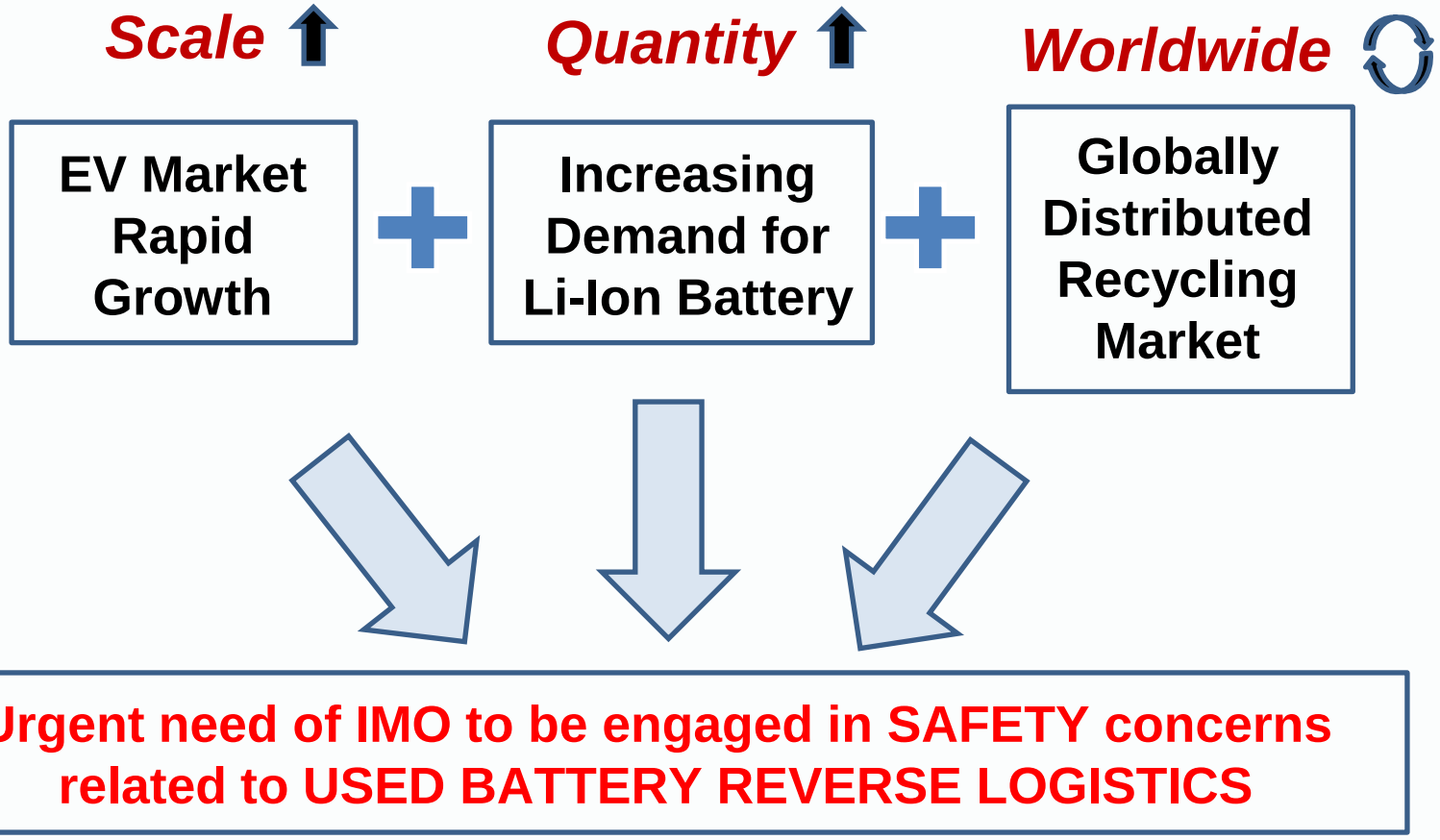
[Urgency] Maritime Transportation of Used Batteries for Reuse & Recycling IN NEAR FUTURE



3. Current State & Problems

- Current State
- Problems 1~3

IMDG Code

IMDG Code : International Maritime Dangerous Goods Code

Class	Classification
1	Explosives
2	Gases
2.1	Flammable gases
2.2	Non-flammable, non-toxic gases
2.3	Toxic gases
3	Flammable liquids
4	Flammable solids
4.1	Flammable solids, self-reactive substances and desensitized explosives
4.2	Substances liable to spontaneous combustion
4.3	Substances which, in contact with water, emit flammable gases
5	Oxidizing substances and organic peroxides
5.1	Oxidizing substances
5.2	Organic peroxides
6	Toxic and infectious substances
6.1	Toxic substances
6.2	Infectious substances
7	Radioactive material
8	Corrosive substances
9	Miscellaneous dangerous substances and articles

IMDG Code 39-18

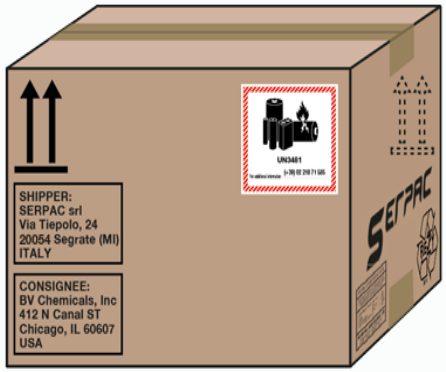
- UN 3090; Lithium metal batteries
- UN 3480; Lithium ion batteries
- UN 3091; Lithium metal batteries contained in equipment or packed with equipment
- UN 3481; Lithium ion batteries contained in equipment or packed with equipment
- UN 3171; Battery-Powered Vehicle

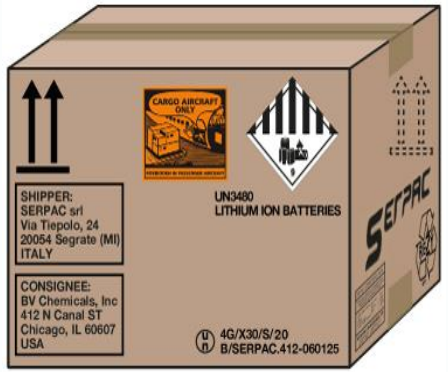
IMDG Code

IMDG Code : Regulations for Pre-Recycle Battery?

Classification	Label and Mark for Lithium Battery packaging	
Special Provision SP 384		**Lithium Battery Dangerous goods Label (No.9A)** -IMDG Code 5.2.2.2.2
Special Provision SP 188		**Lithium Battery Non- Dangerous goods Mark** - IMDG Code 5.2.1.10

- **Special Provision 377**
  Disposal or Recycle shall be marked on package
  Shall be described on B/L
- **PI P909**
  Packaging guideline for Disposal or Recycle
- **PI P908-5**
  Packaging guideline for Battery with Defects





[Problem 1] Ambiguous Classification of Cathode/Anode Active Materials

Cathode 1 : LCO - Lithium Cobalt Oxide

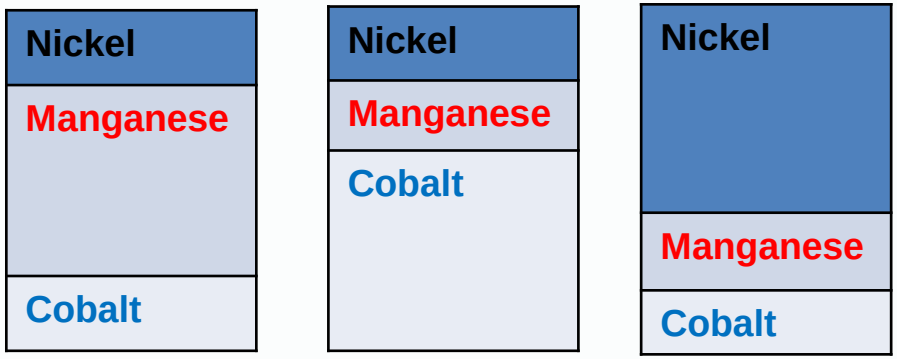
Cathode 2 : NMC - Lithium Nickel Manganese Cobalt Oxide

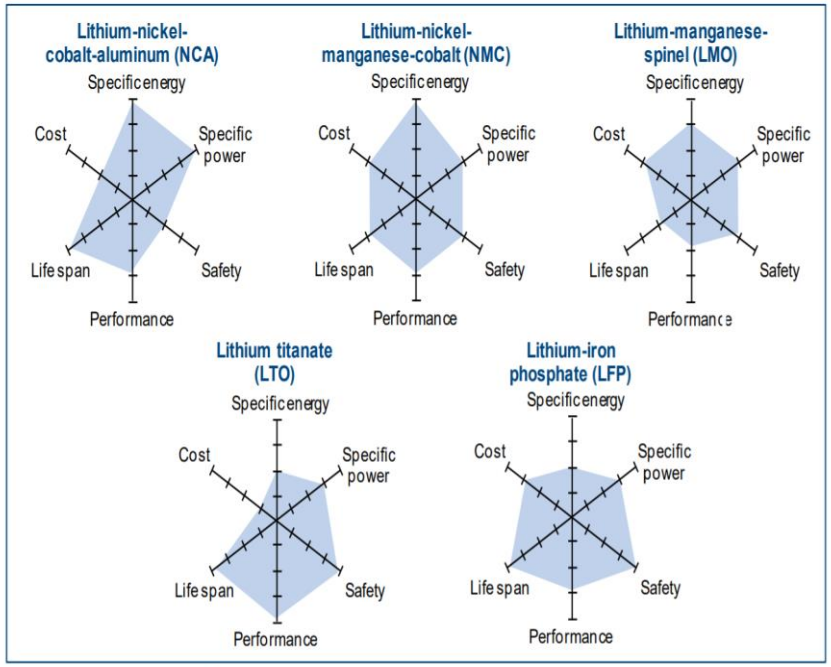
Cathode 3 : NCA - Lithium Nickel Cobalt Aluminum Oxide

Cathode 4 : LFP - Lithium Iron Phosphate

Cathode 5 : LNO - Lithium Nickel Oxide

Cathode 6 : LMO - Lithium Manganese Oxide



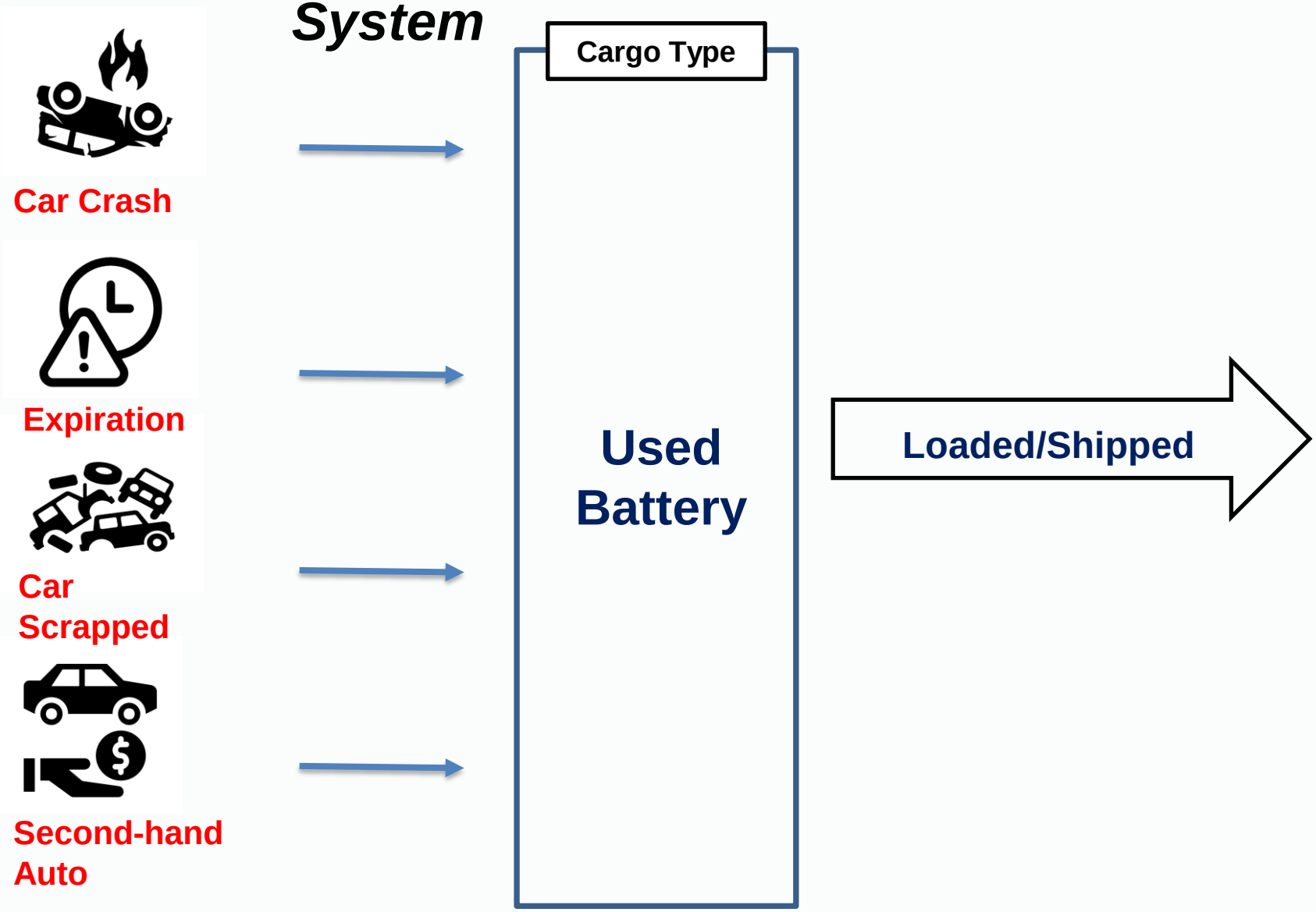


Source: Boston Consulting Group, 2011. Reproduced with permission.

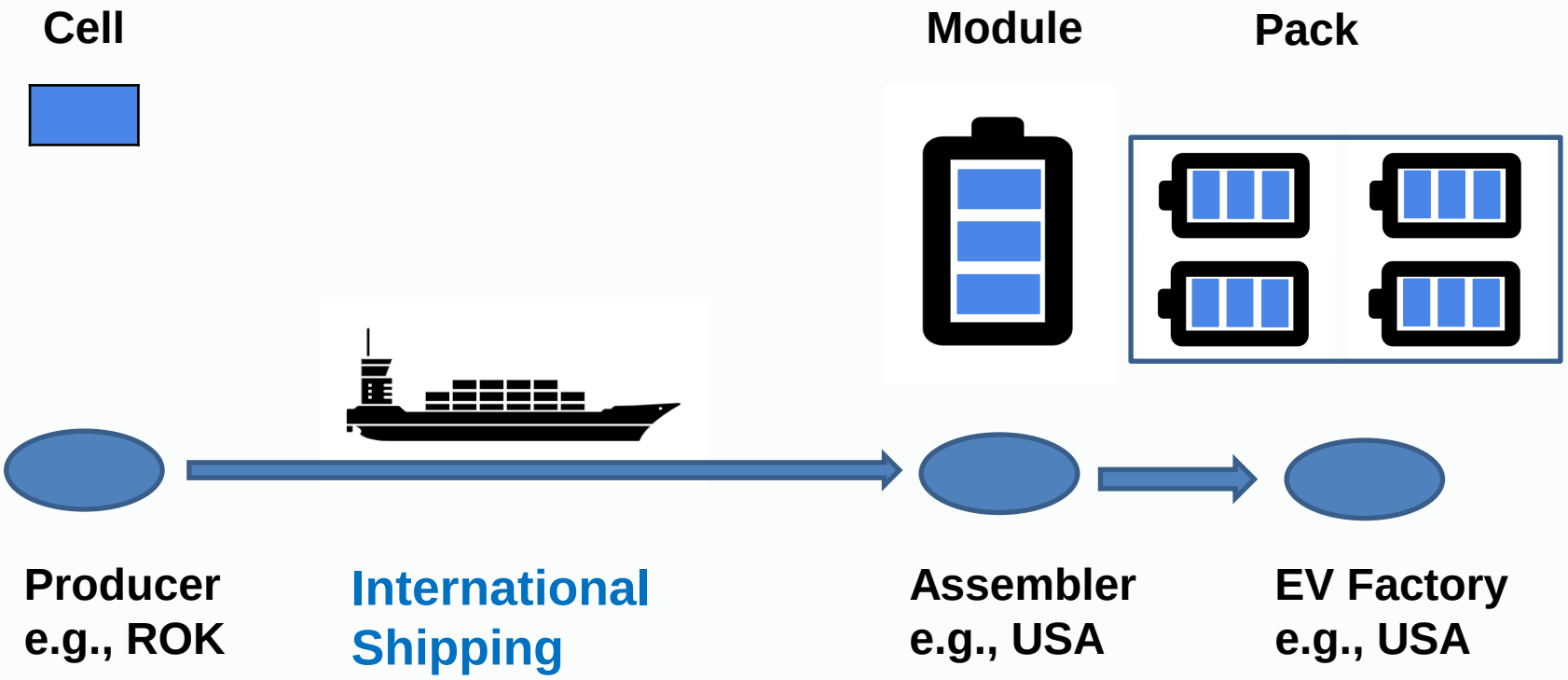
Figure 2-4. Relative comparisons of Li-ion battery performance parameters.

Source: Nur, Ahmet. “An Overview Of Battery Electric Vehicles And Plug-In Hybrid Electric Vehicles.” International Journal Of Advances On Automotive And Technology, 2017. https://doi.org/10.15659/ijaat.17.04.527.

[Problem 2] Lack of Used Li-Ion Battery Tracking System

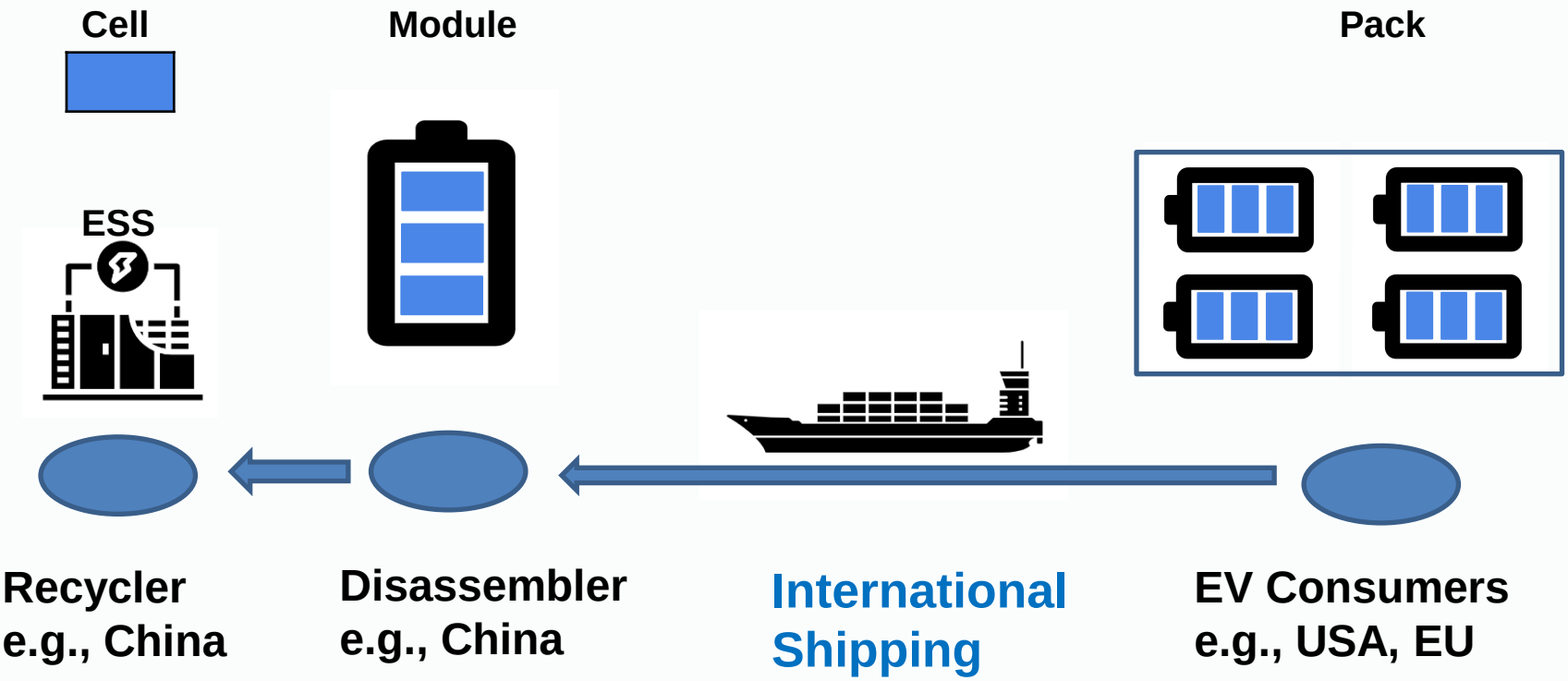


[Problem 3] Complexity and Limitation of Dismantling Li-Ion Battery Packs



< Usual Operations for Battery Production >

[Problem 3] Complexity and Limitation of Dismantling Li-Ion Battery Packs



< Operations for Battery Reuse & Recycling >

4. Proposal & Future Action Required

- Solution: Assigning New UN Code Provisions for ReLiB
- Conclusion

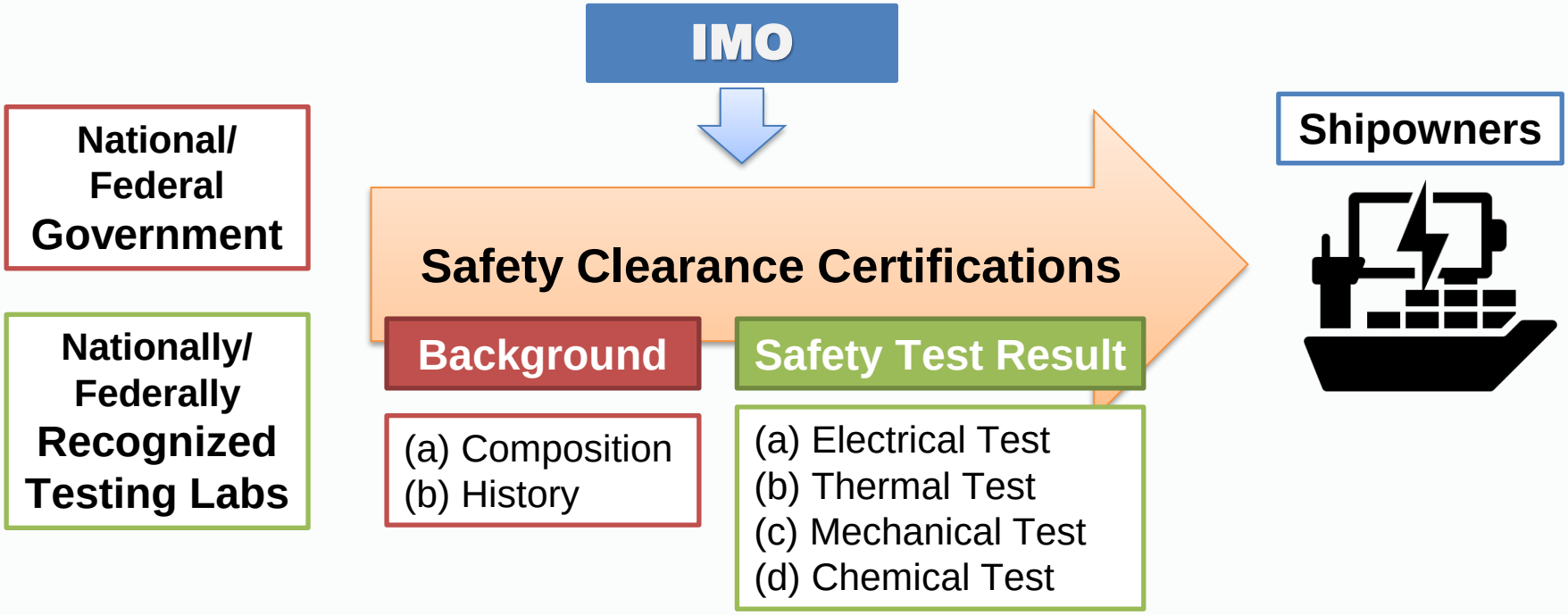
[Solution] Assigning New UN Code Provisions

UN X123 Used Lithium Ion Batteries for Reuse & Recycling Purpose (IMDG Code, Amdt OO-OO)			
Proper Shipping Name (PSN)	**Used Lithium Ion Batteries for Reuse & Recycling Purpose**		
United Nations Number (UN No.)	**X123**	**Class**	9
Label & Placard	 **Label (Class 9A)**  **Placard (Class 9)**		
Special Provisions (SP)	Existing: 188, 230, 310, 348, 376, 377, 384, 387 (Li-Ion in general) **Newly Proposed: XX1, XX2 (Used Li-Ion)**		
Stowage & Segregation	**Category A** if Special Provisions **XX1** and **XX2** are both satisfied; **Category D** if not		
Features of Used Batteries	1. The hazards of leakage, fire, and/or explosion exist. 2. Used Li-Ion batteries are potentially damaged, with the probability depending on the causes of disposal. (e.g., accident, expiration of life-expectancy, leakage, etc.) 3. Dismantling used battery packs incorporates a complicate procedure, adding a challenge on safety inspection.		

Our Proposal: Bottom Line

New UN Code Provisions for the Maritime Transportation of Used Lithium Ion Batteries for Reuse & Recycling Purpose;

<Safety Clearance System under the Supervision of IMO>



[Solution] Assigning New UN Code Provisions

UN X123 Used Lithium Ion Batteries for Reuse & Recycling Purpose (IMDG Code, Amdt OO-OO)	
Special Provision	**Content**
XX1	All vessels transporting used batteries for reuse and recycling shall obtain the following document, at least 14 days prior to the embarkation: **[Background Certification]** **1) Content** The final distributor shall provide following information with each used battery pack, along with proper documentation if further requested: **(a) Composition** : **Physical and Electrochemical Composition** *i) Cathode active material* *ii) Anode active material* *iii) Separator* *iv) Electrolyte* **(b) History** : **Causes and Background behind the Disposal** e.g., Accident, Expiration of Life-expectancy, or Leakage **2) Issuing Authority** : National/federal government of each member state shall examine the above information and issue the certification unless a significant hazard exists.

[Solution] Assigning New UN Code Provisions

UN X123 Used Lithium Ion Batteries for Reuse & Recycling Purpose (IMDG Code, Amdt OO-OO)	
Special Provision	**Content**
XX2	All vessels transporting used batteries for reuse and recycling shall obtain the following document, at least 7 days prior to the embarkation: **[Safety Test Result Certification]** **1) Content** All used battery packs shall be subjected to and pass: **(a) Electrical Test** : Electrical Short, Overcharging, Over-discharging **(b) Thermal Test** : High Temperatures, Charging at Cold Temperatures **(c) Mechanical Test** : Excessive Shock, Impact, Compression **(d) Chemical Test** : Chemical Contamination of Internal Components **The tests shall be conducted primarily in a non-destructive way.** **2) Issuing Authority** : National/federal government of each member state shall issue the certification after the confirmation of test results by nationally/federally recognized testing laboratories.

Conclusion

This proposal would be a commitment to IMO's MISSION to promote SAFE and SUSTAINABLE shipping by adopting the highest practicable standards of MARITIME SAFETY.

References

-Lithium-ion Battery Recycling Market & Technology Trends 2020 report, (Yole Development,2020)

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Thank you for paying attention to our presentation.