Sustainability and the Zinc Battery Supply Chain

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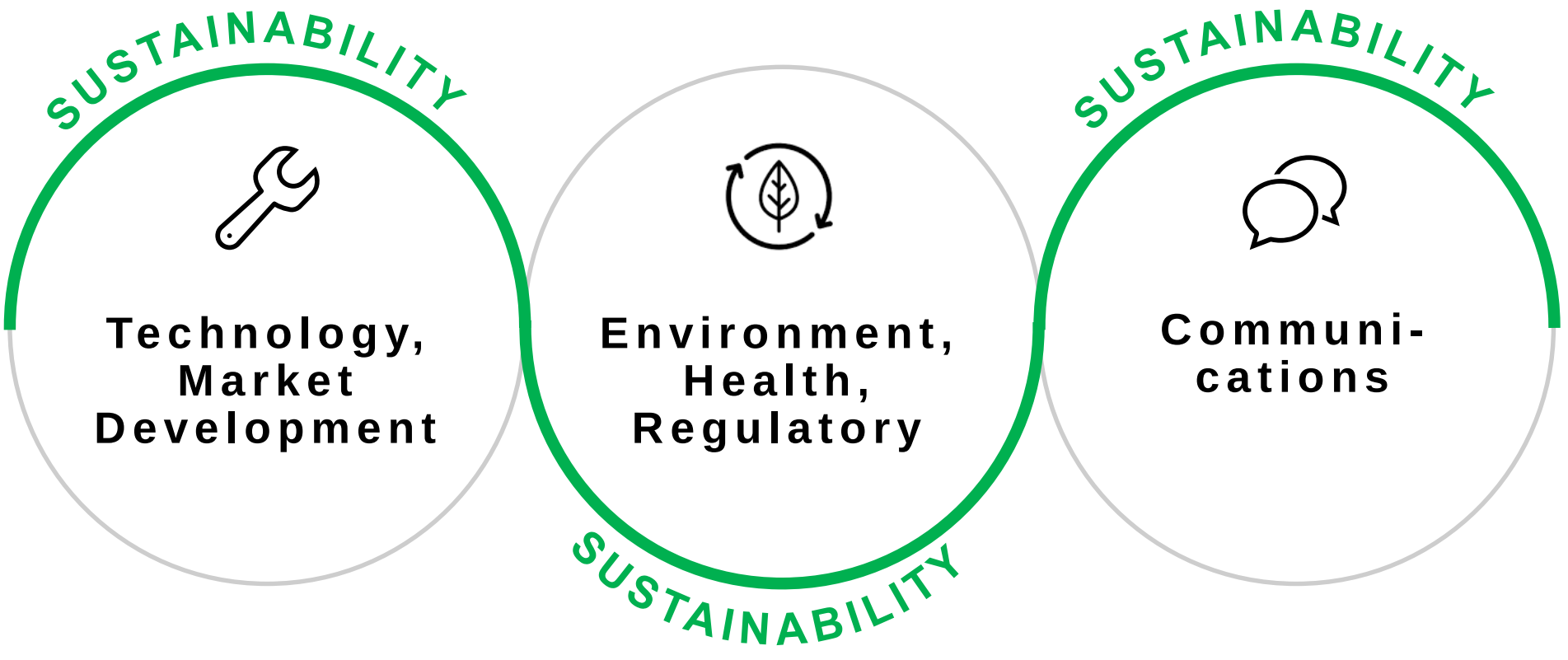
NAATBatt Zinc Battery Workshop V
Nov. 10, 2022

International Zinc Association (IZA)

- 40 full members
- 183 affiliate and associate members
- Offices in North Carolina, Brussels, Delhi, Shanghai

IZA represents the global zinc industry (mining, production, first use production and recycling)

IZA's Core Program Areas



IZA Sustainable Development

1. Responsible Sourcing

LME Requirements – Joint DD Standard, passport

Full ESG and Assurance - Zinc Mark

Harmonizing Frameworks

2. LCA and Carbon Footprint

3. Climate Action and Energy

4. Circular Economy and Availability

DD Standard, FAQ, tools, videos:
[Joint Due Diligence Standard - The Copper Mark]

Complying with LME Responsible Sourcing Requirements

Joint Due Diligence Standard*

- 100% OECD aligned
- LME: Approved Track A standard

* for copper, nickel, lead, and zinc and their by-products

Responsible Sourcing

- From due diligence to ESG*
- Key for market access driven by user groups, financial sector and regulators
- Zinc Mark pilot phase

Partnering for Responsibility

IZA's ambition is to ensure credible responsible sourcing schemes are available for all zinc producers anywhere in the world replying to all regulatory and stakeholder demands.

Responsible Steel standards & certification

LME An HKEX Company

Responsible Minerals Initiative

The Copper Mark – Responsibly Produced Copper

International RBC SER

ICMM

* ESG: environmental, social and governance aspects

IZA Sustainable Development

1. Responsible Sourcing

2. LCA and Carbon Footprint

Sector - LMEpassport CF Guidance for SHG Zinc

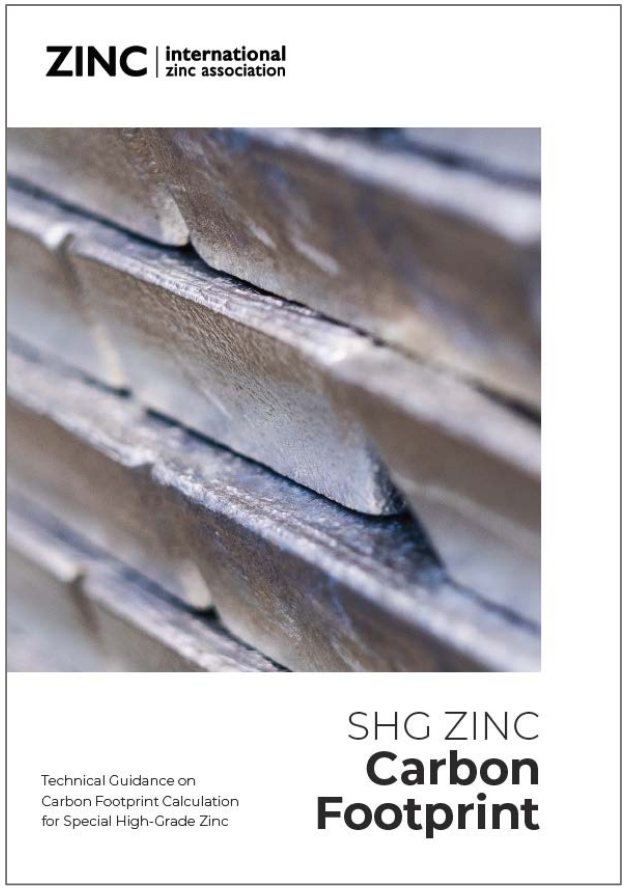
Material – Profiles at site and global level

3. Climate Action and Energy

4. Circular Economy and Availability

Zinc Life Cycle Assessment

https://www.zinc.org/life-cycle-assessment/



https://www.zinc.org/climate_change/

- LCA updates available via “Zinc Environmental Profile” and relevant LCA data bases.
- Carbon Footprint Guidance for SHG Zinc Production LME approved

GaBi Database Content

IZA Sustainable Development

1. Responsible Sourcing

2. LCA and Carbon Footprint

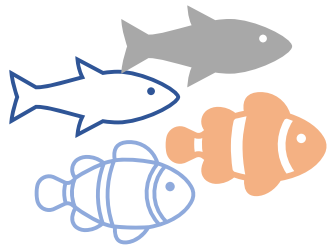
3. Climate Action and Energy

Coordination – IZA Climate Change Task Force

Strategy – Decarbonization Roadmap

4. Circular Economy and Availability

Sector Perspective



- Achieve more as a sector
- Maximize effects along value chains – team up with down stream users
- Represent the sector at regulator and political level

IZA Decarbonization Roadmap

Scoping Report

- Review existing data and information
- Company interviews

Baseline

- Calc. model base line CF
- Materiality assessment
- Risk & opportunity analysis

Decarb. scenarios

Operationalization

CF: Carbon Footprint

1. Responsible Sourcing

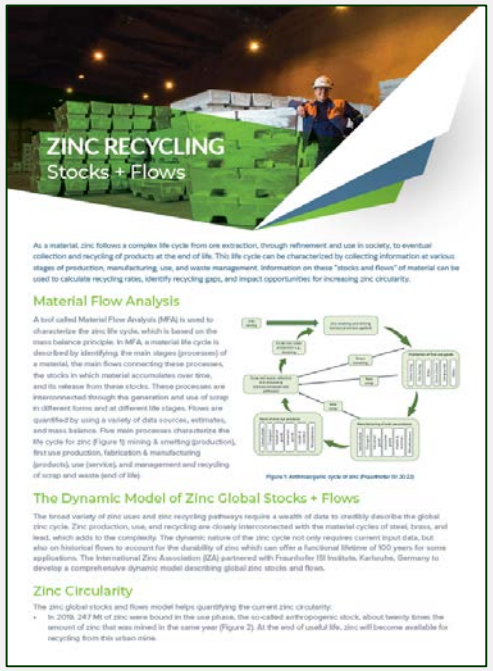
2. LCA and Carbon Footprint

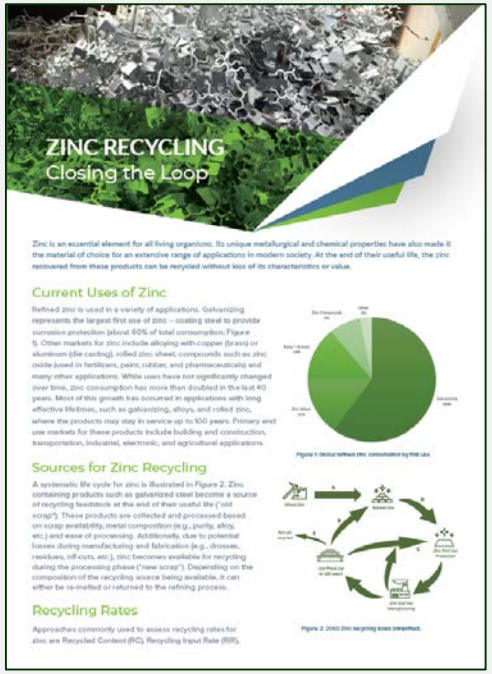
3. Climate Action and Energy

4. Circular Economy and Availability

Demand – 2050 scenarios

Supply – Material Flow Analyses





Maximizing Zinc Circularity

Fact Sheets

- Zinc Stocks and Flows (link)
- 2050 Supply and Demand (link)
- Material Supply (link)
- Closing the Loop (link)

Zinc Batteries are Versatile

ZINC BATTERY INITIATIVE

Zinc has been developed across a wide range of chemistries and applications.

Hybrid systems offer potential for zinc to meet most critical needs.

SILVER ZINC

NICKEL ZINC

ZINC ION

MANGANESE ZINC

ZINC BROMINE FLOW& NON

ZINC AIR

High power density;

Short duration storage

High energy capacity;

Long duration storage

Advantages of Zinc Batteries go Beyond Performance

SAFETY

Zinc batteries are non-flammable and non-toxic.

SUSTAINABLE

Zinc is abundant, recyclable, and has the lowest GHG emissions.

SECURE SUPPLY

Mined in 50+ countries globally, fully integrated supply chains in major regions.

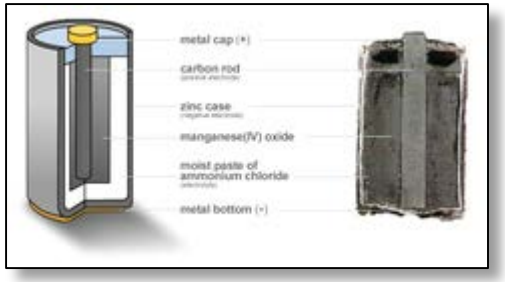
- Long life (15-20 years)
- Flexible operating temps (-35°C to +75°C)*
- Low operating cost
- Non-hazardous transport

*…. Depending on Zn-tech used

Single-use versus Rechargeable

Primary (single-use):

Zinc Carbon – AAA, AA, C, D, 9V

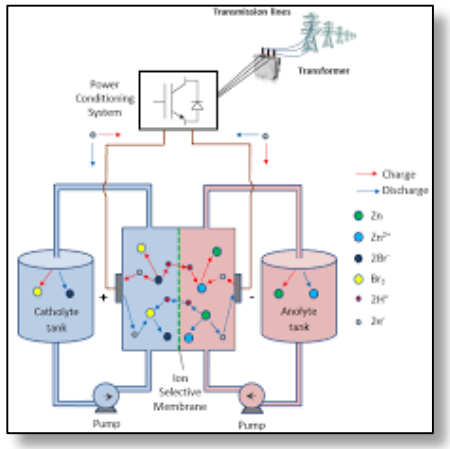


Zinc Manganese (alkaline) – AAA, AA, C, D, 9V

Zinc air – button or coin cells

Rechargeable (secondary):

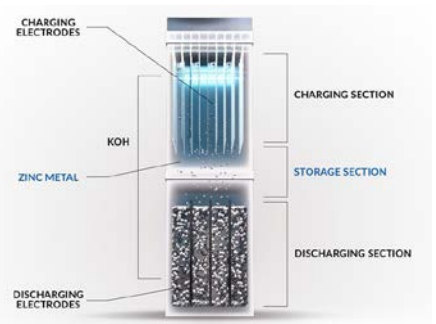
Zinc Bromine – flow



Nickel Zinc – cell

Zinc ion (sulphate electrolyte) – cell

Zinc Manganese (alkaline electrolyte) – cell



Zinc air – cell or flow

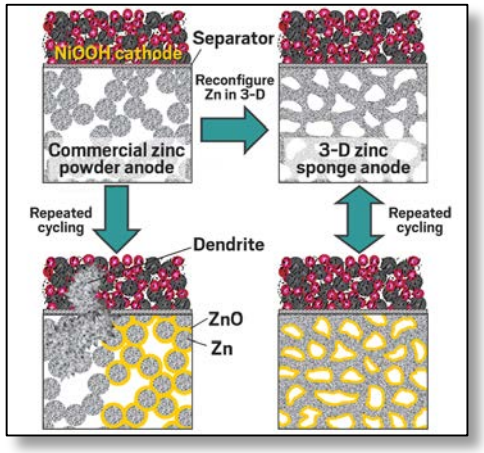
Zinc Starter Materials for Batteries

Primary (single-use):

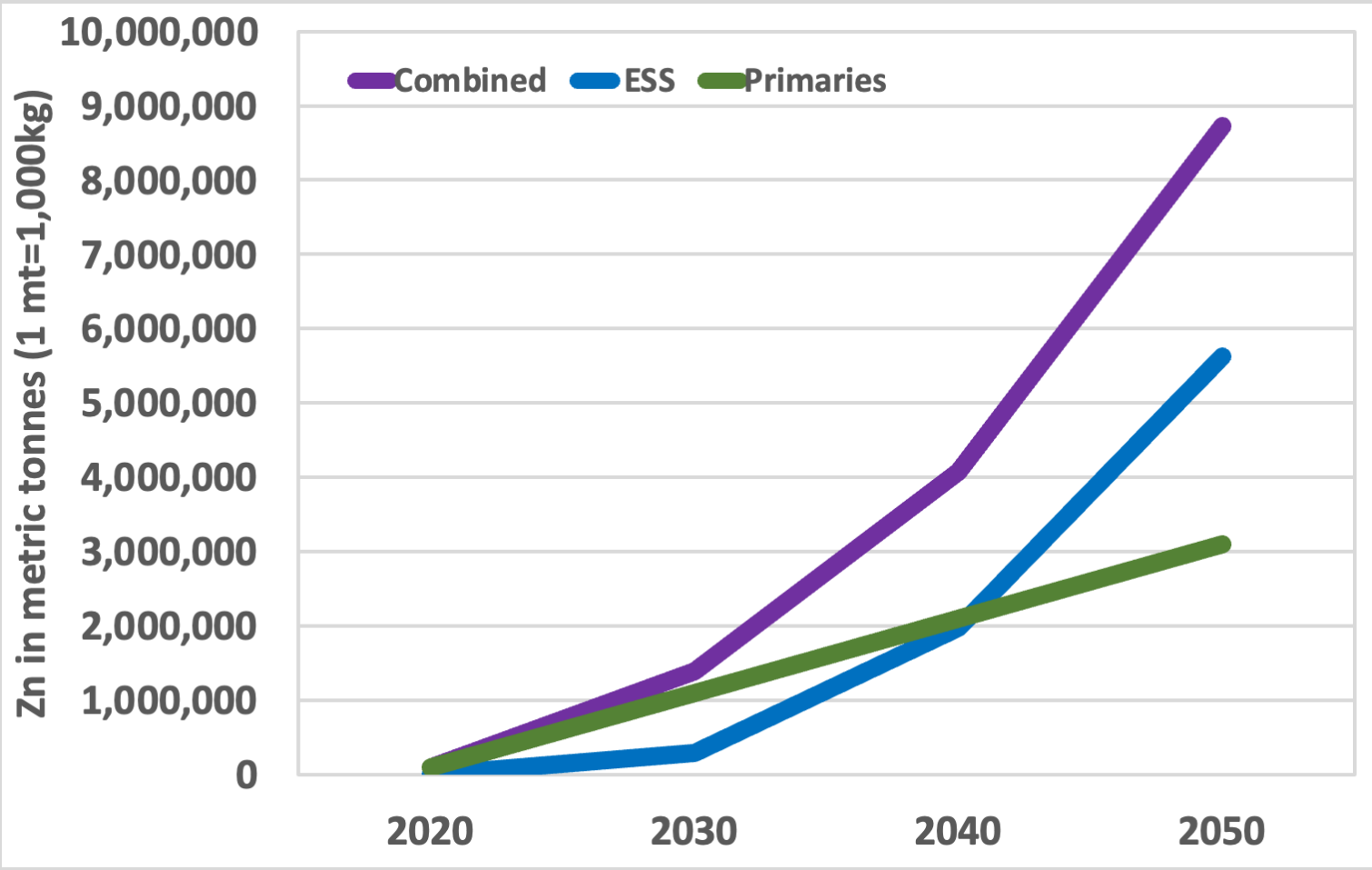
- Alkaline:
  Zinc powder,
  alloyed with Bi, In, Al, Mg,
  and/or Ca (50-500ppm)
  Typical size 200-300µm
- ZnC:
  Zinc sheet, for battery case

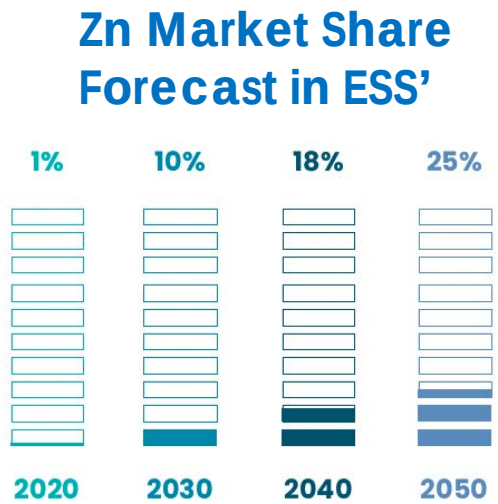
Rechargeable (secondary):

- Zinc bromide solution - $ZnBr_2$ (aq.)
- Zinc oxide – ZnO
- Zinc hydroxide – $Zn(OH)_2$
- Zinc powder, alloyed,
  finer than primary batt.
- Zinc sheet or foil
- Zinc sponge
- Mixtures of the above



Cumulative Battery Zinc Demand Forecast





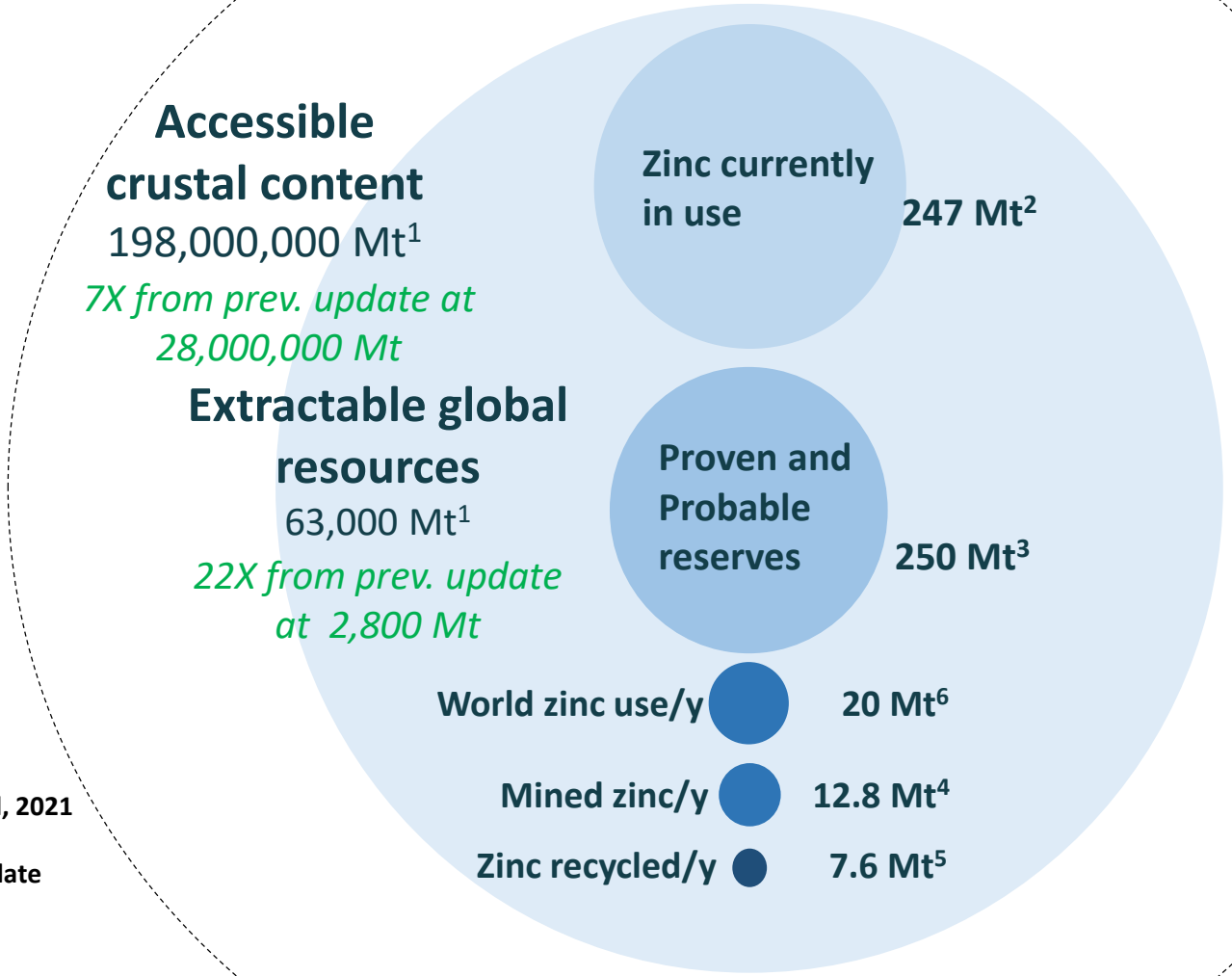
▷ Zinc tonnage forecast for Primary Batteries based on EverZinc estimate and a 0% annual growth rate.
▷ Energy storage demand based on BloombergNEF NEO 2022 GWh forecast for storage batteries, percentage of zinc market share estimates based on consultation from Avicenne Energy, and an average zinc intensity of use of 2.5mt Zn/MWh for ESS.

Source: BloombergNEF NEO (2022), Avicenne (2019), IZA (2022), EverZinc (2022)

Availability of Zinc

Accessible crustal content
198,000,000 Mt[1]
7X from prev. update at 28,000,000 Mt

Extractable global resources
63,000 Mt[1]
22X from prev. update at 2,800 Mt

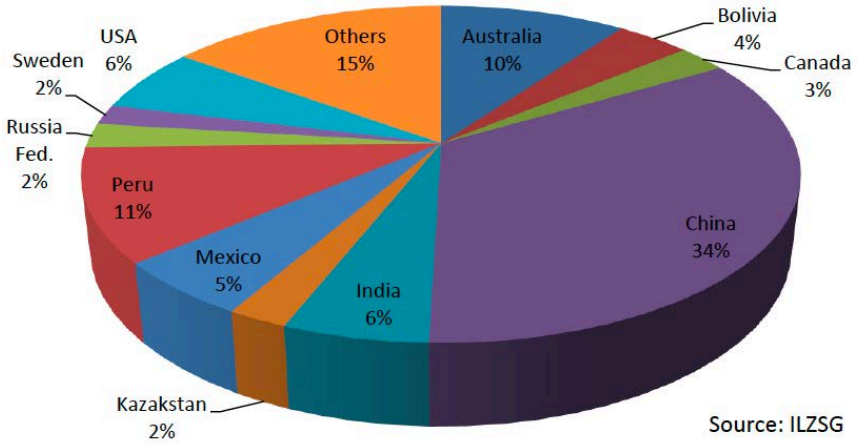


Mt = million tons

1. **"Zinc resources – a state of knowledge" by Eric Pirard, 2021 (5 km mineable depth scenario)**
2. **IZA and Fraunhofer ISI 2021 zinc stocks and flows update (based on 2019 data)**
3. **U.S. Geological Survey, 2021**
4. **International Lead Zinc Study Group. 2019**
5. **IZA and Fraunhofer ISI 2021 update, post- and pre-consumer scrap**
6. **IZA and Fraunhofer ISI 2021, zinc entering first use stage**

Source: International Zinc Association (2022)

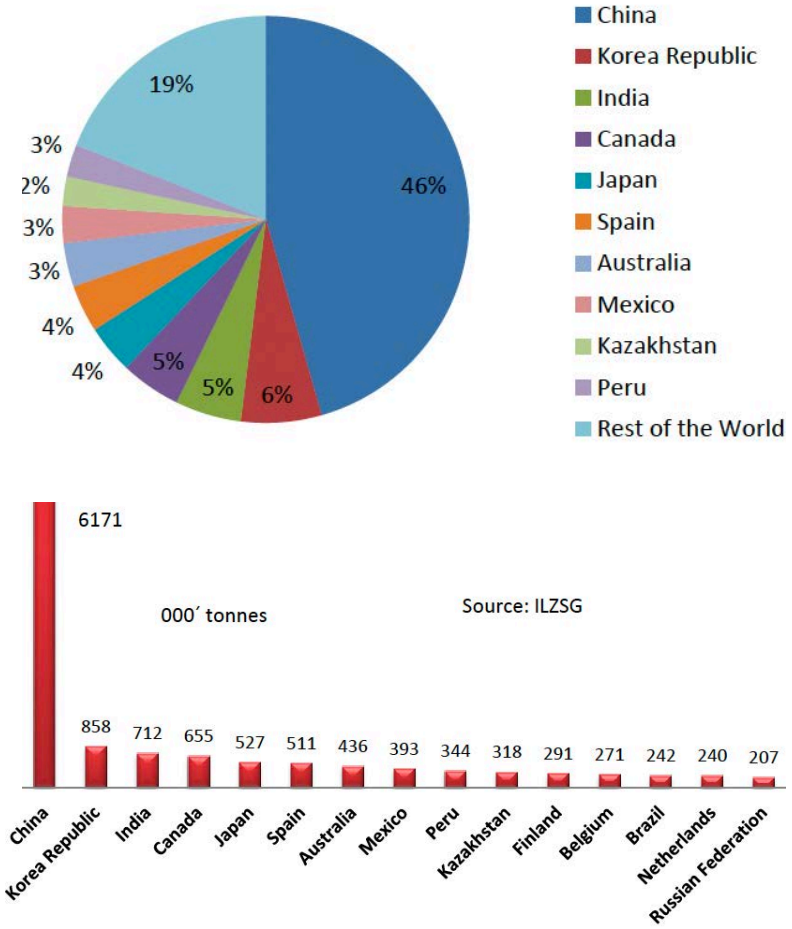
Zinc Mining Countries in 2019



- Since 1960 over 60 countries have mined zinc ore
- In 2019, 51 countries were actively mining zinc
- Top 5 mining countries are China, Peru, Australia, USA and India
- Top 10 mining companies contributed to 41% of the world concentrate production capacity

Source: International Lead and Zinc Study Group (2020)

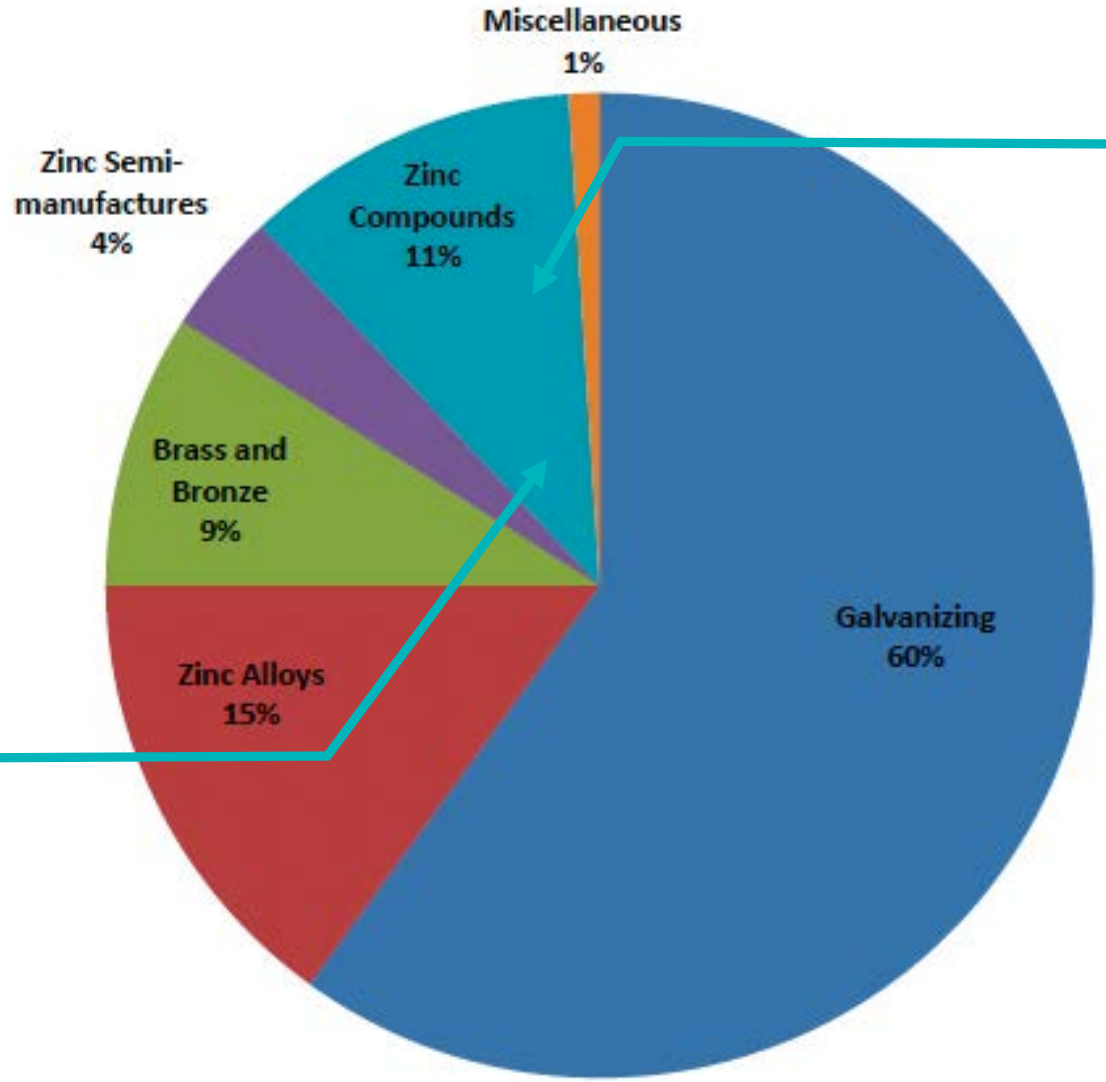
Zinc Metal Producing Countries in 2019



▷ in 2019, 27 countries had zinc metal smelting and/or refining activities
▷ Top 10 refined zinc metal producing countries contributed 81% of world total output

Source: International Lead and Zinc Study Group (2020)

Zinc First Uses in 2019



2.2 Million tonnes

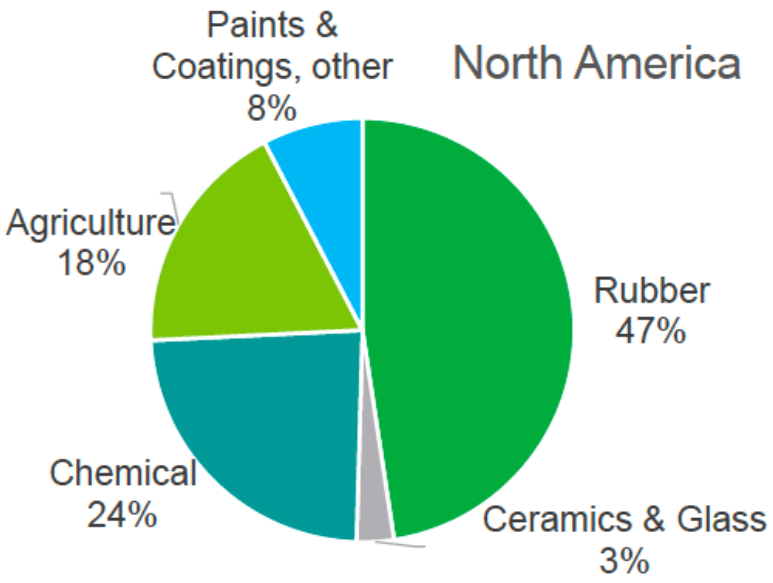
Main zinc chemicals in current use include:
▷ **ZnO**, $ZnCO_3$, **$ZnCl_2$**, **$ZnSO_4$**, ZnS_2, $ZnCO_3$, $ZnSeO_3$, Zn borate,
▷ **Zn powder** and nanoform Zn compounds.

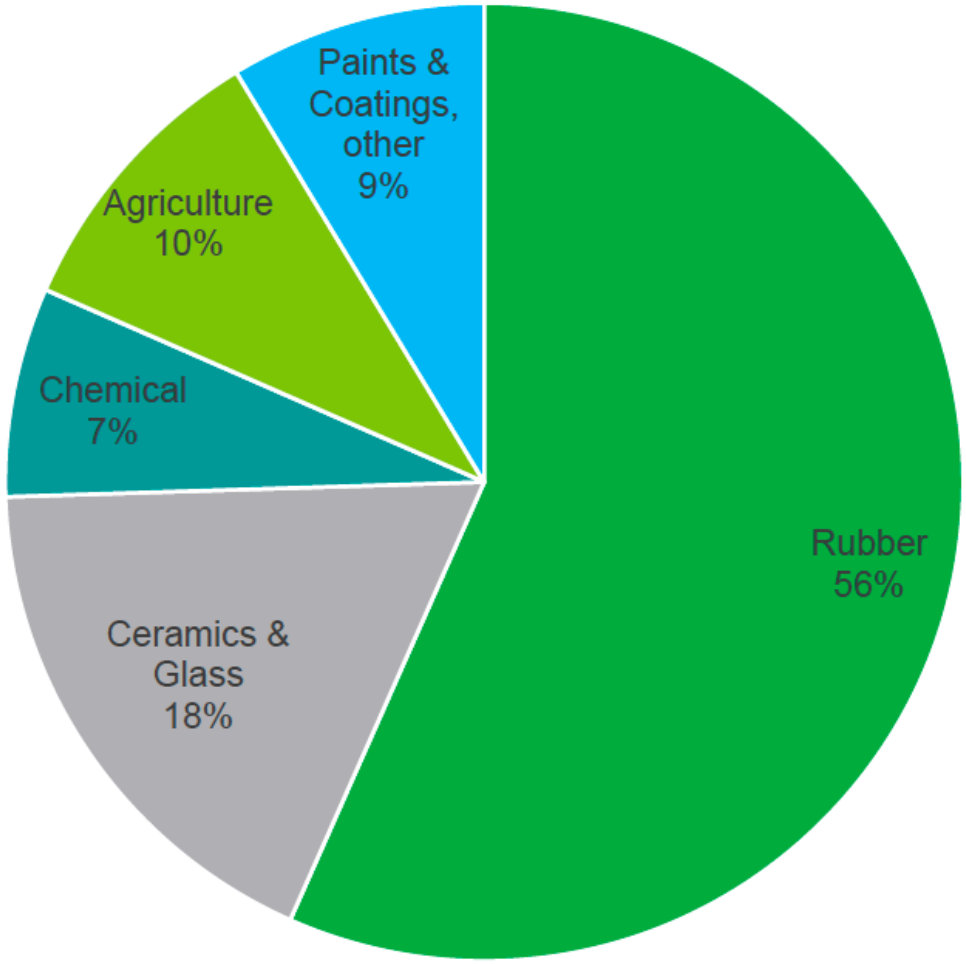
Source: International Lead and Zinc Study Group (2020)

Zinc Oxide Main Uses in 2020

Global demand: 1.7 million metric tons

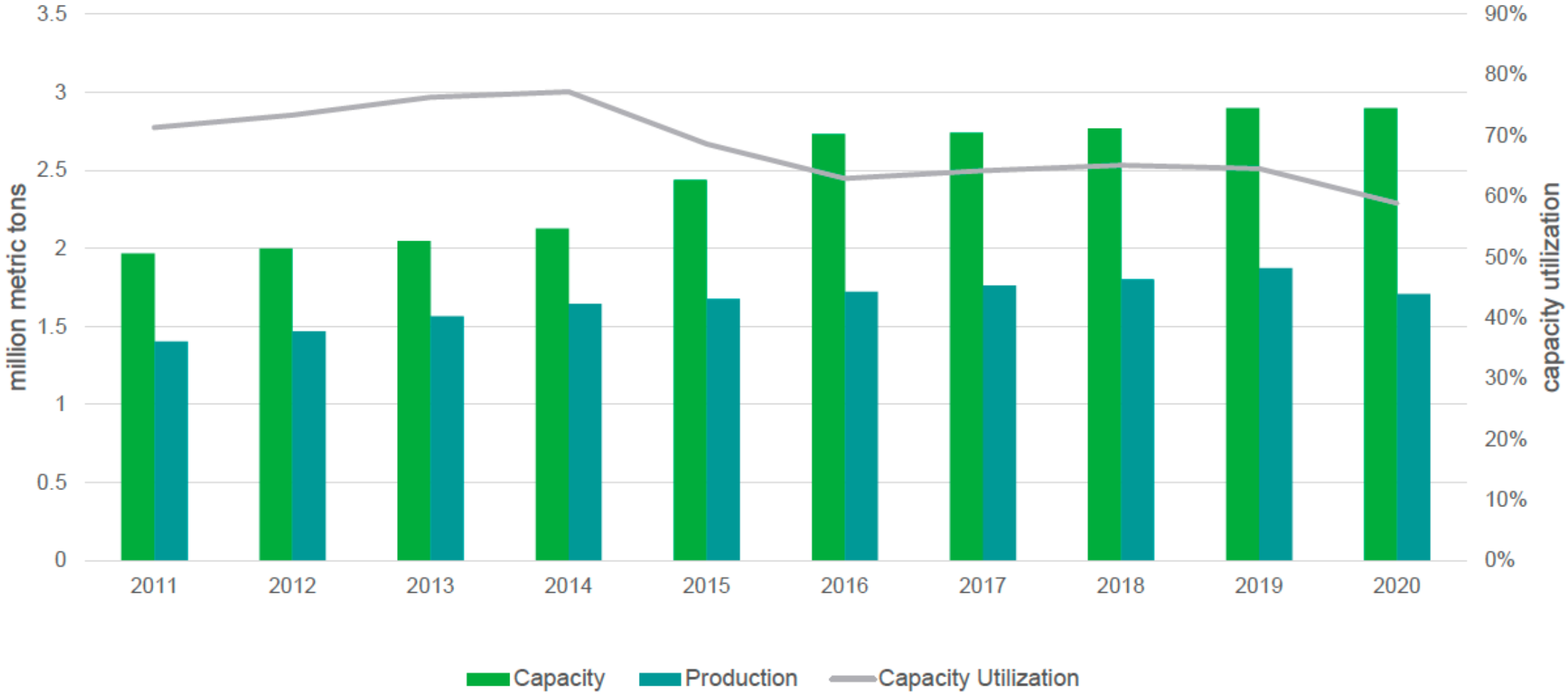
- Rubber compounding remains major end use in all regions
- Ceramics & Glasses is second largest application in all regions but North America





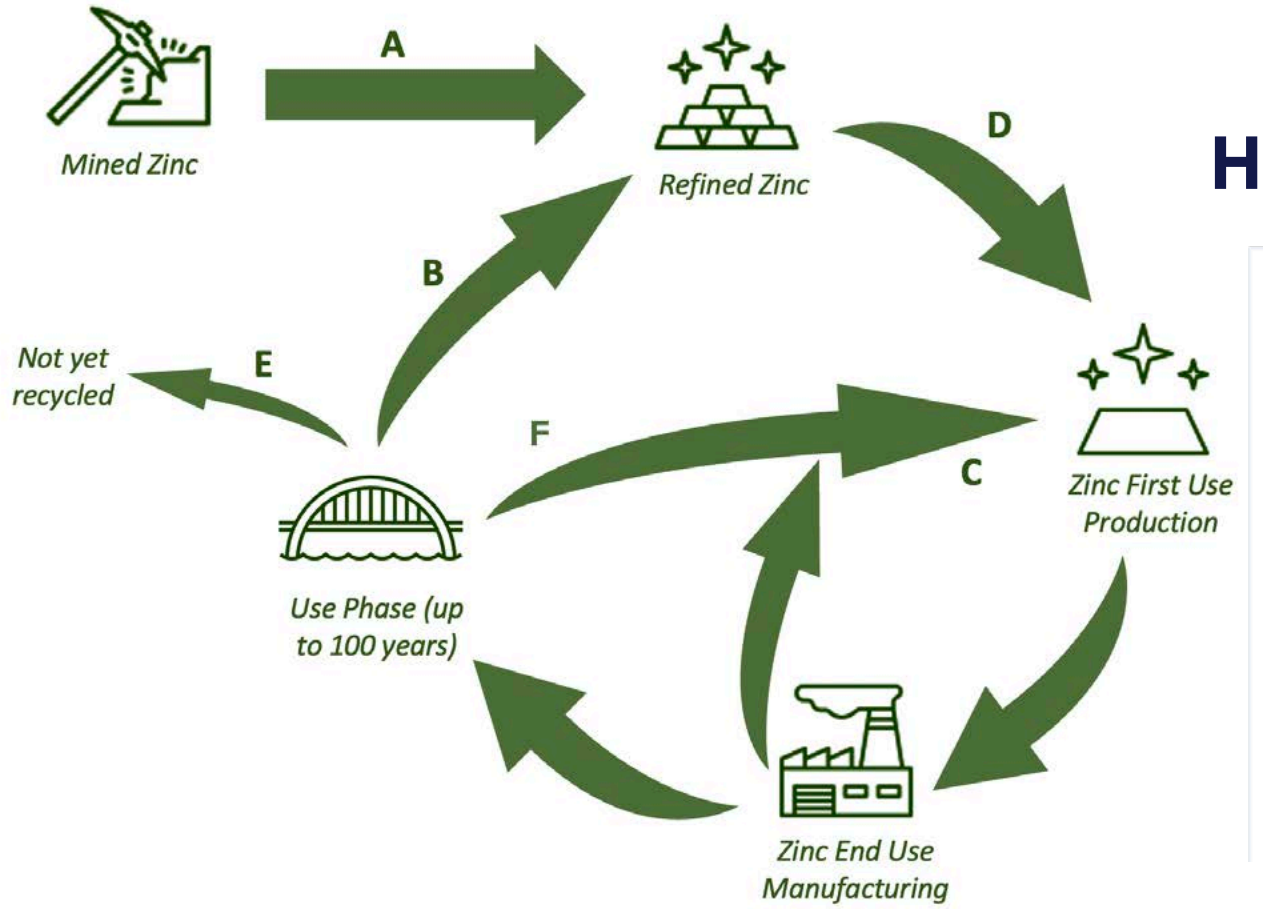
Source: IHS Markit (2021)

Zinc Oxide Supply



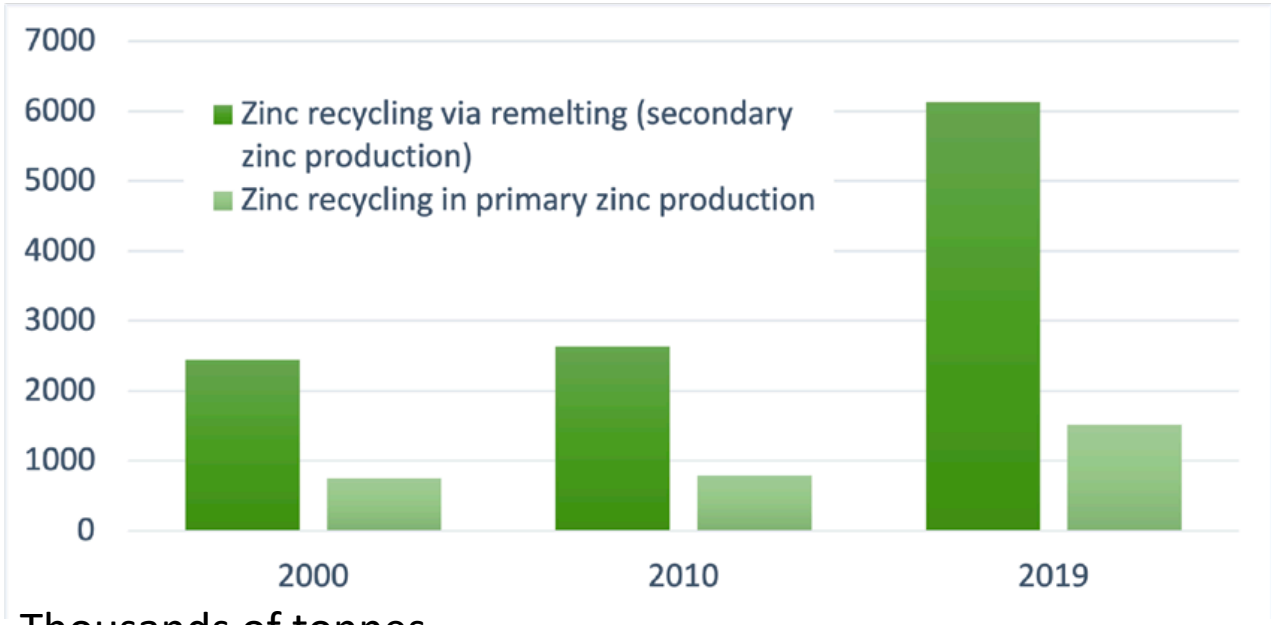
Source: IHS Markit (2021)

Zinc Circularity - Recycling



▷ Zinc recycling loops (simplified).

How Much Zinc is Recycled Today?

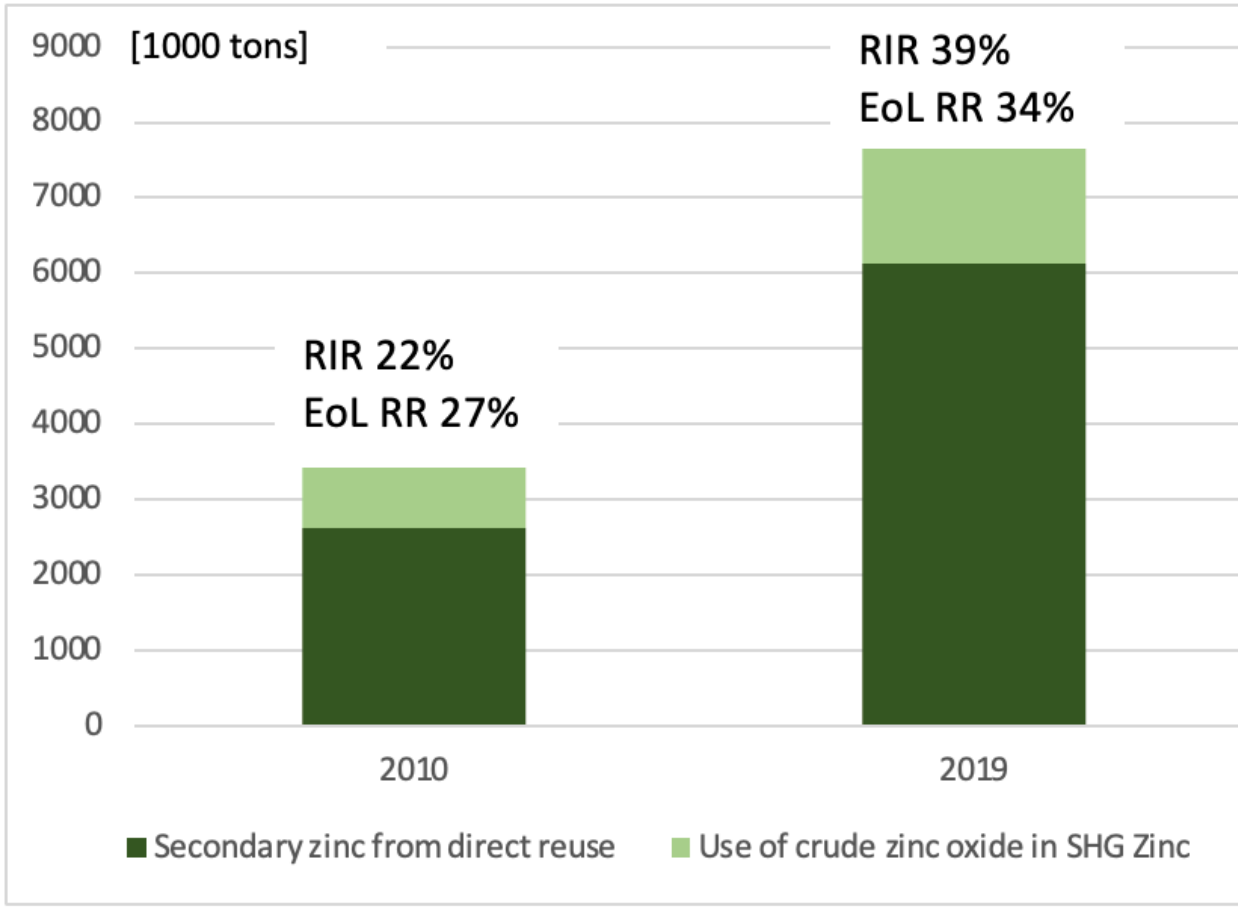


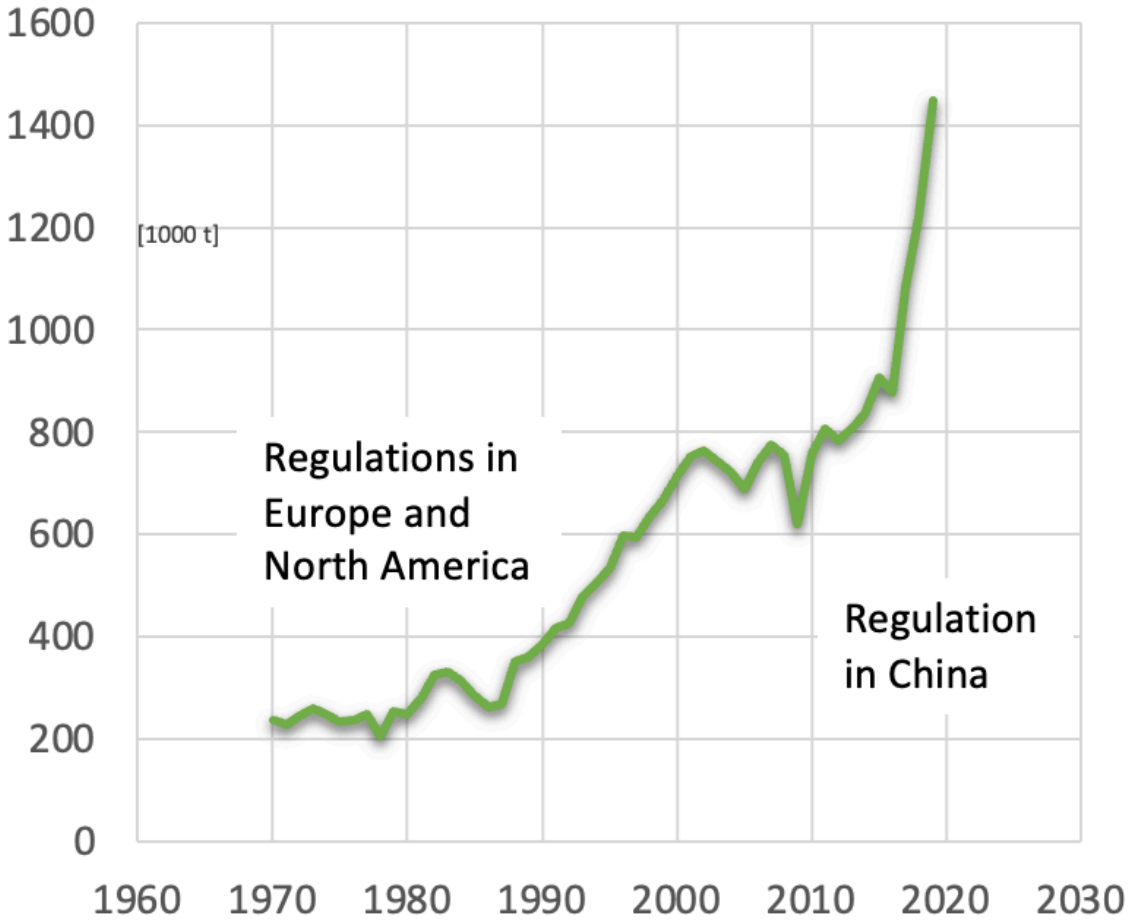
Thousands of tonnes

▷ Zinc recycling

Source: Fraunhofer ISI, Karlsruhe (2022), : International Lead and Zinc Study Group (2020)

Zinc Circularity - Recycling





▷ Zinc recycling doubled between 2010 and 2019 while zinc mine production remained constant at 12-13 Mt; RIP: Recycling Input Rate, EoL RR: End-of-Life Recycling Rate

▷ Zinc recycling from steel mill (EAF) dust increases with regulations being enforced (based on ILZSG statistics).

Source: Fraunhofer ISI, Karlsruhe (2022), : International Lead and Zinc Study Group (2020)

Recycling Paths of Single-use Batteries

Mechanical

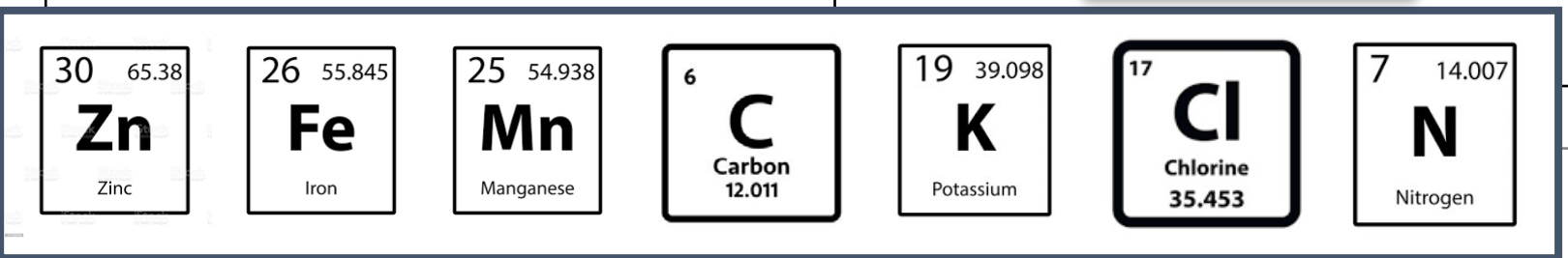
- Separation of steel and black mass
- **Steel scrap raw material for new steel**
- **Black mass raw material for agricultural use**, e.g. fertilizers (K, Zn and Mn are micro-nutrients)

Hydrometallurgical

- Hydro treatment follows mechanical separation
- Black mass is processed to Zn^0, ZnO, $Zn(OH)_2$ or other zinc compounds

Pyrometallurgical

- Treatment of complete spent batteries or after mech. separation
- **Recovery of Fe, Mn (steel) and Zn at processing of complete batteries**:
  - Sumitomo process
  - Inmetco process
  - Special blast furnace
  - EAF (dep. regulations)
- Black mass processed in Waelz Kiln for Zn rec.



Recycling Paths of Rechargeable Batteries

Mechanical

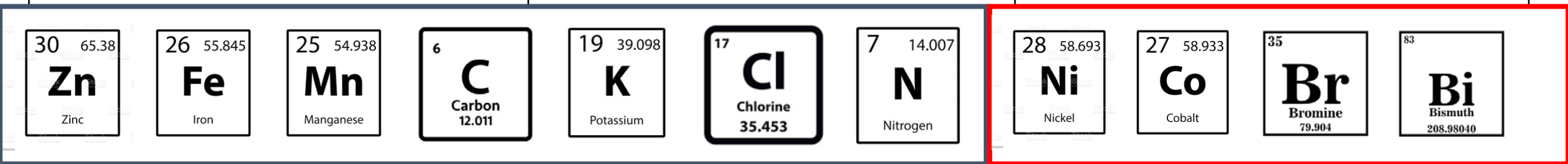
- Flow batteries easy to separate mechanically
- Cell separation of steel and plastics from black mass or paste
- Limited use of black mass or paste as micro-nutrients due to presence of other (eco-)toxic elements

Hydrometallurgical

- Hydro treatment follows mechanical separation
- **Recovery of high-value metals, pot. high recovery rates**
- **Integration in recycling processes of other battery chemistries** (e.g. Li-ion with Co & Ni recovery)

Pyrometallurgical

- Treatment of complete spent batteries vs. after mech. separation
- **Complete batteries processed at Inmetco; Fe, Mn, Ni, Co, Zn rec.**
- Black mass processed in Waelz Kiln for Zn rec.
- Organic materials (plastics, graphite) are lost eventually



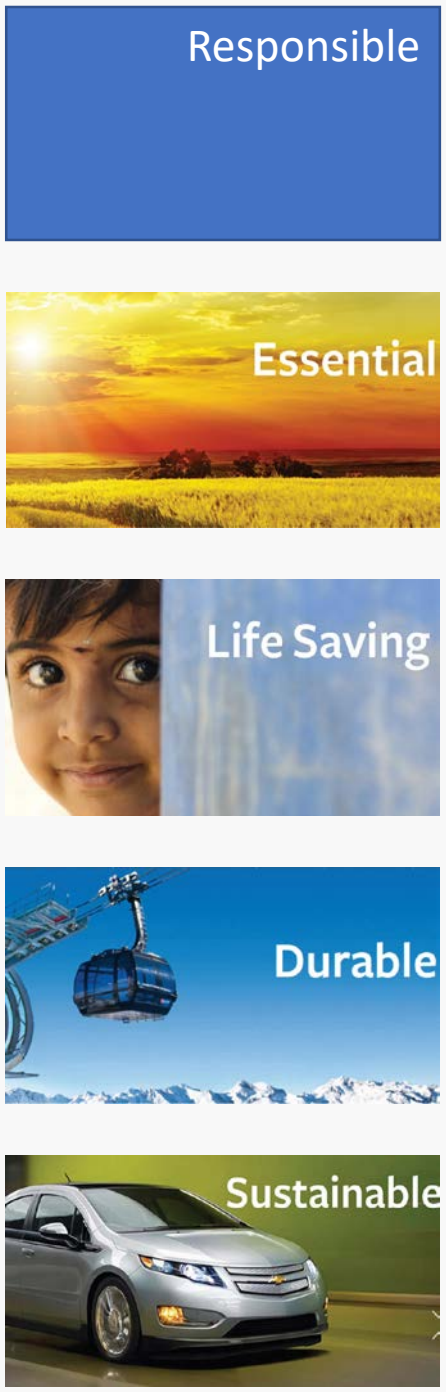
Recycling needs to be Economic

Metal	USD price/mt	Exchange, Closing
Cobalt	$51,955	LME, 29Sep2022
Lithium hydroxide monohydrate	$78,600	LME, 29Sep2022
Nickel	$22,348	LME, 29Sep2022
Copper	$7,542	LME, 29Sep2022
MnO2 (EMD)	$2,394	SMM, 30Sep2022
Zinc	$2,930	LME, 29Sep2022

Source: London Metal Exchange - LME, cash bid closing price; Shanghai Metals Market - SMM for Mn

Challenges to Close the Loop for Zinc Batteries

- ***Zinc batteries are versatile:*** For all battery chemistries, sizes and designs, not one way of recycling is available.
- ***Precondition of recycling is collection and sorting:*** Collection of consumer zinc batteries remains a challenge. Industrial battery collection schemes may become more effective.
- ***Recycling needs to be economic:*** Zinc is not always the most valuable metal in a battery, recycling may not always be economic (like Li in Li-ion)
- ***Closed-loop vs open-loop recycling:*** Zinc battery materials are likely to be recycled in a form and shape not always suitable for use as new starting materials.
- ***Metallurgy is never about one metal alone:*** Recycling of primary and rechargeable zinc batteries is often/will often be for the purpose of recovering many metals and materials, such as steel, Mn, Ni, Co and/or Cu – and of course zinc.



Summary

- ***Sustainability***
  - IZA spearheading Decarbonization, LCA, Stocks & Flow, Zn secondary raw materials, ESG and Due Diligence Standard for global zinc industry
- ***Zinc is a plentiful raw material with huge Extractable Global Reserves***
  - World EGR – 63,000 million tonnes → @12.5Mt/yr = 5,040 yrs.
  - Economic reserves – 250 million tonnes → @12.5Mt/yr = 20 yrs.
  - Demand estimate of apprx. 9 million tonnes cumulative by 2050 easily met
- ***Zinc has a diverse, secure global supply chain***
  - 50+ countries actively mining zinc; 27 countries actively smelting/refining zinc
  - Lower carbon footprint than Lithium and Lead
- ***Zinc recycling***
  - Zinc is versatile and multiple ways of recycling available
  - Recycling needs to be economic for widespread implementation

ZBI - Zinc Battery Initiative

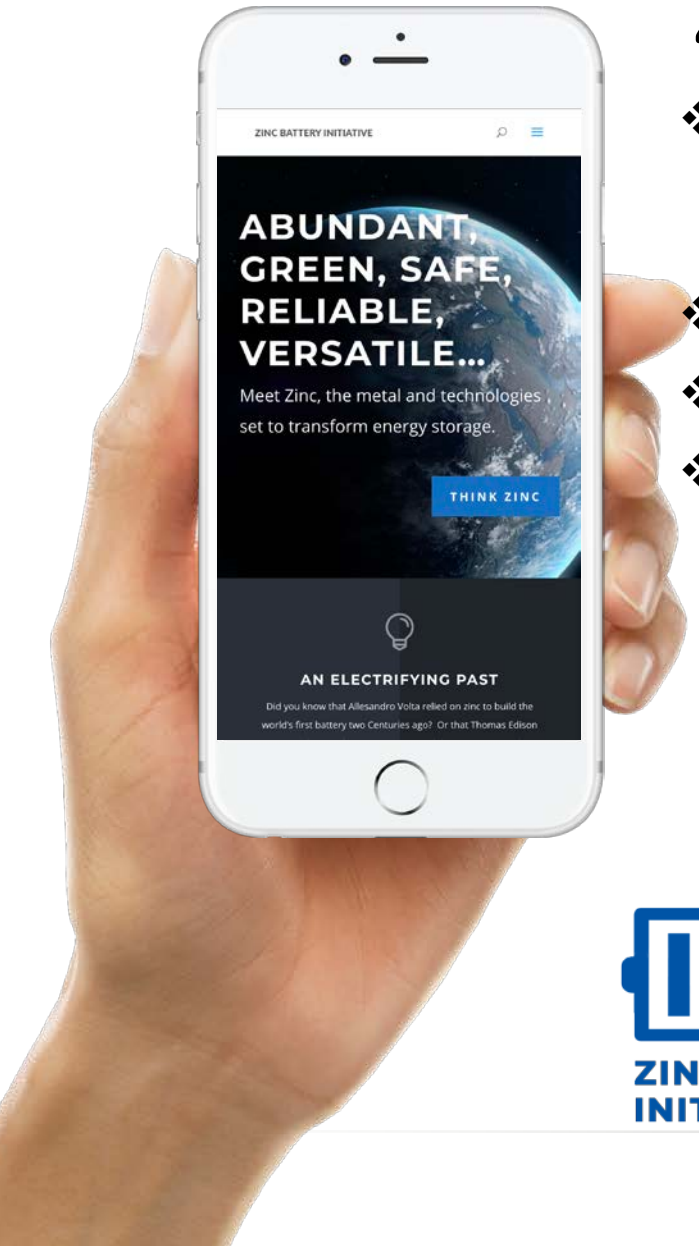
A Partnership to Advance Zinc-based Battery Technologies

The ZBI serves to champion zinc batteries and ensures that all potential customers and other stakeholders understand the value and advantages of zinc-based power and energy storage products.

ZINC BATTERY INITIATIVE

ZINC | international zinc association

ZINC | international zinc association



ZBI – Status

- Formed in late 2020 to promote the new wave rechargeable zinc batteries' remarkable story and encourage further adoption of these products.
- Principal sponsor is the Int'l Zinc Association.
- Grown to 11 members / battery producers.
- Engaged PR firm Silverline Communication to reach out to a variety of media channels in the clean energy / energy storage field
  - Secured press coverages and articles are publishing raising awareness for zinc-based batteries
  - More in pipeline

ENERPOLY

e-ZINC

IMPRINT ENERGY

redflow

SALIENT ENERGY

URBAN ELECTRIC POWER

ZAF Energy Systems

Ægir Technologies, Inc.

ENZINC

ZincFive

ZINC BATTERY INITIATIVE

Silverline Communications

FORBES AGENCY COUNCIL Official Member | 2021

BULLDOG AWARD | BRONZE Most Innovative Agency

MARCOM AWARDS Multi-year award winner

ZELOS

ZINC8

Thank You!

PLEASE VISIT OUR WEBSITES

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www.zinc.org

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ZINC BATTERY INITIATIVE

CALL FOR MEMBERSHIP!

Join IZA's ZBI – the voice of the zinc battery industry