

# Sustainability and the Zinc Battery Supply Chain

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*NAATBatt Zinc Battery Workshop V*  
Nov. 10, 2022



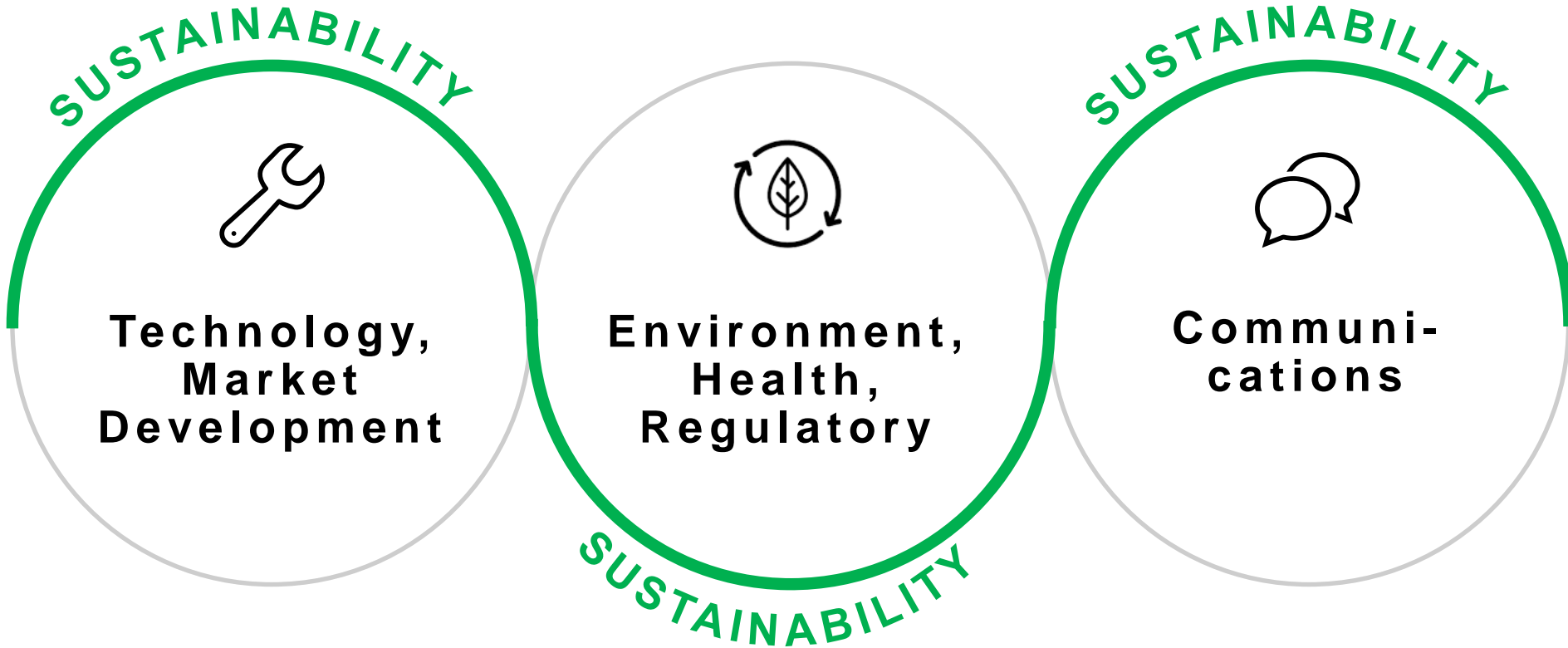
# International Zinc Association (IZA)

- 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



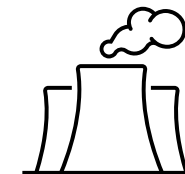


### 1. Responsible Sourcing

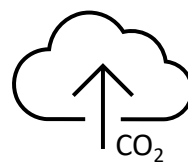
**LME Requirements – Joint DD Standard, passport**

**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

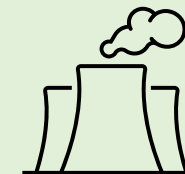
IZA's ambition is to ensure credible responsible sourcing schemes are available for all zinc producers anywhere in the world replying to all regulatory and stakeholder demands.



\* ESG: environmental, social and governance aspects

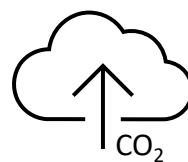


### 1. Responsible Sourcing



### 2. LCA and Carbon Footprint

Sector - LMEpassport CF Guidance for SHG Zinc  
Material – Profiles at site and global level



### 3. Climate Action and Energy



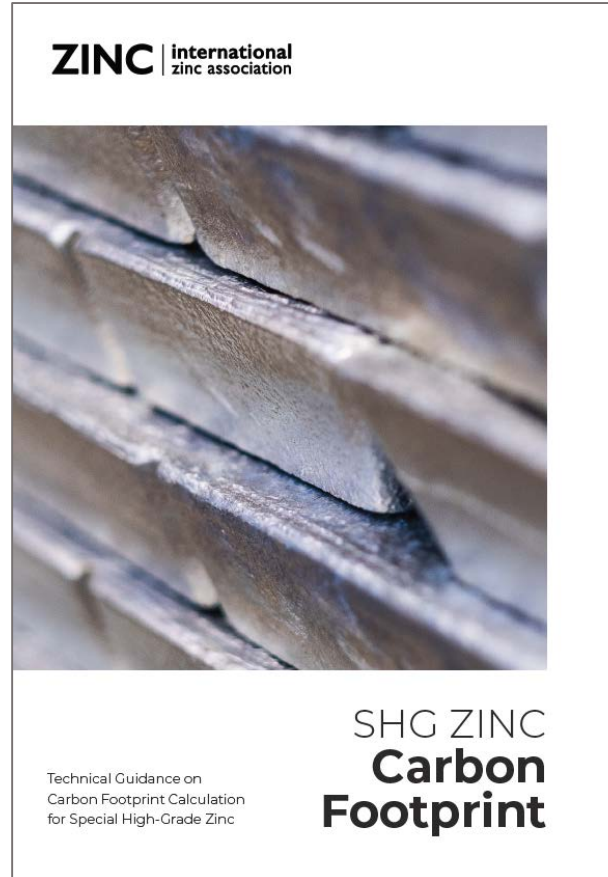
### 4. Circular Economy and Availability



# Zinc Life Cycle Assessment



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



[https://www.zinc.org/climate\\_change/](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

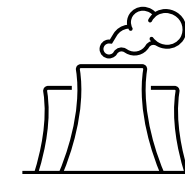


International Zinc Association

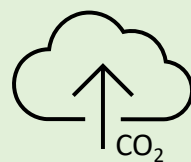




### 1. Responsible Sourcing



### 2. LCA and Carbon Footprint



### 3. Climate Action and Energy

Coordination – IZA Climate Change Task Force

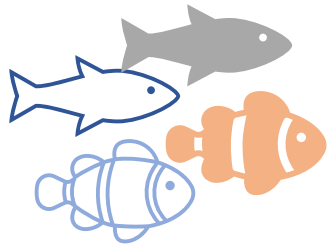
Strategy – Decarbonization Roadmap



### 4. Circular Economy and Availability



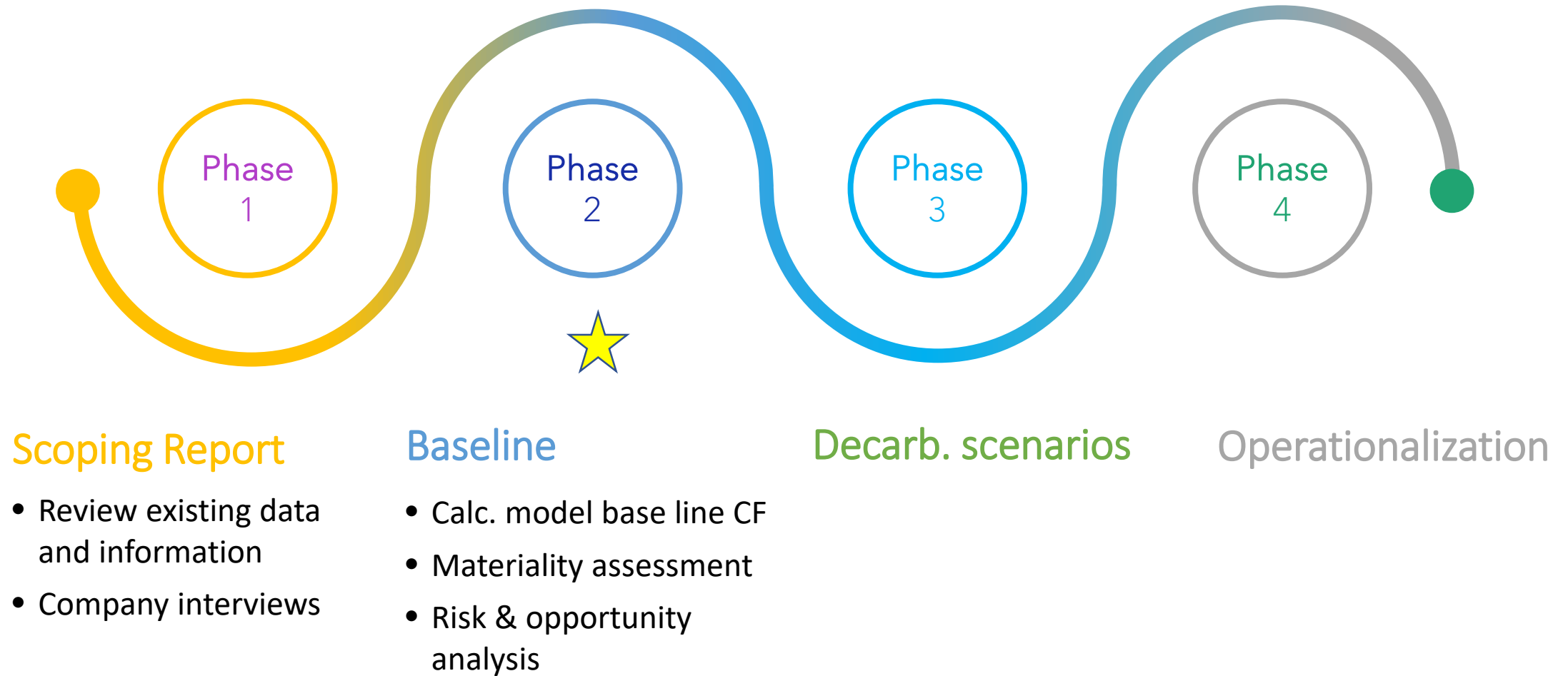
# Sector Perspective



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

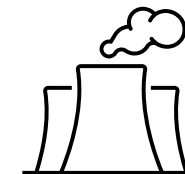


# IZA Decarbonization Roadmap

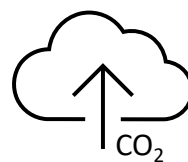




### 1. Responsible Sourcing



### 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

## ZINC RECYCLING Stocks + Flows

As a material, zinc follows a complex life cycle from raw extraction, through refinement and use in society, to eventual collection and recycling of products at the end of life. This life cycle can be characterized by collecting information at various stages of production, manufacturing, use, and waste management. Information on these "stocks and flows" of material can be used to calculate recycling rates, identify recycling gaps, and impact opportunities for increasing zinc circularity.

### Material Flow Analysis

A tool called Material Flow Analysis (MFA) is used to characterize the zinc life cycle, which is based on the mass balance principle. In MFA, a material life cycle is described by identifying the main stages (processes) of a material, the main flows connecting these processes, the stocks in which material accumulates over time, and its release from these stocks. These processes are interconnected through the generation and use of scrap in different forms and at different life stages. Flows are quantified by using a variety of data sources, estimates, and mass balances. Four main processes characterize the life cycle for zinc (Figure 1): mining & smelting production, first-use production, fabrication & manufacturing (products), use (service), and management and recycling of scrap and waste (end of life).

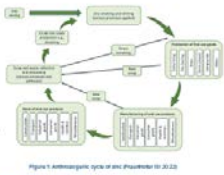


Figure 1: Anthropogenic cycle of zinc (Fraunhofer IZT 2022)

### The Dynamic Model of Zinc Global Stocks + Flows

The broad variety of zinc uses and zinc recycling pathways require a wealth of data to credibly describe the global zinc cycle. Zinc production, use, and recycling are closely interconnected with the material cycles of steel, brass, and lead, which adds to the complexity. The dynamic nature of the zinc cycle not only requires current input data, but also an historical flow to account for the durability of zinc which can offer a functional lifetime of 100 years for some applications. The International Zinc Association (IZA) partnered with Fraunhofer IZT Institute, Karlsruhe, Germany to develop a comprehensive dynamic model describing global zinc stocks and flows.

### Zinc Circularity

The zinc global stocks and flows model helps quantifying the current zinc circularity:  
• In 2019, 247 Mt of zinc were bound in the use phase, the so-called anthropogenic stock, about twenty times the amount of zinc that was mined in the same year (Figure 2). At the end of useful life, zinc will become available for recycling from the urban mine.

## ZINC RECYCLING Material Supply

The world is naturally abundant in zinc. Its unique metallurgical and chemical properties make it the material of choice for an extensive range of applications in a modern and growing society. At the end of their useful life, the zinc recovered from these products can be recycled without loss of its metallurgical characteristics or value. Further, while the attributes of zinc contribute significantly to sustainability during use, zinc recycling also plays a role in reducing mined zinc demand, energy use, emissions, and minimizing waste disposal.

### Zinc is Available from Geological, Mined Sources

There is an estimated 160,000 billion metric tons of zinc contained in the earth's crust in such form and amount that economic extraction is currently feasible or will become feasible by 2050 (accessible crustal content, Figure 3). However, not all of this zinc is immediately available for extraction. The complex interplay of economic, political, and environmental considerations dictates whether a particular ore body can or should be developed. Due to these factors, 63 billion tons of zinc are estimated as recoverable global zinc reserves. Of this, about 250 million tons (Mt) are proven and probable reserves that meet specified criteria for production to achieve current market demands.

Since exploration and mine development are ongoing processes, the amount of zinc reserves is not a fixed number and sustainability of zinc ore supplies cannot be judged by simply extrapolating the combined mine life of today's zinc mines. This concept is well supported by data from the United States Geological Survey (USGS), which illustrates that although refined zinc production increased 80% between 1900 and 2019, the reserve lifetime for zinc has remained unchanged.



Figure 3: Global attributes of zinc resources, reserves, production, and use 2019. Mt = million tons.  
1. Proven, 2019  
2. Proven, 2019  
3. Proven, 2019  
4. International Zinc Association, 2019

## ZINC RECYCLING Closing the Loop

Zinc is an essential element for all living organisms. Its unique metallurgical and chemical properties have also made it the material of choice for an extensive range of applications in modern society. At the end of their useful life, the zinc recovered from these products can be recycled without loss of its characteristics or value.

### Current Uses of Zinc

Refined zinc is used in a variety of applications. Galvanizing represents the largest first use of zinc – coating steel to provide corrosion protection (about 60% of total consumption, Figure 4). Other markets for zinc include alloying with copper (brass) or aluminum (zinc coating), rolled zinc sheet, compounds such as zinc oxide (used in fertilizers, paint, rubber, and pharmaceuticals) and many other applications. While uses have not significantly changed over time, zinc consumption has more than doubled in the last 40 years. Most of this growth has occurred in applications with long effective lifetimes, such as galvanizing, alloys, and rolled zinc, where the products may stay in service up to 100 years. Primary and use markets for these products include building and construction, transportation, industrial, electronic, and agricultural applications.

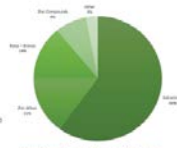


Figure 4: Circular refined zinc consumption by use

### Sources for Zinc Recycling

A systematic life cycle for zinc is illustrated in Figure 2. Zinc-containing products such as galvanized steel become a source of recycling feedback at the end of their useful life ("old scrap"). These products are collected and processed based on scrap availability, metal composition (e.g., coating, alloy, etc.) and ease of processing. Additionally, due to potential losses during manufacturing and fabrication (e.g., drosses, residues, off-cuts, etc.), zinc becomes available for recycling during the processing phase ("new scrap"). Depending on the composition of the recycling source being available, it can either be re-melted or returned to the refining process.



Figure 5: 2050 zinc recycling rates potential

### Recycling Rates

Approaches commonly used to assess recycling rates for zinc are Recycled Content (RC), Recycling Input Rate (RIR),

## ZINC RECYCLING 2050 Demand + Supply

Material demand at global level is expected to increase over the next decades. The development is driven by the growing world population and increasing living standards in developing regions, as well as changing use patterns in a growing economy. Zinc contributes to both improved living standards and changing use patterns from its uses in the building sector, infrastructure projects, and renewable energy production and storage. To ensure long-term zinc availability, the International Zinc Association has asked renowned experts to analyze 2050 zinc demand and supply scenarios.

### Zinc in Modern Society

About 60% of all zinc produced is used to protect steel from corrosion by galvanizing. Steel is the main metal needed for all projects related to building, construction, and infrastructure. Prolonging the lifetime of steel saves valuable natural resources and energy, while at the same time increasing and preserving the living standard of societies worldwide.

Renewable energy production is at the core of climate friendly economies. Zinc not only is involved in galvanizing steel structures that support wind and solar power generation, but zinc (batteries) also support long-duration grid-scale storage, transforming intermittent energy generation (wind and solar) into constant energy supply.

### Zinc 2050 Demand Scenario

Using the zinc global stocks and flows model, Fraunhofer IZT, Karlsruhe, Germany developed a 2050 demand scenario based on population growth and global GDP developments as described by OECD (Global Material Resources Outlook to 2050). As a result, the total amount of zinc used to produce first-use goods is expected to increase from 17.5 Mt in 2019 to 28 Mt in 2050. The energy storage market is forecast to consume an additional 2.8 Mt of zinc by 2050 (Figure 6). Demand expectations estimated by Fraunhofer IZT are well in line with those described elsewhere in published literature over the past ten years and for various time horizons. Unforeseen changes in societal use patterns to support carbon neutrality and subsequent new uses for zinc will also modify scenarios in the coming years.



Figure 6: 2050 zinc demand scenario (Fraunhofer IZT 2019)

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



# Zinc Batteries are Versatile

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

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



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



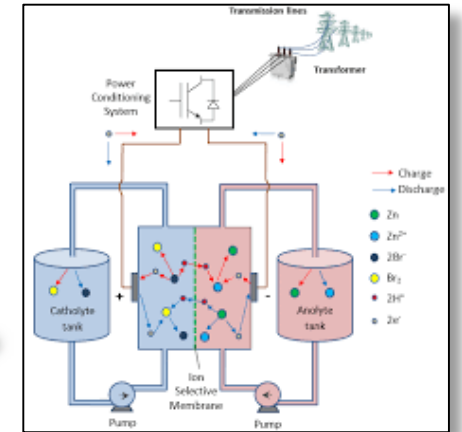
Zinc air – button or coin cells



## Rechargeable (secondary):

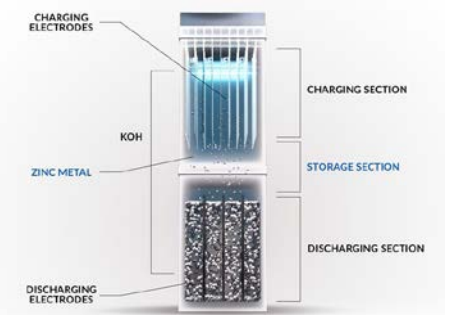
Zinc Bromine – flow

Nickel Zinc – cell



Zinc ion (sulphate electrolyte) – cell

Zinc Manganese (alkaline electrolyte) – cell



Zinc air – cell or flow

# Zinc Starter Materials for Batteries

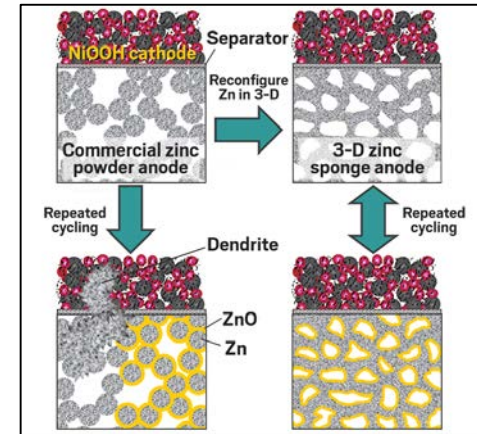
## Primary (single-use):

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

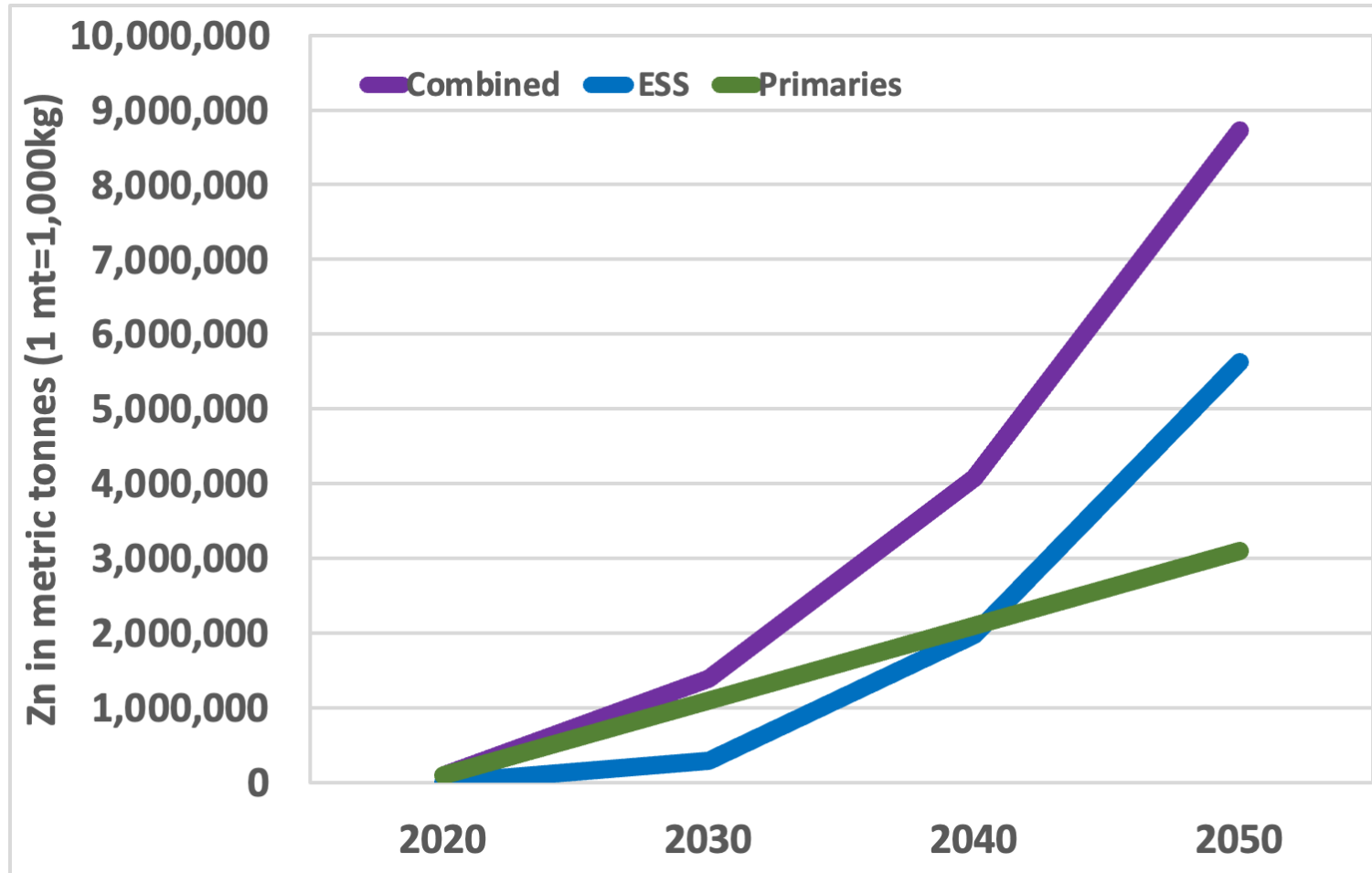


## Rechargeable (secondary):

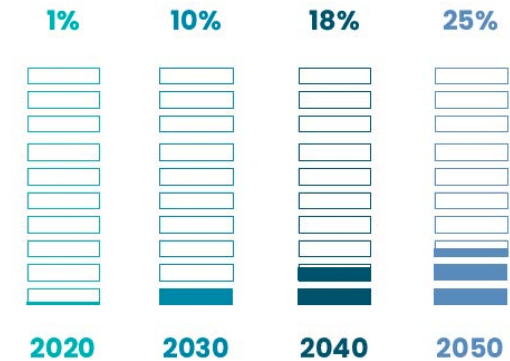
- Zinc bromide solution -  $\text{ZnBr}_2$  (aq.)
- Zinc oxide –  $\text{ZnO}$
- Zinc hydroxide –  $\text{Zn(OH)}_2$
- Zinc powder, alloyed,  
finer than primary batt.
- Zinc sheet or foil
- Zinc sponge
- Mixtures of the above



# Cumulative Battery Zinc Demand Forecast



## Zn Market Share Forecast in ESS'



- ▷ 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.





# Availability of Zinc



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

## Accessible crustal content

198,000,000 Mt<sup>1</sup>

7X from prev. update at  
28,000,000 Mt

## Extractable global resources

63,000 Mt<sup>1</sup>

22X from prev. update  
at 2,800 Mt

Zinc currently  
in use

247 Mt<sup>2</sup>

Proven and  
Probable  
reserves

250 Mt<sup>3</sup>

World zinc use/y

20 Mt<sup>6</sup>

Mined zinc/y

12.8 Mt<sup>4</sup>

Zinc recycled/y

7.6 Mt<sup>5</sup>

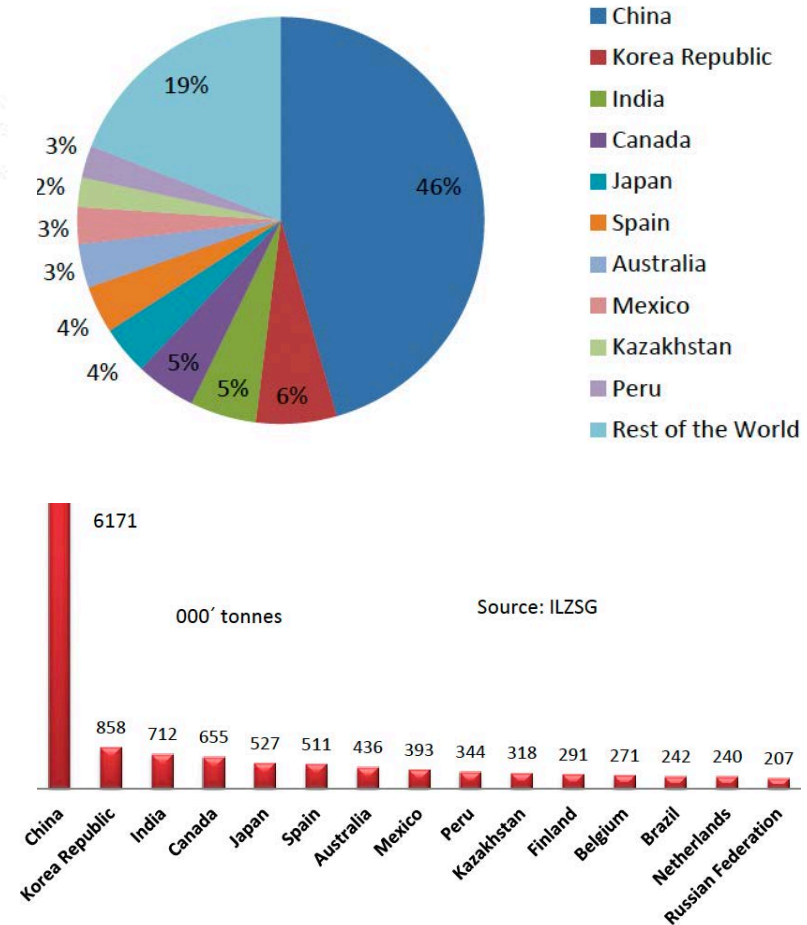


# Zinc Mining Countries in 2019



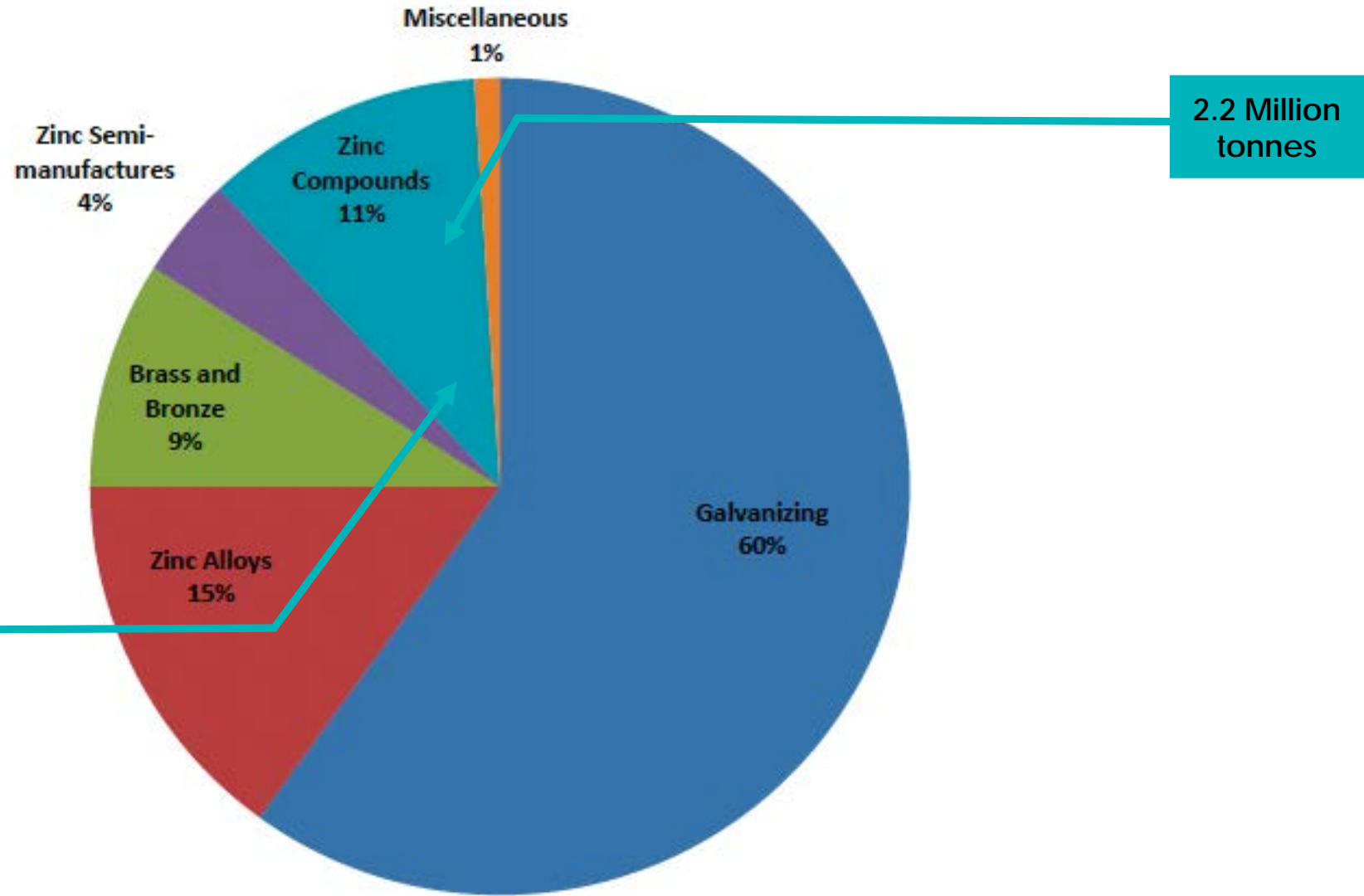
- ▷ Since 1960 over 60 countries have mined zinc ore
- ▷ In 2019, 51 countries were actively mining zinc
- ▷ Top 5 mining countries are China, Peru, Australia, USA and India
- ▷ Top 10 mining companies contributed to 41% of the world concentrate production capacity

# 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

# Zinc First Uses in 2019



Main zinc chemicals in current use include:  
▷ **ZnO**, **ZnCO<sub>3</sub>**, **ZnCl<sub>2</sub>**, **ZnSO<sub>4</sub>**, **ZnS<sub>2</sub>**, **ZnCO<sub>3</sub>**, **ZnSeO<sub>3</sub>**, Zn borate,  
▷ **Zn powder** and nanoform Zn compounds.

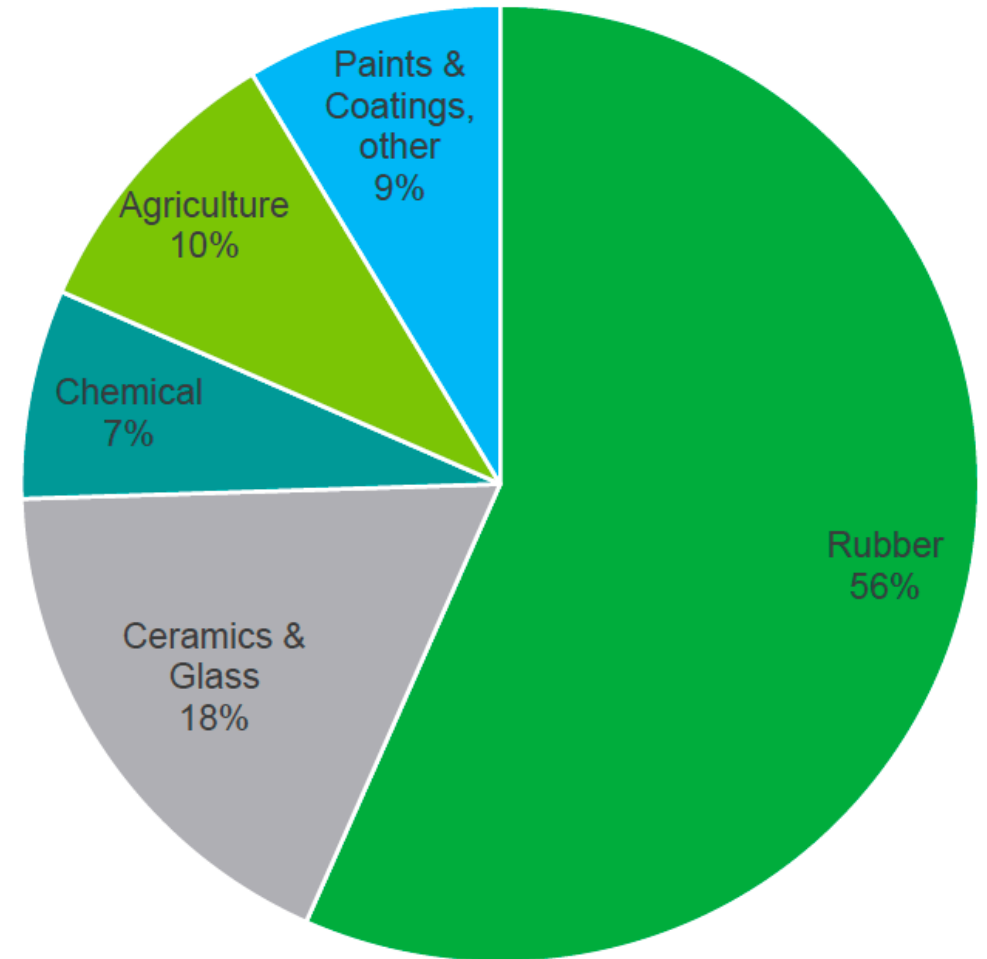
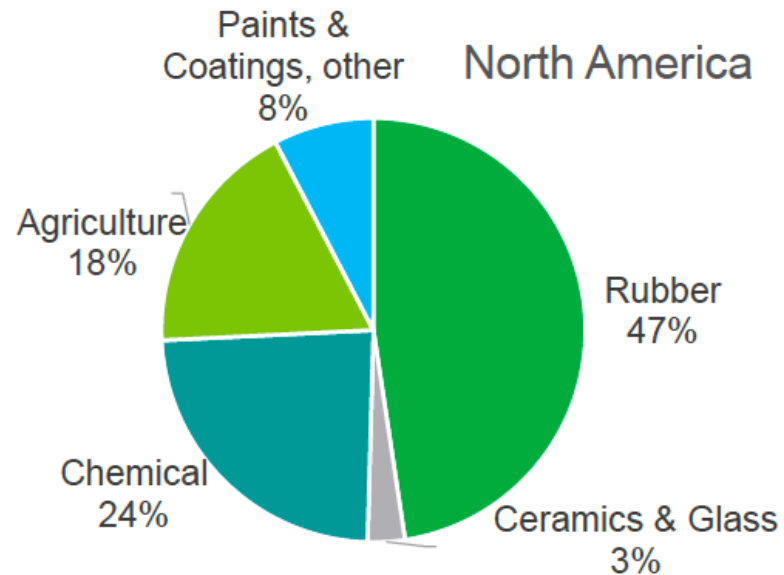




# Zinc Oxide Main Uses in 2020

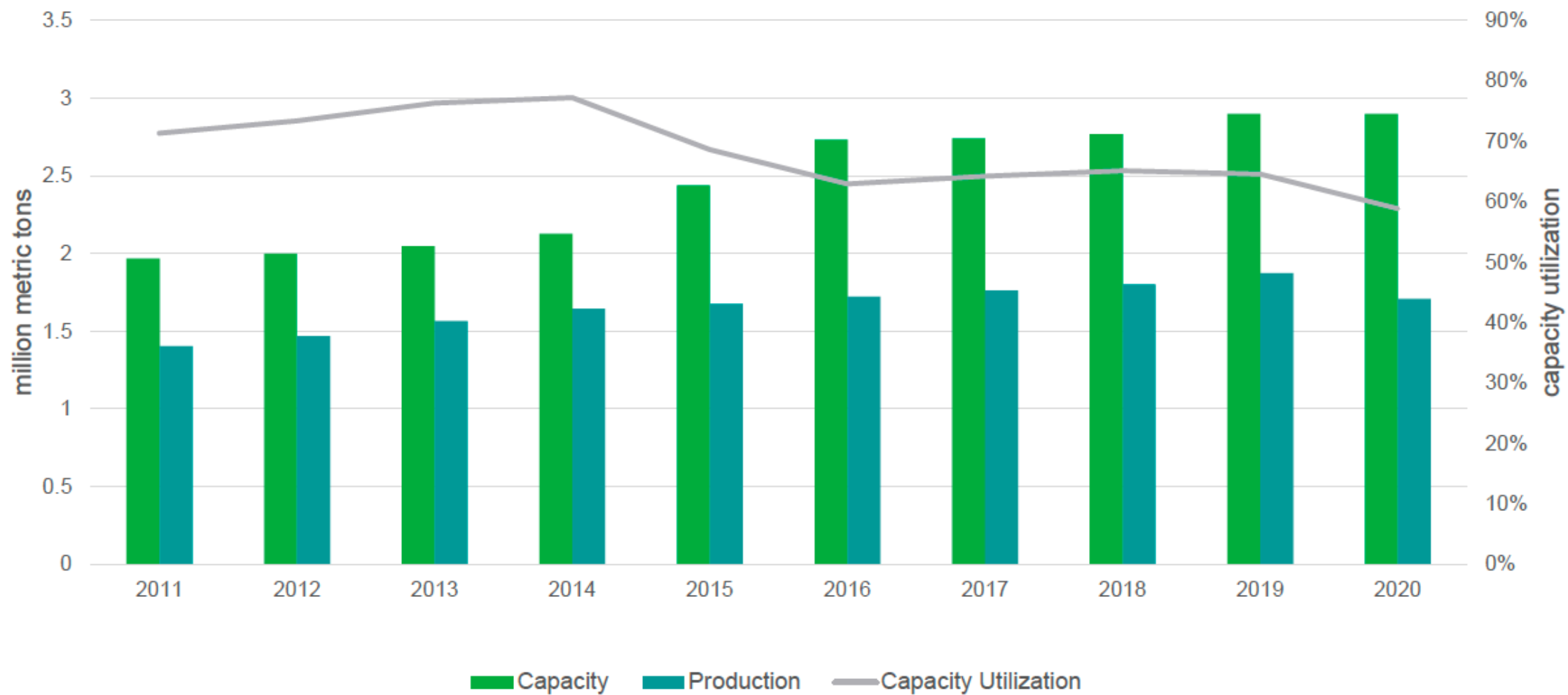
Global demand: 1.7 million metric tons

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

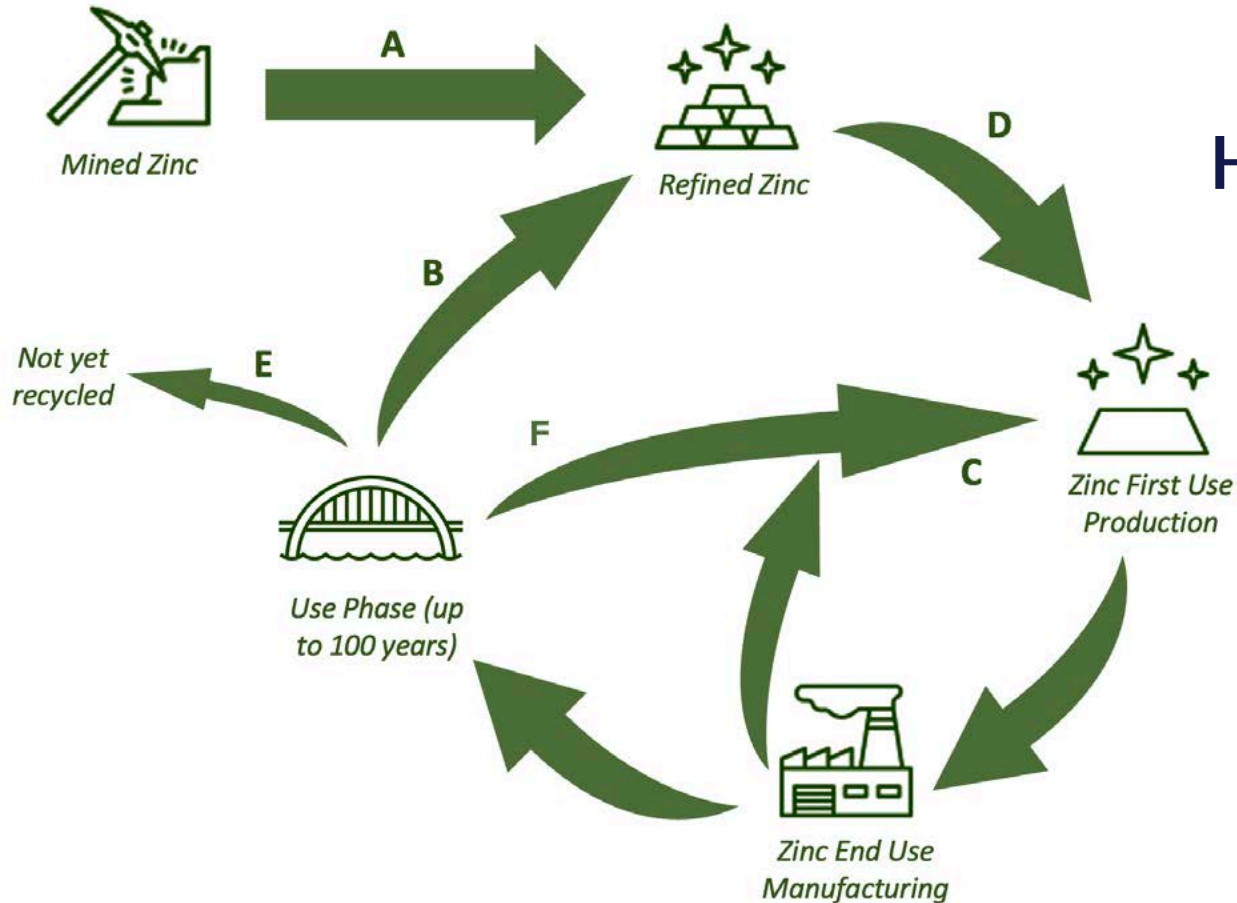




# Zinc Oxide Supply

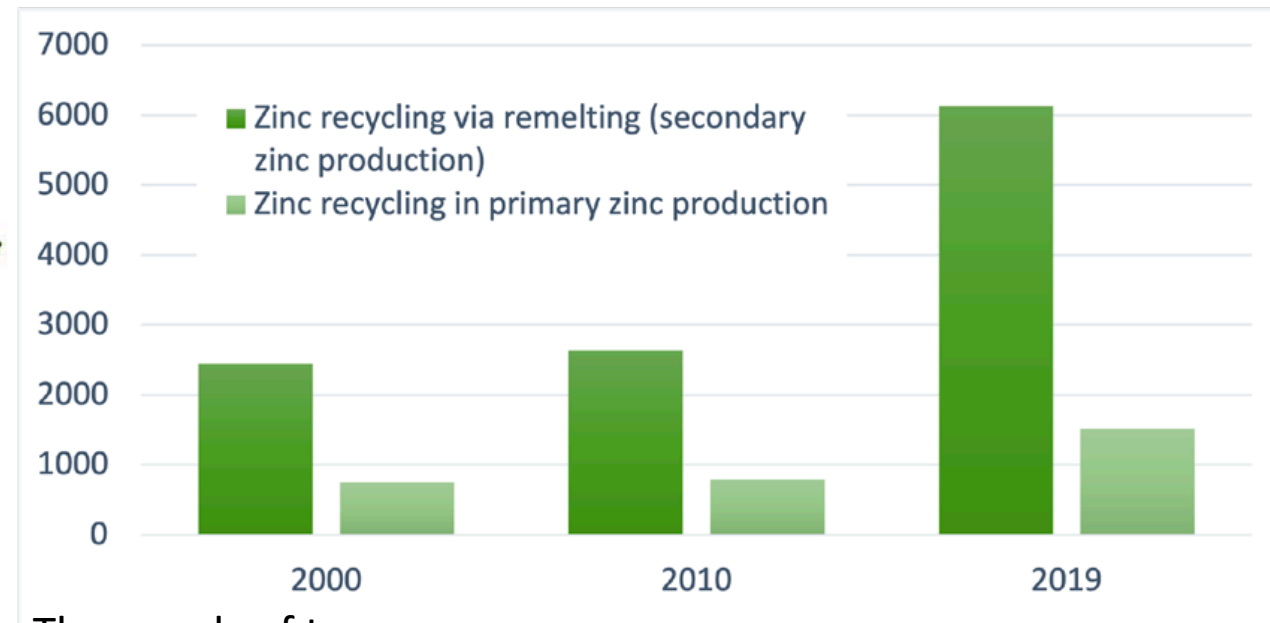


# Zinc Circularity - Recycling



▷ Zinc recycling loops (simplified).

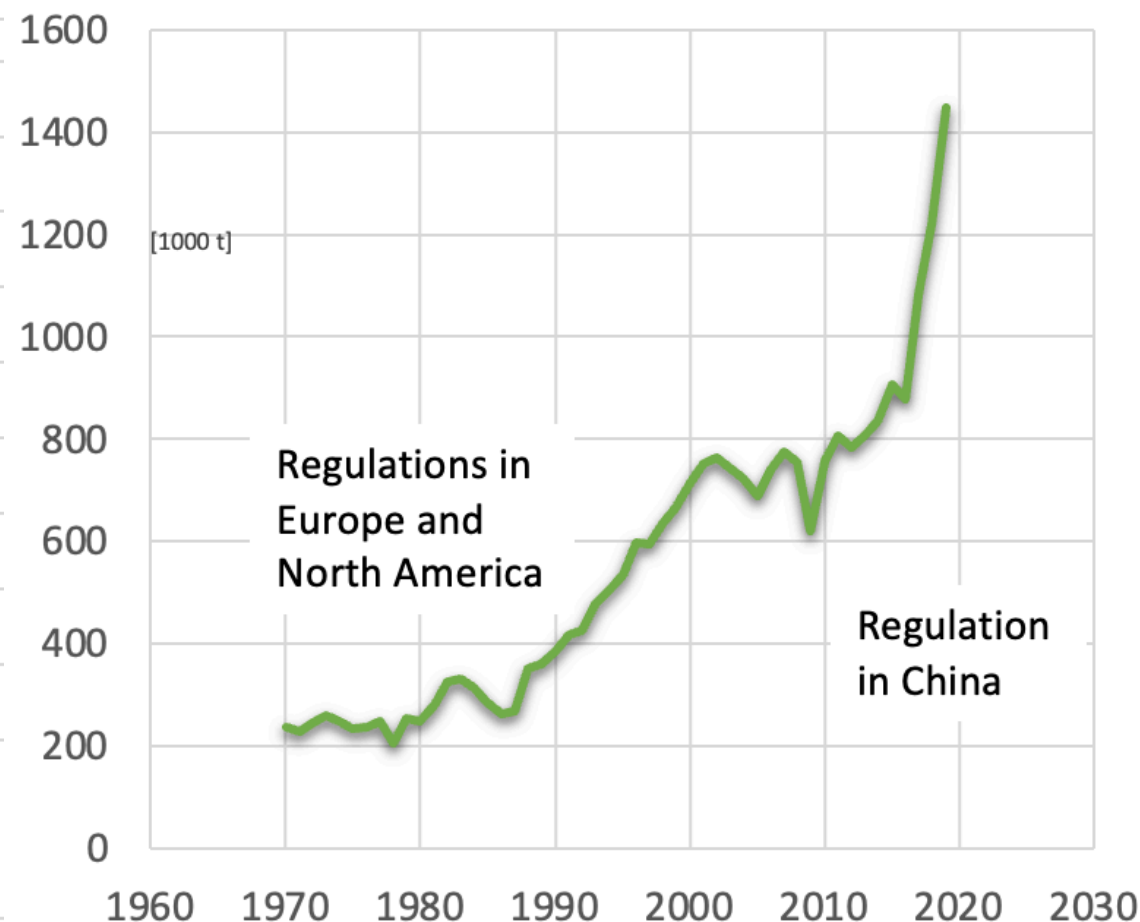
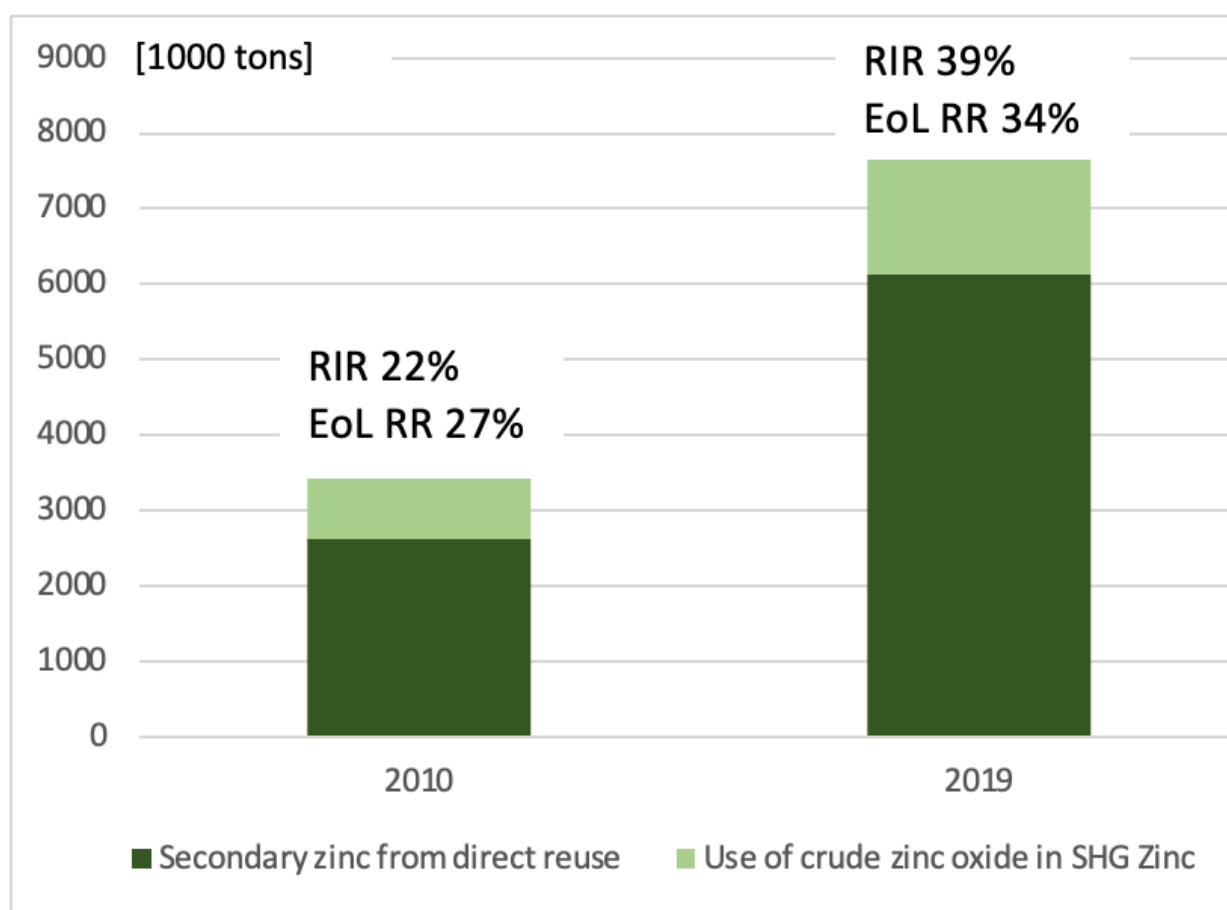
## How Much Zinc is Recycled Today?



Thousands of tonnes

▷ Zinc recycling

# 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).

# 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)

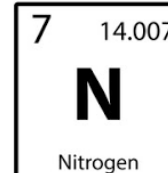
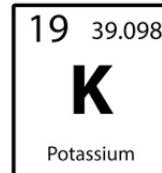
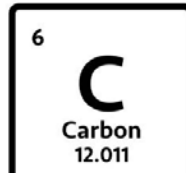
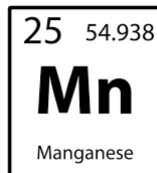
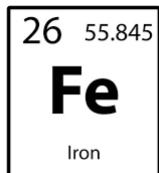
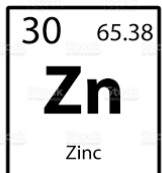
## Hydrometallurgical

- Hydro treatment follows mechanical separation
- Black mass is processed to  $\text{Zn}^0$ ,  $\text{ZnO}$ ,  $\text{Zn(OH)}_2$  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

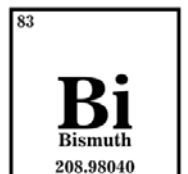
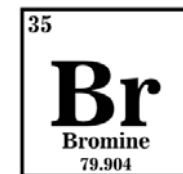
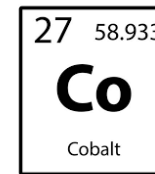
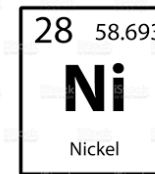
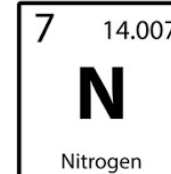
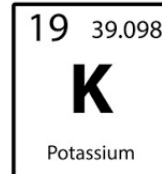
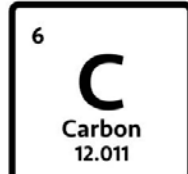
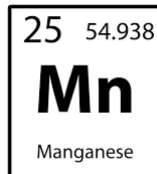
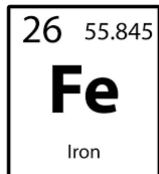
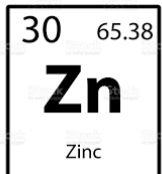
- Flow batteries easy to separate mechanically
- Cell separation of steel and plastics from black mass or paste
- Limited use of black mass or paste as micro-nutrients due to presence of other (eco-)toxic elements

## 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



# 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.



Responsible

Essential

Life Saving

Durable

Sustainable

# 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.

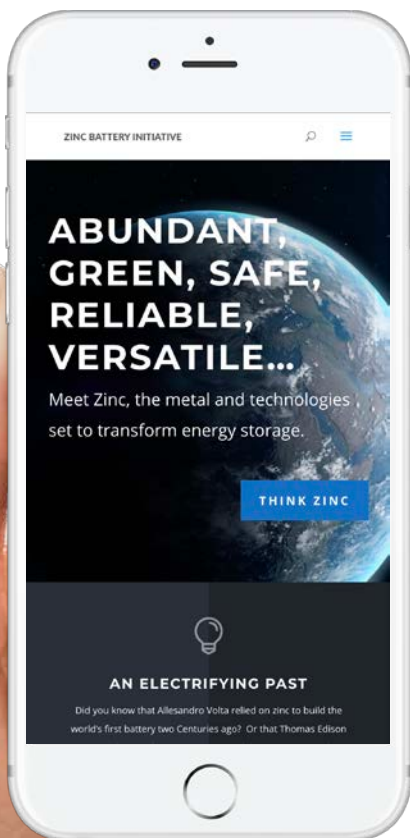


**ZINC** | international  
zinc association



## 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





# Thank You!

PLEASE VISIT OUR WEBSITES

[www.ZincBatteryInitiative.com](http://www.ZincBatteryInitiative.com)

[www.zinc.org](http://www.zinc.org)

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# CALL FOR MEMBERSHIP!

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

