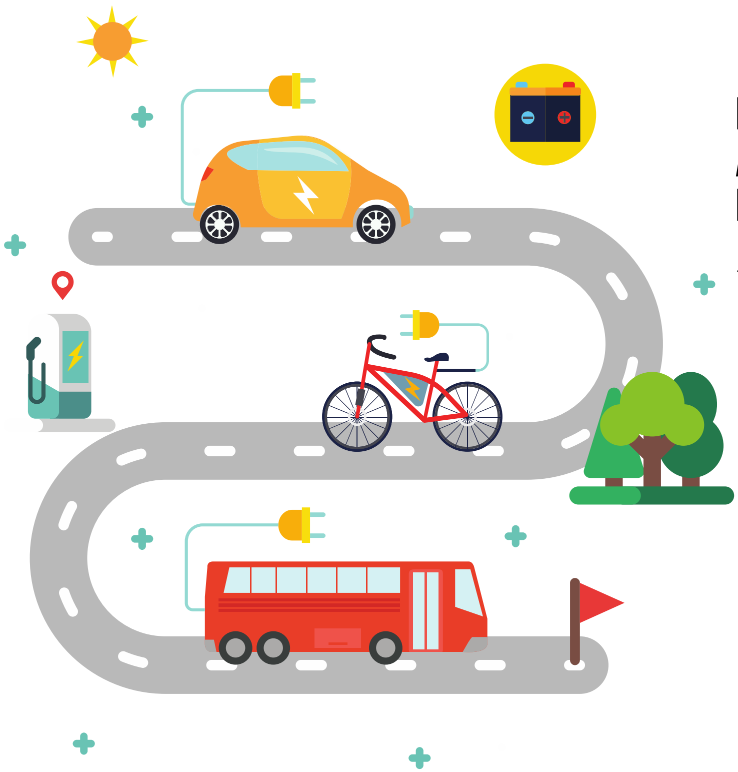


ELECTRIC MOBILITY FORUM

ENGAGE
Connecting Big Ideas To Action

ZIPTRAX
ADVANCED CLEANTECH

Circular Economy Strategy for the Batteries in India: Social, Technical, Environmental and Economic Aspect

January 17, 2020
3:00 PM - 4:00 PM (IST)
WRI India Delhi

Speaker:
Rohan Singh Bais
Director, Ziptrax Cleantech Pvt Ltd

Moderator:
Shravani Sharma
WRI India

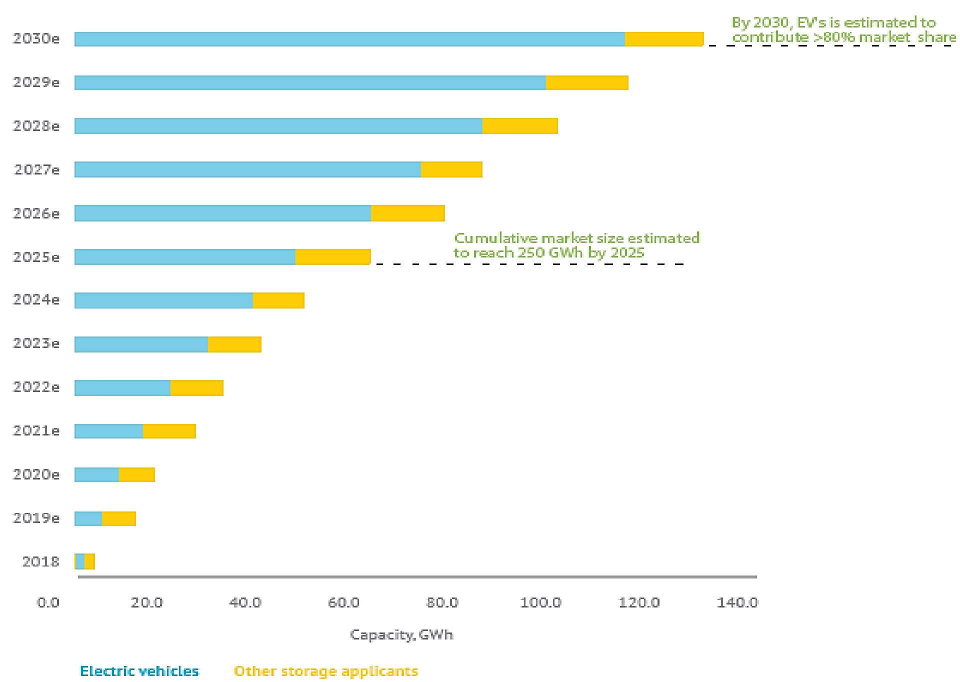
WRI INDIA
—ROSS CENTER

SHAKTI
SUSTAINABLE ENERGY FOUNDATION

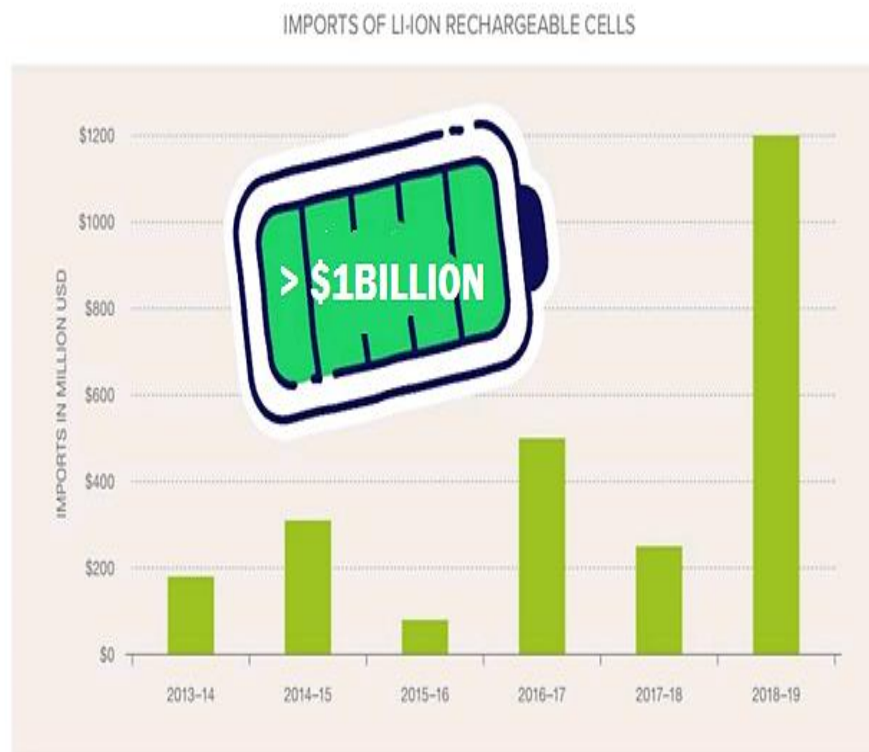
KEY DISCUSSION POINTS

- Status of recycling batteries for electric vehicles in India
- Potential for Re-Use of EV Batteries in other applications
- Mechanisms for Recovery and Utilization of Critical Battery materials.
- Policy frameworks to mainstream battery recycling in India
- Environmental aspects of recycling batteries
- Scope of Job opportunities once the recycling industry is mainstream
- Investment avenues in Li-ion Battery recycling companies.

LI-ION BATTERY GROWTH IN INDIA



Source: JMK Research



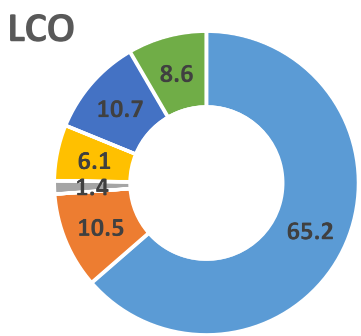
Estimates show the annual lithium-ion battery market in India is set to increase at a CAGR of 37.5% to reach 132 GWh in 2030. Cumulative lithium-ion battery market size is estimated to increase to about 800 GWh by 2030.

At present, lithium-ion batteries are used in the telecom sector, data centers, street lights, and other small consumer applications as well as by the electric vehicles segment.

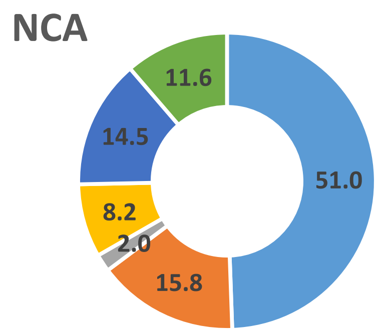
Raasi Solar is the first company that has started the domestic production of lithium batteries in India in 2019 in Tamil Nadu. Many other Indian companies including, Exicom, Amaron, Greenfuel Energy Solutions, Trontek, Coslight India, Napino Auto & Electronics, Trinity Energy Systems, Versatile Auto Components, have also announced their plans to make lithium-ion batteries locally.

Source: JMK, Ziptrax

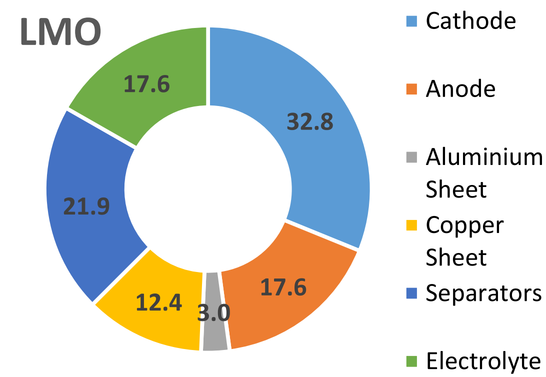
LI-ION BATTERY CHEMISTRY (% by value)



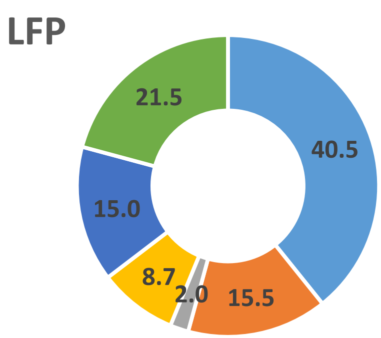
Lithium Cobalt Oxide
USE: Mobiles, laptops, consumer gadgets



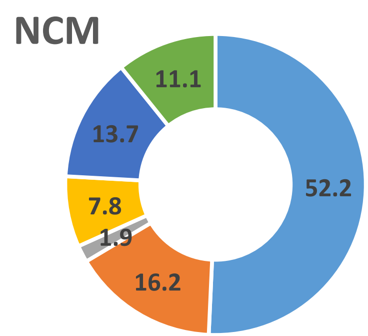
Nickel Cobalt Aluminium
USE: Tesla EVs, Satellites



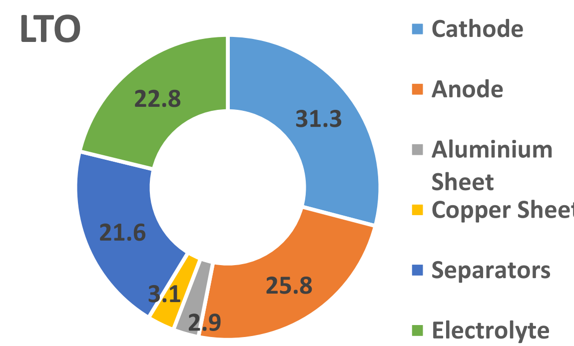
Lithium Manganese Oxide
USE: NISSAN EVs and Consumer Electronics



Lithium Ferro Phosphate
USE: Starter battery, Energy Storage, EVs and ForkLifts



Lithium Nickel Cobalt Manganese
USE: Laptops, consumer gadgets, EVs, Satellites, Energy Storage, etc

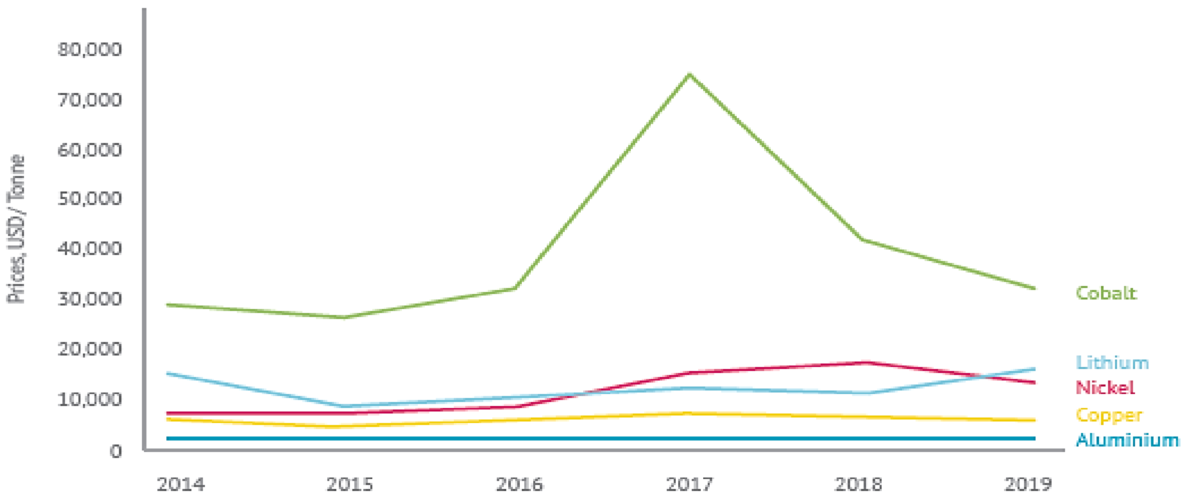


Lithium Titanate Oxide (Anode)
USE: Electric Vehicles and Energy Storage

Source: Ziptrax

ACCESS TO CRITICAL BATTERY MATERIALS

Li-ion Cell Elements & Prices:



Source: London Metal Exchange, JMK Research

BATTERY MATERIAL	COST PER KG (2019)
COBALT	$32/kg
NICKEL	$15.7/kg
LITHIUM	$10.6/kg
COPPER	$5.7/kg
GRAPHITE	$1.8/kg

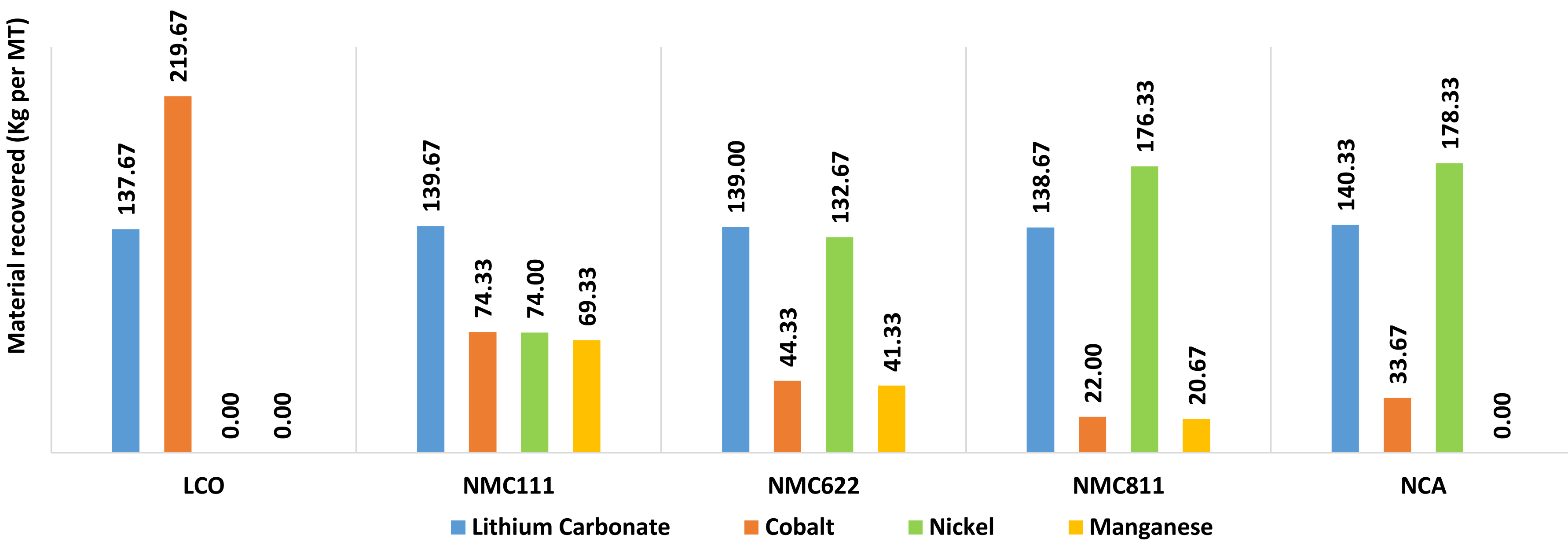
Sourcing of Critical Battery Materials remains a major obstacle for Li-ion Cell Manufacturing to begin in India, with none of the Cathode Materials being presently produced in India. All the above materials need to be imported from various countries or can we recovered from Li-ion battery Waste in India.

To ensure that India has strategic access to lithium and cobalt, in 2018, Government has directed three state-owned mineral companies- National Aluminium Company (NALCO), Hindustan Copper (HCL) and Mineral Exploration Corp. Ltd (MECL) to explore and acquire these strategic mineral assets abroad. This proposal is currently with the Niti Aayog, which would conduct due diligence before it can be formalised.

Source: Ziptrax, LME

RECOVERY OF CRITICAL BATTERY MATERIALS

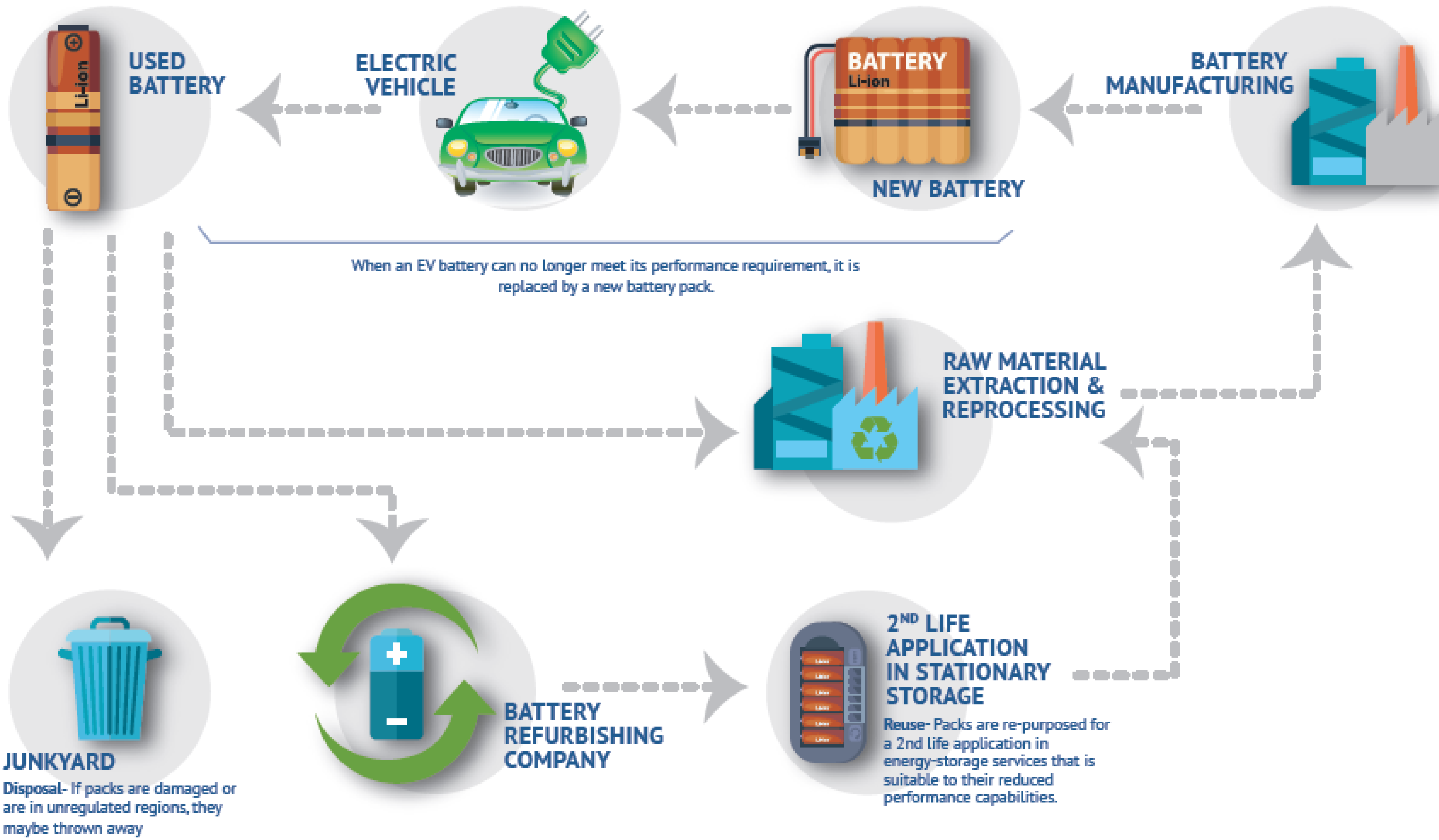
Cathode Metal Recovery from Li-Ion Battery Waste (Per MT)



- The cathode accounts for all the Li, Co, Ni and Mn present in the battery and often gets mixed with anode (graphite) during the pre-treatment, forming a “Black Mass”.
- Recycling Processes are designed to recover Cathode Materials from the black mass and maximizing the monetary recovery from recycling Lithium Ion Batteries.
- Cathode Waste from prominent LiB chemistries have been compared to show potential value of material recovery from Cathodes, LCO and NMC 111 are relatively older types of Li-ion Batteries and typically contain more Cobalt in the cathode.

Source: Ziptrax

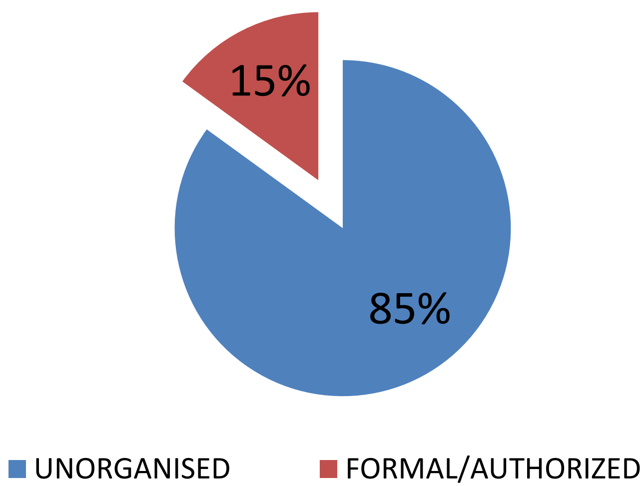
CIRCULAR ECONOMY: SUSTAINABLE LIB LIFECYCLE



Source: JMK Research

CIRCULAR ECONOMY: SDGs AND BEST PRACTICES FOR INDIA

STATUS OF E-WASTE AND BATTERY RECYCLING SECTOR



Total E-waste generated in India is about 2.4 Million Tonnes per Annum), however, total recycled in the Organized sector is less than about 20% or 4,38,085 TPA (Capacity, 2018)

India is enforcing Laws for E-waste rules, Battery Handling Rules, GST, etc. but requires Direct Regulations on Li-ion Battery Recycling.

CIRCULAR ECONOMY & SDG

The circular economy is based around three core principles:

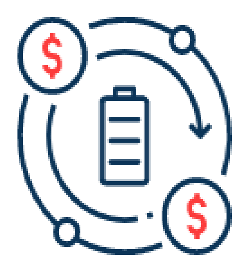
1. Designing waste out of the system (REVIVE);
2. Keeping products and materials in use(REPURPOSE);
3. Regenerating natural systems.(RECOVER)

With the SDGs, the shift to the circular economy will require systemic and transformational change in order to build long term resilience and sustainability.

Globally major economies have regulations and incentives in place for using Closed Loop Li-ion battery Recycling.

WHY LIB RECYCLING IS KEY FOR INDIA?

ENVIRONMENT FRIENDLY MINING



SUSTAINABLE BUSINESS

ACCESS TO FUTURE TECHNOLOGY

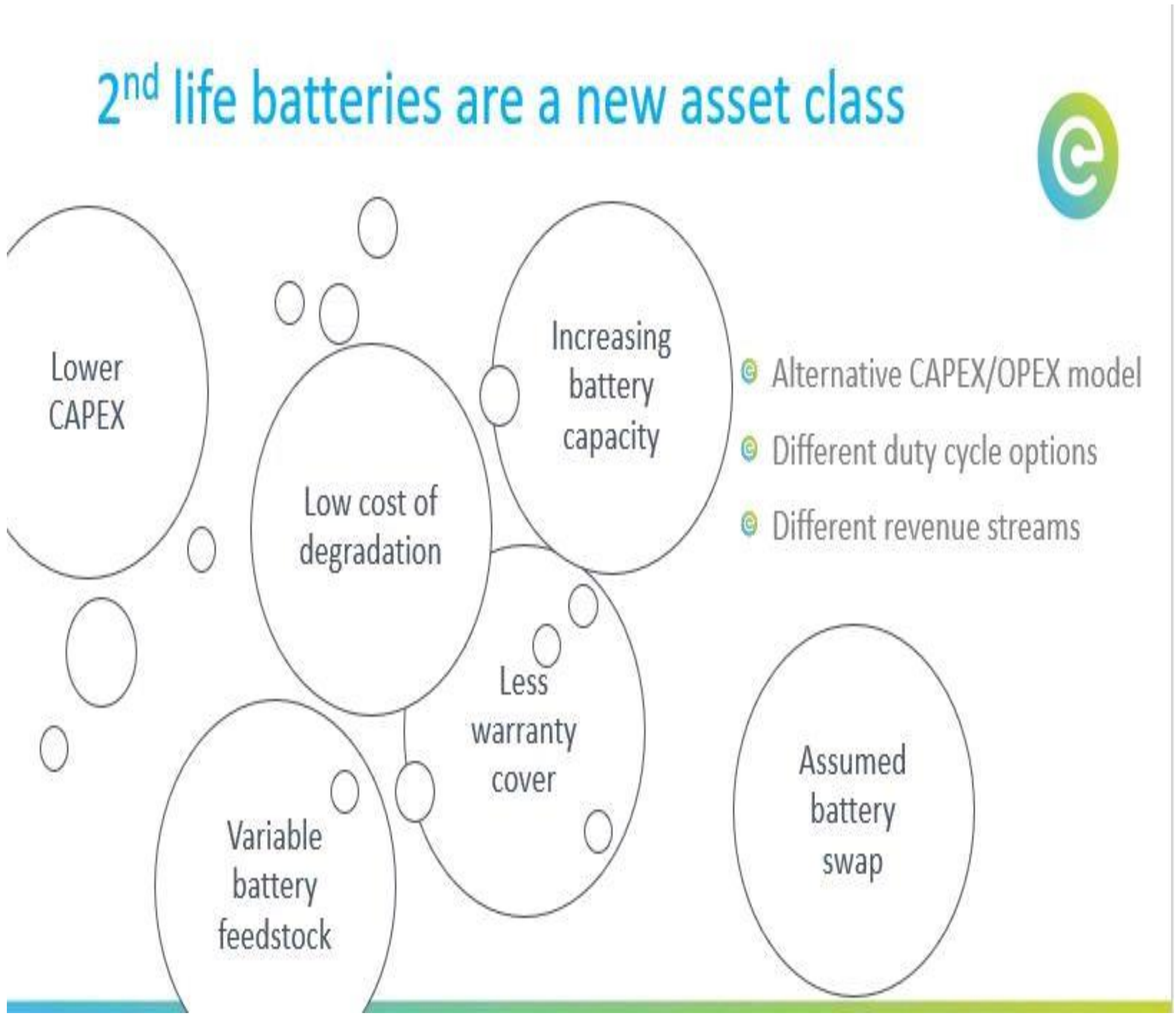
Source: Ziptrax

CIRCULAR ECONOMY: SECOND LIFE POTENTIAL

Shelf life of EV Li-ion Battery is 8-10 year usage period. Performance of Batteries reduced by 20-30%, these are categorized as 'Spent Cells'.

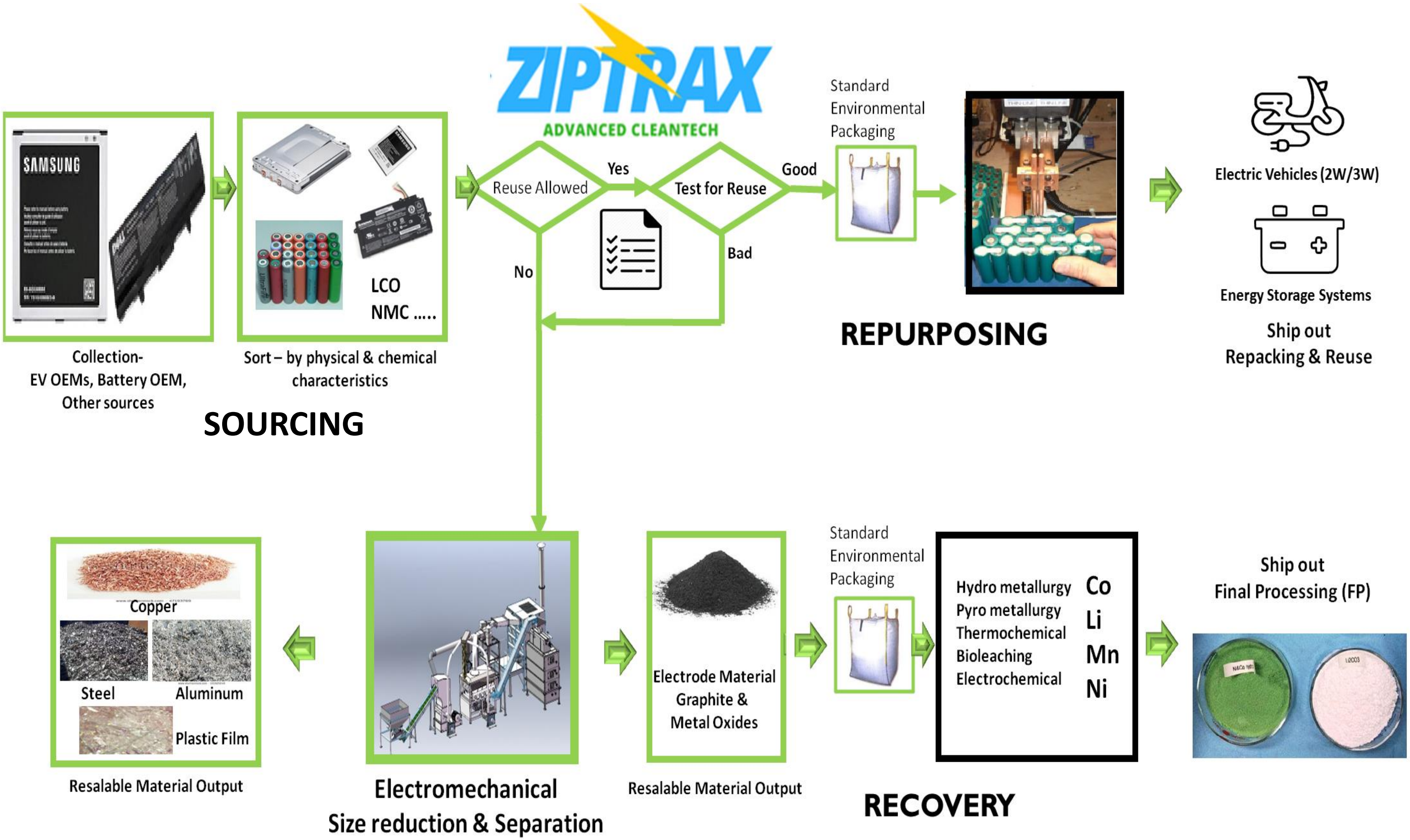
These 'spent' batteries still retain 70%–80% of their initial capacity and can function for several years in 2nd Life Applications:

1.Residential and commercial Power Backup,
2.Power grid stabilization,
3.Renewables integrated ESS,
4.Battery Integrated EV Charging Stations,
5. Light Electric Mobility use,
6. DG Replacement



Source: Electrek

CIRCULAR ECONOMY: CLOSED LOOP LIB RECYCLING

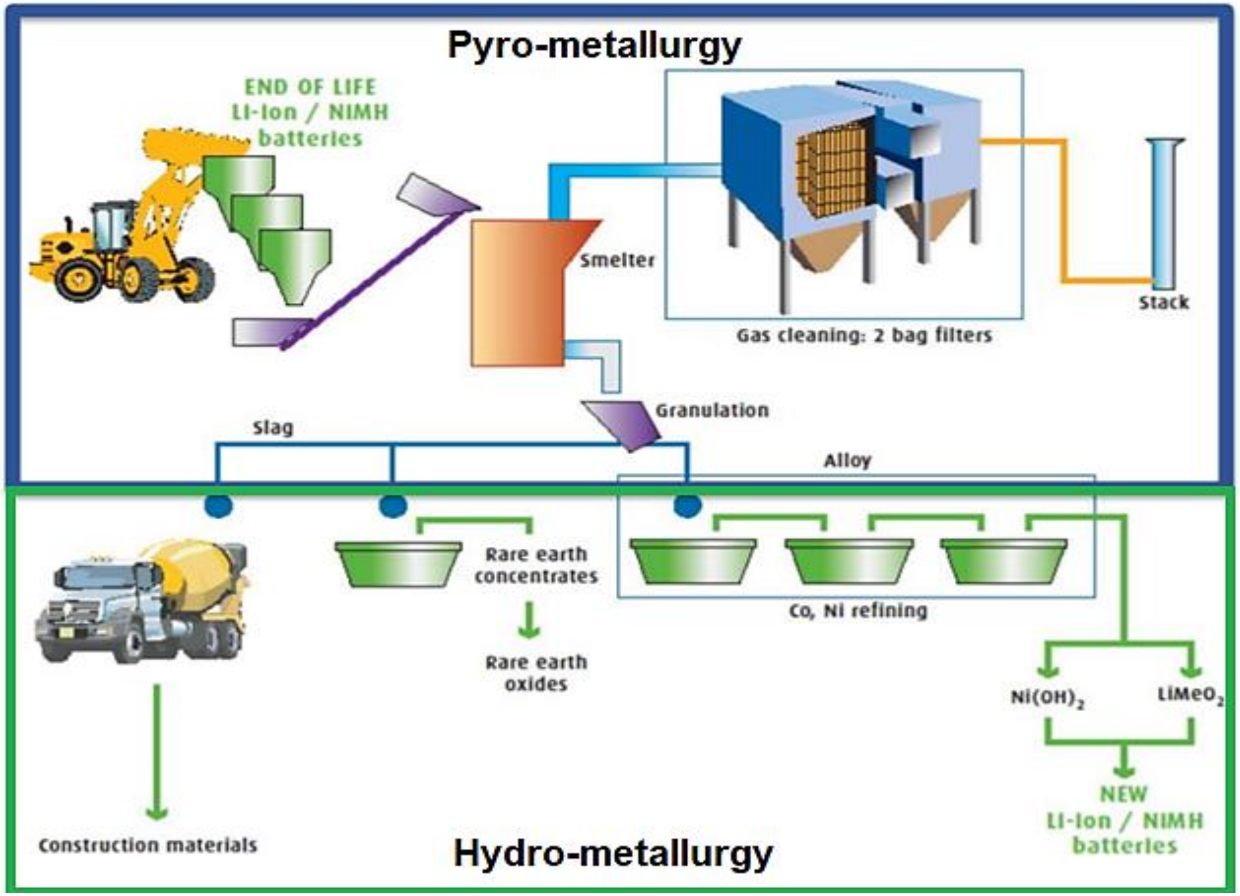


Source: Ziptrax

METHODS OF RECOVERY: PYROMETALLURGICAL

UMICORE has developed a specifically dedicated recycling process for portable batteries by Combined pyro- and hydrometallurgical processes for Lithium-ion and NiMH batteries.
The Pyro-processes operating commercially now are economical for batteries with Cobalt and Nickel based cathodes but Newer chemistry types like NMC 811 or for Manganese oxide or LFP cathodes the recovery is low.

- Li-ion batteries are dismantled and components are fed to a high-temperature shaft furnace with slag-forming agent, sand.
- The electrolyte and plastics burn and valuable metals are reduced to an alloy of cobalt, nickel, copper and iron.
- Metals are recovered from the Alloy by leaching while the Slag (containing Li, Al, Si, Ca, Fe, and Mn (in cathode) is removed.



Battery wastes are subjected to melting without any pre-treatment in an electric arc furnace for maximizing Cobalt and Nickel output as LiCoO2 and Ni(OH)2. Gas cleanup steps are need to stop release of toxic by-products.

Source: UMICORE

METHODS OF RECOVERY: HYDROMETALLURGICAL

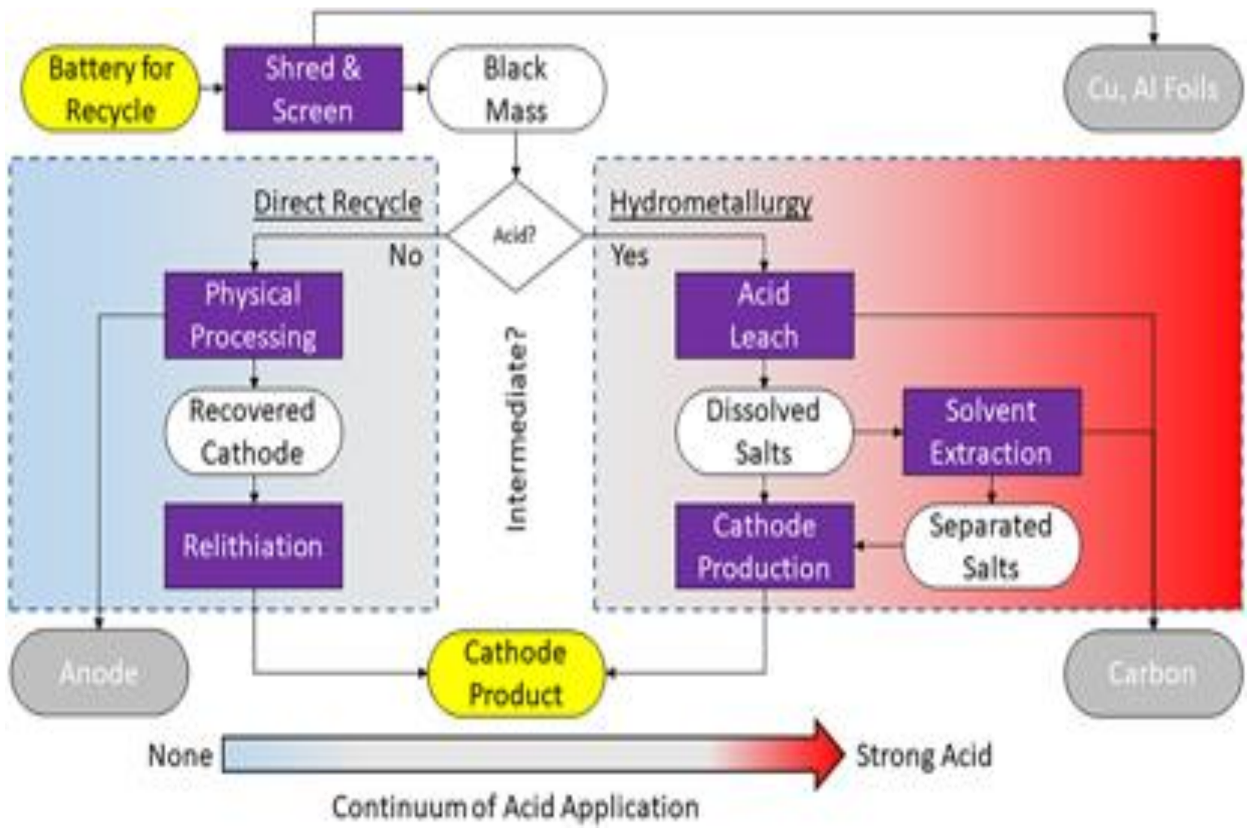
Hydrometallurgy is a more environmentally friendly leaching process from the cathode active materials of spent li-ion batteries and can recover all materials from waste li-ion batteries.

Batteries are pre-treated using physical processes such as shredding and sieving.

The chemical process involves combination of:

1. Acid or base dissolution,
2. Solvent extraction,
3. Chemical precipitation,
4. Electrochemical methods.

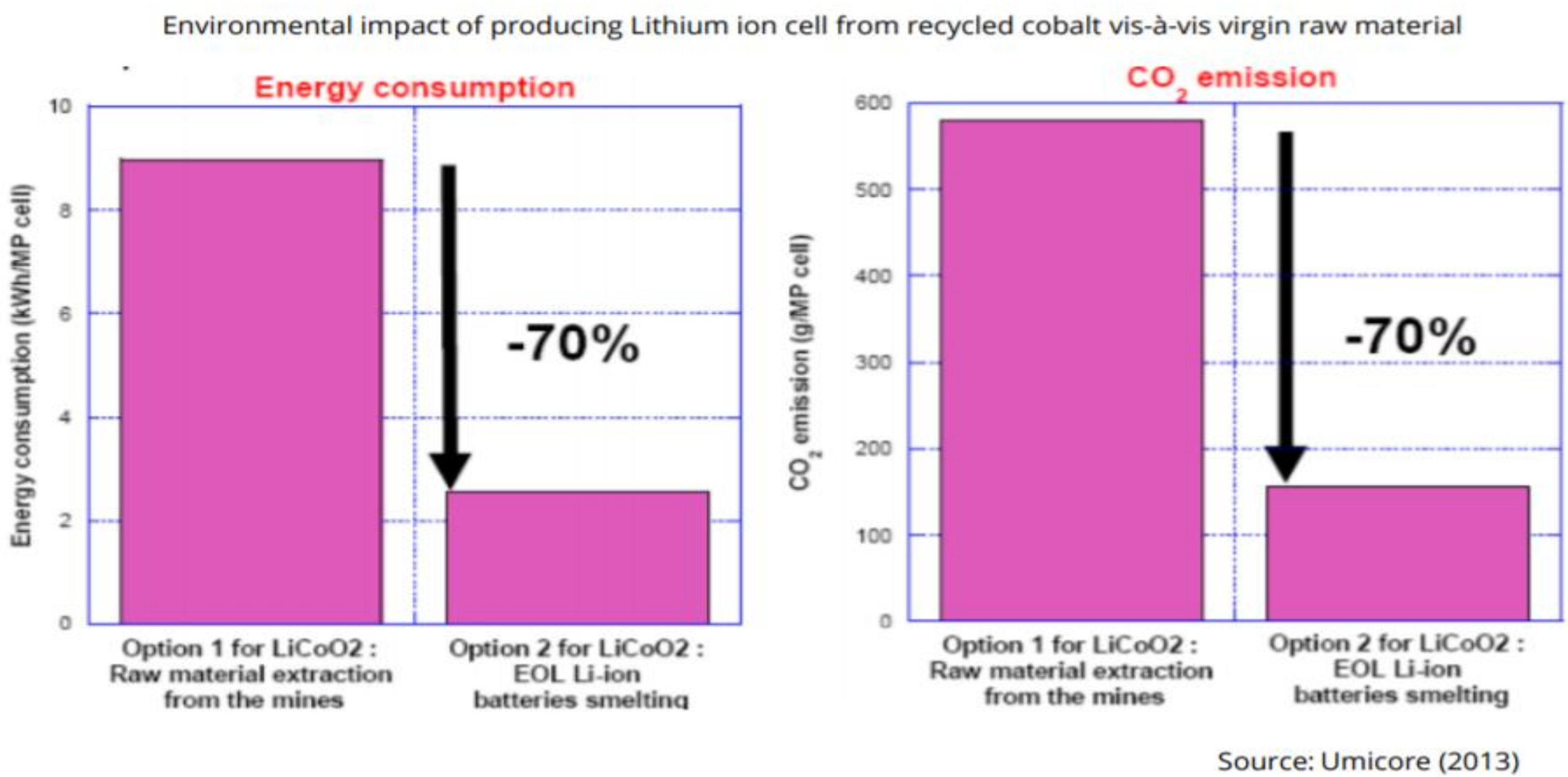
Hydrometallurgical methods are used on the basis of their simplicity, environmentally friendliness (due to almost zero waste water and air emissions), adequate recovery of valuable metals with high purity and low energy requirements.



Hydrometallurgical process has been developed to recover valuable lithium products and other materials from all types and sizes of li-ion batteries.

Source: Cambridge.org

CIRCULAR ECONOMY: IMPACT ON CELL MANUFACTURING



Battery Type	Estimated cost of disposal	Production process	CO2 Emission	Re-use Potential
Lead acid	Profitable; lead has intrinsic value	30 mega joules; 8.3kW*	3 kg per kg	Low
Lithium-ion	Profitable Re-Use; Profitable to extract Nickel, Cobalt, Copper, Aluminum (high market value)	170 mega joules; 47kW*	12 kg per kg (Hydro)	High

CIRCULAR ECONOMY: DRIVERS FOR LIB RECYCLING

Market Driver	Description	Short term impact (0-3 years)	Long term impact (3-8 years)
Electric Vehicle Adoption	Rise in demand of Commercial and Passenger EVs, e-rickshaws, Electric Two-wheelers and buses.	Low	Very High
Renewable Integration of Energy Storage	Coming years will witness substantial growth in renewable energy connected BESS deployment as favourable condition arises and BESS market is expected to grow along with Renewables.	Medium	High
Diesel Replacement	With solar tariffs and energy storage costs decline, penetration of Battery storage as a credible alternate for diesel generation is slowly emerging.	Medium	High
Availability of critical battery materials in India	Access to Critical Battery Raw materials such as high grade Cobalt, Lithium, Nickel and Graphite for lithium-ion cell manufacturing will drive the market for recycling Li-ion batteries.	High	Very High

CIRCULAR ECONOMY: LIMITATIONS FOR LIB RECYCLING

Market Limitation	Description	Short term impact (0-3 years)	Long term impact (3-8 years)
High Capex Investment	High capital cost for setting up facilities, collection of battery waste, safe warehousing and logistics are the limitation for Lithium Ion Battery recycling in India	High	Low
Efforts by government to enable E-waste and battery waste	Extended Producer Responsibility Guidelines under E-waste Management Rules 2016 are being implemented but currently don't mention Lithium ion Battery Waste from EVs and ESS.	Medium	High
Lack of Regulatory policy	Comprehensive regulatory framework is required separately for Advanced Batteries such as Lithium ion and Nickel based Batteries.	High	Medium
Formalization of Waste management sector	Currently 85% of volumes of e-waste and battery waste are managed by the unorganised sector, this makes it very difficult to regulate. To attract large investments and higher processing capacity, sector needs to be formalized systematically.	High	High

CHALLENGES FOR LIB RECYCLING IN INDIA

Challenges To Industry

- Prevent Dumping Of Li-ion Waste In Landfills
- No Recycling Regulations Or Scrappage Policy Specific For Ev & Li-ion Waste.
- End Of Life Asset Liability.
- Lack Of Data On Collection, Segregation And Recycling.
- Fire Hazards In Handling And Storage Of Li-ion Battery
- Challenge Of Recycling Non-cobalt/Nickel Rich Batteries Economically
- Domination Of China And South Korea In Both Manufacturing And Recycling Li-ion Batteries.
- High Capex Investment for setting up recycling and recovery plants.
- Superior Technology to help in reusability of li-ion batteries in second life applications.

OPPORTUNITY FOR LIB RECYCLING IN INDIA

Opportunities And Measures In-sight

- India Li-ion Batteries Market Projected To Grow At Cagr Of 37% In 2020-2030 Period, Being Prime Market For Smart Solutions, Battery Ess And Electric Vehicles,
- Large Employment Opportunity : Li-ion Battery Recycling Industry Is Projected To Value USD 1 Billion By 2025 As India's Top 20 Cities Generate 90% Of Li-ion Battery Waste,
- Li-ion battery Re-utilization In 2nd Use Applications Reduces Initial Cost Of Deployment.
- New Investment Opportunity Also Exists In R&D To Make Recycling Of All Type Of Batteries Economically Viable .
- Increased Financial Support (Subsidies And Incentives) For Data Collection And Dissemination, Standardized Warranty Policies For 2nd Life Li-ion Batteries Can Help Formalize Lib Recycling.
- Industry Developed Performance Standards That Can Be Used By Policy Makers To Clarify Liability Regulations As Latest Recycling Technology Projects Have Validated The Market Potential.
- Electric Vehicle Companies Launching Products In India Have Started Collaborations With Li-ion Battery Recycling Sector For Better Liability Cover As Well As Future Compliance Purposes, Eg, Mg Motors With Umicore.

RECOMMENDATIONS AND CONCLUDING REMARKS

- India needs Regulations for Li-ion Battery Collection, Reuse, Recycling and Disposal.
- Spent lithium-ion batteries and lithium-ion waste should be classified as 'Dangerous Goods', dumping them should be banned.
- India needs to frame policies on incentives such as subsidy for plant setup, tax holiday and income tax reduction in order to boost Formal Recyclers of lithium-ion batteries.
- The EPR Liability should cover battery suppliers, EV OEMs, local assembly units and enable efficient collection mechanisms.
- Recyclers and Manufacturers utilizing Metal Recovery as an Import Substitute for LIB Critical Battery materials should be given tax benefits.

Conclusion

Safe Disposal, Efficient Recycling and 2nd Use of Li-ion batteries create a circular economy with an end-to-end closed loop flow of materials in a Cradle-to-Cradle mechanism. Enabling New Investments in Research & Development of Future Technology as well as create job opportunities.

Li-ion Battery Recycling enables India to deal with cell manufacturing issues (reducing waste, pollution and costs), and eliminates to a large extent the shortage of critical battery materials in India and substitutes their imports.

THANK YOU

CONTACT US: INFO@ZIPTRAX.IN

ZIPTRAX

REPURPOSING|RECYCLING|RECOVERY

SUPPORTED BY:

Shell E4

Energizing and Enabling Energy Entrepreneurs