Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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In cooperation with

NITI Aayog

Battery Ecosystem: A Global Overview, Gap Analysis in Indian context, and Way Forward for Ecosystem Development

Webinar

5 October 2023

Deloitte.

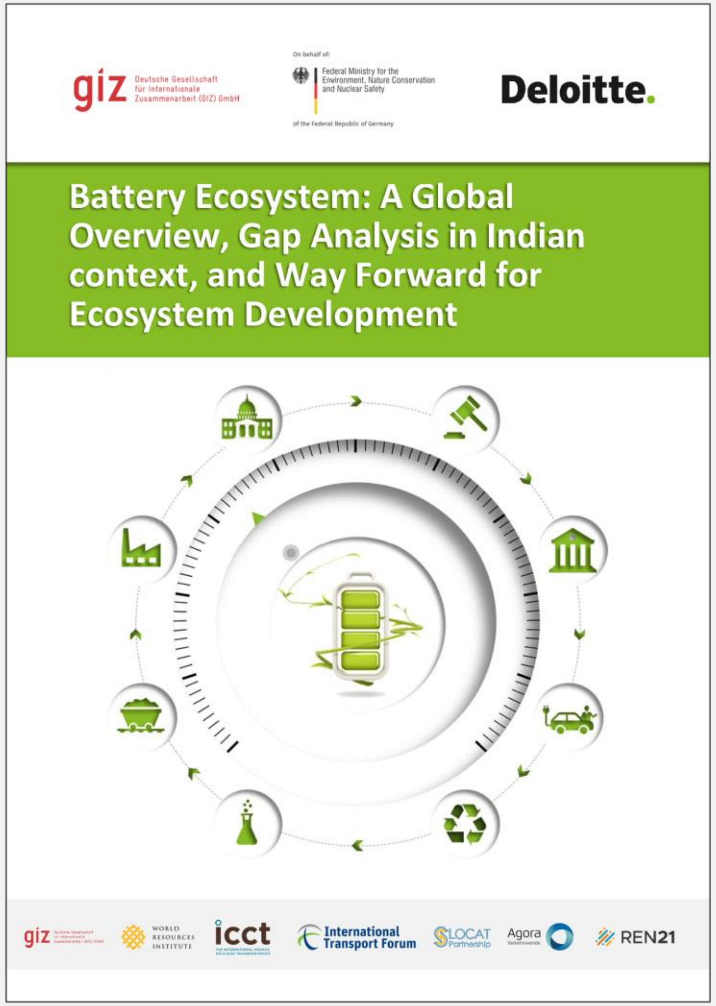
NDC TRANSPORT INITIATIVE FOR ASIA

CONTENTS

GIZ and Deloitte had conducted a study around Li-ion battery ecosystem in 2022

The study aimed to provide a global overview and perform gap analysis in the Indian context and suggest a way forward for battery ecosystem development looking into:

- ✓ **Value chain** for **traction batteries** and current scenario of sourcing, manufacturing, assembling, reuse, and recycling in India and globally
- ✓ **Battery standards** in India, key gaps and ways to bridge them
- ✓ Policies, Regulatory, technical and logistical **barriers** to the **battery swapping**, disposal, recycling and reuse
- ✓ **Financial and economic analysis** of battery swapping and battery recycling businesses



Report link:

In addition to it, we have conducted an analysis of the Reuse and Recycling (R&R) of battery value chain

The study aims to:

- ✓ Help entities in identifying various **stakeholders** in the ecosystem
- ✓ Inform about the various **permissions** required to set up a battery recycling/refurbishing facility
- ✓ Identify the **EHS risks** involved throughout the R&R value chain and suitable mitigation measures.
- ✓ Provide a **Standard operating procedure** (SOP) to ensure safe handling of batteries to minimize battery incidents of any nature
- ✓ Identify key **financial aspects** of a battery reuse facility

Report 1 link:

Report 2 link:

Importance of Battery Reuse and Recycling (R&R) Ecosystem

With growing demand and high import dependency, development of reuse and recycling ecosystem is critical to complement battery manufacturing in India

India lacks mineral availability for lithium-ion battery manufacturing…

Critical Battery Mineral	3 Li 6.94	28 Ni 58.69	27 Co 58.93	25 Mn 54.93	6 C 12.01
Mined in India?	✗	✗	✗	✓	✓

…and relies heavily on imports of Lithium-ion cells

~41% **CAGR** growth observed in lithium-ion cell import (in terms of value) during 2017-2022

Source: ITC TradeMap

Therefore, R&R is critical to address the future demand cumulatively till 2030

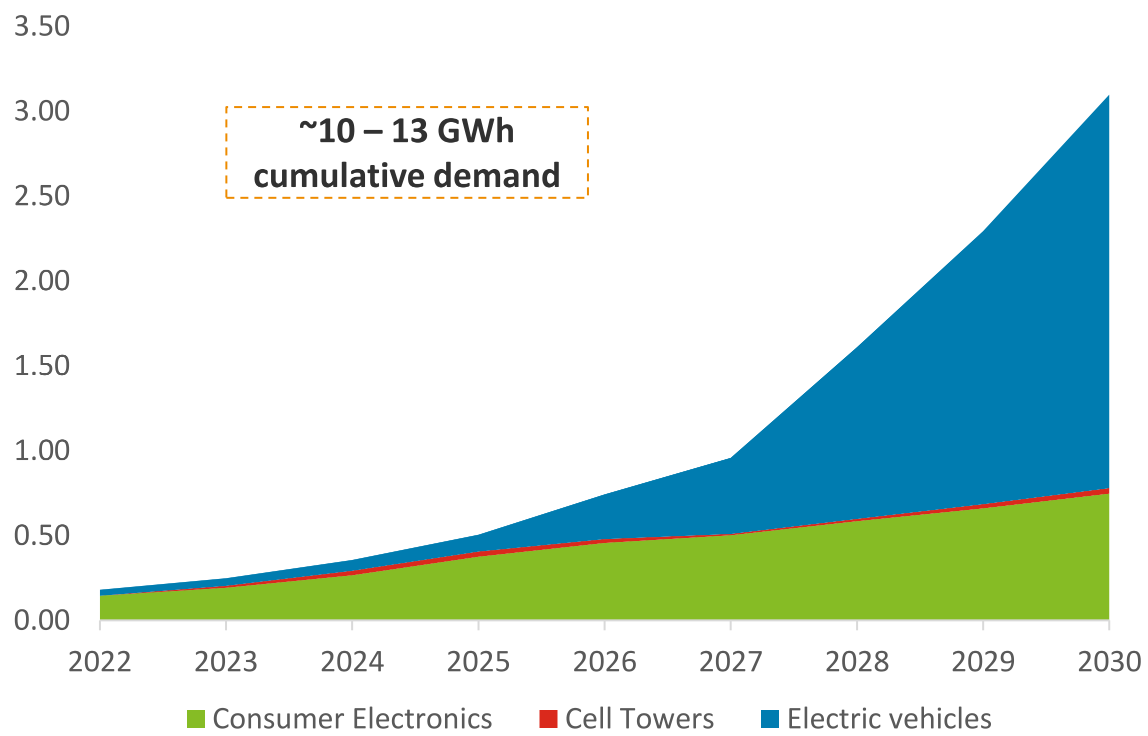
Electric vehicles	BESS	Cell towers	Consumer electronics
202 – 355 GWh	**73 – 115 GWh**	**~2 GWh**	**~65 – 75 GWh**

Source: Deloitte analysis

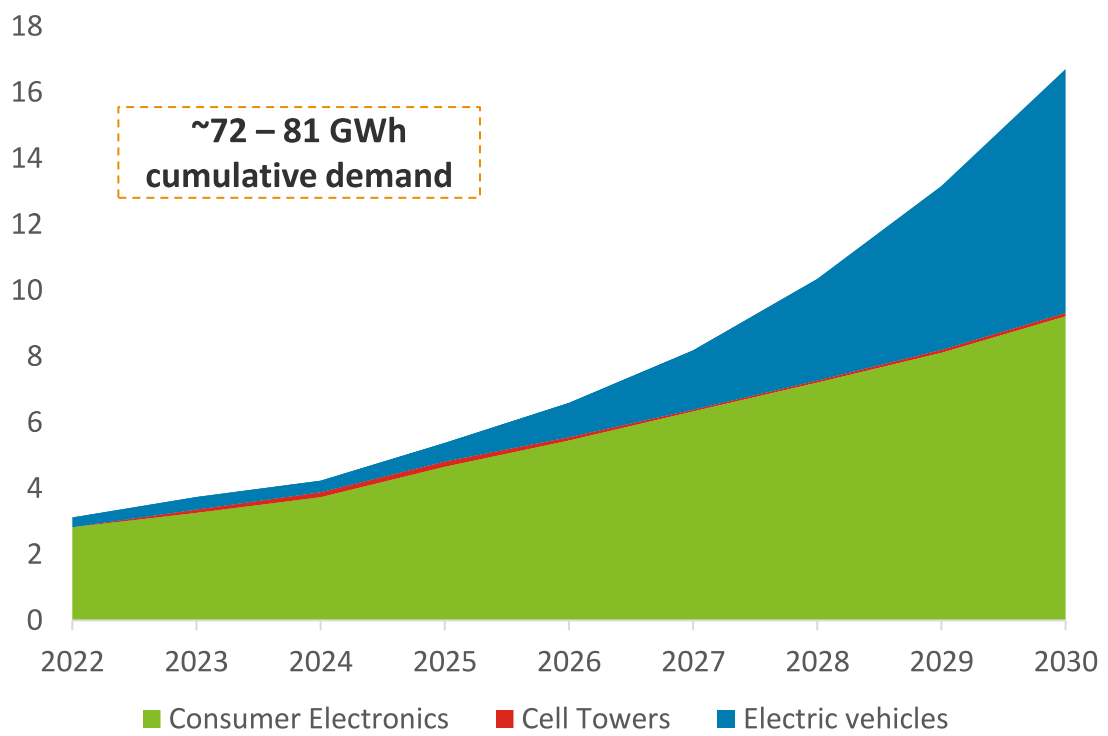
- Recycling is critical to **compensate for the deficit in minerals** in the country
- Second life usage can help **reduce large import volumes** of Li-ion cells
- Efficient recycling would complement indigenous Li-ion cell manufacturing
- In addition, recycling has a **lower environmental impact** (30 -40% lesser emission) than virgin mining

Feedstock of **~72 – 81 GWh** for recycling, **~10 – 13 GWh** for reuse by 2030 cumulatively present investment avenues and pose significant environmental consequences without proper management

Yearly battery reuse demand 2022-30 (GWh)



Yearly battery recycling demand 2022-30 (GWh)



Source: Deloitte analysis

- **EVs and consumer electronics** are expected to be the largest contributors to waste/ degraded battery feedstock **(~98%**) owing to the large volumes of batteries already in operation.

Battery Waste Management Rules, 2022

Applies to producer, dealer, consumer, entities involved in collection, segregation, transportation, refurbishment and recycling of waste batteries; implementation guidelines awaited

Producer

Entity involved in **manufacture and sale** of battery including refurbished Battery, including **in equipment, under its own brand** *OR* **import** of battery as well as equipment containing battery

Producer responsibilities

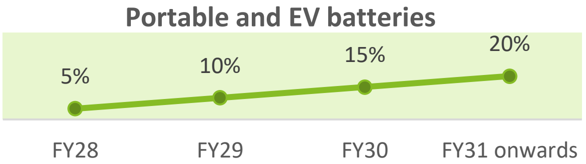
- Extended Producer responsibility (**EPR**) for batteries placed on market (through collection and recycling/ refurbishment targets).
- Ensure collected batteries **shall not be sent for landfilling or incineration**; to be sent for recycling or refurbishing
- Can engage **third party** entities for collection, recycling or refurbishment; can establish **buy back or deposit refund schemes**

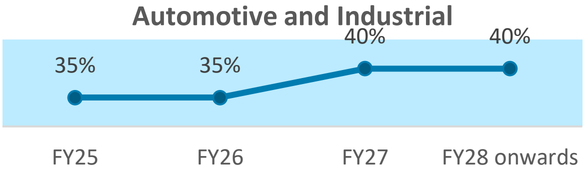
EPR Targets (till 2030), from year of placement on market

Portable in consumer electronics	Portable not in consumer electronics	Automotive	Industrial	EV (E-rickshaw)	EV (2W)	EV (4W)
50 – 70% (FY23 – FY30); 5 years	50 – 70% (FY26 – FY30); 3 years	30 – 90% (FY23 – FY30); 3 years	40 – 90% (FY23 – FY30); 3 years	70% (FY25 – FY30); 3 years	70% (FY27 – FY30); 4 years	70% (FY30 onwards); 8 years

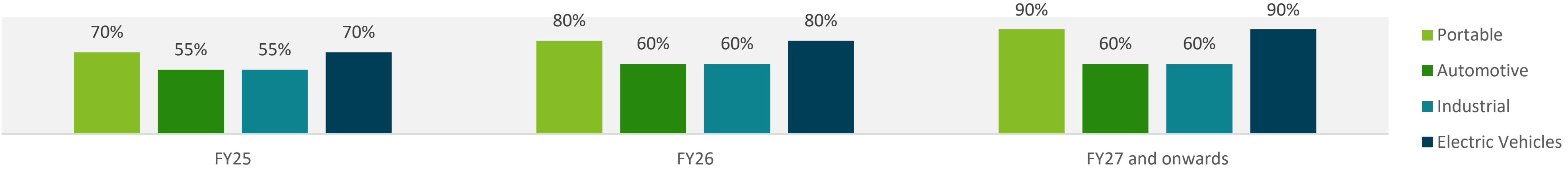
Use of recycled materials

Use of recycled materials in new batteries as a percentage of the dry weight of the batteries





Recovery targets for recyclers



Recycling certificates

Recycling and refurbishing firms shall provide certificate of waste battery processing to producers

Reporting and compliance

Through online portal using payments and invoice uploads

Waste batteries can be a source of numerous hazards without proper controls from an Environmental Health and Safety perspective; guidelines around hazards are critical

Organizations handling lithium-ion batteries need to be aware of the potential hazards and mitigation measures…

A three-pronged approach has been adopted for the study around recycling of batteries:

Stakeholder identification	EHS Risk Screening across recycling and refurbishing (R&R) value chain	Standard Operating Procedures (SOPs)
Stakeholder mapping across: • Waste **feedstock generators** • **Collection and transport** facilitators • **Recycling** & disposal • **Policy** & related enablers	• Identifying risks across multiple steps involved in Lithium-ion battery recycling (from collection till disposal) • Developing a **screening framework** for potential investors to quantify risks	• Outlining procedures to mitigate EHS risks and ensuring streamlined operations across multiple steps in recycling batteries

Identifying stakeholders, qualifying risks and developing SOPs are key to instill investor confidence in the R&R sector of India and for ensuring sustainable practices across the value chain

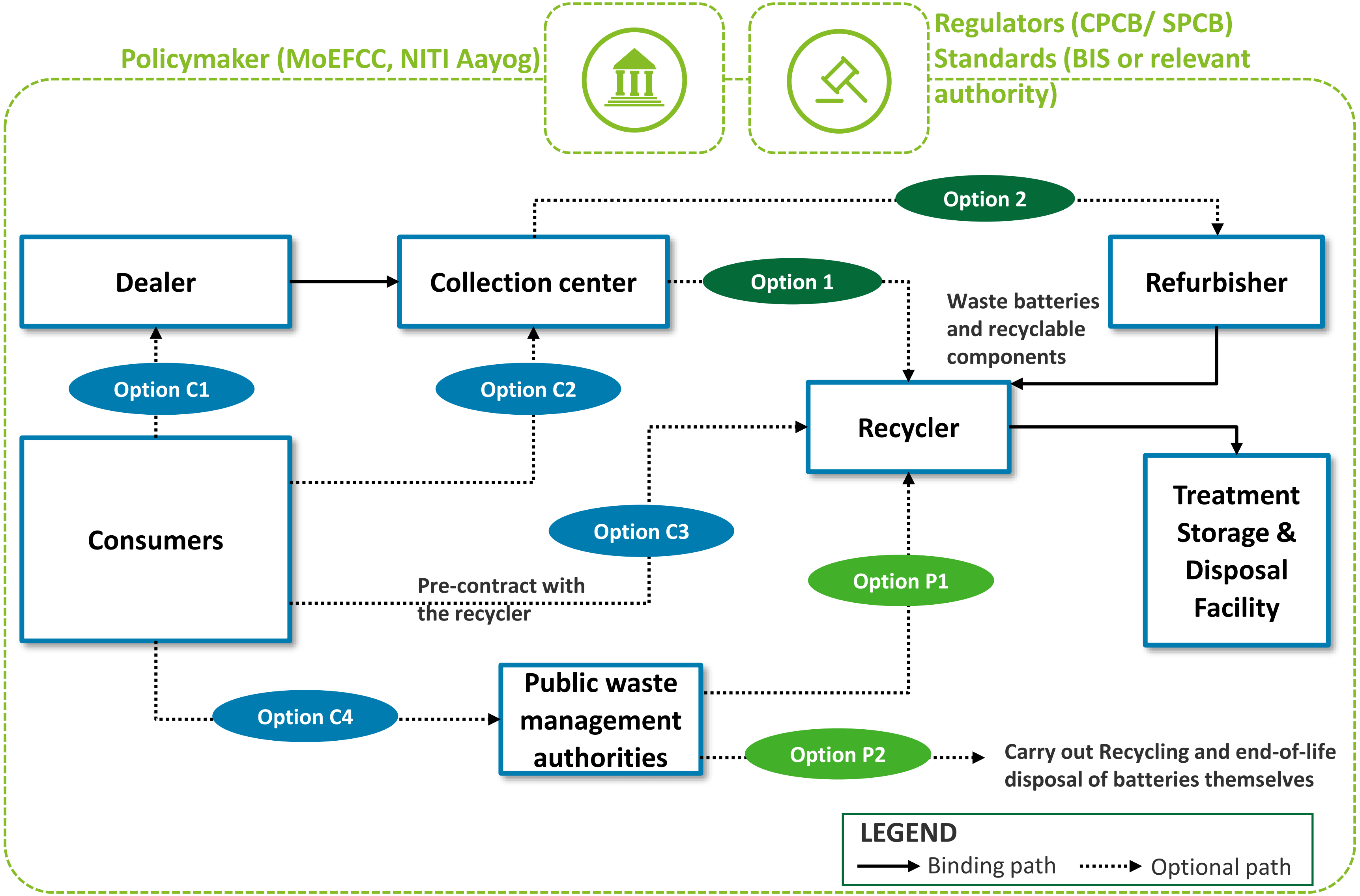
Key study findings

① Battery recycling ecosystem

Battery recycling ecosystem

Major stakeholder categories

- Waste feedstock generators
- Collection and transport facilitators
- Recycling & disposal
- Policymakers and regulators



Key study findings

② Environment Health & Safety Risk Screening Framework

EHS risk screening Framework

Battery Refurbishing and Recycling value chain elements and risks

- Collection and Transportation
- Storage
- Dismantling, refurbishing and recycling operations
- Disposal

Definition of multiple risks in the specific value chain elements

Mitigation measures

- Assessment of likelihood and consequences of the risks
- Population of mitigating measures specific to the consequences of the risks

Mapping

Mapping of measures with the existing certifications viz. OHSAS 18001 ISO 14001 and ISO 45001

Screening framework

Purpose of EHS risk screening :

- **Eliminating/ minimizing** work-related injuries, & occupational hazards
- **Identifying** and **controlling risks**
- Supporting **safe work environment**
- Helping **workers** to **handle** & **dispose batteries** and **battery waste**
- Ensuring **incident investigations** that meet **minimum compliance** requirements

Risk Matrix

- **High risk activities** must be **addressed immediately** and reviewed regularly
- **Moderate and low risk activities** to be addressed after high risk mitigation

	Consequences (rating)		
	Low impact (1)	Serious (2)	Catastrophic (3)
Likelihood (rating)	1	2	3
	Risk score		
Remote (1)	1	2	3
Possible (2)	2	4	6
Probable (3)	3	6	9
LEGEND	Low risk	Moderate risk	High risk

EHS Risk Screening Framework

Particulars	Risk	Likelihood (A)	Consequences (B)	Risk Score (C) = A*B
Collection & Transportation	Improper handling of batteries	2	3	6
	Battery fire	2	3	6
	Inadequate training and awareness amongst employees	2	3	6
	Inadequate processes and procedures	2	2	4
Storage	Battery Fire	2	3	6
	Emission of hazardous gases	2	2	4
	Improper procedures & handling of batteries in storage area	1	3	3
	Inadequate access control to storage facility	1	1	1
	Unavailability of emergency response measures	2	3	6
Dismantling, refurbishing and recycling	Improper handling of batteries	2	2	4
	Battery fire	2	3	6
	Inadequate training and awareness amongst employees	2	2	4
	Inadequate safety measures during dismantling process	1	3	3
	Inadequate processes and procedures	2	2	4

EHS Risk Screening Framework

Particulars	Risk	Likelihood (A)	Consequences (B)	Risk Score (C) = A*B
Dismantling, refurbishing and recycling	Disposal of hazardous waste and gases	2	2	4
	Emission of hazardous waste and gases	2	2	4
	Emergency preparedness	2	3	6
Air pollution	Hazardous emissions	2	2	4
Waste Disposal	Emission of hazardous gases	2	2	4
	Groundwater contamination	1	3	3
	Inadequate monitoring and compliance of EHS norms	2	2	4

Standard mitigation measures for critical risks identified

Risk mapping across value chain

Collection & Transportation

- Improper handling of batteries
- Battery Fire
- Inadequate training and awareness amongst employees

Storage

- Risk of fire from batteries
- Unavailability of emergency response measures

Dismantling, refurbishing & recycling

- Battery Fire
- Emergency preparedness

Standard Mitigation measures

Collection & Transportation

- Avoid transporting batteries in **metal boxes & tape terminals**
- Place the batteries in a **clear plastic bag and put them in a firm box** (vermiculite) with good padding
- Keep batteries **away from heat**
- Maintain temperature to between -20°C to 60°C
- Recommended **SOC is 30%** for shipping or transportation
- **Stack batteries** by using protective barriers (honeycomb cardboard) between them
- Class **ABC or CO2 fire extinguisher**
- **Train operators** in collection and transportation processes
- Provide **written SOPs** for all processes and evacuation procedures while dealing with high voltage batteries
- **Label containers** for hazardous chemicals
- Implement **management controls** for residual risks

Storage

- Store batteries in a **dry & well-ventilated place** (-20 to 60 °C)
- Store LIB on floors made up of concrete, metal, or ceramic or any non-flammable material
- Class **ABC/ CO2 fire extinguisher**
- Keep storage area free of sharp objects
- Adequate **training & mock drills** for employees to prepare for emergency situations
- Proper **communication channel** for OH&S information flow during emergencies
- Provide **SOPs** for filling and operating **USTs and ASTs**
- Security arrangements to allow access of only authorized personnel in facility premises
- On-site portable **spill containment** and cleanup equipment.
- Provide **training** for deploying equipment

Dismantling, refurbishing & recycling

- Complete **discharge** of batteries before dismantling
- Stringent **procedures** for the vendors & contractors' **selection**
- Provide mechanisms, time, training and resources for workers
- Adopt **stringent waste segregation** procedures
- Install **audible alarms** to alert the nearby community
- Adopt appropriate **dust suppression measures**
- Prepare a plan for spill control, prevention, and countermeasure Implement management controls and SOPs for residual risks
- Prepare a **quality assurance plan** for equipment, maintenance materials, and spare parts

Key study findings

3 | Standard Operating Procedures for Battery Recycling

Standard Operating Procedures

A ready reckoner for various stakeholders in the industry to ensure minimal risk and safe battery handling

Planning → Collection and sorting → Transportation → Storage → Dismantling & Refurbishing → Recycling & Disposal

Planning

- **Gather general Information** such as size, weight, form, shape, and serial number of the battery
- Gather **chemical information** such as type, chemistry of feedstock
- Implement **agreements** with refurbishing facilities for feedstock

Collection and sorting

Collection

- Avoid dropping batteries; use non-conductive trays
- Demarcated area, box/bin to collect battery
- **Electrolyte-resistant** box
- Well ventilated, dry and sheltered area for bins or boxes containing battery

Sorting

- Sorting as per size, weight, identifiers
- Manual sorting per condition, chemistry

Safety

- Storage in an environment **away from risk of fire or explosion**
- Firefighting provisions (liquid nitrogen extinguishers, sand, dry ice, etc.)
- **Short-circuit prevention** (enclosure in non-conductive material, away from other batteries)
- Trained personnel

Transportation

General

- **Protect battery terminals** with wax/ cushioning
- **Discharge** below 30% SoC
- Avoid **contact of uninsulated connection** with others
- Place away from heat source/ extreme temp.
- Avoid dropping
- Mark with **recycling sign** or "not for first use"
- Hazmat training for employees

Packaging

- Non-combustible and non-conductive outer packaging
- Use original packaging (up to the extent possible)
- Use **UN approved** boxes or barrels

Transport vehicles

- Well ventilated and sheltered vehicles
- Firefighting equipment provisions
- **Trained drivers** with dedicated vehicles for batteries

For Damaged, defective or recalled batteries

- Placed in **individual, non-metallic packaging**
- Closed, structurally sound containers
- **Mark as "defective/damaged** Li-ion battery
- Appropriate **eye wear and gloves** for leaked batteries

Standard Operating Procedures

A ready reckoner for various stakeholders in the industry to ensure minimal risk and safe battery handling

Planning → Collection and sorting → Transportation → **Storage** → **Dismantling & Refurbishing** → **Recycling & Disposal**

Storage

General
- Storage at **~30%** of rated SoC
- **Below 35°C** storage temp. without heavy objects stacking

Storage area
- Well ventilated, dry, and reserved area
- Ideal surface area – concrete, ceramic, metal, or non-flammable material
- Avoid water-logged or coastal areas for storage

Safety
- Area should have fire detector and a class ABC or CO2 fire-extinguisher
- Use fireproof safety bags or any other fireproof container
- Storage area equipped with fire-extinguishers, emergency kits, protective eye wear, gloves, gas masks and an extraction unit

Dismantling & Refurbishing

General
- **Process design** w/o adverse impact on health of personnel involved or the nearby environment
- Process waste segregated as electronics, metal with iron, battery modules, and residual materials
- Trained personnel for dismantling and refurbishing

Information collection and analysis
- Record adequate information from Battery pack, modules, cells, and BMS to determine SoH

Disassembly and inspection
- Visual inspection followed by discharge before dismantling through static or dynamic resistance

Safety
- Complete discharging during dismantling process
- Electrically isolated tools
- Gloves, shoes, and safety glasses for personnel
- Workstations with firefighting equipment
- Avoid hot/humid conditions
- Install equipment for static discharge for personnel outside working area

Recycling & Disposal

General
- Avoid hot and humid conditions, contact with conductive materials, strong oxidizers, water, acids
- Process waste segregated as electronics, metal with iron, battery modules, and residual materials
- Electrically isolated tools and adequate floor cover

Inspection
- Inspection for signs of damage
- Post inspection, return battery to original container
- Transfer dented batteries to disposal partner to minimize short circuiting

Battery handling
- Coverage of metal work surfaces with insulation
- Avoid forcing batteries into holders and housings
- Wear safety glasses and gloves while handling
- Proper training and permissions prior to handling

Dismantling
- Similar to the procedures for refurbishing

Emergency protocols
- Evacuate all personnel from the area in critical events
- Remove external short-circuits if possible
- Avoid electrolyte exposure & have first-aid provisions

Key study findings

4 | Battery reuse financial model

Setting up a battery reuse facility – Financial analysis output

Key model inputs

- The model was developed for a 1500 TPA **repurposing facility**
- Assumptions were collected through **primary interactions** and **secondary research**

Particulars	Battery repurposing facility
CAPEX*	INR 7.03 Cr
Electricity Consumption	0.035 kWh/kg spent battery
Transportation Cost	INR 5/kg spent battery
Battery purchase cost	INR 180 – 200/kg spent battery
Repurposed battery selling price	INR 7000/ kWh
Capacity utilization	10% in first year to 90% in final year (10^{th} year) as battery reuse adoption rate would increase gradually.

*Note: * Excluding Land cost; #: Considering 0% grant*

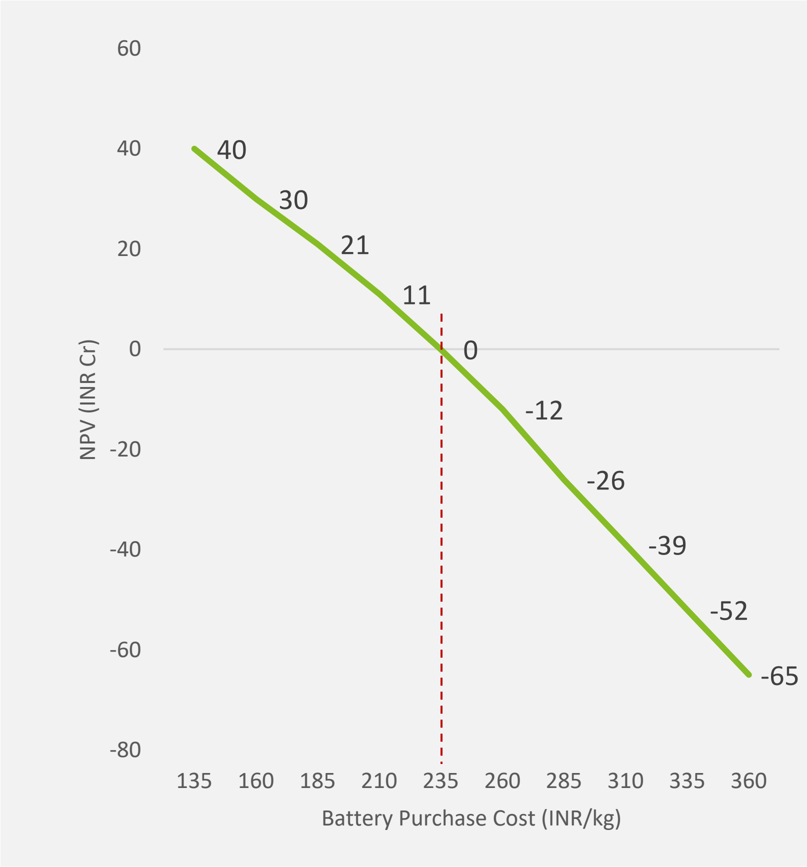
Key model outputs#

1	**NPV**	**INR 17.02 Cr**
2	**IRR**	**35 – 40%**
3	**Avg. Operating Margin**	**10 – 13%**
4	**Average Profit margin**	**4 – 6%**
5	**DSCR**	**4 – 5**
6	**Interest coverage**	**~4 – 4.5**

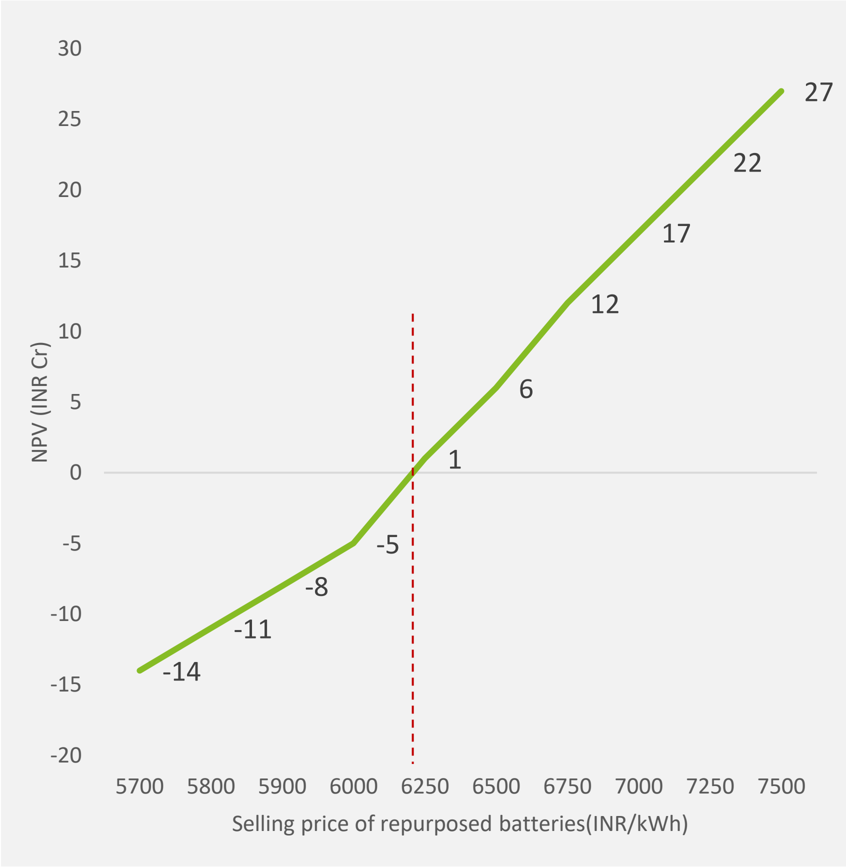
Sensitivity analysis of battery reuse facility

NPV vis-à-vis…

Battery Purchase Cost (INR/kg)



Selling price of repurposed batteries (INR/kWh)



Outcomes of **financial model – NPV & IRR** are highly **sensitive** on the **battery purchase cost** and **selling price of repurposed batteries**

Key recommendations

- Battery repurposing is a business of thin margins and requires adept handling of batteries for thorough testing and development of suitable products

- Second life batteries compete with lead acid batteries which usually have a price point of INR 7000 to INR 8000 per kWh. Batteries must be priced judiciously in the same range to ensure business viability

- Competitive sourcing of retired batteries will decide the viability of business. Influx of retired batteries could promote sourcing of batteries at lower cost as compared to now

- Integration of repurposing facilities in the downstream value chain of battery (recycling) would enable higher circularity for the lithium-ion batteries

THANK YOU!