Business Case Study

Circularity Program - Lithium Ion Battery Value Chain

FutureBridge

Case study (1 / 2): Global Study on Circularity Program - Lithium Ion Battery Value Chain

Client	Leading global Industrial gas company
Industry	Chemicals
Product	Industrial gas

Context

- The client wants to understand the market opportunity of various gases used in the battery recycling process.
- The client is also interested to know about the leading battery recycling technologies across the globe

Key business questions

- Who are the key recyclers dominate the global battery recycling market >> Key companies (~3–5)
- Which are the key technologies adopted by the key players; liaising approach with different parties with in the value chain
- What is the global battery recycling and battery production market?

Engagement scope

1 lobal lithium ion battery market

- How big is the global lithium ion battery market?
- Who are the leading battery manufacturers across the globe?
- Which are the key application segments for global lithium ion battery market?
- What are the key market drivers and restraints for global lithium ion battery market.
- What is the capacity in the global lithium ion battery value chain?

2 Global battery recycling market

- What is the global battery recycling market size?
- Who are the key players in the global battery recycling?
- Which are the key battery recycling technologies?
- Innovation / IP developments during last 3 years
- Developments in the TRL status of technology of recycling technologies
- What is Investments, funding trends in the global battery market

3 Gas-enabled technologies

- Innovation / IP developments during last 3 years
- Developments in the TRL status of technology of gas-enabled technologies
- Developments with regards to participation of entities / players in the ecosystem
- Average price of gas used in the battery recycling

4 Key findings and conclusions

- Decision making process for arriving at price of model
- Estimated addressable gas opportunity for the current and forecast year

Case study (2 / 2): Global Study on Circularity Program - Lithium Ion Battery Value Chain

Research methodology

Secondary research

- Paid commercial databases,
- Company, analyst, trade journal, association, etc. publications

Primary research

- 50+ telephonic interviews with major digital service providers; startups; key opinion leaders; independent consultants and analysts; etc.
- 3–5 hours of consultations with industry experts (20+ years of industry experience)

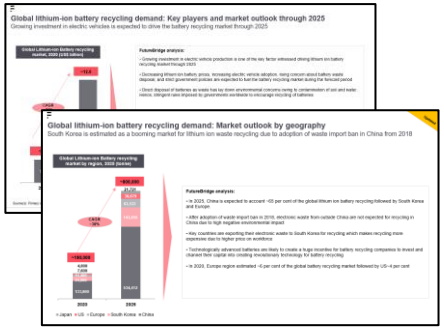
Benefits to Client

- The output of the study helped client gauge market attractiveness (at aggregate and industry level) for gas used in the battery recycling
- Helped client to understand the current and upcoming technologies w.r.t battery recycling

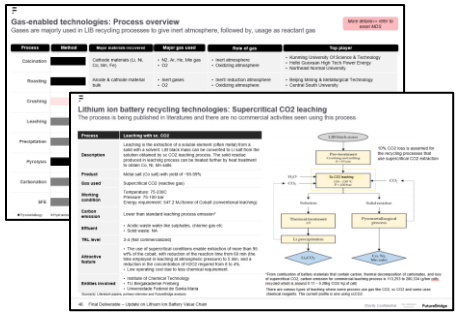
Sample analysis

1 lobal lithium ion battery market

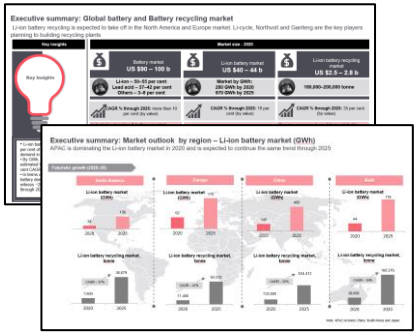
2 Global battery recycling market



3 Gas-enabled technologies



4 Key findings and conclusions



Executive summary: Global battery and Battery recycling market

Li-ion battery recycling is expected to take off in the North America and Europe market. Li-cycle, Northvolt and Ganfeng are the key players planning to building recycling plants

Key insights

- Li-ion batteries accounts ~50 per cent of the global battery demand in 2020
- By GWh, Li-ion battery estimated to witness ~28 per cent CAGR through 2025
- In terms of GWh the Li-ion battery demand is estimated to witness ~28 per cent CAGR through 2025

Market size - 2020

Battery market	Li-ion battery market	Li-ion battery recycling market
US $90 – 100 b	**US $40 – 44 b**	**US $2.5 – 2.8 b**
Li-ion – 50–55 per cent **Lead acid – 37–42 per cent** **Others – 3–8 per cent**	**Market by GWh:** **280 GWh by 2020** **970 GWh by 2025**	**180,000–200,000 tonne**
CAGR % through 2025: more than 10 per cent (by value)	**CAGR % through 2025:** 16 per cent (by value)	**CAGR % through 2025:** 35 per cent (by value)
Industrial automation & battery operated material handling equipment	Increase in demand for EVs	Growing government regulations related to battery recycling
Industrial automation & battery operated material handling equipment	Rising demand from the consumer electronics industry	Growing investments in electric vehicle production
Design inefficiencies in the manufacturing of lithium-ion batteries	Li ion battery hazard during storage & transportation	Significant collection and recycling costs

Key players

Panasonic, LG Chem, EXIDE, Johnson Controls, GS YUASA, EnerSys, FB

Key players

SAFT (a company of TOTAL), SAMSUNG SDI, LISHEN, LithiumWerks, Energy Next LITHIUM ENERGY JAPAN, BYD, A&S POWER

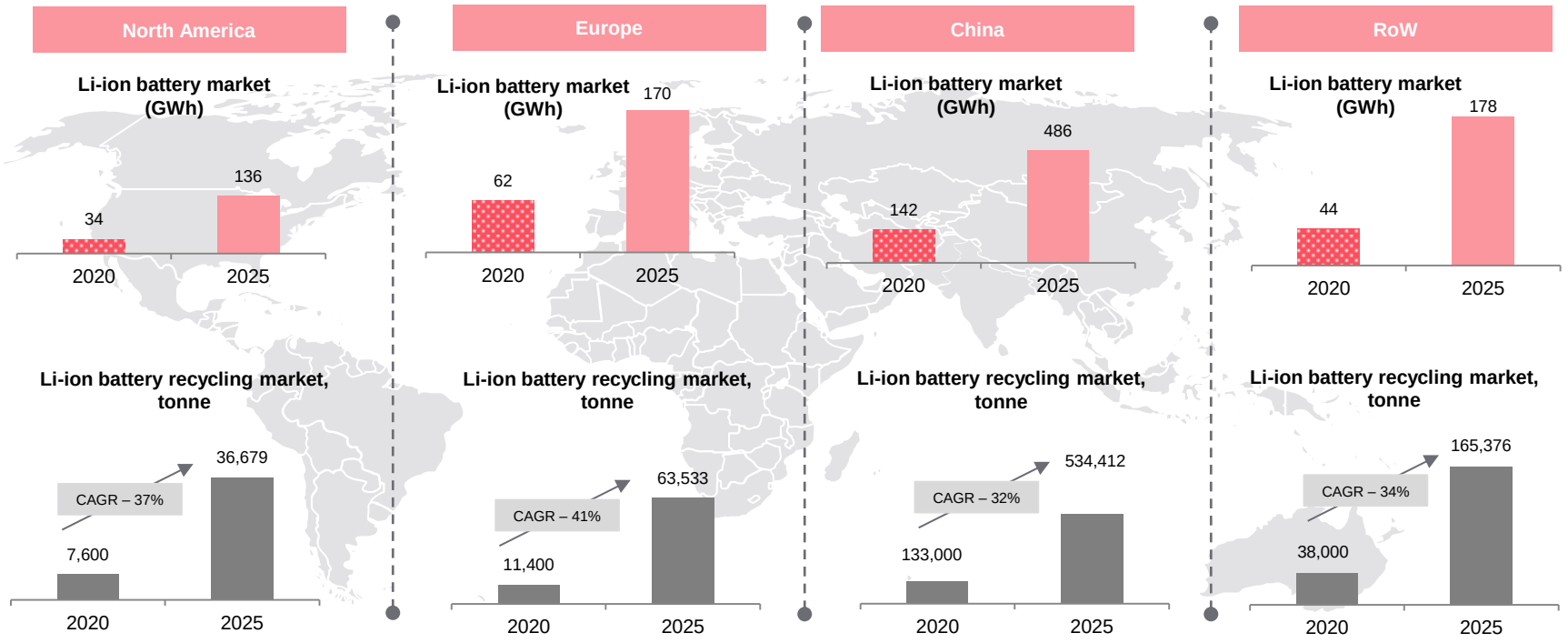
Key players

umicore, NICHIA, RECUPYL, SHANSHANTECH, Neometals, EASPRING, Li-Cycle, fortum

Executive summary: Market outlook by region – Li-ion battery market (GWh)

APAC is dominating the Li-ion battery market in 2020 and is expected to continue the same trend through 2025

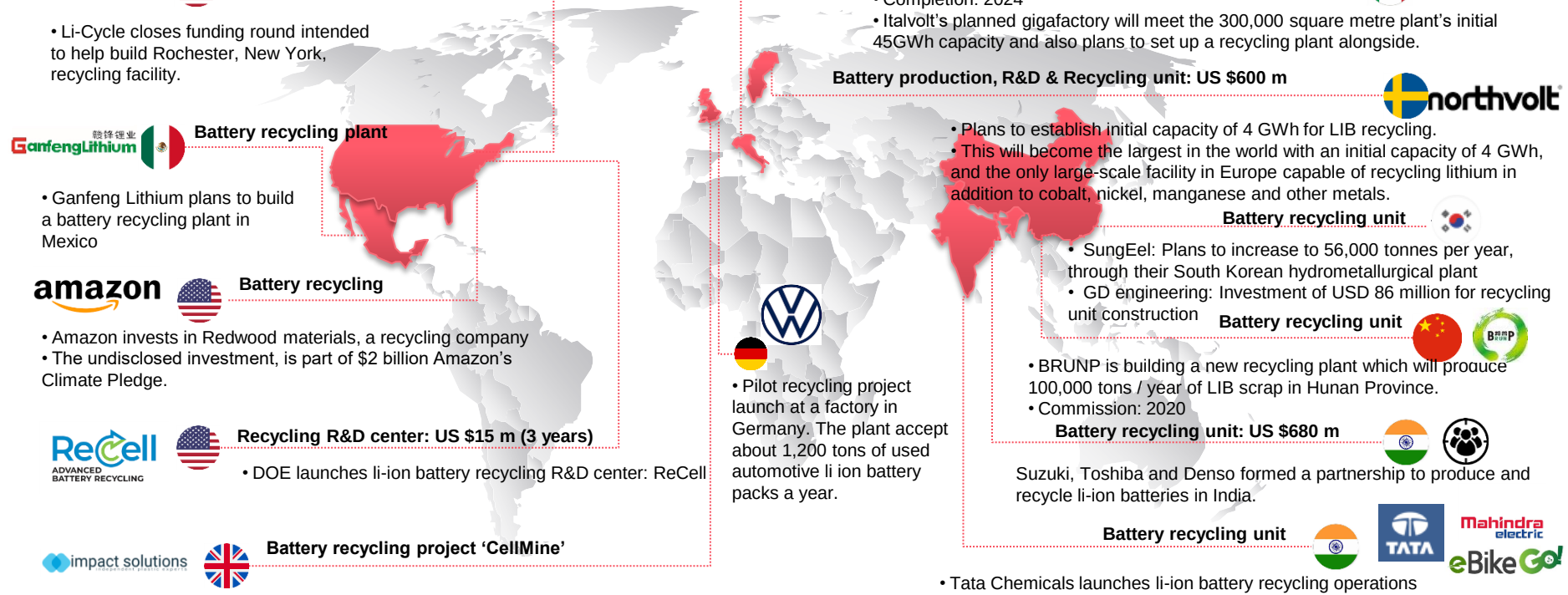
Futuristic growth (2020–25)



Note: APAC includes China, South Korea and Japan

Executive summary: Li-ion battery recycling – recent investment, expansion & partnership activities

There is a high recycling unit investment witnessed in APAC in recent years owing to emerging EV market in these region.



Battery recycling unit

• Li-Cycle closes funding round intended to help build Rochester, New York, recycling facility.

Battery recycling plant

• Ganfeng Lithium plans to build a battery recycling plant in Mexico

Battery recycling

• Amazon invests in Redwood materials, a recycling company
• The undisclosed investment, is part of $2 billion Amazon's Climate Pledge.

Recycling R&D center: US $15 m (3 years)

• DOE launches li-ion battery recycling R&D center: ReCell

Battery recycling project 'CellMine'

• Ecosurety has awarded a total of US $609,905 to four UK-based innovation and research projects offering recycling and reuse solutions among which Impact solutions is one.

Battery production facility: US $4.9 b

• Completion: 2024
• Italvolt's planned gigafactory will meet the 300,000 square metre plant's initial 45GWh capacity and also plans to set up a recycling plant alongside.

Battery production, R&D & Recycling unit: US $600 m

• Plans to establish initial capacity of 4 GWh for LIB recycling.
• This will become the largest in the world with an initial capacity of 4 GWh, and the only large-scale facility in Europe capable of recycling lithium in addition to cobalt, nickel, manganese and other metals.

Battery recycling unit

• SungEel: Plans to increase to 56,000 tonnes per year, through their South Korean hydrometallurgical plant
• GD engineering: Investment of USD 86 million for recycling unit construction

Battery recycling unit

• BRUNP is building a new recycling plant which will produce 100,000 tons / year of LIB scrap in Hunan Province.
• Commission: 2020

• Pilot recycling project launch at a factory in Germany. The plant accept about 1,200 tons of used automotive li ion battery packs a year.

Battery recycling unit: US $680 m

Suzuki, Toshiba and Denso formed a partnership to produce and recycle li-ion batteries in India.

Battery recycling unit

• Tata Chemicals launches li-ion battery recycling operations
• Mahindra Electric to set up battery manufacturing & recycling plant
• Indian EV startup eBikeGo begins drive to recycle their lithium batteries

Executive summary: Recycling technologies – process overview

Most of the pyro metallurgical process uses gases like oxygen and inert agents for most of their processes

Process	Method	Description	Substitute for gas	TRL level	Players
Leaching		Leaching is the loss or extraction of certain materials from a carrier into a liquid.	• Acid and base solutions which act as reactants. E.g: Sulphuric acid	9 (Commercialized)	• Anhui Dewin New Material Technology • Retrieve tecnologies • Hunan Brunp Recycling
Crushing/ Milling		The method used to reduce the size of battery for further processing using millers/ crushers.	• Water solution are used in wet crushing to avoid battery explosion	9 (Commercialized)	• Central South University • Kawasaki Heavy Industries • Retrieve tecnologies
Precipitation		The process of precipitating the metal based component in their salt form from the leachants.	• Instead of using CO2 gas, carbonate solutions are used as reactants.	9 (Commercialized)	• Retrieve technologies • Tianqi Lithium • Hefei Guoxuan High Tech Power Energy
Discharging		The process of removing the left over charge in a spent battery before subjecting it to further recycling process.	• This process uses no reagents	9 (Commercialized)	• Lasertec • Zhang Shengwei • Kunming University
★ Calcination		Calcination, the heating of batteries to a high temperature for the purpose of removing volatile substances	• Calcination could use O2 or use non-oxidizing atmosphere (N2 gas)	9 (Commercialized)	• Changsha Shunyang Metal Product • Guangdong Jiana Energy Technology • Xi An Heimdal Energy Storage Material
★ Roasting		The process of subjecting batteries to high-temperature in order to recover electrode materials as black mass.	• The process could use reactive gas or could use non-oxidizing gas	9 (Commercialized)	• Beijing Mining & Metallurgical Technology • Central South University • Yinlong Energy
★ Disassembling		The process where the operator removes components of the battery pack for further processing	• Inert gas is used for non reactive atmosphere	9 (Commercialized)	• Anhua Tyson Cycle Technology • CN Innovations • Jiangxi University of science & Techonology
★ Pyrolysis		Process of chemically decomposing batteries at elevated temperatures in the absence of oxygen. Condition: 430 °C, under pressure.	• The process usually use nitrogen as protective gas	9 (Commercialized)	• Changsha Silicon Cement Technology Development • Xiangtan University

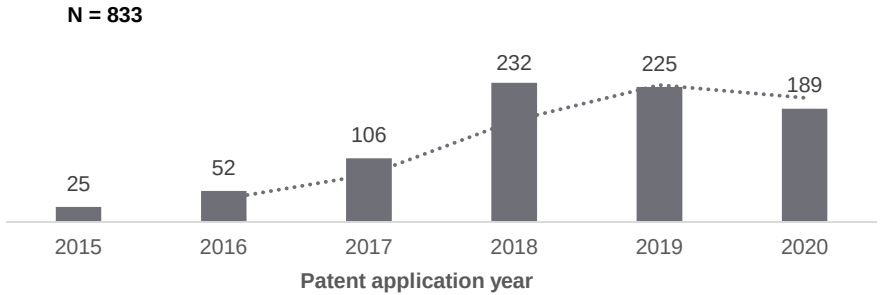
■ Pyrometallurgy ■ Hydrometallurgy
■ Mechanical recycling ■ Pretreatment

★ *Gas based technologies*

IP Landscaping: Patent filing trend and countries

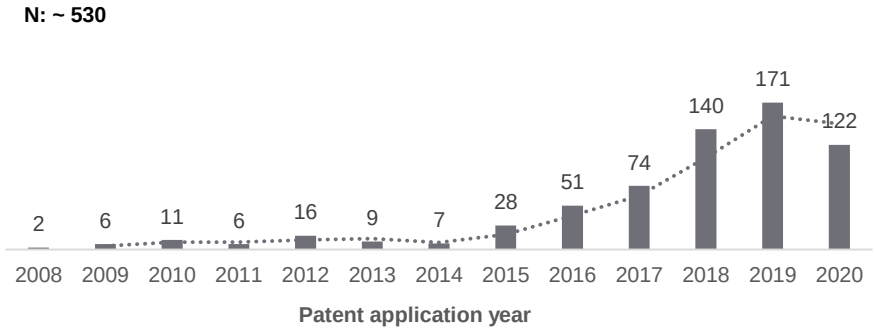
Patent filing for battery recycling processes has drastically increased in past few years.

1 Patent filing trend (Update analysis: 2015-2020)



Note: Patent filings in the year 2019 and 2020 is expected to increase in coming years.

1 Patent filing trend (Update analysis: 2015-2020) – Gas enabled technologies



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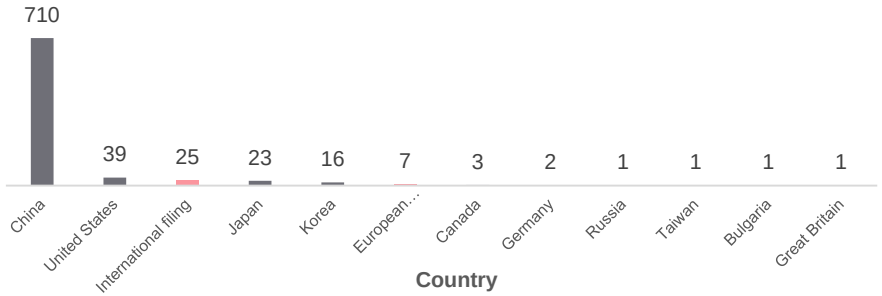
2 Top filing country (2015-2020)



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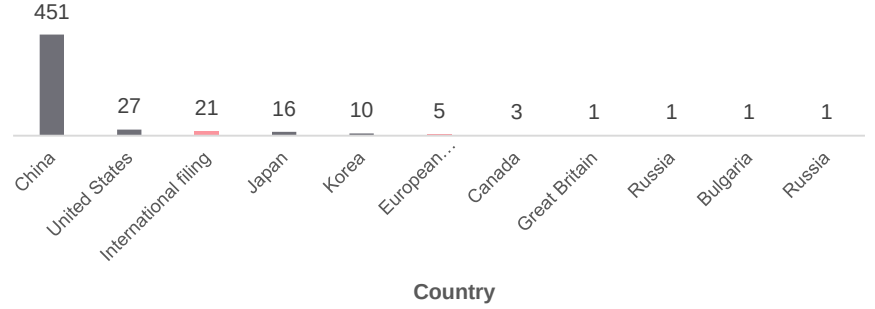
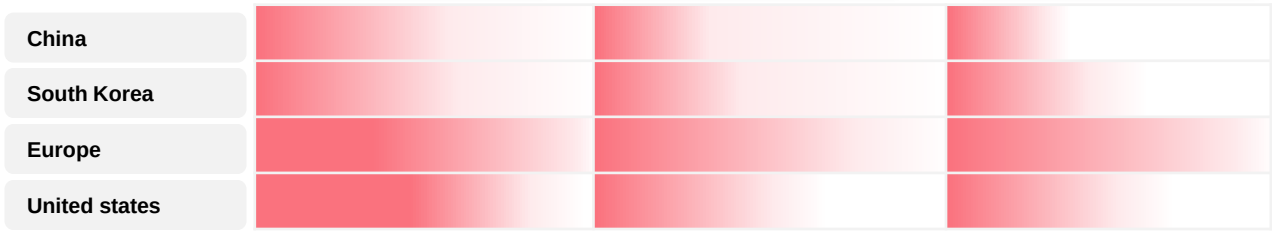


Executive summary: Li ion battery recycling cost structure

Geographically, Europe has most expensive battery recycling cost structure followed by USA. China has most economical recycling cost structure due to various factors.

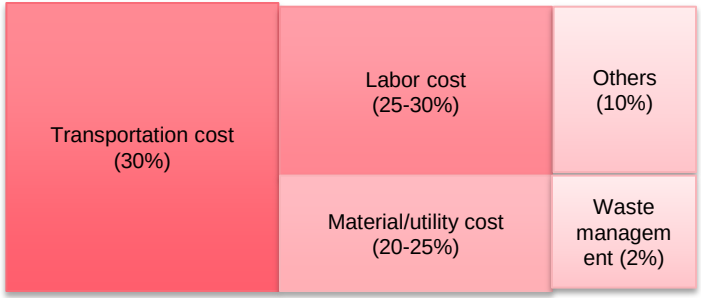
Spent battery → **Collection & transportation** → **Pretreatment (sorting & dismantling)** → **Battery recycling** → **Recycled output**

cost contribution by region



Europe has high labor cost and associated transportation cost as well as scale of recycling is low in the region. This contributes to higher recycling cost in Europe compared to other region

Cost breakdown of recycling process by their contribution share



- In battery recycling, transportation cost has major share which consumes 30% of total cost. This is the average cost of overseas or within a country.
- Labor cost is second most expensive cost factor in recycling which is around 25-30% of entire recycling cost.
- Variable expense is contributed to the material cost involved in recycling process which is third most cost intensive factor.
- Waste management like flue gas/ waste water emission treatment contributes to just 2% of entire recycling cost.

Thank you

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