Battery Recycling Technology Understanding

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SMM bases on extensive primary interview, internal database and modelling, successfully help our client deeply understand the recycling technology from different perspective and its related future development directions

Project Background

As lithium-ion battery (LIB) production and usage grows, LIB recycling has been positioned as an alternative and important source of material. Different technology of LIB recycling may resulting in recovery rate of key metals, such as nickel, cobalt and lithium. Therefore, it is crucial to understand the technical route of battery recycling and understand the key difference that affects the recovery rate.

Key Output

Technology-wise recycling process outline

- Recovery rate and output product of different technology routes
- Key energy consumption, waste generation and emissions of key procedures

Capex & Opex of different technology route

SMM Methodology

Based on client's request, SMM has scoped the project into 2 modules:

- Technology-wise recycling process outline
- Capex & Opex analysis through different technology route

Main Research Methodology:

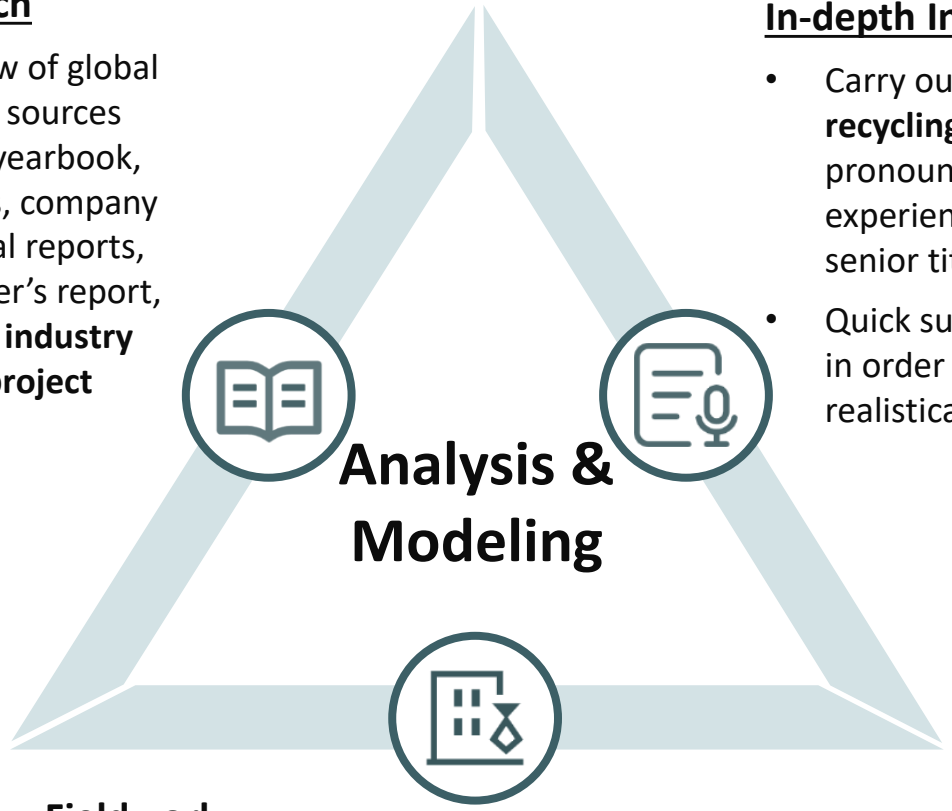
- Primary Interviews：
  - Industry level: conduct in-depth interviews with ~30 recycling value chain players, incl. OEMs (4 samples,) battery plants (3 samples), end users (5 samples), vehicle operators (3 samples), trader/ outlet/ dismantler (9 samples) and refiners (6 samples)
  - Company level: conduct in-depth interviews with different departments of each value chain company, incl. procurement dept., sales dept., cost monitoring dept., senior management, etc.
- Desktop Research： SMM internal databases, industry public reports

SOURCE: SMM Interviews, SMM Analysis

SMM Technology Comparative Study Approach

Secondary Research

- A thorough review of global publicly available sources such as industry yearbook, national statistics, company websites & annual reports, trade press, broker's report, as well as **SMM's industry knowledge and project experience**



In-depth Interviews & Quick Survey

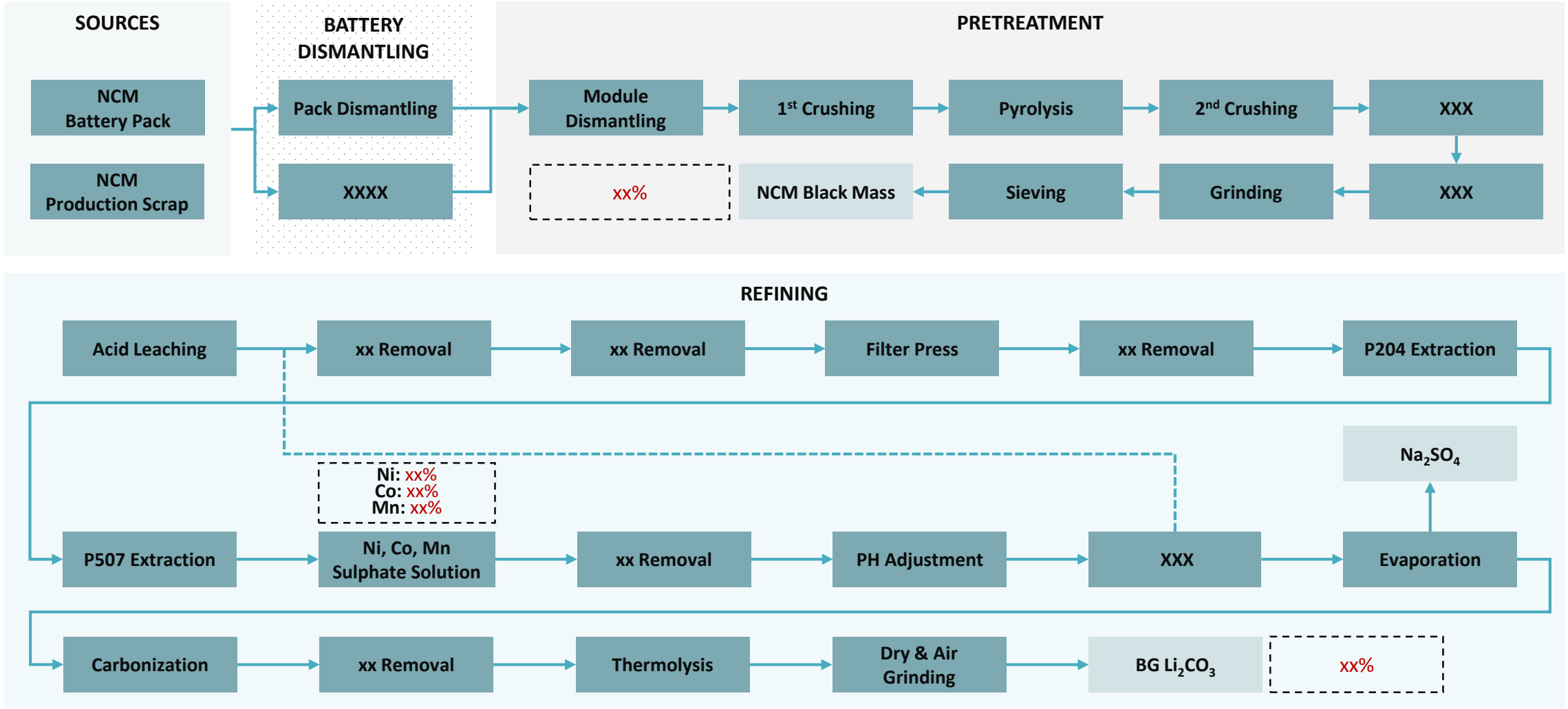
- Carry out in-depth interviews with **LIB recycling industry expert** who pronounce latest 1st-hand working experience and insights, typically with senior titles
- Quick survey to gather bottom-up data in order to reflect the market realistically

Fieldwork

- On-site visits and close communications with leading players to get realistic understanding on key processes & technologies

SOURCE: SMM Interviews, SMM Analysis

NCM Black Mass Technology Route Overview



SOURCE: SMM Interviews, SMM Analysis

Recovery Rate | **Product Flow** | *Process Flow*

Technology Route – Ni & Co & Mn Solution (1/x)

NCM Black Mass
Process

	1 Acid Leaching	2 xx Removal	3 xx Removal	4 Filter Press (2-3 times)	5 xx Removal
Objective	Provide the acid condition for the reaction	xx removal	xx removal	Solid-liquid separation	xx removal
Auxiliary Material	H_2SO_4 (98%), XXX	Iron powder	H_2O_2, XXX	xx	xx
Equipment	Leaching reactor, filter press	Leaching reactor	Leaching reactor	Filter	Reaction tank
Removed Material	-	xx	xx	Solid Material	xx
Output	XXX solution	xx removed Li-extraction solution	Xx removed Li-extraction solution	Solid impurity & xx removed XXX	Solid impurity & xx removed XXX
Outsell	-	-	-	-	-
Notes	• The acid leaching process needs to be heated with XXXX	• Iron powder will replace XXXX	• H_2O_2 used as XXXX • Loss rate of Ni XXXX	• Filter residue is further processed through XXXX	• P204 preferentially XXXX

Key steps that affects recovery rate

SOURCE: SMM Interviews, SMM Analysis

Capex/Opex Analysis – Black Mass Stage

Black Mass Plant

- xx (2021)
- xx M sqm

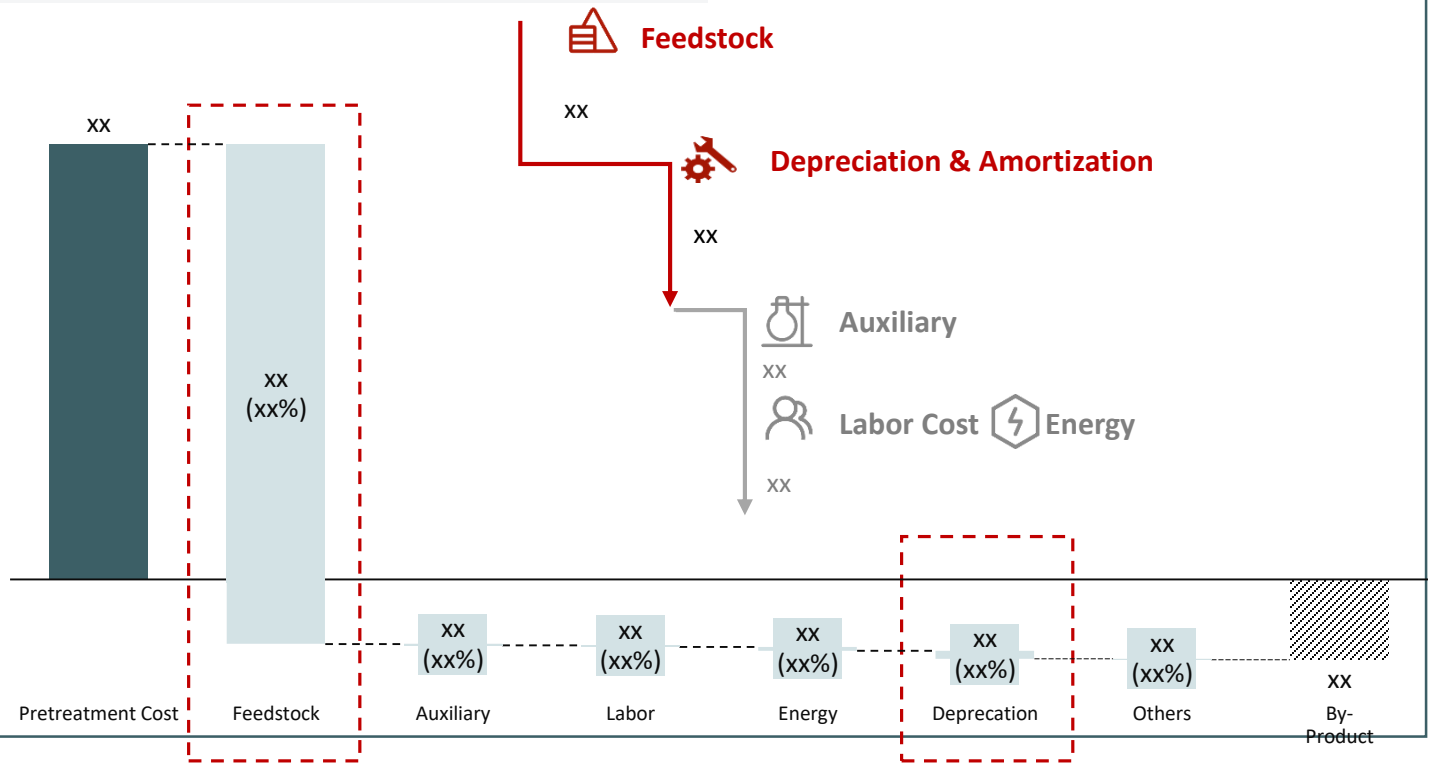
Black Mass Plant CAPEX

(Unit: Million USD)

Black Mass Production Cost Breakdown

Unit: USD/ton (NCM622), 2023H1

Item	Definition
Feedstock	*Waste Production (NCM 622)*
Labor Cost	• Compensations include base salary, bonus, welfare and duty
Depreciation & Amortization	• Depreciation period: xx years • *Depreciation expenses of XXXXX*
Auxiliary Material	• Auxiliary materials include XXXX
Energy	• Energy includes water, electricity and natural gas
By-Product	• Sold separately to earn additional revenue from the same infrastructure and setup include XXXX



Note: Equipment including environmental equipment

SOURCE: SMM Interviews, SMM Analysis

Opex Analysis – Recycling Salt Cost Breakdown

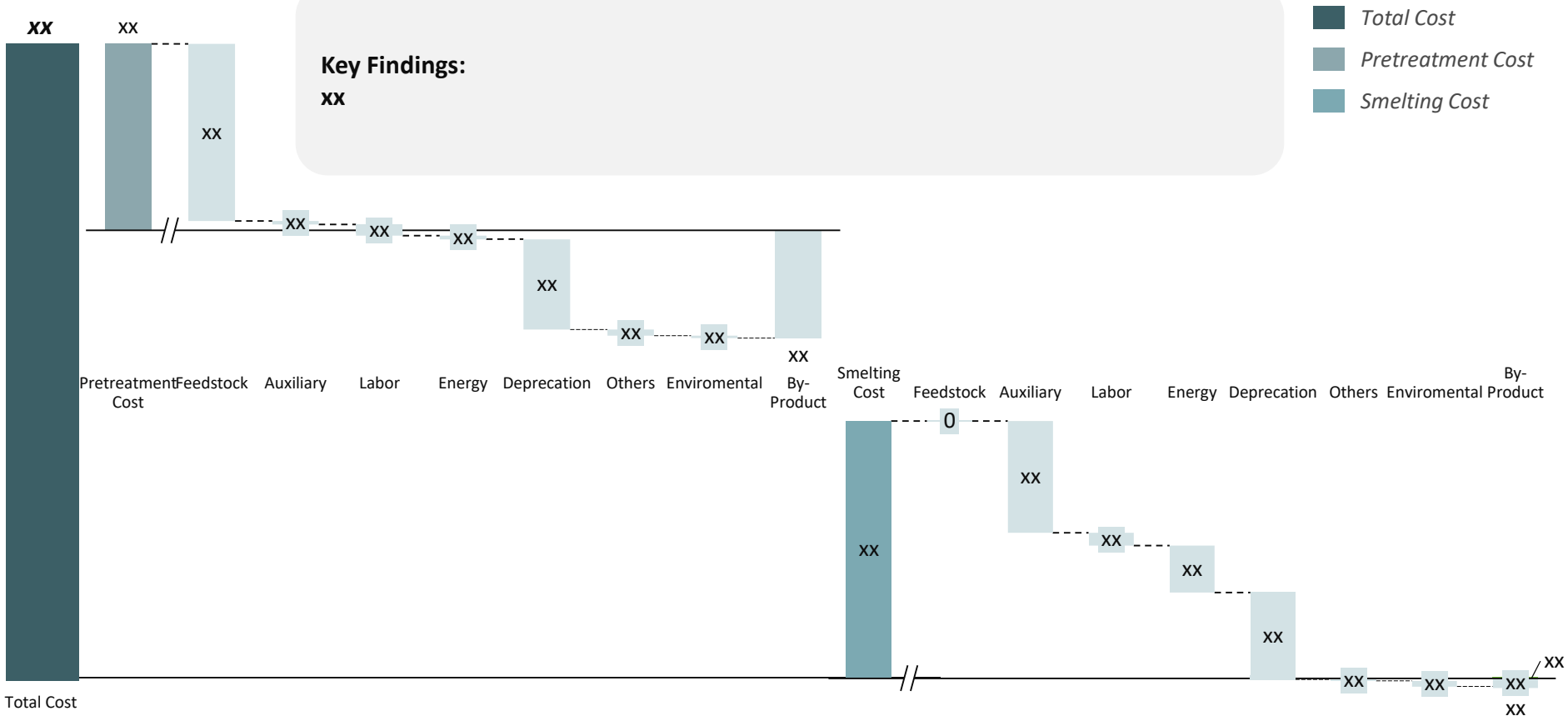
Definition

Raw Material	• Production waste
Auxiliary Material	• Auxiliary materials include solvent and phosphor removal reagent etc.
Environment Protection Cost	• includes the cost of waste gas and waste water treatment cost
Deprecation	• Equipment dep. Period: XXX
Labor Cost	• Compensations include base salary, XXX
Energy	• Energy includes water, electricity and natural gas
Maintenance Cost	• Production equipment repair cost

Recycling Salt Cost Breakdown

Unit: USD/ton (NCM523), 2023H1

Key Findings:
xx

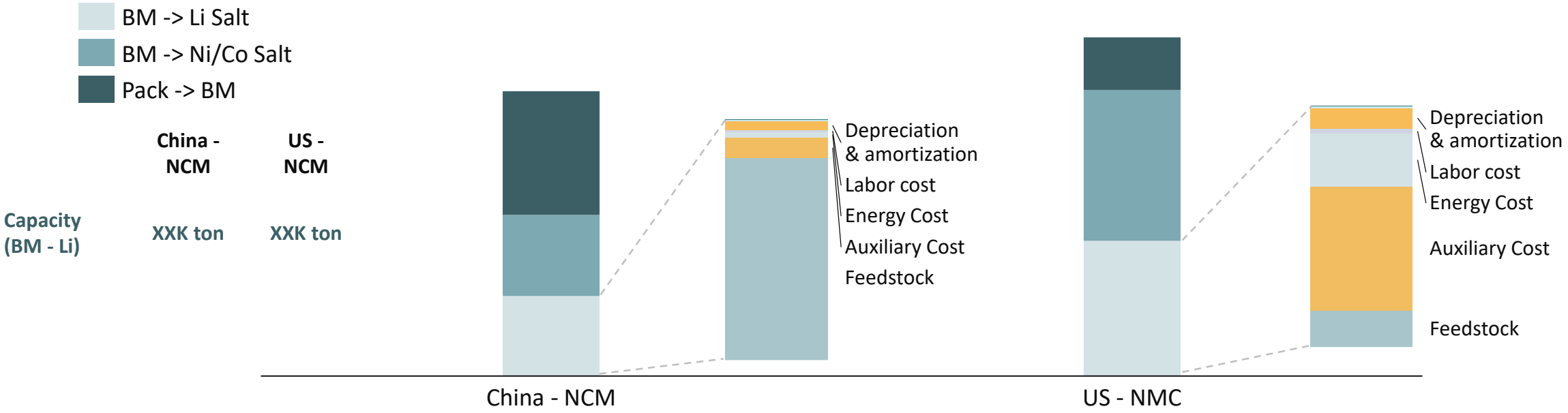


SOURCE: SMM Interviews, SMM Analysis

Notes: Cost calculation based on BM; Cell : BM=2.3:1; BM : $NiSO_4$: $COSO_4$: Li_2CO3= 1 : 0.88 : 0.72 : 0.265

Smelting Stage Lithium OPEX Comparison – China VS US

2023Q1 LIB Recycling OPEX Comparison – NCM by Stage; China Versus US



Key Smelting Stage Li Salt Phase OPEX Analysis:

- Auxiliary cost is high in the Li salt smelting stage due to XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
- Energy cost XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX