

Recycling of automotive LiB*

To realize closed loop recycling from battery to battery

* Lithium-ion battery

At “EEDF13” on January 25, 2024

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Advanced Technology & Strategy Dept, Technology Group



Agenda

- **JX Metals Group**
- **About LiB**
- **LiB recycling project of JX**

The JX Metals Group

The JX Metals Group is a global player in the non-ferrous metals market



Providing value to society as a **technology-based firm**



Global supply chain to support this goal

Building strong upstream, midstream, and downstream supply chains



Main Overseas Operating Sites

Europe

TANIOBIS GmbH (Germany)
JX Metals Circular Solutions Europe GmbH

JX Metals Europe GmbH
Frankfurt Office
Nippon LP Resources UK Limited, etc.

North America

JX Metals USA, Inc.
TANIOBIS USA LLC
Toho Titanium America Co., Ltd.,
eCycle Solutions Inc etc.

Middle East

Advanced Metal Industries Cluster and Toho
Titanium Metal Company Limited (Saudi Arabia)

East Asia

JX Metals Korea Co., Ltd.
JX Mining & Metals Shanghai Co., Ltd.
Nikko Metals Shanghai Co., Ltd.
Nikko Metals Suzhou Co., Ltd.
Nikko Fuji Precision (Wuxi) Co., Ltd.
JX Mining & Metals Dongguan Co., Ltd.
Nikko Metals Taiwan Co., Ltd., etc.

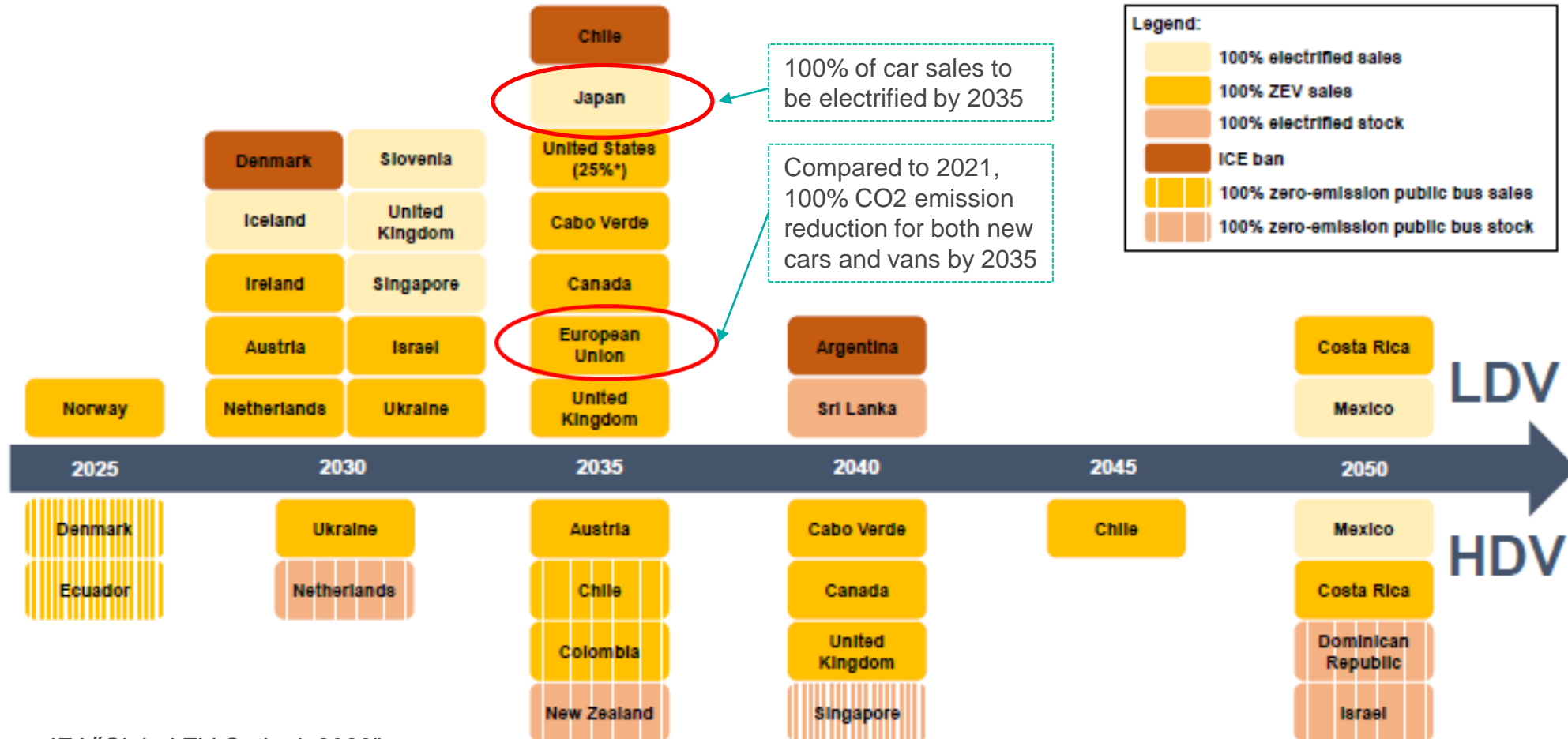
Southeast Asia

TANIOBIS Co., Ltd. (Thailand)
Materials Service Complex (Thailand) Co., Ltd.
Materials Service Complex Malaysia Sdn. Bhd.
JX Metals Singapore Pte. Ltd.
JX Metals Philippines, Inc., etc.

South America

Chile Office
Caserones Copper Mine (Chile)
Escondida Mine (Chile)
Los Pelambres Mine (Chile), etc.

Global zero-emission vehicle mandates and internal combustion engine bans



Source: IEA "Global EV Outlook 2023"

LDV: Light-duty vehicle
HDV: Heavy-duty vehicle

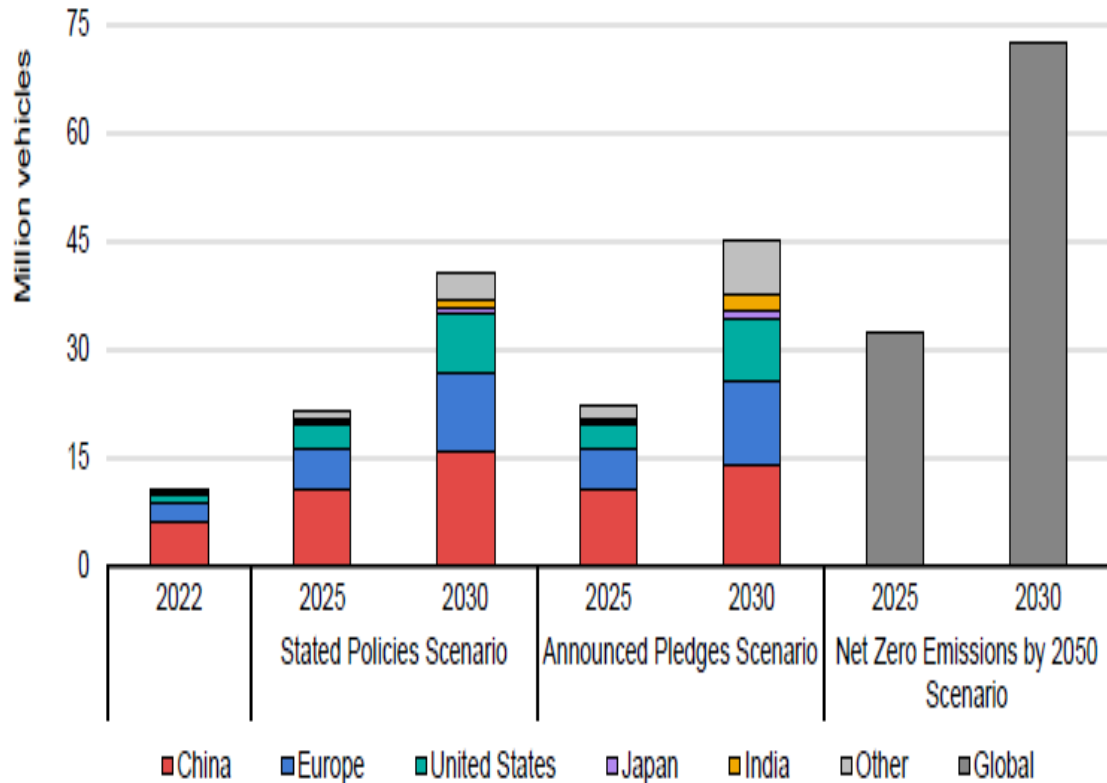
EV sales & projected battery demand (2020-2030)

The number of EV sales will increase rapidly in the future

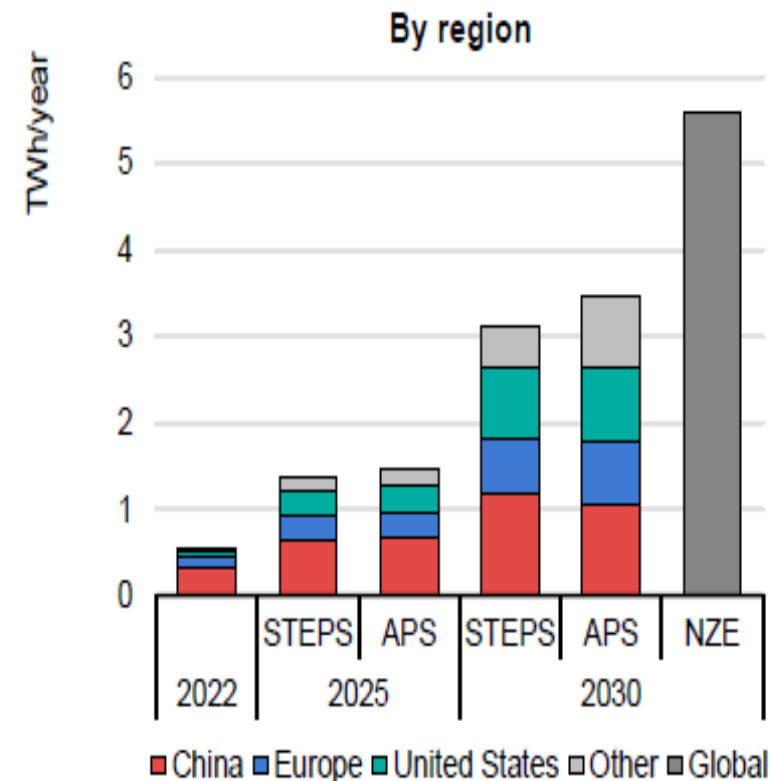


Automotive LiB demand will increase dramatically for years to come

Electric vehicle sales by region, 2022-2030

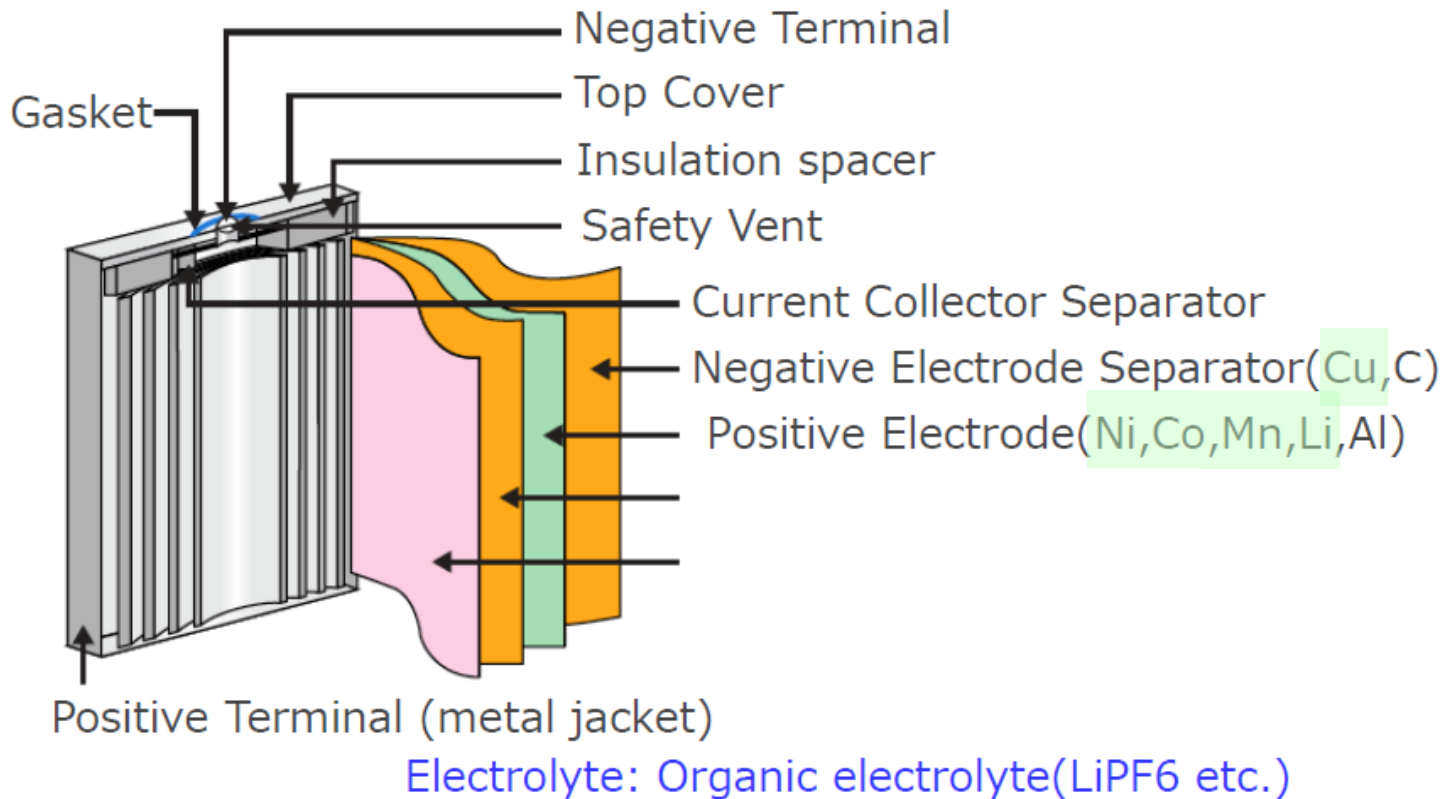


Projected battery demand by mode and region, 2022-2030



Source: IEA "Global EV Outlook 2023"

Structure and composition of LiB



■ Key Features

- High energy/output density, high battery voltage
- High charge/discharge energy efficiency. Low self-discharge rate
- Can be recharged even with remaining capacity

Figure: Structure and composition of square LiB

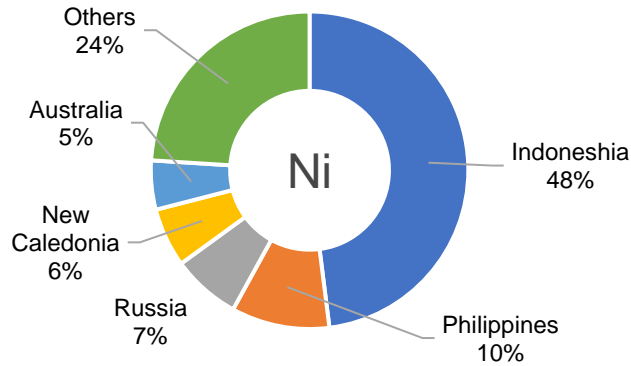
Source: Battery Association of Japan HP
<https://www.baj.or.jp/battery/knowledge/structure.html>

Items to be collected in our project

Two aspects of LiB – Critical Minerals

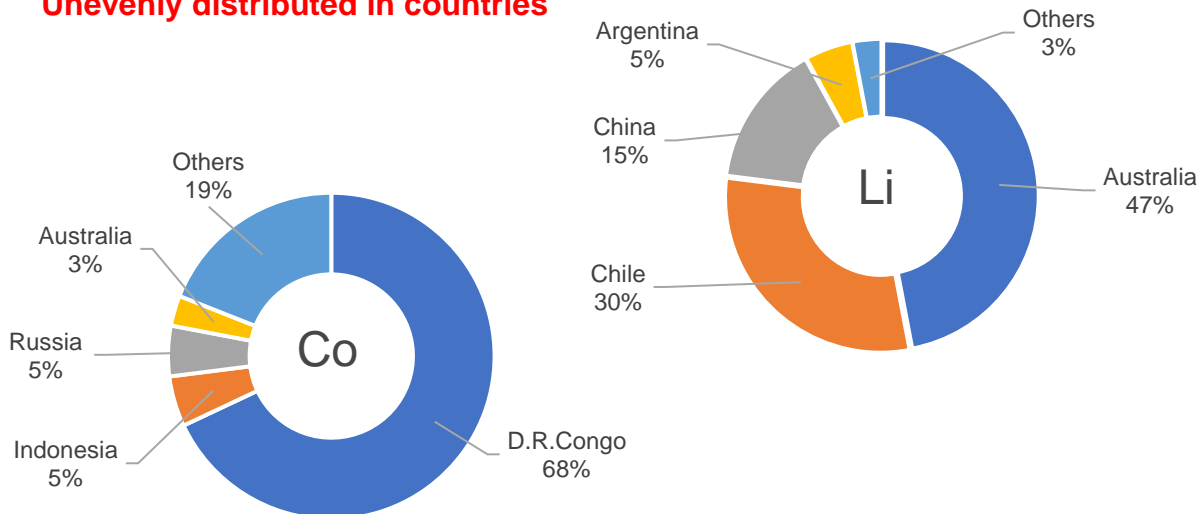
EV battery supply for projected demand

World mine production in 2022

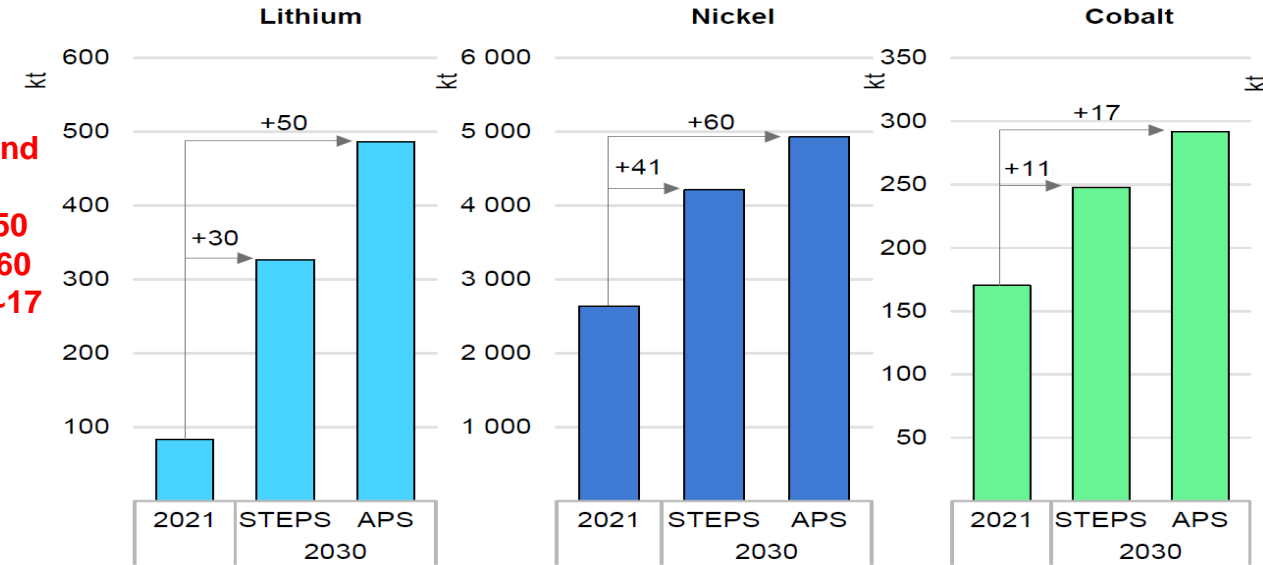


To fulfill the LiB demand in 2030,
 ✓ Li new mine +30~50
 ✓ Ni new mine +41~60
 ✓ New Co Mine +11~17 will be needed

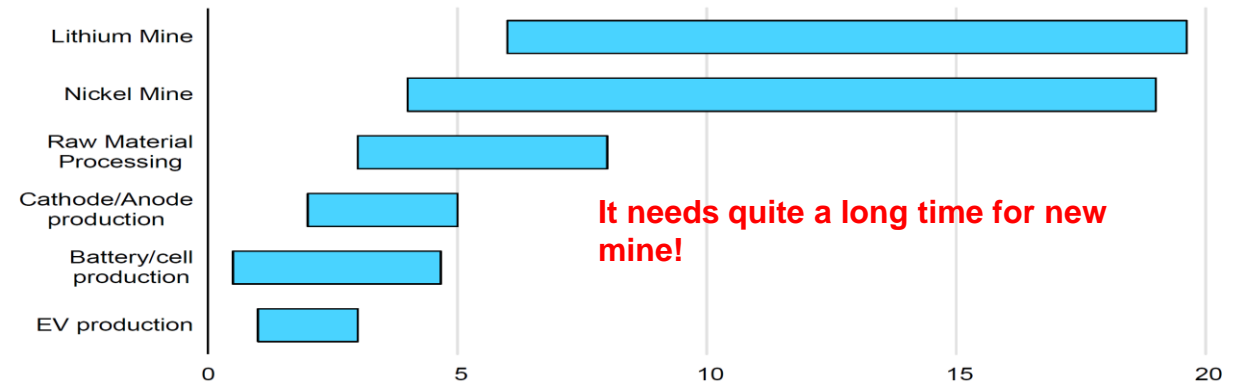
Unevenly distributed in countries



Source : USGS "Mineral Commodity Summaries 2023"



Range of typical lead times to initial production for selected steps in EV battery supply chain



It needs quite a long time for new mine!

Source : Global Electric Vehicle Outlook 2022 (IEA)

Years

Two aspects of LiB – Hazardous Waste

EOL LiB should be properly collected and safely detoxified to prevent fire, health and environmental risks

Risks

- Electric shock by residual voltage
- Ignition during transportation and storage *
- Health and environmental damage due to harmful substances in LiB *

* Flammable organic solvent (Ethylene carbonate), electrolyte which produces hydrofluoric acid when it contacts with water (LiPF₆)

Fire caused by LiB crushing at recycling facility



A huge fire caused by igniting a stored LiB

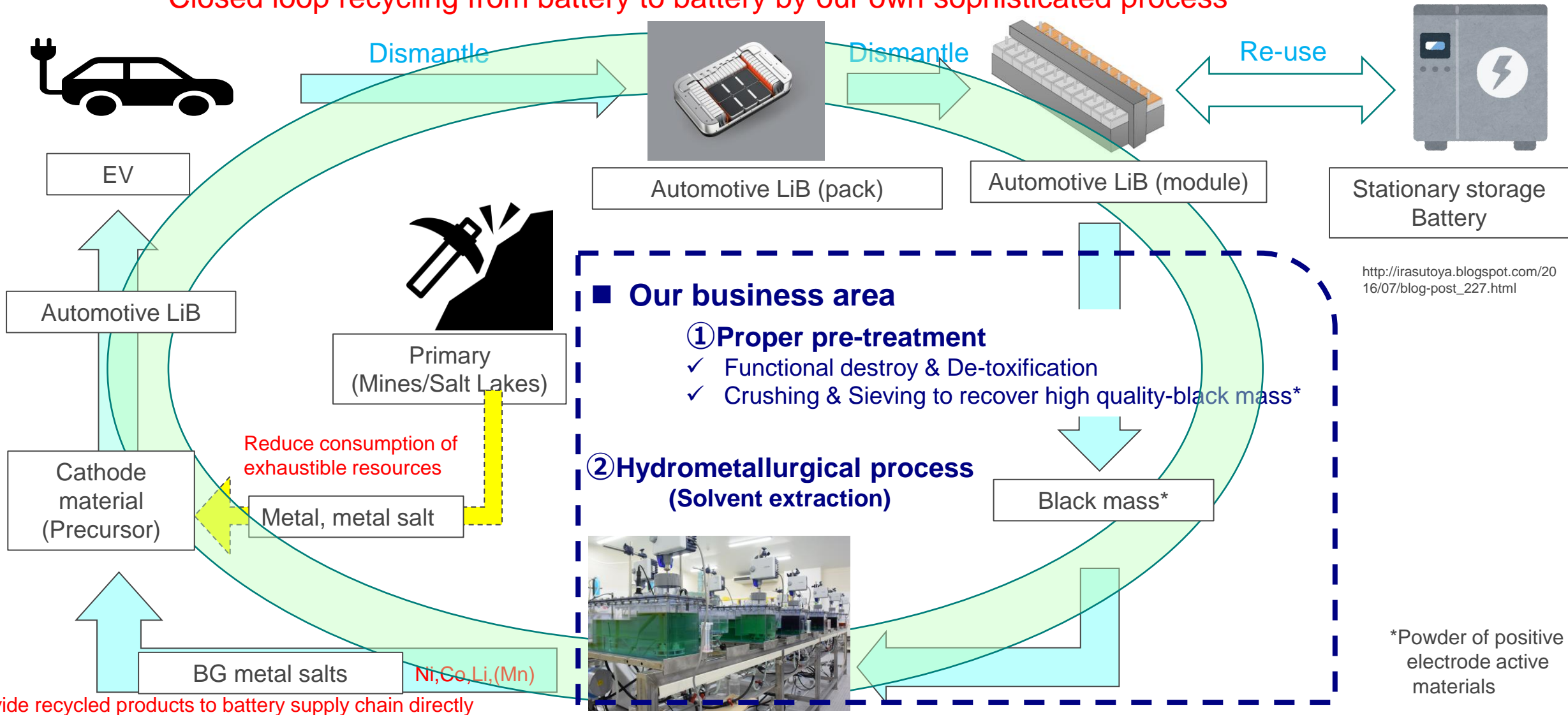


12 days to extinguish the fire

Source: Fire and Disaster Management Agency, Japan

Our concept of automotive LiB recycling

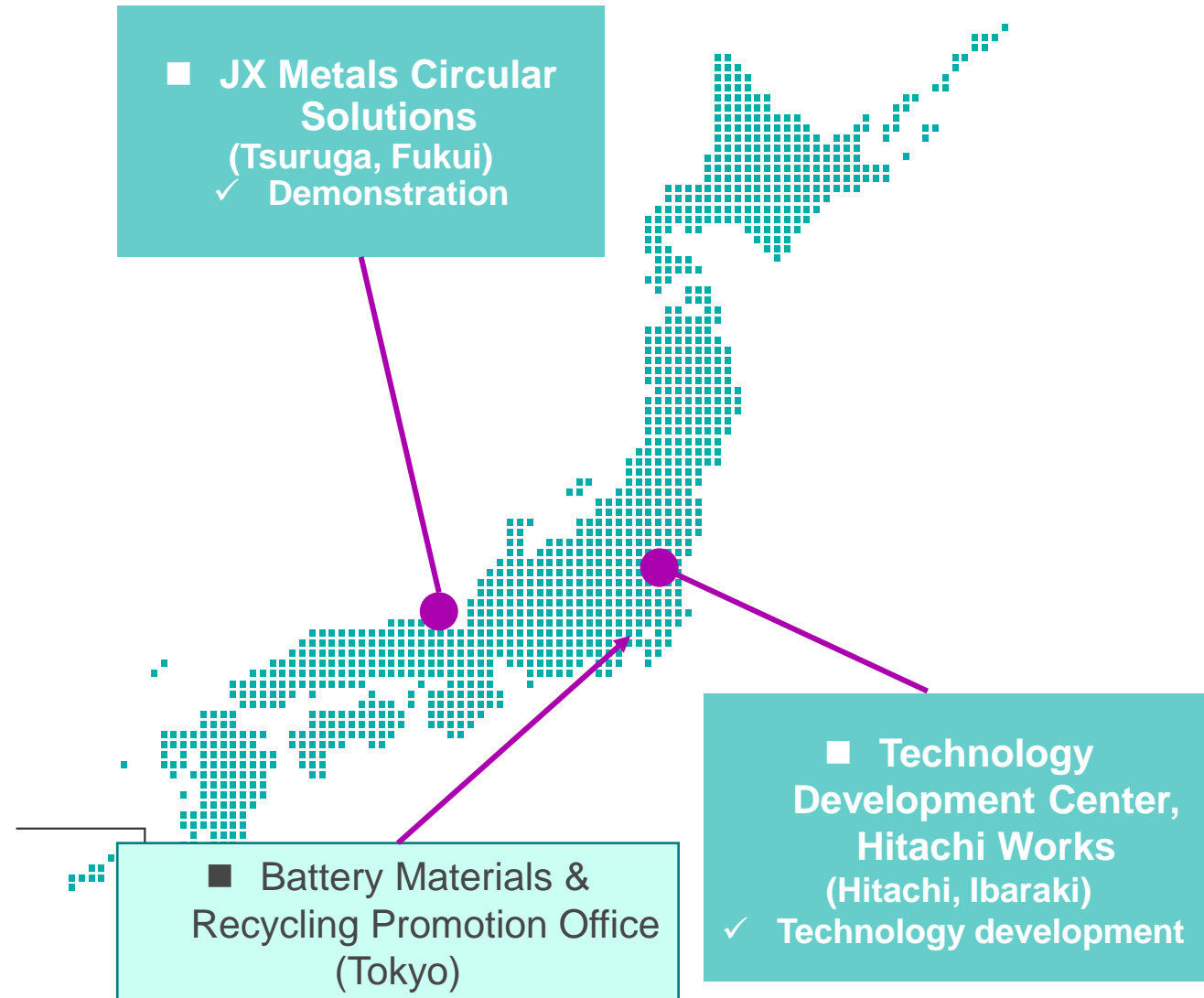
Closed loop recycling from battery to battery by our own sophisticated process



Provide recycled products to battery supply chain directly

Our LiB recycling bases

- JX Metals Circular Solutions Europe GmbH
- TANIOBIS GmbH
(Frankfurt & Goslar, Germany)
- ✓ Demonstration
- ✓ Participant in HVBatCycle research consortium



Green Innovation Fund by NEDO

Our LiB recycling project was adopted in April 2022 and has been developing more sophisticated process by using the fund

■ Theme:

“Development of closed loop recycling technology for automotive LiB”

■ Items:(Collaboration with academia)

- Established Life Cycle Assessment (LCA) evaluation method for LiB recycling
- Development of appropriate pre-treatment technology for automotive LiB module
- Development of advanced hydro-metallurgical process for black mass recovered from automotive LiB

HVBatCycle research consortium funded by BMWK

The HVBatCycle research consortium, led by Volkswagen has been established with the goal of keeping cathode metals, electrolyte and graphite permanently in a closed material cycle (closed loop). The project is funded by the German Federal Ministry for Economic Affairs and Climate Action.

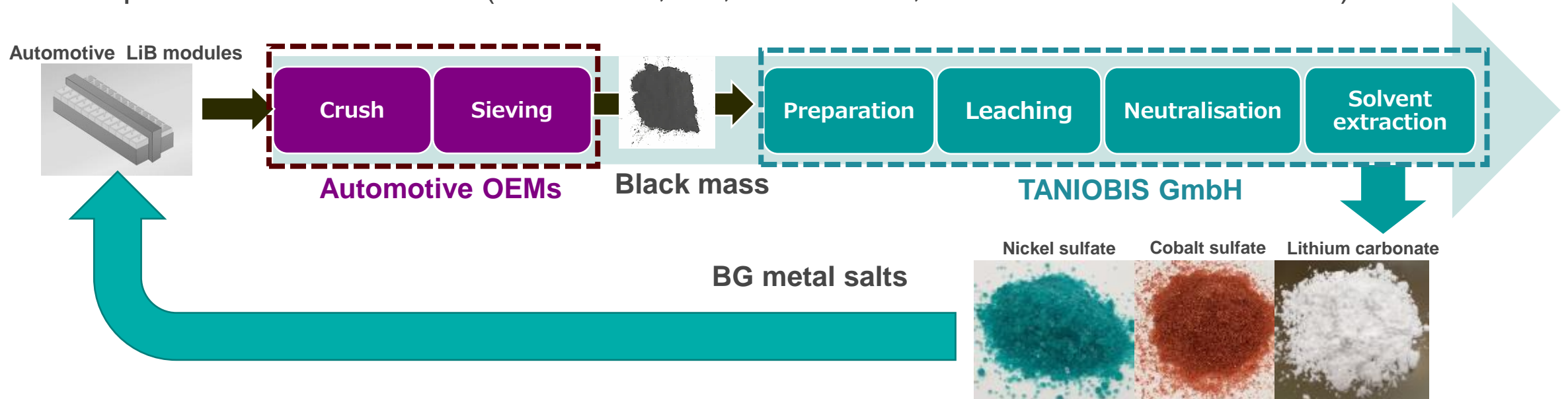
Within the framework of this consortium, TANIOBIS will work to optimize the process to recover high-quality battery raw materials at a high yield using black mass provided by Volkswagen

■ Duration

3 years (Jan.2022 – Dec.2024) subsidised by BMWK

■ Partners

6 companies and 3 institutes (TANIOBIS, VW, Fraunhofer, RWTH Aachen and others)



Abbreviation

Alphabetical

Al	Aluminum	ICE	internal combustion engine
APS	Announced Pledges Scenario	Li	Lithium
BG	Battery grade	LiB	Lithium-ion battery
BMWK	Bundesministerium für Wirtschaft und Klimaschutz	Mn	Manganese
C	Carbon	NEDO	New Energy and Industrial Technology Development Organization
Co	Cobalt	Ni	Nickel
Cu	Copper	NZE	Net Zero Emissions by 2050 Scenario
EOL	end of life	OEM	original equipment manufacturer
EV	Electric Vehicle	PHEV	Plug-in Hybrid Electric Vehicle
HEV	Hybrid Electric Vehicle	STEPS	Stated Policies Scenario
HVBatCycle	High Voltage Battery Cycle	ZEV	Zero Emission Vehicle

