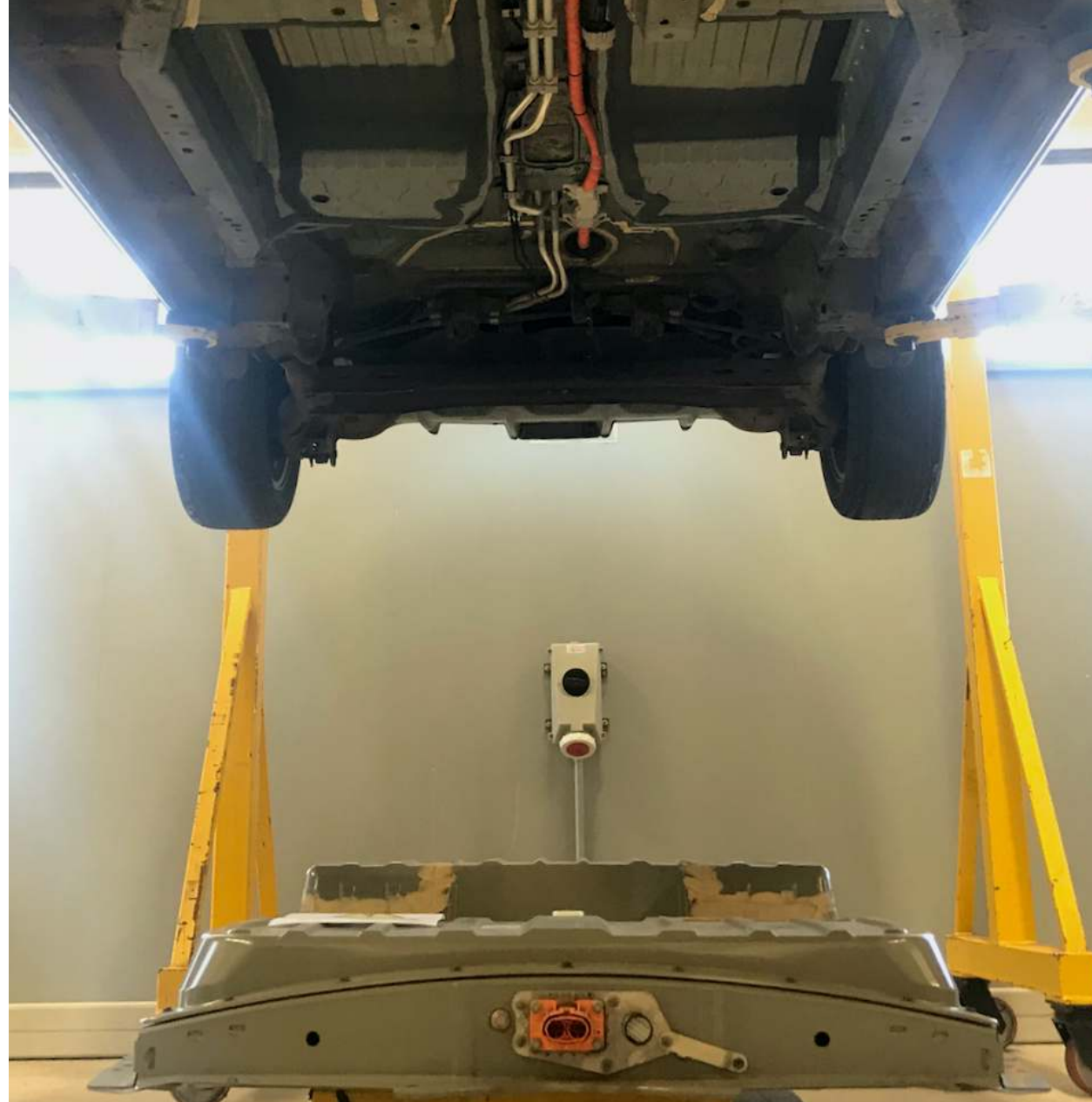


# International outlook lithium battery recycling

Zemo LCA webinar series  
– lithium battery recycling  
23rd March 2022

Hans Eric Melin  
Circular Energy Storage



## About Circular Energy Storage

- Leading provider of lifecycle data for for the lithium-ion battery market
- Subscription of data and analysis and bespoke consulting services such as custom reports, strategy and business development and due diligence
- Over 200 customers throughout the entire battery value chain in North America (42%), Europe (37%) and APAC (18%)

Featured and published in:

**Bloomberg**

**NIKKEI ASIAN REVIEW**

**The New York Times**

**FT** FINANCIAL TIMES

**Energy Storage NEWS**

**greentechmedia:**

**Chicago Tribune**

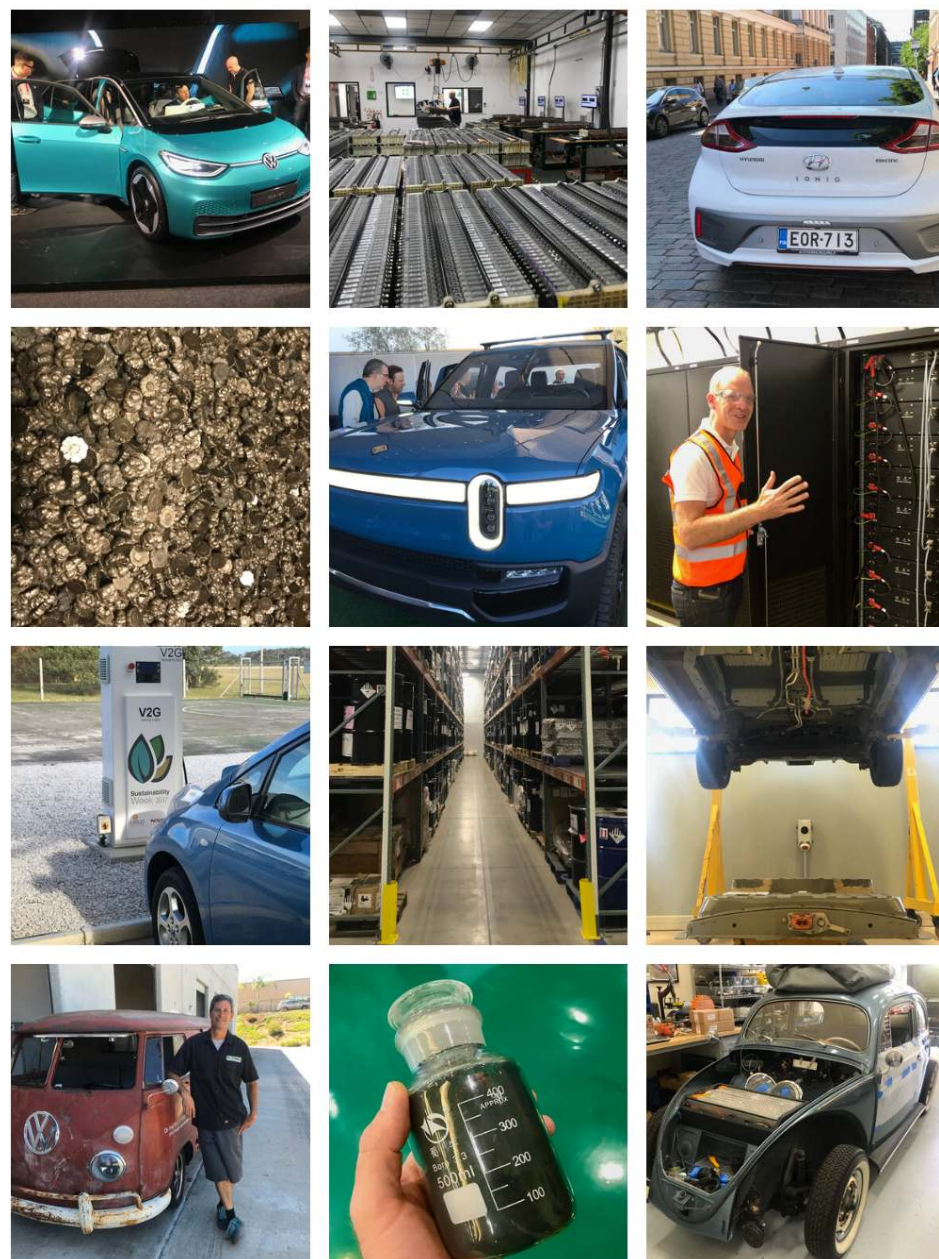
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## Global implications of the EU battery regulation

[HANS ERIC MELIN](#), [MOHAMMAD ALI RAJAEIFAR](#), [ANTHONY Y. KU](#), [ALISSA KENDALL](#), [GAVIN HARPER](#), AND [OLIVER HEIDRICH](#) [Authors Info & Affiliations](#)

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## Circular economy strategies for electric vehicle batteries reduce reliance on raw materials

[Joris Baars](#), [Teresa Domenech](#), [Raimund Bleischwitz](#), [Hans Eric Melin](#) & [Oliver Heidrich](#) 



# Our data – CES Online

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**NEW! Analysis of the impact of Russia's invasion in Ukraine on the end-of-life battery market**

**Latest News**

- Aurubis sets up pilot plant for lithium-ion battery recycling
- Eramet and Suez to set up pre-processing plant in France
- Northvolt to build third battery plant with integrated recycling

**LIB in use 2021: 1251 GWh** | **LIB placed on the market 2021: 444 GWh** | **LIB that reached end of life 2021: 64 GWh** | **LIB available for recycling 2021: 43 GWh**

**Material prices, 1 March 2022**

Metals (LME and SMM 1 March 2022)	USD/kg	Δ	Δ%
Nickel LME	25.45		8.4%
Cobalt LME	73.11		2.5%
Copper LME	9.97		2.6%
Aluminium LME	3.49		27.9%
Scrap steel LME	0.59		28.8%
Librar, carbonate (SMM)	74.86		27.1%
Natural graphite (-140) SMM	6.51		8.1%

**Material value largest chemistries (USD/kg)**

Chemistry	1 March 21	1 April 21	1 May 21	1 June 21	1 July 21	1 August 21	1 September 21	1 October 21	1 November 21	1 December 21	1 January 22	1 February 22	1 March 22
NCM111	17.33	11.27	14.40	14.23	14.92	15.29	15.51	18.41	15.32	23.26	22.23	25.34	36.41
NCM622	10.15	9.27	9.24	8.18	8.43	9.94	10.16	11.07	12.26	13.07	14.28	17.22	19.92
LFP	2.92	3.01	3.19	3.16	3.08	3.21	3.45	3.19	4.41	4.67	5.22	7.21	8.61
LCO													

## Volumes

**Batteries in Use**

**LIB in use 2021: 1251 GWh** | **LIB placed on the market 2021: 444 GWh** | **LIB that reached end of life 2021: 64 GWh** | **LIB available for recycling 2021: 43 GWh**

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## Prices

**Prices used batteries**

**Average price of LIB batteries (USD/kWh)**

**\$190/kWh** | **-4.0%** | **+14.7%**

## Market

**The Recycling Market**

**LIB that reached end of life 2021: 64 GWh** | **LIB available for recycling 2021: 43 GWh**

**LIB that reached end of life 2021: 64 GWh** | **LIB available for recycling 2021: 43 GWh**

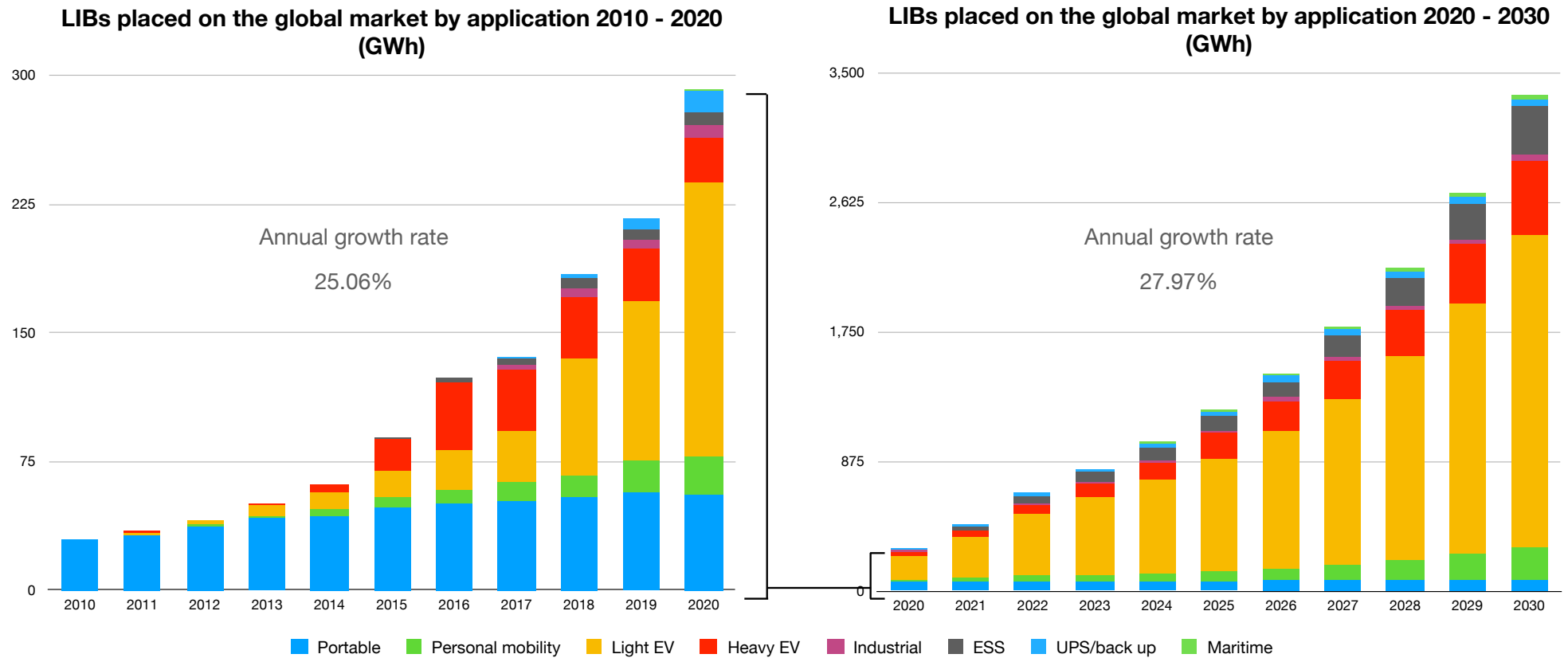
## Technology

**Patents**

**New Patents Filed in Q1 2022: 1940**

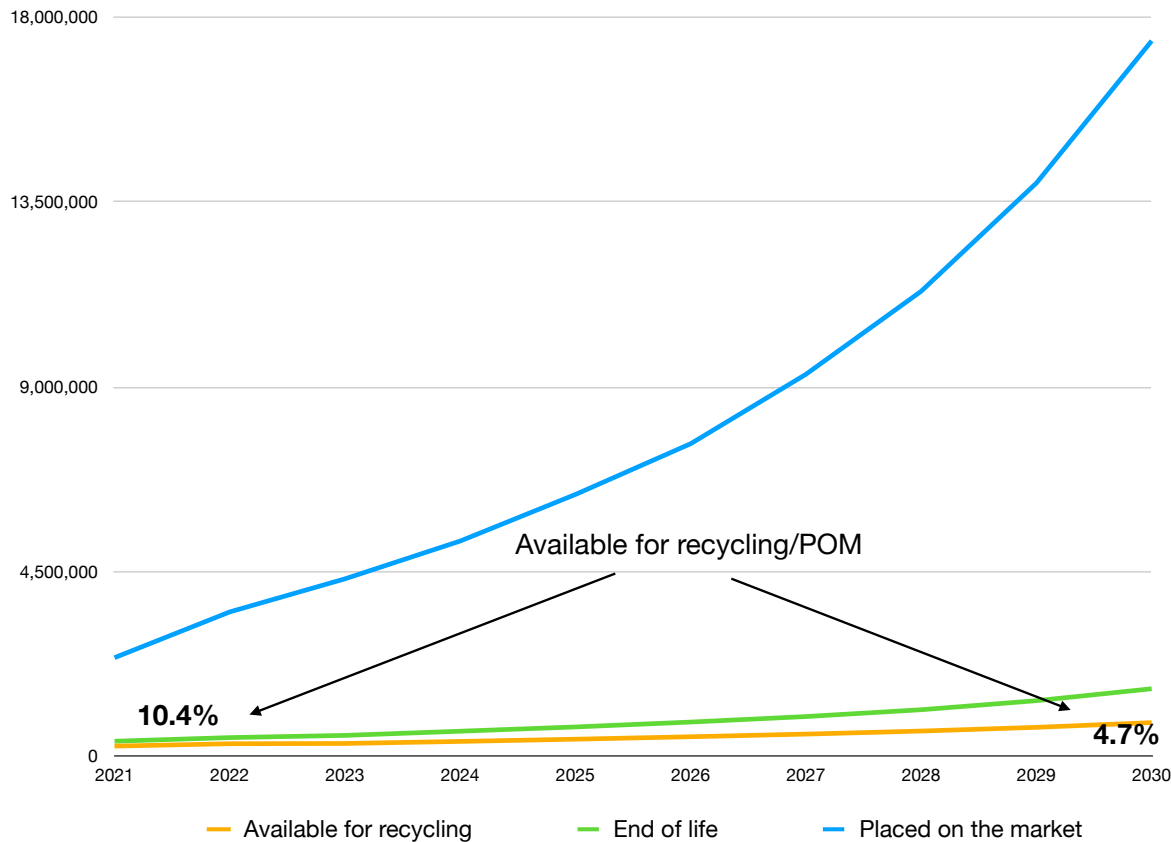
**New Patents Filed in Q1 2022: 1940**

# Batteries placed on the global market



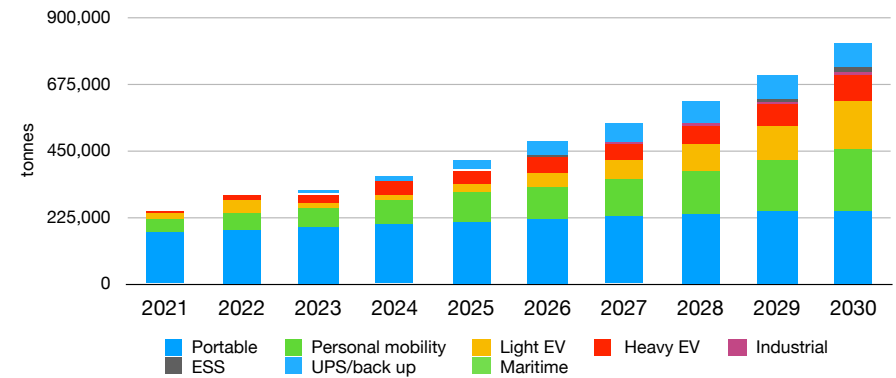
# Still volumes available for recycling will remain low in comparison to what is placed on the market

Global volume of LIBs POM vs EOL and available for recycling 2021 - 2030

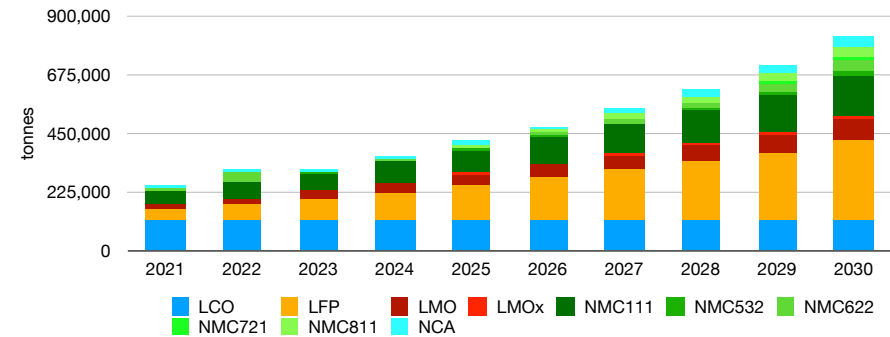


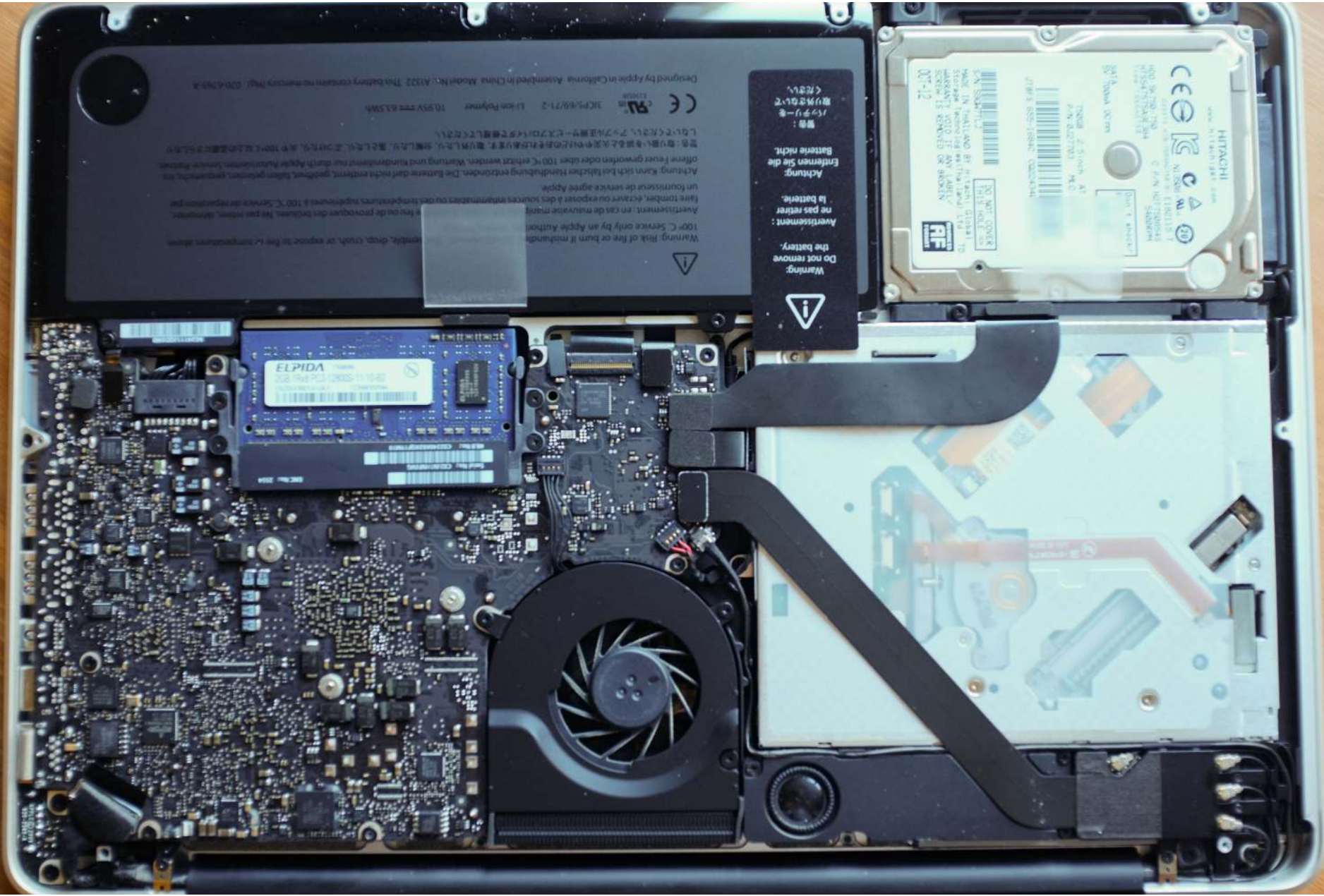
Volumes includes only batteries that has been placed on the market and reached their end of life. The data does not include production scrap or R&D/test batteries

Global volume of LIBs available for recycling by application (cell level)



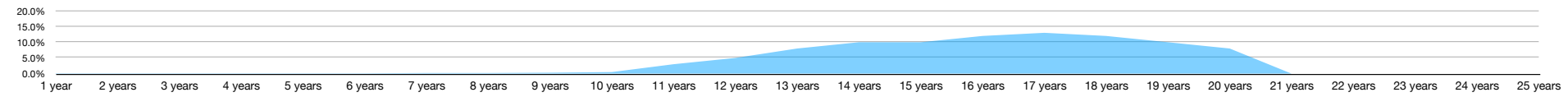
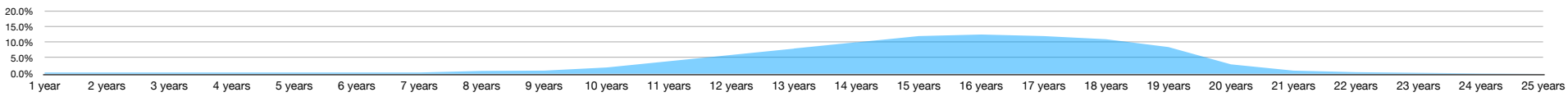
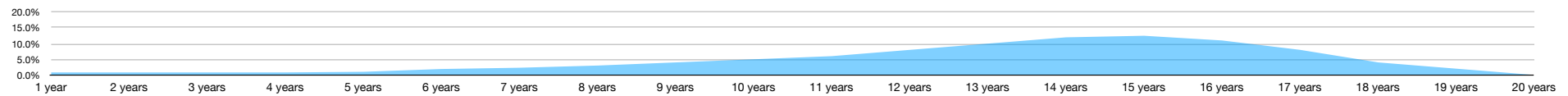
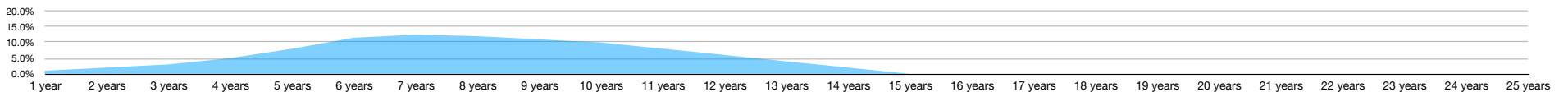
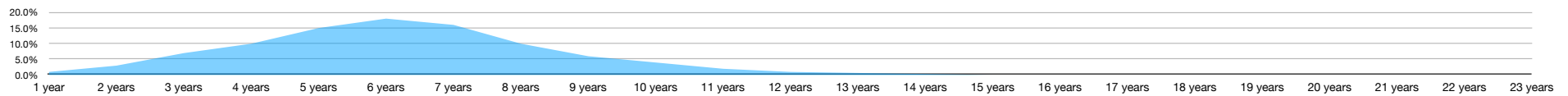
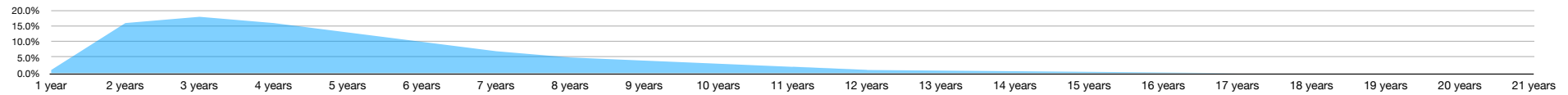
Global volume of LIBs available for recycling by chemistry (cell level)





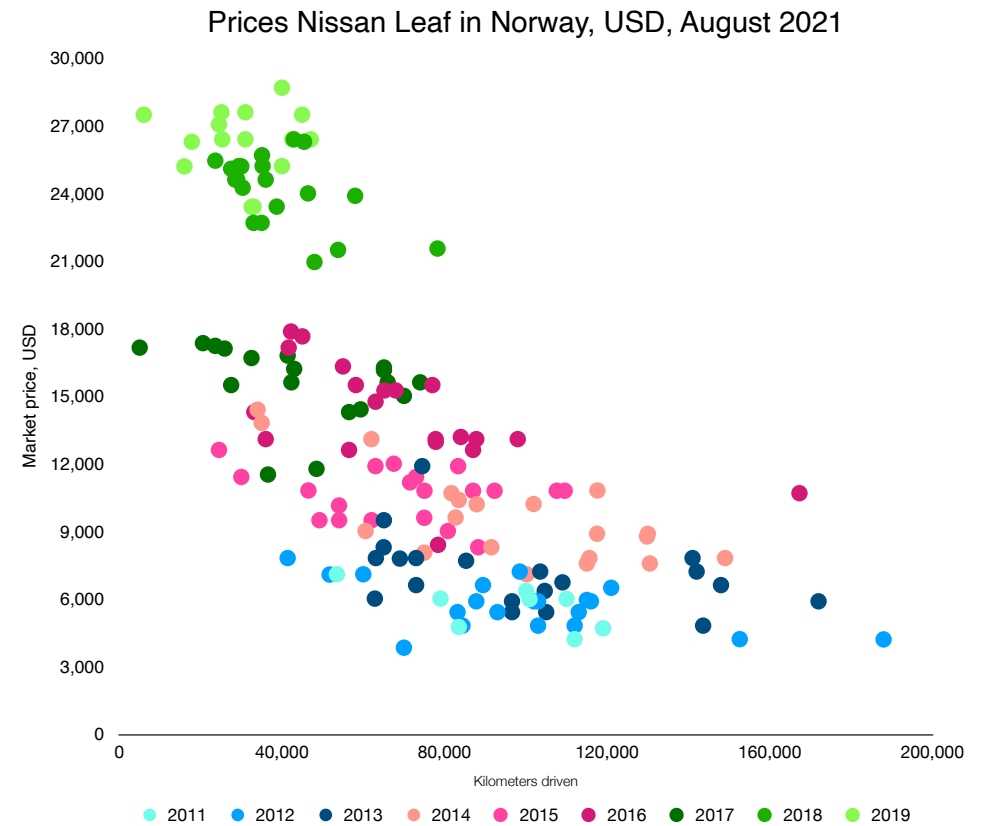
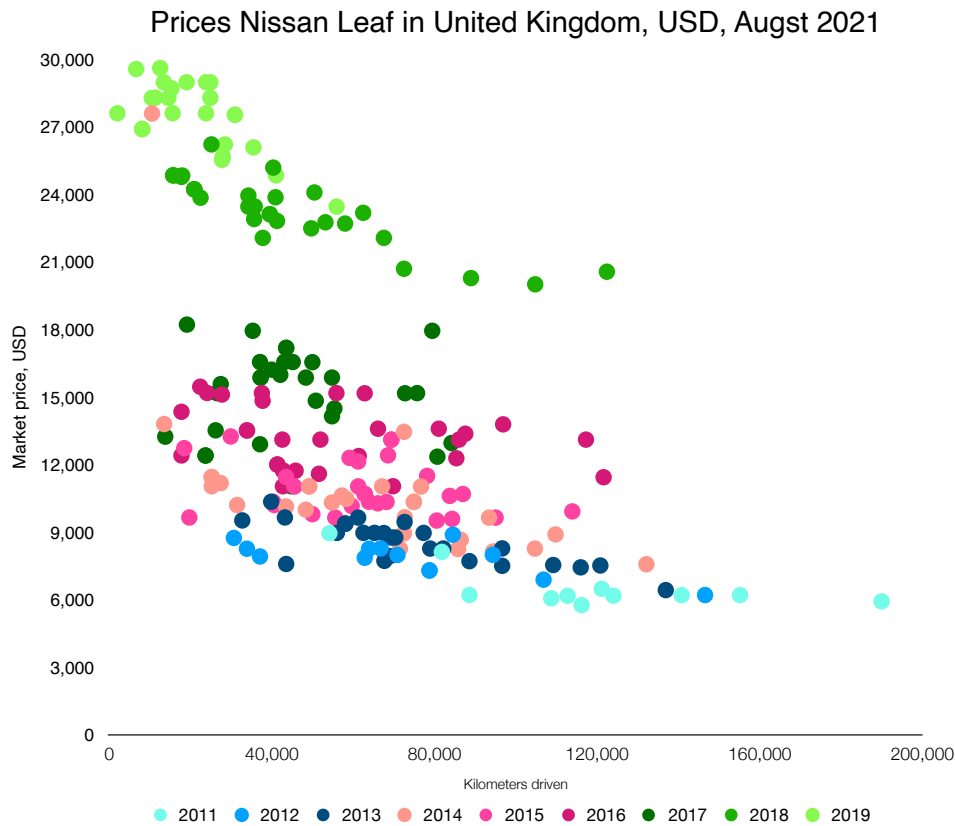


# The lifecycle of lithium-ion batteries

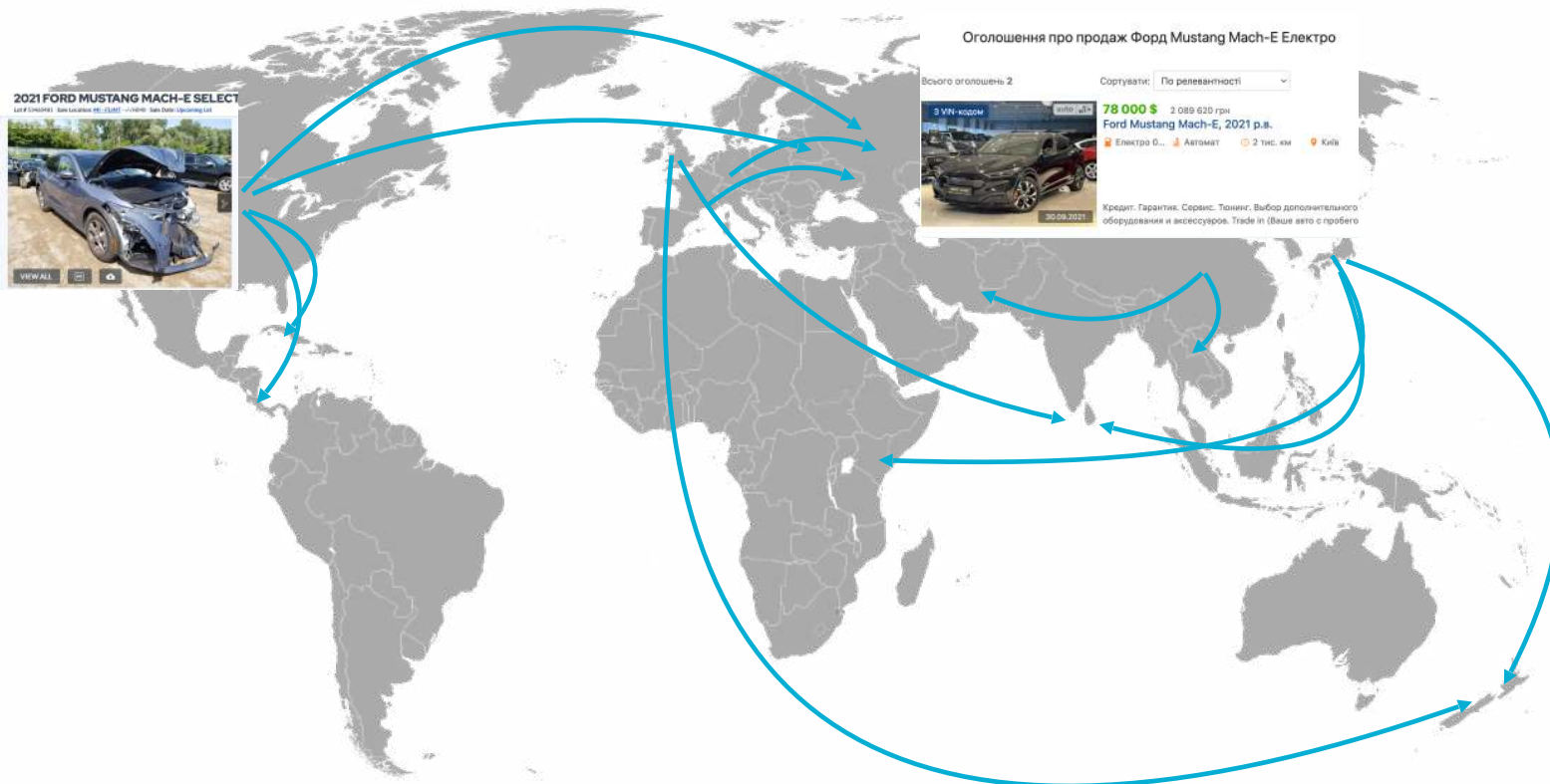




# EVs values have depreciated faster than for ICE vehicles but the vehicles are still far from being scrapped.



# Electric vehicles are exported – and batteries are included



## Top 5 EVs sold in Ukraine August 2021 (89% used import)

### Nissan Leaf

207 units from EU and the US



### Tesla Model 3

71 units from EU and NA



### Renault Zoe

40 units from EU



### Tesla Model S

38 units from EU

















### Chevy Bolt

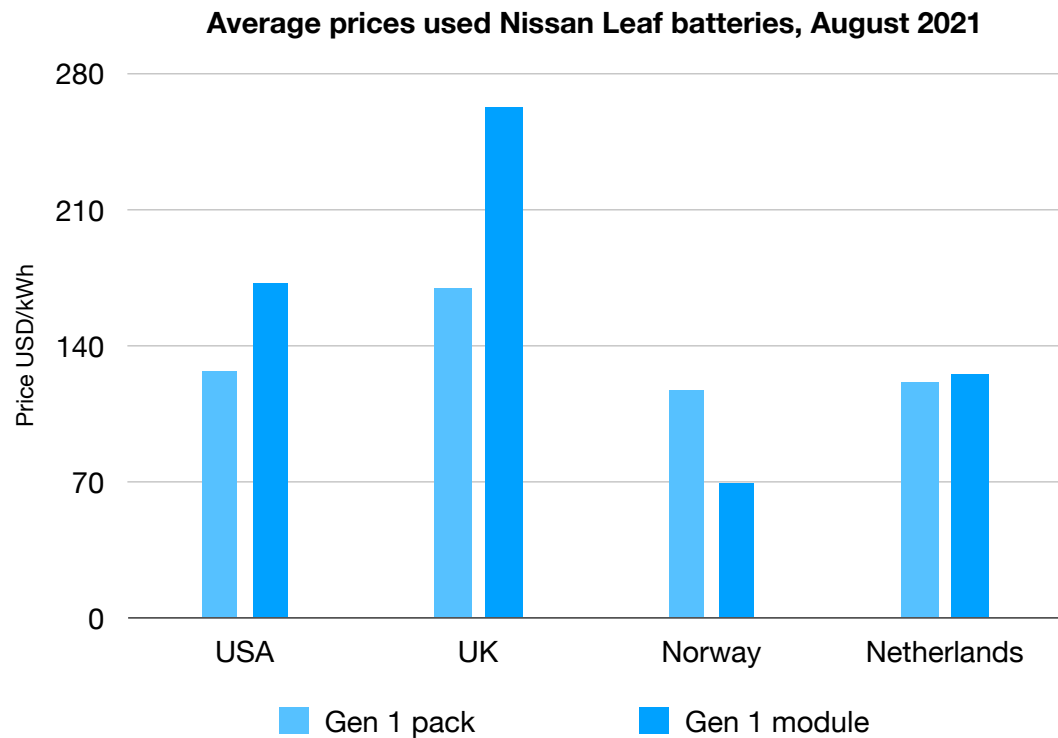
37 units from NA



# If batteries can be reused, most of the them will be – but not always in the expected applications

	Reuse in EV	Stationary energy storage	EV Conversion	Lead-acid battery substitution
Established professional organisations	 In-warranty replacements	 		 UPS/backup
Startups/ SME's	 	 Power packs	 Fork lifts	 2-/3-wheelers
DIY	 Residential ESS	 Classic cars	 Boats	 RV power

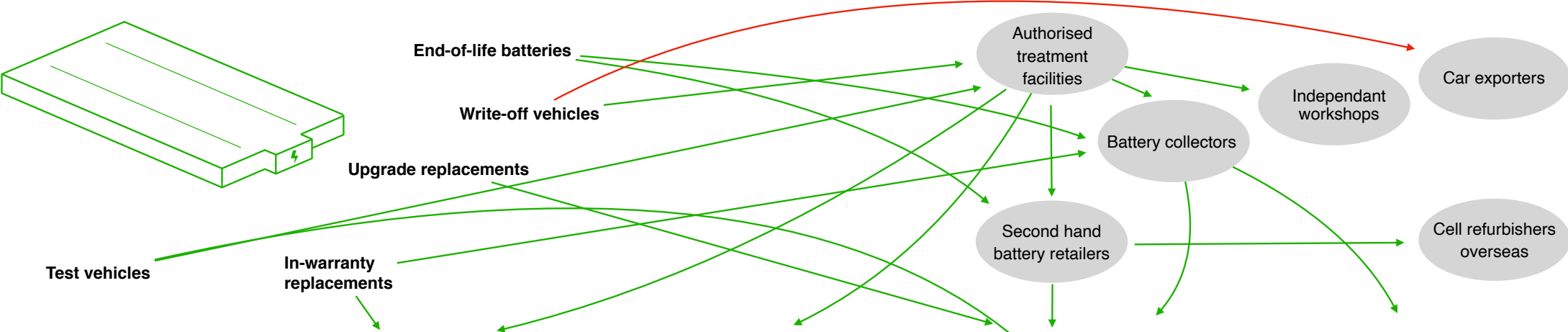
# Values for used EV batteries are continuously high for packs and modules from high volume vehicles





# The end-of-life market for LIBs is diverse, complex and global

The end-of-life market for light electric vehicles is complex and very fragmented. Depending on how the battery reach end of life there will be different routes with different access to the battery for the various players in the market. An important divider for a battery’s destiny is whether the OEMs are in control of the batteries or not.



	Remanufacturing	Reuse	Repurposing	Recycling
Buyers of batteries/ service providers	Reman specialists, OEMs	Independent workshops, upgrade specialists	Second life specialists, EV conversion companies, pack manufacturers, DIY-ers, traders	Traders, pre-processors, integrated recyclers, recyclers overseas
Applications	Replacement batteries (both in-warranty and out-of-warranty)	Out-of-warranty replacement batteries	Energy storage systems, EV-charging, EV conversions, range extenders, leisure batteries, power packs, backup power, maritime electrification	Black mass, metal scrap, mattes and alloys, tradable compounds, precursors
Markets/buyer of end-products	OEMs, drivers of cars >8 years old, drivers in non-original markets	Drivers of cars >8 years old, drivers in non-original markets	Energy companies, fleet operators, car enthusiasts, equipment rental companies, telecom tower operators, private users	The battery material industry, metal processors, other users of specialty chemicals

# Alternative sources of materials will be the main feedstock for recyclers the next 10 years

Production scrap



Batteries from test vehicles and R&D



Unsold batteries

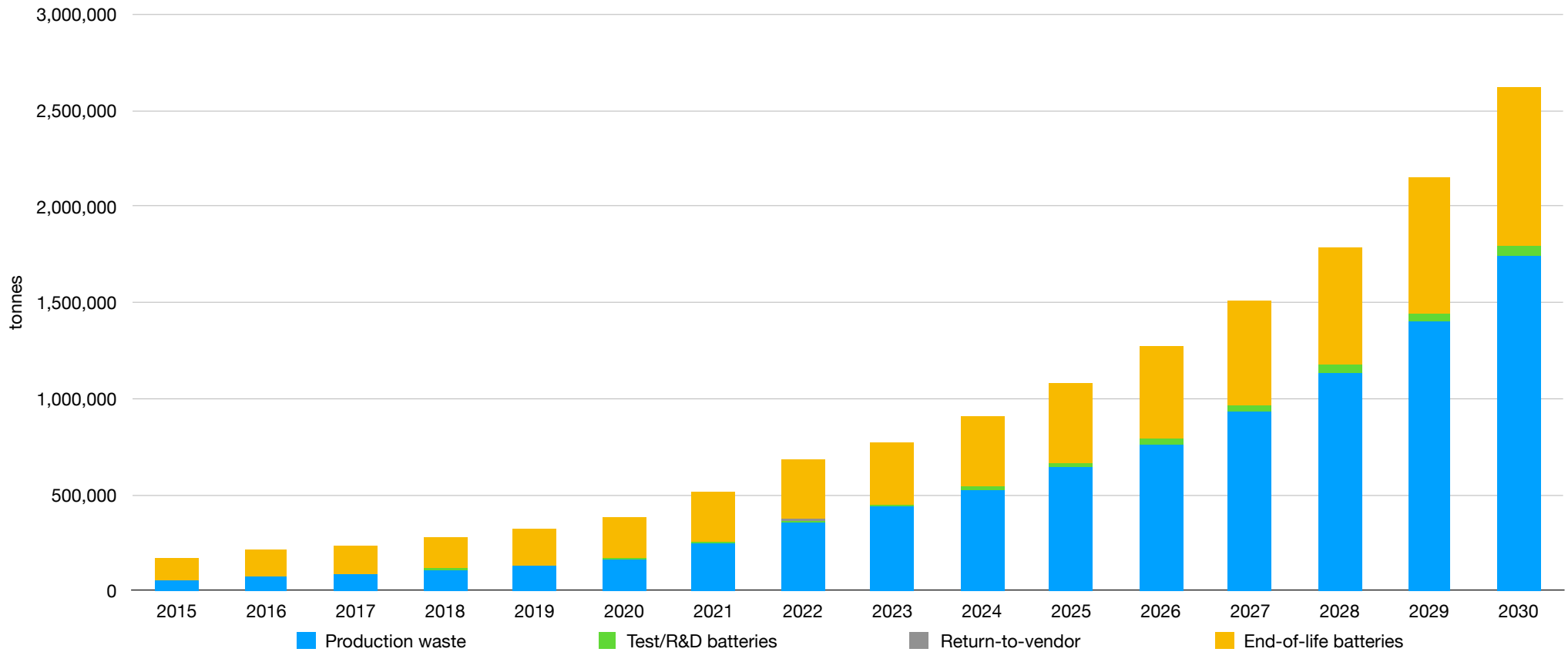


Recalls

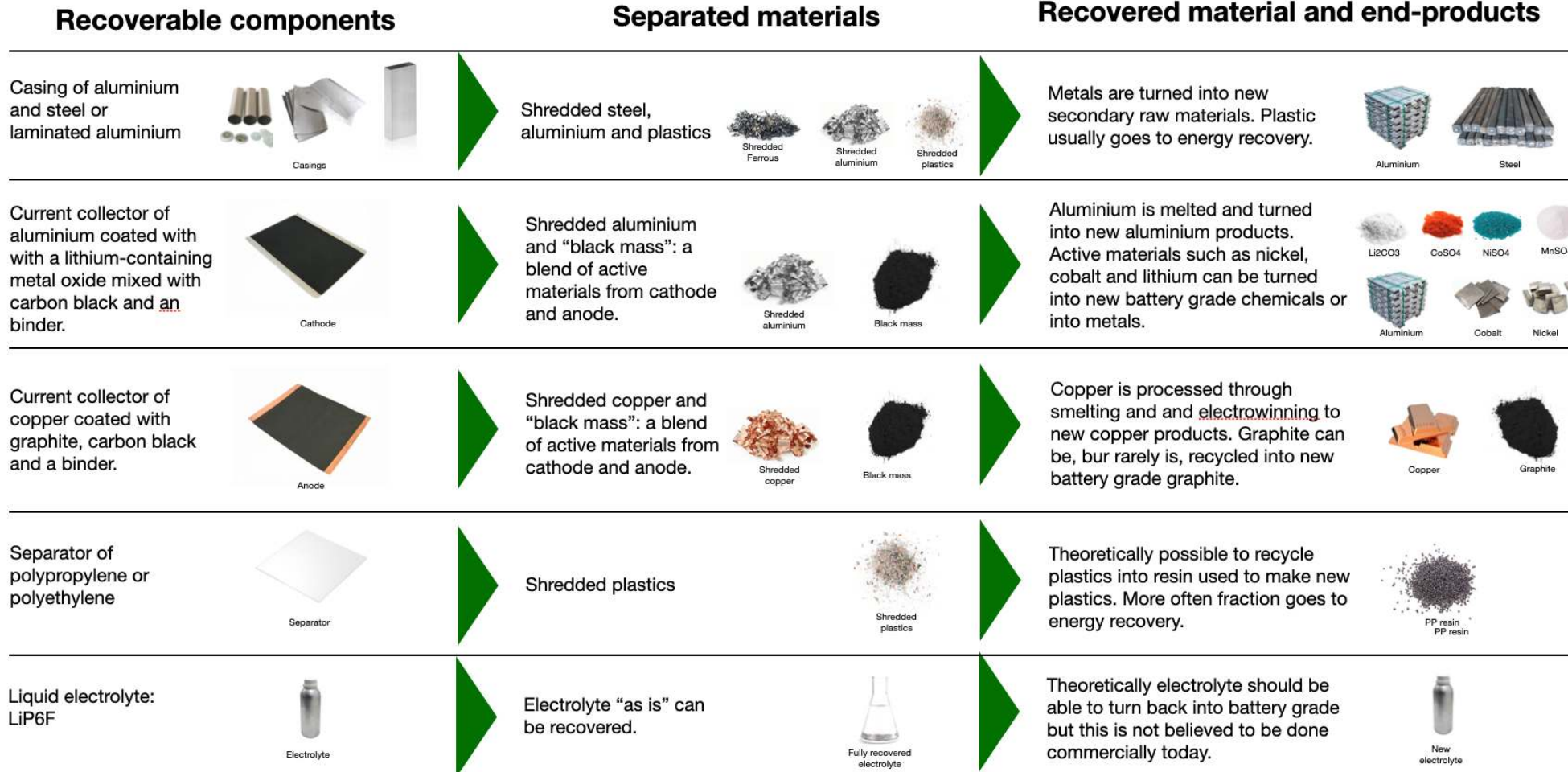


# Volumes of battery waste available

Forecast global recyclable volumes, (cell equivalent)



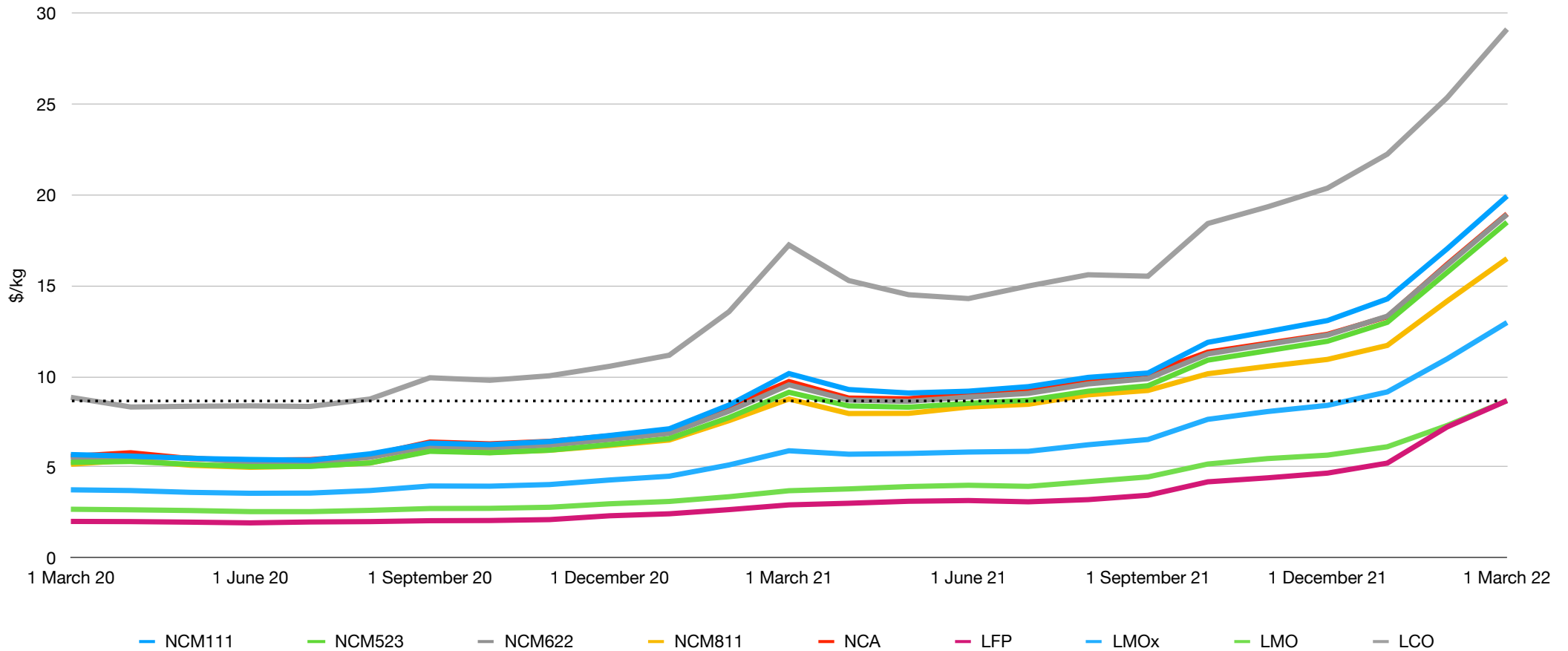
# Recoverable materials in lithium-ion cells





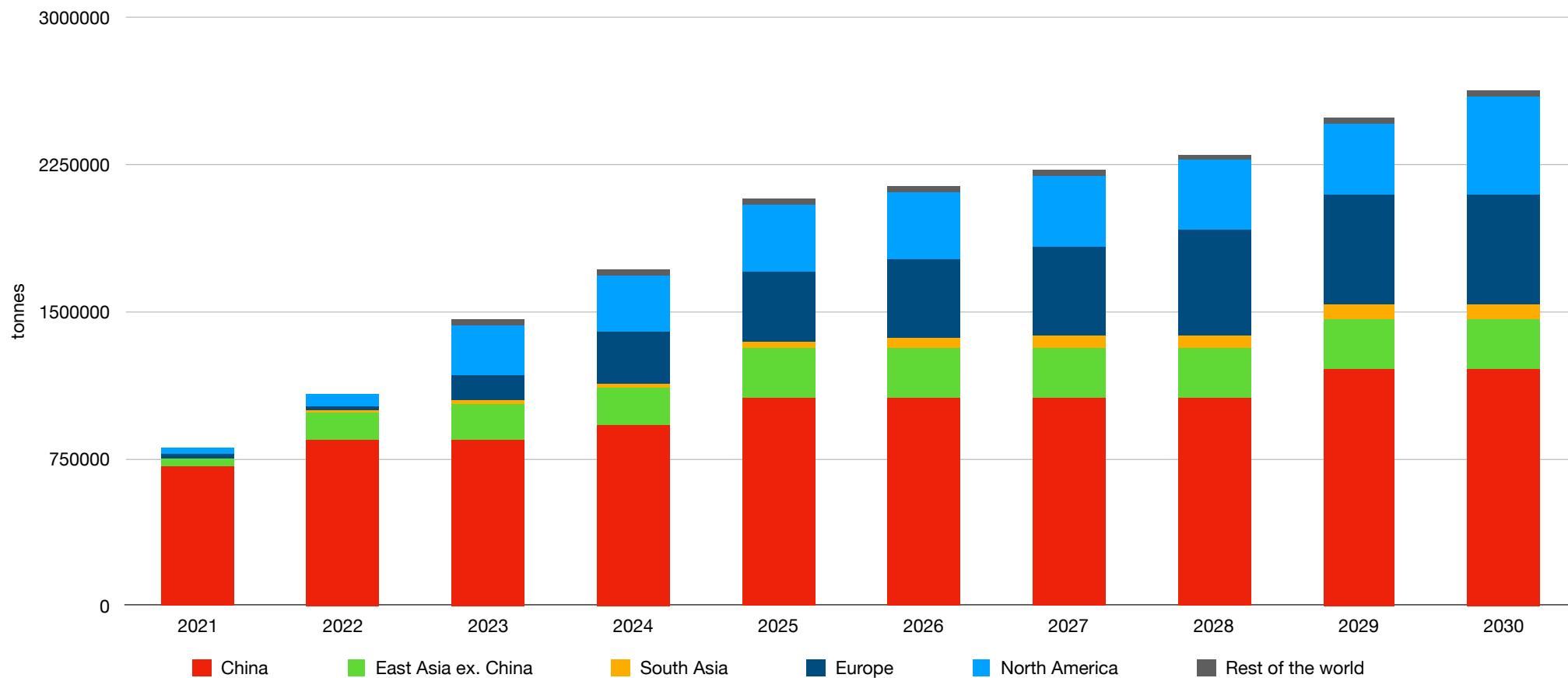
# Prices recoverable materials in lithium-ion batteries

Value recoverable materials in different LIB chemistries March 2020 to February 2022 (USD/kg, cell level)



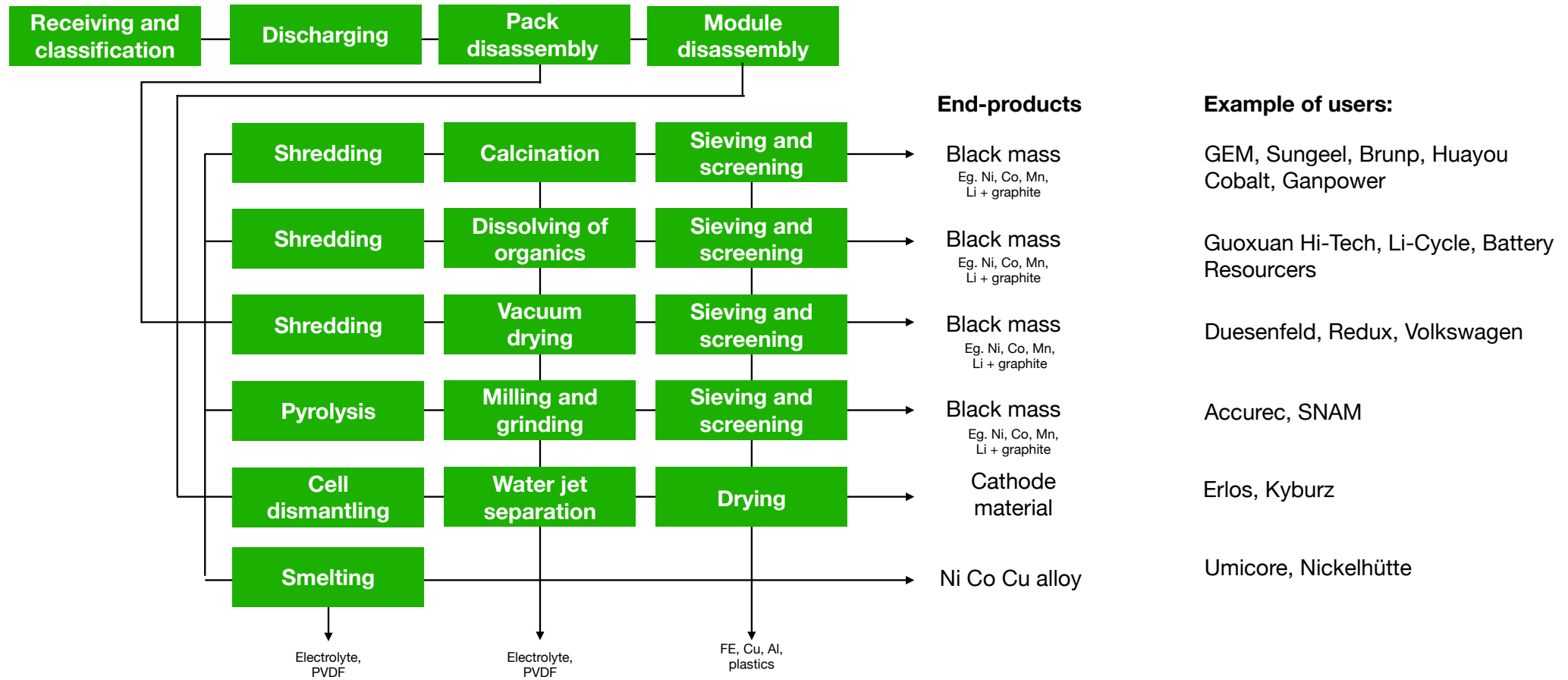
# Current and future planned capacity of material recovery

Global battery recycling capacity, material recovery (tonnes intake, cell equivalent)



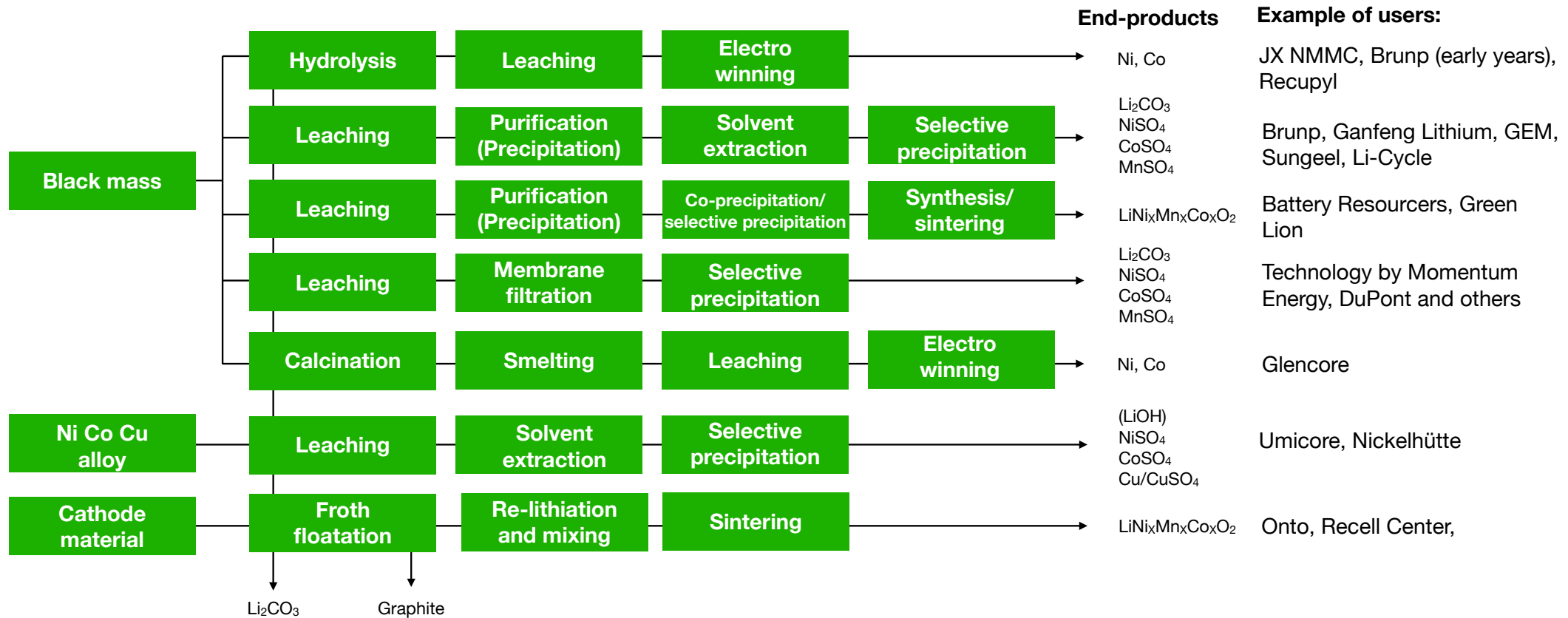
# Industrial pre-processing routes

Multiple systems for pre-processing are in use today all over the world. Many have a similar design but continuous development adds new variants of setups. Here are some of the most common:



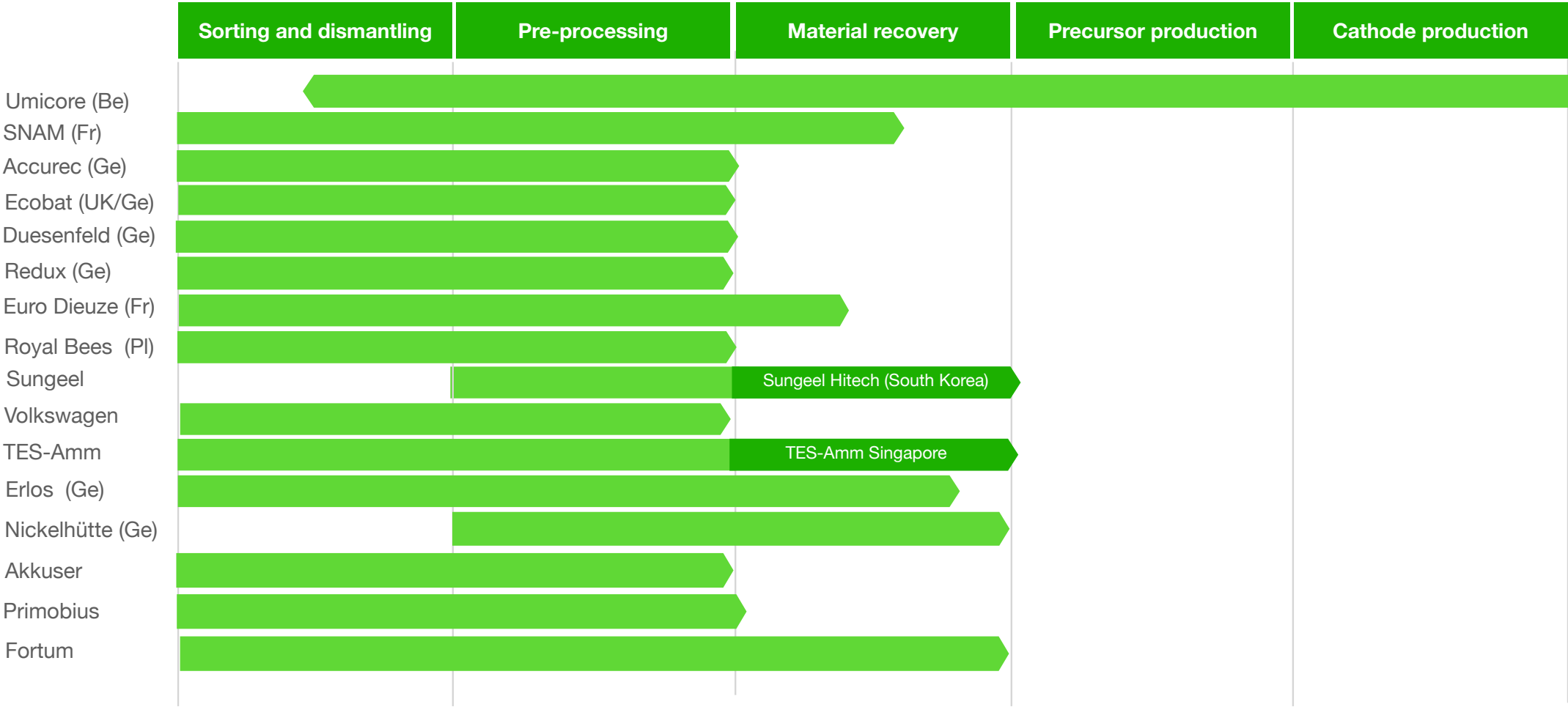
# Industrial material recovery routes

Like for pre-processing there are also multiple systems for material recovery in use today. Some are more common than others but basically all processes without direct recovery of cathode material involves leaching and most often precipitation:

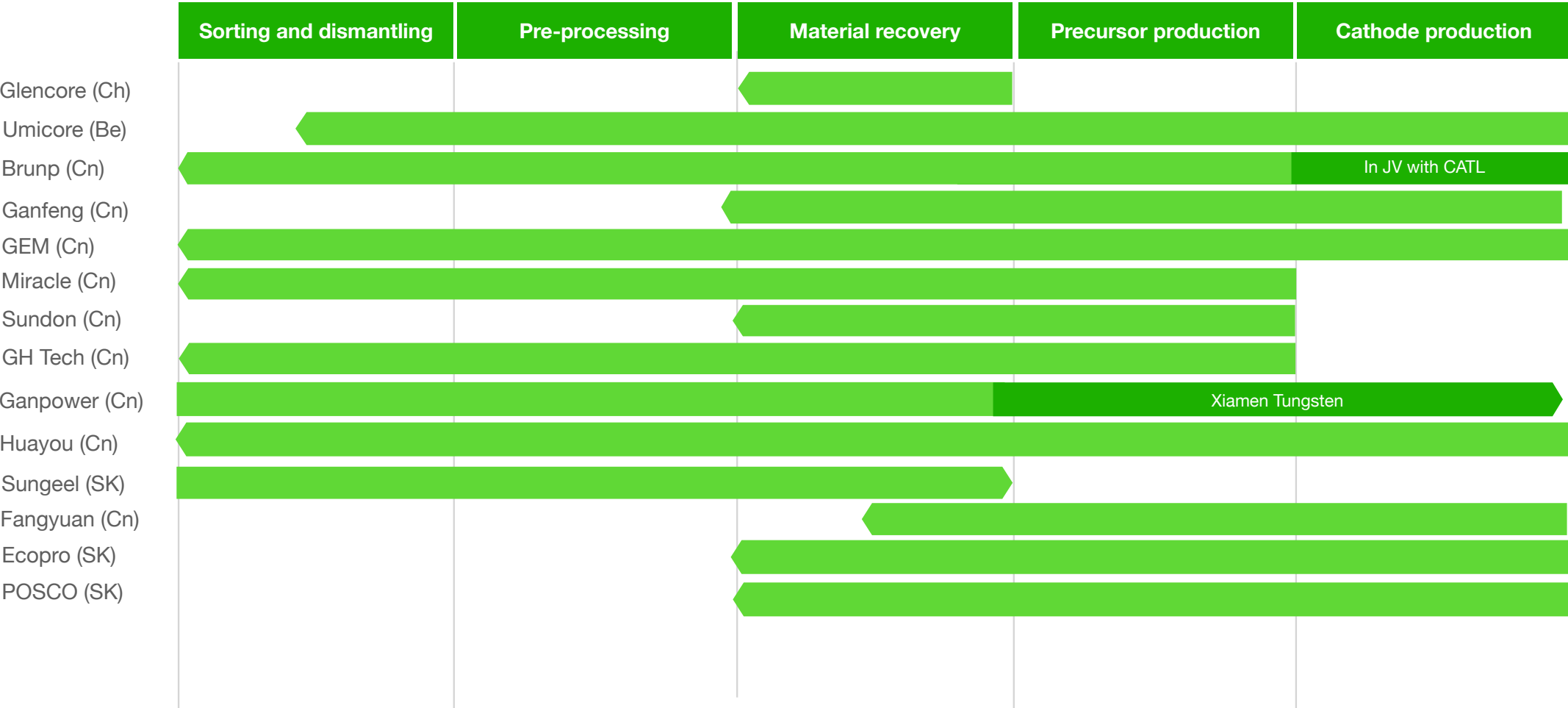


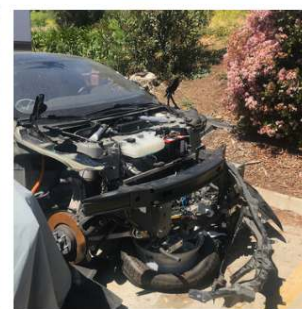
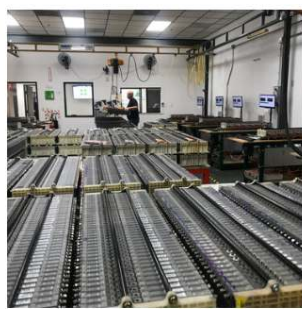


# The recycling value chain – Europe, current players



# The recycling value chain – international leaders





**Thank you!**

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