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IEA TCP HEV Task 40

Critical Raw Materials for Electric Vehicles

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IEA TCP HEV Task 40

CRM4EV
Critical Raw Materials Electric Vehicles

Objective and added value of Task 40:

Integrated view of future supply of critical raw materials for electric vehicles, including

- **battery technology** developments,
- scenarios of global **electric vehicle fleets**
- primary **raw material supply**,
- development of **recycling technologies**,
- **Material demand - supply bottlenecks** until 2030
- **LCA of material and battery production**

- **Task period**: Oct 2018 – Dec 2022
- **Operating agent**: Bert Witkamp / Valuad, Belgium
- Participation of JOANNEUM RESEARCH **financed in Energieforschungsprogramm 5. AS** by:

klima+ energie fonds

Bundesministerium
Klimaschutz, Umwelt,
Energie, Mobilität,
Innovation und Technologie

FFG Forschung wirkt.

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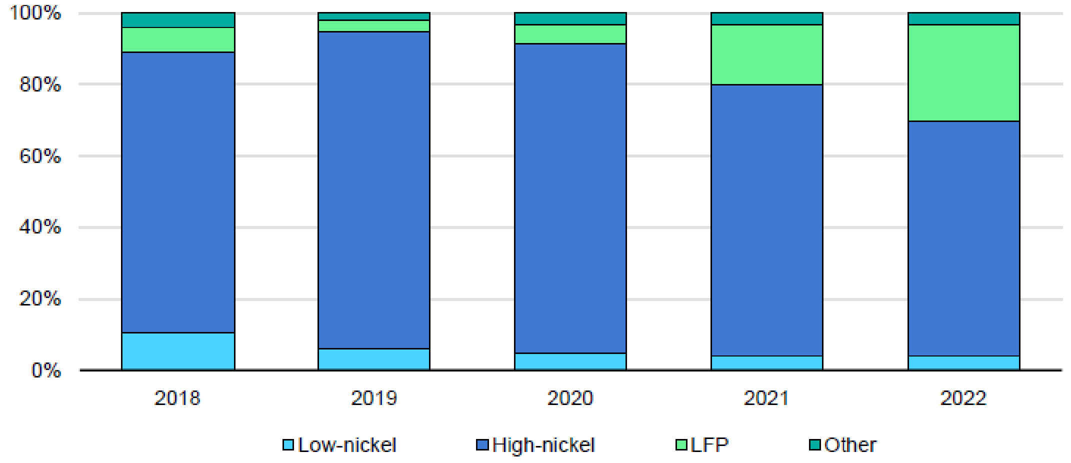
Battery technology developments

Dominant EV battery cathode chemistries 2022



Source: IEA Global EV Outlook 2023

Radar summary of key properties of battery chemistries

	NMC	NCA	LFP
+	High (mass) energy density	High power and energy density	High power density Low cost (high cycle life)
-	High cost CRM Ni, Mn, Co	High cost CRM Ni, Co	Low (mass) energy density CRM Phosphate

Source: Houache 2022

Outlook 2030:

NMC: **High shares of Nickel** / lower shares of Manganese and Cobalt (e.g. NMC532, NMC622, NMC721, NMC811) leave a wide space of design options to find the **optimum between battery performance, lifetime and costs**. **NMC likely to remain dominant in EU**

LFP: dominant technology in China where the 2022 market share of LFP was 61% (Witkamp 2023). Currently there **is no production of LFP-cells in the EU**, but announced by several OEMs.

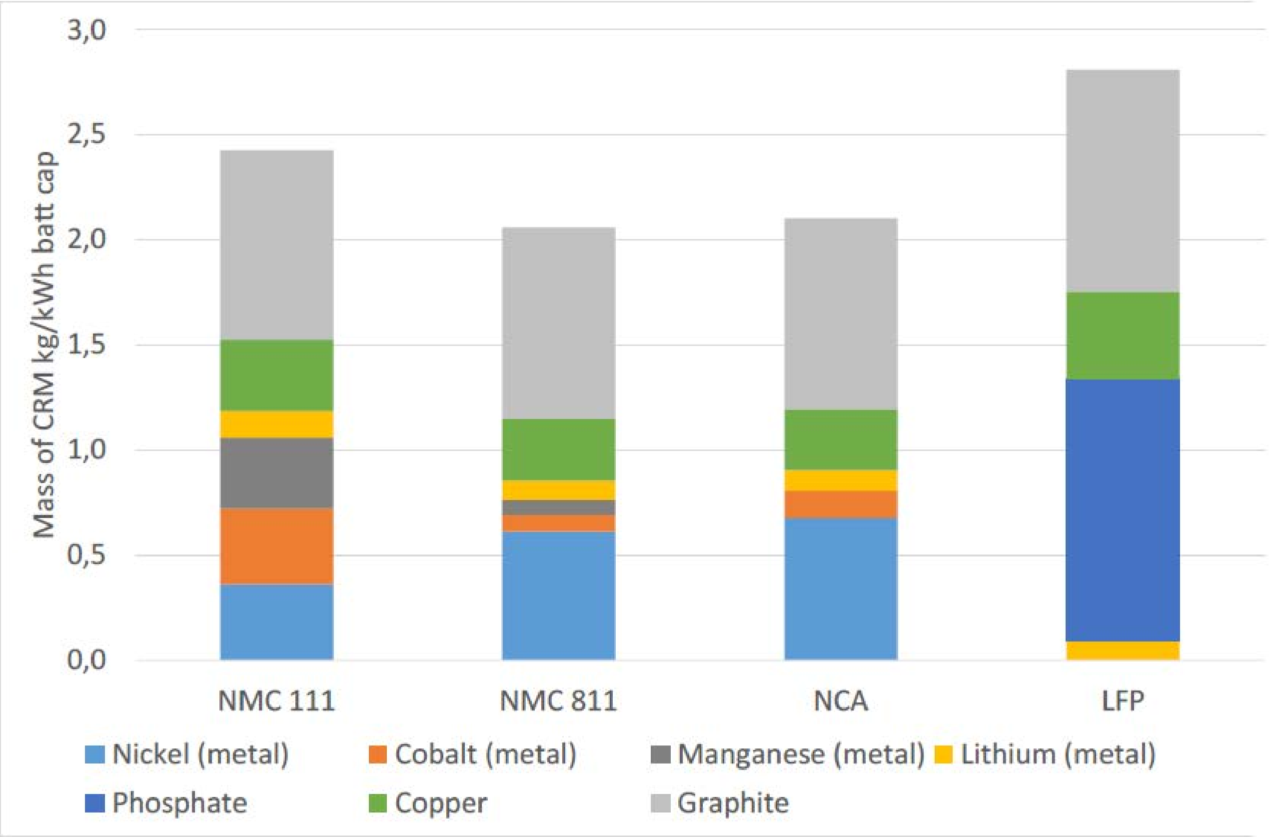
Na-ion: **only post-Lithium-ion** battery technology already being **commercialized today**. Energy density will be slightly lower than that of LFP-chemistries, mainly suitable for storage applications where energy density is not critical. **2030 expected global market share of max 5%** (IEA 2022).

All-solid-state: this development is an enabler also of Lithium metal anodes (which cannot be used with liquid electrolytes) which can result in significant increases in battery energy density compared to current Li-ion batteries with Graphite anodes. Upscaling of production as a challenge. **Not expected to have a significant impact on battery markets before 2030** (IEA 2022).

Critical raw materials for EV batteries

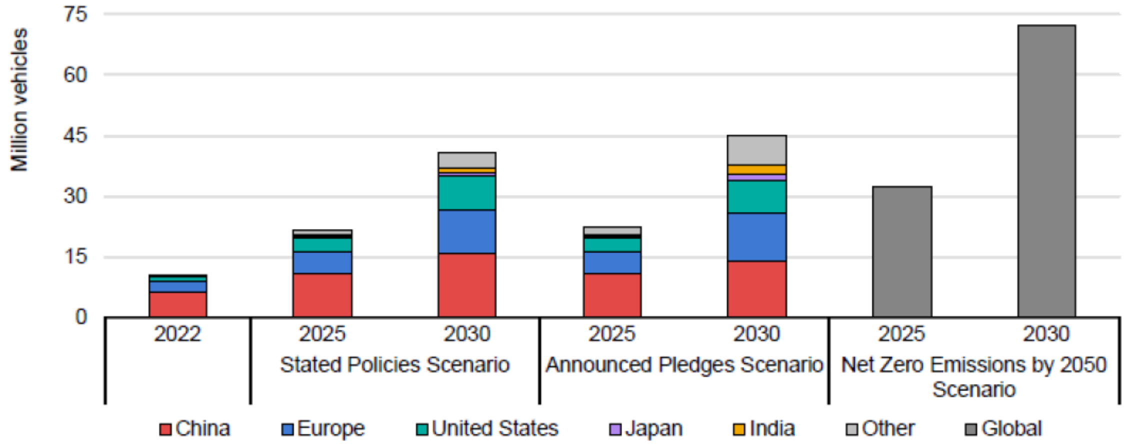
2023 EU-List of Critical Raw Materials CRM in the Critical Raw Materials Act COM(2023) 160			
Antimony	**Copper***	Magnesium	Scandium
Arsenic	Feldspar	**Manganese***	Silicon metal
Aluminium/Bauxite	Fluorspar	**Natural Graphite***	Strontium
Baryte	Gallium	**Nickel – battery grade***	Tantalum
Beryllium	Germanium	Niobium	Titanium metal
Bismuth	Hafnium	Phosphate rock	Tungsten
Boron/borates	Helium	**Phosphorus***	Vanadium
Cobalt*	**Lithium***	Heavy/Light Rare Earth Elements*	Platinum Group Metals Coking Coal

* Relevant EU CRM for EV batteries



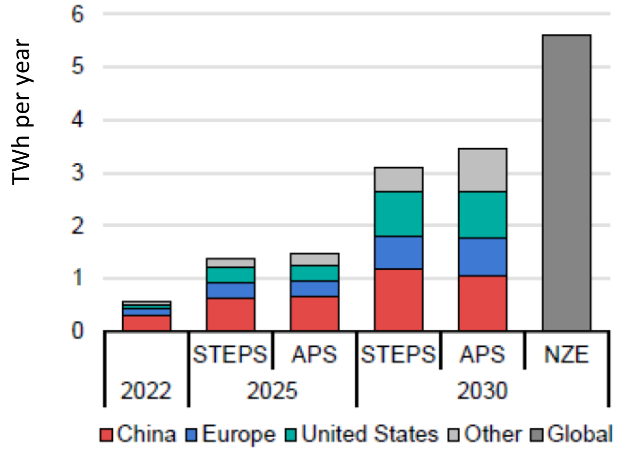
Global battery demand scenarios

IEA scenarios: global EV sales 2030



Source: IEA Global EV Outlook 2023

IEA scenarios: projected global battery demand 2030

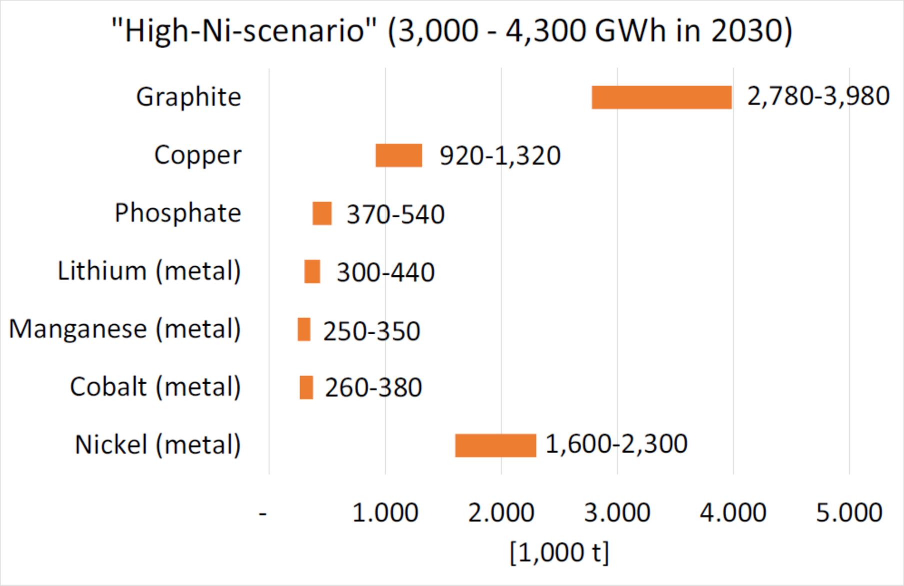


Source: IEA Global EV Outlook 2023

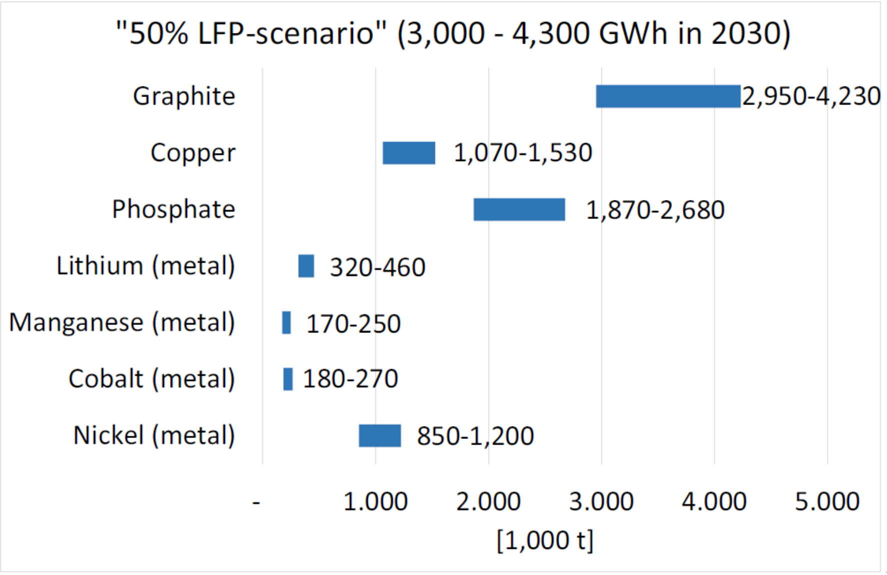
Task 40 scenario 2030

30% YoY growth 2020-2030:
50 million EV sales
3 - 4.3 TWh battery demand
(scenario @ lower end of range)

"High-Nickel": 90% NMC, 10% LFP



"50% LFP": 50% NMC, 50% LFP



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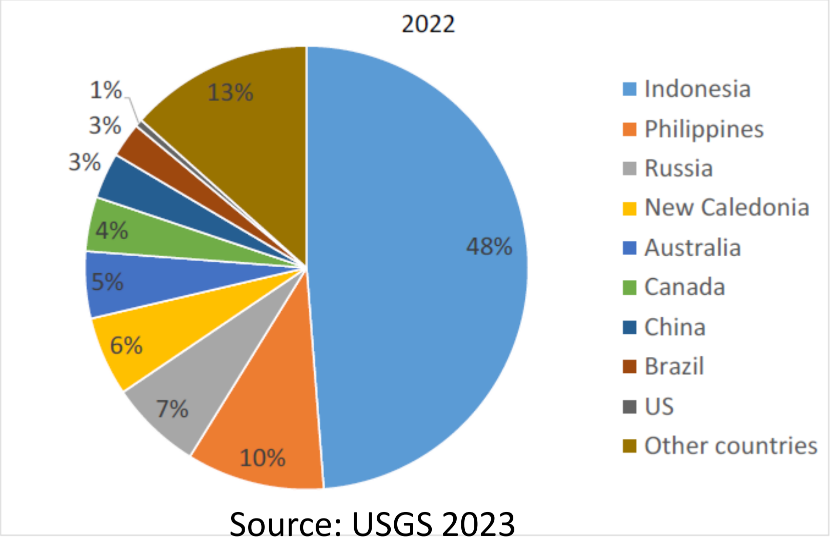
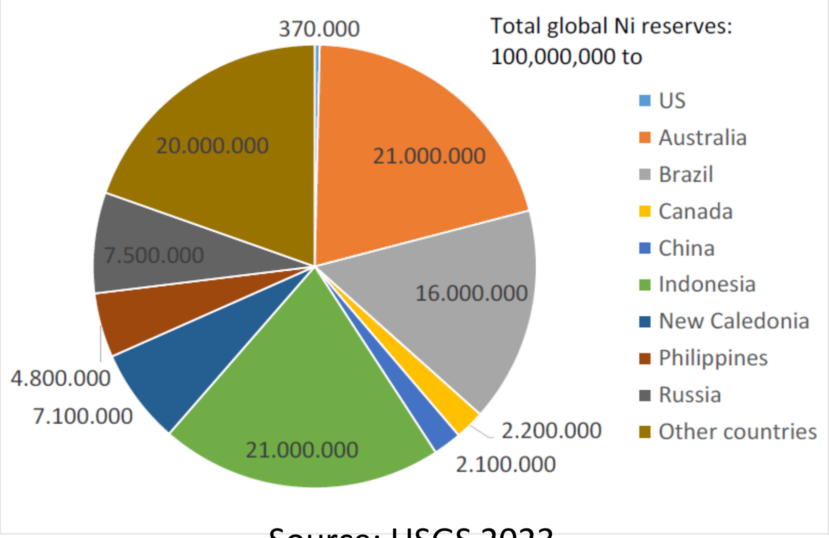
Global material supply scenarios (example Nickel)

Global Ni mining 2022
2.5 Mio tons



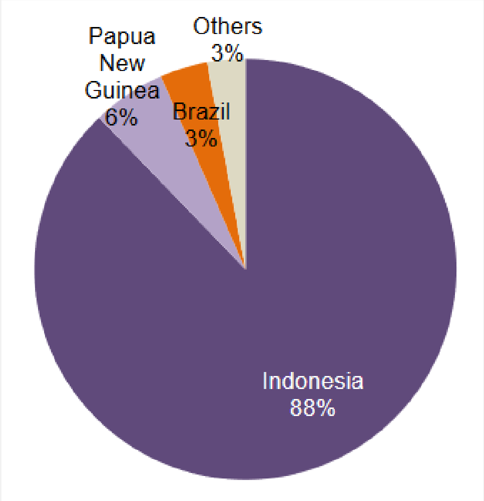
Source: USGS 2023

Global Ni reserves (resources)
100 (600) Mio tons



Source: USGS 2023

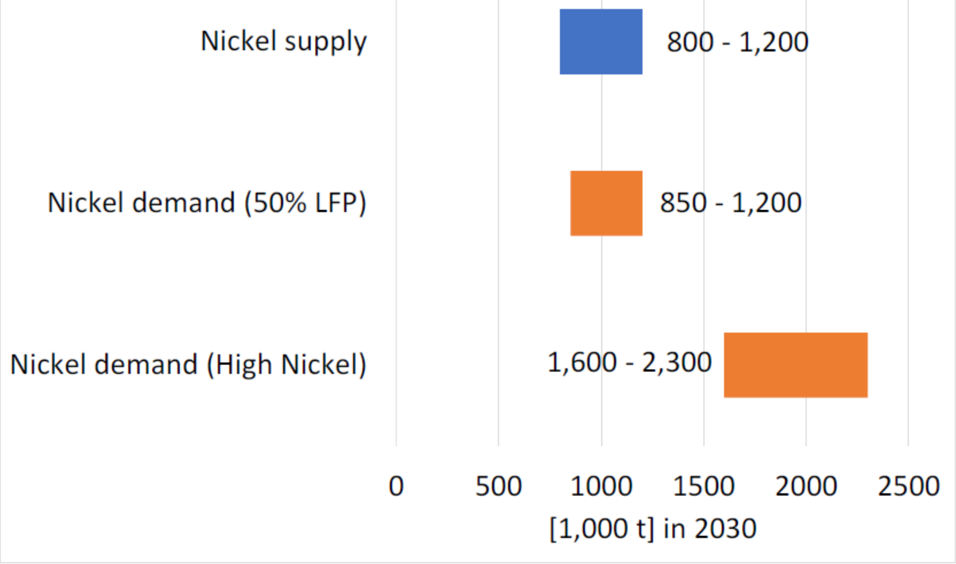
Planned Ni refining projects
2023-2030



Source: IEA 2023

Main driver of Ni (NPI) production is Chinese steel production. Investments into Ni class I (battery-grade) production still low.

Task 40 scenario: battery-grade Ni supply and demand 2030



Task 40 scenario: potential global bottlenecks 2030 in "High-Nickel" scenario

Nickel, Cobalt, Lithium

(REE, Graphite: synthetic alternatives available)

High potential local environmental impacts!

Significant local environmental+social impacts

(surface mines in SE-Asian virgin rainforests)

Increase of coal-related GHG emissions in SE-Asia (+33% 2022)

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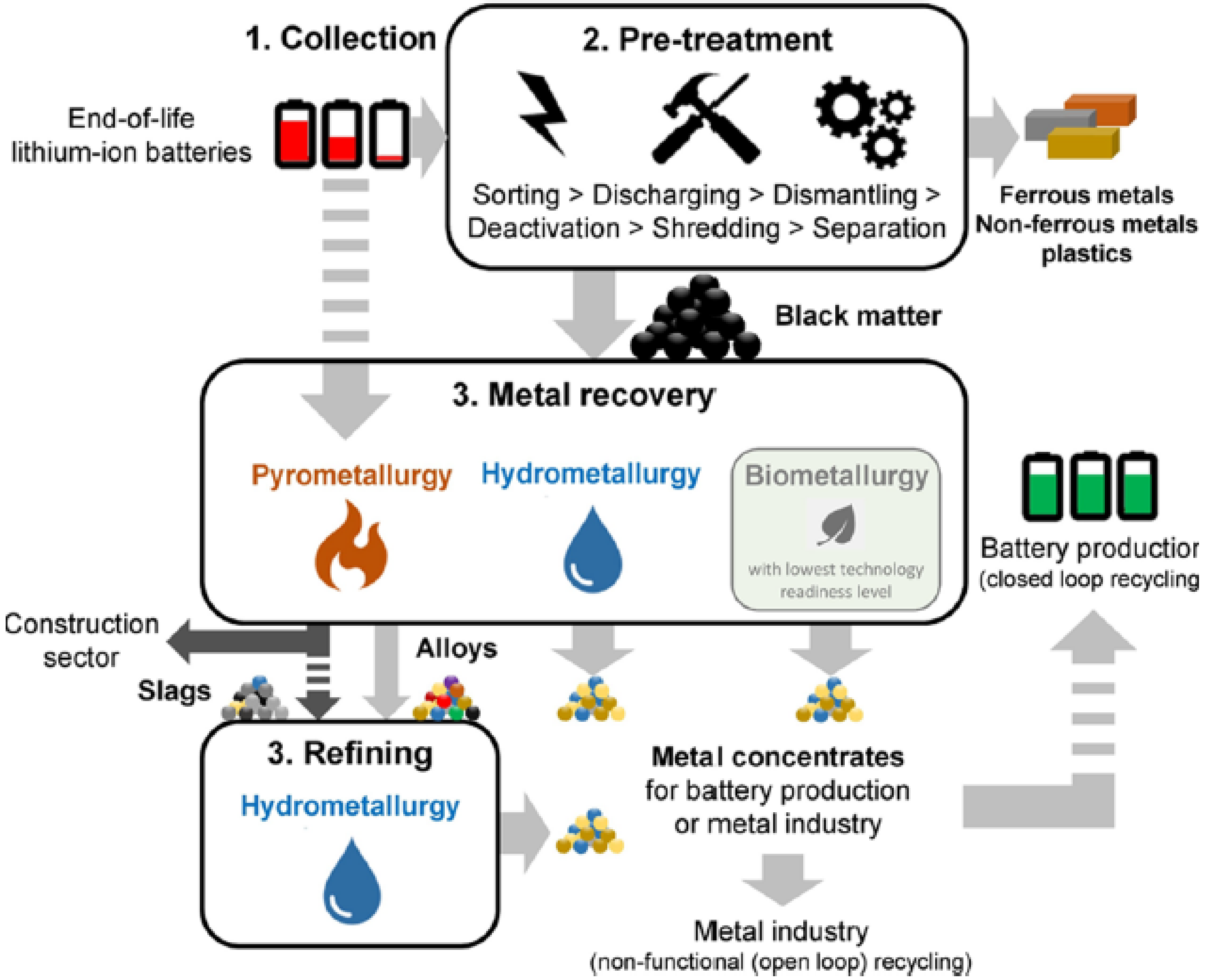
Battery recycling

- **Hydrometallurgy as most likely technology in medium term,** since all metals can be recovered separatly which supports the main purpose of recycling of enabling circular economy to reach EU recycling targets
- Large-scale **NMC-recycling** can be **expected to be in place in 2030** (likely cost-efficient due to critical metals recovered)
- Large-scale **LFP-recycling** can be expected **to be in place later than 2030** (**less cost-efficient** since lithium and copper are the only electrode-metals to be recovered); BUT: new EU-battery directive will require recovery rates for Lithium (50% in 2027, 80% in 2031)
- **Sequence and interplay of processes** depending of input quality and chemistry, required quality of output material as **biggest technical challenge** to reach EU recycling targets



Source: Nigl 2021

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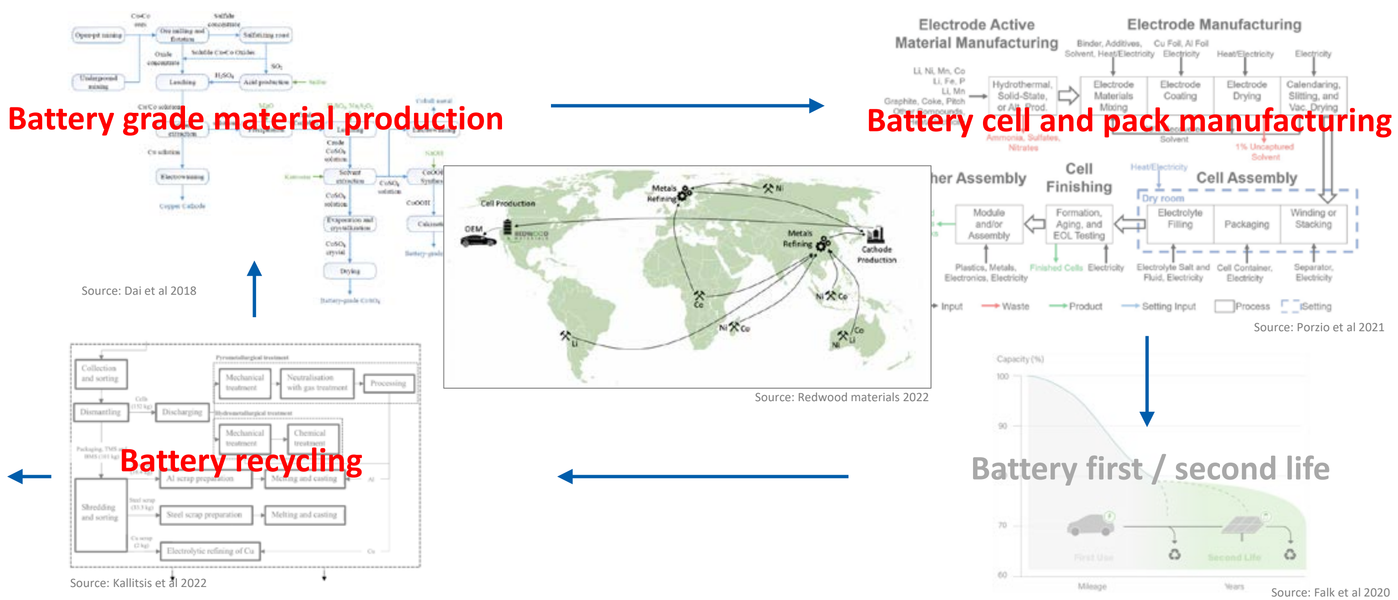
Life Cycle Assessment of battery

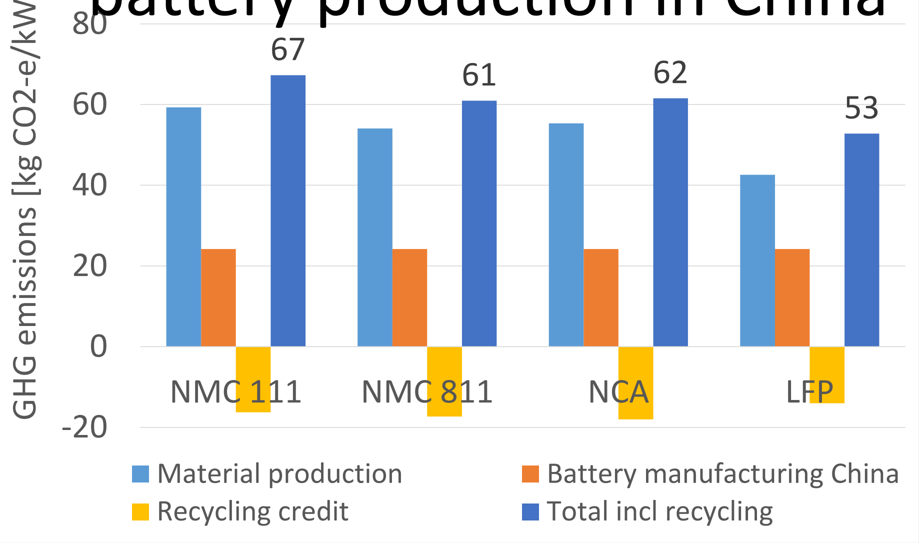


Relevant parameters depend on choice of:

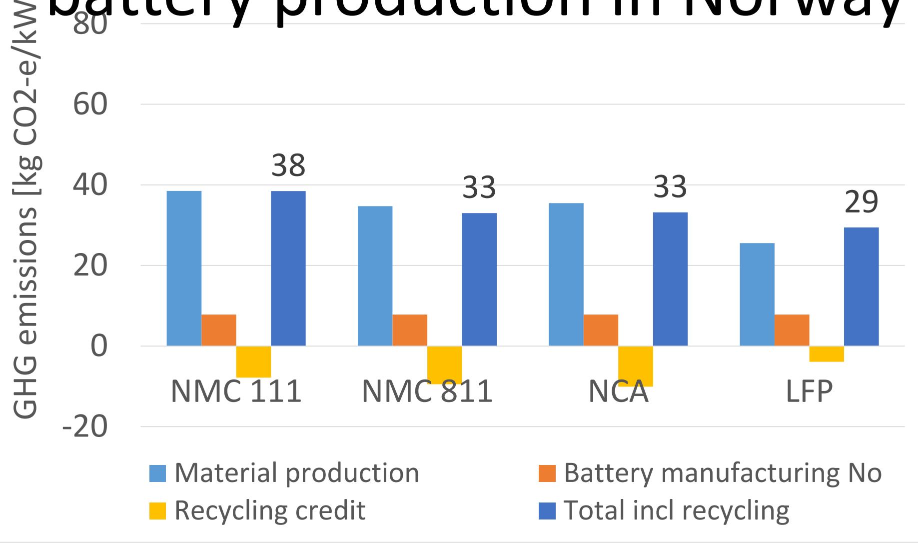
- Battery technology
- Upstream material source and process technologies
- Regional energy mix for material sourcing and battery production

Data sources updated in cooperation with Task partners

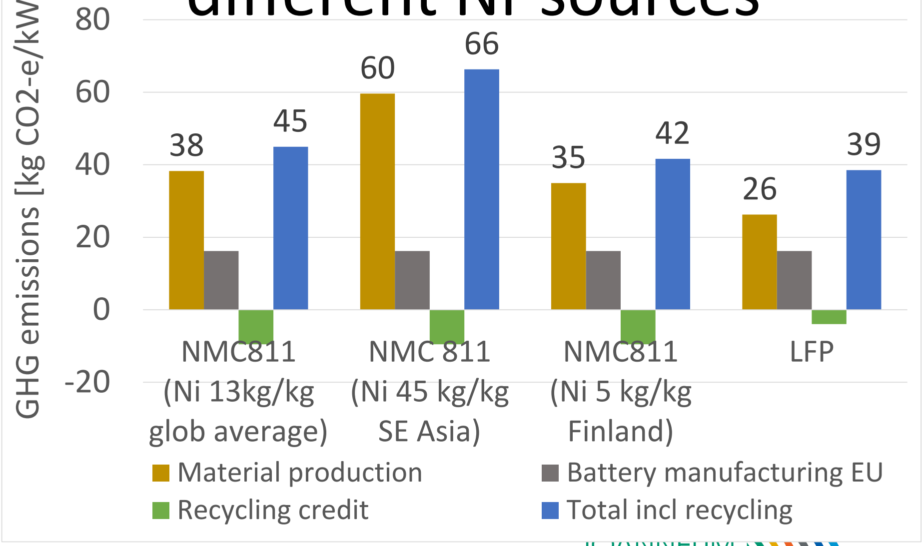
Most material and battery production in China



Most materials from EU and battery production in Norway



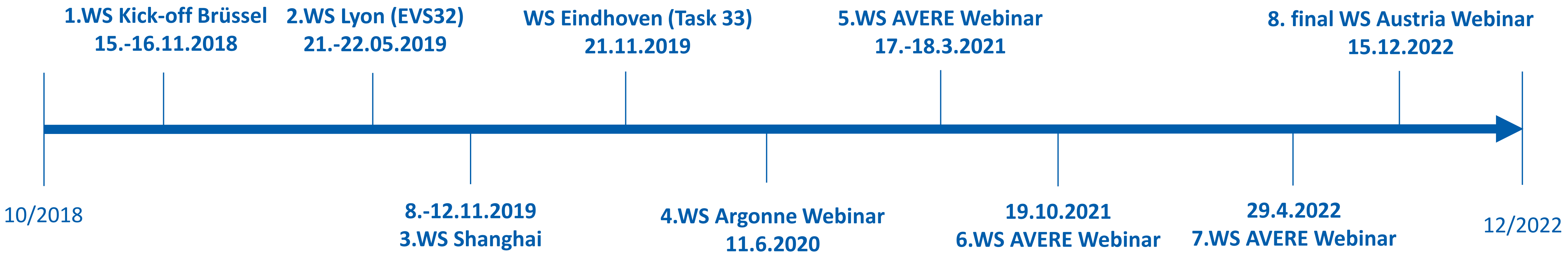
Battery production in EU and different Ni-sources



Recommendations for Austrian and EU research & development

- **Battery recycling**: development of hydrometallurgical technologies combined with battery pretreatment.
  - Only but complex technology, besides direct recycling, to support the development of a closed loop use of battery critical raw materials.
  - Austria has research institutions as well as industries with a profound expertise in metallurgical processes. Austria has a strong position in plant engineering both in the metal industry and the waste recycling branch.
- **Battery research**: development of sodium-ion technology and other technologies with reduced or zero demand in critical raw materials
  - Reduced risk of supply deficits and geopolitical dependencies
  - Due to chemical and physical material properties, Na-ion comes along with reduced energy capacities compared to “close-to-ideal” materials. Research focus on new combinations of cathode / anode / electrolyte materials
- **Battery Life Cycle Assessment:** dynamic modeling, circularity assessment
  - Model the dynamics of the transition of global economics towards climate neutral transport and production systems within the short timeframe of 20 to 30 years.
  - A second research area is to further develop the LCA method to integrate the assessment of circularity to better assess the circularity potential of products and services.

Dissemination



- Final Task 40 report by Joanneum Research currently under review by FFG, publication expected in 2023
- International Task 40 report available on https://ieahev.org/tasks/40/

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Thank you for your attention!

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