Metalot Meet - 10 maart 2021

Introduction to the recycling of used EV batteries

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Rechargeable batteries differ in size, shape, chemical composition

Type of battery		Application	Energy Wh/kg	Power W/kg
Conventional lead acid battery	Pb-acid 0,4-3 KWh	Cars (light/start)	-	-
Nickel cadmium battery	NiCd -0,2 KWh	Electric appliances -	+/-	+
Nickel Metal Hydride battery	NiMH -10 KWh	Electric appliances, phones Bicycles, light applications E-vehicles	+	+
Li-cobalt Li-nickel-cobalt Li-nickel-aluminium Li-nickel-manganese-cobalt Li-iron-phosphate Solid state	Li-ion - 100^{+} KWH	Electric, appliances, phones Bicycles, light applications E-vehicles Traction	++	++

Passenger and commercial EV's will be the major part of Global demand for Lithium-ion batteries

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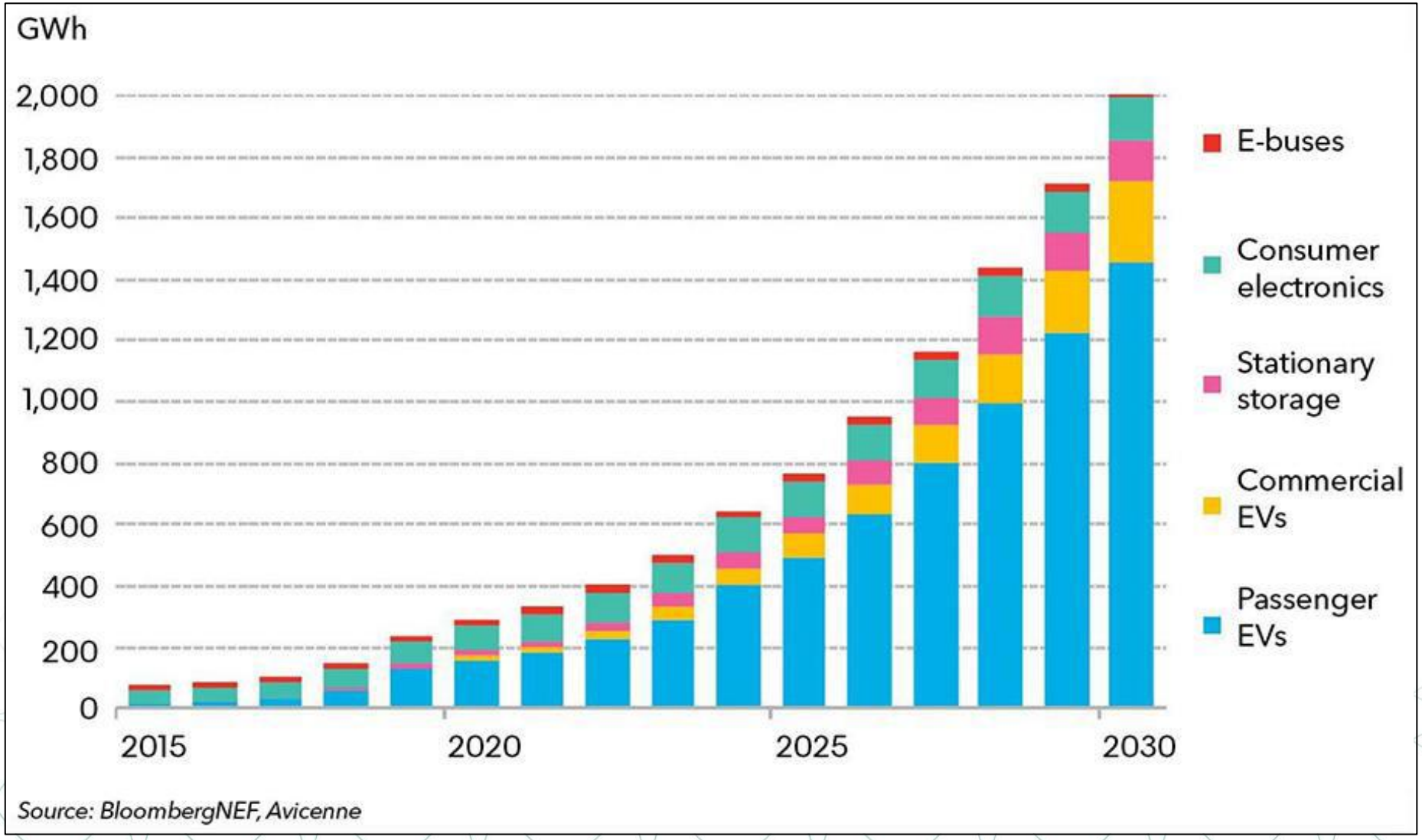

Variety of metal elements and compounds used in Li-ion batteries

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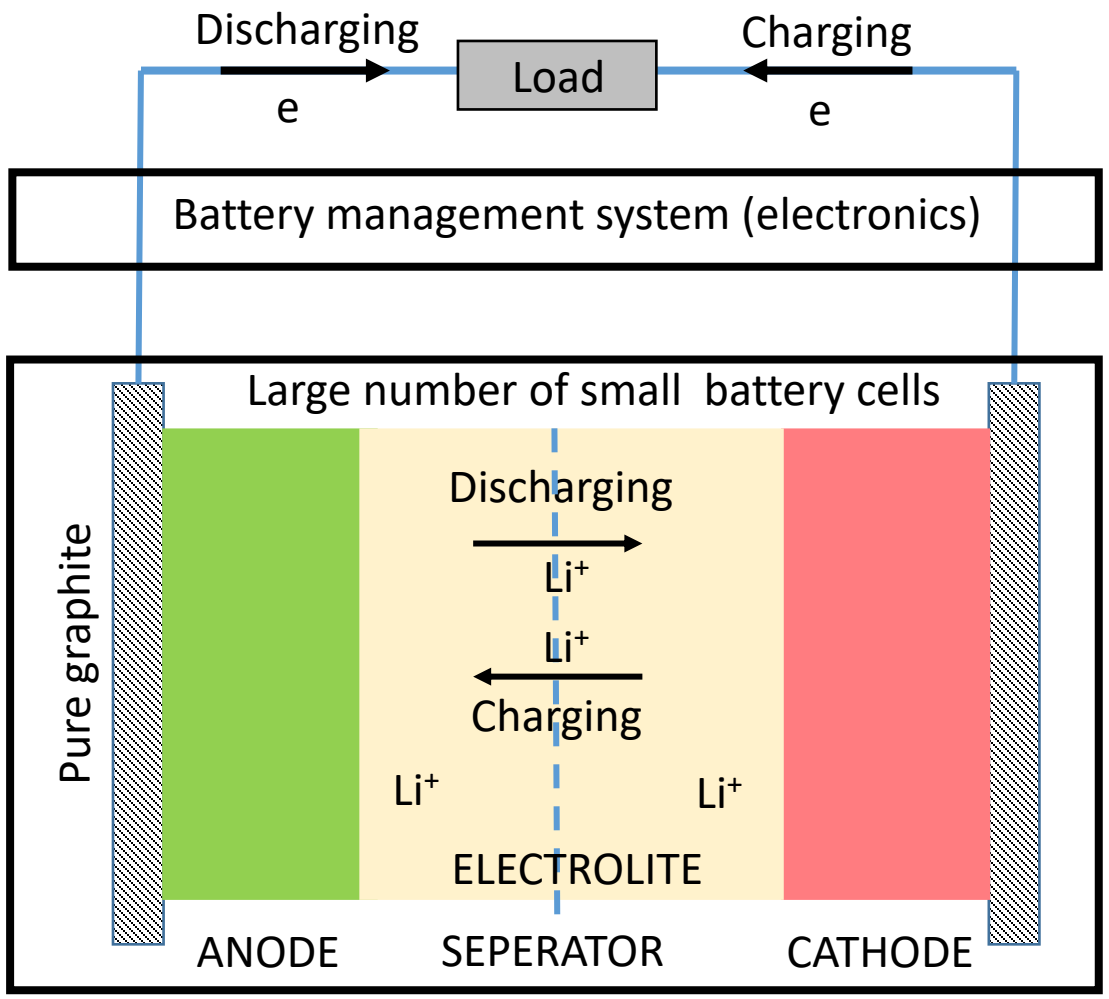

Battery materials

Cathode:
Cobalt (CO)
Lithium (Li)
Nickel (Ni)
Manganese (Mn)
Aluminium (Al)

Oxides

Anode:
Graphite

Casing and connections
Iron (Fe)
Aluminium (Al)
Copper (Cu)
Plastics

Battery management system
Electronic scrap

Composition is different for each type of Li-ion battery

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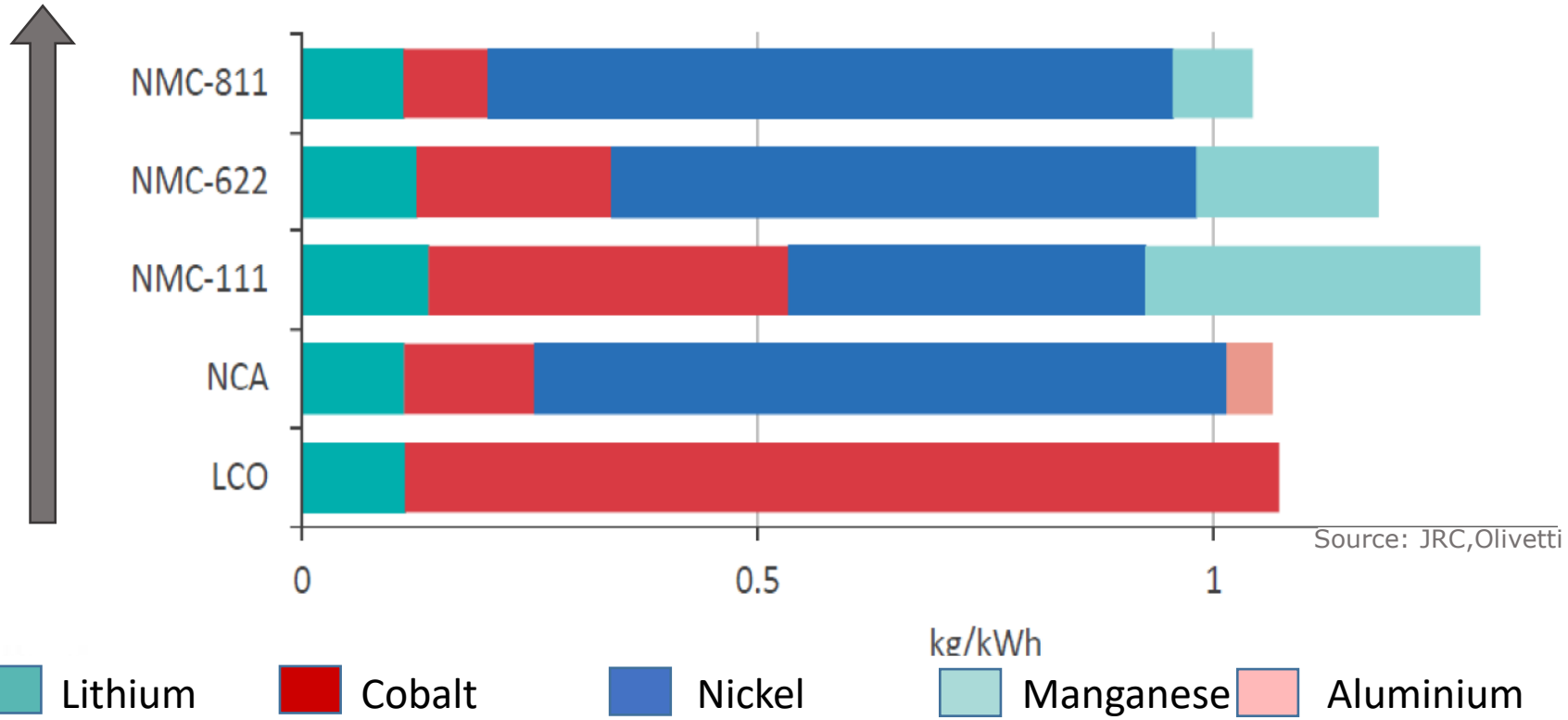
Future technolgies/compositions ???



Uncertainty of the development of Lithium Iron Phosphate batteries ($LiFePO_4$)? Re: Tesla announcement

Nickel becoming major metal element in lithium-ion batteries by 2030

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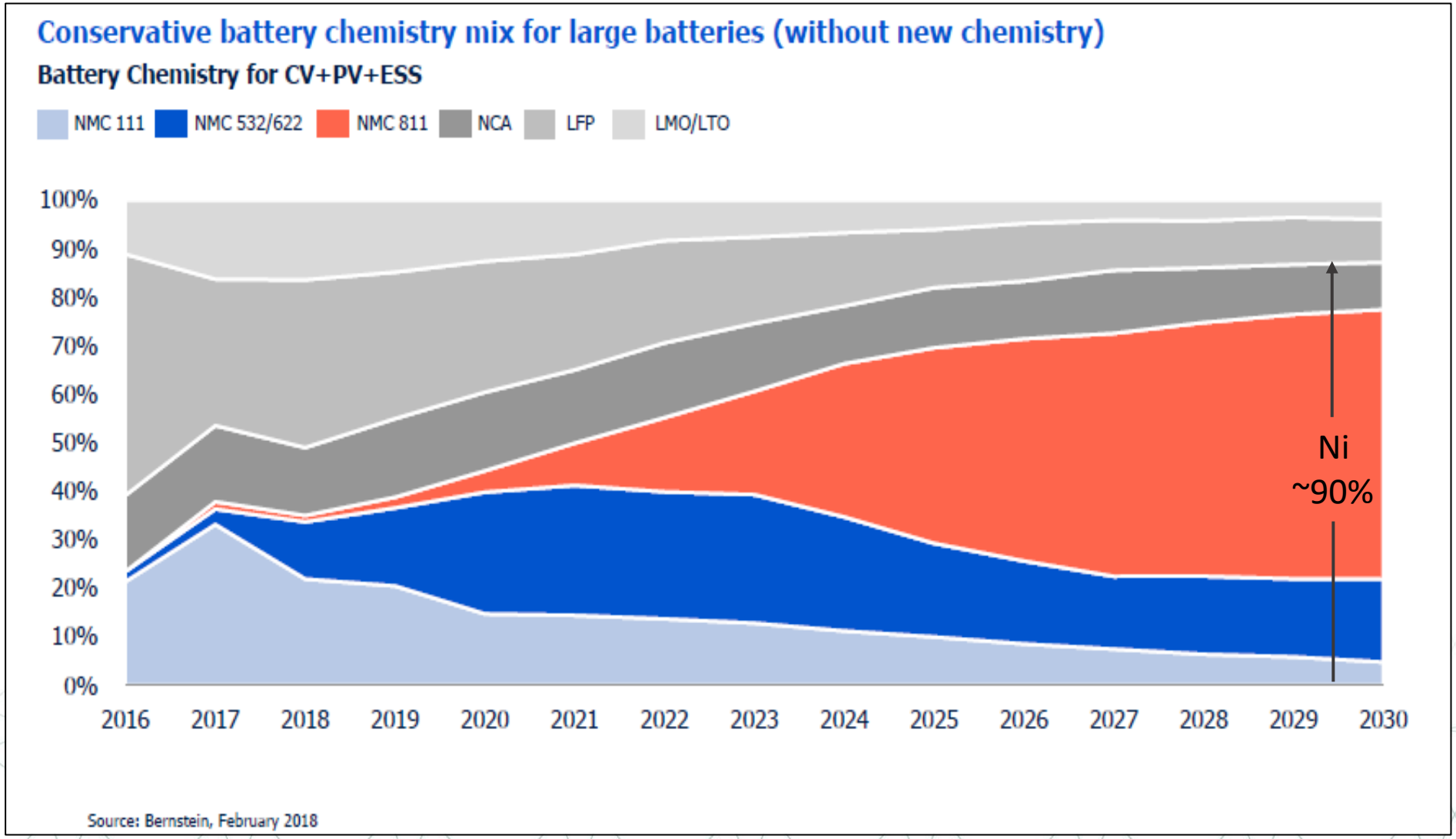
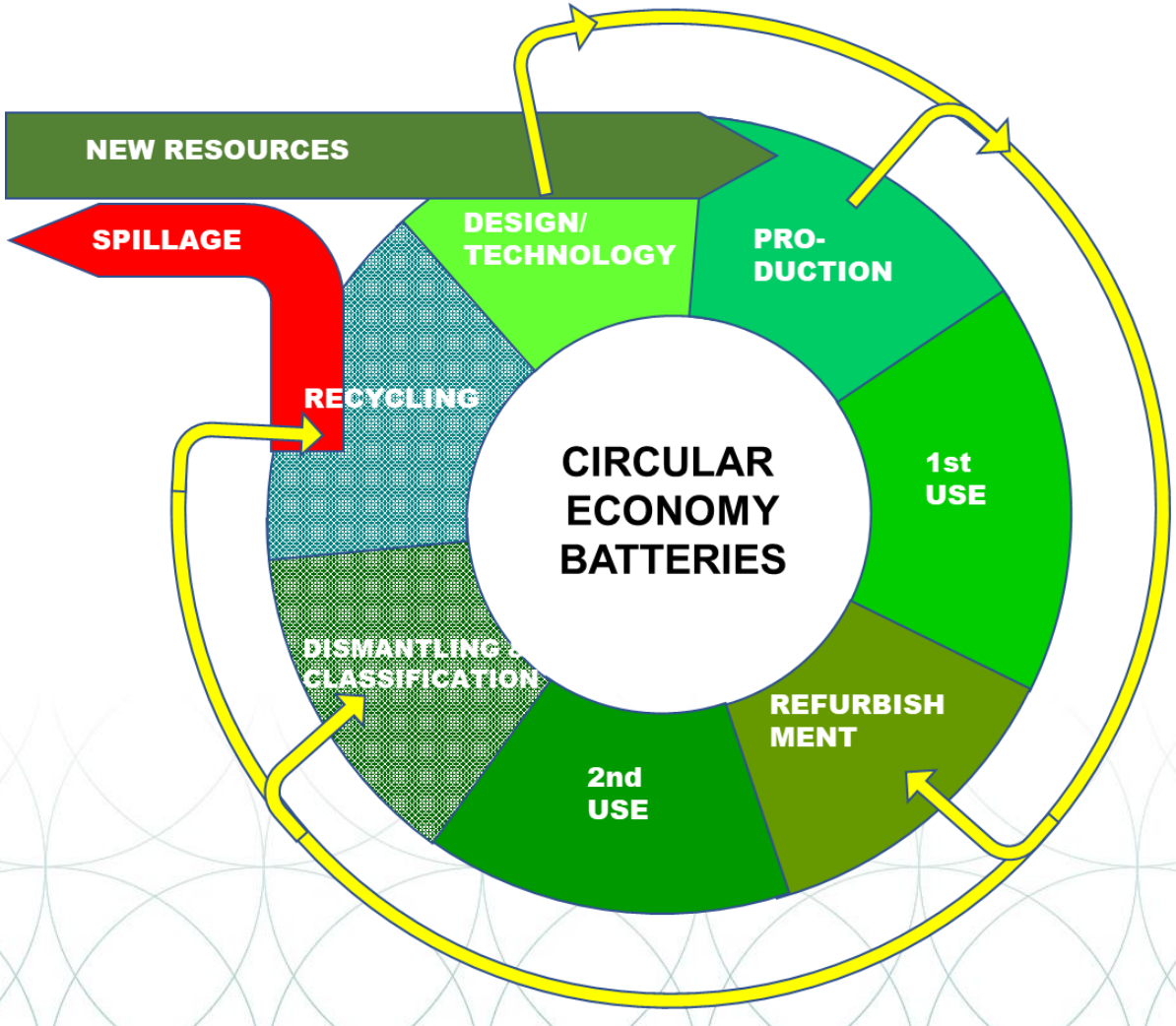


Recovery of battery materials closes the life cycle of (EV) batteries

Current developments are focused on improved battery performance, cost reduction and new battery concepts, while recovery and reuse of materials does not get the required attention:

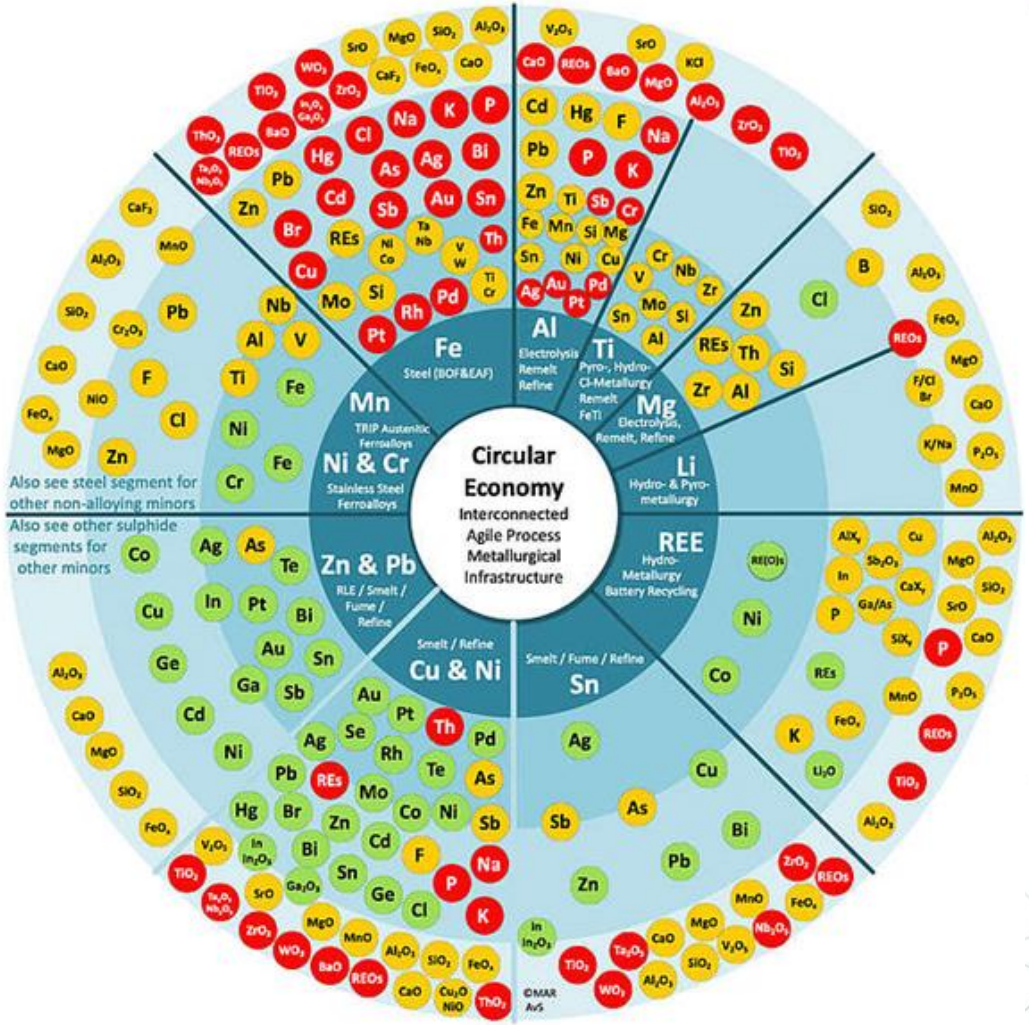
- 2nd life use and end-of-life battery recycling to become an integral part of battery design and production.
- Recycling infrastructure:
  - Collection and dismantling system for battery packs;
  - Crushing/separation methods
  - Recovery processes for metals and plastics.
- Supply chain study for handling end-of-life battery packs from collection to metal recovery in the Netherlands.



Recovery of metals need dedicates metallurgical processes

Recovery of high quality metals, compounds and alloys needs dedicated metallurgical processes.

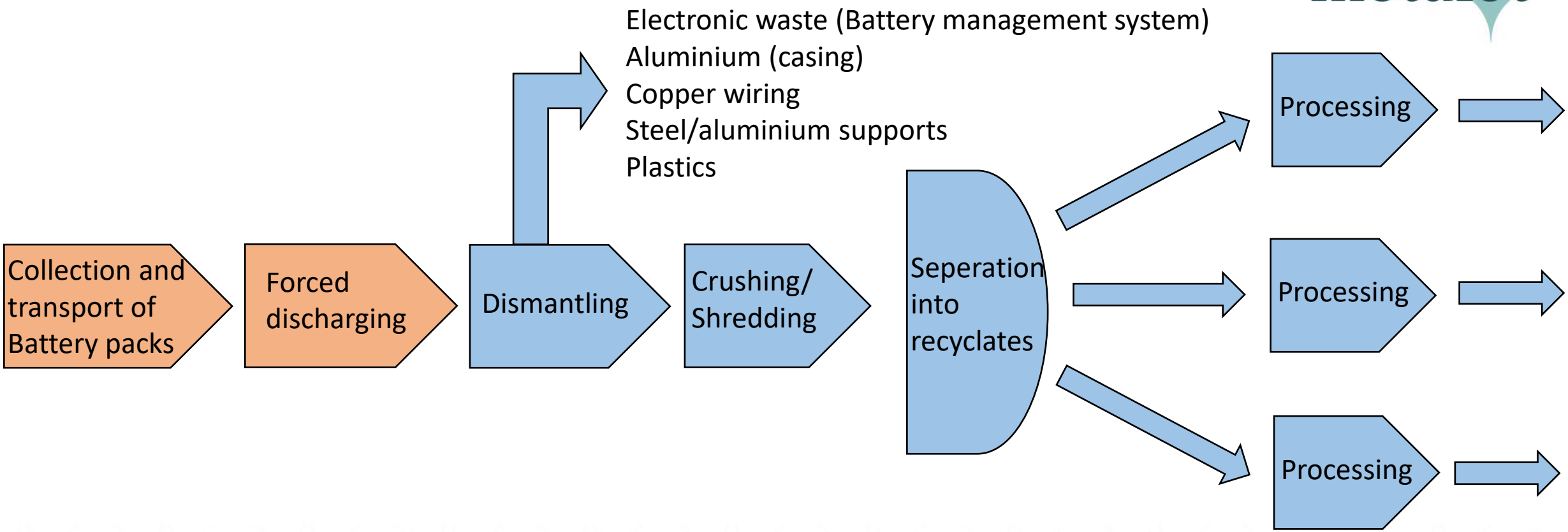
- Each metallurgical process can only recover a specific elements, compounds or alloys. (see segments of the “metal wheel”)
- Therefor batteries need to be collected by type and compositions to avoid mixing of elements. Mixing leads to loss or degradation of quality of valuable elements, compounds and alloys.
- Battery scrap needs to be separated in recyclates before processing. Metals and metal oxides (and pastics) are recovered from these recyclates by processing with dedicates metallurgical processes.



“Metal wheel”- The engine of the Circular economy

Source: Von der Utopie einer Kreislaufwirtschaft - Interview mit Prof. Dr. Markus Reuter, Direktor am Helmholtz-Institut Freiberg

Schematic infrastructure for the recycling of end-of-life batteries



Risks:

- Short cut
- Fire
- Explosion
- Toxic fumes

Separation in recyclates and recovery of materials:

- Ferro/non ferro metals
- Graphite,
- Plastics,
- Etc.

Challenges for the recycling industry

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- **Strong demand of EV batteries will lead to a growing number of used batteries after 2030.**
  - Based on the annual sales number of cars/trucks in the Netherlands the recycling volume of battery materials will grow to >100-150 kton/a after 2030 (EU: > 2,000 kton/a)

- **Drive for better performance and lower cost will lead to ongoing development of new battery design and material compositions.**
  - (Unknown) changes in future composition of the recycling mix.
  - Significant investments needed for the development and installation of new recycling technologies
  - Use of less valuable metals used in future batteries will challenge the economics of a healthy recycling industry.

- **Climate change and environmental regulation (CO2, and NOX) demands for improvement of conventional metallurgical processes or development of new processes.**

- **Safety aspects like fire, explosions and toxic fumes need to be managed during collection, transport and disassembly of battery packs.**

- **Alignment of EU regulation is needed for cooperation between the industry and allow cross border solutions for the treatment of recyclates.**

Recycling of end-of-life batteries in the Netherlands

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Development of an infrastructure for the recycling of end-of-life EV batteries and recovery of metals and plastics:

- **Safe system for the collection of batteries from the market**
  - Collection of batteries by type/composition
  - Logistics for a safe collection and transportation system
  - Facility for fully discharging battery packs and dismantling them into: cells; battery management system; casings, supports, and connectors.
- **Crushing and physical separation techniques** to split the scrap from battery cells into recylates**.**
- **New or improved metallurgical processes** for the recovery of plastics, metals and metal compounds from the recyclates, that comply with the EU regulation for climate change and environmental emissions. (energy consumption, CO2 and NOX emissions).
  - Avoid metallurgical lock-up, loss of metal elements, or degradation of quality.
- **Healthy business model for the full battery recycling chain** considering the reduced value of metals
  - Optimised logistics
  - Co-operation between national and EU industry.
  - Consider legislative issues that hamper effective recycling and treatment of cross border recyclates
  - Indicate business opportunities for the Dutch industry

Safety risk Li-ion batteries

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FEDEX crash caused by Li-ion batteries catching fire during transport

Tesla model S fire in Norway

Samsung Galaxy note 7 fire

Thank you for your attention