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# High Nickel NMC Cathode Materials for xEV: What is the price to pay?

**20/05/2019, EVS 32 Lyon, France**

# Legislation triggered electrification

## And car OEMs embrace electrification

> BMW Group announces next step in electrification strategy

25/07/2017

> Volkswagen Group to expand production of electric vehicles worldwide on a massive scale

13/03/2018

> Hyundai Motor Group Reveals Next-Generation Powertrain Strategy

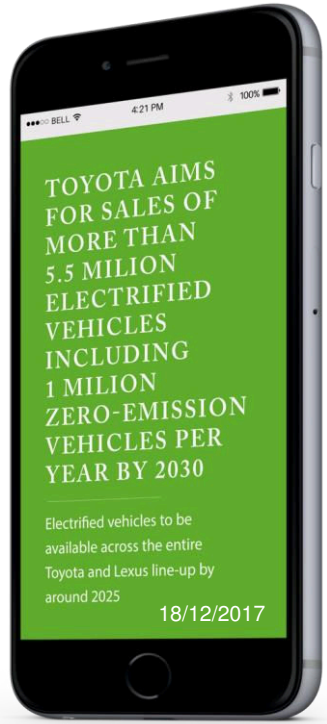
28/10/2017

> VOLVO CARS TO GO ALL ELECTRIC

05/07/2017

> GM Outlines All-Electric Path to Zero Emissions

02/10/2017



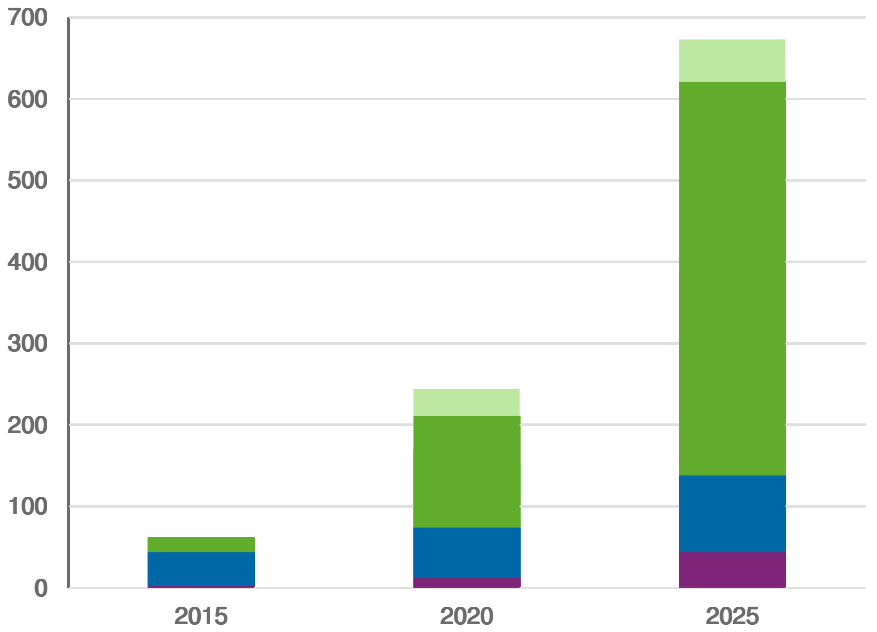

CAR OEMS' PRESS RELEASES

# Market projections

**Electrification**
Regulatory driver

**Portables**
Societal driver

**Energy Storage System**
Regulatory driver




RECHARGEABLE BATTERY MARKET (GWH)

- Heavy Duty Vehicles
- Electrification Current Scenario
- Portables
- ESS

Source: Avicenne, Navigant, Roland Berger, AABC, IHS, Gartner, SNR, CRU, Roskill

# Critical material needs

## Filling the pipeline in coming decade

### Market acceleration

150GWh ca. 500GWh

### Cathode materials

300 Kmt ca. 850Kmt

### Current Supply – Future Demand

| | | | |
|---|---|---|---|
| Li | 250Kmt | 375Kmt | >1.000Kmt |
| Ni | 2.000Kmt | 300Kmt | >1.100Kmt |
| Co | 120Kmt | 90Kmt | >120Kmt |

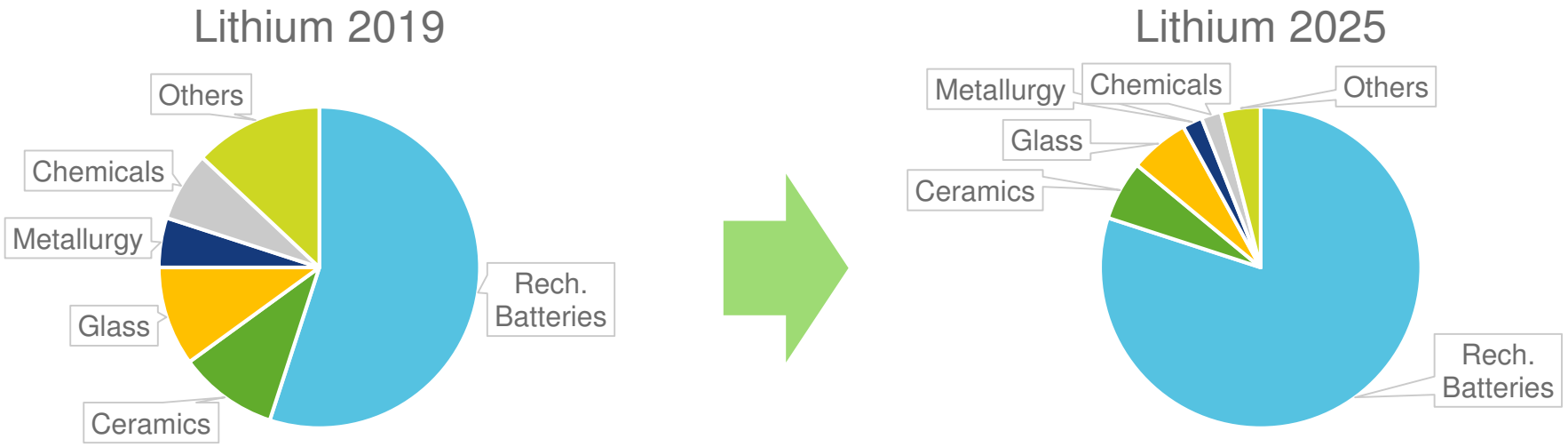
### Metals per car

| | | | |
|---|---|---|---|
| Li | 35kg | = | 40kg |
| Ni | 25kg | ↗ | 50kg |
| Co | 12kg | ↘ | 5kg |

● Now ● 2025 ● 2030

# Lithium market snapshot

## Demand side development



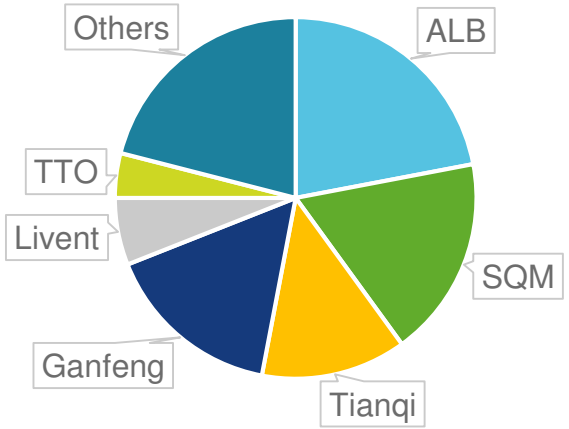

Rechargeable battery application has become the most important use of Lithium and in next decade this will lead to the single dominant application

Substitution in other segments is and will stay limited

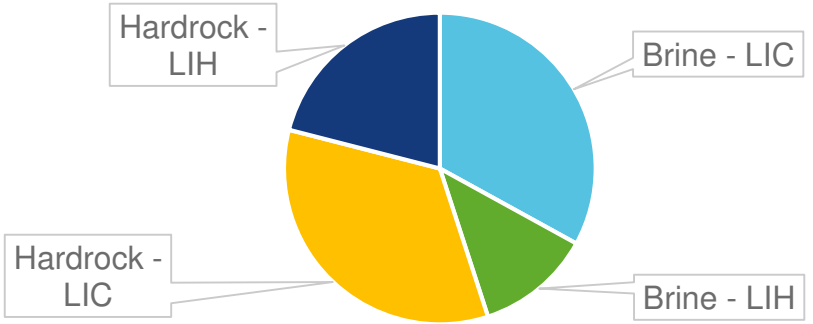
# Lithium market snapshot

## Supply side development

### Supplier Landscape




### Brine vs Hardrock LIC or LIH



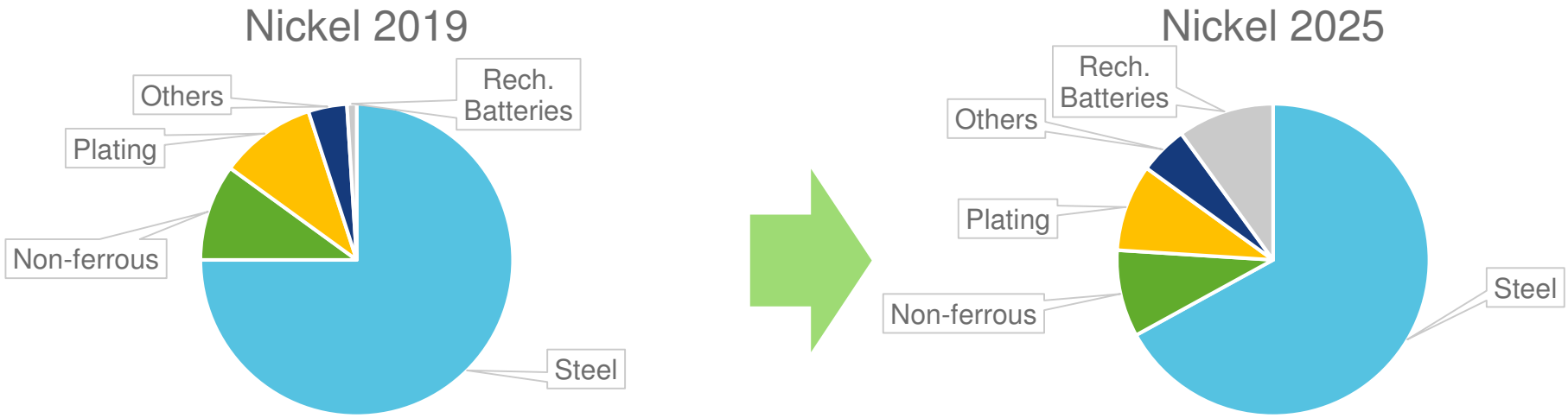

Limited number of suppliers, challenged by big number of ‘juniors’

Very different sources and flows with distinctly different cost basis and time-to-market

Battery application is more exposed to Hardrock flow (agility)

# Nickel market snapshot

## Demand side development

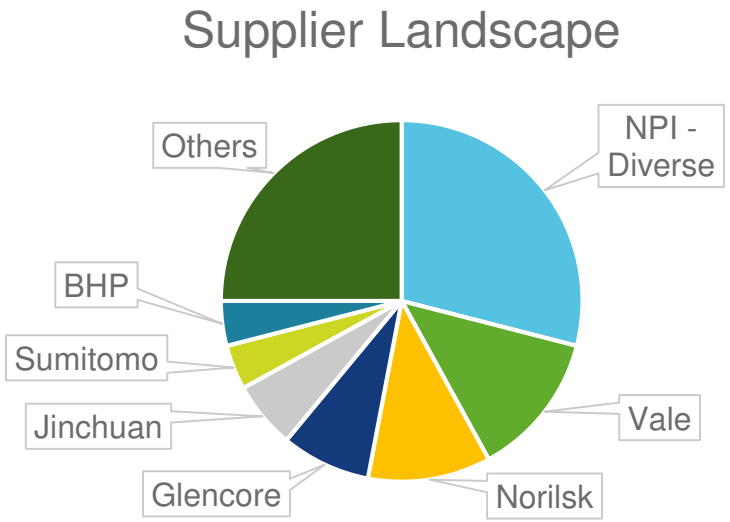


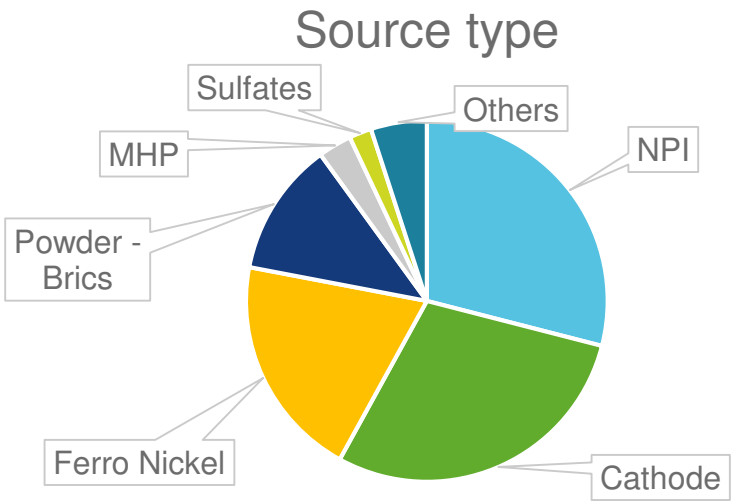

Global Nickel market demand is dominated by (stainless) steel applications

Battery applications require Class-A purity which is currently a small segment

# Nickel market snapshot

## Supply side development



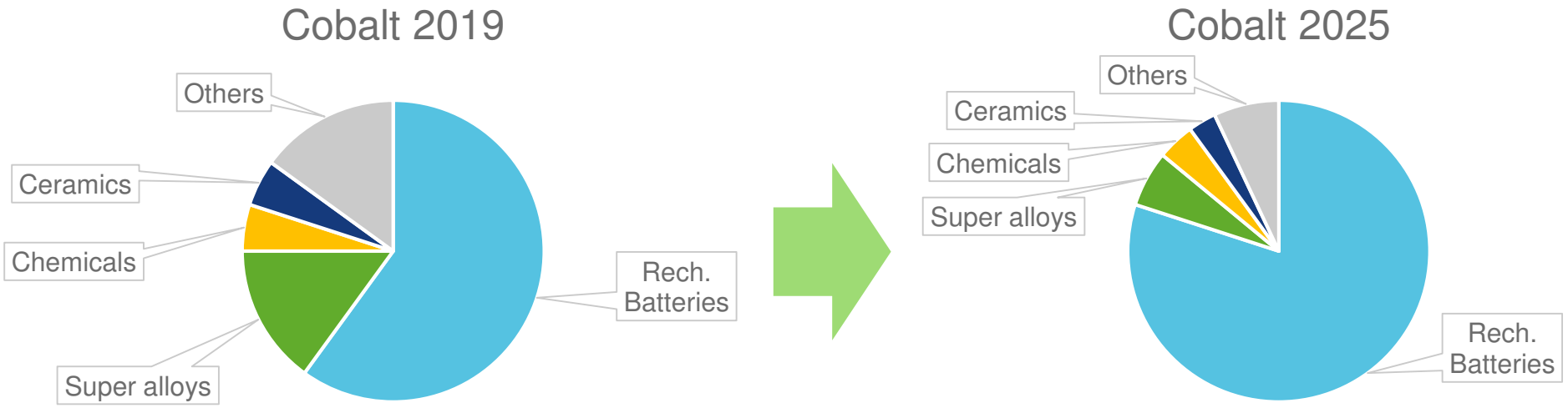




Limited number of historical suppliers, and limited investments at current price level

Very small fraction suitable for battery application

# Cobalt market snapshot

## Demand side development



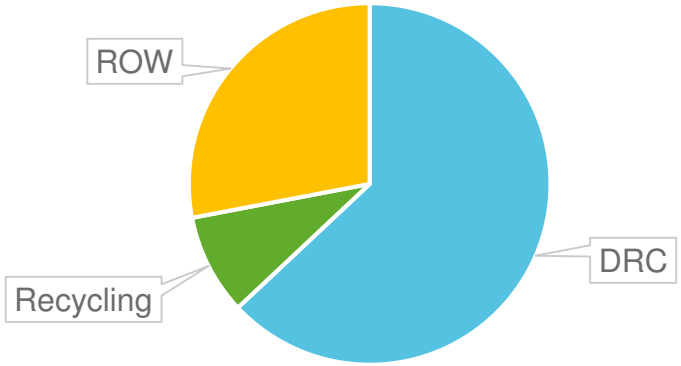

Rechargeable batteries remain by far the main application for cobalt

Total demand growth however modulated due to lower fraction of cobalt in cathode materials

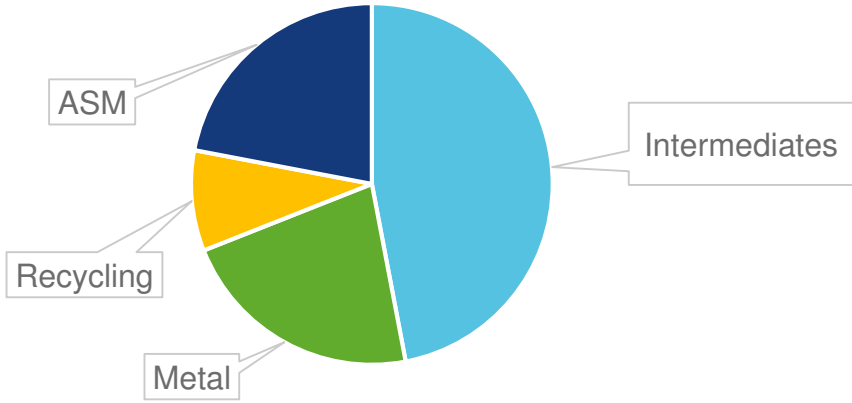
# Cobalt market snapshot

## Supply side development

### Source origin




### Source type




Strong exposure to DRC will remain with pricing supporting Artisanal Scale Mining

Supply increases will come to market as intermediates

Recycling fraction (ca. 10%) expected to grow in coming decade

# Critical material price impact on NMC

| | Li (Lithium) | Ni (Nickel) | Co (Cobalt) | | |
|---|---|---|---|---|---|
| 10yr Low | 4$/kg LCE | 8$/kg Ni | 16$/kg | Total | |
| NMC111 | 3 | 3 | 5 | 11 | $/kWh |
| NMC622 | 2.5 | 4.5 | 3 | 10 | $/kWh |
| NMC811 | 2.5 | 6 | 1.5 | 10 | $/kWh |
| 10yr High | 25$/kg LCE | 45$/kg | 100$/kg | | |
| NMC111 | 18 | 15 | 34 | 67 | $/kWh |
| NMC622 | 16.5 | 25.5 | 19 | 61 | $/kWh |
| NMC811 | 16 | 32 | 9 | 57 | $/kWh |

# Sustainable metal price levels

- Hardrock flow needed
- LiOH use increasing
- Structured supplier landscape

12$/kg LCE

- New mining projects
- HPAL successful
- Increasing Ni in NMC

25$/kg Ni

- DRC status quo
- New copper projects
- Decreasing Co in NMC

30$/kg Co

($/kWh)

| | |
|---|---|
| **NMC111** | **27** |
| **NMC532** | **26** |
| **NMC622** | **29** |
| **NMC811** | **28** |

# Powering ahead

## BMW Group, Northvolt and Umicore join forces to develop sustainable life cycle loop for batteries

Munich/Stockholm/Brussels

The BMW Group, Northvolt and Umicore have formed a joint technology consortium in order to work closely together on the continued development of a complete and sustainable value chain for battery cells for electrified vehicles in Europe. The project is seeking to press ahead with the sustainable industrialisation of battery cells in Europe and the associated acquisition of skills, from cell chemistry and development through to

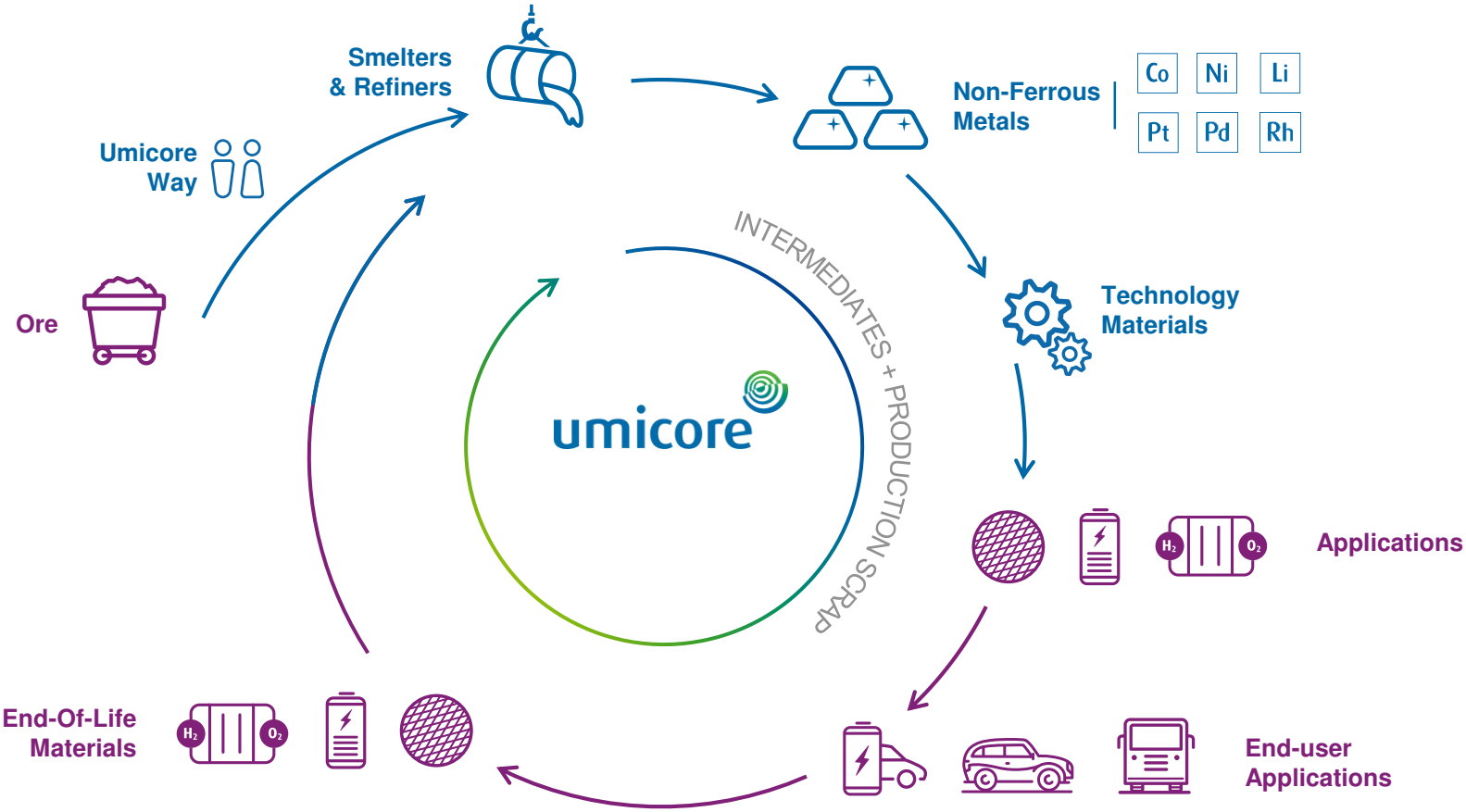
26 October 2018

## New power from old cells: Audi and Umicore develop closed loop battery recycling

- Car manufacturer and materials technology and recycling group test a closed loop for high-voltage car batteries
- 95 percent of valuable battery materials can be recycled
- The partners are developing a raw materials bank concept for these recovered raw materials

**Ingolstadt, October 26, 2018 – Milestone reached: Audi and Umicore have successfully completed phase one of their strategic research cooperation for battery recycling. The two partners are developing a closed loop for components of**

# Mass electrification will require clean, dense and integrated supply chains



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