

China's key materials strategy & ecosystem impact on EV battery industry

Industry Recommendations





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Theme

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Presentation

Methodology and
Executive Summary on Trends

Trends with Facts and Data

Materials, Actors and Ecosystem:
Value Chain &
Implications for Renault



Theme

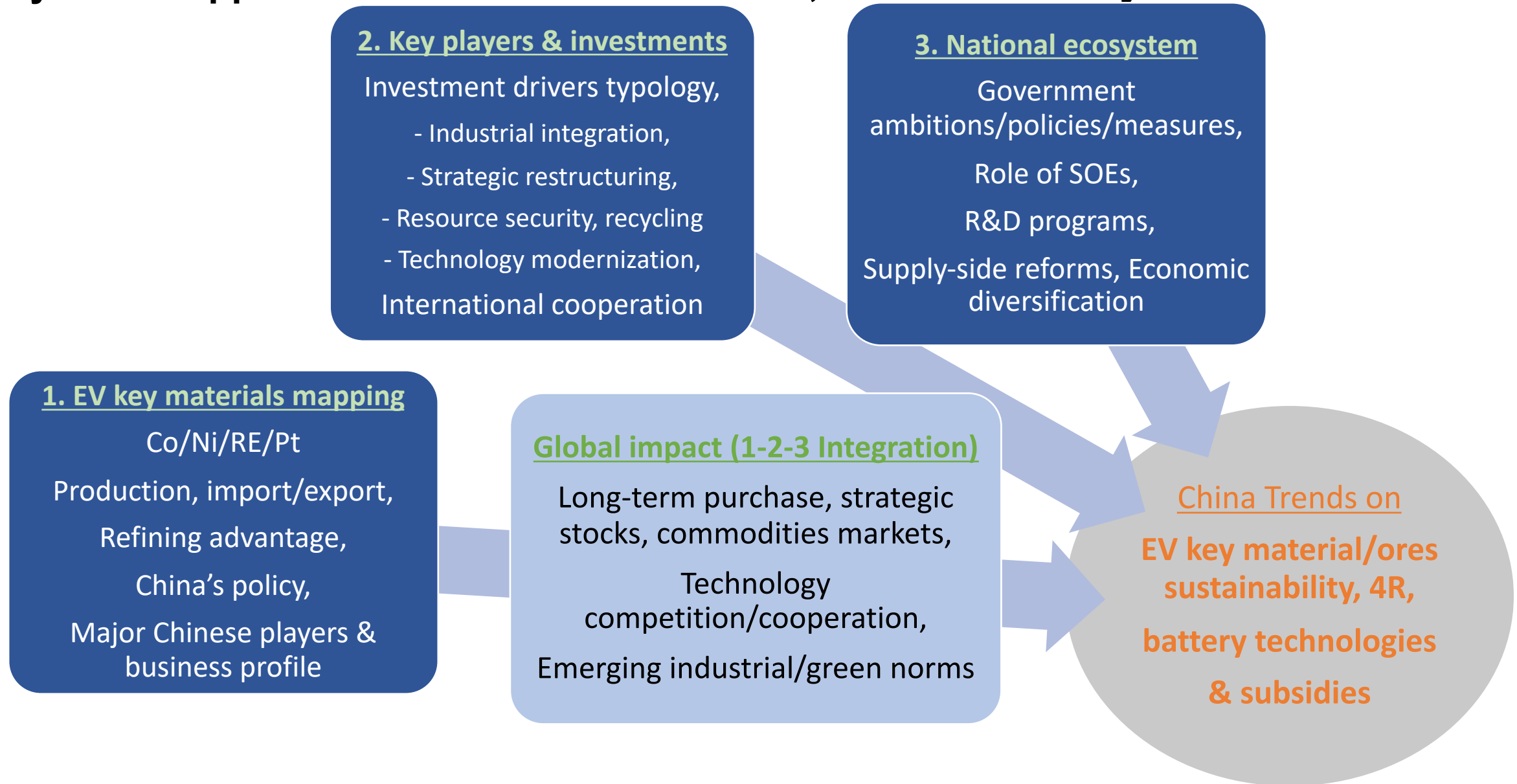
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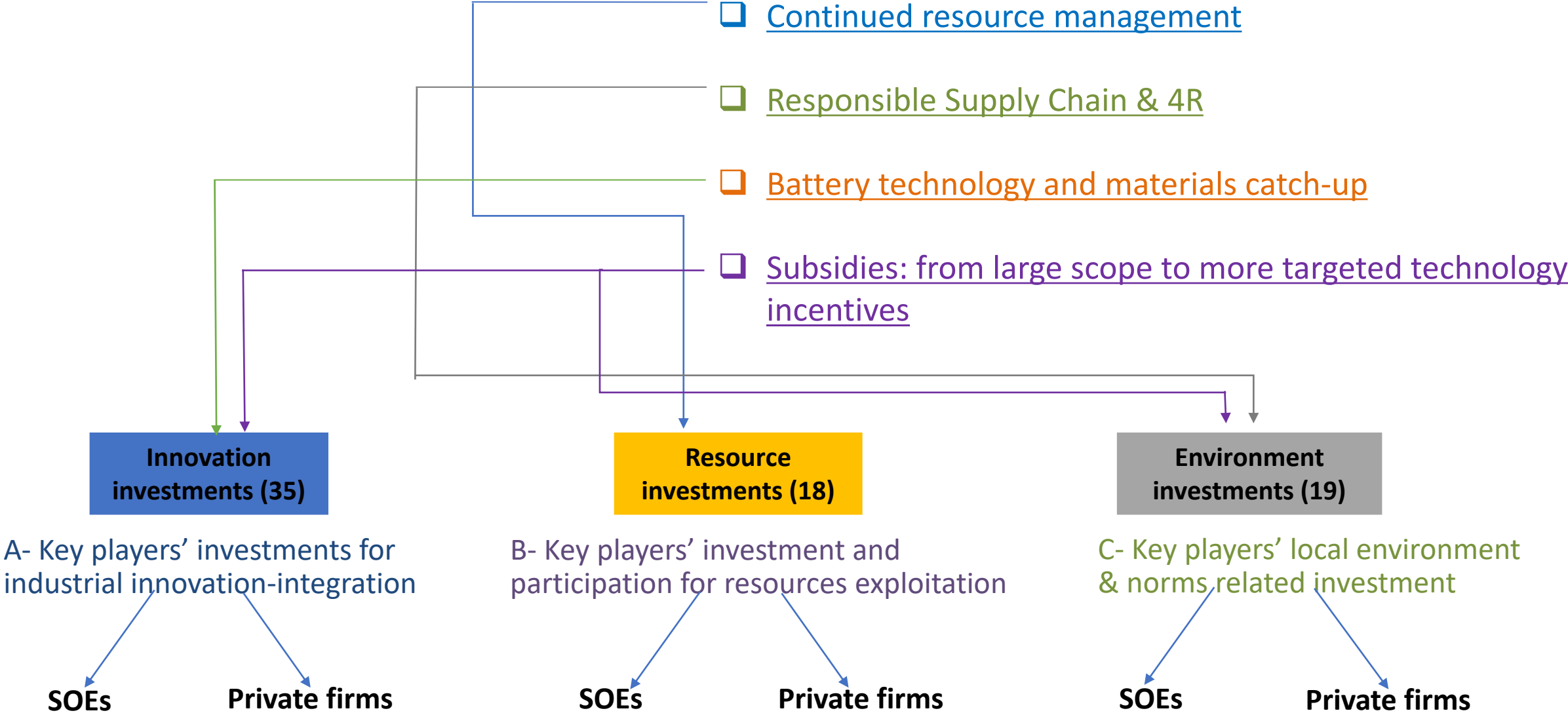
Methodology and
Executive Summary on Trends



Systemic Approach & Contents: from issues, actors and ecosystem to trends



2015-2018 : 4 trends addressed through Categorization of Drivers for 72 major Investment



2015-2018, 72 Investments surveyed - for total 9.16 bn USD (55 bn RMB)



4 Key Trends... that build into industrial advantage and new business models

A Continued ore-resource management stabilising the dependency-securing ratio, that turns into a refining advantage on Co (quantitative) and high purity Ni (technology)

4R: largely catching up: technological upgrade driven by environment norms, that could create service champions on niche business models: re-cycle, re-use

EV-Battery technology & components backed by strong national research programs:
Low-end Mass catching-up on NCA (transition from Pb) +
Front-end Dual strategy: NMC 811 industrialisation + leap-frog research (solid battery)

Subsidies: from large scope to targeted technology incentives, state expertise not just on emissions norms but also energy intensity, material & components specification



4 Key Trends... that create a system with already tested Chinese characteristics / skills

Ore-resource management to refining advantage on Co & high purity Ni

Restructure industry / as in Metallurgy/Chemicals

Technology upgrade through Environment norms, business models on re-cycle, re-use

NMC tech. & components industrialisation
Solid state leapfrog backed by research

Pick the champions as in New Energies-mobilities, frontier Tech, hydrogen

Subsidies for targeted tech., energy intensity & components specification

From resource, to refining, to components : a **Rare Earths-inspired strategy** (Powders, Magnets, Solar, Wind...) **to create an industry**

Towards setting **Global Industry Norms ?**



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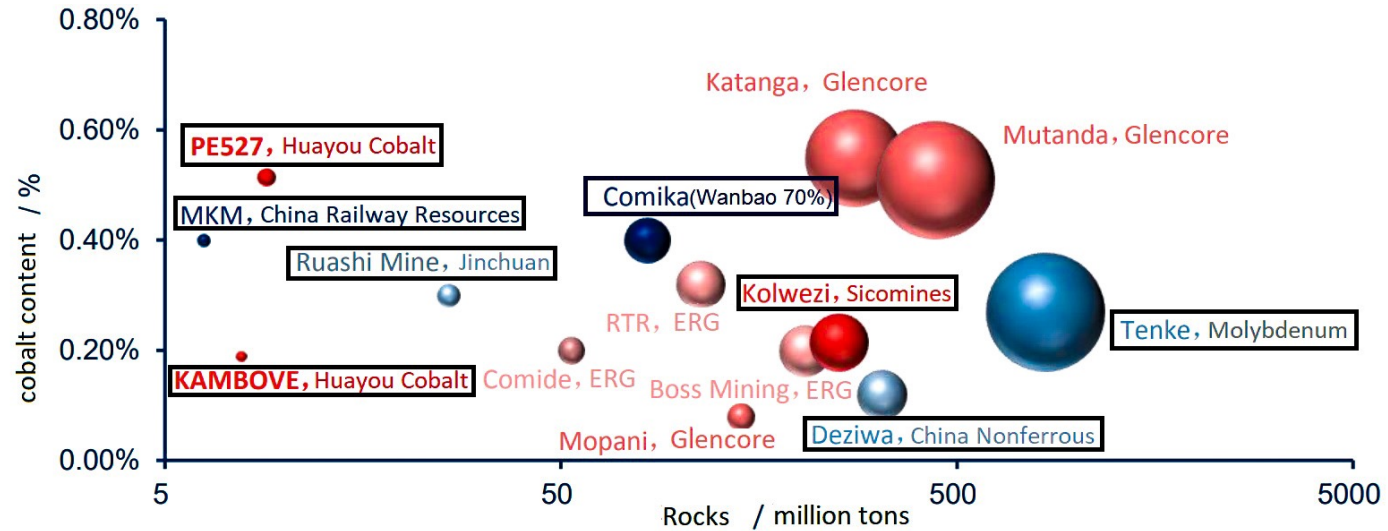
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Trends with Facts and Data

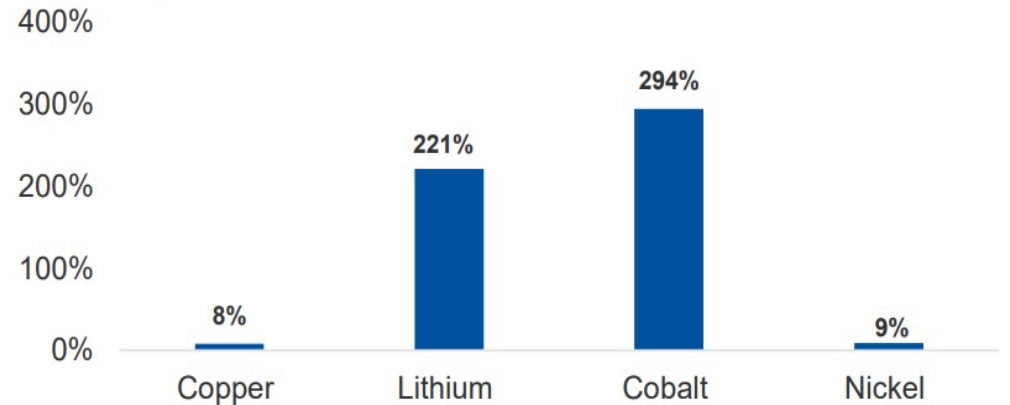


A Continued ore-resource management stabilising the dependency-securing ratio, that turns into a refining advantage on Co (quantitative) and high purity Ni (technology)

- Ore: western companies **market** price makers (>50%), but China secured **off-market** stability on Co (acquisitions 22% + long term contracts 14%)
- This 65% securing allows a refining advantage: quantitative-price in Co, seek tech. advantage in high-purity Ni
- The refining advantage might serve as a leverage on China's increased global Cobalt share by 2025 from today's 58%
- Ni, Pt: different strategy: Continued State companies strategic restructuring



Incremental demand under crediting system 2025, % 2017 demand in China



Supply Chain & 4R : Mostly a catching-up dynamic driven by environment norms, but could create service champions on niche business models: re-cycle, re-use

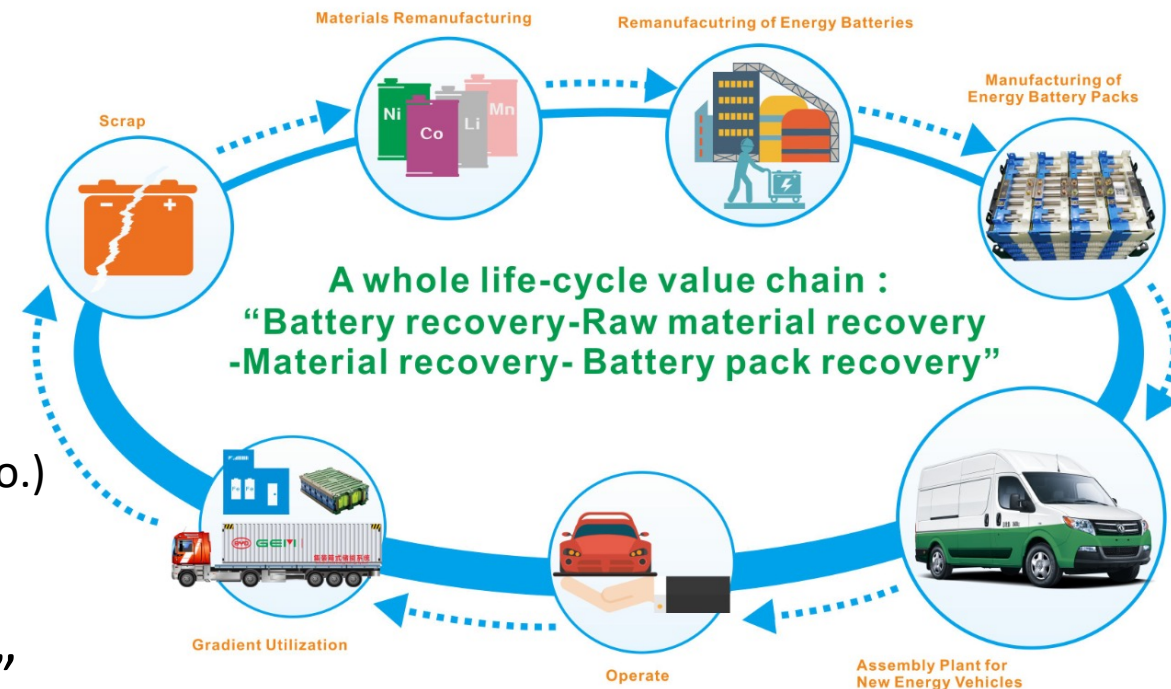
- From 4R to technology partnerships with foreign companies or nationally integrating the industry
- 3 business models of recycling

(1) Lithium/resources battery **materials**
(Huayou Cobalt, Xiamen Tungsten and Tianci Materials...)

(2) Power battery **system** for closed loop for Li
(BYD, Optimum, Guoxuan Hi-Tech, CATL, BAK batteries)

(3) **Dedicated dismantling companies**
(GEM, Hunan Brunp, Zhangzhou Haopeng, Fangyuan Enviro.)

KPI: LCA:
debates on creating a “China Automotive Energy Emission Factor Evaluation and Release Procedure”



GEM – an ambitious investor on process, industrial integration & life-cycle value chain

EV-Battery technology & components backed by strong national research programs:
Low-end Mass catching-up on NCA (transition from Pb) +
Front-end Dual strategy: NMC 811 industrialisation + leap-frog research (solid battery)

1. NCA China 15% 2025

2. Massifying high-Ni ternary precursor

- 2018 - 40,000 t/yr of NCM622
- 2020 - 60,000 t/yr of NCM811
- Energy density 250 Wh/kg;
- CATL: first to launch in 2019; BYD: 10 GWh 2019

3. Solid-state batteries. A few players are at early technology stage and are planning mass production

- State Grid, China Electric Power, Beijing Auto NEV, Pride
- CATL commercialization planned for 2025
- 2013-18, “All Solid State Battery” team applied for 49 patents: 9 authorized and 2 transferred for application.
- Solid-state battery prod. line 100 MWh/yr - 2020: 700 MWh/yr

Despite technology gap with foreign leaders still exist,
Chinese major battery makers are actively investing in next generation high Ni / low Co batteries.

China follows the trend of solid-state batteries.

A few players are at early technology stage and are planning mass production.



Subsidies: from large scope to more targeted technology incentives

Focused programs on **Materials and elements for batteries** are credible

National NEV R&D Plan: \$100 million in 2017

\$125 million in 2018

2017: total subsidies for EV \$7.7 billion

-> average subsidy for EV purchase \$10,000 (25% of average EV price)

Ambitious targets

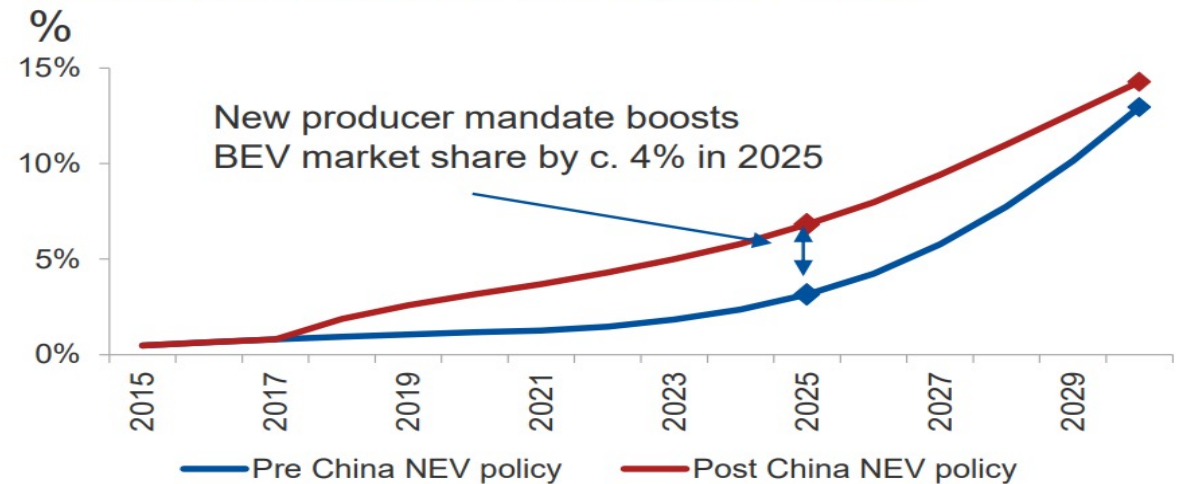
Year 2018, > 30 private invest in EV battery, total >\$20 bn incl. \$5 bn re-use-recycle projects.

2030 objective 90% world capacity - Public management skills

Industry disrupting regulations: not just on emissions like in EU but on technological paths

- **June 2018** a minimum 150 km e-range for BEVs and a specific battery capacity of 105 W/kg.
- + 2030 reducing CO2 emission + building EV market (5 million EVs + 6% annual sales by 2020)

BEV market share in China, 2017-2030



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Materials, Actors and Ecosystem:
Value Chain Mapping &
Implications for Renault

Cobalt value chain : Large Chinese Mining Companies – Integration material - components

4. Major NMC/NCA battery producers

3. Major component suppliers

2. Major raw material suppliers

1. Raw mine products suppliers

China Minmetals

- Key mining-metallurgical SOE
- Owns large mines, refinery lines and material processing
- Diversified businesses incl. engineering, trading, financing

Jinchuan Group

- Controlled by SASAC Gansu
- Mining, refinery, engineering & trade
- Global distribution of resources & assets

GEM (格林美)

- Largest batteries recycling centre (15% of total China)
- Largest producer of Co oxide (>20%)

Easpring Material Technology

- Leading Chinese producer used materials battery

2 JVs of Huayou/LG Chem, 2 JVs of Huayou/POSCO

- Founded in 2018
- Minority stake
- Li-ion cathode

Selen Science & Technology

- Laboratory system engineering & equipment

Crude Co hydroxide

Glencore

- One of the world's largest diversified resource companies.
- more than 90 commodities, through 150 assets and offices in 50 countries.

Refined Ni, Co & Cu products

Huayou

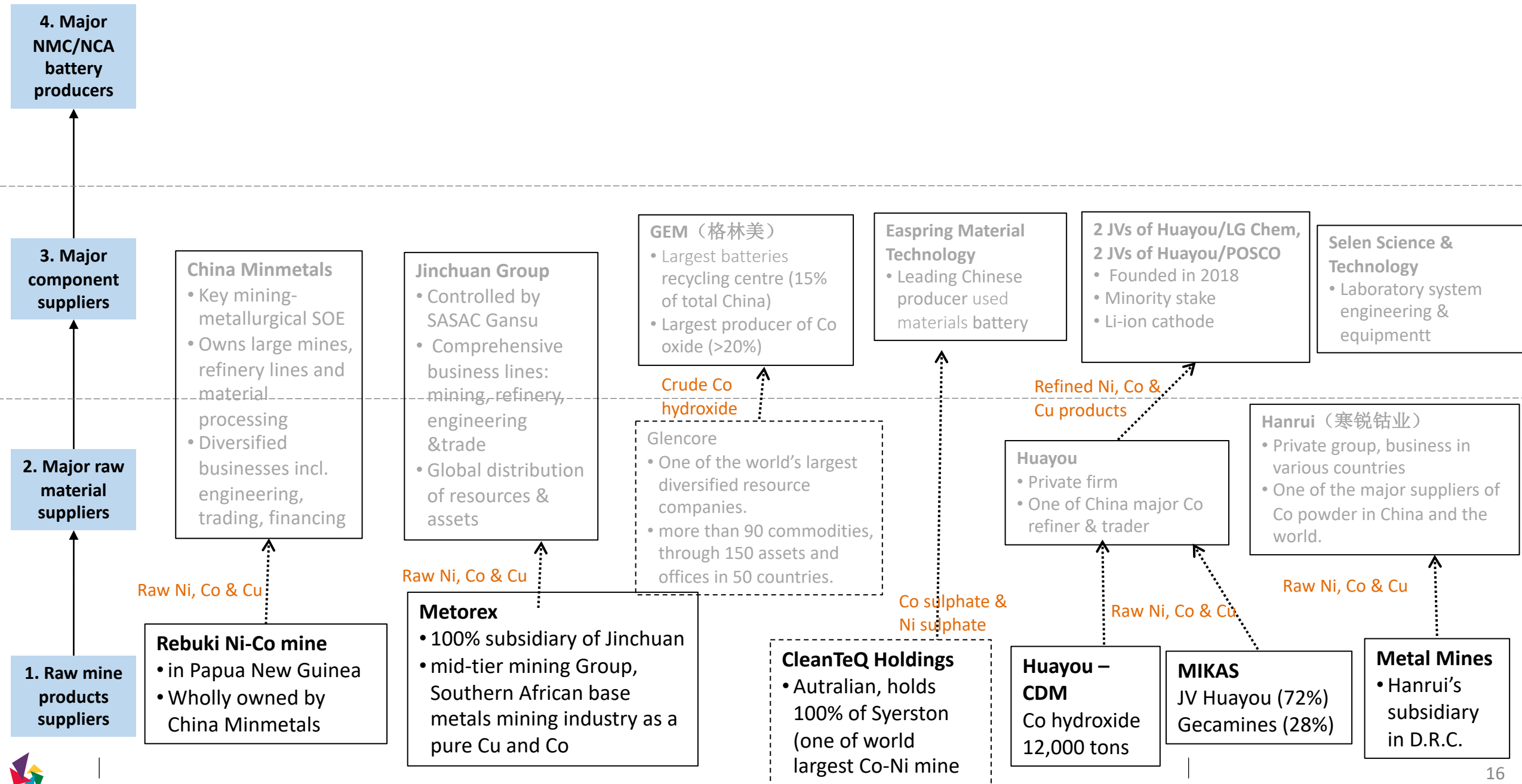
- Private firm
- One of China major Co refiner & trader

Hanrui (寒锐钴业)

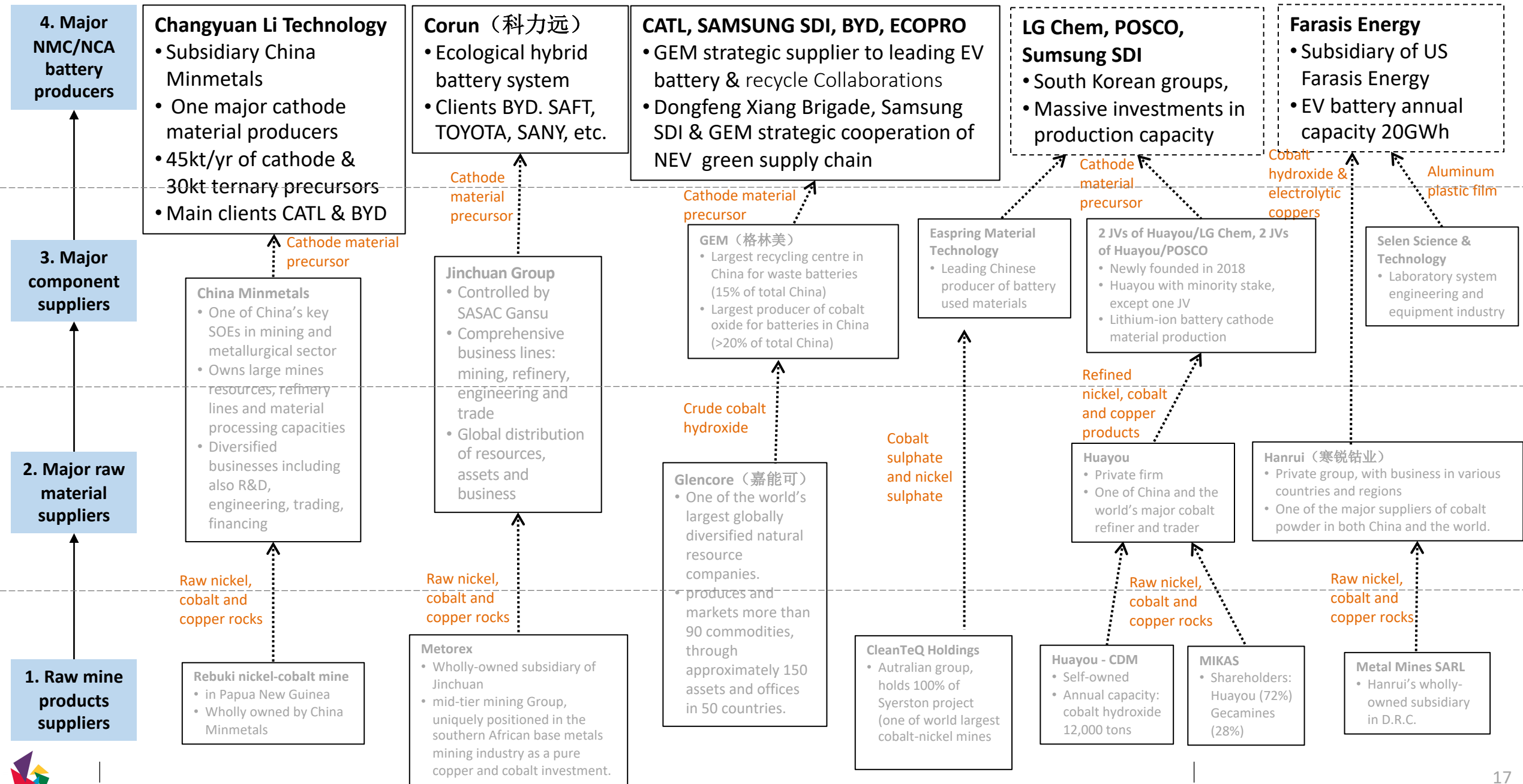
- Private group, business in various countries
- One of the major suppliers of Co powder in China and the world.



Cobalt value chain : Upstream mining integration



Cobalt value chain : Towards downstream technology structuration





SOE (resource-focused) + leading private (technology-focused) compete to dominate the industry

1. Key SOEs build industrial integration platforms, directed by the State (Minmetals, CNMC, Chinalco).
2. Leading private companies insert fast into global supply chain through alliances with foreign partners.
3. **The Visible Hand: important subsidies/ incentives and govt financed R&D programs in EV sector.**
4. **Parallel political measures are taken to push EV growth and green economy.**





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- ***A clear engagement towards global norms on subjects of responsible and sustainable mining.***
- ***High profits in 2017, Huayou 130 MUS\$ overseas Co acquisition, Jinchuan's Zambia Ni started production***
- New cathode types might impact the material consumption (++Ni, +Co, +Li)

KPI rank 1: Co economy + technology

KPI rank 2: Ni & Pt efficiency invest.



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- **A 3-groups-oligopoly:** Huayou Cobalt, Jinchuan, GEM.
- *SOEs focus on waste treatment, emission reduction, Govt-pushed*
- *Private leaders develop new businesses of recycling and reuse (GEM, CATL, BYD)*
- *A strong vertical integration*

KPI: relationships with rising private companies





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- EV battery material: end users cooperation to industrialise edge technologies
- International cooperation with research centers (Japan, California, Germany)
- State-led industry integration, R&D programs for national champions
- Pt National standards for motor vehicle emissions + FC production

KPI: norms on batteries components, energy intensity and range





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Enjeux pour Renault

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From Trends to New Issues: EV whole value chain advantage vs. core battery technology catch-up

1. Integration in mining, refining, component & manufacturing, recycling: a whole industrial VC
2. Scale and «market & production capacity for technology»: cooperation & co-investing

- *Increasing material supply chain management efficiency and social responsibility*

- Building technology and create niche market scenarios
- Collaborating with Japan/S.Korea battery leaders

- Growing supply to foreign car makers -> into global standards making
- Accelerating national market consolidation

China strategy to become technology independent/ Set Norms

1. Forming national EV norms (Increasing National competition / Orient and Pick the winner)
2. Imposing them to foreign players in China through market organisation: not just emissions (EU-way) but global EV norms and regulations making
3. Expanding the global advantage? Fast developing overseas markets BAIC, BYD, Geely, Chang'an, JAC



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Annexures

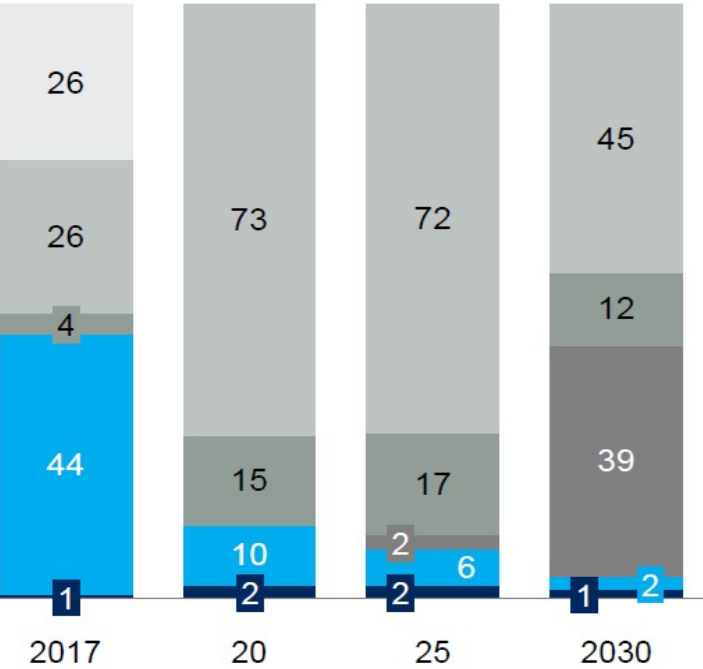


NEV sector trend in China: 6 X current nickel needs and 4 X current cobalt needs by 2020

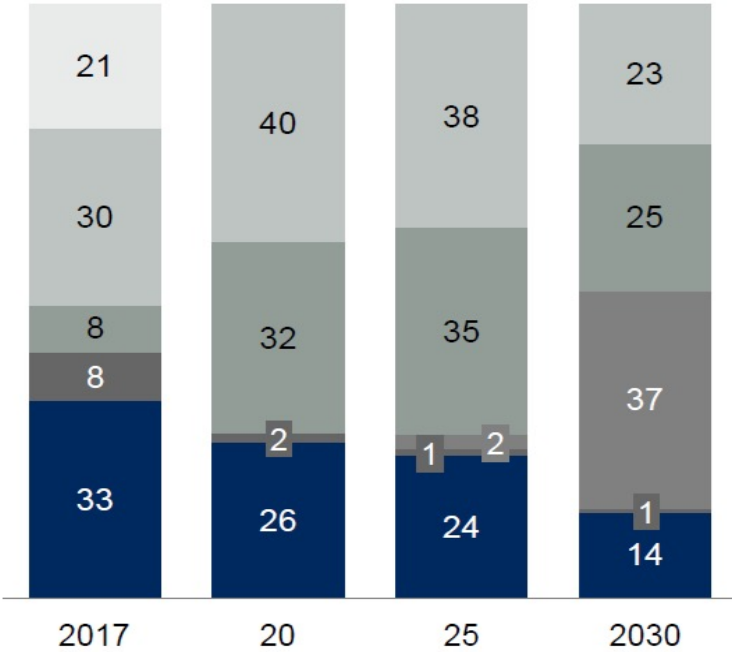
Distribution of EV by battery chemistry¹

NMC 111
 NMC 622
 NMC 811
 NMC 9.5.5
 LMO
 LFP
 NCA

China
Battery capacity demand by chemistry
Percent



Rest of the world
Battery capacity demand by chemistry
Percent



In 2017 China's ternary power battery accounted for 50% of new energy vehicle equipment, driving nickel consumption of 11,200 tons and cobalt consumption of 4,800 tons;

By 2020, China's ternary Power batteries should accounted for 80% of new energy vehicle equipment, driving nickel consumption by 67,000 tons and cobalt consumption by 19,000 tons.

¹ Other battery demand segments have been excluded

SOURCE: McKinsey Basic Material Institute's battery raw materials demand model



GEM – an ambitious investor on process, industrial integration and life-cycle value chain

☐ Largest recycling centre in China for waste batteries (>10% of total China)

- GEM invested 3 billion RMB to construct a large-scale waste battery and power battery material recycling industrial facility
- With annual processing amount of waste batteries and waste cobalt nickel materials >300,000 tons, recycling and reusing valuable metals, such as nickel, cobalt, manganese, copper, aluminum, iron and lithium.

☐ Largest producer of cobalt oxide for batteries in China (>20% of total China)

- More than 50,000 tons/yr capacity of lithium-ion battery used Co and Ni materials and cathode material.
- GEM has formed a full manufacturing system for multispecies used in Li-ion battery materials, including high-purity nickel sulphate, cobalt chloride, cobalt oxide, coarse spherical cobalt oxide, NMC precursor, NCA precursor, NMC ternary material, NCA ternary material etc., accounting for 20% of the Chinese market.

• **Entering into the International Supply Chain**

Capacity of NMC and NCA ternary precursor material 20,000 tons / yr, the battery level spherical cobalt oxide 10,000 t, nickel cobalt manganese acid lithium ternary power materials 15,000 tons. Strategic supplier to Samsung SDI, ECOPRO...

• **Cooperate with BYD, Samsung, to establish the big circular system of power battery**

2015, Energy Storage Station Co, battery degradation utilization, photovoltaic energy storage and energy storage station.

• **Cooperate with Dongfeng and Samsung, to Build NEV Green Supply Chain**

Signed in 2016, to establish the whole industrial chain closed recycling system of “material, battery, new energy vehicle manufacture, supply chain finance and power battery recycling”.



Alternative technologies to reduce cobalt content

Lower Co batteries

Projects at mass production horizon

- **China Metallurgical Group - BYD**, 40,000 t/yr high-Ni ternary precursor (NCM622) & high-purity cerium oxide (20 t/yr); 2nd phase 2020, 60,000 t / yr high-Ni ternary precursor (NCM811) & cerium oxide 40 t/yr.
- **BAK Battery 3.0 Ah cylindrical 18650 battery NCM811 mass-produced**, density 250Wh/kg.
- **Penghui Energy's NCM811 material 2.8Ah, 3.0Ah cylindrical 18650 battery has been mass-produced**.
- **BYD NCM811 power battery R&D put into use in the second half of 2019**. Planning 10GWh high nickel 811 battery capacity in Chongqing.

Early manufacture, towards massification

- **GEM full system for multispecies used in Li-ion battery, including NMC & NCA precursors, NMC & NCA ternary materials** (20% Chinese market).
- **Tianjin Lishen plans NCA and NCM routes at the same time**. energy density 350Wh/kg by 2022. NCM811 early production.

Pilot projects

- **Huayou Cobalt R&D NCM622, NCM811, NCA and NC** under development.
- **Koba Power Battery Ni-H₂ battery for hybrids** (FAW Toyota, GAC Toyota). 100k sets/yr; 2nd gen. Ni-MH power packs-hybrid cars, FC & fast charge bus

Solid-state batteries

Vision – national strategic research

- Chinese Academy of Sciences, Qingdao Institute of Energy, CATL, AVIC Lithium, BYD, Ganfeng Lithium & many others are engaged in solid-state batteries.
- 2013-2018, research team of “All Solid State Battery” published 28 research papers, applied for 49 national invention patents (9 were authorized and 2 transferred for application).

Early projects

- Startup "Qingtao" (founder, from Tsinghua University & CAS), China's first solid-state battery production.

Annual capacity 100 MWh (target 700 MWh by 2020), with a single energy density of 430Wh/kg. Mass production, objective of 300Wh/kg or more.

- In 2018, Ganfeng Lithium Industry announced a solid-state battery pilot line, with a membrane: coated with a layer of solid electrolyte.

2nd generation & 3rd generation solid-state battery: a real solid-state Li battery, with solid electrolyte as a separator, a anode with Li and a cathode with NMC811).

NEV sector trend in China: high probability to reach 2020 target: the government affords re-regulation on technology standards

Country or region	EV 30@30 ¹	2020-30 EV target or objective	Source
China	✓	<ul style="list-style-type: none"> • 5 million EVs by 2020, including 4.6 million PLDVs, 0.2 million buses and 0.2 million trucks. • New energy vehicle (NEV)² mandate: 12% NEV credit sales of passenger cars by 2020.³ • NEV sales share: 7-10% by 2020, 15-20% by 2025 and 40-50% by 2030. 	State Council (2012), EVI (2016b) MIIT (2017) Marklines (2017b)
European Union		<ul style="list-style-type: none"> • Post 2020 proposed CO₂ targets for cars and vans include benchmarks: 15% EV sales by 2025 and 30% by 2030 (exceeding these benchmarks allows for less stringent specific emissions targets to be met by OEMs). 	EC (2018b)

- Government introduced **new requirements to receive NEV subsidies** in June 2018 : a minimum 150 km e-range for BEVs and a specific battery capacity of 105 W/kg.
- NEV sales in China to reach 1,1 million passenger cars this year, up 83 % from 2017, 74 % of them BEVs and 26 % Plug-in Hybrids (PHEV).
- In a total market forecasted to reach 26,3 million passenger cars (+2,2 % vs 2017), this means **4,2 % NEV share**.

