

CHINA & STRATEGIC METALS:



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

## Analytical Report

2019

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# Executive Summary

## Materials Strategy:

**China is taking all measures to decrease import dependency, secure material supply while increasing efficiency and durability.**

1. Through ownership or off-market long term contracts, China has already secured 65% of its cobalt refining needs.
2. China's rare earth resource and refinery capacity are concentrated on several large SOE groups which respect national quotas.
3. The continued SOEs strategic restructuring in metallurgic industry is making China's future champions with higher efficiency (nickel, platinum).
4. Battery technology upgrading (low cobalt) and material reuse/recycle are also reducing import dependency and improving durability.

## Key Players Strategy:

**SOE (resource-focused) + leading private (technology-focused) companies are competing to dominate the industry.**

1. Key SOEs as building industrial integration platforms and operating strategic resource management, directed by the State.
2. Leading private companies are inserting fast into global supply chain with advanced technology or strong alliance with foreign partners.
3. SOEs focus on waste treatment, CSR and emission reduction, pushed by central policies.
4. Private leaders focus on new businesses of recycling and reuse, building comprehensive utilization of resources.

## National Ecosystem:

**Strong State policy support leads to fast EV sector growth, though the technology gap remains & energy mix needs to green up .**

1. The Visible Hand: important subsidies/ incentives and govt financed R&D programs in EV sector.
2. Parallel political measures are taken to push EV growth and green economy, but the real change might be slow to come.
3. Technology gap with leading foreign producers still remain for higher and alternative battery technologies.
4. A clear engagement of China to embrace global norms on subjects of responsible and sustainable mining.

# CHINA & STRATEGIC METALS:

## **Methodology**

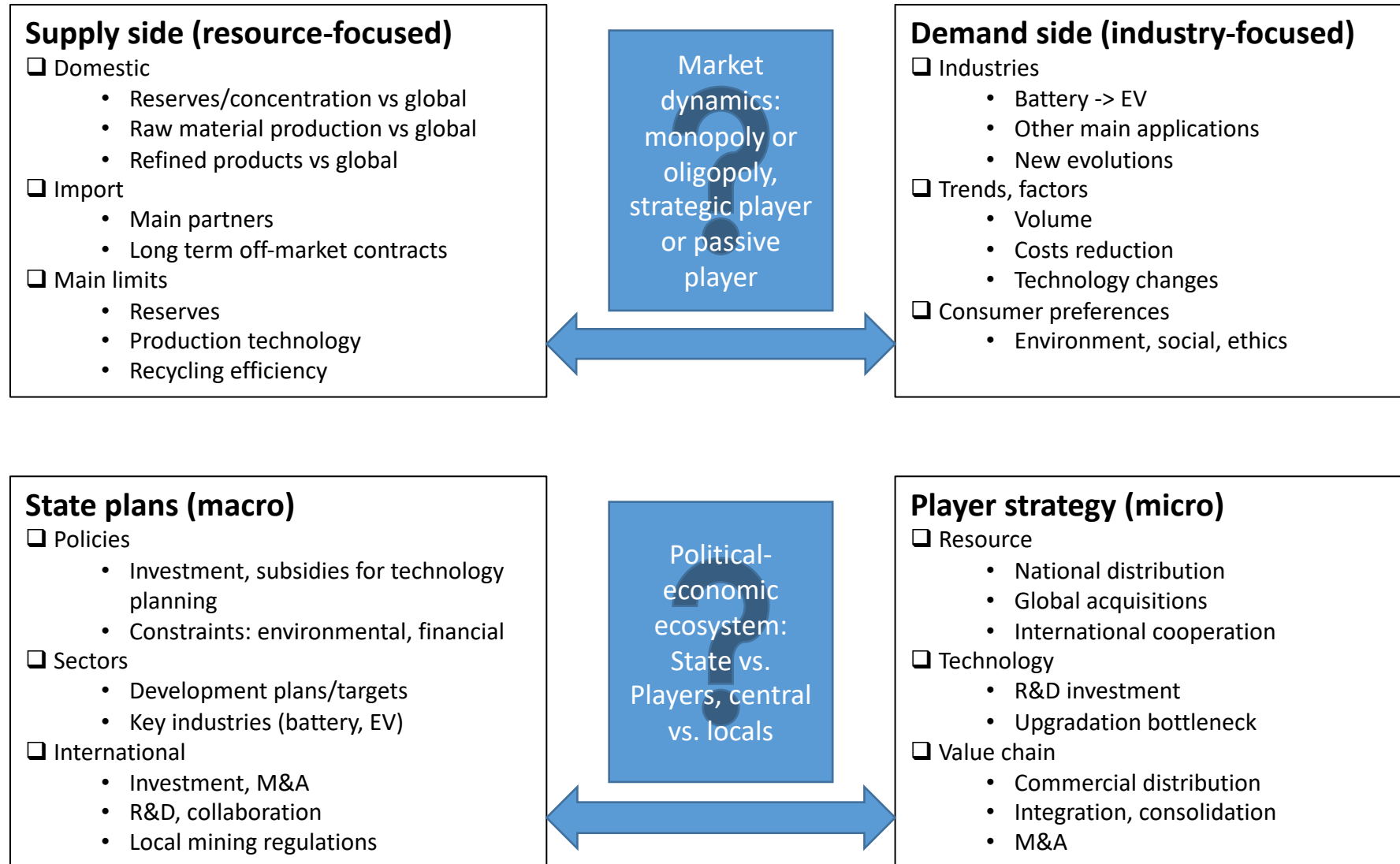
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# Methodology – Conceptual framework on two axes:

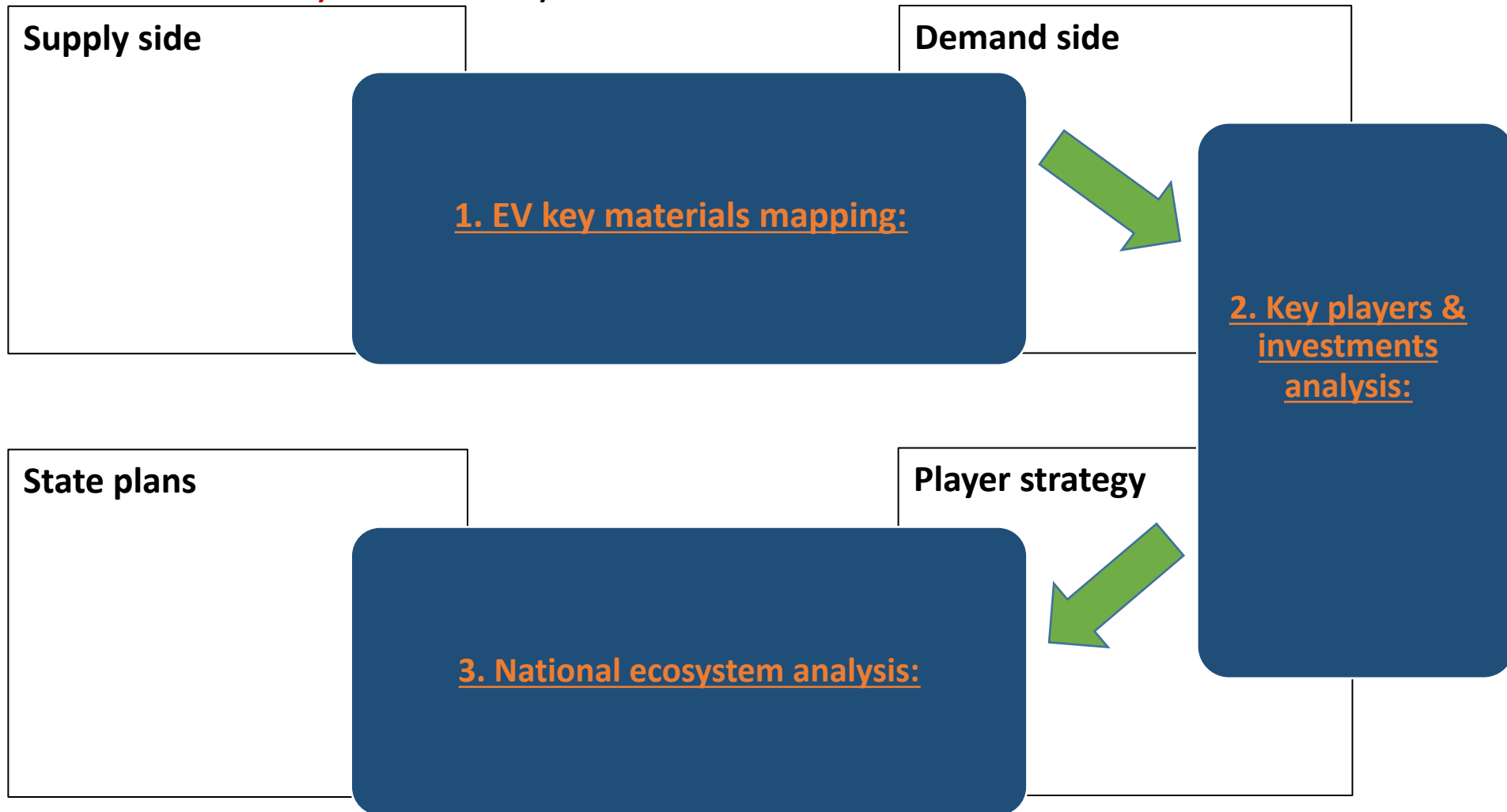
- **Market dynamics:** supply vs. demand

- **Political-economic analysis:** State policy vs. player strategy



## Methodology – Transitional framework on 3 levels of analysis:

- **Market dynamics:** materials mapping
- **From market to strategy:** key players analysis
- **Political-economic analysis:** national ecosystem



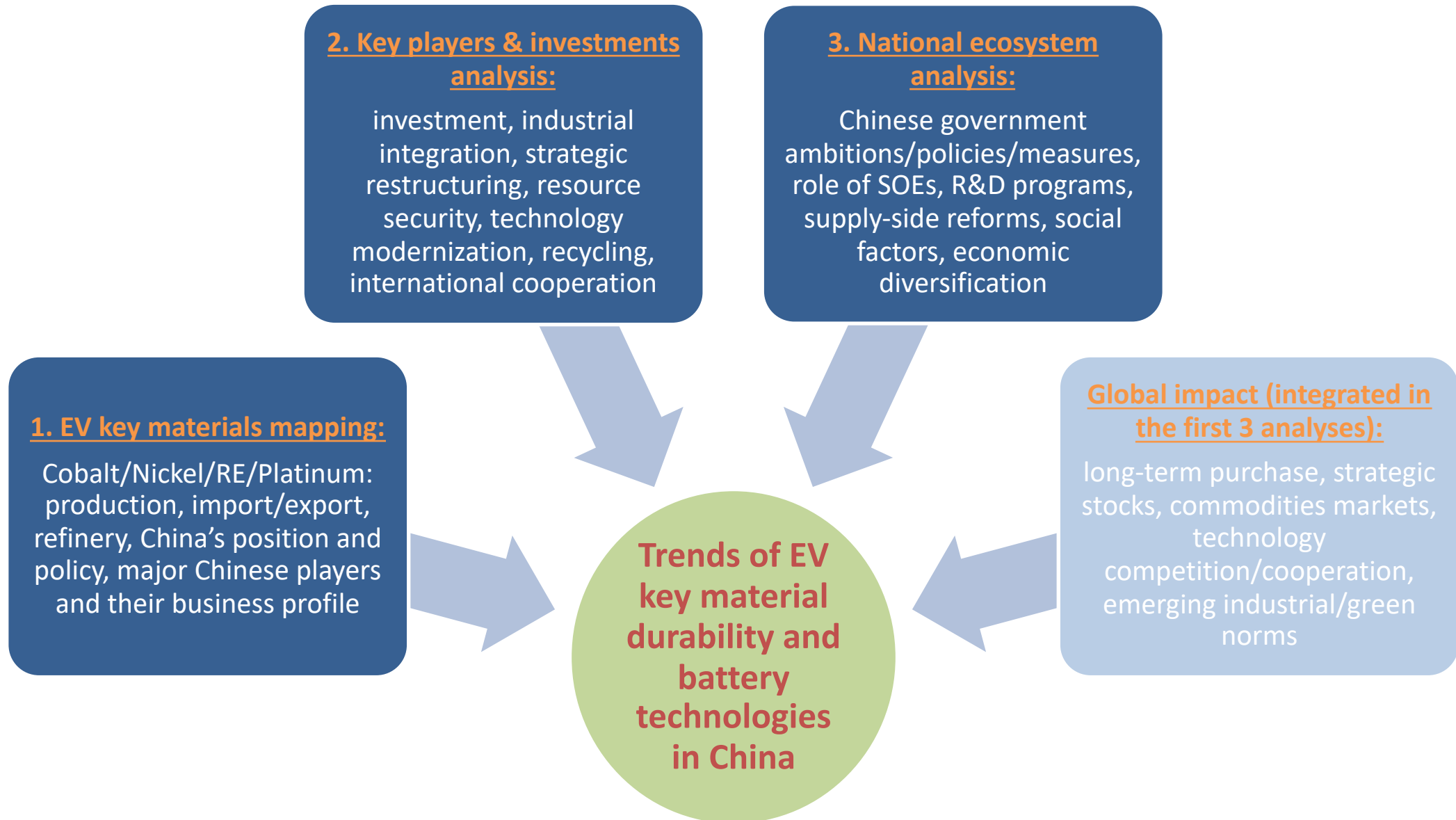


# CHINA & STRATEGIC METALS: **Analysis**

2018 December



# Contents







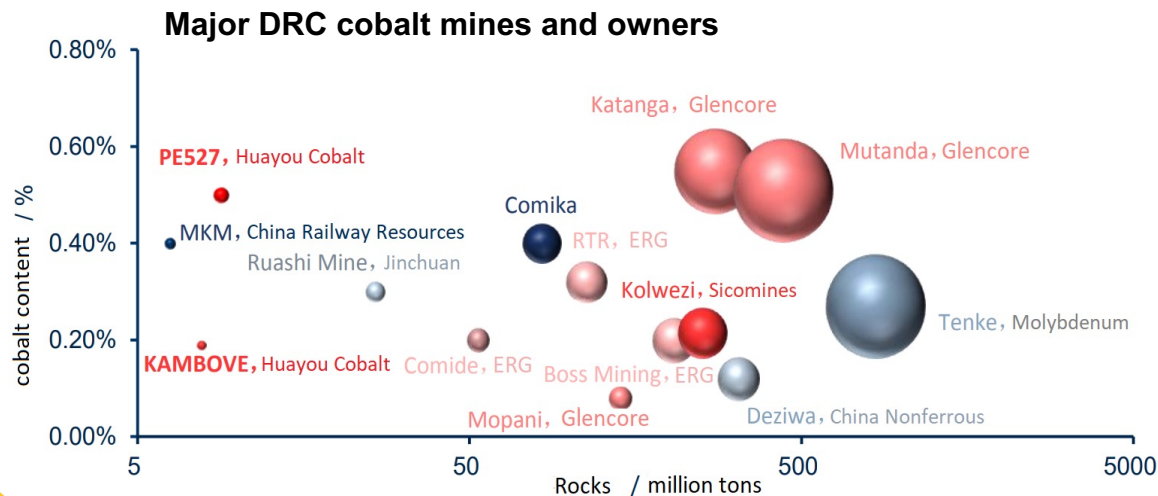
# China has strong import dependency on several strategic minerals

In the *China 2016 Strategic Emerging Industries Resource Report*, rare earths, lithium, fluorite, graphite, platinum, cobalt were listed as strategic mineral resource for EV, HEV, FC battery and H2 storage.

- **Rare earths:** world's 2<sup>nd</sup> largest reserves (15%), largest producer (90%), exporter (90%) & consumer (65%)
- **Graphite:** world's 2<sup>nd</sup> largest reserves (33%), largest producer (74%), exporter (79%) & consumer (53%)
- **Fluorite:** world's 2<sup>nd</sup> largest reserves (15%), largest producer (60%) & consumer (60%)
- **Lithium:** world's 5<sup>th</sup> largest reserves (13.8%), but imports dependency rate is **76%**
- **Platinum:** seriously lacks resources, imports dependency over **64%**
- **Cobalt:** seriously lacks resources, largest producer (>40%), import dependency over **85%**

| China 2016 Strategic Emerging Industries Resource Report |          | China 2016 Strategic Emerging Industries Resource Report |             |
|--|----------|--|-------------|
| Resource Name  | Reserves | Production   | Consumption |
| Rare earths  | 15%      | 90%  | 65%         |
| Graphite   | 33%      | 74%  | 53%         |
| Fluorite   | 15%      | 60%  | 60%         |
| Lithium  | 13.8%    | -  | 76%         |
| Platinum   | -        | -  | 64%         |
| Cobalt   | -        | >40%   | 85%         |

Source: Department of Land Resources, 2016 National Geological Survey Report



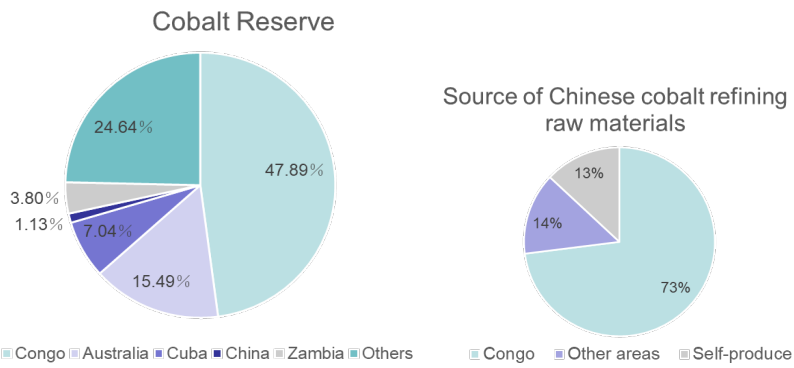
Source: CITIC Securities, Jan 2018

## Meanwhile, China has actively worked to control its cobalt supply:

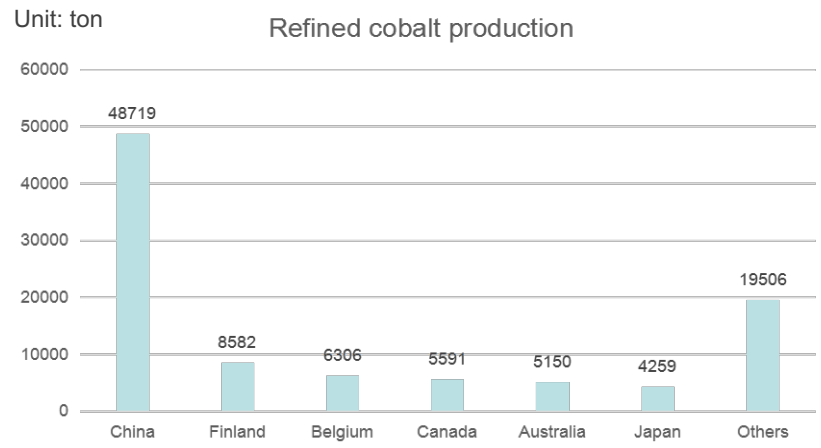
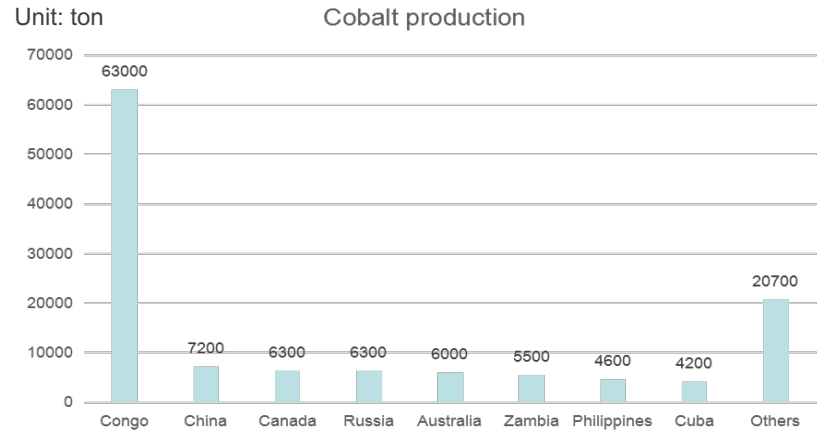
- Chinese companies produced about 58% of global refined cobalt in 2017 (with about 98% of raw material imported from DRC).
- Out of which, about 24.5% is with self-supplied mines and about 13.7% is secured by long-term purchase contract, in total representing a stabilizing 38.2% majority (about **65% of its needs**).
- Therefore, China now has a relatively good control on its cobalt supply.

# Material mapping: cobalt – import dependency, refined products dominance

- The global proven reserves of cobalt resources total 5 million tons, of which 65% are in DRC.
- Glencore** owns about **50%** of the global cobalt reserve, i.e. 2.5 million tons. **Luoyang Molybdenum Industry**, a comprehensive large-scale resource supplier of copper, molybdenum and cobalt, owns 560k tons cobalt reserve (**11%**). The third place is **Jinchuan International**, with cobalt reserve of 450k tons (**9%**), including an equity reserve of 370k tons.
- China is the world's largest refined cobalt producer, making about 48,719 t refined cobalt in 2016 (**49.6% of world**). About 73% of intermediate products related to cobalt are imported, mainly from DRC.
- Darton Commodities (2016): **China has control of about 85% of global refined cobalt supply.**



Source: Mineral Commodity Summaries, Jan 2016



Source: World Statistics Yearbook 2016

## China's position and strategy

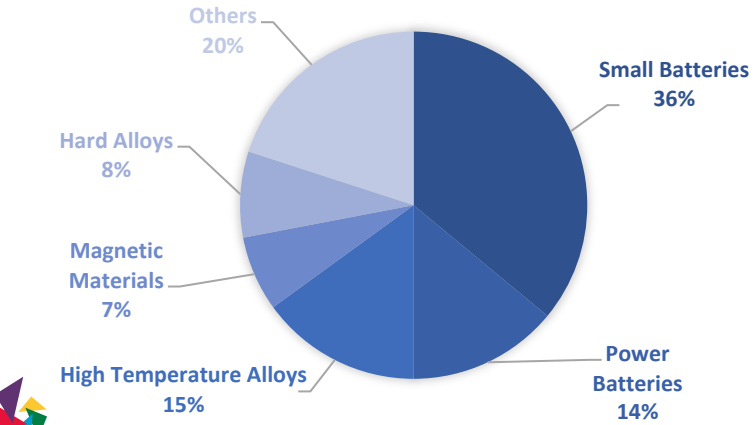
- China has a **quasi monopoly position** in refined cobalt supply (with 3 oligopole groups), even though there are **potential risks from the resource supply side** (DRC).
- Import dependency rate: > 90% (but under control)
- Therefore, China's current development strategy is mainly reflected in the **security of cobalt resources**. At the same time, Chinese producers continue to **improve processing technology and increase recycling projects**.
- With cobalt prices continuing to climb, mainly pushed by battery sector demands, major Chinese cobalt producers have registered **high profits in 2017** and are keeping the speed of **overseas resources acquisitions**.

## Impact of the new Congolese Mining Law

- The new Congolese mining law, in March 2018, increased the mining tax, the state-owned share of mine development, and restrictions on private rights. Implementation time has not yet been determined, but the rising cost of cobalt mines is a probability.
- As a result, Chinese companies have started to increase control of the upstream supply chain.
- Rumour is that China may acquire Eurasian Resources Group's \$1bn Roan Tailings and Reclamation (RTR) project in the DRC, which is already Chinese financed and will start this year to produce 15,000 t cobalt/year.

| Key Chinese cobalt refiners and production (2016) |                       |            |
|---|-----------------------|------------|
| <b>Huayou Cobalt</b>                              | <b>Jinchuan Group</b> | <b>GEM</b> |
| 17,800t   | 12,600t               | 6,000t     |
| (37%)   | (26%)                 | (12.5%)    |

## Industrial applications in China (2016)

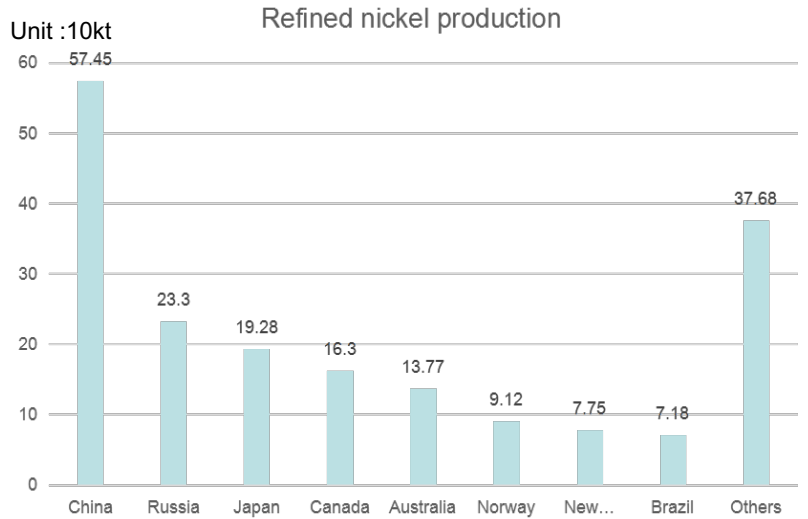
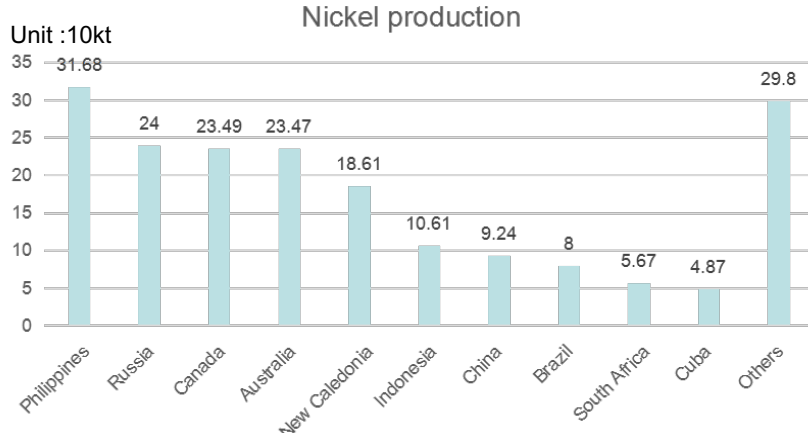


# Material mapping: nickel – import dependency and price-taker

- The world's nickel production is relatively concentrated, with the top ten countries producing about 85.35%.
- China has a low level of nickel reserves (3.2% of world) but produces about **30% of world's refined nickel**.
- About 82%, of nickel produced in China is of >75% purity, but **only 9% of them is >99% purity, for batteries**.
- China's nickel refining raw materials are mainly from the Philippines and Indonesia. During Indonesia's "no-mine period" 2014-16, most of China's nickel ores were imported from the Philippines, representing 95% of the total imports in 2016.

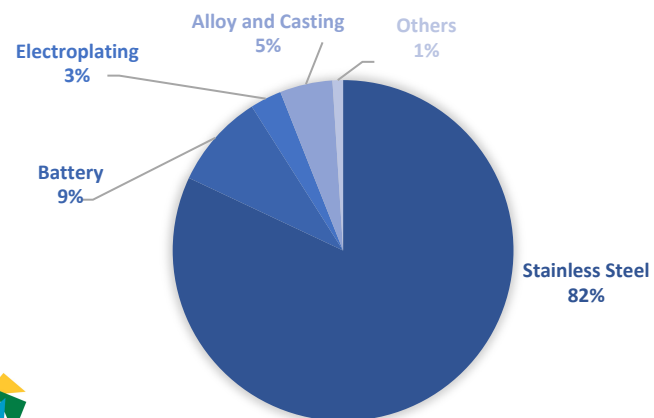
| Country       | Nickel ore reserves (10kt) |
|---------------|----------------------------|
| Australia     | 1900 (24.4%)               |
| Brazil        | 1000 (12.8%)               |
| Russia        | 760 (9.7%)                 |
| New Caledonia | 670 (8.6%)                 |
| Cuba          | 550 (7.1%)                 |
| Philippines   | 480 (6.2%)                 |
| Indonesia     | 450 (5.8%)                 |
| South Africa  | 370 (4.7%)                 |
| Canada        | 290 (3.7%)                 |
| China         | 250 (3.2%)                 |

Source: www.chyxx.com



Source: Mineral Commodity Summaries, Jan 2016

## Industrial applications in China (2016)



## China's position and strategy

- As world's largest refined nickel producer & consumer, but with limited nickel reserves, China has a **high degree of dependency** from Philippines and Indonesia.
- Imports dependency rate: 81.27% (2017)
- In China **nickel production is mainly concentrated in Jinchuan nickel-poor mines**. The group experienced losses for last few years, is applying **new processing and refining technology** while increasing overseas acquisitions.
- Main reasons for losses: high producing costs; overcapacity led to important stocks; stainless steel market downturn due to 2016 EU antidumping tax on China; **price-taker** due to high dependency on import.

## New industrial trend

- Leading Chinese nickel refiners focus on R&D, production of **high purity nickel up to >99.9999%** for EV battery.
- Many make strategic moves to enhance their market share by participating in both **upstream and downstream industrial value chains integration**: acquire national or overseas nickel reserves, enter into EV battery material development, cooperation with end users to accelerate industrialisation of cutting-edge technologies, etc..

| Key Chinese nickel refiners and production (2016) |   |   |
|---|---|---|
| <b>Jinchuan Group</b><br>50,000t<br>(51%)         | <b>Jilin Ji'en Nickel</b><br>24,500t<br>(25%) | <b>Xinjiang Nonferrous Metals</b><br>20,000t<br>(20%) |

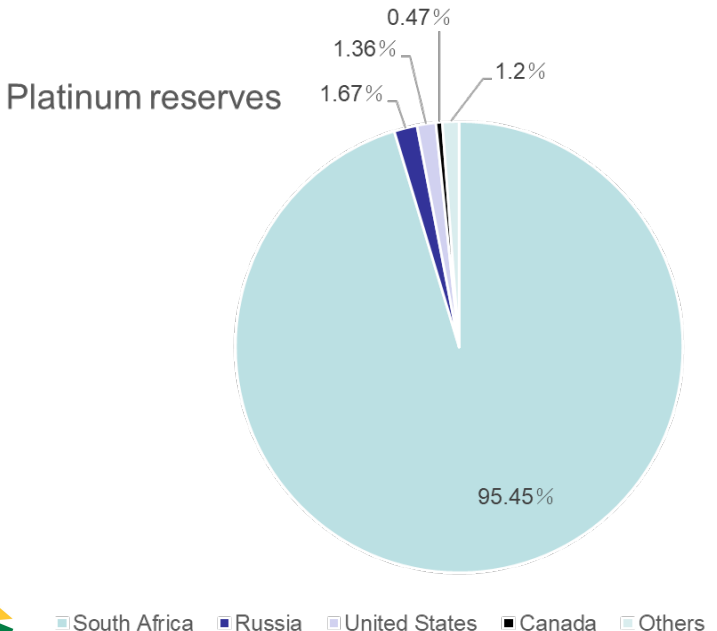
# Material mapping: platinum – growing demands, potential risks

- The global 69,000 t platinum reserves are concentrated in a few countries, with > 95% in South Africa alone. China has only about 365 t platinum reserves (<0.5% of world).
- China is the world's **largest consumer**, with 25% of global demand, but only about 1% of global production.
- **Jinchuan Group** is China's largest platinum metals producer, with current production capacity of 4 t / year.
- In China, platinum group metals are used for automotive **catalyzer (51%)**, jewellery (29%) & other industries (20%).

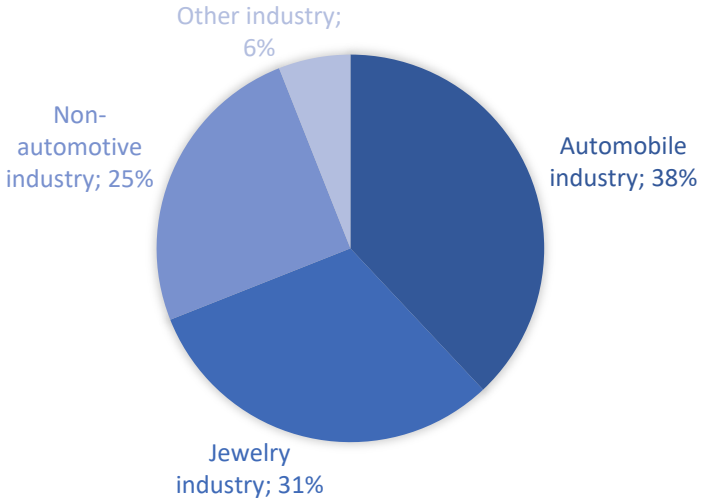
- *Platinum is highly resource consuming, with 250 t rocks producing only 1kg platinum metals. Given low market prices in recent years, many platinum producers have reduced production or temporarily closed mines and factories.*

- *But platinum also produced from secondary resource recovery (catalyser, jewellery).*

- *The content of the platinum group metal in the mineral is only 2.5-6 g/t while its content in the automobile catalyst material is 2.5-6 g/kg. It is much more cost efficient and environmental friendly to recycle from the waste.*



Industrial applications in China (2016)



## China's position and strategy

- **China is highly dependent on imports of platinum** from its main producing countries such as South Africa (49%), Australia and Russia.
- Import dependency rate: about 80%
- Before 2020, the implementation of China's **national standards for motor vehicle emissions** will become the main driving force for the growth of demand for platinum group metals in China. With EV growth, so will demand for platinum in **the production of FC**.
- China will need to improve recycling rate of platinum too to mitigate supply side pressure. **and increasing platinum demand should be partially absorbed by the growing recycling projects.** Some Chinese and foreign companies are specializing themselves in this sector.

| Key Chinese producers and final products amount (2016)           |   |                               |
|--|---|-------------------------------|
| <b>Sino-platinum Metals</b><br>3,000t<br>(mainly from recycling) | <b>CITIC (Shenzhen) Platinum Technology Development</b> | <b>Hebei Zhongbo Platinum</b> |



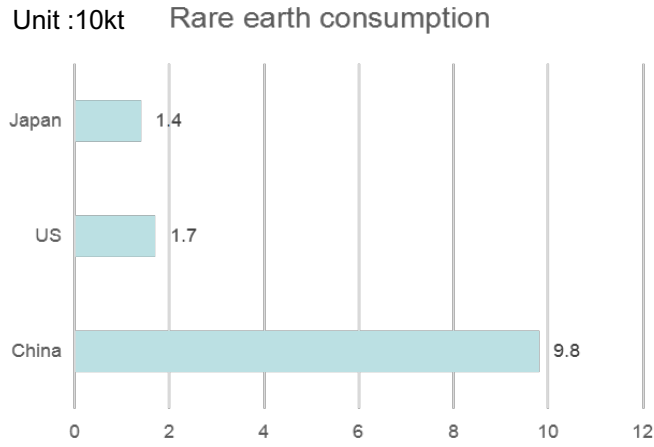
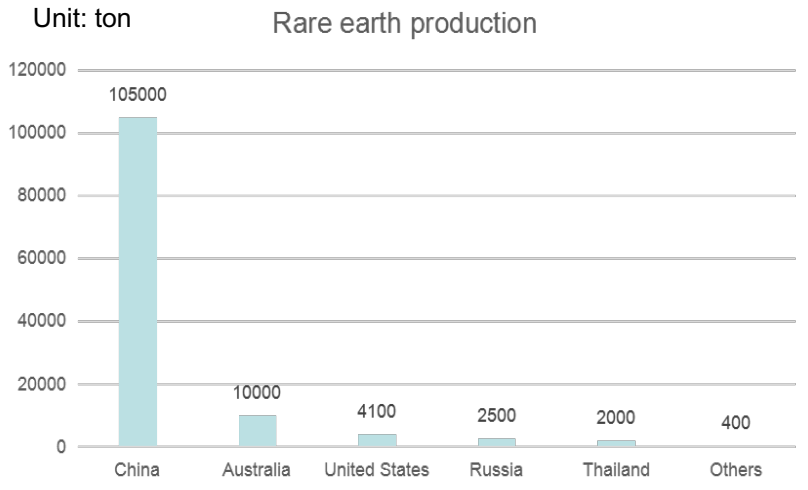
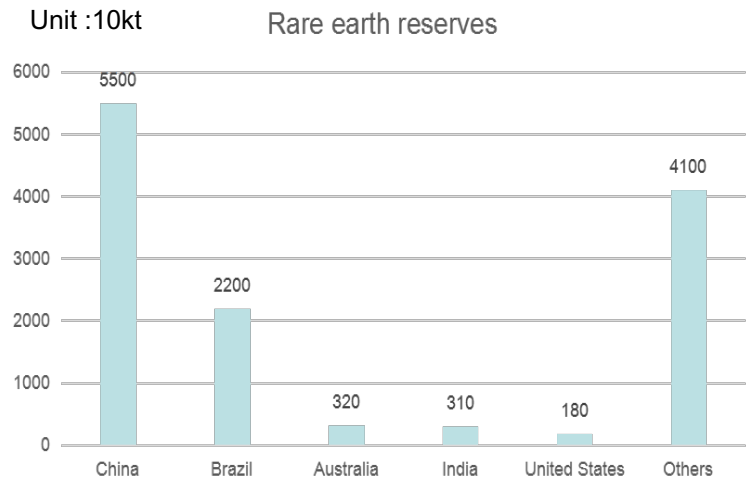
■ South Africa ■ Russia ■ United States ■ Canada ■ Others

Source: Mineral Commodity Summaries, January 2016

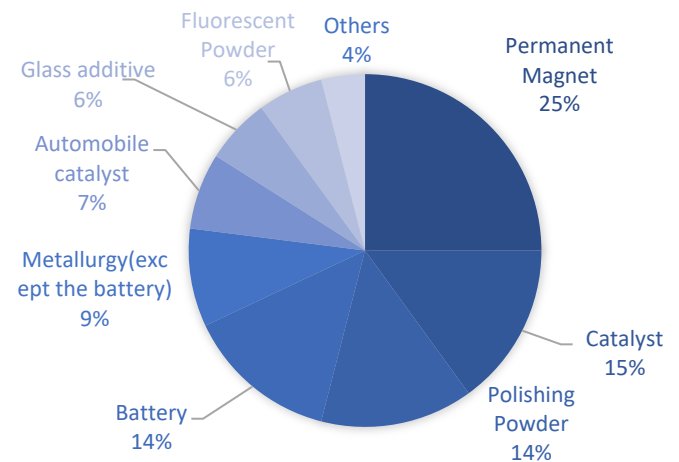
# Material mapping: rare earths – strategic player and secured development

- According to Chinese data, China has world's 2<sup>nd</sup> largest RE reserves (15%)\* after Brazil, is largest producer (90%), exporter (90%) & consumer (65%).
- Japan has more advanced RE processing technology, China exports a large amount of highly-processed RE to >70 countries.
- Some RE such as neodymium, lanthanum, lutetium and their alloys are mainly used for permanent magnets or catalysts of EV batteries.

\* According to U.S. Geological Survey Jan 2018, China has the largest reserve (37%)



## Industrial applications in China (2016)



## China's position and strategy

- China has a **dominant position in RE elements** and many RE resources based industrial development (renewable energy sector). RE elements **will not be the bottleneck** for future EV industry development.
- However, overexploitation, unreasonable industrial structure and serious environmental damage have appeared. Chinese government's current policy is mainly to protect RE resources, coordinate development and **improve RE refining efficiency**.
- China is an absolute **strategic player** in the field of RE. Having a large export volume, it also influences the international market as the Price Maker.
- The future trend is the continued integration of the RE industrial value chains & technology-led fast development of downstream new industries and growing markets.

## Key Chinese producers and final products amount (2016)

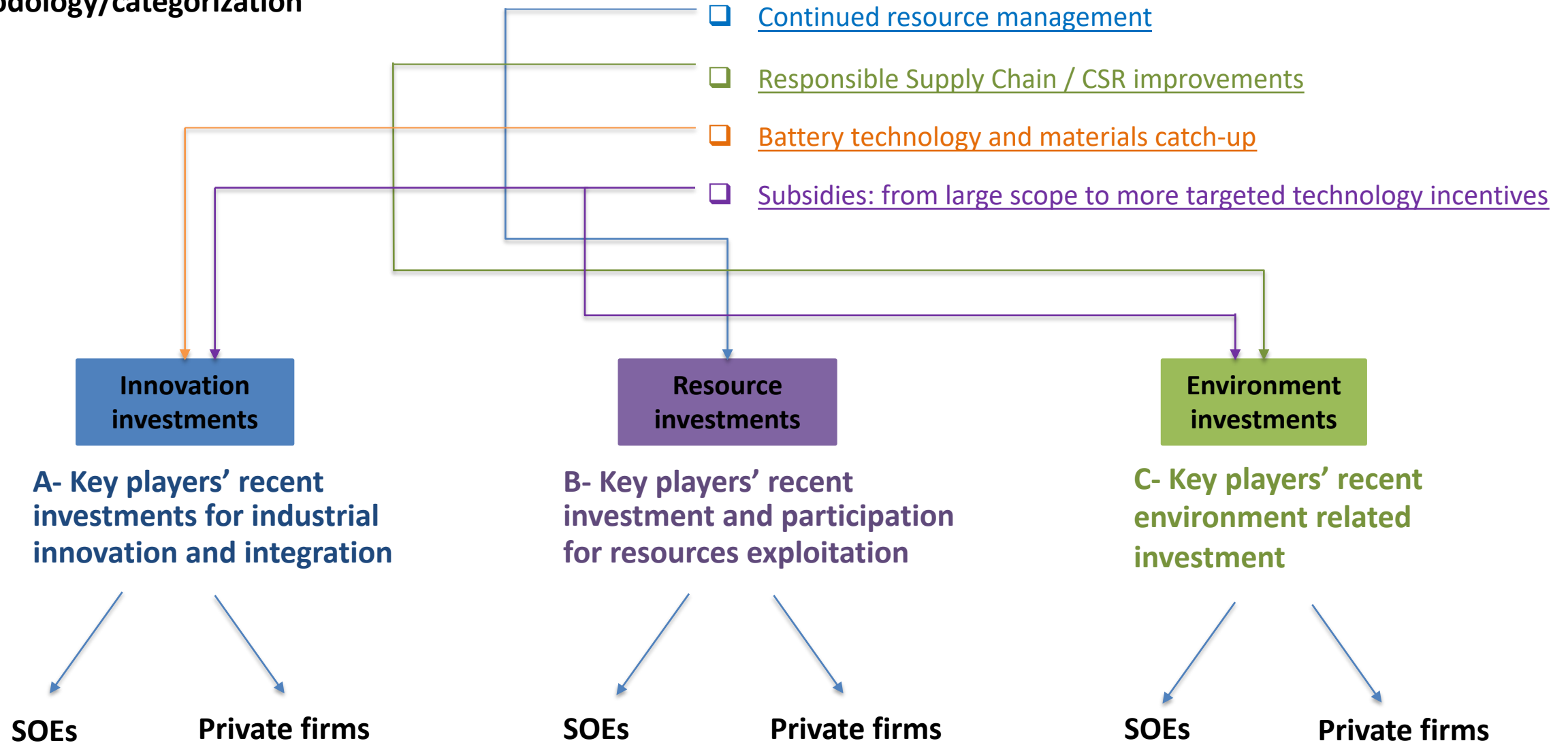
| China Southern Rare Earth Group | Northern China Rare Earth | Aluminum Corporation of China |
|---------------------------------|---------------------------|-------------------------------|
| 46,000t ores (43%)              | 10,000t ores (9.5%)       | 8,500t ores (8%)              |

Source: Mineral Commodity Summaries, Jan 2016





## Methodology/categorization



# Summary

## No absolute mastery by China over materials sourcing, but continued securing management

- China seeks to secure cobalt, nickel & lithium **resource** (mine acquisition/shares, long term contracts)
- China has no real control on cobalt / nickel **prices** or global supplies
- Cobalt procurement is mostly off-market and long term price-secured
- Trends: Chinese companies locating refinery/battery production capacity in resource-abundant countries/regions (Africa/DRC, Indonesia, Australia, South America).
- Trend: Strategic restructuring piloted by the State to integrate industry and form national champions (Minmetals, CNMC, Chinalco)



- More and more globalized supply chain management
- Intercultural management inside huge corporations
- Geopolitical conflicts

## Responsible Supply Chain / CSR: noticeable improvements by large SOEs & leading private Cies

- Major Chinese nonferrous metals groups, EV battery producers and EV makers have implemented related norms and reporting (CNMC, Minmetals, Huayou Cobalt, GEM, CATL, BYD)
- Large groups implement central policies on waste, material recycling, energy saving, emission reduction
- Some private leaders develop profitable business models on recycling business (GEM, CATL, BYD)



- Implementation at smaller size private groups
- Investment capacity, maintenance costs
- Recycling profitability, environment issues

## Battery technology and materials: confirmed EV growth, fast technology catch-up

- SOEs strategic restructuring piloted by the State to integrate industry, lead **R&D programs** and form national champions (Minmetals, CNMC, Chinalco)
- Private leaders are more technologically advanced, which focus on resource recycling and comprehensive utilization and seek larger insertion into global industrial production chain
- International cooperation with major research centers (Japan, California, Germany)
- New cathode types might impact the material consumption (++nickel, +cobalt, +lithium)



- Relation between private leaders and SOEs under strategic restructuring
- Self-develop vs. technology cooperation
- Material supply bottleneck

## Subsidies: from large scope to more targeted incentives

- Meanwhile, continued subsidies are given by the government in technology R&D, waste management, recycling projects and emission reduction measures (under plans of NDRC, MIIT, etc.)



- Qualification and management, public-private R&D mechanisms
- Government financial capacities (given increasing public debts)





## A- Key players' recent investments for industrial innovation and integration

### 1) Key SOEs as operating platforms of the industrial integration and strategic resource management directed by the State

- **Key SOEs are leading actors** in the national industrial technology upgrading and the implementation of all major central plans (Made in China 2025, EV Program, industrial plans, emission reduction, pollution treatment, supply-side reforms). -> **China Minmetals, China Nonferrous Metal Mining Group, Chinalco**
- Financial means that allow SOEs to carry out modernisation to production process usually come from **IPOs**. With new capital raised from the markets and **mainly from institutional investors** (banks, pensions, funds), SOEs are able to invest in more advanced production lines and R&D activities.
- In return, there are different types of **government subsidies** (for technology upgrading, waste treatment, environmental friendly production process, recycling, reducing heavy metal pollution, achieving emission reduction, etc..), which can represent millions of RMB each year.

### 2) Local SOEs as resource provider, innovation labs, rising new leaders or potential targets of key SOEs

- Local SOEs are generally provincial/municipal leaders in its sector and are important contributors to local employment and tax revenues. They are symbolically named 地方性龙头企业 «**local dragon head enterprise**» in the Chinese slang. -> **Jinchuan, Xinjiang Nonferrous, Yunnan Sino-Platinum**
- During 2005-15, with continued reforms on enterprise ownership and industrial upgrading efforts, **local SOEs have assumed crucial roles** in accelerating technology innovation, seeking new economic models and enhancing China's integration into global supply chain through international cooperation (mainly through JVs with more advanced foreign producers).
- Yet, some local SOEs have failed in strong market competition and caused great capital and resource waste. They were whether shut down or merged by other more efficient players.
- In recent years, in order to better and strategically manage national nonferrous resources, the central government is **encouraging M&A among mining and metallurgic groups**, creating some future national champions which are able to optimize the utilization of given national reserves, secure more overseas resource and lead the industrial restructuring to a success.

### 3) Leading private companies, with more advanced technology or strong alliance with foreign leading players

- **Leading private players can be big conglomerates** but usually they are more agile in management and more focused on technology R&D, and more sensible to the market price volatility. -> **Huayou Cobalt, GEM, China Molybdenum, Pengxin Resources, Hanrui Cobalt**
- They also seek expansion into downstream value chain of EV industry, by setting up JVs with battery producers and EV makers, for example in industrial parks dedicated to building a **whole material-processing-battery-vehicle industrial production chain**.
- Some are actively developing new business in **battery materials recycling**, as emphasized by the central government EV sector industrial policy recently.
- As leading players, they usually enjoy **support and relevant subsidies of local government** too, in return of their tax revenue contributions and job creation.



## B- Key players' recent investment and participation for resources exploitation

### 1) SOEs are leading overseas resource acquisition and are actively developing vertical businesses in big project services

- **SOEs are leading actors** in the acquisition of global mining resources. Their subsidiaries are widely present in resource-rich countries and regions. -> **China Minmetals, China Nonferrous Metal Mining Group (CNMC), Chinalco, Jinchuan**
- At the beginning, the typical business model was sovereign aides / local infrastructure projects in exchange for resources, especially in African and South American countries. In recent years, with more private players entering into the global supply chain, the business model has also been evolving towards more market-based type.
- Financial means allowing SOEs to carry out acquisition usually come from **IPOs**. With Capital raised from markets and **mainly from institutional investors** (banks, pensions, funds), SOEs purchase reserves overseas & build refinery there to supply domestic industrial needs. Many of these institutional investors have central government or local **government background**.
- **China Minmetals** operates in 27 countries along the "Belt and Road" and has established 91 wholly-owned companies. It mainly engages in project contracting, resource development, metal smelting, mineral products trading, real estate development, financing services and other services.
- They also collaborate with some major resource owners through project development. NFC, CNMC's subsidiary, is the EPC of Eurasian Resources Group's \$1bn Roan Tailings and Reclamation (RTR) project in the DRC., with >\$700 mn financing by EXIM, ICBC and Sinosure.

### 2) Leading private players focus both on resource securing and insertion in global supply chain

- **Leading private players** often have own overseas subsidiaries operating directly close to raw material reserves, supplying directly to their own refinery lines, producing primary materials for battery application. -> **Huayou Cobalt, GEM, China Molybdenum, Pengxin Resources, Chengtun Mining, Hanrui Cobalt**
- Private players also invest massively in securing upstream resource supply. Compared to SOEs, they often make use of **more diversified strategies**. They use total acquisition, mining share purchase, and also sign long-term contract (3 to 15 years) with major suppliers (Glencore, Freeport, Vincent Mining).
- Major private players raise capital from the **IPOs** too and are often supported by important **private funds**.
- They tend to be more open to international cooperation, actively building strategic alliance with downstream or upstream actors. Compared to SOEs, leading private players are more deeply **integrated in global supply chain**, through their collaborations with foreign partners and clients.
- In 2018, **Huayou Cobalt** established 4 joint ventures with two South Korean groups in producing battery cathode materials.
- Also in 2018, **GEM** was teaming up with 4 other companies (China's top lithium-battery maker CATL and stainless steel-maker Tsingshan Holding Group, Japanese trading house Hanwa and Indonesia PT Bintangdelapan Group) to invest a total of \$700 million in a project to produce **battery-grade nickel chemicals in Indonesia**.

## C- Key players' recent environment related investment

### 1) SOEs focus on waste treatment, CSR and emission reduction, pushed by central policies

- After the 2015 Paris Agreement, Chinese central government into place strict environmental protection regulations to reduction pollution and control CO2 emissions. **SOEs** have to show the way to private firms. They must reduce overcapacity, implement strict waste treatment measures. -> **China Minmetals, CNMC, Chinalco, Jinchuan, Xinjiang Nonferrous**
- Most significant measures are taken in areas of waste water and waste air treatment, heavy metal pollution treatment, energy consumption reduction and energy utilization maximization. Investments are made to improve waste treatment equipment and install more efficient treatment systems.
- Some groups have **developed by-product** using waste gas/liquid or boiler waste, or improve its recycle capacity to **reuse valuable metals and materials**.
- **Jinchuan** dealt with pollution problem by integrating by-products re-utilisation (CO2, SO2, waste heat, etc.) into its new production process. It also carried out a series of sewage and heavy metal treatment projects, such as acid wastewater reuse facilities and increased rare metals recycling.
- SOEs also involve in social contributions to local development, especially in community relations, school building, public facility financing, healthcare, etc. and mostly in under developed regions or zones, which often provide important resource reserves. Its both **a social engagement and a corporate long-term development strategy**.
- Government provides specific subsidies to each environmental protection measure (treatment equipment modernization, emission reduction, waste metal recycle, energy-saving, etc.)

### 2) Private leaders focus on new businesses of recycling and reuse, building comprehensive utilization of resources

- **Leading private players** have carried out waste reduction and emission reduction measures, but most importantly, they focus on developing new business models in waste recycling and reuse, in order to improve cost/profit efficiency, and to guild a **full life-cycle battery material supply chain**. -> **Huayou Cobalt, GEM, Pengxin Resources**
- With EV sector's fast growth, the needs to develop waste battery recycling capacity are becoming strong, and government has also been promoting relative business development.
- **GEM** is a leader in waste battery material recycling, with dedicated industrial parks built in several key provinces (Hubei, Jiangsu, Zhejiang), close to suppliers and clients. In 2017, GEM dealt with over **3 million tons of waste resources**, recovered 37 kinds of resources and rebuilt 58 kinds of products, saving 403 million tons of standard coal, reducing water pollution by 1024 million tons and reducing 1058 million tons of CO2 emissions.
- To private leaders, government also provide subsidies. Some projects are also listed in national pilot programs, receiving direct financial and political support. For example, **Huayou Cobalt's** projects have been selected into **MIIT 2016 Green Manufacturing System Integration Project & NDRC 2016 Resource Conservation and Environmental Projection Project**.

# Battery reuse/recycle: Industrial policy and booming EV market pushed business rush by all major Chinese battery makers and material suppliers.

## Worldwide mapping

- It is estimated that by 2020, the sales of used batteries will reach 3 million. Recycled batteries can be used in static energy storage devices. Used batteries or alternative power systems for short-distance and low-speed vehicles are designed to replace current lead-acid batteries.
- Nissan, Renault, BMW and the **Chinese BYD** have invested in several projects and commercial initiatives aimed at giving used battery a second life.

## China

- There are **three main types of direct participants in the field of power battery recycling**:
  - (1) lithium battery **materials**: by Huayou Cobalt, Xiamen Tungsten and Tianci Materials, they mainly recycles **resources**.
  - (2) Power battery **system**. BYD, Optimum (**now in financial crisis**), Guoxuan Hi-Tech, CATL and BAK batteries. The entry of these enterprises is due to the increase in prices of upstream materials and the intensification of market competition, targeting reduced costs and closed loop for lithium
  - (3) Dedicated recycling/dismantling companies : GEM, Hunan Brunp Recycling, Zhangzhou Haopeng, Fangyuan Environmental Protection and so on. State Grid, China Electric Power Research Institute, Beijing Automotive New Energy, Pride have demonstration commercial energy storage projects.
- **GEM 2016** with Samsung, CATL, BYD, Dongfeng set a new energy lifecycle value chain of “**Battery Recycling - Material Reengineering - Battery Pack Remanufacturing - Automotive Reassembling**”.
- **BYD** (2/5 of new energy passenger vehicles in China) is industry leader in implementation the national policies of *Technology policy for the recycling and utilization of electric vehicle power batteries*. The waste batteries processed at its battery recycling plant.
  - BYD entrusts authorized dealers to recycle used power batteries. When customers need to replace power batteries, dealers will take power batteries out of the car body and send them to BYD Baolong factory for preliminary testing. **If the batteries can be reused, they will be applied in areas such as home storage or base station backup power (“cascade utilization”)**. If the battery cannot be recycled, it will be shipped to the relevant departments of the material factory in Huizhou, using wet recycling method for dismantling.
- China Railway Tower, Chongqing Changan, BYD, Yinlong New Energy, Optimum, Guoxuan Hi-Tech, Thornton New Energy and other 16 companies have together signed a strategic partnership agreement for the recycling of new energy vehicles' power batteries. Camel Group, BYD, CATL, Huayou Cobalt, Guoxuan Hi-Tech, AVIC Lithium and other battery manufacturers have all launched a layout in the field of power battery recycling.



## China has largely improved its EV material supply,

- but it has to continuously and carefully manage the gap between supply and demand,
- especially given the foreseeable fast growth of the Chinese EV market

### Improved global market position:

#### 1. Fundamental factors: technology catch-up + value chain integration

- China's economies of scale and dynamic ecosystem, using «**market & production capacity for technology**» to get cooperation with EU/Asia leaders, deepening its industrial development by co-investing in projects domestically and abroad.
- With on-going integration in mining, material refinery, component production, battery manufacturing & material recycling, a **whole industrial value chain** gradually got formed in China, providing leading companies with strong negotiation power.

#### 2. Long-term factors: securing supply + national policy

- As a major refining country, despite resource dependency, large refiners benefit from size effect to negotiate **long-term purchase contract** to mitigate market volatility.
- Chinese EV battery makers participate in the global EV chain also as **China's subsidy policy** obliges foreign EV carmakers to use Chinese batteries. China's Policy impact on industrial development will stay important on the long-term.

#### 3. Short-term factors: resource for infrastructure + acquisition

- By merits of the state capitalism, Chinese government, banks and industrial groups have collaborated in «**resource for infrastructure**» deals. But it is difficult to judge the model's efficiency. It gradually gives place to more monetary-based transactions.
- Both Chinese SOEs and private companies are making important **investment and acquisitions** to reinforce control on mine resources. But there are limited mines available for acquisition and DRC's mining policy is getting more strict.

### Future trends/challenges:

#### 1. Market factors: How fast will EV sector demand increase?

- China committed to greening its economy, reducing CO2 emission and building a sizeable EV market by 2030, leading to **increasing needs for EV materials**. With material efficiency, demand increase might be slower than EV schedule.
- Many companies are improving refinery efficiency and carrying recycle material, thus **increasing material utilisation rate**. This will reduce supply pressure.

#### 2. Policy factors: Will China reach technology independency? Norms setting?

- Chinese EV battery makers still depend on **EU/Japan/South Korea/US partners' technology**. This may change with leading Chinese players upgrading capacity.
- Competition among Chinese companies is increasing. Heating up of the EV industry, requesting for standards/norms and better market organisation. Given its EV market weight, China will influence **setting the global EV industrial norms**.

#### 3. Financial factors: Investment under how much risk?

- Great amount of **public & private investments** are directed to EV materials & EV battery sectors, creating large industrial bases in different provinces. These investments bear costs and **financial pressure** on governments and companies.
- If the EV market growth reaches expectations, Chinese companies will need to make **further investment** to secure raw materials supply; if the growth is less than expected, they might face **financial losses** on their manufacturing projects.

# Alternative technologies to reduce cobalt content

**Chinese major battery makers are actively investing in next generation high nickel / lower cobalt batteries, but the technology gap with foreign leaders still exists.**

## Projects at mass production horizon

- **China Metallurgical Ruimu New Energy Technology** (China Metallurgical Group's JV with BYD and two other investors), annual output of 40,000 tons of high-nickel ternary precursor (NCM622) and by-product high-purity cerium oxide (20 tons/year); second phase 2020, annual output 60,000 tons of high-nickel ternary precursor (NCM811) and by-product high-purity cerium oxide (40 tons/year).
- **BAK Battery 3.0 Ah cylindrical 18650 battery NCM811 mass-produced**, energy 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 manufacturing system for multispecies used in lithium-ion battery materials, including **NMC precursor, NCA precursor, NMC ternary material, NCA ternary material**, (20% of the Chinese market).
- **Guoxuan Hi-Tech** high nickel 811. ternary 811 soft-packed battery 302Wh/kg. pilot line.
- **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 series under development.
- Since 2016, **Koba Power Battery** (subsidiary of Hunan Corun Energy) produces Ni-H2 power battery for hybrid vehicles (FAW Toyota, GAC Toyota). Annual output is 100,000 sets and the new generation Ni-MH power battery packs will be used in hybrid cars and buses, FC buses, fast charging buses.

**China follows the trend of solid-state batteries. A few players are at early technology stage and are planning mass production.**

## Vision – national strategic research

- The Institute of Materials Science of the Chinese Academy of Sciences (CAS), Qingdao Institute of Energy, CATL, AVIC Lithium, BYD, Ganfeng Lithium and many other research institutions and power battery companies are engaged in solid-state batteries.
- Over 2013-2018, the research team of “All Solid State Battery” published 28 research papers, applied for 49 national invention patents (9 were authorized and 2 transferred for technology application).

## Some early projects

- The startup "Qingtao" (founder, from Tsinghua University & CAS), built China's first solid-state battery production line in Kunshan. **Its annual capacity scale is 100 MWh (700 MWh target by 2020)**, with a single energy density of 430Wh/kg. Once mass production is reached, the density of finished products can be 300Wh/kg or more.
- In 2018, Ganfeng Lithium Industry announced a solid-state battery pilot production line in Ningbo, similar with the current lithium-ion batteries, with a difference in the membrane: coated with a layer of solid electrolyte. There will be second-generation and third-generation solid-state battery products (the third one should be a real solid-state lithium battery, using a solid electrolyte as a separator, a negative electrode with lithium metal and a positive electrode with NMC811).



## Life Cycle Assessment of EV in China: **an actual debate at both political and industrial levels, with very clear recommendations on greening energy mix; but might be slow to change**

**Situation: Pollution in China's NEV industry chain may still exceed that of internal combustion engines:** Considering the battery production process and coal-fired power generation, CO<sub>2</sub> and PM<sub>2.5</sub> / km release are roughly equivalent. Recycling of batteries is a huge pollution, and recycling system is in its infancy.

Based on the above system analysis, for China's current energy structure and overall technical level, the impact of pure EVs on mineral resources, energy consumption, and integrated emissions on the environment is more negative than that of traditional internal combustion engine vehicles.

**Trend:** power plant emissions are monitored. Fuel structure + power plant emissions control improve; power gen. sewage discharge will reduce by more than half by 2030.

**KPI In 2017, was proposed the idea of establishing a “China Automotive Energy Emission Factor Evaluation and Release Procedure”.**

- Wang Binggang (Professor of the China Automotive Technology and Research Center, the leader of the expert group of the National Clean Vehicles Action Coordination Leading Group, the Special Expert of the Major Technology of Electric Vehicles under the 863 Program of the Ministry of Science and Technology, the Director of the Technical Committee of the National Electric Vehicle Technology Innovation Alliance, and the National New Energy Team Leader of Automotive Innovation Engineering).



# Gradual developments of the Chinese guidelines on mineral supply chain

## A clear engagement of China to embrace global norms

- **“Guidelines for Social Responsibility in Chinese Outbound Mining Investments” (2014)**

Launched in 2014, the “Guidelines for Social Responsibility in Chinese Outbound Mining Investments” represent the first industry specific guidance on social responsibility for the Chinese mining industry and are structured along **eight social responsibility issues** (organizational governance, fair operating practices, supply chain management, human rights, labour issues, occupational health and safety (OHS), environment, community development). The Guidelines are **essentially based on ISO 26000** with some exceptions to better reflect the specifics of the mining industry

- **“Chinese Due Diligence Guidelines for Responsible Mineral Supply Chains” (2015)**

CCCMC, in close cooperation with the OECD, developed the guidelines in 2015. They provide guidance for Chinese mining companies to integrate social and environmental factors into their investment decision making and operations abroad and to continuously improve their economic, social and environmental performance. According to the CCCMC, these use the **UN Guiding Principles on Business and Human Rights** and the **OECD Due Diligence Guidance on Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas** as their basis, and are intended to promote integration and coordination with other related standards, regulations and initiatives

- **“Sustainable Mining Action Plan” – SMAP (2016)**

On Nov. 22<sup>nd</sup> 2016, CCCMC, the UK Department for International Development (DFID) and German International Cooperation Agency (GIZ) together developed a three-year action plan to globally establish the guidelines and to achieve a maximum impact in the mining sector, by ensuring a structured and coordinated implementation. The DFID supports the implementation of SMAP through a **co-financed cooperation** with Emerging Market Sustainability Dialogues (EMSD). SMAP is the **first Sino-UK cooperation project** under the framework of the Sustainable Development Cooperation MoU signed by the Chinese government and the UK government, aimed at promoting the sustainable development of the outbound investments of Chinese enterprises through the collaboration of the stakeholders including the government, enterprises, international organizations, NGOs and the local communities.

- The progress in responsible mineral supply chain management is led by **China Chamber of Commerce of Metals Minerals & Chemicals Importers & Exporters (CCCMC)** with over 6,000 member companies.
- We observe a clear will of **China to participate in the global trend on responsible mining**. Chinese authorities actively collaborate with UN, OECD, ILO, IFC, ICMM to set industry norms & practices to satisfy claims from clients, partners, NGOs, as well as the general community.
- We see a **progressive concretization** of these norms and practices, with leading Chinese companies gradually applying responsible management standards. China Nonferrous Metal Mining Group, China Minmetals, China Molybdenum, Huayou Cobalt, Jinchuan, etc. are examples.



# China has adopted different mechanisms of subsidies and incentive policies for NEV sector

## 1) Key R&D Programs

- Under the **13<sup>th</sup> Five-Year Plan**, the Ministry of Science and Technology (MOST) launched a series of NEV projects since 2016.
- **In 2017, 18 NEV R&D projects were set up and the national R&D funds exceeded 669 million yuan.**
  - Main undertakers are Zhongtong Bus, FAW, Chery, China Aviation Lithium Battery, Guangqi, Beijing Institute of Technology, Tianjin University, Xi'an Jiaotong university, Tongji University.
- **National Key R&D Plan**, (2015), is the strategic structure to provide support and guidance for the country's technological, economic and social development.
  - It merged the previous National Key Basic R&D Program (973 Program), the National High Technology Research and Development Program (863 Program), the National S&T Support Program, the International Science and Technology Cooperation and Exchange Program, the Industrial Technology R&D Fund, and the Public Welfare industry research projects, etc.
- On May 7<sup>th</sup> 2018, the MOST released the **2018 National Key R&D Plan** focusing on 8 major research areas with a 3-year project cycle. **One area is NEV including 25 specific projects** such as energy lithium battery technology, self-driving electric vehicle testing and evaluation technology, full-power fuel cell passenger car power system platform and vehicle, which corresponds to **a total 820 million yuan R&D funds.**
  - Major companies and research centers concerned by the plan are Tianjin Lishen Battery, Yutong Bus, Dongfeng, Chang'an, CRRC Times Electric Vehicle, SAIC, China Automotive Technology & Research Center, Shanghai International Automobile City, etc.

## Some current results

- In 2016, three out of top four sellers of NEV worldwide were from China, **BYD, Geely and Beiqi** (BYD: 100,178 units, Tesla: 76,000 units, Geely: 49,218 units, Beiqi; 46,420 units). **Yutong Group** takes a leading position in the bus sector and so far 26,835 electric buses have been sold to >30 countries in the world.
- **7 Chinese power battery enterprises'** have long range of more than 400km with energy density of 140Wh/kg. However, compared to Samsung's latest lithium battery with cruising distance of more than 600km and Panasonic's Cylindrical battery with energy density of 340Wh/Kg, China still lags behind.



# China has adopted different mechanisms of subsidies and incentives policies for NEV sector

## 2) Subsidies to NEV consumers

- In 2017 the Chinese central government paid a subsidy of 20,000 to 44,000 yuan (\$3,000 to \$6,600) to each EV, while most local governments increased these figures by 15% to 50%. **In 2017, an average subsidy of \$ 10,000 per EV was calculated.** Therefore, for a total of 770,000 EV produced and sold in 2017 (+ 53% compared to 2016), the central government and local authorities have already **spent \$7.7 billion on subsidies for the purchase of electric vehicles.**
- The government plans to **gradually reduce direct subsidies by 2020** and has **reduced subsidies to low mileage NEVs.** The rapid development of a number of leading enterprises (BYD, Beiqi, Yutong), the gradual maturity of the market and the energy vehicle subsidy fraud in 2016 all accelerated this.
- In February 2018, the four ministries of China published the new subsidy policy, lowering the subsidy for different types of EVs with battery range of less than 300 km. At the same time, the incentive for EVs with a range of 400 km is increased to 50,000 yuan. It also plans to impose a battery life of 200 km to legitimize the financial subsidy instead of 150 km currently. It is estimated that the **average subsidy for EVs next year could be reduced by more than 30% compared to 2018.**

## 3) Incentives policy

- **Purchase tax exemption policy:** after its first implementation from 1 Sept 2014 to 31 Dec 2017, the total exemption of purchase tax for NEV is extended for another 3 years for 1 Jan 2018 to 31 Dec 2020.
- **Auto loans policy:** from 1 Jan 2018 on, the auto loans for traditional fuel vehicles will remain unchanged at 80%; **the maximum loan ratio for NEV will increase from 80% to 85%;** and the maximum loan ratio for used vehicles will increase from 50% to 70%.
- In addition to subsidies, many cities offer preferential policies for EV, such as granting special licenses or creating dedicated lanes. Compared to fuel vehicles, EVs have a higher probability of obtaining license plates, often very difficult in cities like Beijing or Shanghai. According to some experts, **about 95% of owners** of electric cars in China buy electric cars not for environmental protection but for **"pragmatic" reasons**, such as easier access to license plates in large cities.
- Sales of NEV have not achieved official targets between 2013 and 2015; to fill the gap, governments have encouraged their use in the logistics sector from 2015. With rapid development of e-commerce, logistics has also developed, therefore, new energy logistics vehicles play an important role in environmental protection. State subsidies for new energy logistics vehicles are different from other types of vehicles, usually more generous and for longer period. **Preferential policies for pure electric logistics vehicles** are adopted by **37 provinces and major cities** such as Beijing, Shanghai, Guangdong, Tianjin, Shenzhen and Wuhan.



## **ANNEXES**

- A1. China's increasing control on cobalt supply chain**
- A2. Player profile – Huayou Cobalt, China GEM**
- A3. Major investments in battery technology upgrade**
- A4. Battery reuse/recycle projects list**
- A5. NEV sector trend in China**
- A6. Chinese government subsidy standards for NEV**



## A1. China and Cobalt: increasing control on supply + complementary long-term strategy

China produced about **58%** of global refined cobalt in 2017 (with about 98% of raw material imported from DRC). For the 58% cobalt output, about **24.5%** is with self-supplied mines and about **13.7%** is secured by long-term purchase contract, in total representing a stabilizing **38.2%** majority. Therefore, we could consider that China has a relatively good control on its cobalt supply.

### Major Chinese cobalt miners (24.5% world supply):

**China Molybdenum:** acquired 70% stake from Freeport-McMoRan in Tenke Mine in 2017 which produced 16,420 tons cobalt in 2017 (**10.5% world**);

**Huayou Cobalt:** Total cobalt products 23,700 tons in 2017, with mine resource self-supply rate about 45% => about 4,000 tons cobalt metal in 2017 (**3.6% world**)

1) CDM (Congo Dongfang International Mining): Huayou wholly-owned, annual capacity: cobalt hydroxide 12,000 tons

2) MIKAS: Huayou owns 72%, equivalent to 3,684 tons cobalt metal per year (ready in mid 2019)

**Jinchuan:** acquired Metorex in South Africa in 2011, which produces 6,400 tons cobalt in 2017 from its Ruashi Mine in DRC (**5.8% world**)

**Comika:** about 3,000 tons since 2017 (about **2.7% world**)

**Sicomines/China Railway Resources:** 1,900 tons planned in 2018 (**1.3% world**), from MKM in DRC; is expanding to 4,500 tons per year in coming years

**China Nonferrous (CNMC):** In DRC: 800 tons cobalt in 2018 (about **0.6% world**); increase to 7050 tons in 2019, 8150 tons in 2020 (probably together with Gecamines)

**(Hanrui:** 4,000 tons cobalt through DRC subsidiary Metal Mines (not directly owned, but local procurement for roughing and export))

### Long-term purchase contract (13.7% world supply):

**CATL:** signed a 4-year provision agreement in October 2016 with Glencore for securing cobalt supply to **up to 20,000 tons** (5,000 per year, **4.5% world**).

**SMCO:** signed a 15-year copper-cobalt provision agreement on February 25, 2018 with Vincent Mining, for **> 1,500 tons/year** (about **1.2% world**) **cobalt metal**.

**GEM:** signed a 3-year cobalt hydroxide provision agreement with Glencore on March 15, 2018 to obtain **13,800 tons** cobalt in 2018 (about **8% world**), **18,000 tons** cobalt in 2019 and **21,000 tons** cobalt in 2020.

**Beijing Easpring Material Technology:** signed a **5-year** nickel and cobalt sulphate provision agreement with **Scandium21** on August 30, 2017 (of **20% planned output**).

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### Major foreign cobalt miners (45% world supply):

**Glencore:** 27,400 tons cobalt metal production in 2017 (**25% world**); acquired 100% Mutanda Mine and 86% Katanga Mine from Fleurette Group in 2017

**Eurasia Resources Group:** With Mukondo Mountain mine and other medium-sized mines, has a current production capacity of about 6,000 tons (**5% world**)

**Vale:** 5,800 tons in 2017 (**5.27% world**); 41% of which is sold to China

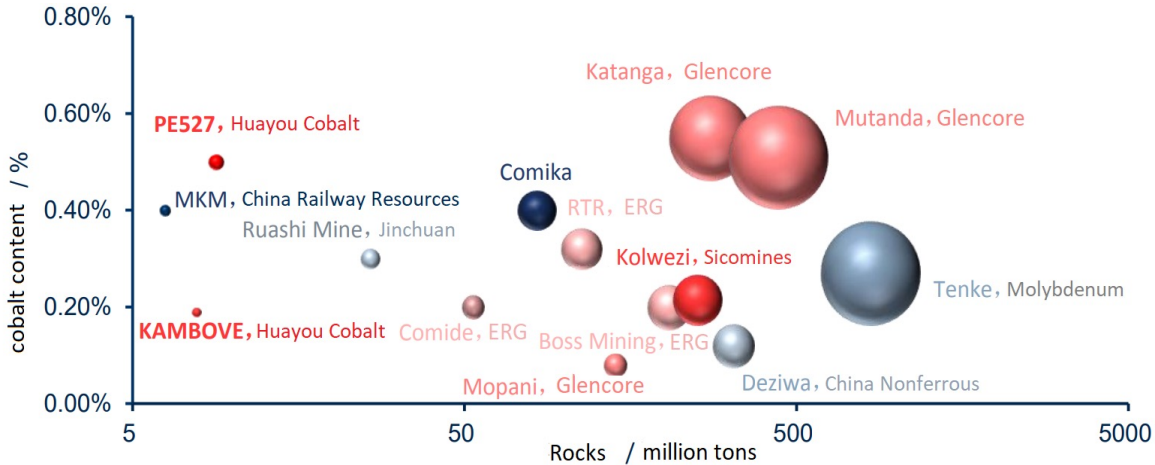
**Gecamines:** 4,167 tons in 2016 (**3.38% world**); with minority interests in major DRC mines, controlled by companies such as Glencore, Freeport and Ivanhoe Mines

**Shalina Resources:** through the Etoile Mine, produces 4,000 tons cobalt per year (**3.6% world**)

**Sherritt:** 3,600 tons in 2017 (**3.28% world**)

# A1. China and Cobalt: increasing control on supply + complementary long-term strategy

Major DRC cobalt mines and owners



Source: CITIC Securities, Jan 2018

Chinese companies's cobalt project development

| Company                 | Project           | Place      | Capacity (metal, tons) | PFS | DFS | Pilot | Finance | Build | Start operation | Full operation |
|-------------------------|-------------------|------------|------------------------|-----|-----|-------|---------|-------|-----------------|----------------|
| Molybdenum              | Tenke             | Fungurume  | 16000                  |     |     |       |         |       |                 |                |
| Jinchuan                | Ruashi Mine       | Lubumbashi | 3500                   |     |     |       |         |       |                 |                |
| Comika                  | Kamoay phase 1    | Kambove    | 3500                   |     |     |       |         |       |                 |                |
| China Railway Resources | MKM               | Kolwezi    | 1200                   |     |     |       |         |       |                 |                |
| Sicomines               | Sicomines phase 1 | Kolwezi    | 800                    |     |     |       |         |       |                 |                |
| Huayou                  | PE527             | Lubumbashi | 3000                   |     |     |       |         |       |                 |                |
| Huayou                  | Mikas (upgrade)   | Kambove    | 1000                   |     |     |       |         |       |                 |                |
| China Railway Resources | Luisha            | Lubumbashi | 1000                   |     |     |       |         |       |                 |                |
| Molybdenum              | Tenke expansion   | Fungurume  | 2000                   |     |     |       |         |       |                 |                |
| Sicomines               | Sicomines phase 2 | Kolwezi    | 6000                   |     |     |       |         |       |                 |                |
| China Nonferrous        | Deziwa            | Kolwezi    | 10000                  |     |     |       |         |       |                 |                |
| Comika                  | Comika phase 2    | Kambove    | -                      |     |     |       |         |       |                 |                |

Source: CITIC Securities, Jan 2018

## On the short-term / mid-term market and trade pattern look stable:

- **EU and US still dominate global cobalt supply market and enjoy pricing power:** European and American companies, relying on Congo's unique colonial history and their first-comer advantage, basically control the large-sized and content-rich mines with service life over 25 years. Therefore, they can better resist the sharp drop in prices and have more constant cash flows. The future increase in global cobalt supply is also mainly based on the expansion of existing European and American large mines.
- **China has increasingly secured supply for its industrial demand, but there is limited room left of improvement; China needs to better manage long-term supply:** China accounts for about 50% of the world's midstream smelting capacity and its downstream new energy vehicle market accounts for half of the world, but until very recently China still produces very little cobalt ore. With increasing acquisitions in mine ownerships and related companies, particularly through the last few years, Chinese companies have managed to secure part of the cobalt rock supply from DRC. Yet, except for China Molybdenum who bought over the Tenke Fungurume mine and China Nonferrous & Sicomines who have important potential reserves in Kolwezi, other Chinese groups have limited mine resource and capacity which can only partially support their development needs. It is even more critical as China has set clear objectives to develop EV market and many industrial projects are already underway, with considerable investments from both public and private sides.



# A1. China and Cobalt: from the old «resource for infrastructure» to the market-based long-term purchase contract

- Resource for infrastructure : difficult to evaluate gains/losses and control risks – the case of Sicominex**

Sicomines is a DRC-based mining company owned by China Railway Group (41.72%), China Power Construction (25.28%), Huayou Cobalt (1%) and DRC's SOEs Gecamines (32%). It was the first and the biggest “resource for infrastructure” deal that China and DRC undertook in 2008. DRC agreed to use 10.6 million tons copper and 627,000 tons cobalt to pay back the US\$ 3 billion infrastructure loan from Chinese banks. The infrastructure projects are also assumed by Chinese companies.

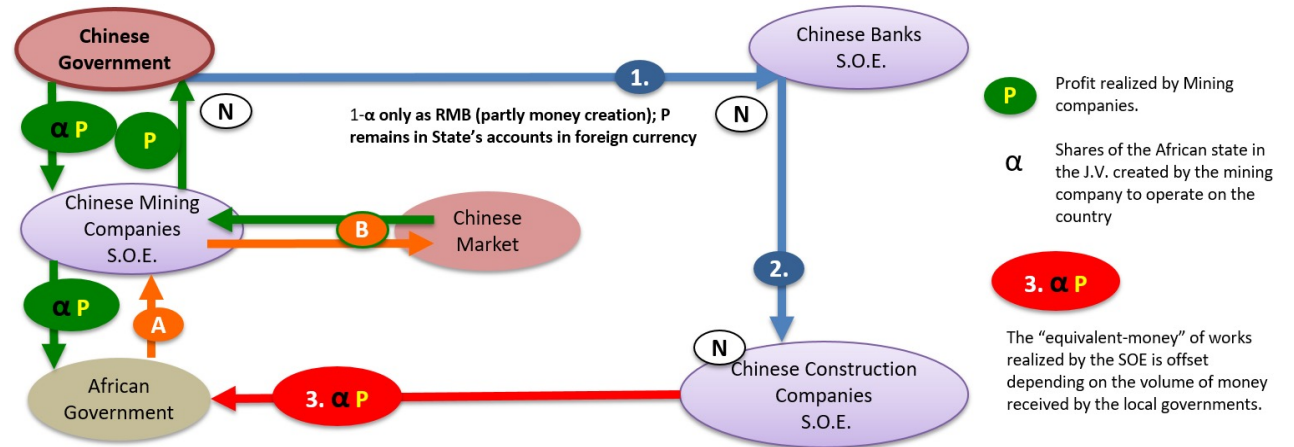
Sicomines, which operates a \$3.2 billion mining project, accounted for 25% of DRC's total exports in 2016. It mainly exported in the form of copper concentrate rather than electrolytic copper and metal cobalt with higher output value. On October 2<sup>nd</sup>, 2017, DRC's Minister of Mines said that the government wants to “ensure timely repayment” of the country's \$6 billion worth of mineral debt to China, therefore Sicomines must make “products of higher output value” as its operating profit is used to repay China's loan. On October 10<sup>th</sup>, 2017, the DRC banned Sicominex from exporting unprocessed copper and cobalt mines. However, as the DRC government revenue relies heavily on taxation on exports of minerals, it makes the ban hard to carry out. A major problem is the lack of available electricity. China Hydropower and China Railway are currently financing \$660 million to build a 240 MW hydroelectric power station to meet the production needs of Sicominex.

The efficiency of the deal is uncertain. At one side, the DRC government was in a weak position in the negotiations after being refused loans by western banks; on the other side, China may have made negative profits since the prices of copper and cobalt have dramatically dropped from 2008 to 2016.

- Long-term purchase contracts : a stabilizing new practice for both parties**

- ✓ In October 2016, the Chinese EV battery producer **CATL** signed a **4-year** provision agreement with **Glencore** for **securing cobalt supply to up to 20,000 tons**.
- ✓ On February 25, 2018, **SMCO** (subsidiary of Shanghai **Pengxin Resources**) signed a **15-year** copper-cobalt concentrate provision agreement with **Vincent Mining LLC**, which corresponds to **> 5,500 tons/year copper metal** and **> 1,500 tons/year cobalt metal**.
- ✓ On March 15, 2018, **Glencore** agreed to sell a total of **52,800 tonnes of cobalt hydroxide to GEM in three years**, including 13,800 tonnes in 2018, 18,000 tonnes in 2019 and 21,000 tonnes in 2020.

## The old model : Resources Vs. Infrastructures

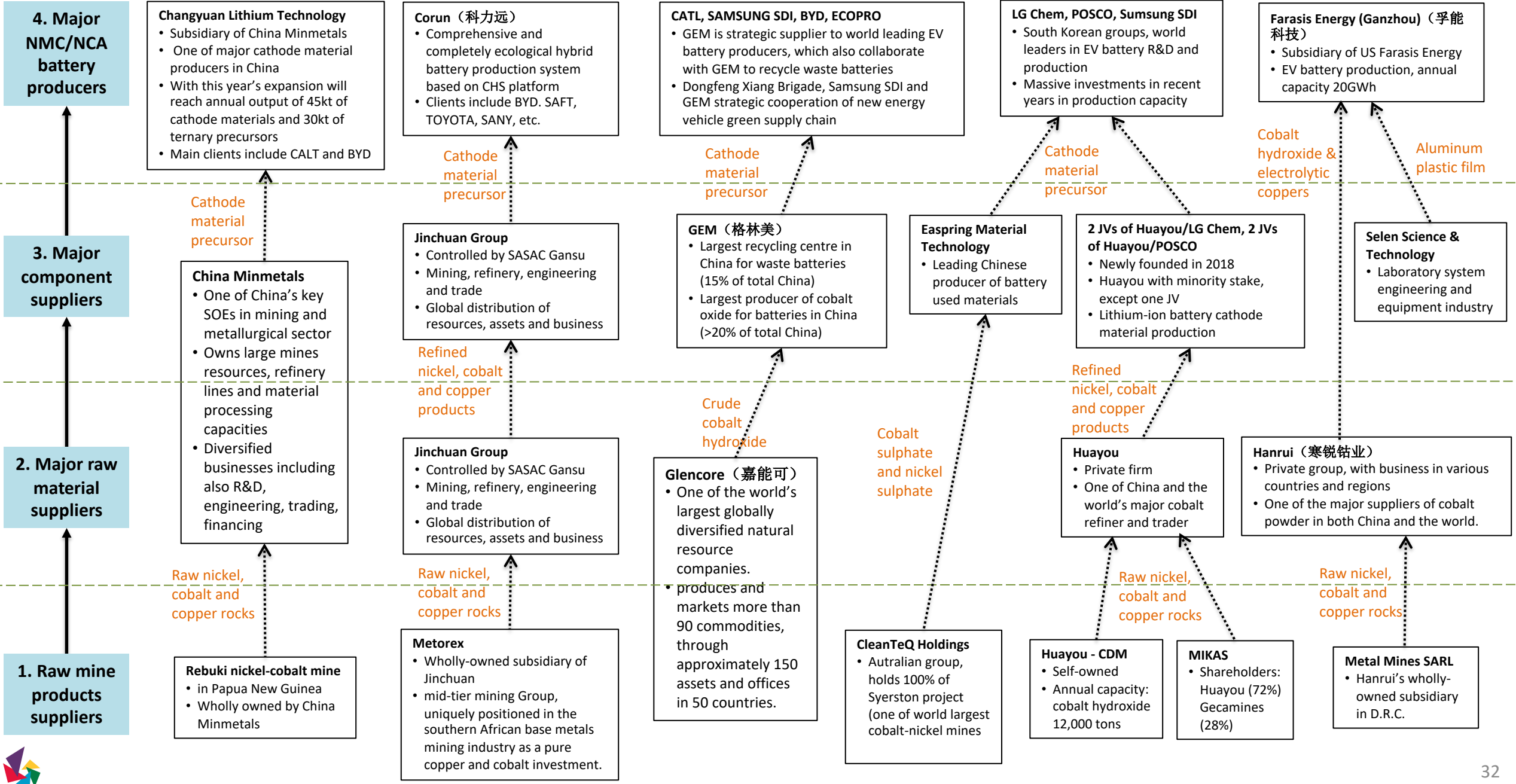


Agreements between Chinese government and African government. China grants a loan\* to the African government. This loan is granted under the form of infrastructure development projects, in exchange of a definite amount of minerals. The money remains in China.

- The money equivalent to the minerals shipped to China is guaranteed by a deposit on a Chinese bank account.
  - Chinese Banks pay directly Chinese construction companies.
  - Chinese construction companies realize works in Africa for a value equivalent to the value of the minerals given to the mining companies.
- A:** Chinese mining companies extract the minerals or are in charge with its shipment to Africa.
  - B:** Chinese mining companies sell the minerals on the Chinese market and get money.
  - N:** On a financial point of view, the operation is neutral for the operator. The money received is equivalent to the money spent or to the value of the service.

Source: previous internal analysis

# A1. Example mapping of cobalt-battery supply chain





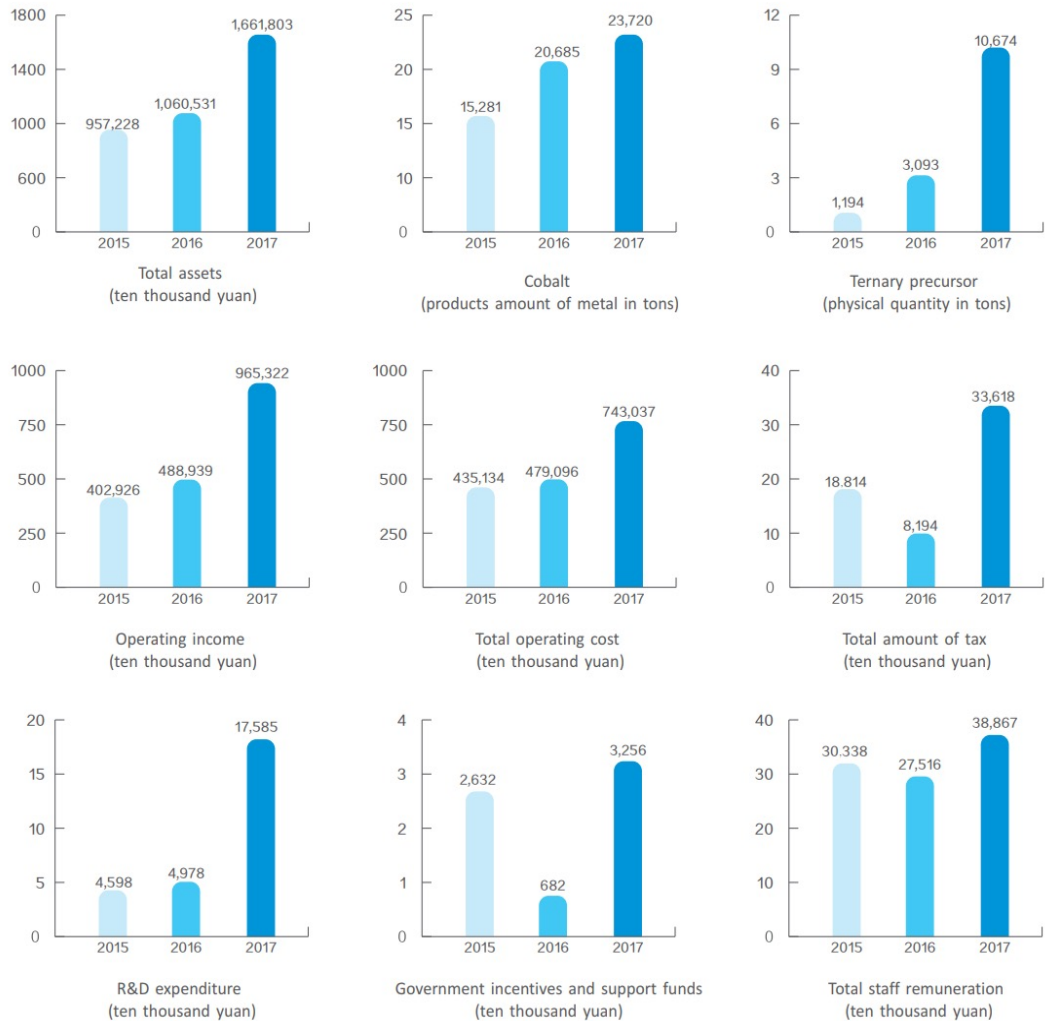
## A2. Key player profile: Huayou Cobalt (Zhejiang)

|  |  |
|--|--|
| <b>Business Scope</b>  |  |
| <ul style="list-style-type: none"> <li>Main activities: nonferrous smelting of cobalt, nickel and copper, and the cobalt new materials deep processing; manufacture of materials for lithium electric power</li> <li>Main productions: cobalt tetroxide, cobalt oxide, cobalt carbonate, cobalt hydroxide, cobalt oxalate, cobalt sulphate and cobalt monoxide; mainly used for Li-ion battery cathode material, high temperature and cemented carbide, frits and glazes, rubber adhesive and petrochemical catalysts</li> <li>The largest cobalt chemicals producer in China</li> </ul>   |  |
| <b>Strategic goals</b>   |  |
| <ul style="list-style-type: none"> <li>Establish "two new and three chemicals" strategy and open the whole industry chain of lithium electric energy materials from cobalt material to cathode material.</li> <li>Production scale: the company will further strengthen the exploration of resources and improve the integrated operation of mining and metallurgy. The self-supply capacity of cobalt (including local trade acquisitions) will reach 50%.</li> <li>Industry cooperation: the company will strengthen the cooperation and industrial synergy with downstream customers to achieve the synergy between ternary precursor and cathode materials, and actively promote the cooperation with the world top 500 enterprises such as POSCO and LG.</li> <li>R&amp;D: nonferrous metal smelting, waste battery recycling, energy storage and other fields</li> </ul> |  |
| <b>Capability and reserves (March 2018)</b>  |  |
| <p>1. Total production capacities:</p> <ul style="list-style-type: none"> <li>Cobalt – 24,900 t / year (target 30,000 t in 2018)</li> <li>Nickel – 10,000 t / year</li> <li>Copper - 50,000 t / year</li> <li>Ternary precursor- 20,000 t / year</li> </ul> <p>2. Total reserves (ore volume):</p> <ul style="list-style-type: none"> <li>Cobalt –20.69 million tons</li> <li>Copper – 31.42 million tons</li> </ul>   |  |
| <p>Total reserves (metal equivalent):</p> <ul style="list-style-type: none"> <li>Cobalt – 70,400 t</li> <li>Copper – 584,000 t</li> </ul>  |  |

| <b>Background</b>  |                   |                   |                  |      |      |      |      |      |       |      |      |      |      |      |      |
|--|-------------------|-------------------|------------------|------|------|------|------|------|-------|------|------|------|------|------|------|
| <ul style="list-style-type: none"> <li>2002: company originally established</li> <li>2006: CDM was founded in Congo (DRC) to acquire and process mineral resources.</li> <li>2008: acquired 75% interest in MIKAS held by West Mining international company.</li> <li>2015: ternary precursor project was built</li> <li>2018: the company and Pohang (POSCO) established two new joint venture companies: Zhejiang Hua You Pohang New Energy Co., Ltd. and Zhejiang Pohang Hua You New Energy Co., Ltd. They mainly engaged in R&amp;D, production and sales of lithium battery related precursors.</li> <li>Ranked 233rd among the top 500 global new energy enterprises.</li> </ul> |                   |                   |                  |      |      |      |      |      |       |      |      |      |      |      |      |
| <b>Structure and sales</b>   |                   |                   |                  |      |      |      |      |      |       |      |      |      |      |      |      |
| <ul style="list-style-type: none"> <li>Major shareholders: Great Mountain Enterprise Pte. Ltd (Singapore) 25.43%, Huayou Investment Co., Ltd 18.56%. (March 2018)</li> <li>In 2017, Huayou Cobalt seized the favorable opportunity, as the cobalt price continued to climb, and signed long-sale sales contracts with a group of important customers, providing a good basis for the planning and sales stability of its production organization.</li> </ul>   |                   |                   |                  |      |      |      |      |      |       |      |      |      |      |      |      |
| <b>News in 2017</b>  |                   |                   |                  |      |      |      |      |      |       |      |      |      |      |      |      |
| <ul style="list-style-type: none"> <li>It has been passed by the board of directors that the company would buy 25,500 shares of Lucky Resources held by Summit Reward Investment Limited with \$66,300,000, accounting for 51% of the total equity of Lucky Resources.</li> <li>Agree to increase capital in subsidiary company MIKAS to build 4,000 t crude cobalt hydroxide and 10,000 t electrolytic copper project with \$65,160,000.</li> </ul>   |                   |                   |                  |      |      |      |      |      |       |      |      |      |      |      |      |
| <b>Key financials</b>  |                   |                   |                  |      |      |      |      |      |       |      |      |      |      |      |      |
| <table border="1"> <thead> <tr> <th>Year</th> <th>Revenues (Bn RMB)</th> <th>Profits (Bn RMB)</th> </tr> </thead> <tbody> <tr> <td>2014</td> <td>4.35</td> <td>0.15</td> </tr> <tr> <td>2015</td> <td>4.03</td> <td>-0.25</td> </tr> <tr> <td>2016</td> <td>4.89</td> <td>0.06</td> </tr> <tr> <td>2017</td> <td>9.65</td> <td>1.89</td> </tr> </tbody> </table>   | Year              | Revenues (Bn RMB) | Profits (Bn RMB) | 2014 | 4.35 | 0.15 | 2015 | 4.03 | -0.25 | 2016 | 4.89 | 0.06 | 2017 | 9.65 | 1.89 |
| Year   | Revenues (Bn RMB) | Profits (Bn RMB)  |                  |      |      |      |      |      |       |      |      |      |      |      |      |
| 2014   | 4.35              | 0.15              |                  |      |      |      |      |      |       |      |      |      |      |      |      |
| 2015   | 4.03              | -0.25             |                  |      |      |      |      |      |       |      |      |      |      |      |      |
| 2016   | 4.89              | 0.06              |                  |      |      |      |      |      |       |      |      |      |      |      |      |
| 2017   | 9.65              | 1.89              |                  |      |      |      |      |      |       |      |      |      |      |      |      |

# A2. Huayou Cobalt – A typical demand-pushed innovation strategy for a qualified supplier

## R&D and industrial chain



- Received request to produce 19μm NCM523 precursor to be used to prepare high-energy density NCM523 anode material (19μm+5μm mixing) in the ESS sector, the end users were Powerwall and Powerpack for Tesla Public and Household Energy Storage. Prepared ultra-large grain size NCM523 product and passed the customer certification, therefore product 523F entered **Huayou → Easpring → LG.C → Tesla** industrial chain, product 523F1 entered **Huayou → Easpring → Samsung SDI → Tesla** industrial chain.
- For the purpose of making better and higher-end products for the new energy power battery sector, this company stepped up R&D investment, developed several models of series products, aside from the above NCM523 series multi-model products, **NCM622, NCM811, NCA and NC series products are under development.**
- In order to improve the capacitance retention ratio and cycle performance of lithium cobalt oxides and prepare HV 4.45V lithium cobalt oxides, the customer raised higher performance requirement for cobaltosic oxide product. Huayou through research on aluminum content, vibration ratio, distribution of grain size, specific surface area and physical phase, prepared aluminum-doped 302S cobaltosic oxide product and passed the customer certification, the technology was applied successfully for an invention patent “Preparation Method of 46 Product Safety Large Grain Size Uniformly Aluminum-doped Cobaltosic Oxide”.

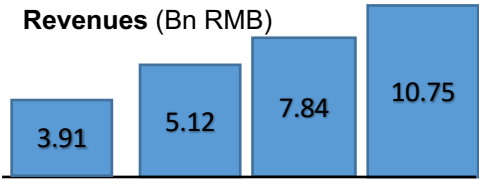
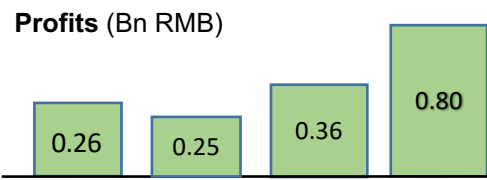
## Awards

- Under the organization of the China Nonferrous Metals Industry Association, experts visited the Quzhou Company and reviewed the advanced nature of “Polymorphic Cobalt Resources High-efficient Green Manufacturing Technology”, the project won Scientific and Technological First Class Award Certificate of the China Nonferrous Metals Industry.
- In 2018 Huayou applied for the National Science and Technology Award Project of “Key Technology and Industrial Demonstration of High Efficiency and Green Manufacturing of Lithium-ion Battery Materials with Polymorphic Cobalt Resources”.



## A2. Key player profile: GEM (Shenzhen)

|  |
|--|
| <p><b>Business Scope</b></p> <ul style="list-style-type: none"> <li>▪ Main activities: recycling of secondary resources R&amp;D, ecological environmental materials, new energy materials, superfine powder materials, precision analyzers, trade, finance, advanced technology consulting</li> <li>▪ Main productions: cobalt, nickel, electro deposited copper, WPC, tungsten, battery materials</li> <li>▪ Owns the world's largest recycling base for waste batteries and cobalt, nickel, tungsten resources, the world's largest superfine cobalt powder manufacturing base, the world's largest ternary power raw material remanufacturing base</li> </ul> |
| <p><b>Strategic goals</b></p> <ul style="list-style-type: none"> <li>▪ Establish “urban mines + new energy materials” strategy, strengthen the core business of cobalt, nickel, tungsten, develop ternary precursor and ternary power battery material.</li> <li>▪ Establish the strategy of centralized procurement of cobalt and nickel raw materials and actively develop supply chain business.</li> </ul>   |
| <p><b>Capability and reserves (March 2018)</b></p> <ol style="list-style-type: none"> <li>Total production capacities:             <ul style="list-style-type: none"> <li>• Cobalt – 5,300 t / year</li> <li>• Nickel – 4,100 t / year</li> <li>• Electrolytic Copper – 26,200 t / year</li> <li>• WPC- 20,000 t / year</li> <li>• Tungsten carbide - 6,000 t / year</li> <li>• Battery material – 53,000 t / year</li> </ul> </li> <li>Total reserves:</li> </ol>   |

| <p><b>Background</b></p> <ul style="list-style-type: none"> <li>▪ 2001: Shenzhen GEM High Technology Co., Ltd was established.</li> <li>▪ 2003: establishing the mining mode of "urban mine" in China, and successfully solved the problem of recycling of waste battery, rare metal waste, electronic waste, scrap automobile and other pollutants in China</li> <li>▪ 2014: invested more than 200 million yuan in building the world's advanced electronic waste green treatment park in Lankao</li> <li>▪ 2016: successfully acquired the world's leading superfine cobalt powder manufacturer—Shu metal South Africa Company</li> <li>▪ Ranked 346nd among the top 500 global new energy enterprises</li> </ul>   |                   |                   |      |      |      |      |      |      |      |       |      |                  |      |      |      |      |      |      |      |      |
|--|-------------------|-------------------|------|------|------|------|------|------|------|-------|------|------------------|------|------|------|------|------|------|------|------|
| <p><b>Structure and sales</b></p> <ul style="list-style-type: none"> <li>▪ Major shareholders: Shenzhen Huifeng yuan investment Co., Ltd. 12.44%, Shenzhen Zhongzhi investment partnership 5.38% (March 2018)</li> <li>▪ Shenzhen Green Eco-manufacture Hi-tech Co.,Ltd (002340) is listed on the Shenzhen Stock Exchange .</li> </ul>   |                   |                   |      |      |      |      |      |      |      |       |      |                  |      |      |      |      |      |      |      |      |
| <p><b>News in 2017</b></p> <ul style="list-style-type: none"> <li>▪ The lithium-ion cathode materials first shipped to Samsung SDI, indicated that GEM officially entered the international market.</li> <li>▪ As the only representative of China's environmental protection enterprises, GEM attend the Conference of Parties held in Geneva, Switzerland, to show the international commitment to the world's environmental protection.</li> </ul>  |                   |                   |      |      |      |      |      |      |      |       |      |                  |      |      |      |      |      |      |      |      |
| <p><b>Key financials</b></p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p><b>Revenues (Bn RMB)</b></p>  <table border="1"> <thead> <tr> <th>Year</th> <th>Revenues (Bn RMB)</th> </tr> </thead> <tbody> <tr> <td>2014</td> <td>3.91</td> </tr> <tr> <td>2015</td> <td>5.12</td> </tr> <tr> <td>2016</td> <td>7.84</td> </tr> <tr> <td>2017</td> <td>10.75</td> </tr> </tbody> </table> </div> <div style="text-align: center;"> <p><b>Profits (Bn RMB)</b></p>  <table border="1"> <thead> <tr> <th>Year</th> <th>Profits (Bn RMB)</th> </tr> </thead> <tbody> <tr> <td>2014</td> <td>0.26</td> </tr> <tr> <td>2015</td> <td>0.25</td> </tr> <tr> <td>2016</td> <td>0.36</td> </tr> <tr> <td>2017</td> <td>0.80</td> </tr> </tbody> </table> </div> </div> | Year              | Revenues (Bn RMB) | 2014 | 3.91 | 2015 | 5.12 | 2016 | 7.84 | 2017 | 10.75 | Year | Profits (Bn RMB) | 2014 | 0.26 | 2015 | 0.25 | 2016 | 0.36 | 2017 | 0.80 |
| Year   | Revenues (Bn RMB) |                   |      |      |      |      |      |      |      |       |      |                  |      |      |      |      |      |      |      |      |
| 2014   | 3.91              |                   |      |      |      |      |      |      |      |       |      |                  |      |      |      |      |      |      |      |      |
| 2015   | 5.12              |                   |      |      |      |      |      |      |      |       |      |                  |      |      |      |      |      |      |      |      |
| 2016   | 7.84              |                   |      |      |      |      |      |      |      |       |      |                  |      |      |      |      |      |      |      |      |
| 2017   | 10.75             |                   |      |      |      |      |      |      |      |       |      |                  |      |      |      |      |      |      |      |      |
| Year   | Profits (Bn RMB)  |                   |      |      |      |      |      |      |      |       |      |                  |      |      |      |      |      |      |      |      |
| 2014   | 0.26              |                   |      |      |      |      |      |      |      |       |      |                  |      |      |      |      |      |      |      |      |
| 2015   | 0.25              |                   |      |      |      |      |      |      |      |       |      |                  |      |      |      |      |      |      |      |      |
| 2016   | 0.36              |                   |      |      |      |      |      |      |      |       |      |                  |      |      |      |      |      |      |      |      |
| 2017   | 0.80              |                   |      |      |      |      |      |      |      |       |      |                  |      |      |      |      |      |      |      |      |

## A2. 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 has invested 3 billion RMB to construct a large-scale waste battery and power battery material recycling industrial facility, including GEM (Hubei Jingmen) Urban Mining Resource Recycling Industrial Park, GEM (Jiangsu Taixing) Battery Materials Industrial Park, GEM (Jiangsu Wuxi) Energy Materials Industrial Park, GEM (Zhejiang Ningbo) Recycling Industrial Park. It covers a total area of more than 2000 acres, 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)

- The annual production capacity of lithium-ion battery used cobalt and nickel materials and cathode material is more than 50,000 tons. GEM has formed a full manufacturing system for multispecies used in lithium-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**

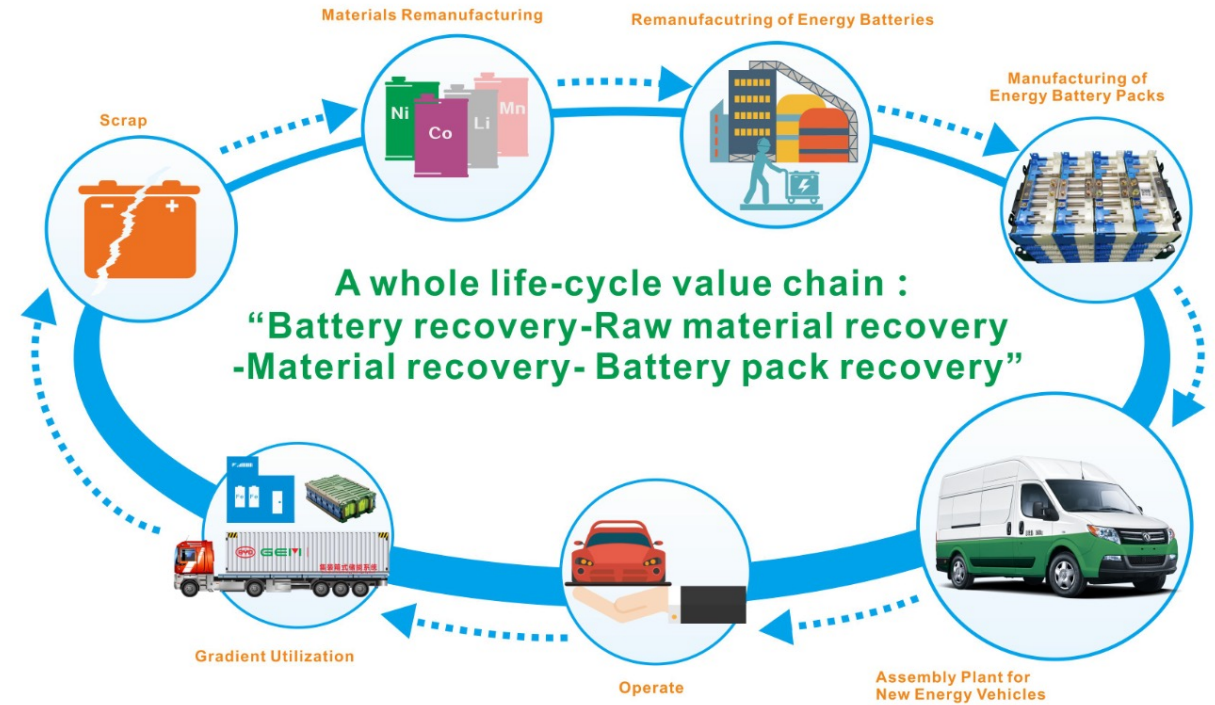
The determined annual production capacity of NMC and NCA ternary precursor material is 20,000 tons, the battery level spherical cobalt oxide 10000 tons, nickel cobalt manganese acid lithium ternary power materials 15000 tons. GEM is the strategic supplier for global well-known battery material enterprises, such as Samsung SDI, ECOPRO, etc.

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

In 2015, GEM cooperated with BYD to invest Energy Storage Station (Hubei) Co., Ltd, aiming to construct a power battery degradation utilization, photovoltaic energy storage and energy storage station.

### • **Cooperate with Dongfeng and Samsung, to Build New Energy Vehicle Green Supply Chain**

Dongfeng Xiang Brigade, Samsung SDI and GEM signed strategic cooperation agreement of new energy vehicle green supply chain 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”.





### A3. Alternative technologies to reduce cobalt content: **Chinese major battery makers are actively investing in next generation high nickel lower cobalt batteries, but the technology gap with foreign leaders still exists.**

- In May 2018, **BAK Battery was the first to announce that its 3.0Ah cylindrical 18650 battery NCM811 was mass-produced**, and the battery energy density was increased to 250Wh/kg. As the earliest enterprise in China to mass produce NCM811 batteries, the list of customers provided by BAK shows the industry's enthusiasm for the new technology solution: the BAK NCM811 battery is applied to Zero Run, Xiaopeng, Yundu, Jianghuai, SAIC Chase, Beiqi New Energy and other brands.
- **Penghui Energy also revealed that the company's NCM811 material 2.8Ah, 3.0Ah cylindrical 18650 battery has been mass-produced**, and began to supply to the relevant OEMs.
- In addition, some domestic battery companies announced the future layout of high nickel 811. **Guoxuan Hi-Tech** announced at the beginning of the year that it has developed a ternary 811 soft-packed battery with an energy density of 302Wh/kg. At present, it has begun to build a pilot line for related products and plans to build a **production line in 2019**.
- **Tianjin Lishen is one of the few battery companies in China that plans NCA and NCM routes at the same time**. Lishen plans to increase the energy density of passenger car cells to 350Wh/kg by 2022. At present, Tianjin Lishen NCM811 has been supplied in small quantities, and NCA has been listed as a long-term plan for the company.
- **BYD announced in June this year that its NCM811 power battery R&D has made significant progress and will be put into use in the second half of 2019**. Based on the establishment of a power battery joint venture with Changan Automobile, it will invest 5 billion yuan to build a 10GWh high nickel 811 battery capacity in Chongqing.
- **GEM** has formed a full manufacturing system for multispecies used in lithium-ion battery materials, including **NMC precursor, NCA precursor, NMC ternary material, NCA ternary material**, accounting for 20% of the Chinese market. GEM is the strategic supplier for global well-known battery material enterprises, such as Samsung SDI, ECOPRO, CATL and BYD.
- **Huayou Cobalt** has also stepped up R&D investment: aside from the NCM523 series multi-model products, NCM622, NCM811, NCA and NC series products are under development.
- **China Metallurgical Ruimu New Energy Technology** (China Metallurgical Group's JV with BYD and two other investors, founded in September 2017) is developing a New Materials Project located in Caofeidian Steel and Electric Power Park, with a total investment of 3.69 billion yuan. It will be constructed in two phases. The first phase is planned to be put into operation at the end of 2018, with an annual output of 40,000 tons of high-nickel ternary precursor (NCM622) and by-product high-purity cerium oxide (20 tons / year); the second phase is planned to be completed in 2020, with a total annual output of 60,000 tons of high-nickel ternary precursor (NCM811) and by-product high-purity cerium oxide (40 Tons/year). The project is currently the largest domestic high-nickel ternary precursor and the world's largest high-purity cerium oxide R&D and production base (2025 key project, MIIT technology transformation and upgrading oriented plan).
- However, some companies are cautious about the technical route of NCM811. As the number one company in China's power battery shipments, CALT was previously released in 2019 to launch high-nickel 811 batteries, but the official said that it would not comment. At the same time, in terms of car companies, Chery New Energy also expressed its plan to purchase NCM811 later, because the technical maturity and safety of NCM811 still need to be verified.
- Since 2016, **Koba Power Battery** (subsidiary of Hunan Corun Energy) started to produce nickel-hydrogen power battery mainly used for hybrid vehicles made by FAW Toyota and GAC Toyota in China. The current annual output is 100,000 sets per year and the new generation Ni-MH power battery pack of Koba will be used in hybrid cars, hybrid buses, fuel cell buses, fast charging buses and other vehicles.

<http://auto.gasgoo.com/a/70072525.html>

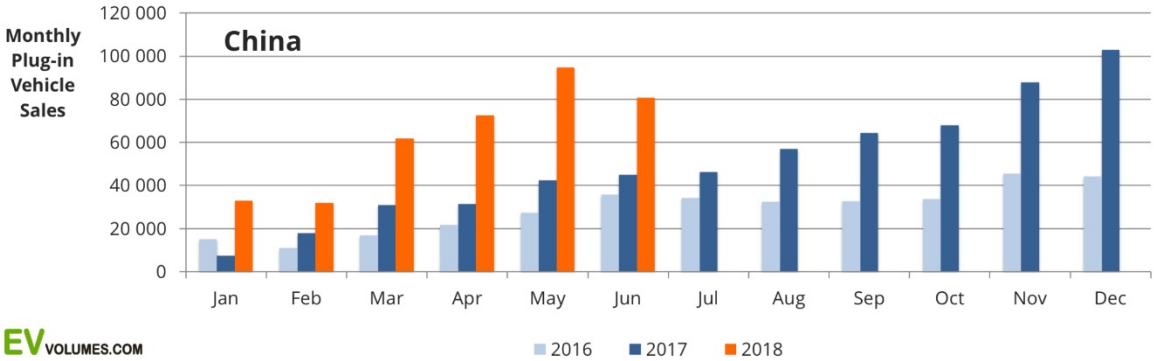


## A4. Battery reuse/recycle: projects

| Power battery producers           | Reuse/recycle projects   |
|-----------------------------------|--|
| Optimum                           | Started to build Lithium-ion phosphate battery energy storage power station since 2012. It now directs the pilot project of large energy storage power station in Shenzhen. It has also developed 1200/750/640KWh movable recharging car for EV or office system.  |
| AVIC Lithium Battery              | Built power battery recycle demonstration line in 2014, with continued R&D, now the recovery rate of copper-aluminum metal is as high as 98% and the recovery rate of cathode materials is over 90%. It was rewarded Major Project of Henan Province in 2016 and received 6 million yuan of special funds.   |
| BYD                               | BYD mainly used third-party agencies to recycle used batteries. The recovery is mainly by means of dissolution; part of the volatilized electrolyte is degraded by the exhaust gas discharge system into normal gas and discharged. The battery case material can be used twice. In September 2015, GEM and BYD cooperated to establish a recycling system of “material recycling – battery recycling – new energy vehicle manufacturing – power battery recycling”.   |
| CATL                              | In addition to cooperation with Yutong, SAIC, BAIC, Geely and other car companies, CATL also cooperates with Hunan Bangpu, which has the qualification of material recovery, to classify and disassemble the power battery for material recovery.  |
| Shanshan                          | The main business includes power battery (pack) recycling, cascade re-manufacturing, and recycling of used batteries. Through industrial cooperation with China Railway Tower Corporation, applied the power battery cascade utilization to the tower communication base station.  |
| Guoxuan Hi-tech                   | Started battery recycle in 2012 and built a cascade utilization project of 1.3MW pure electricity and 4.4MW containerized pure electricity. By the end of 2017, its energy storage market size was planned at about 1 billion yuan and a test line for battery dismantling was built too, with 2000 batteries processed daily.   |
| Beiqi New Energy                  | Its waste lithium-ion power battery recycling demonstration line has a daily capacity of 100 batteries. The recovery rate of the positive electrode material by the regeneration method is more than 85%, the recovery rate of lithium element is over 80%, the recovery rate of copper and aluminum is over 99%, and the electrolyte can be harmlessly treated.   |
| BAK battery                       | Through professional treatment to produce batteries for energy storage, power supply base stations, street lights, power tools, and low-speed electric vehicles, or recycle raw materials to create new batteries. The project of “Dismantling and Recycling of Waste New Energy Vehicles” is underway. It was expected to reach the capacity of comprehensively processing 20,000 scrapped vehicles and 30,000 tons of power batteries in 2017.   |
| Dynavolt                          | The company is planning a national chain service system for used batteries recycle and cascade utilization, through cooperation with battery companies and automakers.   |
| Sound Group                       | In January 2017, the Group signed the largest waste battery resource project in China with the Ningxiang County Government of Hunan Province. The project covers an area of 200 mu and plans to invest 1 billion yuan. It is mainly used to build an industrial base for recycling and deep processing of used batteries and production waste, which will be officially put into operation in 2018.  |
| Ganfeng Lithium                   | Ganfeng Recycle was registered in 2016, dedicated to the recycling and sales of used batteries and metal waste. A current project is developing recycling capacity of 34000 tons of used lithium-ion batteries per year.   |
| Huayou Cobalt                     | In April 2017, Huayou Cobalt established Zhangzhou Huayou Resources Recycling Technology with an investment of 288 million yuan, which can process 85,000 tons of lithium cobalt oxide waste batteries and 5.6 tons of ternary battery waste per year, and is expected to be put into operation in June 2018. At the same time, Huayou actively deployed overseas resources business. In the first half of 2017, it acquired a 70% stake in TMC, a lithium battery recycling company in Korea for \$121 million and made another \$18 million acquisition of Taiwan Bilun Biotech in August. |
| Guanghua Tech                     | On January 29, 2018, the company signed a strategic cooperation agreement on the power battery cascade utilization and harmless treatment mechanism and technical standards with the Guangdong Provincial Economic and Information Commission, China Railway Tower Guangdong Branch and Guangdong Province Circular Economy and Comprehensive Resource Utilization Association .   |
| Third-party companies             | Reuse/recycle projects   |
| GEM                               | GEM has built China's largest used and waste batteries recycling line, with annually recycled cobalt over 4000 tons. <b>GEM 2016:</b> Joined hands with world-renowned companies such as Samsung, CATL, BYD, Dongfeng etc. to establish a new energy lifecycle value chain of “Battery Recycling - Material Reengineering - Battery Pack Remanufacturing - Automotive Reassembling”.   |
| Brunp Group                       | The Group handles more than 20,000 tons of used batteries annually and produces 10,000 tons of nickel-cobalt-manganese hydroxide per year. Its total recovery rate exceeds 98.58% and its resource recycling scale ranks first in Asia. In addition to independently building power battery recycling points, it also explores a recycling network with the OEM and battery factories, and is building a reverse big data system with the upstream to provide monitoring and evaluation services for power battery recycling for new energy vehicles and power battery companies.            |
| Fangyuan Environmental Protection | In October 2014, Fangyuan Environmental Protection and Shenzhen BTR New Energy Materials signed a strategic cooperation agreement to carry out comprehensive cooperation on the ternary cathode material of lithium-ion batteries and to jointly build the country's largest demonstration base for production of cathode materials for power batteries. The base and the demonstration base for the recycling of used batteries for electric vehicles.  |
| Chaowei Group                     | In March 2016, Chaowei Group invested in Changxing Yiwei New Energy Co., Ltd., which is mainly engaged in power lithium-ion battery after-sales, battery recycling and cascade utilization. The group is actively preparing for the construction of safe transit warehouses and service outlets in Beijing, Shenzhen, Guangzhou and plans to build 7 safe transfer warehouses and more than 3,000 service outlets nationwide by the end of 2018 to achieve 24-hour after-sales service.  |
| Highpower Tech                    | Established by Highpower Group and Beiqi New Energy Automobile, it is specialized in recycling, processing and utilization of waste secondary battery. Now it has the first demonstration center for recycling of used batteries in Jiangxi.   |
| Jintaige                          | With an annual production capacity of 10,000 tons of waste lithium batteries, the second phase of the project is currently under construction, and a new production line dedicated to the disposal of waste power batteries will be added. After completion, it will reach annual recycling capacity of 16,000 tons of lithium waste battery, and recovering 2000 tons of cobalt, 1000 tons of nickel, 600 tons of copper, 500 tons of manganese and 360 tons of lithium.  |
| Wina                              | In 2014, the company invested 1.7 billion yuan to build the “Recycling and Comprehensive Utilization of Waste Lithium Ion Power Battery” project. The construction period is 3 years. After completion, it can recover 3 billion Ah of power batteries and > 25.500 tons of metal. with battery recycling capacity about 2.4 billion Ah.   |

# A5. NEV sector trend in China: high probability to reach 2020 target

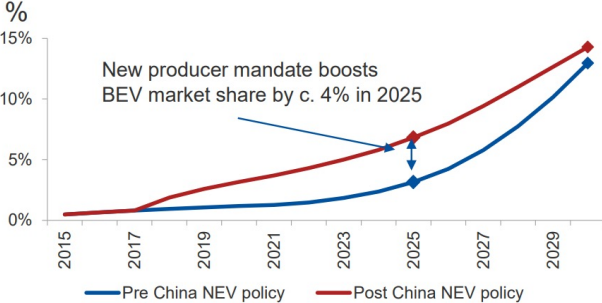
| Country or region | EV 30@30 <sup>1</sup> | 2020-30 EV target or objective   | Source   |
|-------------------|-----------------------|--|--|
| China             | ✓                     | <ul style="list-style-type: none"> <li>5 million EVs by 2020, including 4.6 million PLDVs, 0.2 million buses and 0.2 million trucks.</li> <li>New energy vehicle (NEV)<sup>2</sup> mandate: 12% NEV credit sales of passenger cars by 2020.<sup>3</sup></li> <li>NEV sales share: 7-10% by 2020, 15-20% by 2025 and 40-50% by 2030.</li> </ul> | State Council (2012), EVI (2016b) MIIT (2017)<br><br>Marklines (2017b) |
| European Union    |                       | <ul style="list-style-type: none"> <li>Post 2020 proposed CO<sub>2</sub> 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).</li> </ul>  | EC (2018b)   |



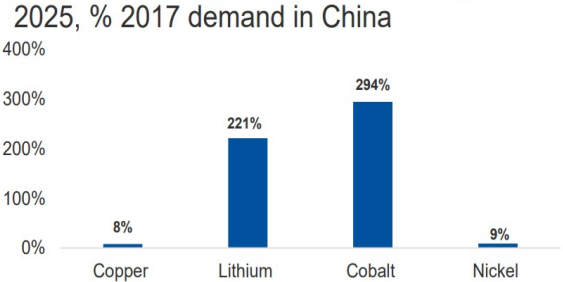
- NEV deliveries in China for 2018 H1 were clearly above the past 2 years growth rates: nearly 373 000 plug-in passenger cars, including 15 000 imports. This is 114 % more than for the same period of last year. On top of that come 49 000 commercial vehicles, mostly LCV and electric buses, 60 % more than 2017 H1.
- China is, by far, the world's largest market for Plug-ins. 50 % of global plug-in volume was sold in China, for 2018, counting passenger cars only. For electric commercial vehicles, 70 % of the global volume is in China and exports of electric buses from China to other markets are significant.
- In May, the NEV share reached a new high with 4,8 % in a total monthly passenger car market of nearly 2 million units.
- Keen to raise the standard of the Chinese EV industry, the Government introduced **new requirements to receive NEV subsidies** in June: a minimum 150 km e-range for BEVs and a specific battery capacity of 105 W/kg. This has slowed down the pace considerably as some popular BEV models did not comply and stopped selling. June growth was reduced to 80 % and preliminary results for July show a 61 % y-o-y increase. We expect this trend to continue during the 2nd half, until best-sellers like the BAIC EC-Series are back on track again.
- Despite the slow-down, we expect 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**.

**Back in 2016, the Chinese Government set NEV targets for 2020: 6 % share in vehicle sales and 5 million NEVs on the road.** With the current adoption rate, these targets, considered highly ambitious in international comparison back then, will be surpassed by a good margin. If BEV continue to present about 70% of NEV sales, BEV market share will be above 4% around 2020.

BEV market share in China, 2017-2030



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



<https://www.iea.org/media/Workshops/2018/Session3BenjaminJonesCRUgroup.pdf>

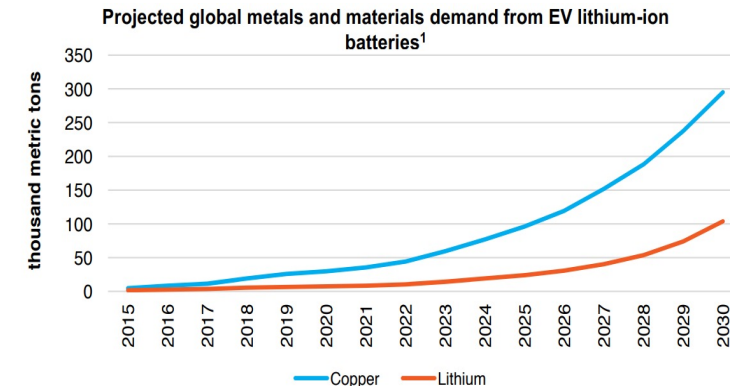
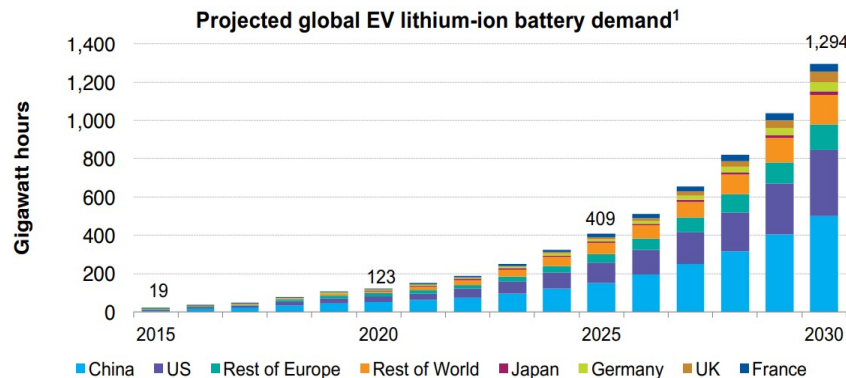
# A5. NEV sector trend in China: 6 X current nickel needs and 4 X current cobalt needs by 2020

## Global forecast for increasing key material needs:

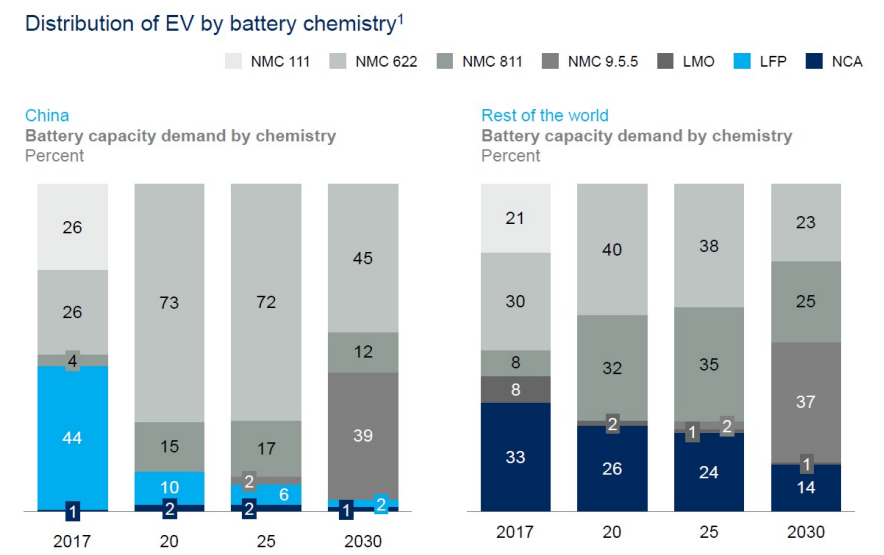
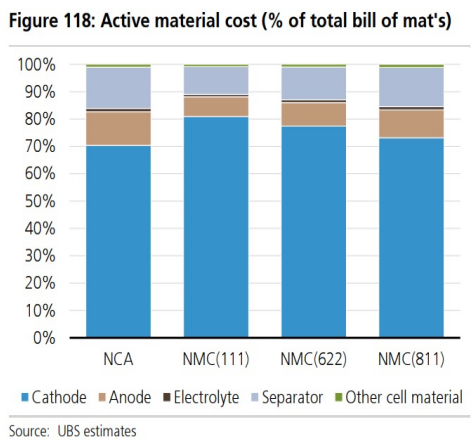
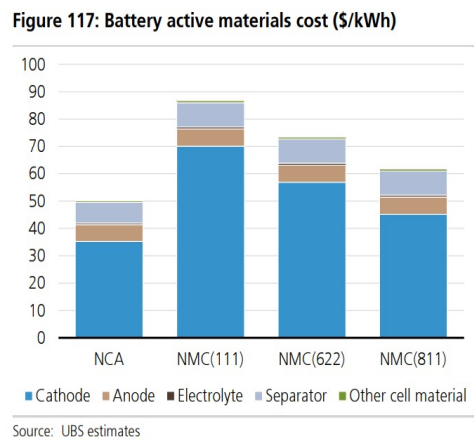
Widespread adoption of electric vehicles may dramatically increase demand for lithium-ion battery and non-ferrous metals such as lithium and copper.

- Global lithium-ion battery demand is projected to grow 3750% by 2030. (Bloomberg New Energy Finance data, 12/31/2017)
- The revenue pool for lithium, an indispensable component of electric vehicle batteries, is expected to grow 450% by 2025. (Jeff Desjardins. "The Massive Impact of EVs on Commodities in One Chart." Visual Capitalist. 15 September 2017)
- Copper demand for electric cars may rise nine-fold by 2027. (Reuters. "Copper demand for electric cars to rise nine-fold by 2027: ICA" Reuters. 13 June 2017)

[http://kraneshares.com/resources/presentation/2018\\_01\\_19\\_kars\\_pr esentation.pdf](http://kraneshares.com/resources/presentation/2018_01_19_kars_pr esentation.pdf)



According to the data of the China Nonferrous Metals Industry Association Cobalt Branch, 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; it is estimated that **by 2020**, China's ternary Power batteries 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





## A6. Chinese government subsidy standards for NEV

« China began actively promoting electric cars in 2009 by introducing subsidies and setting sales targets. Sales began to take off in 2013. Electric vehicles took center stage in China's industrial strategy with the 2015 launch of the Made in China 2025 plan. **China has provided \$8 billion in subsidies so far, \$15,000 per electric vehicle produced, twice those offered by the US.** Beijing's municipal government has earmarked \$1.3 billion to replace 70,000 city taxicabs with electric models. »

- Wall Street Journal, Oct. 2017

### Government subsidy standards for NEV

Unit: 10,000 yuan

| Vehicle Type                       | Mileage (kilometres) | 2013 | 2014  | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|------------------------------------|----------------------|------|-------|------|------|------|------|------|------|
| Pure electric vehicles             | 2013-2015(80著R<150)  | 3.5  | 3.325 | 3.15 | —    | —    | —    | —    | —    |
|                                    | 2016-2020(100著R<150) |      |       |      | 2.5  | 2    | 2    | 1.5  | 1.5  |
|                                    | 150著R<250            | 5    | 4.75  | 4.5  | 4.5  | 3.6  | 3.6  | 2.7  | 2.7  |
|                                    | R着250                | 6    | 5.7   | 5.4  | 5.5  | 4.4  | 4.4  | 3.3  | 3.3  |
| Pluggable hybrid electric vehicles | R着50                 | 3.5  | 3.325 | 3.15 | 3    | 2.4  | 2.4  | 1.8  | 1.8  |
| Fuel cell electric vehicles        | —                    | 20   | 19    | 18   | 20   | 20   | 20   | 20   | 20   |

### Price of NEV

Unit: 10,000 yuan

|                 | Price       | Price after subsidy |
|-----------------|-------------|---------------------|
| BYD EV450       | 24-26       | 14.99-16.99         |
| BYD EV300       | 25.98-30.98 | 14.98-19.98         |
| Jianghuai iEV6s | 21.98       | 10.98               |
| Huatai Iev230   | 21.35-22.55 | 12.35-13.55         |
| Qichen          | 24.78-26.18 | 14.98-16.68         |
| BYD e6          | 30.98-36.98 | 20.18-26.18         |
| Beiqi EX360     | 18.39       | 7.99                |
| Beiqi EC200     | 15.88       | 5.68                |