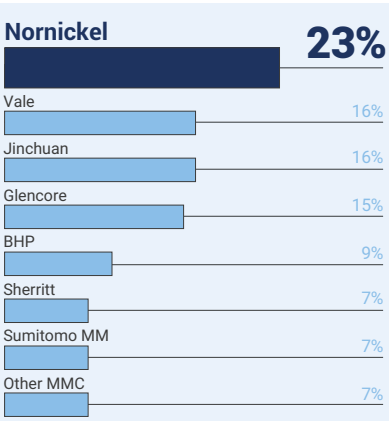
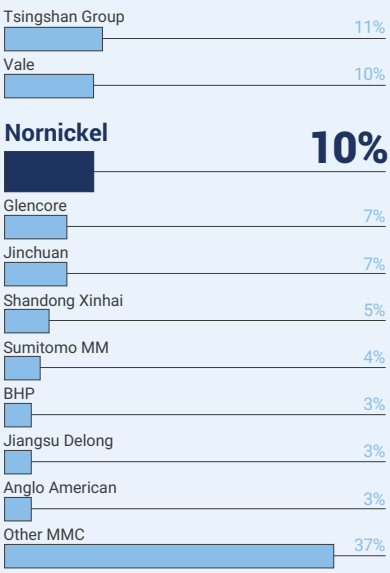
NICKEL

Ni

No. 1
in high grade nickel production



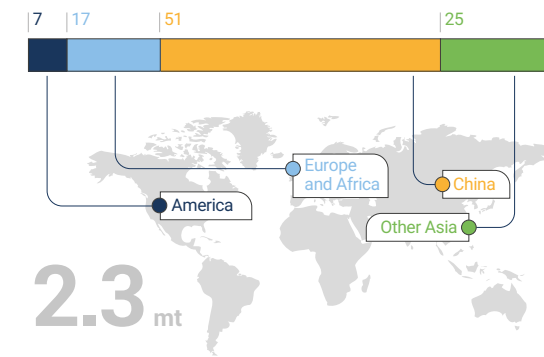
No. 3
in primary nickel production



Key trends in the nickel market

In 2018, the nickel deficit grew on the back of higher demand (primarily for stainless steel production in Indonesia and cathode materials for lithium-ion batteries) and slower production growth. Increased output of NPI, ferronickel, nickel sulphate, and other salts could not offset the deficit stemming from the decline in nickel metal and powder production.

Primary nickel consumption by region *(%)*

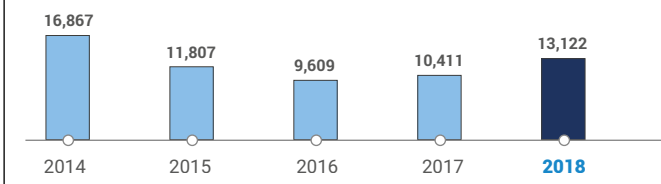


Outlook: cautiously optimistic. In 2019, the market deficit may go down to 50 kt as a result of significant increase in NPI production in Indonesia and China.

Source: *Company data*

An expected boom in the electric cars' sector and major outflows from the London Metal Exchange (LME)'s stocks triggered by the increased demand contributed to higher nickel prices in late 2017 through June 2018. In the second half of 2018, the escalating US-China trade war reversed the trend, and in October 2018, market concerns over a potential construction of large-scale lateritic nickel ore leaching facilities in Indonesia pushed the prices further down.

Average annual nickel price *(USD/t)*



In 2018, the average nickel price grew by

26%

Source: *LME (settlement)*

Nickel price and keyindustry developments in 2018 *(USD/t)*

1 › Rise in the US Federal Reserve interest rate

2 › The Company's announcement of planned delisting of Polar Division's cathodes on LME starting 18 April erroneously interpreted as new sanctions against Russian products introduced together with RUSAL sanctions

3 › The US considering import duties on Chinese imports worth USD 50 bn

4 › Consistent decline in the LME stocks, higher stainless steel production and expected electric car boom

5 › Rise in the US Federal Reserve interest rate

6 › The US announcing import duties on Chinese goods worth USD 50 bn

7 › The US announcing import duties on Chinese goods worth USD 200 bn

8 › Rise in the US Federal Reserve interest rate

9 › Announcement of planned construction of large-scale lateritic nickel ore leaching facilities in Indonesia for battery components

10 › Rise in the US Federal Reserve interest rate

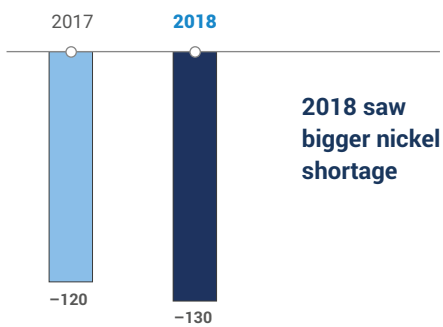
Source: *LME, Company data*

Market balance

In 2018, nickel shortage went up to 130 kt mainly driven by a 7%, or 159 kt y-o-y increase in metal consumption largely attributable to the Asian producers of stainless steel and batteries. At the same time, primary nickel production grew by 7%, or 148 kt. Only nickel production from lateritic ore was on the rise: in 2018, low grade nickel production increased by 16%, or around 170 kt y-o-y, mainly due to the Chinese and Indonesian NPI output growth. High grade nickel production decreased by 2%, or 22 kt, largely on the back of production cutbacks in Canada.

During the year, total LME and SHFE stocks decreased by 191 kt (47%) to 219 kt, which is about 4.5 weeks of global consumption.

Primary nickel production – consumption balance *(kt)*



2018 saw bigger nickel shortage

Source: *Company data*

Consumption

Nickel consumption is predominantly driven by the stainless steel industry (over 70% in 2018). Stainless steel comes to the market in various grades from all over the world, whereas its smelting structure ultimately determines the primary nickel consumption patterns. **Austenitic stainless steel** comprising the 200 series and 300 series steel is the most widespread type of that product (over three quarters of the global production). The 300 series steel has a higher nickel content (normally 8–12%, or up to 20% in a number of select grades). Nickel added in this proportion improves the steel's corrosion resistance and robustness in a wide range of temperature conditions, boosts its ductility and durability in aggressive environments, and enhances its non-magnetic properties. This series enjoys the highest demand, as it is applied in various industries, including construction, food and chemicals manufacturing, transportation, energy, etc. The 200 series steel cannot serve as a full substitute for the high nickel content grades, as it has a lower nickel content due to the addition of manganese. The 200 series steels are susceptible to surface (pitting) corrosion and non-resistant to heat and aggressive environments. Due to the lower price, this steel grade is often used in the production of consumer goods, such as home appliances. China and India account for over 90% of the total 200 series steel output.

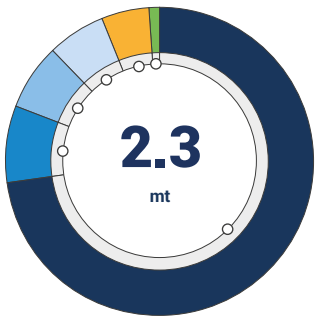
Austenitic-ferritic (duplex) stainless steels also use nickel and are characterised by a higher content of chromium (18–25%) and molybdenum (1–4%), but they account only for 1–2% of the global smelting output.

Ferritic and martensite stainless steels (400 series) usually do not contain nickel, while their properties are similar to those of low-carbon and highly corrosion-resistant steels. However, their mechanical properties are inferior to those of austenitic stainless steels. These steels are mainly used to manufacture automotive exhaust systems, cargo container frames, water heaters, washing machines, utensils and cutlery, kitchenware, home decor items and razor blades.

In 2018, the total stainless steel output increased by 5% and hit a record high of 50.3 mt. The growth was driven by a rise in 300 series steel production to over 2 mt at the Indonesian facility launched in mid-2017, one of the largest stainless steel facilities globally. Indonesia is a new steel market player with a robust growth outlook. The country has sufficient reserves of high grade lateritic ore, growing NPI capacities and, hence, low cash cost of austenitic stainless steel.

Over 50% of Indonesian stainless steel exports from January to October 2018 headed to China, primarily in form of slabs and hot-rolled steel. Growing imports had a negative impact on China's 300 series

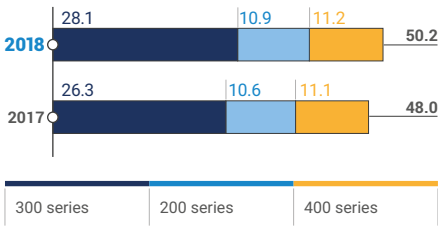
Primary nickel consumption in 2018 by industry *(%)*



	%	mt
Stainless steel	73	1,681
Alloys	8	194
Special steels	7	153
Electroplating	6	147
Batteries	5	124
Other industries	1	14

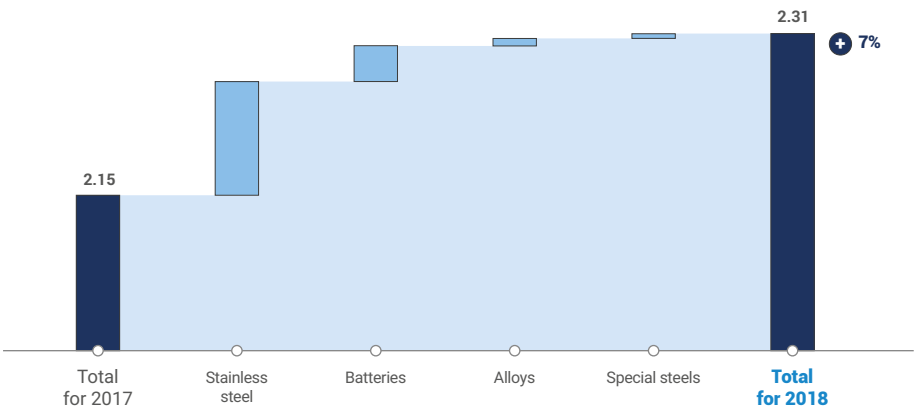
Source: *Company data*

Stainless steel production by grade series in 2017–2018 *(mt)*



Source: *Company data*

Primary nickel consumption in 2018 *(mt)*



stainless steel output, where it stayed flat according to our estimates.

Taiwan, the second largest importer of Indonesian stainless steel, also reported a 15% drop in domestic production. With that, the primary nickel consumption went down by only 8 kt because of the historically high use of scrap in the country. Other regions saw consistent 2–4% growth of austenitic stainless steel production.

Consumption of primary nickel by the global stainless steel producers rose by 7% to 1.68 mt as a result of an increase in the global 300 series and 200 series output by 7% and 4%, respectively, and a slight decrease in the average share of scrap. However, the use of high grade nickel in stainless steel smelting went down by 60 kt mostly due to the growing availability of low grade nickel.

Nearly all types of nickel feedstock are used in stainless steel production (except for a number of specific products, including nickel powder and compounds). Since the quality of nickel barely affects the quality of conventional stainless steel grades, the manufacturers opt for the cheapest nickel feedstock, turning to high grade nickel as their last resort. This is the reason why high grade nickel share has been declining in the structure of nickel units consumed in stainless steel production in recent years.

The battery industry uses nickel as a major component of the active cathodes for battery cells. The extent of nickel utilisation depends on the battery type.

Lithium-ion batteries (Li-Ion). Li-Ion batteries were first commercially released in 1991 and became fairly widespread in most areas due to their high energy capacity retained after multiple recharge cycles.

Nickel-metal hydride batteries (Ni-MH). Ni-MH batteries were developed in 1989 as a substitute for Ni-Cd batteries to avoid using cadmium. Currently, though, the nickel-metal hydride battery market is growing at a slow pace (with hybrid vehicles being its only growth driver) and faces considerable competition from the lithium-ion batteries.

Nickel-cadmium batteries (Ni-Cd). The first nickel-cadmium batteries were developed in 1899. Currently, their use is restricted, since cadmium is prohibited as a toxic substance under the EU ban.

The key driver behind Li-Ion battery growth is electric vehicles gaining ground.

In 2014–2018, CAGR of electric cars (plug-in HEVs and battery electric cars) has been around 46%. The key factors driving electrification of the transport system are incentives offered by the state, more stringent environmental controls, and improved technical specifications of batteries.

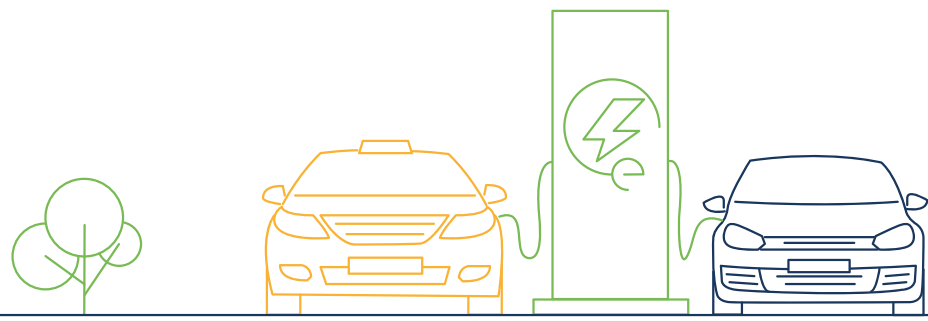
The electric car market growth is led by China. By 2020, it plans to increase the NEV (electric cars and plug-in HEVs) sales to 2 mln, and by 2025 – up to 7 mln vehicles. The Chinese government has implemented a number of initiatives to stimulate transport electrification, including subsidies for buying electric cars and mandatory requirements for large automakers regarding the production of electric cars and plug-in HEVs. In large cities and regions, the trend is supported by local initiatives.

Buyers of electric cars in a number of other countries, including Belgium, Germany, the UK and France, enjoy considerable subsidies and fiscal incentives. For instance, Norway (where electric cars account for 30% of all sales) grants tax exemptions (one-off registration tax and VAT) to buyers. Also, annual electric car tax is six times lower than that for a car powered by an internal combustion engine.

The key driver behind Li-Ion battery growth is **electric vehicles gaining ground**

~46%

CAGR of electric cars (plug-in HEVs and battery electric cars) in 2014–2018



USD 100 bn

of investments in electric cars earmarked by automakers

5%

growth of primary nickel consumption for alloys

The investments in electric cars earmarked by automakers already amount up to USD 100 bn.

There are several types of lithium-ion batteries depending on the cathode materials: LCO (lithium, cobalt oxide), LFP (lithium, iron, phosphate), LMO (lithium, manganese oxide), NCM (nickel, cobalt, manganese), NCA (nickel, cobalt, aluminium).

LCO is primarily used in portable electronic devices, but given high cobalt price coupled with unstable chemical compounds and low energy capacity, LCO is not applied in electric vehicles. However, other types of cathodes are widely used in the industry. LFP and LMO tend to be replaced with other cathode materials containing nickel as a result of a higher gravimetric and volumetric capacity of NCM and NCA, which helps to increase mileage.

The share of NCM and NCA in the total cathode material output used in Li-Ion batteries (excluding LCO) went up from 32% in 2012 to 78% in 2018.

Growing nickel consumption in Li-Ion batteries comes not only on the back of increasing share of nickel-containing types, but also higher average nickel content in the cathode material triggered by the need to substitute expensive cobalt units. While in 2016 NCM 1:1:1 (with nickel mass fraction of 20%) accounted for the lion share of nickel-magnesium compounds of the cathode material, in 2018 nickel-intensive compounds – NCM 6:2:2 (with nickel mass fraction of 36%) and NCM 5:3:2 (30%) took the lead. Going forward, batteries are expected to switch to NCM 8:1:1 (with the nickel mass fraction of 48%), and some producers announce plans to launch commercial production of LNO, a cathode material with nickel content of over 50%.

Further development of the automotive industry, the growing popularity of electric and hybrid cars, along with the evolution of the cathode technology towards nickel-intensive types lay the groundwork for major expansion of primary nickel consumption in this industry in the long run.

In 2018, the growth of primary nickel consumption for alloys stood at 5%, primarily driven by high demand from the aerospace industry. Heat-resistant alloys with high nickel content are among the key materials for aircraft engines. The order backlog of the major passenger aircraft producers is estimated at 7–10 years, and will support the nickel demand from the industry.

Importantly, the demand for nickel alloys from the oil and gas industry has recovered on the back of the oil price growth in the first half of 2018. Nickel is widely used in decorative and protective platings with their thickness ranging from 1 to 100 microns. Nickel electroplating is highly corrosion-resistant, hard and pleasing aesthetically. It is used for corrosion protection, and as an alternative to chromium plating. In recent years, China has been the leading manufacturer of nickel electroplating products. Since 2012, though, the electroplating industry has started to develop in other Asian countries, and the Chinese businesses are now transferring their production to achieve cost savings.

Production

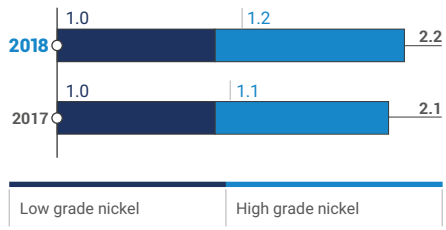
Primary nickel can be split into two major groups:

High grade nickel (cathodes, briquettes, carbonyl nickel and compounds) is produced from both sulphide and lateritic nickel ore. In 2018, the major high grade nickel producers included Nornickel, Jinchuan, Vale, Glencore, Sumitomo Metal Mining and BHP Billiton.

Low grade nickel (ferronickel, NPI and nickel oxide) is only produced from lateritic ore. In 2018, the major low grade nickel producers included Chinese and Indonesian NPI companies and also ferronickel producers: Eramet, Anglo American, South 32, Pamco and Posco (SNNC).

In 2018, primary nickel production grew by 7%, or 148 kt y-o-y, driven only by an increase in low grade nickel output (ferronickel and NPI). Compared to 2017, the low grade nickel production grew by 16%, or 170 kt.

Primary nickel production in 2017–2018 *(mt)*



Source: *Company data*

In 2018, high grade nickel output dropped by 2%, primarily driven by the following factors:

- discontinued nickel cathode production in Canada;
- reconfiguration of key players' production assets, including the upgrade of the Company's refining facilities;
- lower nickel briquette output on Madagascar due to hurricanes and in Canada on the back of shortages in Cuban feedstock supplies caused by heavy rains.

148 kt

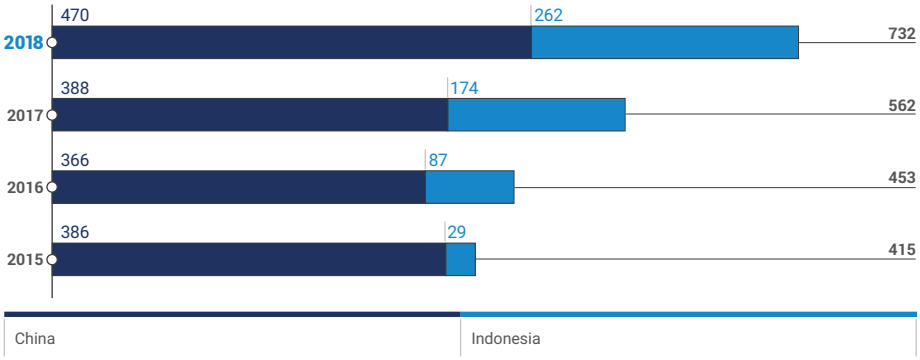
of primary nickel production growth in 2018

This was coupled with greater output of nickel sulphate that serves as a key feedstock for the precursors of the cathode material in Li-Ion batteries. Apart from the integrated production of nickel sulphate through matte, the key sources of feedstock for nickel sulphate are the hydrometallurgy semi-products and crude nickel sulphate, a by-product of copper and PMG production. The shortage of primary feedstock for nickel sulphate production entailed higher demand for nickel briquettes and powders as well as scrap batteries in 2018.

The growth in low grade nickel production was significantly above the decline in high grade nickel production. The global low grade nickel output growth in 2018 amounted to 16% as a result of increased NPI production in China and Indonesia and ferronickel production in all key regions except Europe, where a number of manufacturers had to cut output.

The key driver behind NPI production growth was the lifting of the ban on exports of unprocessed nickel ore from Indonesia in March 2017 contributing to the availability of rich nickel ore. China's total ore imports in 2018 grew by 34% and amounted to 47 mln wet tonnes, boosting the national NPI output growth by 21%, to 470 kt.

NPI production in 2015–2018 *(kt)*



Nickel ore and concentrate imports to China in 2016–2018 *(mt)*