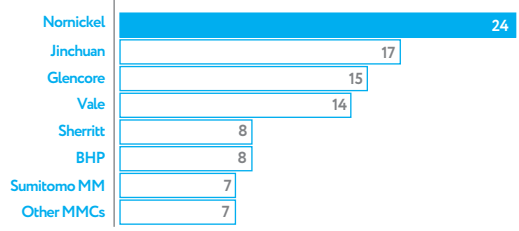
NICKEL (Ni)

KEY TRENDS IN THE NICKEL MARKET

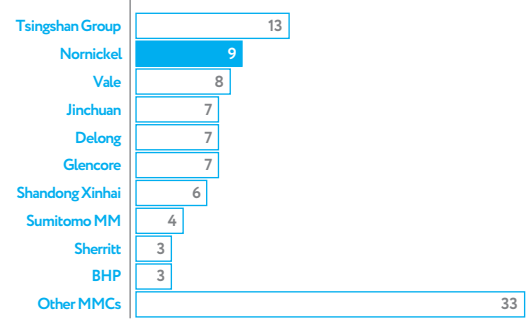
In 2019, nickel deficit in the market narrowed to 42 kt (down from 149 kt in 2018). The commissioning of new facilities in Indonesia and China led to a record increase in nickel pig iron (NPI) production, completely offsetting the nickel consumption growth in stainless steel in China (against weaker consumption outside China) and the higher demand for battery manufacture.

Nickel prices showed mixed trends and high volatility during the first half of 2019. High demand from the stainless steel sector in China and the impact from the Brumadinho dam disaster in Brazil (threatening to reduce nickel output from Vale's assets) were offset by negative macroeconomic effects of the US–China trade war and low global manufacturing PMI.

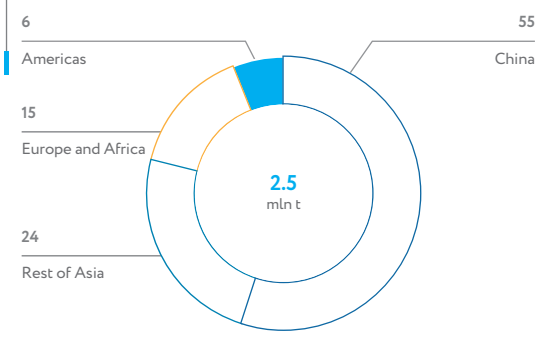
No. 1 in high-grade nickel production (%)



No. 2 in primary nickel production (%)



Primary nickel consumption by region (%)



Source: Company data

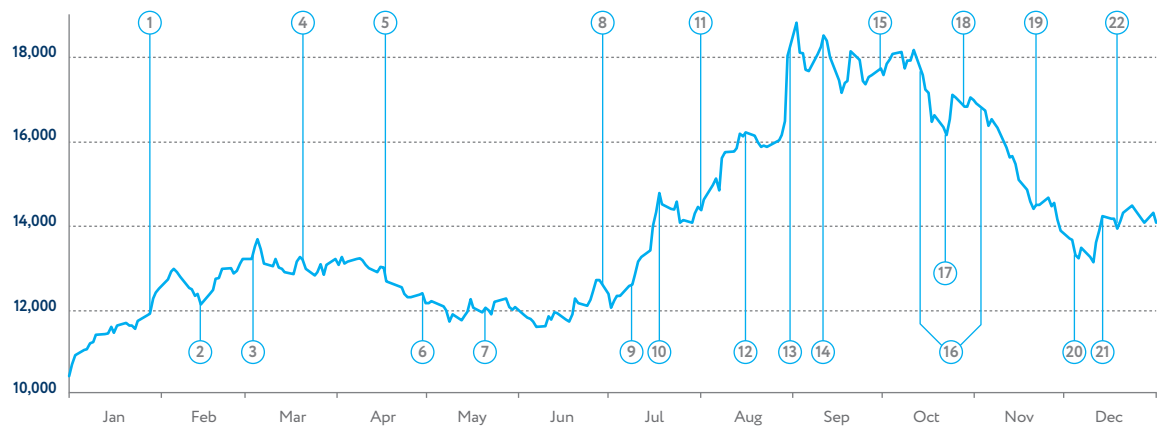
The price went up in the second half of the year after rumours that Indonesia may reintroduce a ban on ore exports, as well as on the news of increased capital intensity of laterite leaching projects. In August, the Indonesian government officially announced a nickel ore export ban effective from 1 January 2020, two years earlier than planned, in an effort to increase domestic processing of mineral resources and capture more value. As a result, the nickel price soared to USD 18,625/t (a five- year high), but this was followed by a period of consolidation. In the fourth quarter, the price dropped on the back of a significant decline in electric vehicle sales in China, caused by reduced government subsidies and stagnation in the stainless steel market, along with falling nickel premiums.

Average annual nickel prices (USD/t)

2014	2015	2016	2017	2018	2019
16,867	11,807	9,609	10,411	13,122	13,936

Source: London Metal Exchange (Cash Settlement)

London Metal Exchange nickel price (USD/t)



Sources: LME, Company data

1/ Dam failure at Vale's iron ore mine in Brazil gives rise to concerns over potential decline in nickel production
2/ Considerable growth in Chinese stainless steel production
3/ Positive market expectations regarding China–US negotiations to resolve trade disputes
4/ Optimistic PMIs in China
5/ SLN given green light to export nickel ore from New Caledonia
6/ US government increases tariffs on Chinese goods worth USD 200 bn from 10% to 25%
7/ Strengthening of the US dollar
8/ Ferronickel production halted at Vale's Onca Puma plant
9/ Indonesian President meets with the CEOs of China's Tsingshan, Huayou and Brunp
10/ News of an increase in the capital intensity of potential laterite leaching projects in Indonesia
11/ First reports of a potential ban on nickel ore exports from Indonesia from the beginning of 2020
12/ Ramu mine in Papua New Guinea closed after an industrial waste spill
13/ Indonesian ban on ore exports officially announced for 1 January 2020
14/ Production at Onca Puma resumed
15/ Nickel inventories dwindle at LME-approved warehouses
16/ Electric vehicle sales in China fall considerably
17/ Off-take agreement with SK Innovation for the supply of nickel sulphate from the Sconi project (Australia) terminated
18/ Market players' concerns over the threat of early termination of ore exports from Indonesia
19/ Reports that Vale would write off USD 1.6 bn from the book value of its Goro nickel asset in New Caledonia
20/ Nickel deliveries to LME-approved warehouses commence
21/ European Commission approves a total EUR 3.2 bn in subsidies to boost battery production in Europe
22/ US -China phase 1 trade deal agreed

MARKET BALANCE

In 2019, nickel deficit in the market shrank to 42 kt (from 149 kt in 2018), driven primarily by an increased production of nickel pig iron in Indonesia and China (by 32%, or 228 kt) on the back of cheap supplies of high nickel content laterite ores. There were only marginal increases in the production of refined nickel (1%, or 11 kt) and its chemical compounds (22%, or 21 kt), mostly due to higher nickel sulphate production in China for use in the manufacture of lithium batteries. Conversely, production of other forms of low-grade nickel decreased by 4%, or 17 kt.

Consumption grew by 6%, or 133 kt, mostly due to increased demand for nickel in the Chinese stainless steel segment (by 13%, or 127 kt). Total consumption outside China decreased by 5%, or 32 kt. Nickel consumption for cathode precursors used in the manufacture of lithium batteries grew 26%, or 38 kt, driven by the electrification of transport. Demand from special steels and alloys rose by 2%, while consumption in electroplating decreased by 1%.

The combined nickel inventories of the London Metal Exchange (LME) and Shanghai Stock Exchange (SSE) dropped 16% to 191 kt. The two-year long depletion of inventories accelerated markedly in September–October but ceased in December when 85 kt of nickel was delivered to LME-approved warehouses. The key factors behind the metal inventories winding down (117 kt from January to November 2019) included expectations of higher demand from the battery sector in 2020–2021, the Indonesian nickel ore export ban, and delays to laterite leaching projects in Indonesia. However, when the nickel price dropped in the fourth quarter, market traders' "paper profits" began to ebb, and the cost of holding long physical positions mounted, leading to a backflow of metal into the exchange.

Nickel production and consumption balance (kt)

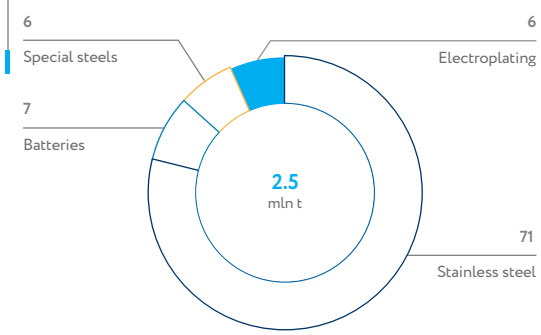
Source: Company data

CONSUMPTION

MAIN CONSUMING INDUSTRIES

The main area of nickel consumption can be found in the production of stainless steel (over 70% in 2019), which comes in several different grades. Austenitic stainless steel is the most common family of stainless steels (over three quarters of the global production) and includes the 200 series and 300 series.

Nickel consumption by industry (%)



The 300 series steels have an increased nickel content, ranging usually between 8% and 12% but reaching 20% in some grades. Nickel in these concentrations improves resistance to corrosion and strength in a broad range of operating temperatures, ensures good ductility, resistance to aggressive environments, and strips the metal of its magnetic properties. This series is the most versatile and sees a wide range of uses in construction, food, transport, the chemical and energy industries, and other sectors.

In comparison, nickel content in the 200 series is lowered by alloying with manganese, and these steels are not complete substitutes for grades with high nickel content. The 200 series steels are prone to surface (pitting) corrosion, are not heat resistant and are not resistant to aggressive environments. However, due their lower cost, they are widely used in consumer goods such as domestic appliances. China and India alone account for over 90% of the total 200 series steel production.

Although they account for only 1% to 2% of global smelting, austenitic-ferritic (duplex) stainless steels also use nickel and are distinguished from other grades by a higher content of chromium (18% to 25%) and molybdenum (1% to 4%).

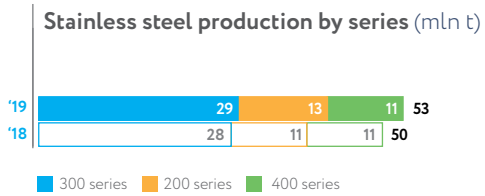
Ferritic and martensitic stainless steels (400 series) typically do not contain nickel, and their properties are similar to those of low-carbon corrosion-resistant steels; however, their mechanical properties are inferior to those of austenitic stainless steels. These steels are mainly used to manufacture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

Stainless steel production uses almost all types of nickel feed (except for some special products, such as nickel powder and compounds). As nickel feed quality has practically no impact on the quality of stainless steel, steel mills predominantly use cheaper feeds. It is for this reason that high-grade nickel has been losing its share of nickel units consumed in stainless steel production in the past few years.

In 2019, total stainless steel output increased by 5% to a record high of 53 mln t. The increase was mostly driven by growing stainless steel production in China, where nickel consumption grew by 13%, or 127 kt, due to higher demand and the restricted stainless exports from Indonesia. Production of nickel-heavy 300 series increased by more than 1.2 mln t, with Tsingshan, the world's largest stainless steel producer, accounting for over 75% of the production growth.

Following a period of strong growth in 2018, Indonesian stainless steel production in 2019 increased by only 50 kt, or 1 kt of nickel. The increase is mostly attributed to growth in 200 series with low nickel content, as 300 series production decreased marginally. This was accompanied by a reshuffle of stainless export flows amid higher trade tariffs on Indonesian products in China and other countries. Exports to China fell by 635 kt, while exports to India, South Korea, Italy, Taiwan and Thailand rose by a total of 650 kt.

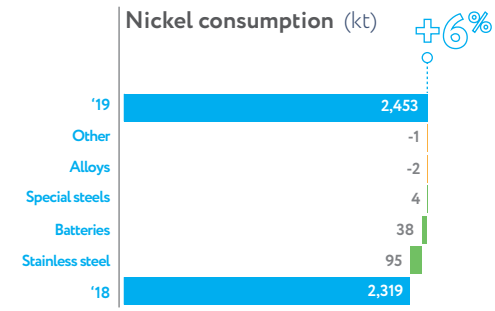
With China increasing its output, a growing availability of low-grade nickel, and cheap Indonesian



Source: Company data

exports, stainless steel production in other countries and regions fell considerably. The fall was particularly prominent in Europe, South Africa, Japan, and Taiwan. The total level of stainless steel smelting in the USA decreased by 7%, but primary nickel consumption went down by only 2%, or 1 kt, due to the declining production of 400 series, which does not contain nickel.

Thanks to a 2% rise in global 300 series production, a 17% rise in 200 series production, and a marginal reduction in average scrap metal share, primary nickel consumption in stainless steel production grew by 6% to 1.75 mln t. Nonetheless, the use of high-grade nickel in the stainless steel sector decreased by 131 kt, mostly driven by increased supply of nickel pig iron.



Source: Company data

The battery industry uses nickel as a key element in the production of cathode precursors for battery cells. However, nickel consumption trends vary depending on the type of battery.

Lithium batteries (Li-ion). Li-ion batteries were first commercially launched in 1991 and became widespread due to their ability to retain a high level of energy capacity, even 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, the nickel-metal hydride battery market is growing at a slow pace (with the hybrid vehicle projects of some manufacturers being its only growth driver) and is facing formidable competition from lithium-ion batteries.

Nickel-cadmium batteries (Ni-Cd). The first batteries using nickel were developed back in 1899. These days their use is limited, as the EU prohibited cadmium on grounds of toxicity.

Road transport electrification has been the spark behind the growth in lithium battery production. The 2016–2019 CAGR of electric vehicles (plug-in HEVs and battery electric vehicles) was around 45%. The impetus for transport electrification has come from government incentives, but other key drivers include more stringent environmental regulations, improved battery performance, and lower production costs of battery cells.

In recent years, China has been an important growth centre for EV manufacturing, with plans to increase NEV (electric vehicles and plug-in hybrids) sales to 25% of total vehicle sales by 2025. To this end, China implemented a number of initiatives to stimulate transport electrification, including subsidies for the purchase of electric cars and mandatory requirements for large automakers to produce electric vehicles and plug-in HEVs. However, government subsidies were slashed in the second half of 2019, resulting in the first-ever decline in NEV sales, by 4% y-o-y.

As a result, the centre of battery industry growth is shifting to Europe. In a number of countries, including Belgium, Germany, the UK, and France, buyers receive handsome subsidies and tax incentives for buying EVs; in Norway, where EVs account for 42% of total vehicles sold, buyers are exempted from vehicle registration tax and value added tax (VAT).

Europe's share in global NEV sales grew from 23% in 2018 to 27% in 2019, and is expected to reach 38% by 2025. In March 2019, the European Commission approved new requirements for greenhouse gas emissions from road transport, which call for a more than 2X reduction of CO_2 emissions by 2030 from a 2018 baseline. The initiative pressures automakers to expedite electrification under the punishment of fines reaching into the billions. A battery production chain is being developed in anticipation of increased demand in the region. The total announced capacity (CATL, LG Chem, SK Innovation, Samsung, and Northvolt) already exceeds 400 GW·h by 2025, which would be equivalent to 300 kt of nickel.

Battery cell production is one of the final stages of battery manufacturing, preceded by the production of cathode precursors, and when lithium, graphite or silicon are added as the anode, the production of cathode material itself. In 2019, China held its position as the leader in cathode precursor production (61% of global production), while cathode material production was split between China (43%), Japan (30%), and South Korea (26%).

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

LCO batteries are principally confined to mobile electronics, as high cobalt prices, low power, and chemical instability of the compounds used prevent their application in EVs. However, other types of cathodes are widely employed in the EV sector. The current trend is to replace LFP and LMO

with nickel-containing NCM and NCA batteries, owing to the higher energy density and specific energy of the latter, which increases vehicle range.

Growing nickel consumption in Li-Ion batteries is driven not only by an increasing share of battery types containing nickel, but also by a higher average nickel content in the cathode material, which, in turn, is caused by the need to substitute expensive cobalt units. In comparison to 2016, when NCM 1:1:1 (with a nickel mass fraction of 20% of the total cathode mass) accounted for the lion's share of nickel-magnesium compounds in cathode materials, 2019 saw nickel-intensive compounds – NCM 6:2:2 (36%) and NCM 5:3:2 (30%) – take the lead. Going forward, conversion to NCM 8:1:1 (with a nickel content of 48%) is expected, and some producers announced plans to launch commercial production of LNO, a cathode material with nickel content exceeding 50%.

The further development of the automotive industry, with the growing popularity of electric and hybrid cars, along with the evolution of cathode technology towards nickel-intensive types make for a major uptick in growth of primary nickel consumption by the industry in the long run.

Changes in demand in other consuming industries were negligible. Demand for nickel used in special steels with improved structural properties and stability grew by 3%, or 4 kt. Nickel consumption for the production of heat-resistant alloys with a high nickel content, which are key materials for the production of aircraft engines, remained unchanged. Even against the backdrop of the grounding of the Boeing 737 Max, major commercial aircraft manufacturers are building their order books 8 to 10 years ahead, which should prop up nickel demand from the sector. Nickel consumption for standard alloys dropped by 1%, or 2 kt, due to low demand from the oil and gas industry on the back of falling oil prices in 2019.

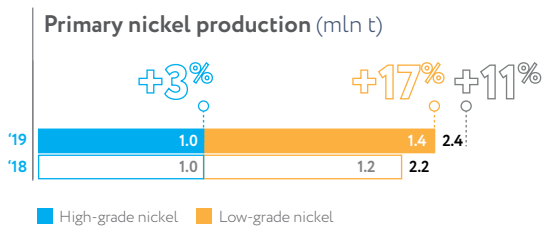
Nickel is widely used for corrosion protection and as an alternative to chrome plating. Having a strong resistance to corrosion, a high level of hardness and aesthetic properties, nickel can be used to apply decorative and protective electroplating to products. Amid a lower availability of high-grade nickel, which is traditionally used in the premium electroplating segment, nickel consumption for electroplating in 2019 decreased slightly (by 1%, or 2 kt), due to reduced demand in China and other Asian countries.

PRODUCTION

Primary nickel can be sorted into two major groups:

- High-grade nickel (cathodes, briquettes, carbonyl nickel and nickel compounds), produced from both sulphide and laterite feed. 2019's main producers of high-grade nickel were Nornickel, Jinchuan, Glencore, Vale, Sherritt, and BHP
- Low-grade nickel (ferronickel, NPI and nickel oxide), produced from laterite feed only. In 2019, the key producers of low-grade nickel included Chinese and Indonesian NPI smelters, as well as ferronickel producers such as Eramet, Posco, South 32, Anglo American, and Pamco

Primary nickel production in 2019 grew by 11%, or 242 kt y-o-y, driven primarily by a surge in low-grade nickel (NPI) output.



Source: Company data

In 2019, high-grade nickel production increased by 3%, or 32 kt. Despite a marginal decrease in production by Vale and BHP, total smelting of refined metal increased, thanks to higher output by Nornickel and Jinchuan.

This was coupled with an increased output of nickel sulphate, which is a key feed for the production of cathode precursors used in Li-Ion batteries. Integrated production of nickel sulphate uses nickel matte, but elsewhere, the main feed for nickel sulphate production is hydrometallurgy semi-products (mixed hydroxide residue and mixed sulphide residue) and crude nickel sulphate, a by-product of copper and PMG production. In 2019, the main feeds for sulphate production were hydrometallurgy semi-products, as well as nickel briquettes and powders, which are melted down during shortages of other feeds.

Low-grade nickel production grew by 17%, or 211 kt, boosted by a significant increase in NPI production.

In China, a record level of stainless steel smelting, coupled with a stable growth in ore imports, were the key drivers behind 2019's 24% increase in NPI production to 584 kt. In Indonesia, the startup of new production facilities of Jinchuan, and brownfield expansions at existing smelters using local ores with high nickel content resulted in NPI production growth of 46%, or 114 kt.

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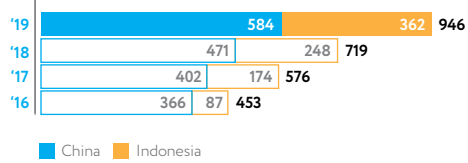
NPI production (kt)



Saleable nickel ore imports into China in 2016–2018 (mln t)