

GRK BYSTRINKOYE, ZABAYKALSKY REGION

GRK Bystrinskoye (Bystrinsky GOK) is Nornickel's 50.01%-owned subsidiary. Bystrinsky GOK is located in the Gazimuro-Zavodsky District, Zabaykalsky Region, 16 km east of Gazimursky Zavod village, 350 km away from Chita.

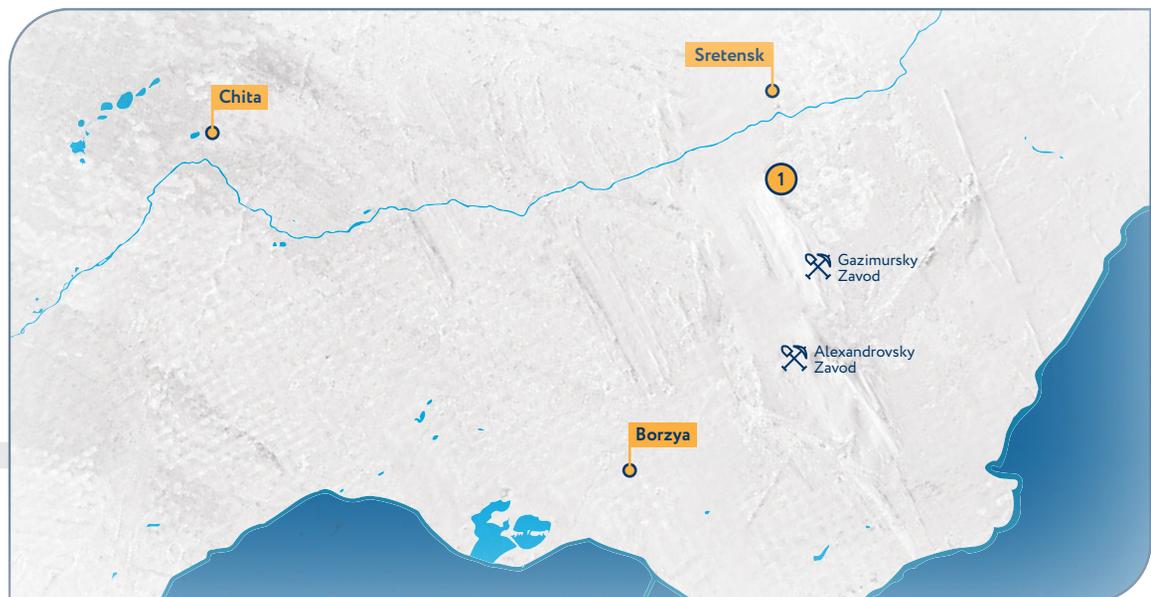
Nornickel's new asset is the largest greenfield project in the Russian metals industry, integrating ore mining, concentration and shipment of end products to customers. The expected volume of ore mined and processed at Bystrinsky GOK is approximately 10 Mtpa.

Nornickel commenced the construction of Bystrinsky GOK in 2013. The construction project includes open-pit mining at the Bystrinskoye deposit, a mining and processing plant (MPP) along with all of the associated infrastructure, including a power

line and a 227-km Borzya–Gazimursky Zavod railway line, and a rotation camp. In October 2017, Nornickel started the pre-commissioning activities, and in September 2019 Bystrinsky GOK was commissioned. The project is expected to ramp up to design capacity by 2021.

In 2019, Bystrinsky GOK accounted for 9% of the Group's total copper end products.

1 Bystrinsky GOK



MINING

Bystrinsky GOK mines gold-iron-copper ores of the Bystrinskoye deposit.

Ore output (mln t)

Mining asset	Mine type	2018	2019
Total ore		7.86	10.49
Bystrinskoye deposit		7.86	10.49
- Verkhneildikansky open pit mine	Open-pit	7.43	8.60
- Bystrinsky-2 open pit mine	Open-pit	0.43	1.89

CONCENTRATION

Concentration facilities

- Concentrator

The concentrator construction commenced in 2015; the facility's purpose is to process ores of the Bystrinskoye deposit into copper, iron ore, and gold concentrates. The key processing stages include crushing, milling, flotation, thickening, filtration and end product packaging. The concentrator has two processing lines. In 2018, Bystrinsky GOK started pre-commissioning of the processing lines, and in 2019 the concentrator was commissioned.

In 2019, it processed 7.5 mln t of ore (2018: 3.8 mln t). The increase was due to scheduled ramp-up to design capacity.

Copper and iron ore concentrates are sold via third parties, while gold concentrates are further processed at the Polar Division.

Products:

- Copper concentrate
- Gold concentrate
- Iron ore concentrate.

Production volumes

Product	2018	2019
Ore processing, mln t	3.8	7.5
Copper (in copper concentrate), t	19,417	43,489
- copper content in the concentrate, %	25.4	25.5
Gold (in copper and gold concentrates), koz	89	177
- gold content in the concentrate, g/t	6,218	4,034
Iron ore concentrate, kt	346	1,311
- iron content in the concentrate, %	64.1	64.6

NORILSK NICKEL HARJALVALTA, FINLAND

Norilsk Nickel Harjavalta is Nornickel's wholly owned subsidiary, acquired by the Group in 2007. The Harjavalta facility processes Nornickel's Russian feedstock and nickel-bearing raw materials sourced from third-party suppliers.

Founded in 1959, it is Finland's only nickel refinery and one of the largest nickel producers in Europe. Harjavalta's capacity is 66 ktpa of nickel products.

The facility uses sulphuric acid leaching with metal recovery rates above 98%, which is a best practice in the global mining and metals industry.

In 2019, Norilsk Nickel Harjavalta accounted for 27%, 3% and 2% of the Group's total nickel, copper and PGM finished products, respectively.

1 Norilsk Nickel Harjavalta Plant



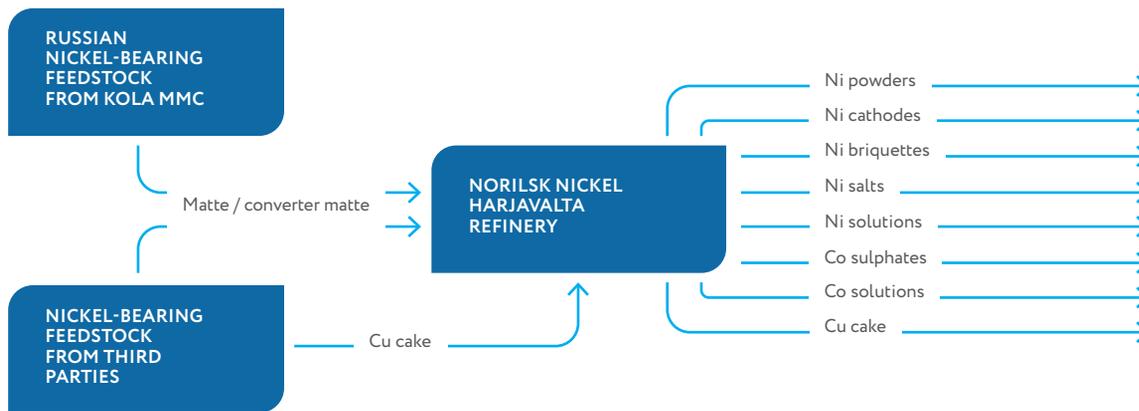
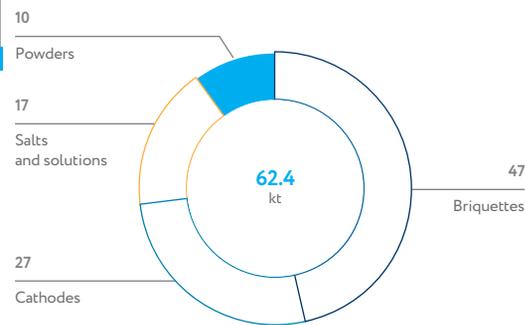
SMELTING

Facility's process chart

In 2019, the refining facilities of Kola MMC were gradually increasing their nickel feedstock supplies to Norilsk Nickel Harjavalta in line with the Group's downstream reconfiguration strategy. Third-party feedstock supplies, i.e., converter matte from Boliden and nickel salts from other suppliers, were regular and marginal in 2019. Metal recovery rates remained flat y-o-y.

In 2019, Norilsk Nickel Harjavalta produced 62 kt of saleable nickel (up 3% y-o-y),

Saleable nickel output by product in 2019 (%)



an all-time high for the refinery. The growth was driven by the reconfiguration of refining facilities and increased nickel feedstock supplies from Kola MMC. The production of copper in copper cake totalled 13 kt, down 28% y-o-y, while the output of saleable palladium in copper cake decreased by 8% y-o-y and platinum output increased by 5% y-o-y. The decrease in copper and palladium output was due to the start of copper cake shipments to the Polar Division for further processing.

Products:

- Nickel cathodes and briquettes
- Nickel salts, powders, and solutions

- Cobalt sulphate and solutions
- PGM-bearing copper cake

Refining capacity utilisation (%)



Production volumes

Product	2017	2018	2019
Nickel, t	59,716	60,765	62,422
- from own Russian feedstock	55,021	59,337	58,939
Copper (in copper cake), t	13,441	18,036	12,948
- from own Russian feedstock	12,328	17,980	12,667
Palladium (in copper cake), koz	42	58	54
- from own Russian feedstock	35	58	51
Platinum (in copper cake), koz	10	11	12
- from own Russian feedstock	6	11	9

NKOMATI, SOUTH AFRICA

Nkomati is a joint venture between Nornickel (50% interest) and African Rainbow Minerals. Nkomati's performance is reflected in Nornickel's financial results using proportional consolidation, based on our stake.

In 2019, total ore mined by Nkomati reached 3.5 mln t (attributable to the Group's 50% shareholding) with an average nickel content of 0.26% and copper content of 0.11%.

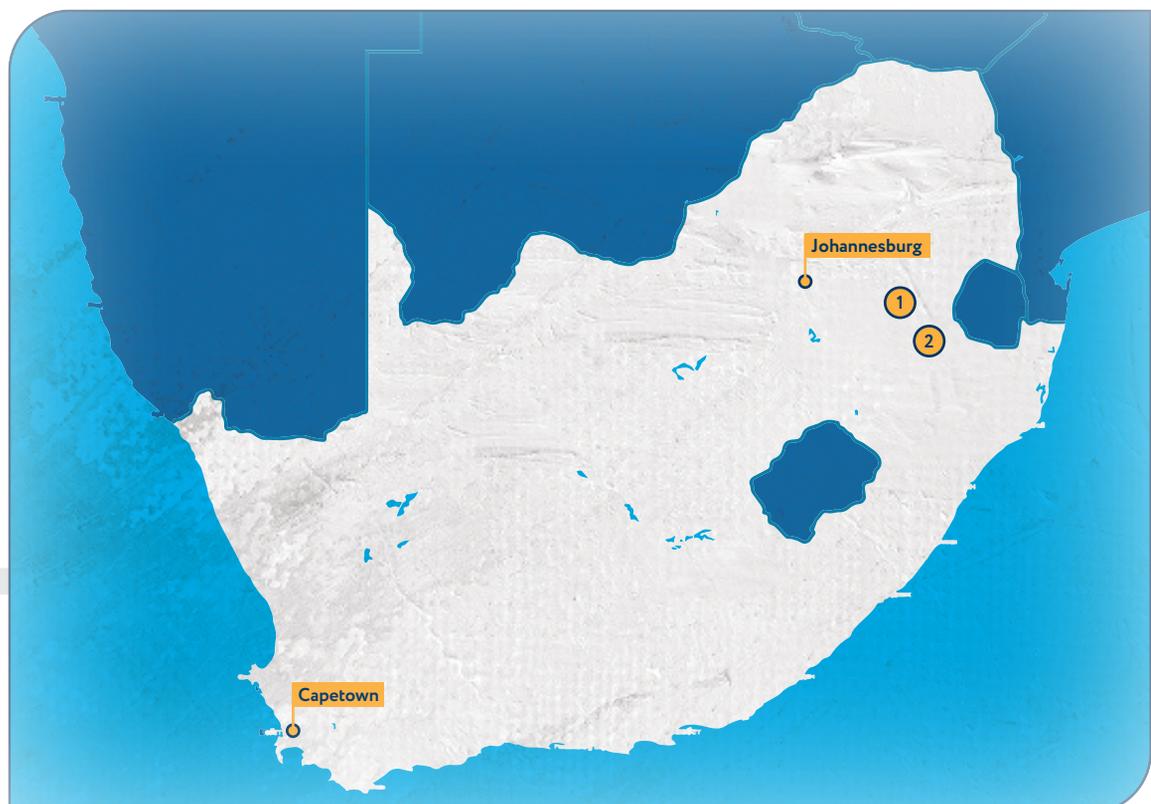
Nkomati is located in the Mpumalanga Province, South Africa, 300 km east of Johannesburg.

It is the only South African company to produce nickel concentrate, which also contains copper, cobalt, and PGMs. Nkomati produces chrome concentrate as well.

MINING

The Nkomati deposit has a substantial resource base represented by disseminated copper-nickel sulphide ores. The deposit consists of several ore bodies. The major ones are a solid sulphide ore body with a high nickel content and a peridotite chromite mineralisation zone with a relatively lower nickel content and a relatively higher chrome content.

① Mine ② Concentrator



CONCENTRATION AND SMELTING

Concentration facilities

- Concentrator for ore mined in the main section, with installed capacity of 375 kt per month.
- Concentrator for ore mined in the peridotite chromite section, with installed capacity of 250 kt per month.

The mined ore is processed at concentrators using the sulphide flotation technology, with the resulting concentrates then sold by Nor Nickel to third parties.

In 2019, Nkomati produced 6.5 kt of nickel (down 2% y-o-y), 3.4 kt of copper (up 12% y-o-y), 33 koz

of palladium (down 1% y-o-y), and 14 koz of platinum (up 6% y-o-y) (attributable to the Group's 50% shareholding). The drop in nickel and palladium production and the increase in copper and platinum output were due to changes in the processed ore composition and the commencement of production ramp-down as part of plans to scale down production at Nkomati Nickel Mine during 2020.

Products:

- Saleable concentrate.

Production volumes¹

Product (in concentrate)	2017	2018	2019
Nickel, kt	8.0	6.6	6.5
Copper, kt	4.5	3.1	3.4
Palladium, koz	46	33	33
Platinum, koz	20	13	14

^{1/} Volumes based on the 50% ownership.

SALES AND DISTRIBUTION

In 2019, Nornickel maintained its long-standing reputation as a reliable supplier of high-quality products. The integrated index of customer satisfaction with the Company's products and services matched the target level.

As a top global producer of base and platinum group metals, Nornickel sees its role as leading the industry on building an improved ecosystem for all market players and to this end launched a project to digitise all metal sale contracts in 2019.

The Company supplies its products to 37 countries and has products registered for delivery against contracts at the London Metal Exchange and the Shanghai Futures Exchange. Registration at the world's top exchanges ensures the liquidity and premium pricing for the Company's products.

PRODUCT RANGE

One of Nornickel's objectives is to make sure its product range matches the current and anticipated global metals demand.

Nickel product diversification is a priority in developing the product range as the Company is implementing a range of initiatives to enhance and expand its existing product range, with a particular focus on changes in the metals demand structure, including the rapid growth in the share of the electric vehicles and batteries. In particular, Nornickel continues active interactions with the battery sector players to expand its product range to meet the new requirements for shape and quality emerging in the market.

Norilsk Nickel Harjavalta is recognised as one of world's foremost producers of nickel used to make precursors (semi-products essential for manufacturing the cathode material that forms part of batteries). Norilsk Nickel Harjavalta's nickel and cobalt sulphates are considered the industry benchmark and are widely used in battery manufacturing. Norilsk Nickel Harjavalta is uniquely flexible when it comes to manufacturing various shape products, which enables it to factor in consumer preferences in developing its product portfolio.

Main consuming industries and sales markets

POLAR DIVISION AND MEDVEZHNY RUCHEY



Copper cathodes



Commercial selenium (powder)



Commercial sulphur



Tellurium ingots



KOLA MMC



Nickel cathodes, nickel carbonyl (powder and pellets), intermediate products



Copper cathodes, copper matte



Cobalt cathodes, cobalt concentrate



Sodium sulphate



Sulphuric acid



Sales markets:

- Russia
- Europe
- Asia
- Americas

Main consuming industries:

- Cables and wires
- Rolled products and pipes
- Metallurgy
- Chemical industry
- Glass making
- Electrical engineering
- Feeds and fertilizers
- Fertilisers, paper and pipes
- Rubber vulcanisation
- Stainless steel
- Alloys and superalloys
- Non-ferrous metallurgy
- Rubber industry
- Photo- and thermoelements
- Special steels and alloys
- Electroplated coatings

1/100% of shares are owned by the government. Precious metals are refined from raw materials produced by the Polar Division and Kola MMC under a tolling agreement.

NORILSK NICKEL HARJAVALTA



Nickel cathodes, nickel briquettes, electrolytic nickel powder, nickel sulphate, nickel hydroxycarbonate



Copper cake



Cobalt sulphate



GRK BYSTRINSKOYE



Copper concentrate



Iron ore concentrate



KRASTSVETMET¹



Platinum



Palladium



Rhodium



Iridium



Ruthenium



Silver



Gold



Welding electrodes

Synthetic detergents

Pulp & paper

Textiles

Leather goods

Healthcare and veterinary

Batteries

Additives and catalysts

Rolled products

Special steels

Jewellery

Investments

Auto catalytic converters

Electronics

Electrochemical industry

SALES STRATEGY

Sales, along with production, have traditionally been a key value adding part of Nornickel's business.

When it comes to nickel products, the sales strategy focuses on achieving a balance between supplies to stainless steel manufacturers and other industries. Electric vehicles and batteries are a priority segment in the nickel consumption structure, as its growth rates suggest that in a few years time it will become a key source of demand, second only to stainless steel.

Therefore, the Company is running a programme to support high-growth applications of nickel applications, primarily in the battery sector. Cooperation with the growing battery sector relies on our wide range of nickel products, high reliability of supplies, availability of the Company's own global sales platform and a long track-record of partnering with automotive manufacturers and chemical companies. The Company also maintains an ongoing, proactive dialogue with new leading players. All these factors make Nornickel well-positioned to become a key element in the battery components value chain.

In the battery segment, the Company is set to support the electric vehicles market and related value chains, build long-term partnerships with key industry players, and expand the market and its accessibility for nickel and cobalt products. Nornickel's sales team is closely monitoring changes in the technical requirements for nickel and cobalt products in the sector. The Company is actively engaging major players in the battery segment, as evidenced by its agreement with BASF, signed in 2018. Under the agreement, pilot production facilities were launched, commencing supplies of test product batches for certification by consumers in 2019.

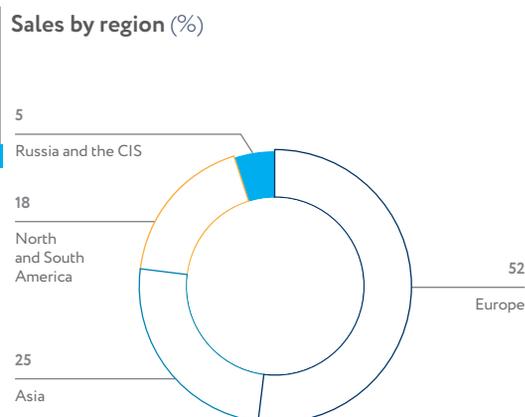
In the alloys and special steels sector, we seek to maximise the benefits of our product portfolio and improve product quality to boost our share in high-quality, premium segments.

In the electroplating sector, Nornickel is optimising its product offering to better meet customer needs and acquire new customers in China and other markets. The Shanghai Futures Exchange completed the approval procedure for the NORNICKEL brand of electrolytic nickel produced by Kola MMC, with a registration certificate expected to be issued early in 2020.

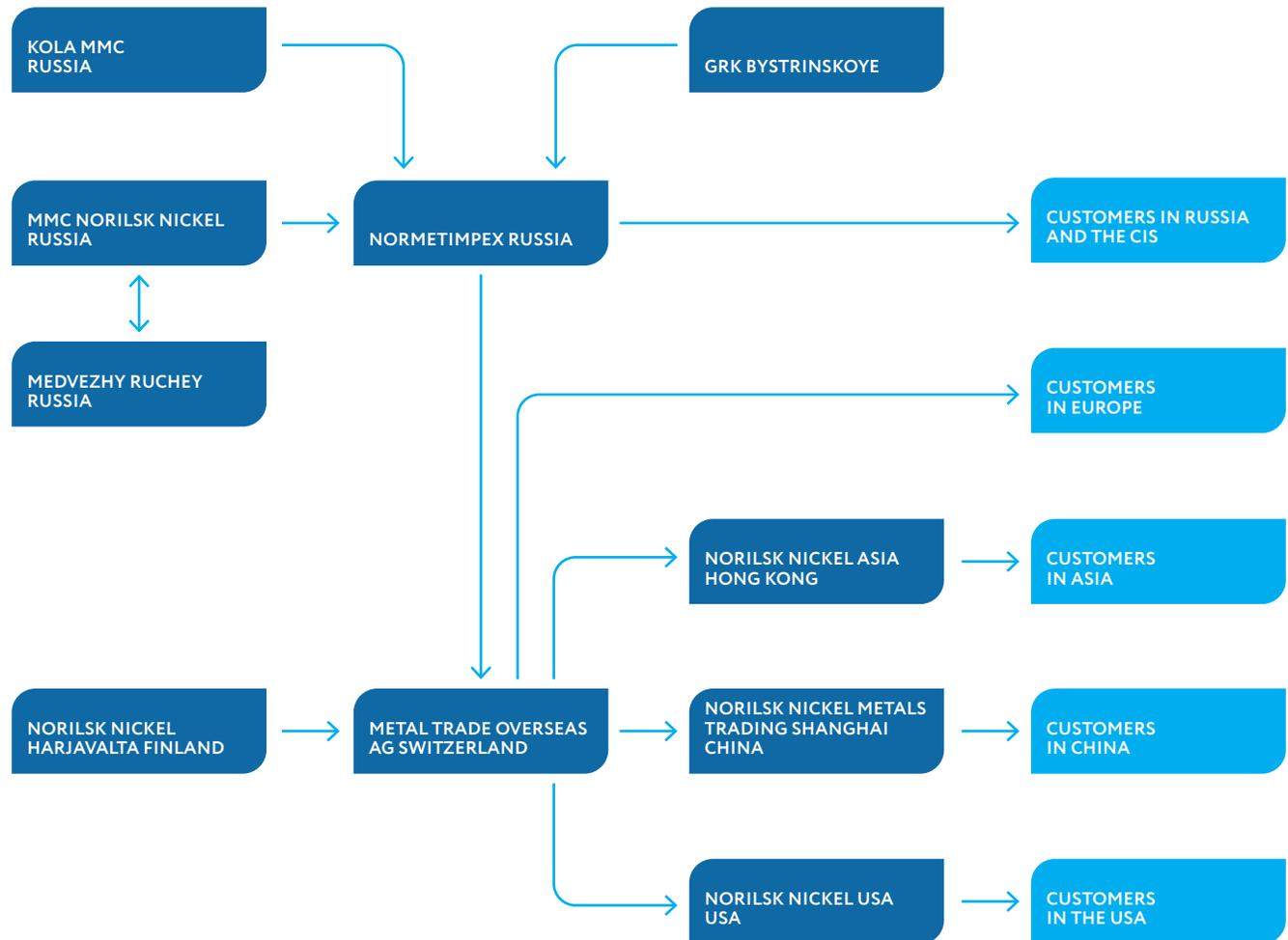
In 2019, the London Metal Exchange (LME) added the NORILSK I brand of electrolytic cobalt produced by Kola MMC to its list of brands approved for LME delivery.

As the world's largest producer of palladium, the Company continues to implement its strategy of entering into direct long-term contracts with end consumers to ensure sustainable and strong demand for platinum group metals.

One of Nornickel's priorities is to ensure stable supply of palladium as the world palladium market remains significantly undersupplied. As the leading supplier of this metal, the Company's strategy includes a number of measures to ensure long-term stability of the palladium market, including greenfield and brownfield expansion project such as the South Cluster.



The Company's product distribution diagram



ENERGY ASSETS

Nornickel owns an integrated network of fuel and energy assets, including four hydrocarbon deposits.

Most of Nornickel's production facilities are located beyond the Arctic Circle, operating in sub-zero temperatures for eight months of the year. It is therefore critical for the Group to ensure energy supplies to its production and infrastructure facilities, as well as to communities in its regions of operation.

Norilskgazprom (100% stake) produces gas and gas condensate at the Pelyatkinskoye, Yuzhno-Soleninskoye and Severo-Soleninskoye gas condensate fields, as well as the Messoyakhskoye gas field. The Pelyatkinskoye gas condensate field was transferred to Norilskgazprom in 2019 following the reorganisation of Taimyrgaz.

2,803.5
mln Mcm
natural gas production

92
kt
gas condensate production

44.5%
electricity generated
from renewable sources

- **Start of production:** 1969
- **Gas reserves:** 246.6 bcm
- **Gas condensate reserves:** 4,727 kt
- **Gas production in 2019:** 2,803.5 Mcm
- **Gas condensate production in 2019:** 92 kt

Production¹

Asset	2017	2018	2019
Natural gas, Mcm	3,014	2,896	2,804
- Taimyrgaz	2,086	2,027	0
- Norilskgazprom	928	869	2,804
Gas condensate, kt	100	90	92
- Taimyrgaz	98	88	0
- Norilskgazprom	2	2	92

^{1/} Data on gas condensate production include production losses (carryover with separation gas).

Norilsktransgaz (100% stake) transports natural gas and gas condensate from deposits to consumers.

The length of gas and gas condensate pipelines totals 1,588 km. The pipelines were commissioned between 1969 and 2018.

NTEK (100% stake) is focused on electricity and heat generation, transmission and sales harnessing the assets of Norilskenergo, a branch of Nor Nickel. Energy is produced from both renewable (e.g. hydropower) and non-renewable (e.g. natural gas) sources. NTEK supplies electricity, heat, and water to households in the city of Norilsk and to all production facilities within the Norilsk Industrial District. In terms of its location and operational mode, the local electricity grid is isolated from the national grid (the Unified Energy System of Russia), which means stricter reliability requirements. NTEK operates five generating facilities – three thermal power plants with installed electricity generation capacity of 1,190 MW, and two hydropower plants (HPPs) with total installed capacity of 1,091 MW. The total installed capacity of all plants is 2,281 MW.

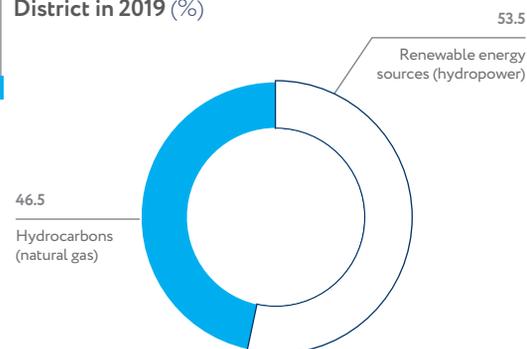
Ust-Khantayskaya and Kureyskaya HPPs (491 MW and 600 MW of installed capacity, respectively) are Nor Nickel's two renewable electricity generation facilities. In 2019, renewables accounted for 44.5% of total electricity consumed by the Group and 53.5% of total electricity consumption within the Norilsk Industrial District.

To boost the share of renewables such as hydropower, capture fuel and energy savings, and improve the reliability of energy and gas supplies, Nor Nickel's investment programme contains a number of large-scale priority projects. In 2019, the spending under the programme totalled about RUB 7.7 bn (USD 119 mln).

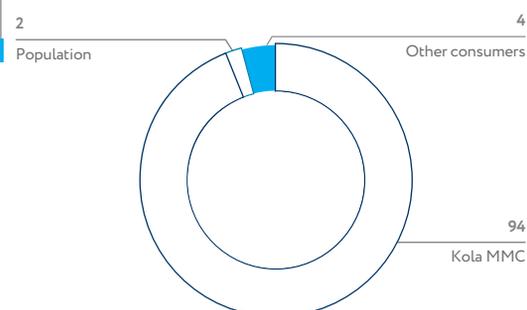
Selected major projects being implemented by Nor Nickel to improve equipment reliability, enhance energy efficiency, and boost product output:

- Replacement of seven hydropower units at Ust-Khantayskaya HPP

Power generation breakdown in the Norilsk Industrial District in 2019 (%)



Arctic-Energo electricity sales breakdown in 2019 (%)



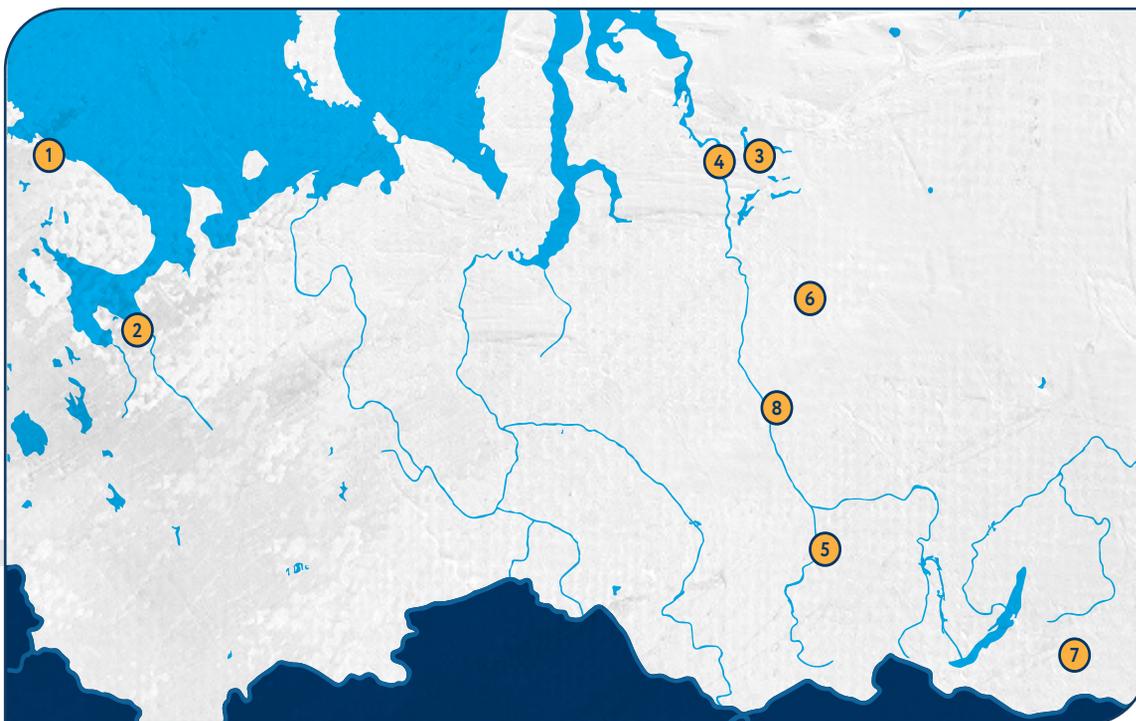
- Replacement of power units at CHPP-2 and CHPP-3 in Norilsk
- Upgrade of power grids, main gas pipelines, and gas distribution networks within the Norilsk Industrial District

Arctic-Energo (100% stake) is a default electricity supplier to Kola MMC in Monchegorsk, established to ensure efficient and uninterrupted electricity supply at cheapest rates to Kola MMC operations. In 2019, it sold 2,719,610 thousand kWh of electricity.

TRANSPORT ASSETS

Nornickel owns a modern transport infrastructure capable of handling most challenging freight logistics tasks and ensuring continuity and sustainability of operations. Nornickel's transportation and logistics assets cover the full range of transportation and freight forwarding services.

- 1 Murmansk Transport Division (Murmansk terminal, 6 heavy-duty ice-class vessels)
- 2 Arkhangelsk Transport Division
- 3 Norilsk Airport, Norilsk Avia, NordStar Airlines (100% stake)
- 4 Polar Transport Division (Dudinka Port)
- 5 Krasnoyarsk Transport Division, Krasnoyarsk River Port (89% stake) and Nornickel-ERP LLC
- 6 Yenisey River Shipping Company (82% stake)
- 7 Bystrinsky Transport Division
- 8 Lesosibirsk Port (51% stake)



FREIGHT SHIPPING SERVICES

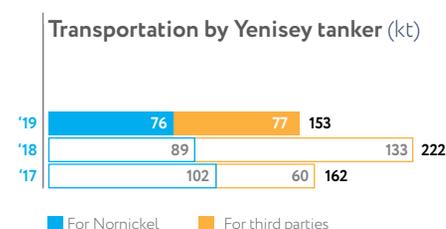
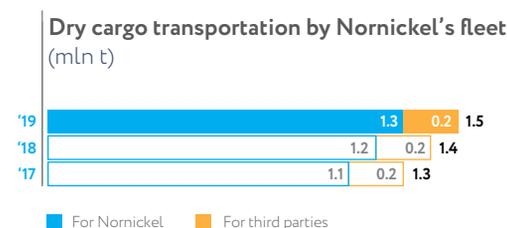
Nornickel has a unique Arctic fleet comprising five dry cargo vessels and one Yenisey heavy-duty ice-class tanker (ARC 7 as per the classification of the Russian Maritime Register of Shipping). The vessels are capable of breaking through Arctic ice up to 1.5 m thick without icebreaker support. The Yenisey tanker carries gas condensate exports from the Pelyatkinskoye gas condensate deposit to European ports, and makes commercial voyages to other destinations.

Nornickel's dry cargo fleet provides year-round freight shipping services between Dudinka, Murmansk, Arkhangelsk, Rotterdam, and Hamburg sea ports while also making commercial voyages to other destinations. In 2019, 68 voyages were made from Dudinka (2018:66), including 11 direct voyages to European ports (2018:10).

AVIATION ASSETS

Norilsk Avia (Nornickel interest 100%) serves the transportation needs of local communities in the Norilsk and Taimyrsky Dolgano-Nenetsky Districts of the Krasnoyarsk Region. The air company has its own fleet of 16 helicopters and provides air services related to the operations of the Norilsk Nickel Group, emergency air medical assistance, search-and-rescue operations, and local passenger traffic.

NordStar Airlines (Nornickel interest 100%) is an aviation project that has been steadily growing since its establishment in 2008. Its fleet comprises 13 aircraft. NordStar Airlines is a major air carrier in the Siberian Federal District and the anchor airline of Norilsk Airport. The air carrier's annual passenger



traffic is in excess of one million people. The airline's current route network covers over 30 cities in Russia and the CIS..

Norilsk Airport (Nornickel interest 100%) is located 36 km away from Norilsk. It plays an essential role in ensuring the region's transport accessibility as it connects the north of the Krasnoyarsk Region with other parts of Russia.

During 2019, the public private partnership between Nornickel and the Federal Air Transport Agency (Rosaviatsiya) renovated the airport's patrol road, security fencing, utility and communication networks; and the renovation of the airport apron's concrete pavement was 95% complete at end-2019.

The renovation programme is scheduled for completion in 2020.

Norilsk Nickel's transportation and logistics assets include:

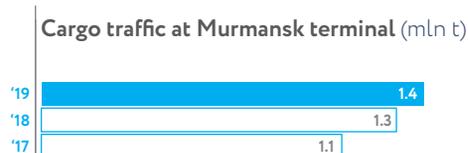
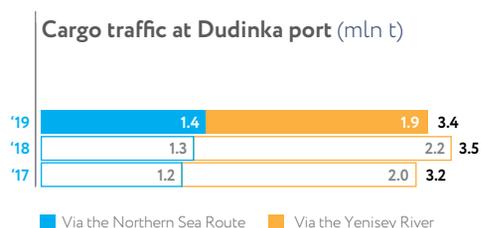
- sea fleet — 6 heavy-duty ice-class vessels;
- river fleet — 556 vessels, including 161 self-propelled and 395 towed vessels;
- rail car and locomotive fleet — 118 container flatcars, 1 switch locomotive, 1 Yermak electric locomotive, and 1 2M62 diesel locomotive;
- aircraft fleet — 16 helicopters operated by Norilsk Avia and 15 planes operated by NordStar Airlines.

TRANSPORT DIVISIONS AND PORTS

The Polar Transport Division and Dudinka Port are the key industrial facilities of the city port of Dudinka, accessible by both sea and river vessels.

Located in the Far North, Dudinka Port is the world's only port that gets flooded every year during the spring thaw. From November to May its water area and the Yenisey River freeze over. At this period, Dudinka Port handles only sea vessels using icebreakers to de-ice the berths and provide support during manoeuvring and mooring operations. In May and June, during the flooding, the service is suspended to be resumed for sea and river vessels when ice flows pass and the water level goes down.

Dudinka Port transships cargoes destined for Taimyr Peninsula, including goods for local residents (except for perishables and mail). In summer, river vessels deliver equipment and materials (sand, round timber, clinker, etc.) for process needs from Krasnoyarsk and Lesosibirsk; sulphur shipments are directed both via the Yenisey River and via sea routes. Converter matte and metal products are shipped by sea from Dudinka throughout the year.



The Polar Transport Division operates its own fleet of port service vessels which includes a river-class icebreaker, towboats, motorboats, a bunker barge, and a floating crane. To reduce its environmental footprint, the division runs programmes to cut fuel consumption and prevent pollution of the Dudinka and Yenisey Rivers, while also investing in bioresource management (e.g. releasing fingerlings).

The year-round ice-free sea port of Murmansk is home to Nornickel's **Murmansk Transport Division**. Murmansk Transport Division's key functions:

- Shipment of Nornickel's finished metal products from Murmansk to European ports
- Receipt of converter matte from Dudinka and its shipment by rail to Kola MMC
- Shipment of empty containers, equipment, and materials to Dudinka

In addition to sea transportation, Murmansk Transport Division is focused on freight forwarding, transshipment and storage of cargoes, and rail transportation between Murmansk and Monchegorsk.

The division's shipping department complies with international maritime conventions by ensuring environmentally friendly and safe sea transportation, with the vessels undergoing regular scheduled repairs and safety inspections. In addition, in 2019, Murmansk Transport Division's Information Security Management System was certified to ISO/IEC 27001:2013.

Arkhangelsk Transport Division is based in Arkhangelsk. The division provides year-round transshipment services for Nornickel's cargo via Arkhangelsk sea port, which is conveniently linked to other Russian and foreign regions by road, air and rail.

Krasnoyarsk Transport Division is based in Krasnoyarsk. This division is responsible for transportation and forwarding of Nornickel's.

In 2019, **Nornickel- Yenisey River Shipping Company** (100%) was established to coordinate operations of Krasnoyarsk port and Yenisey River Shipping Company, which operate a strictly seasonal service due to the Yenisey River getting frozen in winter. When ice flows pass, the Group uses the ports to transship Nornickel's cargoes to Dudinka, including crushed granite, clinker, materials, equipment, and socially significant cargoes (as part of the Northern Deliveries programme).

Yenisey River Shipping Company (82%) carries the bulk of the Group's and third-party cargoes shipped on the Yenisey River. The company owns over 600 river vessels, including self-propelled and towed ones. The fleet operates in the Yenisey, Angara, Nizhnyaya Tunguska and Podkamennaya Tunguska Rivers, and their largest tributaries.

Krasnoyarsk River Port (89%) is one of the largest ports in the Yenisey basin. The port transships cargoes delivered by road, rail and water, provides storage services and transports cargoes using private railway lines. The port has three operating areas – Yenisey, Zlobino, and Peschanka.

Lesosibirsk Port (51%) is located 40 km downstream of the point of confluence of the Angara and Yenisey Rivers and downstream of the hard-to-navigate rapids. This secures the delivery of Nornickel's cargoes at times of low water on the Yenisey and the use of fully loaded ships. The port's unique benefits:

- The only dedicated port on the Yenisey River capable of handling explosives with a storage option

- Offers year-round service (rail-to-road and road-to-rail cargo transshipment services in between the navigation periods)
- Has access to the Baikal (M53) federal highway via the Krasnoyarsk–Yeniseysk highway
- A railway to Achinsk links Lesosibirsk to the Trans-Siberian Railway.

Bystrinsky Transport Division was established in 2017 to support shipments of finished products from Bystrinsky GOK and handle its inventories. Bystrinsky Transport Division provides maintenance services for the 227-km Naryn (Borzya)–Gazimursky Zavod private railway line built through a public private partnership.

INVESTMENT IN TRANSPORTATION AND LOGISTICS ASSETS

In 2019, Nornickel completed scheduled repairs of vessels, overhauled several berths and port cranes, deployed integrated security technologies and solutions, upgraded communications hardware, introduced fuel consumption metering, and launched a programme to replace mobile port cranes at Dudinka Port.

Investment in transportation and logistics assets

Expenditure	2017		2018		2019	
	USD mln	RUB bn	USD mln	RUB bn	USD mln	RUB bn
TOTAL	46.2	2.7	35.1	2.2	55.6	3.6
Capital construction	22.2	1.3	6.4	0.4	3.1	0.2
Equipment purchases	15.4	0.9	12.8	0.8	40.2	2.6
Other	8.6	0.5	15.9	1.0	12.4	0.8

**WHY
WE
DO
THIS**

**We develop
digital
technologies
to deliver
operational
efficiency gains**

SYSTEMS

went live

**NEW
INITIATIVES**

slated for rollout
before 2024

17
50



Technology Breakthrough

A programme aimed at embedding advanced digital solutions into designing, planning and operational control processes throughout mining operations

RESEARCH AND DEVELOPMENT INNOVATIONS

RESEARCH AND DEVELOPMENT

R&D is a major driver behind the implementation of the Company's strategic priorities. In 2019, Nornickel's R&D and feasibility studies mainly focused on providing research data for the updated Norilsk Nickel Group Strategic Development Plan. Operations. Mining, processing, metallurgy.

Gipronickel Institute is Nornickel's main R&D facility. Part of the Norilsk Nickel Group, it is also one of Russia's largest research and engineering hubs for mining, concentration, metallurgy and processing of minerals, providing a wide range of research and technology services.

PATENTS AND LICENCES

Implementation of uniform approaches to intellectual property (IP) management is a major driver of Nornickel's innovative development.

The Company registers its exclusive rights to inventions and means of identification both in Russia and beyond.

International registration process for Nornickel's Method for Continuously Converting Nickel-Containing Copper Sulphide Materials is now in progress, with a Kazakhstan patent for this invention granted in 2019.

A Certificate of State Registration for 10-day/shift Operations Planning and Control System for Underground Mines software was also granted in 2019. The software solution is being rolled out across the Group as part of its mining automation project.

Also in 2019, the Company completed the registration process and obtained an international certificate of registration for the NORNICKEL trademark in the USA for the first time in its history.

DIGITISATION

Nornickel is the industry's digital leader:

- Nornickel won the first place and the gold award in the Business Transformation Category at SAP Quality Awards in the CIS region for two years in a row – 2018 and 2019 – for its project to roll out SAP ERP
- The Company won the first place for the Machine Vision-Based Detection of Ore Contaminants on Concentrator Conveyors project
- Bronze award was given for the Smart Tailing Dump project leveraging all currently available state-of-the-art dam movement monitoring technologies
- Nornickel's project to optimise flotation processes at Talnakh Concentrator was awarded a BCG Olympics medal in 2019 as the best project internationally to win this highly prestigious annual global competition

Adoption of state-of-the-art technology, including digital solutions, is critical to business competitiveness. Nornickel places considerable emphasis on researching and adopting various digital technologies to optimise production processes, improve overall business performance, and eliminate bottlenecks, resulting in a higher conversion productivity, lower costs and a streamlined organisation. The Company has built a portfolio of various applied technology solutions which can be of interest to other players in the metals and mining industry as well as other industries.

In July 2019, Rosbank and Nornickel migrated the interface between their information systems to a host-to-host digital platform developed by Rosbank and Nornickel's experts supported by BDO Unicon Business Solutions. The host-to-host solution provides a high-speed secure data transfer directly between Nornickel's corporate SAP system and Rosbank's host-to-host service.

It now takes Nornickel's Treasury barely a moment to send payment orders to Rosbank and receive settlement account statements from it. Migration to the host-to-host solution has not only made

payments faster and more secure but also streamlined Nornickel's internal processes and going forward enables fundamentally new, digital business use cases around interfaces with banks and counterparties.

TECHNOLOGY BREAKTHROUGH PROGRAMME

The Company runs the Technology Breakthrough programme to integrate advanced technologies into the design, planning and operational control processes of its mining activities, driving the operational efficiency of its production processes. About 40 IT initiatives were developed during its first phase (Technology Breakthrough 1.0).

The key projects within the programme: development of mining equipment and personnel positioning and communication systems; mining operations planning and dispatch; and deployment of various solutions including geological modelling and mine planning solutions, metals balance calculation, industrial asset management, process data storage, and health and safety systems.

Basic infrastructure building

Nornickel has equipped all of its underground mines with positioning and communication systems. More than 300 kilometres of fibre have been laid, with over 1,000 Wi-Fi access points installed underground. Every day, each person out of more than 6,500 is given special equipment with an RFID tag to track the person's movements within the mine. Similar tracking solutions are installed on moving machinery, totalling more than 500. Video surveillance is provided for key infrastructure facilities underground. A control room operator monitors movements of each employee and can contact them by phone. An anti-collision technology is used to warn drivers of people in the way. The Company has deployed a powerful system providing complete information on people and machinery positions and ore flows in mines by feeding virtually unlimited volumes of data from the surface underground and back.

Geological modelling and mine planning solutions

The deployment of geological modelling and mine planning solutions has enabled the development of a single mining database and 3-D models of underground ore bodies. The software can also be used to design underground workings and obtain survey data. The system enables data preparation and feeding to automated drill rigs, with significant gains to be achieved in drilling and blasting performance. Geological modelling and mine planning software can also accelerate development and analysis of multiple mining options to identify the most effective one and plan mining accordingly.

Simulation modelling system

The software analyses data on underground workings, their geometry, underground transport and ore production plans to calculate an optimal quantity of required underground machinery. The purpose is to optimise ore production and transportation from the mine to the surface. Nornickel's mid-term plans are to use the simulation modelling system to test the use of remotely controlled underground machinery.

Smart digital mines

It took a lot of time and effort to develop underground infrastructure across all mines operated by the Company before operational control centres could launch and assume associated control and management functions. Wireless data transmission system points and fibre links were installed under the Polar Division's machinery tracking and radio communication project, implemented as part of the Technical Breakthrough programme. Each underground working now has Wi-Fi access and is fitted with video cameras.

The Company has also developed a unique 10-day/shift scheduling software to eliminate the decentralised approach and manual planning for certain mine parts. The software allocates tasks and equipment to workings and shifts in accordance with the process cycles and pre-set inputs to create the mine operation 10-day/shift schedule with 10-day increments and task scheduling for each specific shift. Mining plans covering different periods and parts of all underground mines are integrated

into higher-level plans within a single centralised planning system. The operational control centres now operate in accordance with the new mining planning processes. The 10-day/shift scheduling software creates work plans using data from the Micromine geological modelling and mine planning software which creates a 3D model of the mined ore body with a clear representation of beds and seams and helps optimise reserve development sequencing and production techniques.

Process data storage

All data is fed into a process data warehouse, which also collects telemetry data from moving machinery: motor RPM, fuel consumption, working hours, etc. The single process data warehouse collates over 60,000 parameters for all enterprises of Nornickel. The data is then used in other Technology Breakthrough systems such as Production Dispatch, Metals Balance, and in the SAP ERP equipment maintenance and repair management system.

Technical Breakthrough 1.0 has improved total metal recovery and increased the quality of saleable ore by 6.5% between 2016 and 2019, achieving total savings of billions of Russian roubles.

In 2020, Nornickel will launch the second phase of the programme – Technical Breakthrough 2.0, which will include 11 projects. The second phase will mostly focus on Industry 4.0 levers, with certain autonomy embedded in all mine development projects. The Company will now harness big data to improve production planning and overhaul the production process, implementing projects to roll out artificial intelligence, robotics, digital twins, etc.

Nornickel is developing a database enabling it to plan for unmanned production. In particular, mining at depths between 2 km and 2.5 km in the Glubokaya mine (at the Skalisty Mine site) will maximise the use of autonomous mining systems.

DIGITAL LAB

Nornickel actively deploys digital technologies to address local production tasks. Its R&D division Digital Lab has been active for almost two years.

Two initiatives of the Digital Lab won awards at the Mine Digital contest held as part of the Minex Russia geological forum. The gold winner was the Conveyor Contaminant Identification project applying artificial intelligence technology to recognise non-metallic matter on the conveyor which, if entering the concentrator's crusher, can damage the equipment. Bronze award was won for the Smart Tailing Dump project which focuses on the analysis of satellite radiolocation data to track potential strata movements with a millimetre accuracy.

Concentrator conveyor contaminant identification system

The Digital Lab won the gold award for this initiative at the Mine Digital contest held as part of the Minex Russia geological forum.

The system uses artificial intelligence technology to recognise non-metallic matter on the conveyor which, if entering the concentrator's crusher, can damage the equipment. The system will reduce the wear of crushing equipment and the frequency of unscheduled repairs, and is planned to be launched in the mid-term across all of Nornickel's sites.

Industrial exoskeletons

In 2019, Nornickel made its first-ever public presentation of an exoskeleton system developed jointly with the South-West State University. The presentation featured rapid training and testing of exoskeletons on a testing ground, providing the companies in the audience with an opportunity to get a first-hand feel for the new solution. The presentation generated great interest from many companies, and as a result several exoskeletons were shipped for testing to production sites of several Russian metals companies. The exoskeletons were also presented by Nornickel at an advanced project exhibition held by the Agency for Strategic Initiatives.

Industrial exoskeletons are designed for use in harsh environments, helping to resolve health and safety issues and improve operational efficiency. An exoskeleton is put on over the safety workwear and is attached to the person's body by special straps. It can help persons lifting or carrying weights of up to 60 kg by taking up to 90% of the weight. Thanks to its small size, an exoskeleton can be used in hard-to-reach areas inaccessible to specialised machinery. Nornickel's exoskeletons have some smart features: apart from the exoskeleton itself, the system also includes an onboard computer to monitor ambient air pollution concentrations, temperature, illuminance levels, and the user's operating modes in real time.

H&S compliance monitoring solution

Health and safety violations are detected and recorded by video cameras using machine vision and artificial intelligence. The system drives employee accountability, simplifies monitoring and reduces accidents at work.

Short circuit detection in copper electrolysis at metallurgical plants

An integrated hardware/software solution has been developed to detect short circuits in copper electrolysis, stabilising the electrolysis process and increasing the output of copper cathodes.

Drones for aerial surveillance of hard-to-reach areas

Nornickel is developing drones capable of video recording and autonomous movement deep underground without relying on GPS. The drones will be used to inspect the condition of facilities in hard-to-reach areas, enabling faster inspections, reduced diagnostic costs, and most importantly, improved safety. Nornickel has also designed drones for automatic scanning of mine areas that are out of bounds for employees, which will also prevent unscheduled shutdowns and accidents.

Mine surveying robot

Nornickel has piloted a robotic system capable of laser scanning and autonomous movement in workings, which enables high-quality 3D surveying including for hard-to-reach areas. The Company will be able to use the data feed from the robot for integration with its geological modelling and mine planning system.

**WHY
WE
DO
THIS**

We are looking for solutions

to drive operational efficiency within the existing asset portfolio and ease the workload of metallurgists

INITIATIVES

moved into large-scale rollout

INITIATIVES

Digital Lab worked on

6

53

Digital Lab

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