

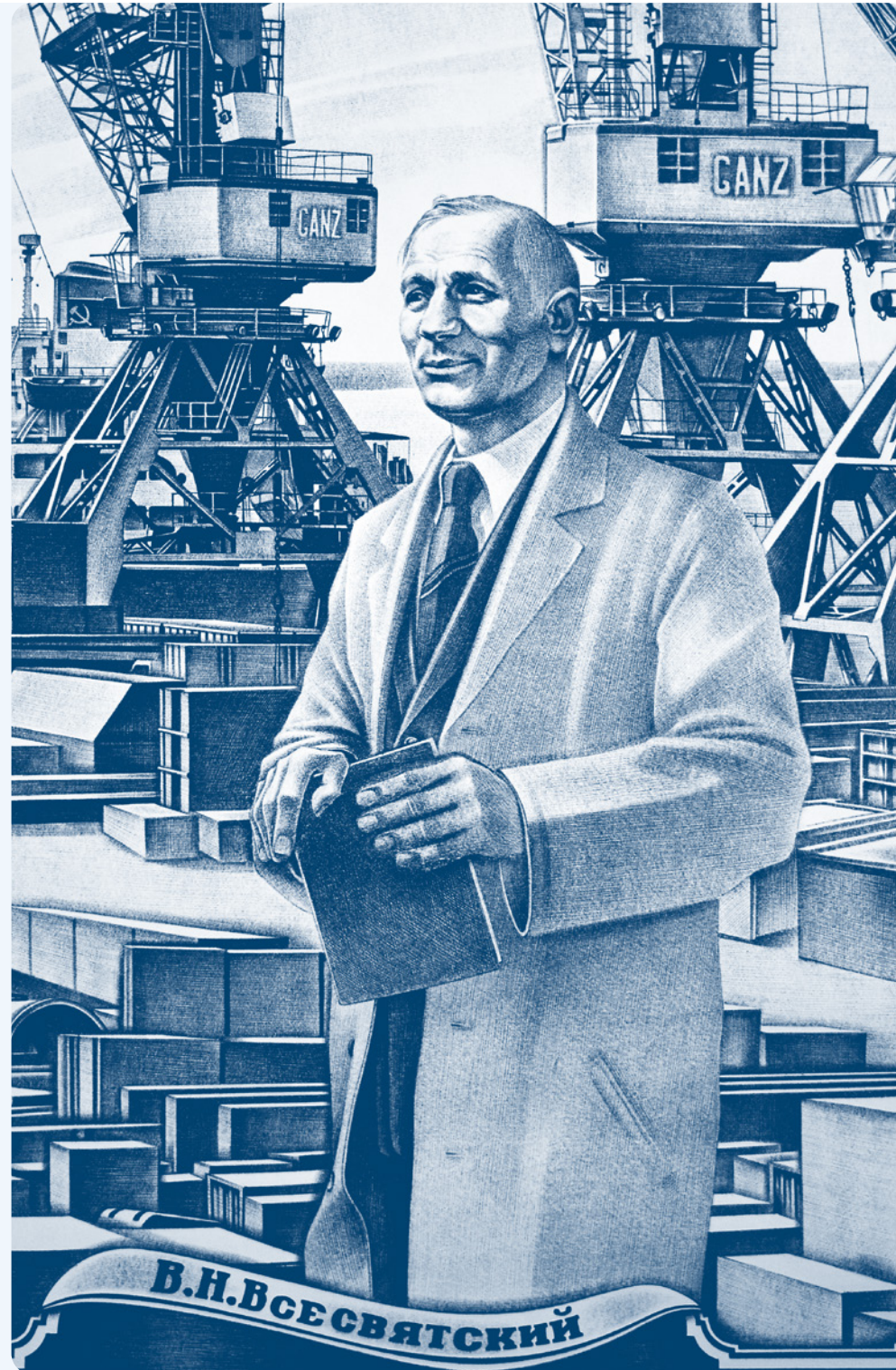
# RESEARCH AND DEVELOPMENT

## How has the trajectory of the Company's R&D endeavours evolved over the past 20 years?

Nornickel embraces R&D and innovation efforts as the fundamental drivers of increased production, high product quality, and reduced environmental footprint. The Company was systematically building a substantial intellectual foundation by accumulating R&D assets, fostering relationships with research institutes, and nurturing corporate scientific expertise.

As Nornickel evolved, so did its goals and objectives. While the initial focus was on maximising the extraction of non-ferrous and precious metals from ore and curtailing expenses, the emphasis has now shifted due to new environmental standards and production reconfiguration, which profoundly influenced process flow redistribution and technological re-engineering. Today, designing cost-efficient and effective technical solutions and diversifying Nornickel's product range are front and centre.

Throughout these 20 years, the Company has conducted extensive R&D across multiple focus areas, established dedicated labs and research centres (including mobile environmental, forensic chemistry, and digital labs), brought to life over 2,000 employee-driven improvement initiatives, and actively participated in numerous applied research conferences.



## Nornickel's contribution to the Science and Universities national project

### Relevant UN SDGs



### Related federal projects

Development of science and scientific-and-production cooperation

Development of advanced R&D infrastructure

### Key initiatives and focus areas

Endeavours of Gipro-nickel Institute, Palladium Centre, and Nornickel Digital Lab

Support for graduates of vocational education institutions

Cooperation with universities to develop and test advanced technologies and train highly skilled staff

Development of cooperation with the Russian Academy of Sciences

Fundamental and applied research and the practical adoption of innovative, cost-efficient, and eco-friendly technologies are key to delivering on Nornickel's strategic ambitions.

### Primary goals of Nornickel's R&D efforts



Enhancing and advancing production processes



Diversifying the product portfolio



Providing technological support for operations



Ensuring technological sovereignty

Nornickel's approach to R&D is guided by the principles enshrined in its R&D Management Policy.

The decision-making process is supported by the R&D Council's consultations and expert reviews.

In 2023, the Company pushed forward [existing and commenced new R&D projects and feasibility studies](#) seeking to amplify efficiency and environmental safety in production, complete major reconstruction and upgrade of production facilities, enhance concentration capacities, and bolster financial health.

Nornickel propels proprietary tech advancements primarily through the Group's Gipronickel Institute, Palladium Centre, and Nornickel Digital Lab. Furthermore, the Company engages specialist engineering firms and leading Russian universities for research endeavours (under effective agreements with the Siberian Federal University, Fedorovsky Polar State University, and other scientific and academic institutions).

## Gipronickel Institute

Gipronickel Institute, Nornickel's principal research and design hub and one of Russia's premier institutes for mining, concentration, metallurgy, and mineral processing, undertakes a vast array of services. These include designing

eco-friendly, high-tech facilities, supporting construction, operation and manufacturing of saleable products, and information modelling for both Nornickel's Russian business units and third parties in the metals and chemicals sectors.

### Areas of focus for Gipronickel Institute's research

Ore deposit samples

Rock samples

Valuable non-ferrous feedstock

**Ni** Nickel

**Co** Cobalt

**Cu** Copper

**Au** Aluminium

**Sn** Tin

**W** Tungsten

**Mo** Molybdenum

**Hg** Mercury

**S** Sulphur

In 2023, Nornickel's R&D projects and feasibility studies received a total of

**RUB 198.9** mln

in financing, with

**14** unique initiatives completed

**90** years track record

**>1,000** employees

**12** countries, where Gipronickel's projects have been accomplished

**>6,500** R&D innovations in Gipronickel's history

The multifunctional engineering centre boasts four technology and two testing labs. In 2023, Gipronickel Institute established a dedicated lab focused on creating competitive domestic cathode materials (CAM) for lithium-ion batteries. The team devised multiple production processes for CAM using nickel and cobalt sulphates and a precursor synthesis co-precipitation method (PCAM), including CAM alternative production schemes (PCAM). The R&D activities helped produce market quality cathode materials equalling their commercial counterparts as certified by independent laboratories. A pilot batch of CAM was manufactured, with an end-to-end technology put in place that covers the lifecycle "feedstock – cathode material – recycling". Battery recycling

initiatives kicked off with preliminary lab tests that yielded high-quality samples, paving the way for intellectual property registration (three patents pending). Looking ahead, the Company plans to produce high-purity materials, specifically crystalline nickel and cobalt sulphates, along with advanced products like PCAM/CAM.

Moreover, in 2023, Gipronickel Institute identified prospective tech partners to advance concentration and metallurgical processing techniques within the scope of the Kolmozerskoye deposit development project. In 2024, Nornickel plans to develop a technology for extracting lithium from spodumene ore, with the first pilot batch expected in 2026.

In 2023, the Institute's innovative solutions obtained international patent protection: the continuous converting technology – in South Africa, and the roast-leach-electrowin technology – in Kazakhstan and China. Applied in production, these technologies help tackle environmental challenges, conform to environmental laws, reduce the cost of end products, and enhance metal recovery for saleable products<sup>1</sup>.



<sup>1</sup> For more details on the technologies, please see the [2022 Sustainability Report](#).

# Palladium Centre

We also engage in R&D focused on palladium due to its significant role in fostering a green economy.

In most cases, palladium exhibits superior catalytic activity and high magnetic susceptibility, thereby bolstering the efficiency of technological processes. These properties broaden its utility across various industries, including hydrogen energy, chemical synthesis, and microelectronics. When mixed with

other elements, it can manifest unique optical features that could amplify the performance of solar generators. Consequently, palladium-based materials and alloys can improve cost efficiency and expedite the growth of several cutting-edge industries.

Our current portfolio boasts over 20 products at different stages in the development pipeline, with 14 classified as ESG.

**14** ESG products in the portfolio (out of more than 20)

**>100** new palladium-based materials in the long run

The Palladium Centre is actively forging a network of experts and customers, encompassing collaborative research with both domestic and international institutes and labs. This strategy includes engaging with potential customers in the Asia-Pacific to reduce time to market for innovative products.

In the long run, the goal is to create over 100 new palladium-based materials. Their deployment could spur at least 40 tonnes of new palladium demand by 2030<sup>1</sup>.

These projects and initiatives align with the goals of the Company's Sustainable Social Development Strategy, fostering technological and social progress through Norinickel's offerings, such as water purification systems using palladium, batteries for green transport, hydrogen energy solutions, and more.

« With the Company's support, my colleagues and I have developed and brought to life innovations that bolster sustainable practices within the roasting section of the Refining Shop and boost productivity.

For example, we successfully implemented a method of nickel electrowinning from chlorine dissolved tube furnace nickel powder in the Refining and Nickel Electrolysis shops. Another achievement was the launch of the Reducing Agent Transportation project, which helped us cut the Transport Shop's costs.

**Alexander Krasikov,**  
grade 5 roaster, Refining Shop, Kola MMC  
(length of service with the Company – 33 years)



## Hydrogen energy

Palladium applications in hydrogen energy are extensive across the entire production chain: from hydrogen dissociation from water, extraction from gas, transportation, to its use in fuel cells.

In 2023, the Company:

- successfully produced catalyst samples for electrolyzers that incorporate 30% replacement of iridium with palladium. These samples exhibit a threefold boost in performance in contrast to their commercial counterparts;
- synthesised fuel cell catalysts, where 25% of platinum is replaced by palladium, yielding more than a twofold performance hike versus commercial alternatives. Our target is to elevate this replacement level up to 80%.

These samples are currently undergoing validation by reputable overseas partners ahead of supplies to end users.



## Solar power

The Company is designing a cutting-edge thin-film solar panel cell based on palladium chalcogenide to enhance efficiency in comparison to the conventional silicon, tellurium, or copper based alternatives.



## Chemical synthesis

We are developing an array of products for novel chemistries such as catalysts conducive to synthesising glycolic acid for skincare use, FDCA acid for biodegradable packaging, and elements for the disinfection of water. The customer trial phase is slated for 2024.



## Electronics, spintronics, and reserve

In partnership with R&D institutes, fundamental research is underway to explore palladium's prospective uses on a longer horizon – in superconductors, supercapacitors, microelectronics, spintronics, and even medical devices.

Pd

<sup>1</sup> The Company's internal projections.

Major R&D and feasibility studies in 2023

Initiative	Achievements in 2023	Plans for 2024	Expected effects
Research into the CO <sub>2</sub> absorption capacity of tailings (waste rock), with outlook for reducing the Company's gross emissions explored	<ul style="list-style-type: none"> <li>Comprehensive lab studies concluded;</li> <li>computer modelling completed;</li> <li>inputs collected and prepared for devising assessment and accounting methods</li> </ul>	Plans are underway to finalise this methodology and seek validation with international independent experts. Moreover, the Company plans examining accelerated mineralisation processes	<ul style="list-style-type: none"> <li>Lower gross CO<sub>2</sub> emissions;</li> <li>diminished carbon footprint of the Company's products</li> </ul>
Molecular modelling for using the Company's by-products as substitutes for natural materials in filling compounds	<ul style="list-style-type: none"> <li>Comprehensive lab studies concluded;</li> <li>optimal formulations meeting the Company's criteria for backfilling processes identified</li> </ul>	Pilot tests scheduled in the Skalisty Mine	<ul style="list-style-type: none"> <li>Lower by-product generation and accumulation;</li> <li>lower natural material consumption</li> </ul>
Processing sulphur dioxide into sulphuric acid, subsequently neutralised with limestone to produce gypsum cake kept in a gypsum storage facility	Comprehensive testing of the first processing line under the Sulphur Programme launched at Nadezhda Metallurgical Plant	Completion of construction and installation works; start of comprehensive trials of the remaining processing lines	Once the project reaches its target parameters, the Company will be able to meet 2024 statutory requirements for cutting pollutant emissions in Norilsk by at least 20% and further on by 45% upon the project's completion
Research into enhanced recovery of magnetic pyrrhotite from concentrator tailings using wet magnetic separation	The economic benefits of applying magnetic separation to tailings at the Talnakh Concentrator verified	Plans are in place to introduce magnetic separation of tailings at the Talnakh Concentrator	Expected effect in three years: nickel and PGM output increase of 1,500 tonnes and 602 kg, respectively
Introduction of ejector flotation machines as part of the Norilsk Concentrator upgrade	Pilot tests with a flotation machine completed by Passat at the Norilsk Concentrator	Roll-out is scheduled as part of the Norilsk Concentrator upgrade	The Concentrator's ore processing capacity is anticipated to grow by 100–150 ktpa, translating into annual financial gains of RUB 0.5–1.0 bn
Research into the flotation process for copper-nickel ores at the Company's concentrators	<ul style="list-style-type: none"> <li>Studies completed into ionometric mapping and ion composition optimisation of slurry at the ore flotation stage;</li> <li>potential discovered for ion-selective electrodes to effectively control reagent consumption</li> </ul>	Tests will extend to winter slurries to reinforce these findings	Positive validation could increase nickel, copper, and PGM recovery into the Talnakh Concentrator's bulk concentrate by 0.5%, translating into annual financial gains of RUB 1.2–1.6 bn

Initiative	Achievements in 2023	Plans for 2024	Expected effects
A study on production of artificial anhydrite from gypsum to be used in hardening filling compounds at mines	<ul style="list-style-type: none"> <li>A trial batch of heat-treated gypsum produced for filling compound tests;</li> <li>inputs for feasibility study provided;</li> <li>research into making artificial anhydrite using a roasting-free method conducted;</li> <li>physical and mechanical properties of original gypsum and artificial anhydrite examined</li> </ul>	—	<ul style="list-style-type: none"> <li>No need to expand gypsum storage continually;</li> <li>no need to mine natural anhydrite</li> </ul>
Efforts to restore the metallic cobalt production chain underway at Kola MMC	Metallic cobalt production established at Kola MMC's temporary site	—	Annual metallic cobalt output target: 1 ktpa
Implementation of the process to reduce the share of crushed converter matte	A portion of crushed converter matte substituted with the non-magnetic fraction from the initial grinding phase	Some of the resulting converter matte sent to Norilsk Nickel Harjavalta. Transition to this technology expected in 2025	Reducing the PGM work-in-progress volume by 1.8 tonnes
Kola MMC's product development plan involves operational, investment, and research efforts	<ul style="list-style-type: none"> <li>Pilot tests for thicker nickel production completed</li> <li>the first test batches of nickel carbonate produced and dispatched;</li> <li>the first batches of premium HIGH PURITY nickel products manufactured</li> </ul>	<ul style="list-style-type: none"> <li>Developing a programme for the Plating Grade nickel production process;</li> <li>NORINICKEL PLATING GRADE nickel to be produced in thicker slugs and cathodes</li> </ul>	Diversification of sales segments
Production of high-purity precious metal powders (Pt, Pd) at Kola MMC	Technologies for yielding refined platinum, palladium, gold, and silver developed	Kola MMC is set to launch a test section for the precious metal refining technology, enabling Norinickel to build in-house capabilities in this area, enhance the main operational parameters of the process and quality of precious metal semi-products / products at a pilot scale, using the Company's real-life concentrates for further in-house refining projects	This venture envisages annual processing of 36 tonnes of platinum-palladium concentrate in the research section, resulting in the production of at least 3 tonnes of platinum and 12 tonnes of palladium powder