Nippon Denko Compendium

Nippondenko daijiten

January 2024

NIPPON DENKO

Contents

NIPPON DENKO

Company Overview

Company Overview

■ Established October 1925

■ Head Office 1-4-16, Yaesu, Chuo-ku, Tokyo

■ Employees 950 : Consolidated / 616 : Non-consolidated

■ Businesses Ferroalloys / Functional Materials / Incineration Ash Recycling / Aqua Solutions / Electric Power

■ Group Affiliates 6 domestic / 2 overseas affiliates

■ Scale

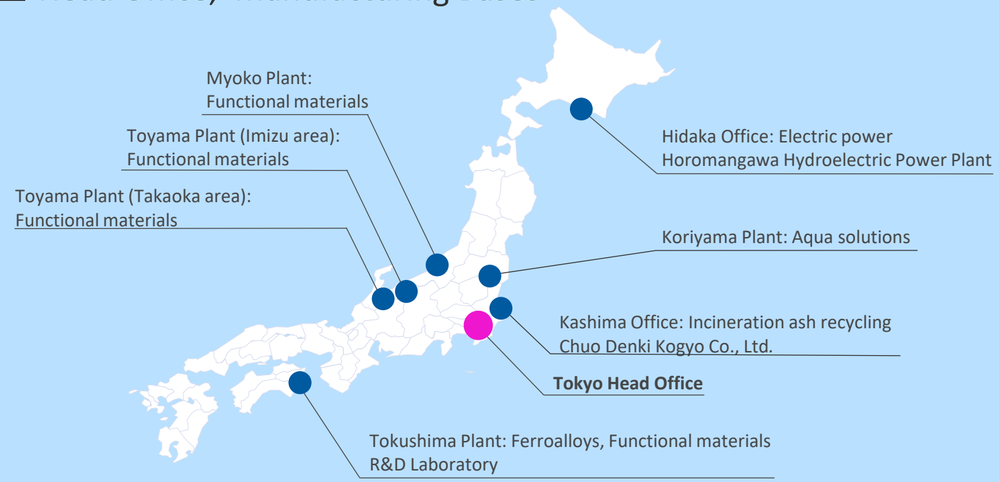
FY2022 (Consolidated)	millions yen
Net sales	79,341
Total assets	104,943
Shareholders' equity	11,084
Equity ratio	65.9%

■ Stock

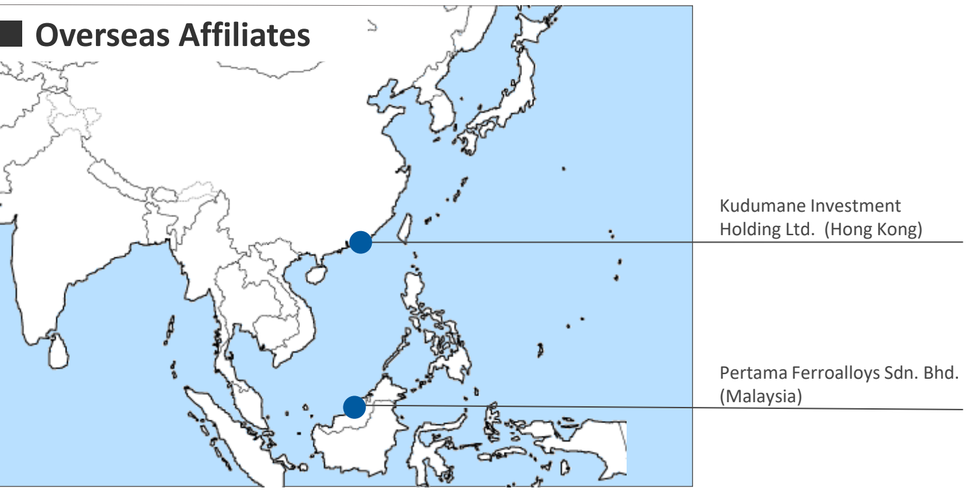
Total number of issued shares	146,931,567

(As of Dec. 31, 2022)

■ Head Office, Manufacturing Bases



■ Overseas Affiliates



Businesses and products

Businesses	Products	Applications
Ferroalloys	High-carbon ferromanganese and other ferroalloys	Steel, stainless steel, and specialty steel
Functional Materials	Zirconium oxide Boron oxide, Boric acid Metal hydride alloys Ferroboron Manganese inorganic chemical products Cathode materials for lithium-ion batteries	Laminated ceramic capacitors and optical glass, etc. Liquid crystal glass substrate and glass fiber, etc. Nickel-hydrogen batteries in HEV Steels, magnets and amorphous metals Additives for laminated ceramic capacitors and cathode materials for lithium-ion batteries. etc. Lithium-ion batteries in EV
Incineration Ash Recycling	Melting and solidification of incineration ash in electric furnace	Detoxification and recycling of incineration ash
Aqua Solutions	Wastewater treatment equipment Pure water production system	Recovery of heavy metals in wastewater and water reuse Hydrogen production and high-purity water cleaning for experiments and analysis
Electric Power	Electric power	Sale of electricity

History of Nippon Denko

■ Ferroalloys ■ Functional Materials ■ Incineration Ash Recycling ■ Aqua Solutions ■ Electric Power

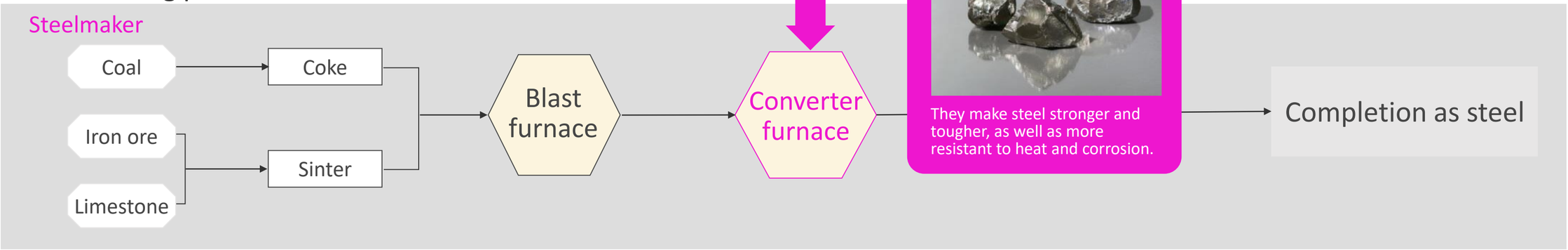
1925	■ Established Ogaki Denki Yakin Kogyosho Co., Ltd. (later Nippon Denki Yakin Co., Ltd.) and started production and sale of various ferroalloys.	
1963		• *Nippon Denko Co., Ltd. Is formed through the merger of Nippon Denki Yakin Co., Ltd. and Toho Denka Co., Ltd.*
1969	■ Tokushima Plant built, started operation. (equipped with pier facilities and large electric furnace)	
1970	■ Started production at Kashima Plant. (Ibaraki Prefecture: Current Kashima office)	
1976	■ Started production of manganese inorganic chemical products at Taguchi Plant. (current Myoko Plant)	
1984	■ Started production and sale of ferroboron by using electric furnace.	
1989	■ Started production and sale of zirconium oxide.	
1992	■ Started production of metal hydride alloys at Taguchi Plant. (current Myoko Plant)	
1996	■ Started sale of AQUA PACK, cartridge-type demineralizer.	
1999	■ Started sale of MR PACK, pure water production equipment.	
2000	■ Completed expansion of ferroboron production facility. ■ Completed zirconium oxide new production plant. ■ Completed construction of boron recovery facility.	
2002	■ Started nickel recovery and recycling business. ■ Completed construction of dedicated waste melting furnace (EM1) at Kashima Plant. (current Kashima Office) / Started operation of industrial waste recycling.	
2003	■ Acquired a business of lithium manganese battery materials.	
2004	■ Started fluorine and phosphorus recovery and recycling businesses / Started delivery of pure water production equipment for fuel cell. ■ Completed construction of waste melting furnace (EM2) at Kashima Plant. (current Kashima Office)	
2005	■ Installed an in-house power generator utilizing the electric furnace gas at Tokushima Plant.	
2010	■ Completed the first stage of large-scale plant for automotive battery materials.	
2011	■ Completed the second stage of large-scale plant for automotive battery materials.	
2012	■ Capital investment in Pertama Ferroalloys Sdn. Bhd.	
2013	■ Acquired manganese mining interests in South Africa. ■ Obtained approval for soil decontamination at Kashima Plant.	
2014	■ Received facility certification for renewable energy Feed-In Tariff (FIT) program under the Japanese government.	• *Changed its corporate name upon merger with Chuo Denki Kogyo Co., Ltd. (English name unchanged)*
2018	■ Completed construction of waste melting furnace (EM3) at Kashima Plant. ■ Started Sumitomo Metal Mining's contract manufacturing of cathode materials for lithium-ion at Toyama Plant. (Takaoka area)	• *Merger with Chuo Denki Kogyo Co., Ltd. completed.*
2019	■ Started the operation at Horomangawa Hydroelectric No. 3 Power Plant.	
2022	■ Started the operation of self-consumption solar power generation system at Koriyama Plant. ■ Completed construction of incinerator ash No. 4 melting furnace at Kashima Office. (former Kashima Plant)	

Ferroalloys

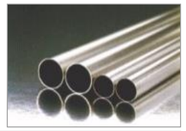
Ferroalloys, an essential material for steel

Ferroalloys are of vital importance in making steel, as they are a necessary “seasoning” found in every piece of steel.

Steelmaking process



Major ferroalloy products and applications

Ferromanganese (Nippon Denko’s main product) Ferrosilicomanganese	Make steel stronger  Nippon Denko’s main product: Ferromanganese  
Ferrovanadium	Oil well casings, line pipes, springs  
Ferrochrome	Stainless steel products  
Ferrosilicon	Deoxidizing

Ferroalloys market scale (2022)

In Japan, approx. 873.8 billion yen

(Source: Nippon Denko estimates)

The trading price depends mainly on global market conditions.

Trading takes place at a price calculated by converting the global price in US dollars to yen at foreign exchange rates.
(Similar to the export industry, the profit structure is such that a weaker yen increases profits.)

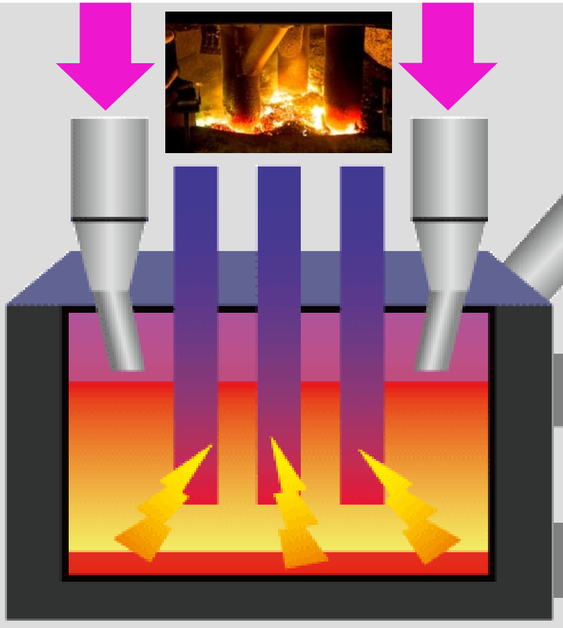
How are ferroalloys made?

Our main product, High-carbon ferromanganese

Main raw materials

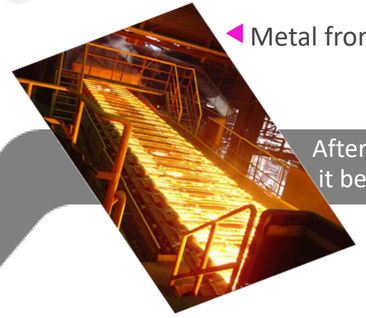
Manganese ore:
is main raw material for High-carbon ferromanganese.
It contains impurities and must be refined in an electric furnace.

Coke:
is made by steaming and baking coal.
It is acting as a reducing agent and removes oxygen in the ore.



Electric furnace
Melts raw materials at very high temperatures.

Every measure is taken to protect the environment.
Exhaust gas is used as fuel for in-house power generation.



Metal from electric furnace

After cooling, it becomes a product

Slag
By-products of the metal production process.

High-carbon ferromanganese

High-carbon ferromanganese is a ferromanganese product with a relatively high carbon content.

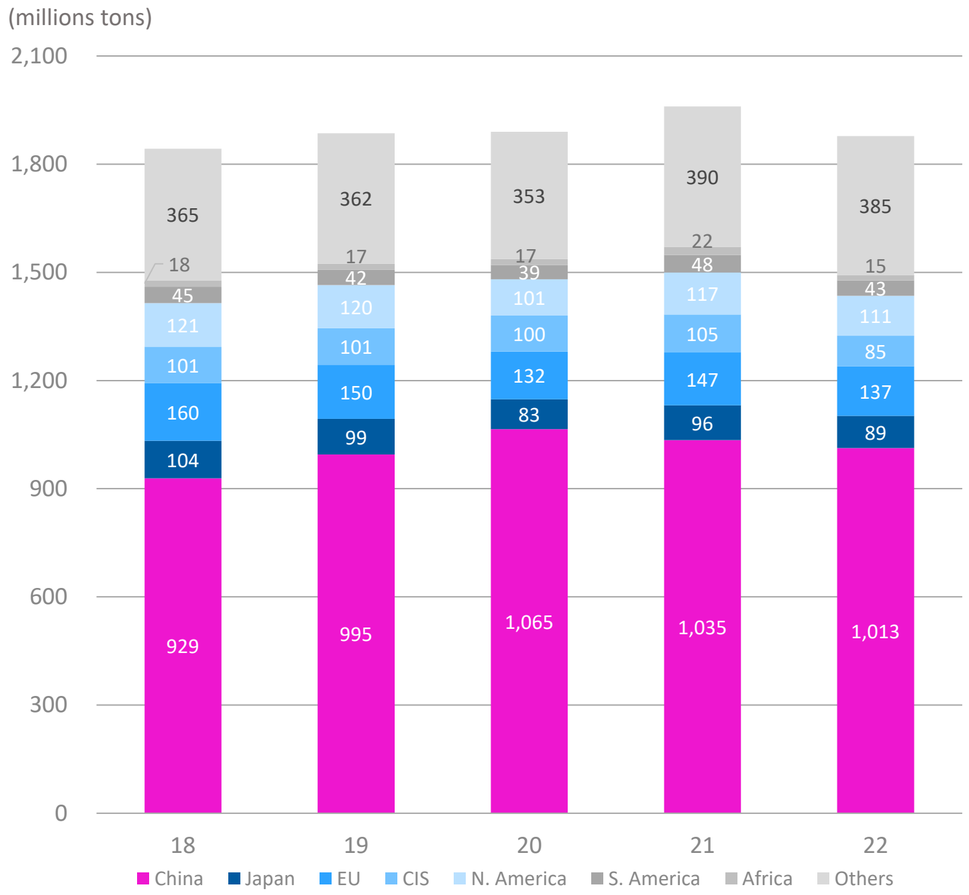
Nippon Denko has the

No. 1 share

in Japan

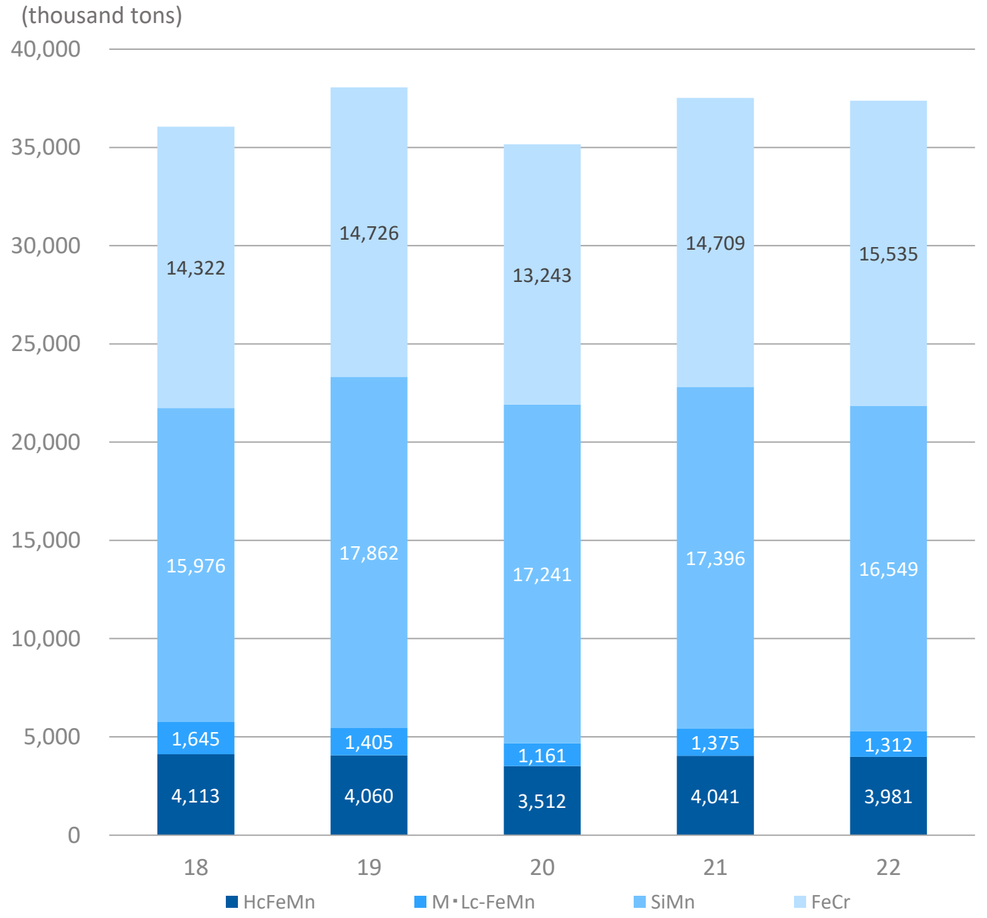
Global crude steel production by country and ferroalloy production by product

Global crude steel production



(Source: World Steel Association data)

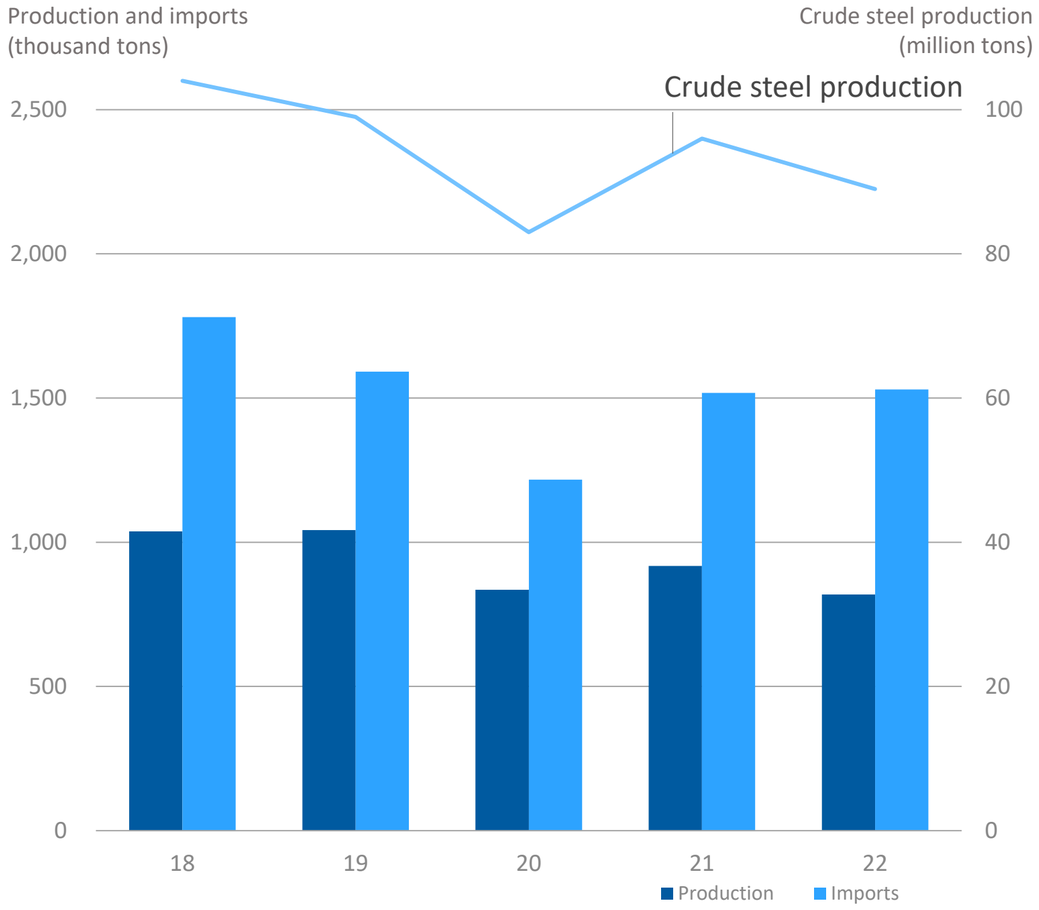
Global ferroalloy production



(Source: IMnI and ICDA data)

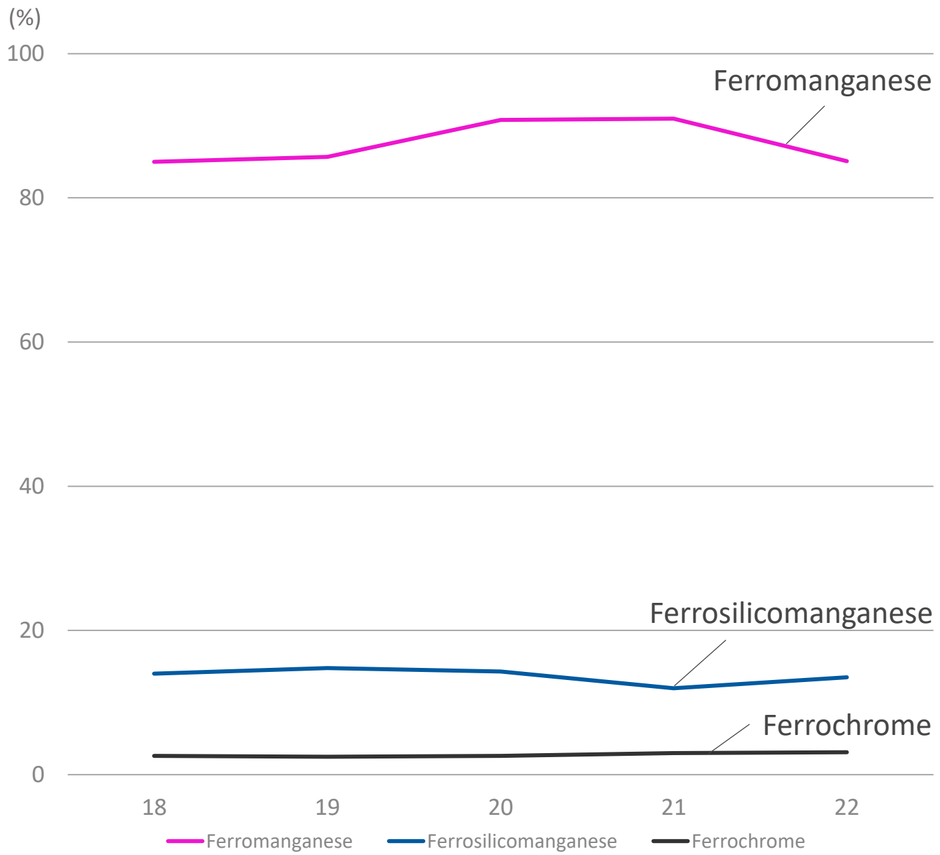
Ferroalloy production in Japan: Ferromanganese is produced domestically

Ferroalloys production and imports, and crude steel production trend in Japan



(Source: Steel statistics)

Ferroalloys production rates in Japan

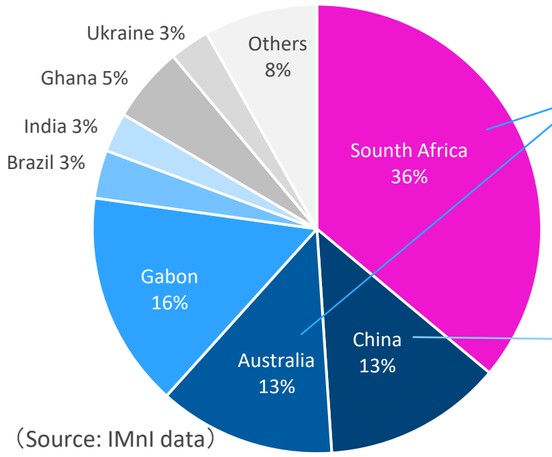


(Source: Steel statistics)

Manganese ore: Ferroalloy's raw material, global production and trading volume

Global production of manganese ore

2021: 62.08 millions tons



（Source: IMnI data）

Mostly high or medium-grade ore

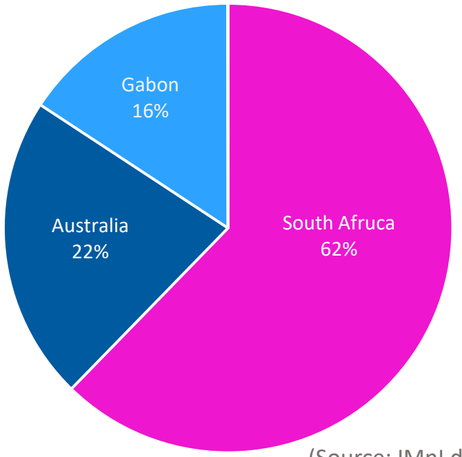
Less likely to produce slag and have higher metal recovery rates than low-grade ores.

Ore from China is mostly low-grade

Processing low-grade ore results in a large amount of slag, for a low metal recovery rate.

Japan's manganese ore imports

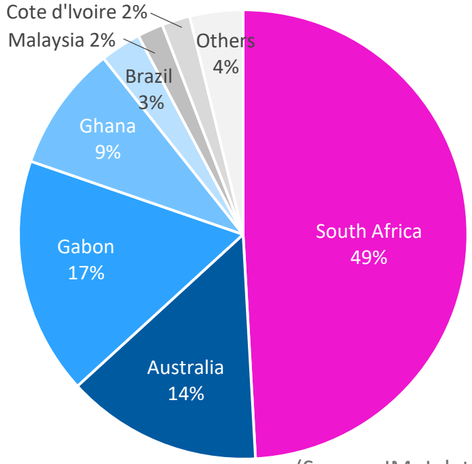
2022: 0.87 millions tons



(Source: IMnI data)

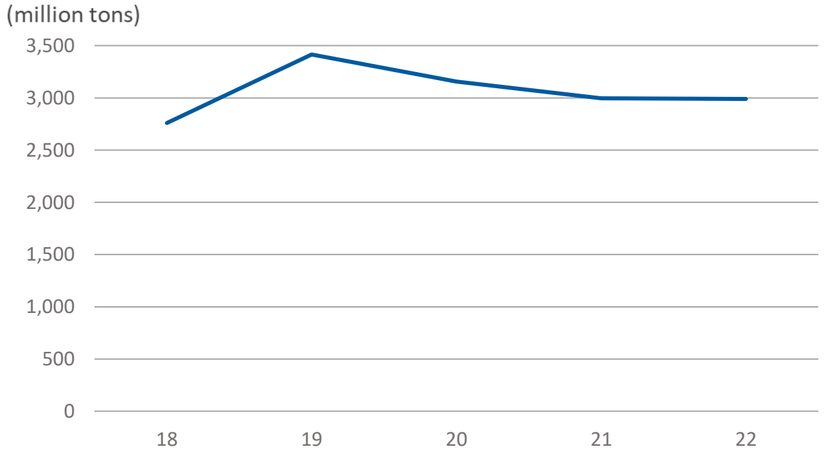
China's manganese ore imports

2022: 29.89 millions tons



(Source: IMnI data)

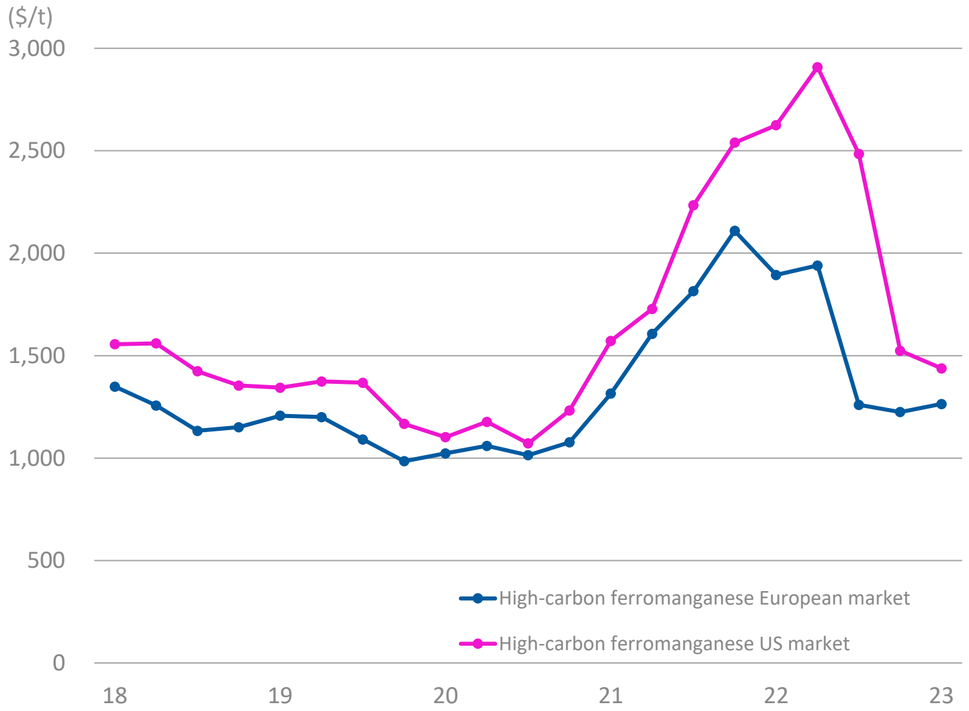
China's manganese ore import volume



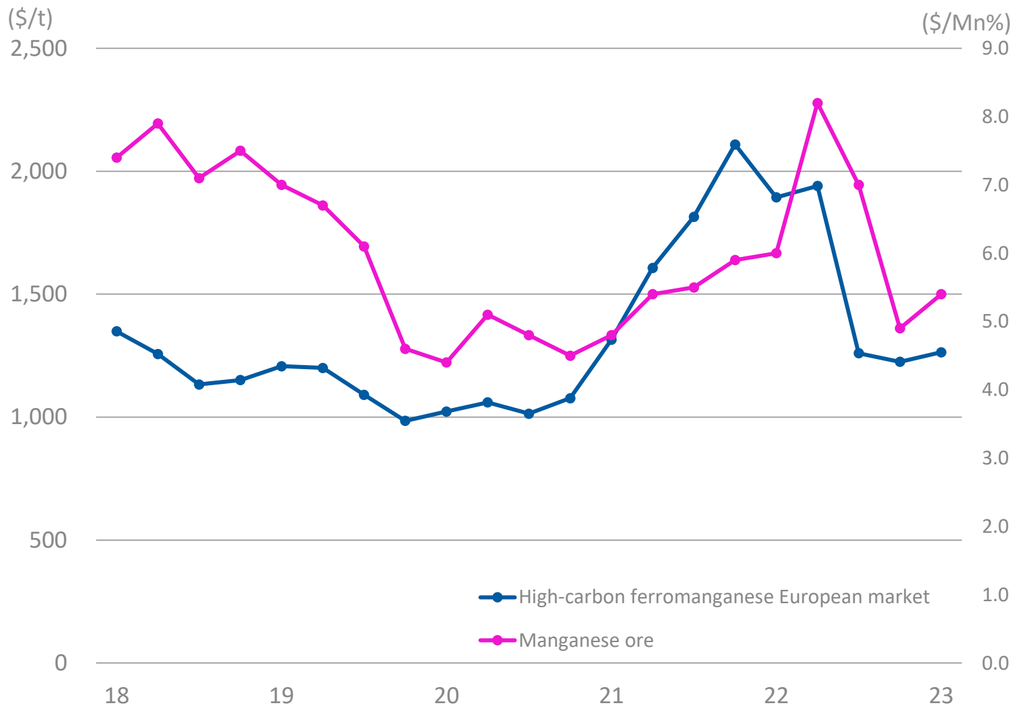
(Source: IMnI data)

Ferroalloy market prices and manganese ore prices

Product price (quarterly average)



Product prices and ore prices



High-carbon ferromanganese (FMnH) & Manganese ore prices transition data

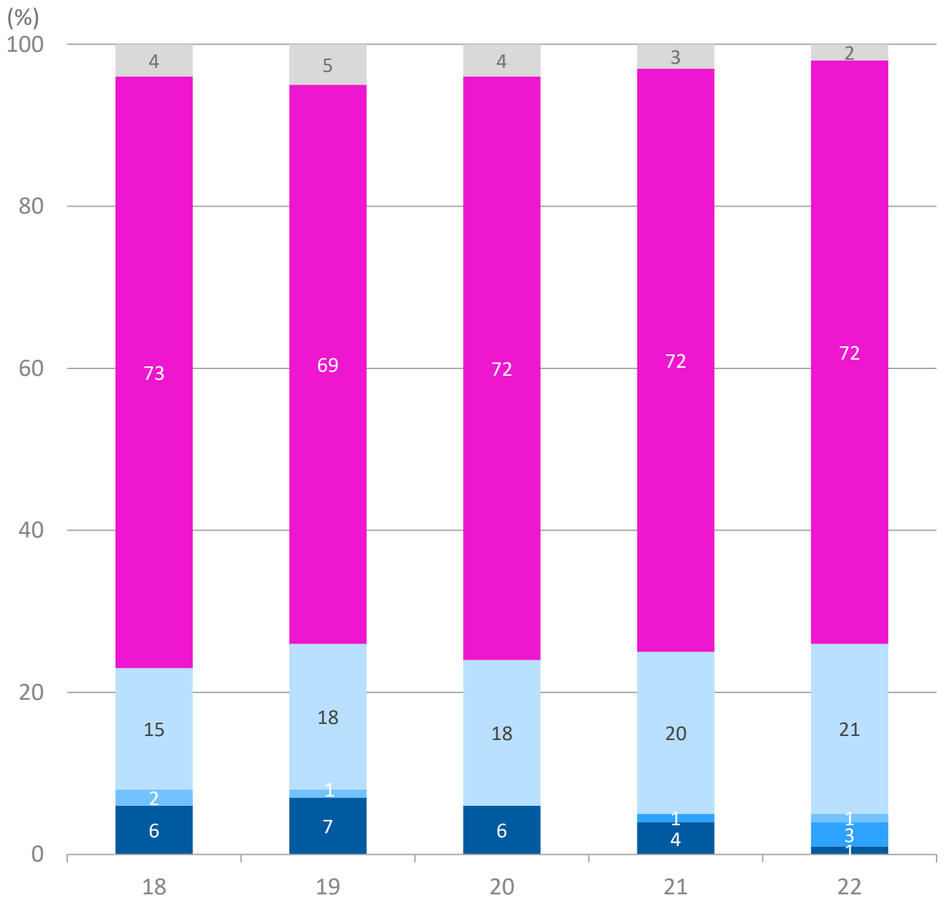
FMnH ($/t) / Mn Ore ($/Mn%)

	18				19				20				21				22				23
FMnH (Eur)	1,349	1,257	1,133	1,151	1,207	1,200	1,091	985	1,023	1,060	1,014	1,077	1,315	1,607	1,815	2,109	1,894	1,940	1,260	1,225	1,264
FMnH (US)	1,556	1,560	1,424	1,354	1,344	1,374	1,368	1,167	1,102	1,177	1,072	1,232	1,572	1,728	2,234	2,540	2,625	2,908	2,485	1,524	1,438
Mn ore	7.4	7.9	7.1	7.5	7.0	6.7	6.1	4.6	4.4	5.1	4.8	4.5	4.8	5.4	5.5	5.9	6.0	8.2	7.0	4.9	5.4

Source: Metals Week (US market) Metal Bulletin (European market)

Ferroalloys business of Nippon Denko

Ferroalloys business sales trend ratio by product



High-carbon ferromanganese is our main product. It is produced domestically, taking advantage of the competitiveness of Tokushima Plant.

Low-carbon ferromanganese (SLP) has a very high manganese content with few impurities. It is used as an additive in the final stage of steelmaking, in place of manganese metal.

(Please refer to page 14 for details)

Manganese metal: A metal with a manganese purity of nearly 100%. It is used as an additive in making steel, stainless steel, and aluminum.

SLP ferromanganese

What is low-carbon ferromanganese (SLP)?

(SLP: Super-Low Phosphorus)

▲Low-carbon ferromanganese (SLP)

- Very low-carbon ferromanganese with manganese purity of 90% and low phosphorus content.
- As a raw material essential for high-grade steel production, it is used in place of manganese metal.

Superiority

- Producing high-purity ferromanganese from the by-product of High-carbon ferromanganese using proprietary technology
- Further demand is expected due to the high-grade steel production increase

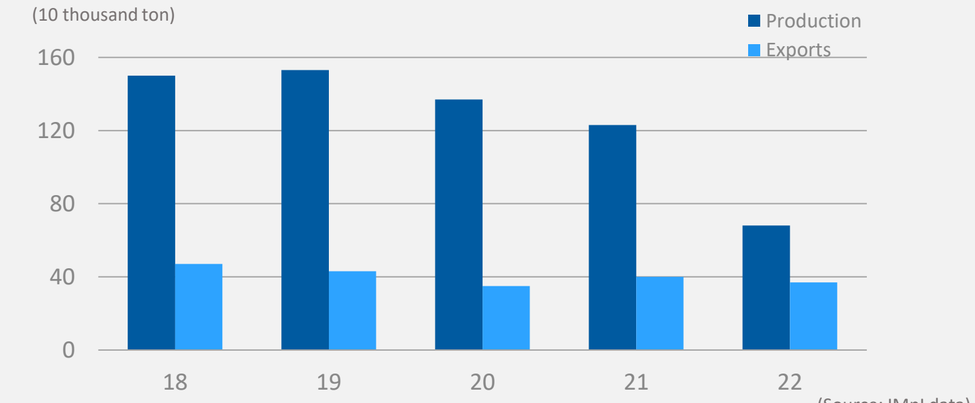
Strategy

- Added one electric furnace in 2008. Annual production capacity had raised from 18,000 tons to 30,000 tons.
- Expanded annual production capacity from 30,000 tons to 40,000 tons in 2010.
- Contributing a stable procurement to customers and increase profitability.

Manganese metal

- Annual demand for manganese metal in Japan is about 50,000 tons, all of which is imported, some 90% of it from China.
- Because of the very high dependence on China, producing it in areas other than China or possibly switching to an alternative are options being considered.

Chinese production and exports of manganese metal



(Source: IMnI data)

Resource strategy and optimal location are the ways to win out over rivals

Optimal production location in accordance with the product type

Domestic location : Tokushima Plant

Type of product : High-carbon ferromanganese, Low-carbon ferromanganese (SLP), etc.

Tokushima Plant (Anan city, Tokushima prefecture)

- Produces ferroalloys with low electric power consumption and is one of the most competitive plants in the world
- Just-in-time supply available due to its adjacent location to the coast
- Annual production capacity: 270,000 tones

Overseas location : Pertama Ferroalloys Sdn. Bhd

(25% ownership ratio)

Type of product : Ferrosilicomanganese, Ferrosilicon

Pertama Ferroalloys Plant (Malaysia)

- Securing competitive green electricity from Southeast Asia's largest hydroelectric power plant (Bakun Dam, 2,400 MW)
- Produces ferroalloys that consume large amounts of electricity
- Annual production capacity: 220,000 tones

Resource strategy

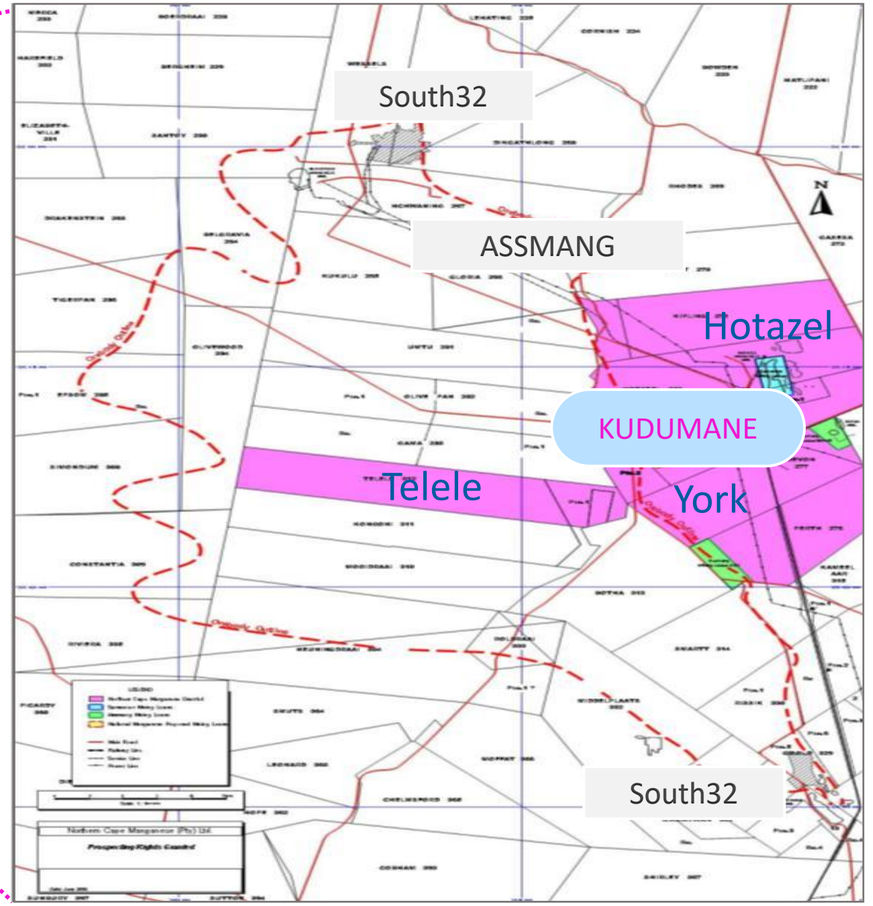
Obtaining stable supply of the ores needed for ferroalloy production

- Acquired manganese mining interests.

  Investment in Kudumane Japan GK which invests to Kudumane Manganese Resources (25% ownership ratio)

- Diversification of ore procurement sources

Kudumane manganese mining area



Functional Materials

Functional materials products list

Functional materials products	Usage	
Zirconium oxide	For electronic ceramics	Raw material of PZT piezoelectric actuators, laminated ceramic capacitors, etc.
	For glass	Used as additives in high-refractive optical glass lenses, etc.
	For functional films	Raw material of optical adjustment coating, hard coating materials, etc.
	Composite oxide for catalysts	Catalytic promoter for purifying automobile exhaust gas
Boron oxide, boric acid	For glass	Used as additives in liquid crystal glass, optical glass, glass fiber, etc.
	For other applications	Raw material of boron compounds, disinfectants, surface treatment agents, etc.
Metal hydride alloys	Anode materials for nickel-hydrogen batteries (mainly for HEV)	
Ferroboron	For steels	Used as additives in steel as one kind of ferroalloy
	For magnets	Raw material of neodymium iron boron (NdFeB) magnet alloy
	For amorphous alloys	Raw material of amorphous alloy (FeSiB)
Manganese inorganic chemical products	Please refer to page 23 for details.	
Cathode materials for lithium-ion batteries	Cathode materials for lithium-ion batteries (mainly for EV)	

Zirconium oxide

What is zirconium oxide?

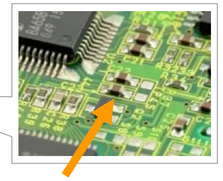
- Electronic ceramics made from zirconium oxide have the electrical properties for storing electricity and converting between electricity and pressure.
- A high refractive index is achieved by using zirconium oxide as an additive in optical glass and functional film.

Nippon Denko and zirconium oxide

- Started production at Tokushima Plant in 1989
- Won acclaim for ultrafine particles and high purity
- Sold mainly for use in electronic parts and optical lenses

Main applications and products

Electronic ceramics	Glass / Film
● Laminated ceramic capacitors and ceramic filters used in the electrical circuits of digital home appliances, PCs, cell phones, and other digital devices ● Inkjet control devices in inkjet printers ● Image stabilization in digital cameras and other devices, and in gyro sensors for tilt detection in smartphones	Optical lenses for digital cameras, films for liquid crystal displays (LCDs), etc.



Ceramic capacitors

▲ Inkjet printer

Boron oxide

What is boron oxide?

- Boron oxide is calcined and anhydrous boric acid.

Nippon Denko and boron oxide

- The only manufacturer in Japan
- Started production at Tokushima Plant in 1986. (the first in Japan)
- In 2022, it also began production for external sales at Toyama Plant.
- Nippon Denko supplies high-quality, high-purity products that contain minimal impurities.
- Other than glass, expanding business for electronic pats materials, etc.

Main applications

Glass panels	Glass panels for monitors, TVs, etc.
Glass fiber	Electronic parts substrates for high-speed data transmission

Metal hydride alloys

Metal hydride alloys

- Started commercial production in 1992
- Adapted by Toyota HEVs and global No.1 supplier of metal hydride alloys for HEV’s batteries
- ISO 9001 and ISO 14001 certified plant

Metal hydride alloys plant (Myoko, Niigata Prefecture)

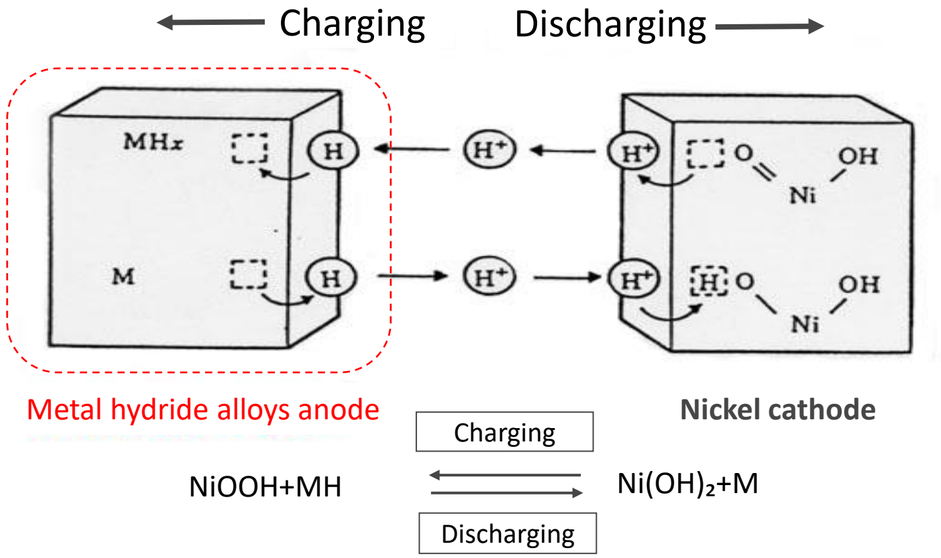
Main applications

Anode material for nickel-hydrogen batteries used as drive batteries in HEV.

Features of metal hydride alloys

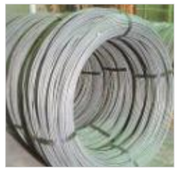
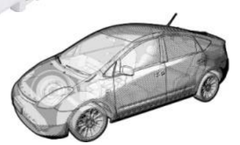
- Long life span equivalent to vehicle life
- Ample output to ensure startability at low temperatures and power acceleration

Principles of nickel-hydrogen batteries



Ferroboron

Nippon Denko is the only ferroboron manufacturer in Japan.

Products	Description	Usage or applications
For steel	Adding a very small amount (10 to 100 ppm) of boron to steel improves its hardenability and high-temperature strength.	Applications Wires used in suspension bridges, bolts and nuts, claws of power shovels.  
For magnets	A neodymium iron boron (NdFeB) magnet is the strongest kind of permanent magnet. These magnets are essential to making electronic devices smaller and lighter, higher efficiency and energy-savings.	Applications of NdFeB magnets ● Motors of HEV and EV. ● Head actuator mechanism for hard disk drive reading and writing. ● Motors in energy-efficient appliances (air conditioners, etc.) ● Electrical generator in wind power system.  
For amorphous alloys	Amorphous (noncrystalline) alloy ribbons with thickness of just a few tens of microns are produced by extremely rapid cooling of the alloys composed of Fe, Si, B, etc. from molten state, at a rate of around a million degrees celsius per second.	Used mainly as the steel core material of amorphous transformers When amorphous alloys are used as steel core material in transformers, electrical (no-load) loss at the steel core is very small for improved energy efficiency. 

Manganese inorganic chemical products

Manganese inorganic chemical products

- Started commercial production in 1976
- The only Japanese domestic manufacturer of diverse manganese inorganic chemical products
- ISO 9001 and ISO 14001 certified plants
- Kosher and FDA certified plant (manganese sulfate)

Manganese inorganic chemical products manufacturing plant (Myoko, Niigata Prefecture)

Usage of manganese inorganic chemical products

Products	Usage
Manganese sulfate	Animal feed additives, catalyst raw materials, supplements, fertilizers
High-purity manganese sulfate	Cathode materials for lithium-ion batteries
Manganese carbonate	Animal feed additives, surface treatment agent raw materials, soft ferrite
High-purity manganese carbonate	Additive in laminated ceramic capacitors, thermistors
Chemical manganese dioxide	Ozone decomposition catalysts, deodorizing catalysts, oxidizing agents for organic synthesis
Reduced ore	Flux

Features of manganese inorganic chemical products

- Holder of technology for high-purity refining of manganese ore
- Thorough removal of alkaline metals and alkaline earth metals by crystallization and recrystallization processes
- Thorough removal of iron by use of oxidizing agent and optimization of reaction pH

Manganese sulfates

Manganese carbonates

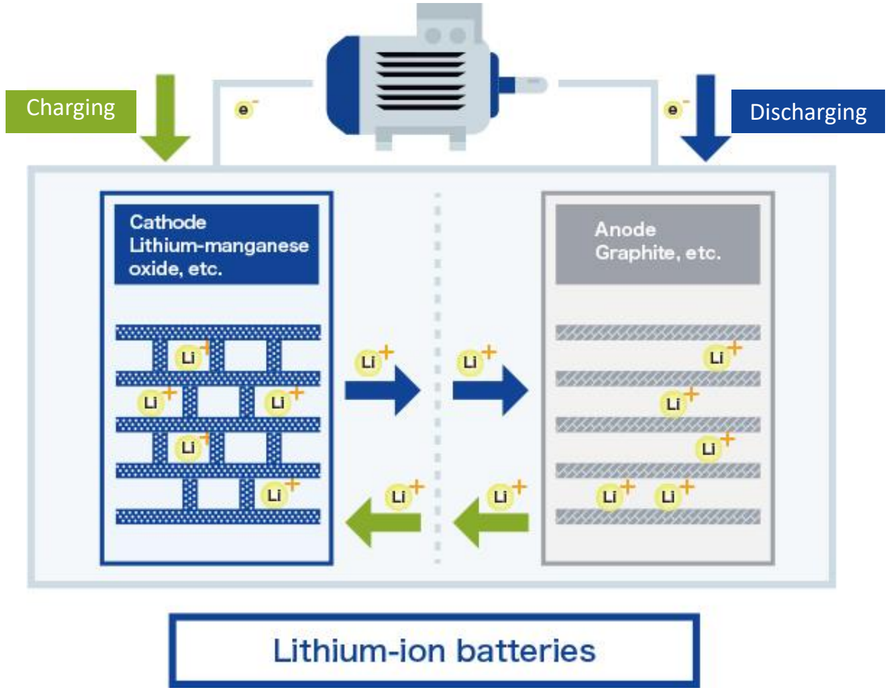
Cathode materials for lithium-ion batteries

Cathode materials for lithium-ion batteries

- Started commercial production in 1997
- The pioneer of cathode materials for large lithium-ion batteries
- ISO 9001 and ISO 14001 certified plant
- The contract manufacturing from Sumitomo Metal Mining

Battery materials manufacturing plant
(Takaoka, Toyama Prefecture)

Principles of lithium-ion batteries



Main applications

Cathode materials for lithium-ion batteries uses as drive batteries in EV and HEV etc.

Cathode materials for large lithium-ion batteries in smart house or energy storage system etc.

Incineration Ash Recycling

Incineration Ash Recycling

History of business

- Chuo Denki Kogyo became the first private company in Japan to begin treatment of incineration ash generated from municipalities by melting in a ferroalloy furnace in 1995.
- Second dedicated furnace was put into operation in 2004.
- Third dedicated furnace was put into operation in 2018.
- Fourth dedicated furnace was put into operation in October 2022.

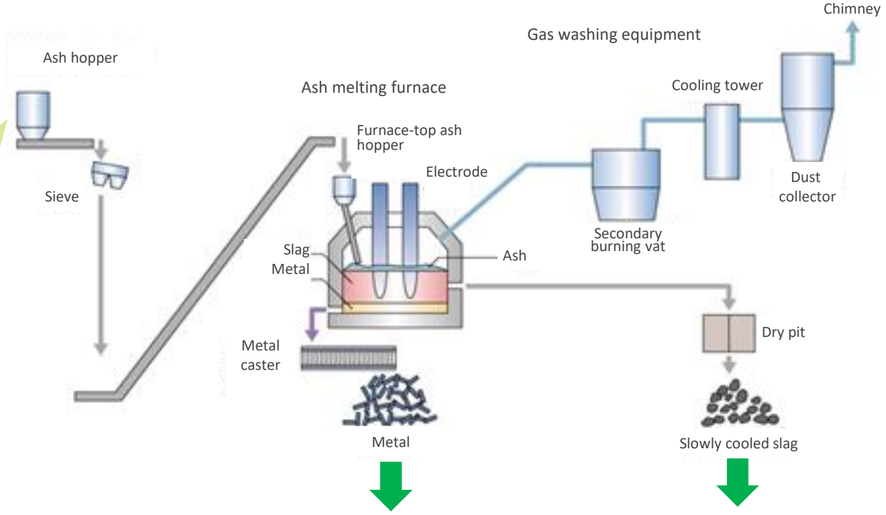
Features

- Melting and solidification at high temperature → decomposition of dioxin, detoxification and stabilization of heavy metals
- Slag (ECOLAROCK) produced by melting is safe and environmentally friendly product for use in civil engineering and construction materials (roadbed material, revetment construction, etc.)
- Valuable metals (gold, silver, copper, etc.) contained in metals produced by melting are recycled (recycling of urban mines)

Incineration ash storage facility

Dedicated carrier vehicles

Incineration ash
(collected from municipalities)



Valuable metals separated and collected at nonferrous smelter and refiner

(ECOLAROCK)

Roadbed material

Leveling material

Material for river embankment work

<Applications Example>

- Roadbed material
- Leveling material for solar panel installation
- Embankment material for disaster recovery
- Base material for river embankment work

Aqua Solutions

Aqua Solutions

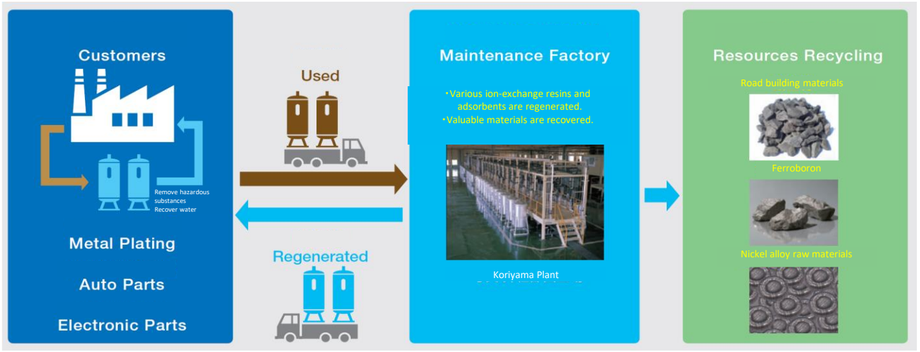
Has a large ion-exchange resin recycling plant in Koriyama, Fukushima prefecture.
Rental, sale, and regeneration of water treatment equipment, ion-exchange resin towers with the consignment regeneration scheme.

Clean Recycle Technology

Ion-exchange towers for wastewater treatment that enable the recovery of water and resources.

Ion-exchange resin towers of wastewater treatment

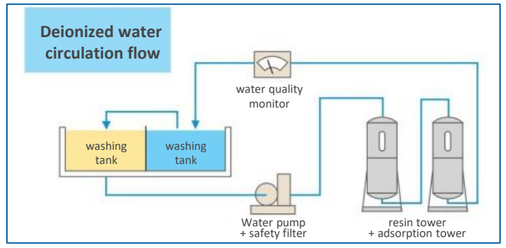
ND MINICHROPACK：Chrome and other heavy metal, various acid, alkali waste water
B-CLEPACK：Boron removal
NI-PACK：Nickel removal
F-PACK：Fluorine removal



Features

1. Reuse and resources recycling of water or the chemicals
   - Reuse waste water as deionized water or pure water.
   - Recycling of the absorbed ion.
2. Consignment regeneration scheme
   - No requirement for effort or chemicals to regenerate at the customer's site.
   - No sludge is generated.
3. Various sales method
   - Choice of rental or purchase.
   - Propose the best combination of equipment, taking into consideration for the period of use, workload and budget, etc.

Example of Usage Flow



Pure Water Technology

Pure water production that pursues further purity.

AQUA PACK

Cartridge demineralizer

- Simple and easy-to-use demineralizer filled with ion-exchange resin.
- By simply connecting the unit directly to a faucet.
- Creates high-purity water by removing Ca, Na, SO4, Cl, SiO2, etc., in tap water.

MR PACK

Pure Water System that combines the reverse osmosis membrane (RO membrane) with the ion-exchange resin tower.

- Compact design.
- Easy to operate by automatic control.
- Can be customized according to customer requirements.

- For washing of surface treatment
- For experiments and analysis
- For the water boilers and air conditioning
- For hydrogen production

Contribution to the hydrogen society

Ene-Farm Purified water manufacturing for home-use fuel cells	As an alternative energy source, Ene-Farm (home-use fuel cells) is on the rise. Ene-Farm uses hydrogen extracted from gas to generate electricity. Purified water is needed to extract hydrogen from the gas. We are expanding our business into these fuel cell fields based on the advanced ion exchange resin technology we have accumulated over the years.	
On-site Purified water manufacturing for hydrogen stations	Toyota Motor Corp. launched fuel cell vehicles on the market in 2014, and hydrogen stations are being promoted. We started manufacturing purified water equipment for hydrogen production in 2005 in preparation for the Aichi Expo, and we have the top share in Japan for on-site hydrogen stations.	

Electric Power

Electric power business

Overview of electric power business

- Built a hydroelectric power plant at Horomangawa River in Hokkaido in early Showa period for the pioneer of the development of the power supply in Hidaka area.
- Renewed the power generation facilities at the No. 2 and No. 3 power plants.
- Shifted to the business of selling electricity through the Feed-In Tariff system (FIT).

Power generation facility	Output	Operation
No. 2 Power Plant	4,406kW	Started from Nov. 2017
No. 3 Power Plant	6,221kW	Started from Feb. 2019

Horomangawa Power Plant Dam No. 3

Horomangawa Hydroelectric Power Plants

No. 3 Power Plant