Nickel in Society – Appendix

1. Glossary

Alloy: A metallic material, homogeneous on a macroscopic scale, consisting of two or more elements (at least one a metal) so combined that they cannot be separated by mechanical means. Alloys usually have different properties from those of the component elements.

Catalyst: A substance which initiates or accelerates a chemical reaction without itself being affected.

Contact dermatitis: Many chemical agents, including nickel, can cause allergic contact dermatitis which results in inflammation of areas of the skin in sensitised individuals.

Corrosion: The attack upon metals by chemical agents converting them to nonmetallic products.

Creep: the tendency of a solid material to move slowly or deform permanently under the influence of stresses.

Ductility: The ability of a metal to deform or permanently change shape without fracturing.

Electroforming: The creation of an object by electrically depositing metal from a liquid on a master mould.

Electroplating/Plating: The depositing of a coating of metal suspended in a solution on a base material using electricity.

Electropolishing: The polishing or smoothing of the surface of metal parts by removal of metal.

Hazard: The intrinsic ability for a substance, object or situation to cause adverse effects.

Invar®: A nickel iron alloy notable for its uniquely low coefficient of thermal expansion.

Life cycle: The life cycle of a product is the sum of all the phases caused by the product's existence from "cradle" (i.e. resource acquisition) to "grave" (i.e. end of life).

Nitinol: A nickel titanium alloy notable for its shape memory characteristics.

Risk: The chance that harm will actually occur.

Risk Assessment: A scientific process to determine whether, how, and under what circumstances, harm might be caused to people or ecological systems.

Risk Management: A policy process that incorporates economic, social, legal, and technical feasibility considerations to determine a specific course of action to protect people and ecological systems.

Stainless steel: Stainless steel is an iron alloy bearing at least 10.5% chromium and less than 1.2% carbon. Stainless steels have a passive film on their surface created by the presence of chromium (and often aided by other alloying elements, nickel, molybdenum) that resists corrosion.

2. About the Nickel Institute

The Nickel Institute is a non-profit organization that represents the interests of more than 20 companies which together produce about 90% of the world's annual nickel output. The Nickel Institute promotes on behalf of its members the production, use and recycling of nickel in a socially and environmentally responsible manner.

The global nickel industry consists of individual nickel companies which differ in many ways, from location, size, production processes and product mix.

The Nickel Institute encourages readers seeking further information on the sustainability practices of the nickel industry to consult ***http://www.nickelinstitute.org/*** and the websites of the individual nickel companies that contributed to this global report.

Company Name	Web site
Anglo American Brasil Ltda.	www.angloamerican.co.uk
Anglo Platinum	www.angloplatinum.com
BHP Billiton	www.bhpbilliton.com
Bochemie A.S.	www.bochemie.cz
Consolidated Minerals Ltd.	www.consminerals.com.au
Eramet S.A.	www.eramet.fr
European Nickel PLC	www.enickel.co.uk
Gladstone Pacific Nickel Ltd	www.gladstonepacific.com.au
Glencore International AG	www.glencore.com
JFE Mineral Company, Ltd.	www.jfe-mineral.co.jp
JSC MMC Norilsk Nickel	www.nornik.ru
Minara Resources Ltd.	www.minara.com.au
Nippon Yakin Kogyo Co., Ltd.	www.nyk.co.jp
Pacific Metals Co., Ltd.	www.pacific-metals.co.jp
P.T. International Nickel Indonesia TBK	pt-inco.co.id
Rio Tinto PLC	www.riotinto.com
Sherritt International Corporation	www.sherritt.com
Sumitomo Metal Mining Co., Ltd.	www.smm.co.jp
Talvivaara Mining Company Ltd.	www.talvivaara.com
Umicore	www.umicore.com
Vale Inco Ltd.	www.inco.com
Vale Inco Japan Ltd.	www.inco.com
Xstrata Nickel	www.xstrata.com

In addition to the companies listed here, the Nickel Institute works in partnership with a variety of organisations, including:

Downstream User Groups	
International Stainless Steel Forum	www.worldstainless.org
Regional Stainless Steel Development Associations	
- Australia	www.assda.asn.org
- Brazil	www.nucleoinox.org.br
- China	www.cssc.org.cn
- Europe	www.euro-inox.org
- India	www.stainlessindia.org
- Japan	www.jssa.gr.jp
- Korea	www.kosa.or.kr
- Mexico	www.cendi.org.mx
- New Zealand	www.hera.org/nz/nzssda
- North America	www.ssina.com
- Russia	www.ussa.su
- South Africa	www.sassda.co.za
- Thailand	www.tssda.org
European Committee for Surface Treatment	www.cets-surface.eu
International Institute of Welding	www.iiw-iis.org
National Association for Surface Finishing	www.nasf.org
RECHARGE	www.rechargebatteries.org

Media and NGOs	
Climate Action	www.climateactionprogramme.org
EurActiv	www.euractiv.com
Friends of Europe	www.friendsofeurope.org
The Natural Step	www.naturalstep.org

Metals Associations	
International Council of Mining and Metals	www.icmm.com
China Nonferrous Metals Industry Association	www.antaike.com
Eurometaux	www.eurometaux.org
North American Metals Council	www.namc.org
International Chromium Development Association	www.icdachromium.com
International Molybdenum Association	www.imoa.info

Professional Bodies	
ASM International	www.asminternational.org
Materials Technology Institute	www.mti-global.org
NACE International	www.nace.org

Universities	
Technical University of Denmark	www.dtu.dk
Yale University	www.yale.edu

3. Nickel Production and Consumption

Nickel is a naturally occurring element that is found in two main types of deposits: nickel sulphides and nickel laterites.

Nickel sulphides often occur together with economically recoverable amounts of copper, cobalt, gold, silver, and platinum group metals (PGMs). The largest occurrences are in Canada, Russia, Australia and Southern Africa.

Nickel laterites often occur together with cobalt and iron, but do not contain other valuable constituents. The largest occurrences are in Southeast Asia, Australia, South America and the Balkans.

As shown in Table 1, nickel mining and processing take place directly in the countries where the nickel deposits are found in nature. However, other considerations such as access to reliable energy sources and access to markets also influence where the nickel production takes place, as shown in Table 2.

Table 1: Top 10 nickel mining countries/regions in 2008

No.	Country/Region	Nickel Mining (in thousand metric tonnes of contained nickel)
1	Russia	267.5
2	Canada	257.1
3	Indonesia	204.1
4	Australia	191.0
5	New Caledonia (France)	102.6
6	Cuba	70.5
7	China	68.4
8	Brazil	38.4
9	Botswana	34.9
10	Philippines	34.8

Source: *INSG World Nickel Statistics, 2009*

Table 2: Top 10 primary nickel producing countries/regions in 2008

No.	Country/Region	Primary Nickel Production (in thousand metric tonnes of nickel)
1	Russia	257.7
2	China	199.3
3	Canada	177.0
4	Japan	161.2
5	Australia	115.9
6	Norway	88.7
7	Finland	57.1
8	Colombia	41.6
9	United Kingdom	39.5
10	New Caledonia (France)	37.5

Source: *INSG World Nickel Statistics, 2009*

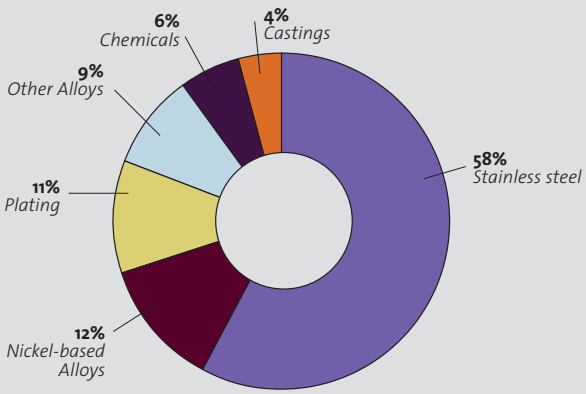
In many ways, nickel is a metal of advanced societies. Its major uses are for high-performance technological products which take advantage of its valuable characteristics such as high heat resistance, strength, and durability. As shown in Table 3, below, the use of nickel is influenced by both a society's level of affluence and the nature of its manufacturing sector.

Table 3: Top 10 nickel consuming countries/regions in 2008

No.	Country/Region	Nickel Consumption (in thousand metric tonnes)
1	China	360.0
2	Japan	161.1
3	United States	119.6
4	Germany	95.0
5	Taiwan	57.0
6	South Korea	49.8
7	Italy	45.1
8	Belgium	44.9
9	Spain	36.6
10	Finland	34.5

Source: *INSG World Nickel Statistics, 2009*

Figure 1: First Use applications for nickel

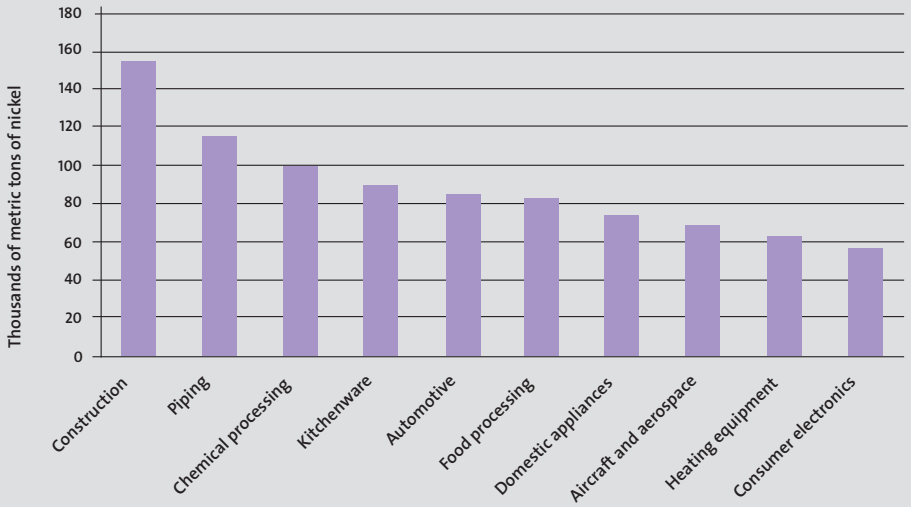


Only a small amount of nickel is used as a product in its own right. Most often, it is combined with other materials to produce stainless steel and other alloys with distinct performance characteristics. Nickel is also used as a plating material, and to produce special chemical products for batteries and catalysts. These are known as 'First Use' applications, the proportions of which are shown in Figure 1.

Source: *Heinz H. Pariser Alloy Metals & Steel Market Research, 2008*

The nickel-containing alloys and chemicals produced during the 'First Use' stage are sold to product manufacturers who use the nickel-containing alloys as part of their manufacturing process. This group comprises a large number of manufacturers of components, sub-assemblies, and other products that are then used in the manufacture of further products. Collectively, they are known as 'End Use' applications. The ten most dominant End Use applications for nickel are shown in Figure 2, below.

Figure 2: Top 10 End Use applications for nickel in 2007



4. Nickel Recycling

The Nickel Institute works in coalition with the broader metals industry towards the establishment of an accurate understanding of metals recycling.

In 2006, this coalition of metals industries came to a common definition of three recycling rates:

- **Recycling Input Rate:** The Recycling Input Rate (RIR) measures the proportion of metal and metal products that are produced from scrap and other metal-bearing residues. This measure is largely used by the metal industry to optimise their processes, and has limited use as a policy tool.
- **Overall Recycling Efficiency:** The Overall Recycling Efficiency Rate (Overall RER) indicates the efficiency with which end-of-life (EOL) scrap, new scrap, and other metal-bearing residues are collected and recycled. The key target audiences of this indicator are the metals industry and scrap processors.
- **End-of-Life Recycling Efficiency:** The End-of-Life Recycling Efficiency Rate (EOL RER) indicates the efficiency with which EOL scrap from obsolete products is recycled. This measure focuses on end-of-life management performance of products and provides important information to product designers and environmental policy makers.

Nickel is recycled in two ways. For the most part, nickel is recycled within the stainless steel loop, thereby preserving the value-added properties of nickel. Some nickel, however, gets combined with other metals and is recovered as a minor constitutent of carbon steel scrap.

Table 4, below, details the three defined recycling rates for nickel. It also indicates the proportion that is recycled in stainless steel and the proportion that is recycled as carbon steel.

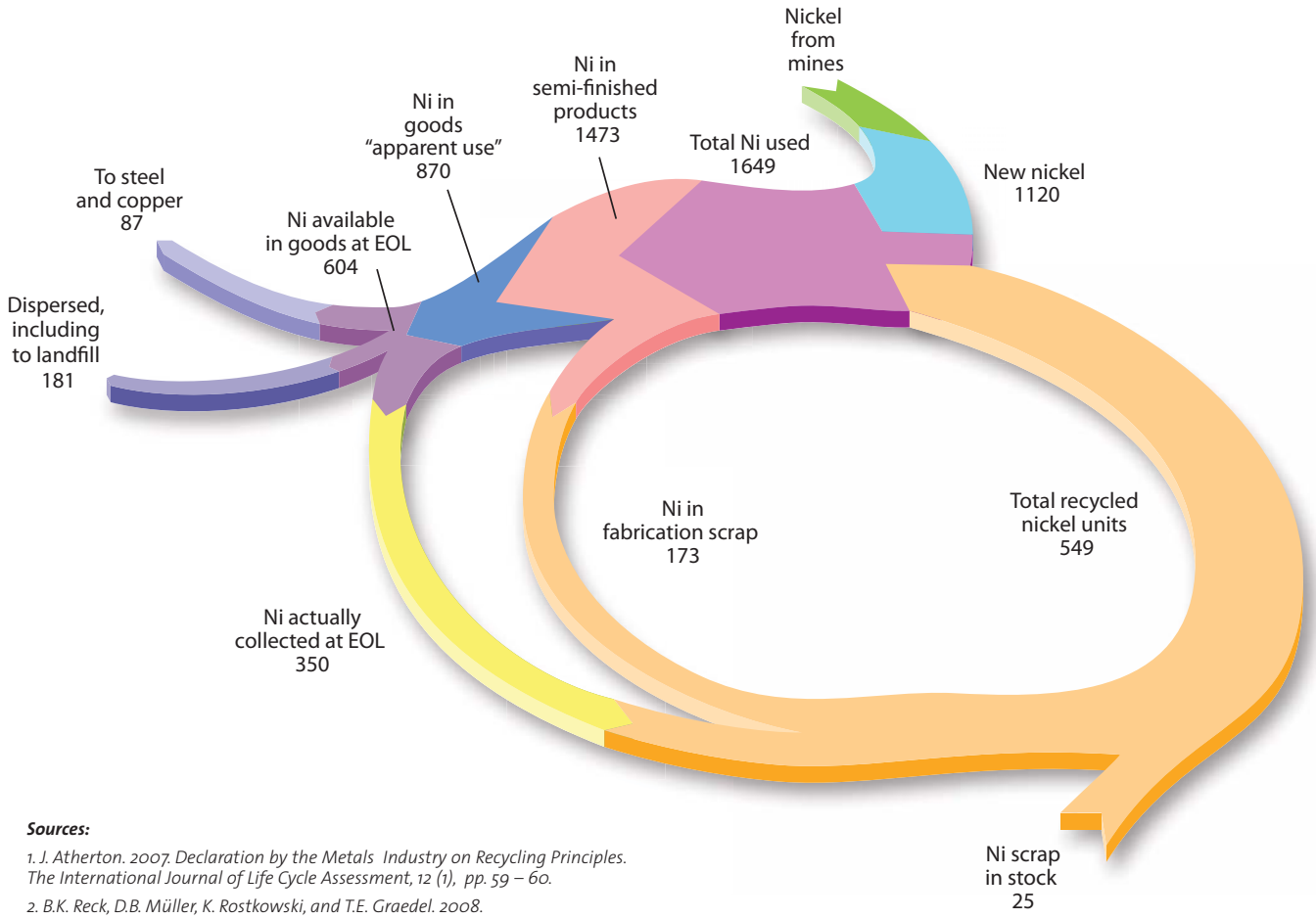
Table 4: Recycling Rates for Nickel

	Nickel in Stainless Steel	Nickel in other first uses*	Average recycling rate
Recyling input rate	43%	11%	33%
	Proportion of nickel recycled within stainless steel loop	**Proportion of nickel recycled within carbon steel loop**	**Total recycling rate**
Overall recycling efficiency rate	69%	11%	80%
End-of-life recycling efficiency rate	57%	14%	71%

** alloy steels, nickel- & copper-based alloys, plating, foundry, batteries, catalysts*

The recycling rates were determined using results from a material flow analysis (MFA) of nickel, performed by researchers at Yale University. The study, largely based on trade data, estimated the 'stocks' of nickel that build up in equipment that is serving out its intended use, as well as the 'flows' of nickel that is mined and recovered as scrap. A graphical representation of this global nickel cycle is shown in Figure 3.

Figure 3: Nickel stocks and flows for the year 2000, in thousands of metric tonnes.



Sources:

1. J. Atherton. 2007. Declaration by the Metals Industry on Recycling Principles. The International Journal of Life Cycle Assessment, 12 (1), pp. 59 – 60.

2. B.K. Reck, D.B. Müller, K. Rostkowski, and T.E. Graedel. 2008. Anthropogenic nickel cycle: insights into use, trade, and recycling. Enviromental Science & Technology, 42 (9), pp. 3394-3400.

5. Environmental Data

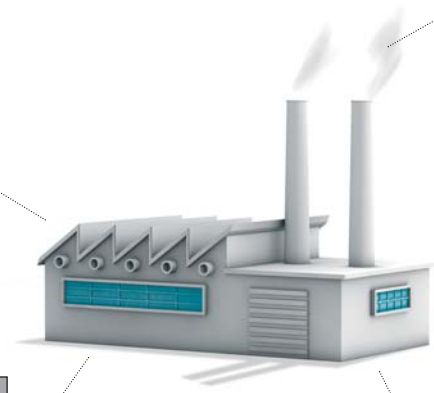
The Nickel Institute supports the use of Life Cycle Assessment (LCA) to acquire a full life cycle picture of environmental impacts of a product over its life cycle from "cradle" (i.e. resource acquisition) to "grave" (i.e. end of life).

For nickel-containing products, it is important to take into account their long service life and recyclability in order to obtain a balanced assessment of their climate change impact.

With the aim of providing transparent information about the environmental impacts of its products, the industry has established a Nickel Life Cycle Inventory (LCI) for a range of primary nickel products, measuring impacts from "cradle" to "gate" (i.e. the factory gate). A graphical representation of the inputs and outputs included in this analysis is shown below in Figure 4.

Figure 4: Environmental inputs and outputs for making 1 kg of primary nickel products

Inputs	Ferronickel	Nickel Oxide	Class I Nickel
Coal (kg)	1.7	2.4	1.7
Natural Gas (kg)	0.41	2.7	1.8
Fuel oil (kg)	2.3	3.5	2.0
Nickel (kg)	0.63	1.9	1.8
Iron ore (kg)	4.0	0.00057	0.0012
Limestone (kg)	0.17	0.31	0.24
Uranium ore (g)	0.011	0.019	0.036
Water (l)	216	238	1916



Emission to air	Ferronickel	Nickel Oxide	Class I Nickel
Carbon Dioxide (kg)	8.7	20.3	13.6
Carbon Monoxide (g)	27	48	37
Nitrogen Oxides (g)	49	66	52
Nitrous Oxide (g)	4.2	1.5	1.3
Sulphur Oxides (g)	52	1698	961
Methane (g)	16	36	28
Other Hydrocarbons (g)	12	17	13
Metals (g)	0.7	8.1	4.3
Ammonia (g)	1.1	3.6	5.6
Chloride (g)	0.00081	0.0010	0.34
Dioxins (g)	2.5E-09	3.4E-07	3.8E-07
Volatile Organic Compounds (g)	0.57	2.0	2.2
Hydrogen Chloride (g)	0.30	0.75	0.83
Hydrogen Cyanide (g)	1.3E-07	3.0E-05	6.8E-05
Hydrogen Fluoride (g)	0.021	0.046	0.047
Hydrogen Sulfide (g)	0.024	0.036	0.027
Sulfuric Acid (g)	7.0E-06	31	17

Emissions to water	Ferronickel	Nickel Oxide	Class I Nickel
Biochemical Oxygen Demand (g)	0.59	0.85	1.7
Chemical Oxygen Demand (g)	5.0	6.7	4.2
Sulfates (g)	0.61	143	76
Nitrogenous Matter (g)	0.92	1.7	224
Phosphates (g)	1.9E-05	0.0076	0.011
Total Organic Compounds (g)	0.030	0.33	0.23
Metals (g)	0.00049	0.15	0.16
Dioxins (g)	-	-	5.4E-05
Acids (g)	0.00093	0.011	0.019

Solid waste	Ferronickel	Nickel Oxide	Class I Nickel
Tailings and Process Residues (kg)	6.8	144	72
Waste Rock and Backfill (kg)	48	135	72
Other Solid Waste (kg)	0.63	1.4	1.1

Products
Data shown is per 1 kg of product (ferronickel, nickel oxide or class I nickel)

Source: *Nickel Institute, Life Cycle Assessment of Nickel Products, 2003.*

6. Socio-Economic Data

A 'value chain' examines the creation of wealth and jobs in an economy through the entire manufacturing process, from the production of basic raw materials through the successive manufacture of more sophisticated materials and components, to the use of end-products by consumers.

The socio-economic benefits of nickel, therefore, extend much further than the mining and production of the metal itself. This widespread use of nickel, nickel alloys, and nickel technology also generates an enormous range of indirect benefits – namely wealth and jobs.

In fact, about 2 million jobs worldwide are critically dependent on nickel. Table 5, below, presents a regional distribution of where these jobs are located.

Table 5: Number of jobs that are critically dependent on nickel in 2006

No.	Selected Countries/Regions	Direct Industry	Indirect Industry	Total Employment
1	EU*	23 000	667 000	690 000
2	USA	18 900	405 000	443 000
3	South Africa	35 200	114 000	184 000
4	South Korea	11 500	142 000	165 000
5	Brazil	36 600	83 900	157 000
6	Japan	21 100	101 000	144 000
7	Canada	37 000	30 900	105 000
8	Australia	29 900	12 400	72 200
	TOTAL	**213 000**	**1 560 000**	**1 960 000**

**Data for EU is for 2007*

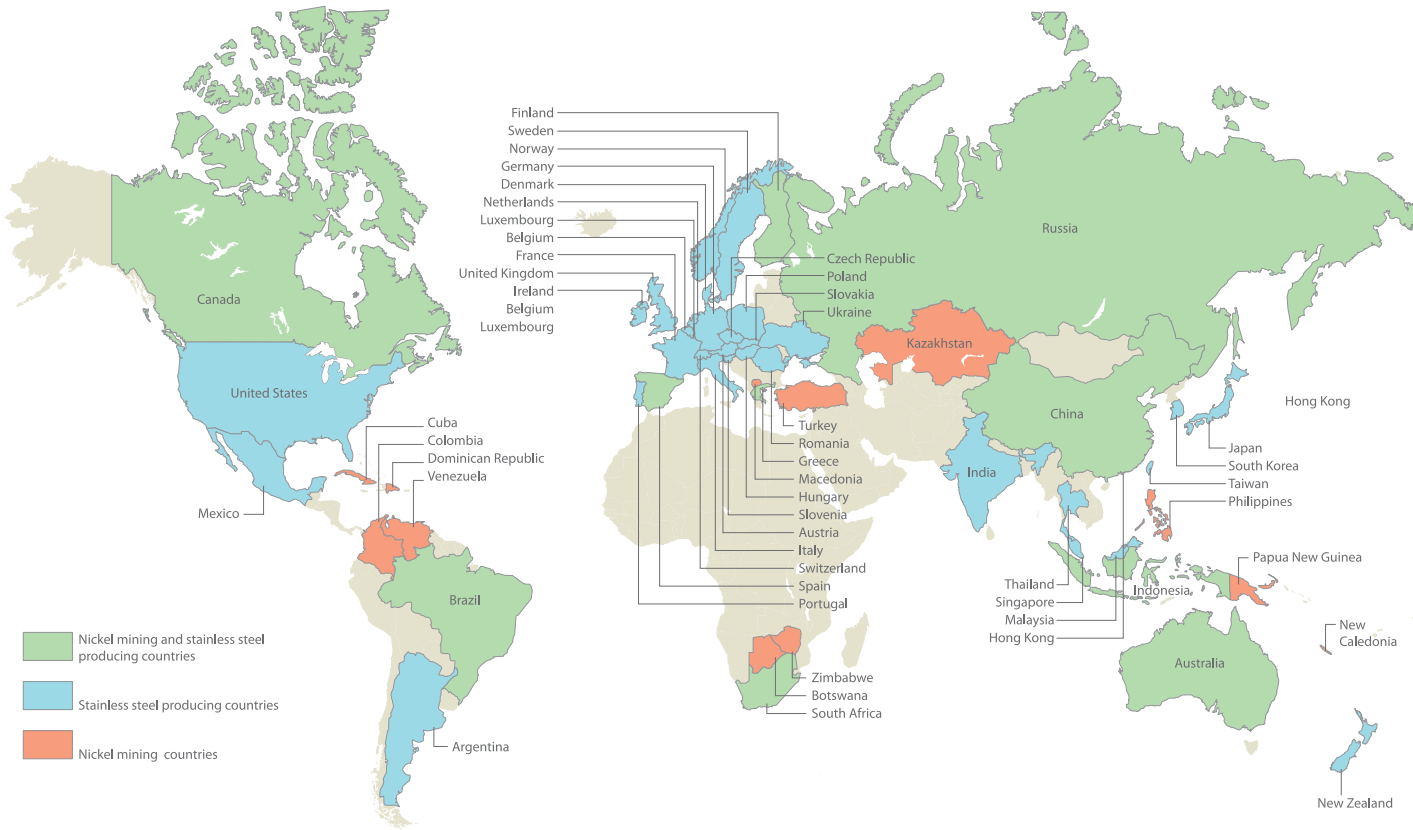
Sources:

1. PriceWaterhouseCoopers, Socio-Economic Impact of the Nickel Industry and Nickel Value Chain, 2009.
2. Weinberg Group, Socio-Economic Impact of the Nickel Industry in the EU, 2008.

Notes:

1. Data for China and Russia are not available, but presumed to be in the top 10 countries that employ people in the direct nickel industry.
2. Direct industry includes mining, producing, recycling, transportation and logistics services, as well as contract exploration and engineering.
3. Indirect industry refers to those industries that use nickel as a first use and as an end use. First uses include stainless steel, nickel and other alloys, plating, casting, and chemicals. End uses include automobiles, aircraft, home appliances, consumer electronics, engineering equipment, construction materials, piping and kitchenware.

Figure 5: The global nickel industry by country. Around 60% of nickel is used in stainless steel, making stainless steel production an important part of the nickel value chain.



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