ECONOMIC VIEWPOINT

Green Technologies and Metals

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Although, consumption of metals mainly came from construction, industrial production and infrastructures historically, the development of green technologies could very well reshape the makeup of demand. From the electrification of transportation to the development of renewable energies, new needs for metals are emerging, and questions are arising about the impact of these changes.

This *Economic Viewpoint* explores how the development of green technologies could affect aluminum, copper, nickel, lithium and graphite. Although several other metals could be analysed, these five will play a strategic role in the global economy in the next few decades, and will be critical in developing solar energy, electric vehicles and green buildings. An inadequate reaction from supply or weaker than expected demand could put pressure upward or downward pressure on prices or favour the develop of some technologies over others.

Definition

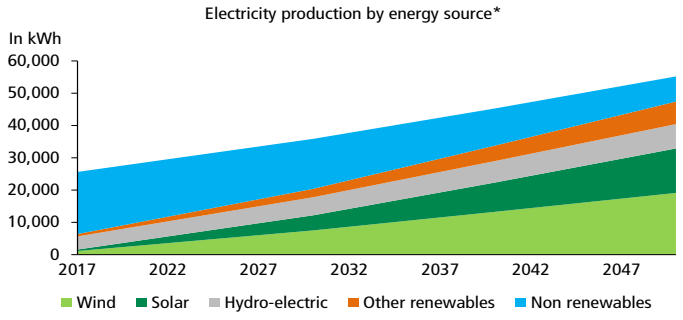
No widely accepted or internationally recognized definition of green technologies exists. The term is often used to describe renewable energies, electric vehicles, and material recycling methods. For this exercise, we are defining green technologies as all technologies, services and goods which have the potential to reduce our environmental footprint. This definition makes it possible to include renewable energies, batteries, and the electrification of society in green technologies, and tackle the impact on base metals from a global perspective.

All the scenarios and forecasts used in this analysis are based on models constructed according to the main objective of the Paris Climate Agreement: i.e., keeping the rise in global temperature to less than 2° C from pre-industrial levels, and on the model bank of the International Energy Agency (IEA). Since 194 countries, including the United States and China, signed the agreement, these models offer a general vision of the growth trend for green technologies. This *Economic Viewpoint* does not intend to predict the future; instead, it explores the evolution of green technologies and their potential impacts on the metal market through to 2050.

Green Technologies

Most countries have announced that they intend to get rid of polluting energies, so renewable energies will clearly play an important role in the coming decades. The International Renewable Energy Agency (IRENA) expects the proportion of energy produced from renewable energies to rise from 13% in 2017 to 65% in 2050. While the electricity produced from hydro, geothermal and other sources would increase, the main drivers of this growth would be solar and wind power. IRENA predicts that their electricity output will increase by about 18,000 kWh and 13,000 kWh (kilowatt hours) respectively by 2050 (graph 1).

GRAPH 1
The share of renewable energies could increase



* Based on the forecasts in the energy transformation scenario.
Sources: International Renewable Energy Agency and Desjardins, Economic Studies

According to the IEA's baseline scenario, which includes policies already adopted or announced, the number of electric vehicles on the road could go from 8 to 140 million from 2019 to 2030. In the more aggressive scenario, in which the energy transition

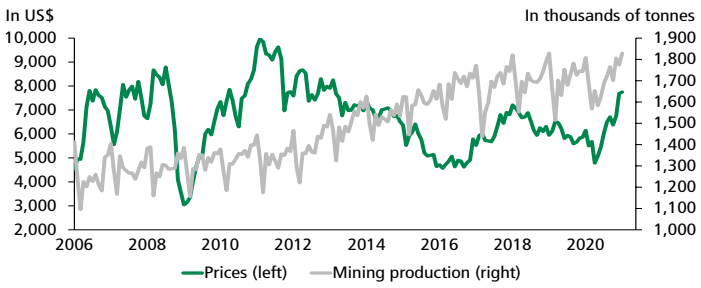
rolls out quickly, the number of electric vehicles on the road could hit 245 million in 2030. The Asian nations, mainly China, would see the strongest growth, becoming the biggest market for electric vehicles. The electrification of transportation is creating unprecedented demand for batteries, although the supply chains have not yet been developed. Batteries could also be an important factor in transforming the power grid. They are essential to the large-scale use of intermittent means of electricity production, such as solar panels and wind turbines. The World Bank is predicting that energy storage needs could quintuple by 2050, going to 22 kWh. From electric vehicles to the power grid, batteries could be ubiquitous, requiring a large quantity of metals.

Several other technologies have not been mentioned so far, such as green buildings that use and produce electricity, electric smelters for refining metals, and charging stations for electric vehicles. For simplicity's sake, all technologies that promote greater use of electricity to reduce the environmental footprint are implicitly included when we refer to electrifying society. In the scenarios, this is represented by more intensive use of certain metals, such as copper and aluminum.

Copper

Copper's good electrical conductivity makes it one of the most utilized metals in green technologies. It is therefore not surprising that copper production has increased 30% since 2006. The electrification trend is already impacting copper prices: it has appreciated 43% since the start of 2019 (graph 2) due to growing demand and the limited supply. Green tech development could intensify demand. This metal represents 12.0% and 4.5% of metal demand for solar and wind energy respectively, and it is also broadly used in electrical wiring according to the World Bank.

GRAPH 2
After good growth, copper production has stagnated for several years



Sources: International Copper Study Group, Datastream and Desjardins, Economic Studies

The economic outlooks are therefore favorable for an increase in copper demand to meet green technology needs. For renewable energies alone, excluding batteries, the cumulative demand until 2050 could total about 30 million tonnes, according to the World Bank. Note that this projection excludes infrastructure and industrial needs, which account for over 50% of the demand for copper. Once they are incorporated into the scenarios, demand could increase 150% to 250% by 2050. Although many factors, such as the economic conjecture, technological innovation, and government policies, could have a big influence on these forecasts, a positive trend seems evident.

On the other side, the supply faces several obstacles; the copper market is currently in deficit because of inadequate investment in new mine development in recent years. This is highlighted by the stagnating production since 2016. A number of capacity expansion projects are in the works, but it will be 2024 before they come on line and the market returns to the equilibrium. Moreover, the Commodities Research Unit (CRU) expects that more than 200 mines will exhaust their reserves by 2035, and some, like Grasberg in Indonesia, and Chuquicamata in Chile, will have to shift form open-pit mining to underground tunnels, which are more complex to operate, because the easily accessible deposits will have been depleted. While in the past Chile and Peru were the most important copper miners, the high price level as well as the favorable outlook for demand are encouraging the rest of major producers, such as Australia and Canada, to increase their capacity production (table 1). Although the supply of copper is growing, more investment will be needed in the medium and long term to keep up with changing demand.

TABLE 1
Copper production in 2019

	MINING PRODUCTION	REFINING
Australia	934,000	426,000
Canada	573,000	281,000
Chile	5,790,000	2,270,000
China	1,680,000	9,780,000
Congo	1,290,000	1,080,000
United States	1,260,000	1,030,000
Peru	2,460,000	308,000
Russia	801,000	1,050,000
Rest of the world	3,100,000	3,640,000
TOTAL	**20,400,000**	**24,500,000**

Sources: U.S. Geological Survey and Desjardins, Economic Studies

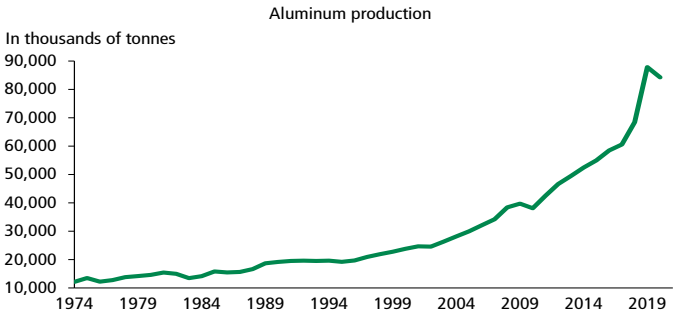
Aluminum

Aluminum's versatility allows it to play a key role in the emergence of green technologies and in decarbonizing society. This light, malleable, recyclable, good electric and thermic conductor material sees its demand increases as its use intensifies in sectors such as the automobile industry, construction and renewable energies.

The global production of new aluminum, also called primary aluminum, has increased substantially since the 1970s, going

from 12 to 84 million tonnes (graph 3), to keep pace with the rapidly growing demand. Although the pace of growth should slow, the European Aluminium expects annual demand for aluminum to rise 50% or more by 2050, due to its increased use in various economic spheres. In this scenario, China, the biggest consumer of aluminum, should see its aluminum consumption slow, then shrink by around 2035. Today it accounts for 50% of global demand; in 2050, it would only represent 40% due to decreases needs in infrastructure and stronger international demand. The main drivers of demand growth would be the other Asian countries, primarily India. For their part, the developed economies would see their demand rise, but more slowly.

GRAPH 3
Aluminum needs are proliferating

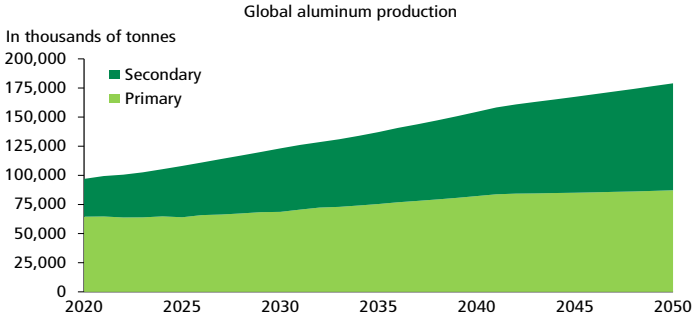


Sources: International Aluminium Institute, Datastream and Desjardins, Economic Studies

According to the World Bank, the development of renewable energies, excluding batteries, would require an additional 110 million tonnes of aluminum over thirty years. Solar and wind energy would be the main consumers, as cumulative demand to 2050 would be 90 and 10 million tonnes respectively. Aluminum's beneficial characteristics make the metal essential to the growth of green technologies. Hence its nickname: metal of the future.

While there is enough aluminum production capacity to meet demand, the pollution generated by aluminum mining and smelting operations powered by fossil fuels could drive major changes on the supply side. Primary aluminum production is very energy intensive, but producing aluminum from recycled materials, called secondary aluminium, takes twenty times less energy. As a result, World Aluminium projects that the proportion of the metal produced from recycled materials will go from 30% in 2020 to 50% in 2050, while total aluminum production will increase by 82 million tonnes (graph 4). Most of the production growth would therefore come from recycled aluminum. Also, new technologies are coming on line, such as electric smelters that are more efficient and less polluting, if they use a clean energy source, than the coal-powered smelters commonly used in Asia. The supply could be restructured in terms of the production methods used in the coming years,

GRAPH 4
Production of secondary aluminum could increase substantially



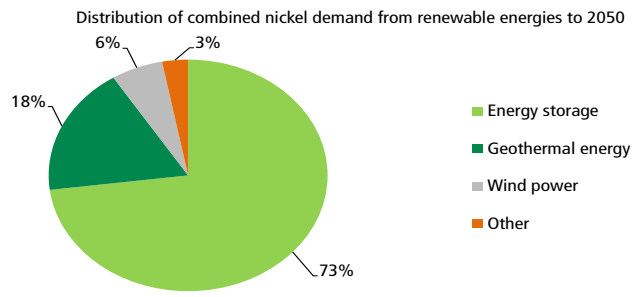
Sources: World Aluminium and Desjardins, Economic Studies

which could limit production while new technologies are integrated. This situation is currently occurring in China, with the temporary closing of coal-powered aluminum smelters under the government green plan.

Nickel

Nickel also benefits from good versatility and fairly widespread use in electronics, energy storage, and stainless steel. However, demand from batteries is not homogeneous, as mineral needs vary according to the type of cathode used. For nickel, NMC811 models, a more efficient type of battery being developed for electric vehicles, show the strongest demand for nickel, hitting 80% of the mineral needs for some sub-types. However, a mix of different types requiring different quantities of metals could be used, which would spread demand over several materials, like lithium, cobalt and graphite. According to the World Bank, cumulative demand for nickel for batteries to 2050 should be between 15 and 25 million tonnes, depending which models are used. When all renewable energies are incorporated into the forecast, aggregate demand is around 35 million tonnes. Unlike aluminum and copper, for which demand is distributed among the various green technologies, nickel needs are concentrated in energy storage (graph 5).

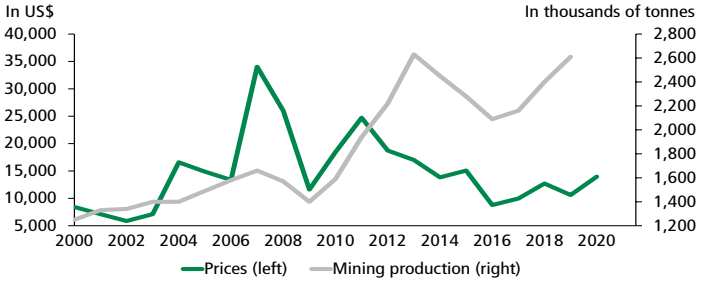
GRAPH 5
Majority of nickel production for green energies is used in battery production



Sources: World Bank and Desjardins, Economic Studies

The nickel market is segmented into two classes: high quality, called class 1, and lower quality, called class 2. Because green technologies use class 1 nickel, supply growth could be focused around production of this class. Class 2 production, particularly for stainless steel, could remain substantial, as needs continue to increase. Historically, class 1 nickel was produced from sulfur deposits, but the small number of new deposits discovered and new mines developed are steering production toward laterite deposits. However, prices have been low in recent years, which has slowed the development of new production capacity (graph 6). The nickel supply could thus lag behind demand, creating upward pressure on prices over the short and medium term.

GRAPH 6
Weak nickel price slowed supply

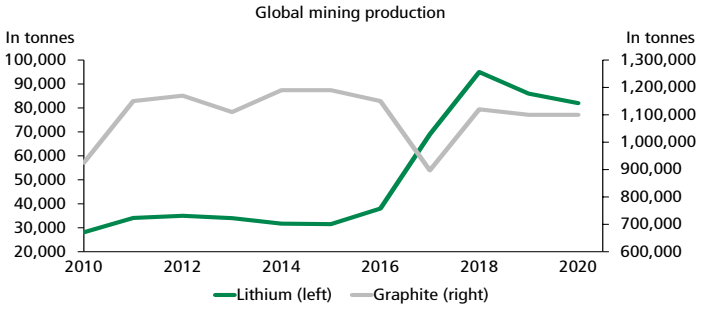


Sources: U.S. Geological Survey, Datastream and Desjardins, Economic Studies

Lithium and Graphite

In the past, lithium and graphite production was relatively low because the metals were not used much. As mentioned earlier, the growing production of electric vehicles and favourable outlooks have led to substantial increases in lithium production (graph 7). Australia is responsible for the growth, it quadrupled its output from 2017 to 2018, becoming the world's leading lithium producer. The World Bank expects demand for these metals to increase by a little less than 500% by 2050. In relative term, this is the strongest growth among the metals discussed in this *Economic Viewpoint*. As with nickel, demand growth depends on the models of batteries used and production costs. An ore shortage or surplus could influence which types of batteries are produced and thus demand for the metals used for energy storage.

GRAPH 7
Major increase in lithium production



Sources: U.S. Geological Survey and Desjardins, Economic Studies

Lithium production's development is often described as the new gold rush. For countries like Argentina, Australia, Chile and China, which together have over 80% of the world reserves, exploitation of lithium, also called white gold, could representative lucrative opportunities (table 2). Although production should continue to increase in the countries that are the most lithium-rich, new players like the United States and Canada could enter the market. Rising demand, and the dependence on China, more and more seen as a vulnerability, have prompted many governments to rethink the structure of their supply chains. New projects are therefore being developed in California, by Rio Tinto, and Manitoba, by QMC Quantum Minerals.

TABLE 2
Global lithium reserves in 2020

	RESERVE*	PROPORTION
	tonnes	%
Argentina	1,900,000	9.05
Australia	4,700,000	22.38
Brazil	95,000	0.45
Canada	530,000	2.52
Chile	9,200,000	43.81
China	1,500,000	7.14
United States	750,000	3.57
Zimbabwe	220,000	1.05
Rest of the world	2,100,000	10.00
TOTAL	**21,000,000**	**100.00**

* Reserves are deposits of ore that can be exploited.
Sources: U.S. Geological Survey and Desjardins, Economic Studies

The situation is similar for graphite, demand from energy storage is encouraging producers to develop new production capacity. China is the biggest producer with over 60% of the market share, i.e., 7 million tonnes produced in 2019. Unless new mines are developed, the supply may not be able to keep up with demand. Brazil, China, India, and Turkey could therefore play a key role in expanding the supply thanks to their large reserves and capacity to develop new mining operations (table 3 on page 5). While the smallest producers, like Madagascar and Tanzania, should increase their graphite output, they face sustainable development and funding challenges. In addition, several countries are reluctant to export their natural resources in order to maximize local economic benefits.

TABLE 3
Global graphite reserves in 2020

	RESERVE*	PROPORTION
	tonnes	%
Brazil	70,000,000	22.88
China	73,000,000	22.81
India	8,000,000	2.50
Madagascar	26,000,000	8.13
Mozambique	25,000,000	7.81
Uzbekistan	7,600,000	2.38
Tanzania	17,000,000	5.31
Turkey	90,000,000	28.13
Rest of the world	3,400,000	1.06
TOTAL	**320,000,000**	**100.00**

* Reserves are deposits of ore that can be exploited.
Sources: U.S. Geological Survey and Desjardins, Economic Studies

Conclusion

Despite the huge range of differences among the many green technologies, they have one thing in common: more intensive use of metals. Demand for metals should therefore increase substantially by 2050 to meet these new needs. Demand for some metals, like lithium and graphite, could increase 500%. Even for copper, where relative growth is weaker, the absolute increase is staggering. However, the speed at which the energy transition happens and at which new technologies are integrated will be critical to price fluctuation in the metals market. An inadequate response from production, heavy price volatility, or lower needs than anticipated could result in a misaligned supply and demand, triggering upward or downward price pressures. Some green technologies could be favoured over others if production costs are too high or if the carbon footprint is too high.

Statistics Canada estimates the country produced $28B in metallic minerals in 2019. As prices are high and demand from green technologies grows, the value of metal production is expected to increase, since the country's subsoil is very rich in nickel and copper with 2.8 million and 9.0 million tonnes respectively in reserve. In addition, Canada is the fourth largest producer of primary aluminum in the world with 2.9 million tonnes produced in 2019. Of the ten primary aluminum smelters in the country, nine are located in Quebec, and mainly use hydroelectricity as an energy source making Canadian aluminum one of the least polluting among the main producers. Quebec is also making inroads in the battery sector, since it is the only province producing lithium and graphite, and Hydro-Quebec wishes to promote these advantages with the production of a 100% Quebecer solid electrolyte battery which can be used in electric vehicles. The availability of the natural resources necessary for the development of green technologies thus offers promising economic prospects in Canada.