

10 Cobalt Supply & Demand 2015

Supply

Although cobalt is ranked element No. 33 in Earth's crustal abundance, making up 0.002% of it on average, this metal is fairly widely disseminated. Its relatively low concentration usually means that it is produced as a by-product of another metal. Almost all land-based deposits contain cobalt in combination with nickel or copper and a few with arsenic and silver. Until recently, world supply was predominantly African from the Copper Belt of the Democratic Republic of Congo (DRC) and Zambia but in later years, changes in the supply characteristics of cobalt have occurred. Other important cobalt producers now include Australia, Brazil, Cuba, Russia, Canada, Madagascar and China. Cobalt as a by-product of nickel operations has increased significantly with the development of several important nickel laterite projects and with the advent of innovative extraction technology there is greater possibility now to develop cobalt as a primary metal. A rough split of cobalt production arisings would currently be:

Nickel Industry	-	~50%
Copper Industry & Other	-	~44%
Primary cobalt operations	-	~ 6%

Country	Mined	Refined	Approx. Refined Qty
Australia	√	√	5,000
Belgium		√	6,300
Botswana	√		In Cu & Ni ore/conc
Brazil	√	√	1,300
Canada	√	√	5,500
China	√	√	49,700
Cuba	√		See Canada
Finland		√	8,600
France		√	130
India			100
Japan		√	4,250
Madagascar	√	√	3,500
Morocco	√	√	1,700
New Caledonia	√		See France
Norway		√	3,100
Russia	√	√	2,000
South Africa	√	√	1,300
D.R. of Congo	√	√	3,300
Uganda		√	Ceased operations
Zambia	√	√	<u>3,000</u> ~99,000 (tonnes)

Refining can be from newly mined ores or from older slags, by-products and scrap. The definition is that "new" cobalt is produced.

Cobalt can also be derived as a by-product of precious metal mining, for example, platinum in South Africa (usually as sulphate) and is produced as the primary product from concentrates and tailings in Morocco. Here CTT commissioned a refinery in 1999 which produces refined metal and oxide.

The list of potential new sources of cobalt is large, ranging from significant cobalt-containing nickel and copper deposits in Canada, Western Australia, the DRC, Zambia, Madagascar and the Philippines, not to mention deep-sea nodules and discoveries of cobalt containing polymetallic minerals in Yemen and Western Australia. The main development has been the increasing mining activity in the DRC where, until recently, significant volumes of ore and concentrate were being mined for refining elsewhere, mainly China. The DRC Government has from time to time put restrictions on the export of ores and concentrates in order to encourage greater development of downstream processing in the country and has also been reviewing and in some cases re-negotiating mining contracts in that country.

It would appear that developments in the DRC will be an important factor in cobalt production and according to the USGS, the global distribution of mined cobalt production is as follows:

Africa	~ 60%
Americas	~ 11%
Australasia	~ 8%
Russia	~ 5%
Asia	~ 10%
ROW	~ 6%

The cobalt market has maintained a solid rate of growth in demand, and is sustaining a CAGR of >5% and this growth rate is likely to be sustained or even increased in the foreseeable future, driven largely by increased demand for cobalt in rechargeable batteries (Li-ion systems particularly) and superalloys for aerospace applications. The USA Defence Logistics Agency who had been selling stockpiled material into the market for over 20-years has now ceased sales for the time being, and at 31st December 2015 the uncommitted cobalt inventory in the US DLA stockpile remained at 301 tonnes.

Because cobalt is essentially a by-product metal in primary nickel and copper operations, the price of cobalt is usually of limited relevance to the viability of the primary operations. However, the viability of primary cobalt operations is critically dependent on the price of cobalt and therefore strong project economics are important for these types of operations.

Table 1 is a guide to 2015 world refined cobalt output. In the past, we have tried to estimate global cobalt resources in the ground, but these are continually being revised as new and richer ores appear and prices change. There seems to be enough known land sources of cobalt to last for at least 100 years and for many, many more years if speculative and hypothetical resources for deep sea, ocean floor resources are taken into account (about 120million tonnes according to the USGS). So we are confident that cobalt is not running out, but its availability will depend upon many factors such as accessibility, price, demand, technological development and global economic growth. In addition metal is 'used but not consumed' in many processes and applications and so can theoretically be infinitely recycled. This is particularly true in metallurgical applications.

Global reserves of cobalt are of the order of 7.1million tonnes according to the USGS (2016) and they calculate that the reserves are dispersed as follows:

Table 2 – Refined Cobalt Production/Availability (Rounded Tonnes)		
Europe	Production/Supply	Source of Feed
Belgium	6,300	Various secondary/Australia/DRC
Finland	8,600	Africa/New Caledonia/Australia/Others
France	130	Nickel by-product New Caledonia
Norway	3,100	Canada/Africa/Australia/Russia/Others
Africa		
Madagascar	3,500	Domestic
Morocco	1,700	Domestic
South Africa	1,300	Domestic
D.R. Congo	3,300	Domestic
Uganda	000	Domestic (Ceased ops)
Zambia	3,000	Domestic/DRC
Americas		
Brazil	1,300	Domestic
Canada	5,500	Domestic/Australia/Cuba/Secondary
Asia		
China	49,700	Domestic (small)/DRC/intermediates
India	100	Domestic/Cuba/DRC/secondary
Japan	4,250	Australia/Philippines
Others		
Australia	5,000	New Caledonia/Domestic
Russia (Export)	2,000	Domestic
DLA (Deliveries)	___0	Stock Release (via DLA stock report)
TOTAL	~99,000	<i>NB: Availability figures rounded for illustration</i>

Africa	~54 %
Americas	~12 %
Australasia	~18 %
Asia	~ 5 %
ROW	<u>~11 %</u>
	<u>100 %</u>

Production

In 2001, the CDI re-examined its methodology for determining cobalt statistics. It has been recognised that in the past, production statistics have contained a varying degree of double counting as some CDI members' figures included material sent to other members for further refining. The Institute has drawn up a definition for refined production which we believe removes this discrepancy such that, as of 1998, all double counting was eliminated.

World refined cobalt production has been defined as **“all cobalt units, whether in metal or chemicals, derived from feed requiring further refining”**. For the purposes of this definition, the following sources of material shall not be counted as feed: a) DLA and other stockpile releases; b) Russian; c) Likasi, DRC; d) Lower grade Moroccan.

Using this definition, Tables 3 and 4 illustrate 2015 availability of refined cobalt. The origin is where the refinery is located. The feed sources can be from many other places, not necessarily domestic. One should also be clear that we are talking about “available new” cobalt, which should not be confused with “sales”. We include refining in Belgium from secondary feedstocks (such as old slags and cements), and stock releases from the DLA if and when they occur.

Table 3 – CDI Members Refined Cobalt Production (Tonnes) - 2015

Member companies	2009	2010	2011	2012	2013	2014	2015
Ambatovy, Madagascar	0	0	0	0	2083	2915	3464
BHPB/QNPL, Australia ⁽¹⁾	1700	2141	2631	2369	0	0	0
CTT, Morocco	1600	1545	1788	1314	1353	1391	1722
Eramet France	368	302	354	326	308	219	133
Gecamines, DRC ⁽²⁾	415	745	650	870	700	500	400
Glencore ⁽³⁾ : Katanga, DRC						2800	2900
Minara, Australia						2900	3300
Mopani, Zambia						0	0
Nikkelverk/Raglan/Sudbury ⁽⁴⁾	3510	3208	3067	2969	3400	3600	3100
ICCI, Canada	3721	3706	3853	3792	3319	3210	3733
Freeport Cobalt, Finland (was OMG)	8850	9299	10441	10547	10010	11452	8582
Rubamin, India (Left CDI 2012) ⁽⁵⁾	0	517	579	200	45	0	0
Sumitomo, Japan	1332	1935	2007	2542	2747	3654	4259
Umicore, Belgium ⁽⁶⁾	2150	2600	3187	4200	5415	5850	6306
Vale, Canada	1193	940	2070	1890	2240	2051	1858
Zambia ⁽⁷⁾	235	3934	4856	5435	5000	4317	2997
Total	25074	30872	35483	36454	36620	44859	42754

Notes: 1. 2009: BHPB 700mt Jan - Jul and Queensland Nickel Pty (QNPL) 1000mt Aug-Dec. See also Note 12

2. Estimated production after 2012; 3. Glencore joined CDI 2014 4. Previously reported as Xstrata, Norway

5. Rubamin joined CDI in 2009 and left in 2013; 6. Includes Umicore's global refined production

7. Chambishi Metals plc Zambia

The inclusion of “secondary” material refining is subject to some comment. Umicore’s Belgium tonnage includes their production in China. Hence the 49,700 tonnes reported for China (see Table 4) excludes Umicore’s production in that market which is estimated at about 1,500 tonnes per annum. In 2007 Norilsk of Russia announced that it was disposing of some cobalt units to OMG Group and so the production attributed to Russia has reduced from 2008/09 and that for OMG Group, Finland (now Freeport Cobalt) has increased according to the bilateral agreement. As of 2009 Norilsk was no longer a Member of the CDI. In April of 2012 Freeport McMoran Inc bought the cobalt assets of OMG International. Taking these comments into consideration, Table illustrates refined cobalt production from CDI members from 2009 to 2015.

Table 4 – Other Refined Cobalt Production/Availability (Tonnes) - 2015

Non-Member companies	2009	2010	2011	2012	2013	2014	2015
China ⁽⁸⁾	25544	35929	34969	29784	36062	39292	48719
India ⁽⁹⁾	1001	670	720	600	250	100	150
Kasese, Uganda	673	624	661	556	376	0	0
Katanga, DRC (See Glencore) ⁽¹⁰⁾	2535	3437	2433	2129	2300	0	0
Minara, Australia (See Glencore) ⁽¹⁰⁾	2350	1976	2091	2400	2700	0	0
Mopani, Zambia (See Glencore) ⁽¹⁰⁾	1271	1092	1100	230	0	0	0
Norilsk, Russia ⁽¹¹⁾	2352	2460	2337	2186	2368	2302	2040
QNPL, Australia ⁽¹²⁾				0	2281	2519	1850
South Africa ⁽¹³⁾	236	833	840	1100	1294	1332	1300
Votorantim, Brazil	1012	1369	1613	1750	1653	1350	1300
Total	36974	48390	46764	40735	49284	46895	55359
DLA Deliveries	180	-8	0	0	0	0	0
Total Supply	37154	48382	46764	40735	49284	46895	55359

Notes: 8. Excludes Umicore's refined production in China; 9. Excludes Rubamin between 09 and 13 & est thereafter

10. From 2014 this reports as Glencore in Table 1; 11. Norilsk ceased to be a CDI member in 2009

12. QNPL ceased to be a CDI Member from 2014; 13. Estimates for Nov & Dec 15

The total refined cobalt available from 2009 to 2015 is shown in Table 5:

Table 5 – Total Refined Cobalt Availability (Tonnes) - 2015

	2009	2010	2011	2012	2013	2014	2015
CDI Members	25,074	30,872	35,483	36,454	36,620	44,859	42,754
Others	37,154	48,382	46,764	40,735	49,284	46,895	55,359
Total⁽¹³⁾	62,228	79,254	82,247	77,189	85,904	91,754	98,113

Notes: 14. Total Supply does not include any estimates for producers not reporting their production

Availability should not be confused with sales, as we make no recognition of stocks which may have changed in 2015. Not all “primary” production is from freshly mined ore. The supply figures merely indicate material which **could** come onto the market as new cobalt. “Re-use”, recycling – e.g. remelting superalloy scrap as a source of cobalt – is another matter and no account of that type of recycling is considered here, apart from that treated by the major cobalt producers.

Demand

The most difficult part of interpreting the supply/demand equation is to quantify accurately the figures collected and it is generally recognised that figures based on official reports are lower than actual figures.

The CDI has continued to analyse critically cobalt import/export data over the last year in an attempt to improve its demand statistics. Each year it publishes a statistics book jointly with the World Bureau of Metal Statistics (WBMS) which includes apparent cobalt demand by geographical location calculated from import/export data. This publication can be purchased from the CDI or the WBMS. Published data suggest that worldwide apparent cobalt demand in 2015 was about 87,000 tonnes, which is a 7.5% increase over the previous year.

Superalloy is the end-use sector that was historically the major user of cobalt and there has been a continued increase in cobalt demand for these applications, particularly in the aerospace sector. Aircraft and engine manufacturers all forecast strong future deliveries (going out about 10 or 20 years), which will be positive for future cobalt demand. The superalloy sector has now been overtaken by rechargeable batteries as the main end-use sector as can be observed from table 6. Further significant increases in this sector are projected over the next decade in line with increases in battery demand, particularly for portable devices and for the new generation of Hybrid Electric Vehicles (HEV) and Electric Vehicles (EV). Growth is a factor of the global economy, but demand for batteries continues to be buoyant and the aviation sector has generally proved resilient to economic factors in the longer term.

Over the past 15 years, there have been two major shifts in cobalt demand patterns. First, there was a significant shift in demand from the USA and Western Europe to Asia. The apparent demand in Asia has increased significantly since 2002, whereas demand in the USA and Western Europe has remained relatively steady. Second, the increase in demand resulted largely from increases in chemical applications, most notably rechargeable batteries and catalysts. In 2014, it is estimated that chemical applications accounted for about 62% of worldwide cobalt demand and the balance 38% in metallurgical applications. The proportion of cobalt used in chemical applications is expected to have increased further in the future as a result of strong demand for rechargeable batteries.

Cobalt is considered a ‘technology enabling’ substance as it is at the forefront of technological developments and innovation, whether for energy storage systems and catalytic processes, which are so important for the global green agenda, or enabling greater efficiencies in the operation of gas turbines and chemical processes. So subtle and essential is cobalt that it also forms the basis of many established and new biotech applications crucial for human health and diagnostics. In fact cobalt is so important for industrial development that the EU has recognised that it is a ‘critical’ metal for the EU in its **Raw Materials Initiative**, which was undertaken to help support EU industry from the effects of possible disruption to the supply of critical mineral availability.

Demand estimates in the individual market segments are shown in Table 6:

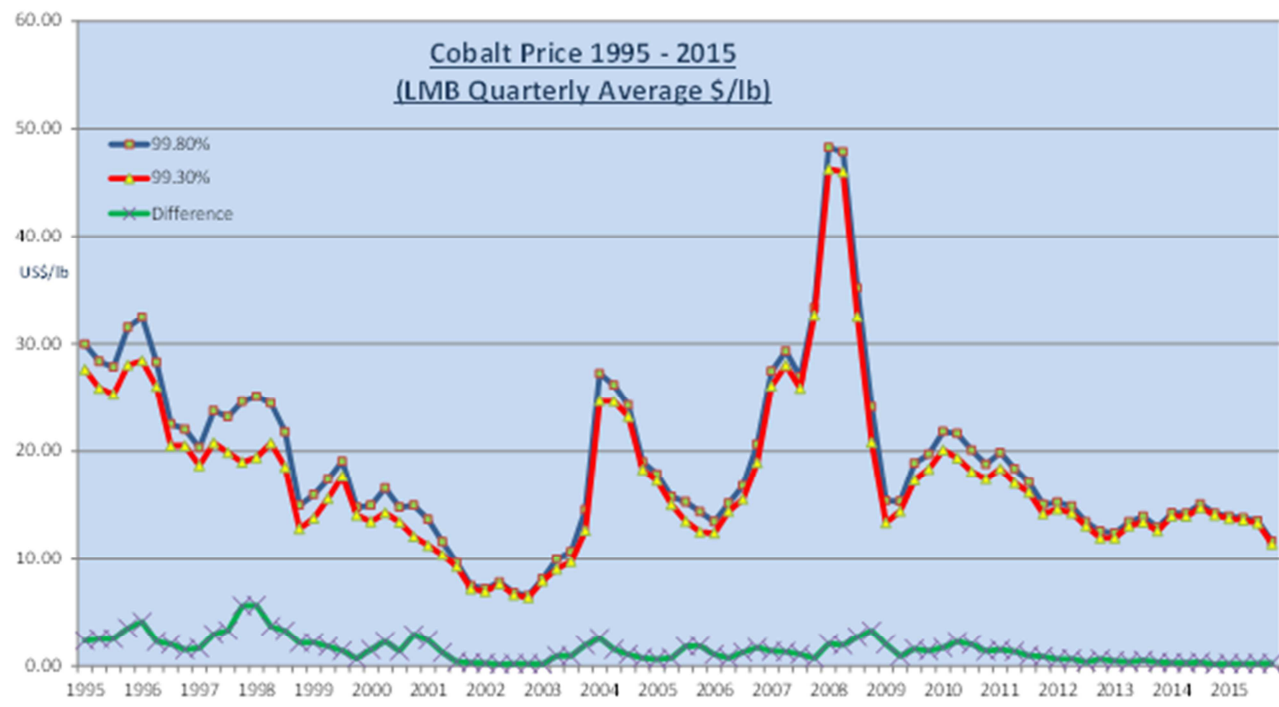
Market	%	Cobalt Materials Possibility
Superalloy (Ni/Co/Fe/Cr...)	16	Metal, recycle
Hardfacing/HSS & Other Alloys	7	Metal & mesh powders, recycle
Magnets All Types	5	Metal, powders, recycle
Hard Materials – Carbides, Diamond Tooling	10	Powders – Fine and very fine
Catalysts	7	Salts – carbonate, sulphate, nitrate, acetate, metal
Colours – Glass, Enamels, Plastics, Ceramics, Artists Colours, Fabrics	5	Oxide, + some sulphate, hydroxide, carbonate
Feedstuffs, Biotech, Anodising, Recording Media, Electrolysis....	4	Mainly sulphate, but some carbonate and hydroxide
Batteries	42	Hydroxide, powder, LiCoO ₂
Tyre Adhesives, Soaps, Driers (paint/ink)	<u>4</u>	Soaps & complexes made from metal starting point
	100	

Price

Over the years there have been numerous attempts to determine a cobalt price discovery mechanism and whilst the generally used London Metal Bulletin free-market quotation is commonly used, in 1999, WMC (now BHP Billiton) began selling cobalt on its website (the Cobalt Open Sales System - COSS) and in September 2000 it was joined by OMG who began selling its briquettes in this manner. In addition to these producers, a number of trading companies began to offer a buying and selling service through the Internet. However, at the end of 2008 BHP suspended the COSS.

The London Metal Exchange (LME) started the trading of cobalt (minimum Co content 99.3%) in February 2010 and turnover has been encouraging for this new contract. Up until now the main price reference has been the London Metal Bulletin free-market quotation. The LME offers a regulated market with which to establish a price, trade spot and future cobalt contracts and enables the possibility to manage price risk.

The following graph illustrates the change seen in the average quarterly London Metal Bulletin (LMB) free-market price quotation for cobalt since 1995 for 99.8% (HG) and 99.3% (LG) minimum cobalt. Based on quarterly averages, this graph does not show short-term price fluctuations.



As can be observed from the graph there was a dramatic fall in cobalt prices at the end of 2008, along with all other commodities and global company stock values, heralding the worst global recession in 60-years. From the 2009 price lows we saw a modest recovery through to early 2012 and thereafter the price has drifted with a tendency to fall.

The cobalt price (*average Metal Bulletin bid/offer*) opened 2015 at US\$14.30/lb (HG) and US\$14.15/lb (LG) and ended the year at US\$10.30/lb (HG) and also US\$10.30/lb (LG). The 2015 average LMB price for cobalt HG was US\$13.26/lb and US\$13.05/lb for LG cobalt. By comparison the LME average cash price for the calendar year was US\$12.91/lb – this is an in-warehouse price.