

Cobalt value chain

Final Summary Report

Cobalt Institute

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throughout the project by the CoRC-CI Secretariat and
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Document evolution

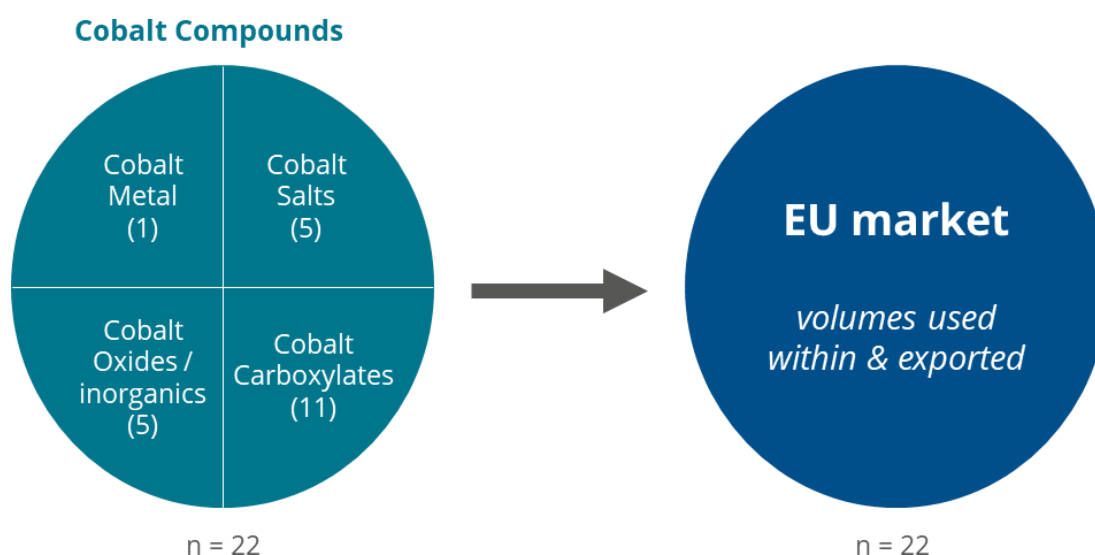
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Executive summary

The Cobalt Institute (CI) engaged eftec to provide support to their 2018 value chain and SEA model project, by preparing a collation of the underlying data that has previously been collected for the CI-CoRC in previous survey projects within one summary report. Data on the volumes manufactured/imported and used (both within the EU and exported) was gathered from four separate reports covering 22 cobalt compounds (which encompasses all the main cobalt compounds).



This summary report has been shared with CI-CoRC members to enable them to validate the findings or propose revisions where appropriate. This summary report will also be used by the CI-CoRC Secretariat as part of ongoing advocacy with EU regulators (member states competent authorities (MS CA), the European Chemicals Agency (ECHA), the European Commission (EC)).

The Cobalt Institute (CI) has commissioned Roskills in 2018 to develop a European Economic Area (EEA) Cobalt value chain and SEA model and accompanying report. Value chains illustrate the economic benefits from the numerous uses of a substance in quantitative terms such as the gross value added (GVA) and jobs created due to cobalt (i.e. cobalt metal and all cobalt compounds). At each stage in the supply chain, value is added by each actor, which reflects compensation for labour, capital, non-financial assets and natural resources used in production. The value chain is hence derived by summing the value added along the supply chain.

Figure 1 illustrates the overall EU cobalt value chain. It includes details of the number of EU manufacturers (M) and importers (I), how many M/I sites there are in the EU and the number of persons these M/I's employ. It also includes a best estimate of the total volume of cobalt (based on 22 cobalt compounds) used in the EU, the total volume of cobalt exported outside of the EU, and what sectors (broad uses) are using these cobalt compounds. The Roskills study will use this report to assist with the valuation of the EU cobalt value chain including estimates on the number of people employed downstream use (i.e. users of the cobalt compounds).

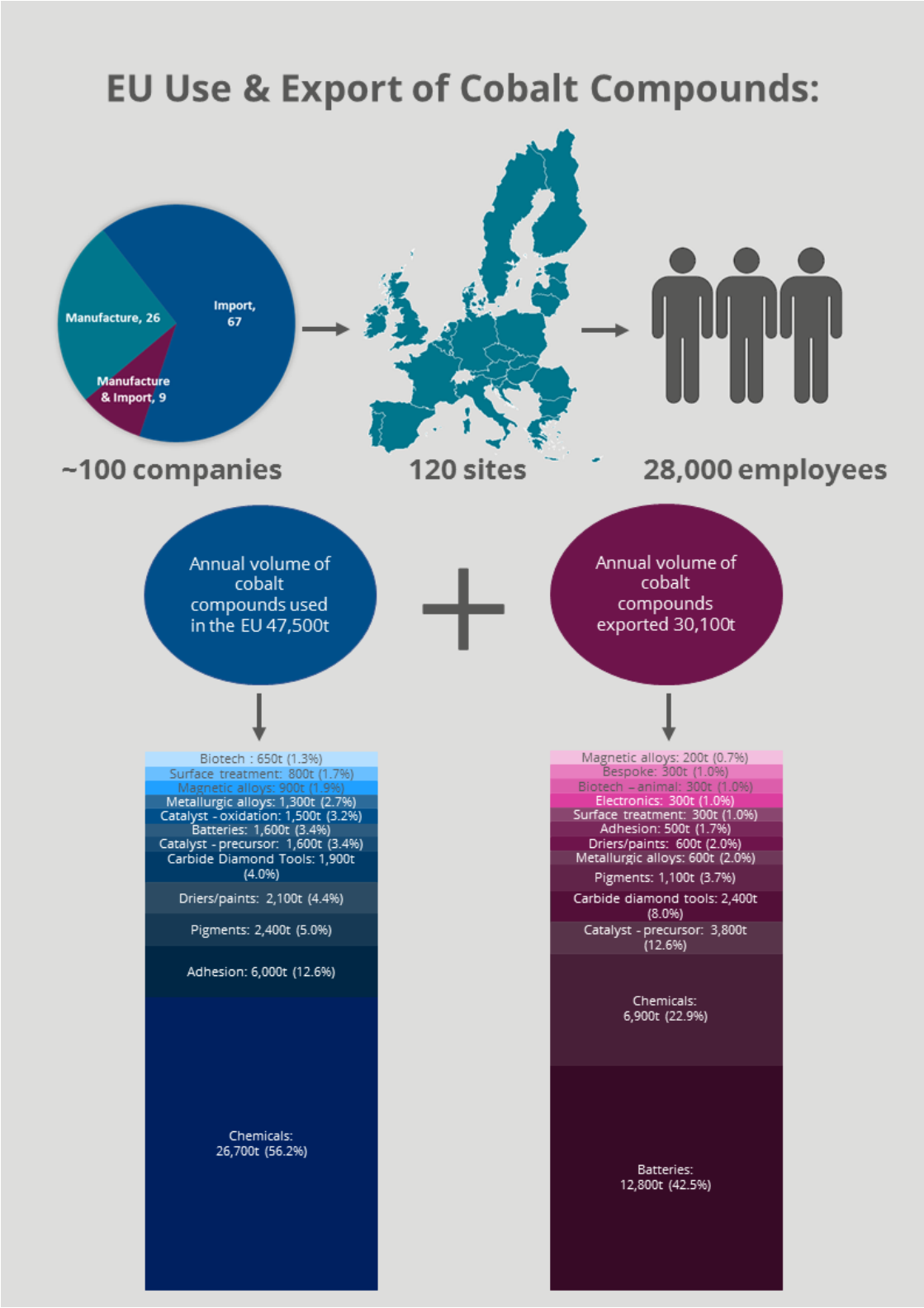


Figure 1: EU Cobalt value chain summary

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Abbreviations

CfE	Call for Evidence
CI	Cobalt Institute
CoRC	Cobalt REACH Consortia
CSR	Chemical Safety report
DU	Downstream User
EC	European Commission
ECHA	European Chemicals Agency
EEA	European Economic Area
GVA	Gross Value Added
I	Import
IPA	Isophthalic acid
LoA	Letter of Access
M	Manufacture
MSCA	Member States and Competent Authorities
PTA	purified terephthalic acid
REACH	Registration Evaluation Authorisation and Restriction of Chemicals
SEA	Socio Economic Analysis
tpa	tonne per year

Box 1: Note to readers of this report and users of the cobalt value chain data

- This report provides volume data of cobalt substances in tonnes per year. Appendix 1 provides the conversion factors required to convert the substance tonnage data reported into the amount of cobalt contained within each type of compound (e.g. cobalt units).
- It is recognised that there may be different interpretations of the use of the term 'intermediates' globally. In this study, the term 'intermediates' refers to the use of the cobalt substance(s) following the definition under REACH: 'a substance that is manufactured for and consumed in or used for chemical processing in order to be transformed into another substance' (EC, 2006). This is different to the industry interpretation of the term 'intermediates' as raw materials from mining production that will undergo further chemical refinement (e.g. unrefined cobalt or cobalt-containing substances).
- The heading 'chemicals sector' covers many intermediate uses (e.g. the transformation of one cobalt compound to another), and this broad use name has also been used in this report to preserve confidentiality of the underlying data.
- The 'Total number of people directly employed in the EU' refers to the number of workers employed by the manufacturers/importers of the cobalt substance(s). This is different to the number of workers exposed to the cobalt substance(s) and/or the number of workers involved in processes that are reliant on the cobalt substance(s), as companies may manufacture/import other substances.

1. Introduction

The Cobalt Institute (CI) has engaged eftec to provide support to their 2018 value chain and SEA model project, by preparing a collation of the underlying data that has previously been collected for the CI-CoRC in previous survey projects within one summary report. This summary report can then be shared with CI-CoRC members to enable them to validate the findings or propose revisions where appropriate. This summary report will also be used by the CI-CoRC Secretariat as part of ongoing advocacy with EU regulators (member states competent authorities (MS CA), the European Chemicals Agency (ECHA), the European Commission (EC)).

The Cobalt Institute (CI) has commissioned Roskills in 2018 to develop a European Economic Area (EEA) Cobalt value chain and SEA model and accompanying report. Value chains illustrate the economic benefits from the numerous uses of a substance in quantitative terms such as the gross value added (GVA) and jobs created due to cobalt (i.e. cobalt metal and all cobalt compounds). At each stage in the supply chain, value is added by each actor, which reflects compensation for labour, capital, non-financial assets and natural resources used in production. The value chain is hence derived by summing the value added along the supply chain.

During the kick-off meeting with Roskills and the CI Secretariat on the 16th March 2018, the Roskills' value chain and SEA model and available data was discussed. As arranged, eftec will provide the CI Secretariat with an Excel spreadsheet (for subsequent use by Roskills) and this summary report. This overall compilation of flow data for cobalt compounds will include both respondent data and assumptions used to derive EU level extrapolated numbers. The CI-CoRC Secretariat will be consulted to avoid double counting of overall cobalt units in the value chain.

Three REACH Consortia have been established by the Board of the CI to implement REACH (Registration Evaluation Authorisation and Restriction of Chemicals) on behalf of the cobalt industry, with the purpose of preparing the registration dossiers for cobalt metal and cobalt compounds. The three cobalt REACH Consortia cover **cobalt metal** (Blue Consortium), **cobalt carboxylates** (Green Consortium) and **inorganic cobalt** compounds (Red Consortium). The **grey** shaded substances noted in **Table 1.1** have not been analysed due to incomplete data-sets; however most of the cobalt compounds have been analysed by eftec (both in terms of number of substances but also from total tonnes used perspective).

Table 1.1: Cobalt substances

Blue Consortium	Green Consortium	Red Consortium
Cobalt Metal	Cobalt (II) 4-oxopent-2-en-2-olate	Cobalt carbonate
	Cobalt oxalate	Cobalt dichloride
	Cobalt, borate 2-ethylhexanoate complexes	Cobalt dinitrate
	Cobalt, borate propionate complexes	Cobalt sulphate
	Resin acids and Resin acids, cobalt salts	Cobalt sulphide
	Fatty acids, tall-oil, cobalt salts *	Cobalt oxide
	Naphthenic acids, cobalt salts	Tricobalt tetraoxide
	Cobalt di(acetate)	
	Cobalt bis(2-ethylhexanoate)	Dicobalt trioxide
	Cobalt ⁽²⁺⁾ isononanoate *	Cobalt trihydroxide
	Neodecanoic acid, cobalt salt	Cobalt dihydroxide
	Stearic acid, cobalt salt	Cobalt hydroxide oxide
	Oleic acid, cobalt salt *	Reaction mass of cobalt, copper and iron
	Cobalt ⁽²⁺⁾ propionate	Cobalt lithium dioxide
	Cobalt, borate neodecanoate complexes	Reaction mass of cobalt sulphide, nickel sulphide and trinickel disulphide

Note: * these cobalt substances have been transferred to the inactive list of the consortium agreement (as of June 2018).

2. Method

By collecting data from four previous survey reports (which based on six relevant questionnaires) relating to different cobalt compounds, this summary report provides information to assist with calculating the overall cobalt value chain, for the following cobalt compounds:

- Cobalt metal (survey carried out in 2014)
- Five cobalt salts (survey carried out originally in 2014 and further survey carried out in 2017)
- Tricobalt tetraoxide (survey carried out in 2015)
- Cobalt oxides and other inorganic cobalt compounds (surveys carried out in 2015 and 2016)
- Cobalt carboxylates (survey carried out in 2016)

Table 2.1 provides a summary of the surveys and links to the relevant sections of the report. As outlined below, whilst the surveys were carried out between 2014 and 2015, the underlying data will be for previous years. For the five cobalt salts, a more recent survey showed that the total volumes produced and used in the EU in 2014-16 had remained broadly steady (albeit a small increase). Therefore, whilst these datasets are not considered recent, they represent the best datasets available.

Table 2.1: Overview of surveys and relevant sections of report

Cobalt compounds	Cobalt metal	Five cobalt salts	Cobalt oxides and other inorganic cobalt compounds **	Cobalt carboxylates
REACH Consortia	Blue	Red	Red	Green
Time period	2011-13	2011-13*	2011-13	2012-2014
Relevant section in report	See Section 3 – Cobalt metal	See Section 4 – Five cobalt salts	See Section 5 – Cobalt oxides/inorganics	See Section 6 – Cobalt carboxylates

Table notes: * Average company data verified with survey in 2017 and remains comparable. ** Note, this includes tricobalt tetraoxide.

The following sections provide more details on the volume of cobalt substances and the number of people directly employed in the EU by manufacturers/importers of the cobalt substance(s). For more information on how best to interpret the data reported in this section, please refer to [Box 1](#).

To estimate the total volumes and uses of cobalt and its compounds within the EU, the respondent data has been aggregated. The total volumes of M/I were known using REACH registration dossiers, market reports, and previous CoRC/CI submissions/publications. Therefore, by using the total market data and aggregated respondent data it was possible to estimate the volumes and uses of those companies who did not respond to the survey (i.e. 'non-respondents').

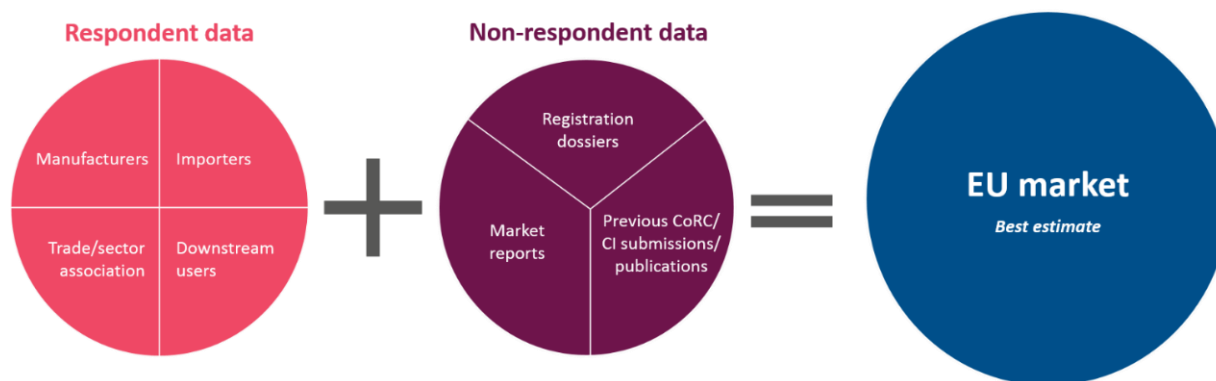


Figure 2.1: Method for estimating the total cobalt EU market

It is recognised that there is some residual uncertainty in estimating the size of the non-respondent market, but this was deemed essential to do so in some cases. For example, the response rate for the Green Consortium substances was extremely high meaning that no-extrapolation was necessary. For the Blue and Red Consortia substances some extrapolating of the respondent data was necessary.

The previous questionnaires collected data for a range of uses specific to each substance. For this report the data has been collated and sorted into the following broad uses (alphabetical order):

- Adhesion (including rubber adhesion agent)
- Batteries
- Bespoke/niche applications
- Biotech – animal feed and fertiliser
- Biotech – biogas production
- Biotech – fermentation, biotech processes, health and medicine
- Carbide diamond tools
- Catalysts – used as catalyst precursor
- Catalysts – used as oxidation catalyst/for PTA and IPA
- Chemicals
- Driers/paints
- Electronics
- Magnetic alloys
- Metallurgical alloys
- Pigments (including decolourising (glass))
- Surface treatment
- *Other*

Roskills only require broad use data for their value chain and SEA model. Although for each substance the previous survey studies do provide further details on the specific uses of the cobalt substance. For example, the broad use ‘batteries’, is the collection of data from:

- Cobalt metal survey (NiCd cathode, NiMH cathode + anode and Li-ion cathode)
- Cobalt salts survey (use as precursor in battery manufacturing – reported under the chemicals sector)
- Cobalt tricobalt survey (use as active material in batteries and use as precursor in battery manufacture)
- Cobalt oxides survey (use as active material in batteries and use as precursor in battery manufacture)

Therefore, to characterise the EU battery value chain it is necessary to collate the use-volume data for cobalt and several cobalt compounds, and also to avoid any double-counting of cobalt units in this value chain.

3. Cobalt Metal

This section reports information on cobalt metal (Blue consortia compound). For more information on how best to interpret the data reported in this section, please refer to [Box 1](#).

3.1 Manufacture and Import

Based on REACH registration data at the time (2015), there were 32 M/I's supplying to the EU market. This total reflects known company mergers since 2015. However, it does not include more recent registrants who will have registered as a M/I no later than June 2018 (i.e. those producing/supplying cobalt at >1tonne per year (tpa) but less than 100 tpa).

The latest registration data was provided by the CI-CoRC Secretariat to enable the analysis to be updated to the period 2015-2017. There is now a total of 23-member companies who are part of the REACH consortium and 48 companies who have a Letter of Access (LoA), all of whom have registered cobalt metal for REACH. As set out in **Table 3.1**, these 71 companies have been further breakdown (in terms of M, I or M and I).

Table 3.1: M/I of cobalt metal (total EU market)

Number of M/I's supplying to the EU market				Data on M/I's	
Manufacturers (M)	Importers (I)	Both M and I	Total	Total number of sites in the EU	Total number of people directly employed in the EU
6	58	7	71	84	20,100

Table notes:

- The total number of M/I's is based on the latest REACH registration data as of 2018 (this has been adjusted to account for known mergers since 2015). All 48 LoA companies have been assumed to be importers of cobalt metal - many of whom are downstream users who directly import cobalt metal for internal use.
- Figures have been rounded (employment to nearest 100 tonnes) – This has been extrapolated using respondent volume data relative to total volume M/I for the whole of the EU.
- The total number of people employed includes all workers within the company (e.g. sales, HR and finance) and not only the number of workers involved with the manufacture/import of cobalt metal.
- Data relates to the EU-28 + Norway.

Table 3.2 provides a breakdown of the total EU market for the M/I of cobalt metal. During the period 2011 – 2013 the total volume of cobalt metal manufactured in the EU (EU-28+Norway) is estimated at approx. 13,500 tonnes per year on average and imports approx. 14,600 tonnes per year on average during the same time period. Around 15,700 tpa are used in the EU and around 12,400 tonnes per year are exported.

Table 3.2: Break-down of M/I volume sold (total EU market)

Volumes (Annual average tonnes, 2011-2013)		Volumes used (Annual average tonnes, 2011-2013)			
Manufactured	Imported	Internally used in EU	Sold in the EU	Internally used outside EU	Sold outside the EU
13,500	14,600	6,500	9,200	200	12,200
TOTAL: 28,100		EU TOTAL: 15,700		EXPORT TOTAL: 12,400	

Table notes:

- The total volumes (and breakdown) estimated is based on using respondent data and REACH registration data. Although internal use of cobalt metal within the EU does not need to be included within the registration data, based on communications with CoRC at the time, it is thought that the volume has been factored into the registration data.
- The tonnage estimate is also considered to be a good match for the period 2015-17
- Figures have been rounded (volumes to nearest 100 tonnes).
- Data relates to the EU-28 + Norway.

Based on the latest registration data, the total annual average volume M/I for the period 2015-17 is also estimated in the region of 29,000t per year. Therefore, the breakdown presented in **Table 3.2** is considered to be representative also for the period 2015-17 and no further extrapolation was deemed necessary.

3.2 Use within the EU

Table 3.3 provides an estimated breakdown of the total volume used within the EU by each broad use category. For cobalt metal, the main uses within the EU were for the chemicals sector (e.g. manufacture of other cobalt compounds), manufacture of carbide diamond tools, use in batteries, use in metallurgical alloys and used catalysts.

Table 3.3: Broad uses of cobalt metal within the EU (total EU market)

Broad use	Annual volume used (tonnes, 2011-2013)		
	Internal use	Sold	Total
Adhesion (inc. rubber adhesion agent)	-	-	-
Batteries	<<100	1,500	1,500
Biotech – animal feed and fertiliser	-	200	200
Biotech – fermentation, biotech processes, health and medicine	-	-	-
Carbide Diamond Tools	200	1,700	1,900
Catalysts – used as catalyst precursor	-	1,100	1,100
Catalysts - used as oxidation catalyst/for PTA and IPA	-	200	200
Chemicals	5,900	1,900	7,800
Driers/paints	-	500	500
Electronics	-	-	-
Magnetic alloys	-	900	900
Metallurgical alloys	300	1,000	1,300
Pigments (inc. decolourising (glass))	-	approx. 200	approx. 200
Surface treatment	-	approx. 200	approx. 200
Total	6,500	9,200	15,700

Table notes:

- Figures have been rounded (volumes to nearest 100 tonnes) - The total volume sold (9,200) is slightly different to sum of the individual broad use volume sold due to rounding.
- Within this table, the symbol "<" refers to less than 50 and "<<" refers to significantly less than 50 (i.e. <10).
- Data relates to the EU-28 + Norway.

The breakdown shown in **Table 3.3** is largely based on the same approach used previously (eftec and wca, 2016), which was based on several data sources and agreed upon with the CI secretariat. However, due to the revised list of broad uses and update to the data, some minor revisions were necessary, which are set out in **Table 3.4**.

Table 3.4: Breakdown (%) of cobalt metal by broad use category

Broad use	%	Logic
Adhesion (inc. rubber adhesion agent)	-	Same as previous study
Batteries	10%	
Biotech - animal feed	1%	Reflecting small volume used in respondent data
Biotech - fermentation, biotech processes, health and medicine	-	Same as previous study
Carbide Diamond Tools	12%	
Catalysts - used as catalyst precursor	7%	Same as previous study (just broken down more)
Catalysts - used as oxidation catalyst/for PTA and IPA	1%	
Chemicals	50%	Approximately same as previous study (just broken down more)
Driers / paints	3%	
Electronics	-	Same as previous study
Magnetic alloys	6%	
Metallurgical alloys	8%	
Pigments (inc. Decolourising (glass))	1%	Reflecting small volume used in respondent data
Surface treatment	1%	
Total	100%	-

3.3 Uses of volumes exported

Table 3.5 provides a breakdown of respondent data for volumes exported outside of the EU by each broad use category. It has been extrapolated based on the respondent breakdown and the totals shown in **Table 3.2**.

Table 3.5: Broad uses of cobalt metal exported outside of the EU (total export market)

Broad use	Annual volume exported (tonnes, 2011-2013)		
	Internal use	Sold	Total
Adhesion (inc. rubber adhesion agent)	-	-	-
Batteries	<100	6,200	6,300
Biotech - animal feed	-	<50	<50
Biotech - fermentation, biotech processes, health and medicine	-	-	-
Carbide Diamond Tools	<<100	2,400	2,400
Catalysts - used as catalyst precursor	-	200	200
Catalysts - used as oxidation catalyst/for PTA and IPA	-	<<50	<<50
Chemicals	-	2,300	2,300
Driers / paints	-	400	400
Electronics	-	-	-
Magnetic alloys	-	200	200
Metallurgical alloys	100	500	600
Pigments (inc. Decolourising (glass))	-	<50	<50
Surface treatment	-	<50	<50
Total	200	12,200	12,400

Table notes:

- Figures have been rounded (volumes to nearest 100 tonnes).
- Within this table, the symbol "<" refers to less than 50 and "<<" refers to significantly less than 50 (i.e. <10).
- Data relates to the EU-28 + Norway.

3.4 Substance summary

Figure 3.1 provides a visual summary of the EU cobalt metal value chain. It is estimated that 28,100 tonnes per year of cobalt metal is manufactured/imported into the EU. Over half (approx. 56%) of this volume is used within the EU and the remainder (approx. 44%) exported outside of the EU. For cobalt metal, the main uses within the EU were for the chemicals sector (e.g. manufacture of other cobalt compounds), manufacture of carbide diamond tools, use in batteries, use in metallurgical alloys and used catalysts.

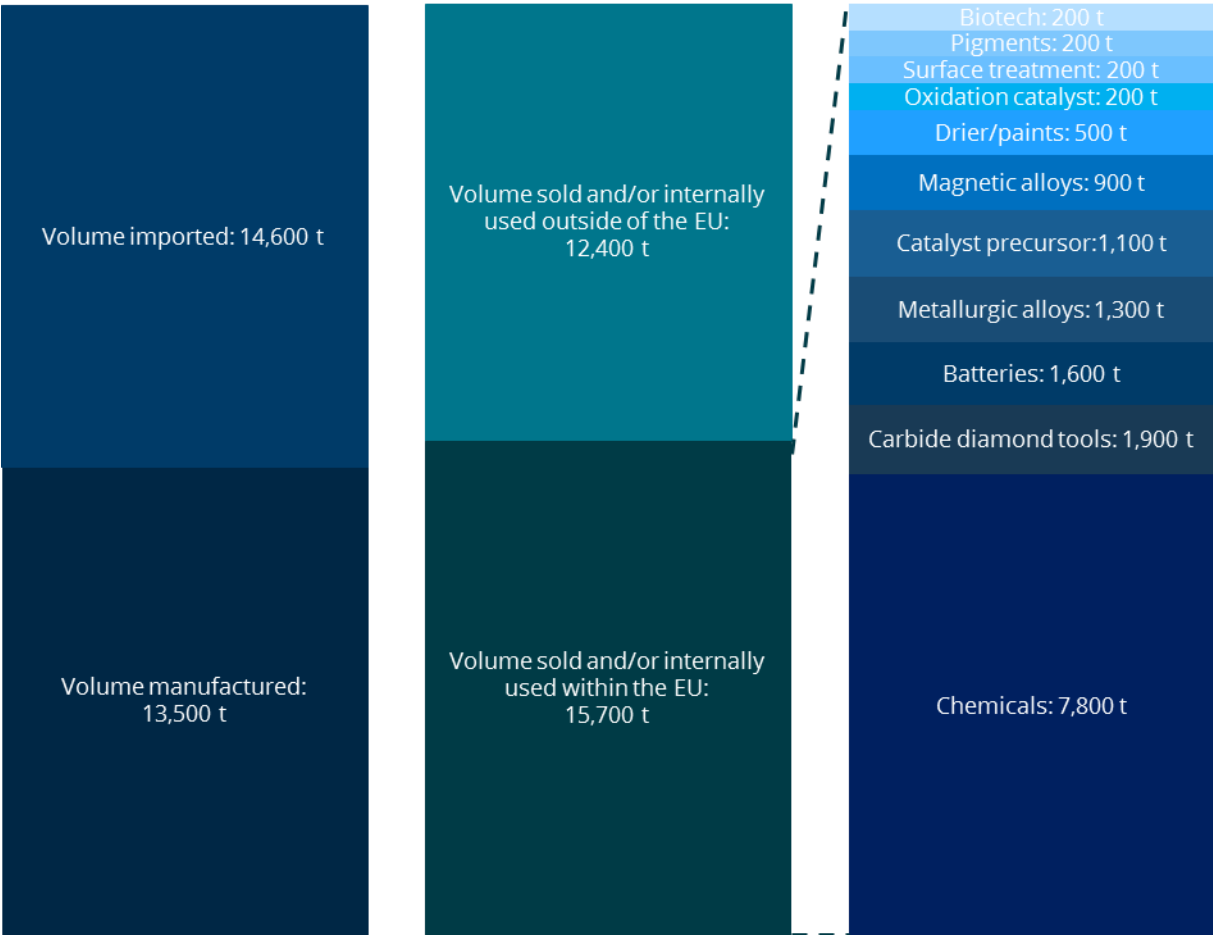


Figure 3.1: EU cobalt metal value chain (tonnes per year)

4. Five cobalt salts

This section brings together information on five cobalt salts:

- Cobalt carbonate
- Cobalt dichloride
- Cobalt dinitrate
- Cobalt sulphate
- Cobalt di(acetate)

For more information on how best to interpret the data reported in this section, please refer to [Box 1](#).

4.1 Manufacture and Import

In the supplementary note on the number of workers and M/Is in the EU-28 prepared in January 2018 (eftec, 2018a), based on REACH registration data at the time (2017), there were 30 M/Is supplying to the EU market. This total reflects known company mergers since 2015. However, it did not fully include more recent registrants who will have registered as a M/I before the final REACH deadline of end-May 2018 (i.e. those producing/supplying cobalt at >1tonne per year (tpa) but less than 100 tpa). Based on the latest registration data provided by the CI-CoRC Secretariat to enable the analysis to be updated to the period 2015-2017 there is estimated to be 33 M/I's (with 3 additional companies who have a Letter of Access (LoA), all of whom have registered at least one of the cobalt salts for REACH). As set out in [Table 4.1](#), these 33 companies have further breakdown as shown (in terms of M, I or M and I).

Table 4.1: M/I of cobalt salts (total EU market)

Number of M/Is supplying to the EU market				Data on M/Is	
Manufacturers (M)	Importers (I)	Both M and I	Total	Total number of sites in the EU	Total number of people directly employed in the EU
22	8	3	33	At least 33	5,300

Table notes:

- The total number of M/I's is based on the latest REACH registration data as of 2018 (this has been adjusted to account for known mergers since 2015). The total number of LoA companies were reported by salt so it is possible that the number of LoAs is higher than 3 but the analysis takes the highest number of LoAs for an individual salt. All 3 LoA companies have been assumed to be importers of one of the five cobalt salts.
- Figures have been rounded (employment to nearest 100 tonnes) – This has been extrapolated using respondent volume data relative to total volume M/I for the whole of the EU. The total number of employees matches that presented in the supplementary note on the number of workers and M/Is in the EU-28 prepared in January 2018 (eftec, 2018a)
- The total number of people employed includes all workers within the company (e.g. sales, HR and finance) and not only the number of workers involved with the manufacture/import of the five cobalt salts.
- Data relates to the EU-28 + Norway.

[Table 4.2](#) provides a breakdown of the total EU market for the M/I of the five cobalt salts. During the period 2011 – 2013 the total volume of the five cobalt salts manufactured in the EU (EU-28+Norway) is estimated at approx. 36,800 tonnes per year on average and imports approx. 600 tonnes per year on average during the same time period. Around 30,000 tpa are used in the EU and around 7,400 tonnes per year are exported.

Table 4.2: Break-down of M/I of the five cobalt salts volume (total EU market)

Volumes (Annual average tonnes, 2011-2013)		Volumes used (Annual average tonnes, 2011-2013)			
Manufactured	Imported	Internally used in EU	Sold in the EU	Internally used outside EU	Sold outside the EU
36,800	600	16,600	13,400	700	6,700
TOTAL: 37,400		EU TOTAL: 30,000		EXPORT TOTAL: 7,400	

Table notes:

- The total volumes (and breakdown) estimated is based on using respondent data and REACH registration data.
- The tonnage estimate is also considered to be a good match for the period 2015-17 – based on the survey carried out in late 2017 for the ECHA Call for Evidence (Annex B of the CoRC/CI Joint Response).
- Figures have been rounded (volumes to nearest 100 tonnes).
- Data relates to the EU-28 + Norway.

Based on a survey with M/Is (and DUs) carried out in late 2017 for the ECHA Call for Evidence (Annex B of the CoRC/CI Joint Response), the total annual average volume M/I for the period 2015-17 is also estimated in the region of 37,400 tonnes per year and volumes used in the EU at 30,000 tpa. Therefore, the breakdown presented in **Table 4.2** is considered to be representative also for the period 2015-17 and no further extrapolation was deemed necessary.

4.2 Use within the EU

Table 4.3 provides an estimated breakdown of the total volume used within the EU by each broad use category. For the five cobalt salts, the main uses within the EU were for the chemicals sector (e.g. manufacture of other cobalt compounds) and used as catalysts.

Table 4.3: Broad uses of the five cobalt salts within the EU (total EU market)

Broad use	Annual volume used (tonnes, 2011-2013)		
	Internal use	Sold	Total
Batteries*	-	-	-
Bespoke/Niche Applications	-	<50	<50
Biotech - animal feed and fertiliser	-	300	300
Biotech - biogas production	-	100	100
Biotech - fermentation, biotech processes, health and medicine	-	<<50	<<50
Catalysts - used as catalyst precursor	<50	1,200	1,200
Catalysts - used as oxidation catalyst/for PTA and IPA	<50	1,200	1,200
Chemicals*	16,600	10,100	26,700
Electronics	-	-	-
Pigments (inc. Decolourising (glass))	-	-	-
Surface treatment	-	500	500
Other	-	-	-
Total	16,600	13,400	30,000

Table notes:

- Figures have been rounded (volumes to nearest 100 tonnes)
- Within this table, the symbol "<" refers to less than 50 and "<<" refers to significantly less than 50 (i.e. <10).
- Data relates to the EU-28 + Norway.
- * Due to the data collection and confidentiality, volumes used for 'Batteries' and 'Adhesion (inc. rubber adhesion agent)' is underreported in this table, as these uses are included within the chemicals sector. For example, estimates reported in the market demand and trends of cobalt salts note (eftec, 2018b) and the JRC report (Alves et al., 2018) indicate a higher proportion of cobalt compounds are being used within the batteries sector.

The breakdown shown in **Table 4.3** is consistent with the breakdown presented in the CoRC/CI Joint Response (annex C) of the ECHA Call for Evidence (CfE) submission, which are set out in **Table 4.4**. The only difference is that pigment use is now considered to be obsolete and the tonnage has been reallocated to the chemicals sector.

Table 4.4: Breakdown (%) of five cobalt salts used by broad use category (as reported in the CfE)

Broad use	Total volume used in the EU28 (Annual average tonnes, 2011-13)
Bespoke uses	<<100
Biotech	400
Catalysts	2,400
Chemicals industry	26,600
Pigments	<<100
Surface treatment	500
Total	30,000

4.3 Uses of volumes exported

Table 4.5 provides a breakdown of respondent data for volumes exported outside of the EU by each broad use category. It has been extrapolated based on the respondent breakdown and the totals shown in **Table 4.2**.

Table 4.5: Broad uses of the five cobalt salts exported outside of the EU (total export market)

Broad use	Annual volume exported (tonnes, 2011-2013)		
	Internal use	Sold	Total
Batteries	-	400	400
Bespoke/Niche Applications	-	300	300
Biotech - animal feed and fertiliser	-	300	300
Biotech - biogas production	-	-	-
Biotech - fermentation, biotech processes, health and medicine	-	-	-
Catalysts - used as catalyst precursor	-	2,300	2,300
Catalysts - used as oxidation catalyst/for PTA and IPA	-	-	-
Chemicals	700	3,100	3,800
Electronics	-	-	-
Pigments (inc. Decolourising (glass))	-	<<50	<<50
Surface treatment	-	300	300
Other	-	-	-
Total	700	6,700	7,400

Table notes:

- Figures have been rounded (volumes to nearest 100 tonnes).
- Within this table, the symbol "<" refers to less than 50 and "<<" refers to significantly less than 50 (i.e. <10).
- Data relates to the EU-28 + Norway.

4.4 Substance summary

Figure 4.1 provides a visual summary of the EU value chain for the five cobalt salts. It is estimated that 37,400 tonnes per year of the five cobalt salts are manufactured/imported into the EU. The majority (approx. 80%) of this volume is used within the EU and the remainder (approx. 20%) exported outside of the EU. For the five cobalt salts, the main uses within the EU were for the chemicals sector (e.g. manufacture of other cobalt compounds) and as a catalyst - used as catalyst precursor.

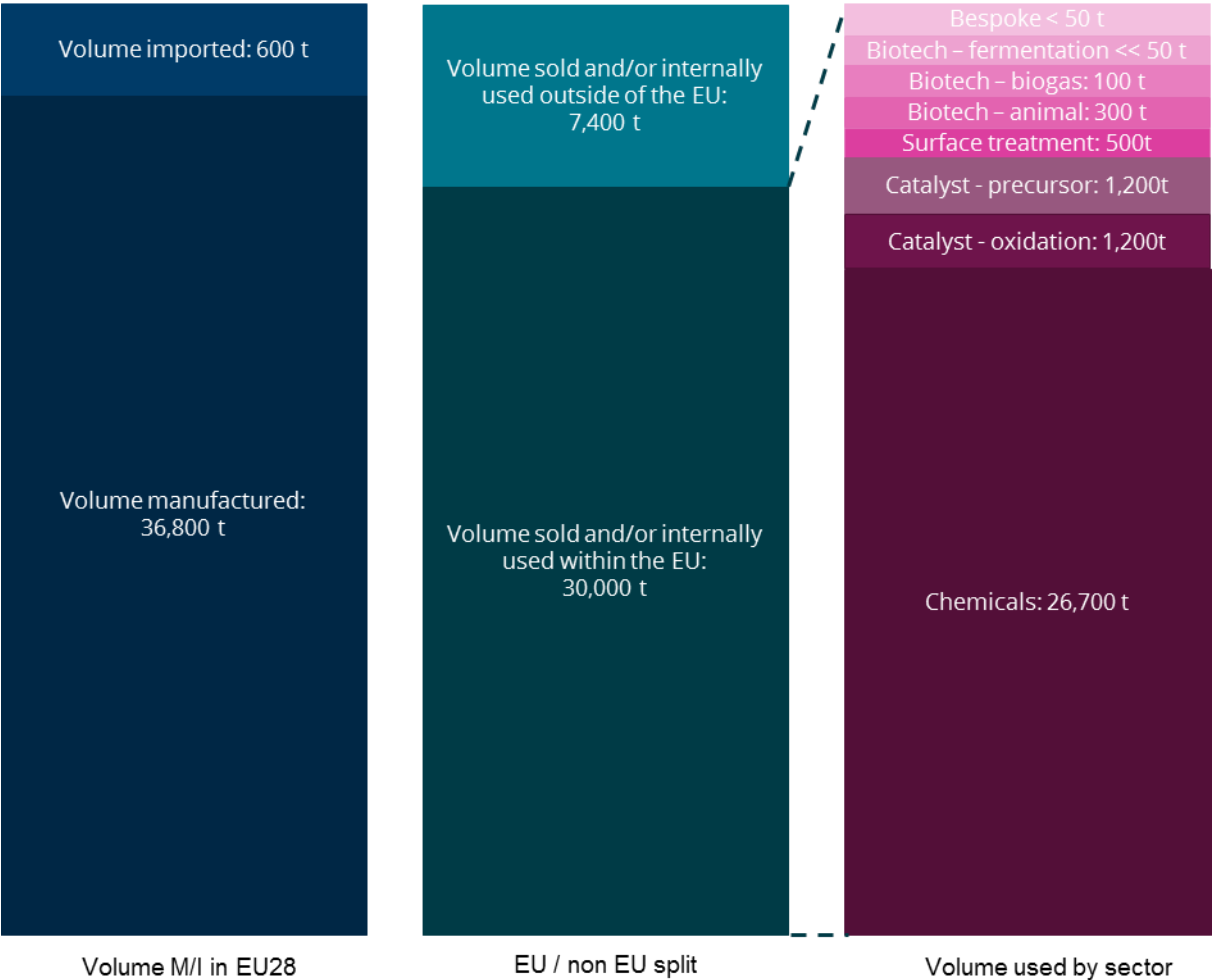


Figure 4.1: EU value chain for the five cobalt salts (tonnes per year)

5. Cobalt oxides/inorganics

This section brings together information on five Red consortia substances (referred to as five inorganic cobalt compounds in this section):

- Cobalt oxide
- Tricobalt tetraoxide
- Cobalt dihydroxide
- Cobalt hydroxide oxide
- Cobalt sulphide

For cobalt sulphide, when the oxides survey was carried out in 2016 there was only one respondent who provided data, so the oxides report did not include a chapter on cobalt sulphide. According to the latest registration data (for the period 2015-2017) there are less than three manufacturers/importers of cobalt sulphide. There are however 24 letter of access (LoA) companies who have recently registered approx. 4,400 (rounded to the nearest 100 tonnes). These LoA companies (all assumed to be importers) volume data is accounted for in this section where based on discussions with the CoRC-CI Secretariat, it is assumed all this volume is internally used within the EU and within the 'chemicals sector'. For more information on how best to interpret the data reported in this section, please refer to [Box 1](#).

5.1 Manufacture and Import

As all known companies responded to the surveys, there was no need to extrapolate data concerning Tricobalt tetraoxide and Cobalt dihydroxide. For Cobalt hydroxide oxide and Cobalt oxide due high response rate to the surveys very little extrapolation was required. According to the latest registration data (for the period 2015-2017) there are less than three manufacturers/importers of cobalt sulphide; there are however 24 letter of access (LoA) companies who have registered approx. 4,400 (rounded to the nearest 100 tonnes). These LoA companies are all assumed to be importers of cobalt sulphide. As set out in [Table 5.1](#) there are estimated to be around 53 companies M/I for the four cobalt oxides (a large proportion being those companies with a Letter of Access).

Table 5.1: M/I of the four cobalt oxides (total EU market)

Number of M/Is supplying to the EU market				Data on manufacturers	
Manufacturers (M)	Importers (I)	Both M and I	Total	Total number of sites in the EU	Total number of people directly employed in the EU
9	36	8	53	62	13,400

Table notes:

- The total number of M/I's is based on REACH registration data as of 2015 (this has been adjusted to account for known company mergers since 2015), therefore excludes new registrants after 2015.
- It has been conservatively assumed that each non-respondent (31 in total) only has 1 site in the EU
- The number of workers employed for each non-respondent has been estimated based on the lowest number of workers employed (substance level) by a respondent. The average number of worked employed was not used as it would have overestimated the number of workers employed due to data provided by a few large companies.
- Figures have been rounded (employment to nearest 100 tonnes)
- The total number of people employed includes all workers within the company (e.g. sales, HR and finance) and not only the number of workers involved with the manufacture of cobalt metal.
- Data relates to the EU-28.

Table 5.2 provides a breakdown of the total EU market for the M/I of the four cobalt oxides and cobalt sulphide. During the period 2011 – 2013 the total volume of these five inorganic cobalt compounds manufactured in the EU-28 is estimated at approx. 15,600 tonnes per year on average and imports approx. 9,700 tonnes per year on average during the same time period. Around 15,700 tpa are used in the EU and around 9,700 tonnes per year are exported.

Table 5.2: Break-down of the M/I volume of the five inorganic cobalt compounds (total EU market)

Volumes (Annual average tonnes, 2011-2013)		Volumes used (Annual average tonnes, 2011-2013)			
Manufactured	Imported	Internally used in EU	Sold in the EU	Internally used outside EU	Sold outside the EU
15,600	9,700	11,000	4,700	<50	9,700
TOTAL: approx. 25,300		EU TOTAL: approx. 15,700		EXPORT TOTAL: approx. 9,700	

Table notes:

- The total volumes (and breakdown) estimated is based on using respondent data and REACH registration data was used to estimate volumes used by non-respondents. It excludes new registrants after 2015. It is assumed that all LoA companies internally use cobalt sulphide within the EU.
- All figures have been rounded (volumes to nearest 100 tonnes) – As a result there is a slightly discrepancy between the breakdown of volumes used total (approx. 25,400) and the total volume M/I (approx. 25,300).
- Data relates to the EU-28.

5.2 Use within the EU

Table 5.3 provides an estimated breakdown of the total volume used within the EU by each broad use category. For the five inorganic cobalt compounds (which include cobalt sulphide), the main uses within the EU were for the chemicals sector (e.g. manufacture of other cobalt compounds), use in pigments and use in the catalyst sector.

Table 5.3: Broad uses of five inorganic cobalt compounds within the EU (total EU market)

Broad use	Annual volume used (tonnes, 2011-2013)		
	Internal use	Sold	Total
Adhesion (inc. rubber adhesion agent)	-	100	100
Batteries	100	<50	100
Bespoke/Niche Applications	-	<<50	<<50
Biotech - animal feed and fertiliser	-	<<50	<<50
Biotech - fermentation, biotech processes, health and medicine	-	-	-
Carbide Diamond Tools	-	-	-
Catalysts - used as catalyst precursor	400	1,200	1,600
Chemicals	10,400	1,100	11,500
Driers / paints	-	-	-
Electronics	-	<50	<50
Magnetic alloys	-	<50	<50
Metallurgical alloys	-	-	-
Pigments (inc. Decolourising (glass))	100	2,100	2,200
Surface treatment	-	100	100
Total	11,000	approx. 4,700	15,700

Table notes:

- Figures have been rounded (volumes to nearest 100 tonnes) - Within this table, the symbol "<50" refers to less than 50 and "<<50" refers to less than 10)
- Data relates to the EU-28.

5.3 Uses of volumes exported

Table 5.4 provides a breakdown of total volumes exported outside of the EU by each broad use category. It has been extrapolated based on the respondent breakdown and the totals shown in **Table 5.3**.

Table 5.4: Broad uses of four cobalt oxides exported outside of the EU (total export market)

Broad use	Annual volume exported (tonnes, 2011-2013)		
	Internal use	Sold	Total
Adhesion (inc. rubber adhesion agent)	-	100	100
Batteries	-	6,100	6,100
Bespoke/Niche Applications	-	-	-
Biotech - animal feed and fertiliser	-	-	-
Biotech - fermentation, biotech processes, health and medicine	-	-	-
Carbide Diamond Tools	-	-	-
Catalysts - used as catalyst precursor	<50	1,300	1,300
Chemicals	-	800	800
Driers / paints	-	-	-
Electronics	-	300	300
Magnetic alloys	-	<<50	<<50
Metallurgical alloys	-	-	-
Pigments (inc. Decolourising (glass)	-	1,100	1,100
Surface treatment	-	<<50	<<50
Total	<50	9,700	9,700

Table notes:

- Based on an estimated 29 manufacturers/importers within the EU (this accounts for known company mergers since 2015).
- Figures have been rounded (volumes to nearest 100 tonnes).
- Figures have been rounded (volumes to nearest 100 tonnes) - Within this table, the symbol "<50" refers to less than 50 and "<<50" refers to less than 10)
- Data relates to the EU-28.

5.4 Substance summary

Figure 5.1 provides a visual summary of the EU value chain for the four cobalt oxides. It is estimated that approx. 25,300 tonnes per year of the four cobalt oxides are manufactured/imported into the EU. Over half (approx. 62%) of this volume is used within the EU and the remainder (approx. 38%) exported outside of the EU. For the four cobalt oxides, the main uses within the EU were for the chemicals sector (e.g. manufacture of other cobalt compounds), use in pigments and use in the catalyst sector.

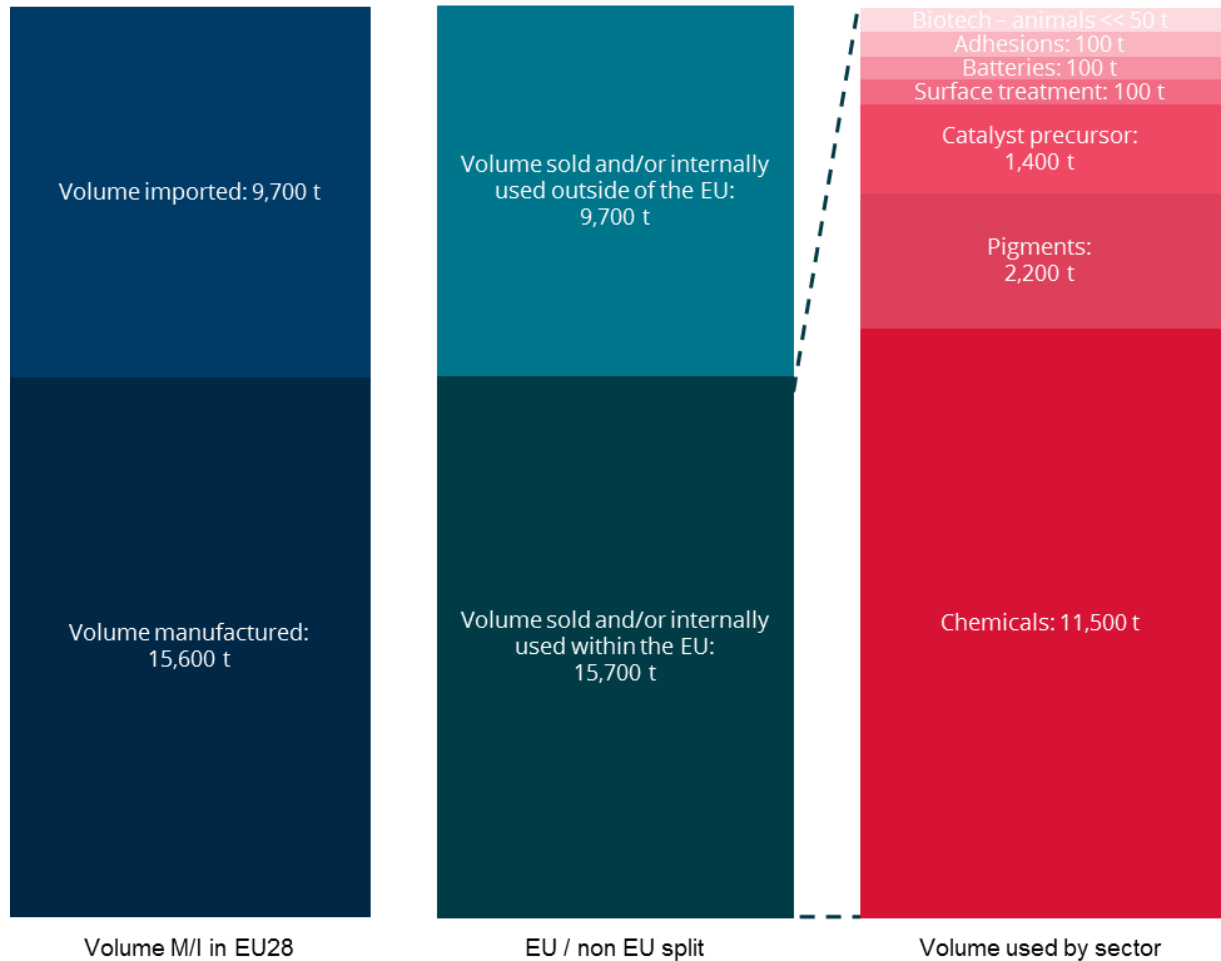


Figure 5.1: EU value chain for the four cobalt oxides (tonnes per year)

6. Cobalt carboxylates

This section brings together information on 11 Green consortia compounds (referred to as cobalt carboxylates in this section):

1. Cobalt (II) 4-oxopent-2-en-2-olate
2. Cobalt oxalate
3. Cobalt, borate neodecanoate complexes
4. Cobalt, borate 2-ethylhexanoate complexes
5. Cobalt, borate propionate complexes
6. Resin acids and Resin acids, cobalt salts
7. Naphthenic acids, cobalt salts
8. Cobalt bis(2-ethylhexanoate)
9. Neodecanoic acid, cobalt salt
10. Stearic acid, cobalt salt
11. Cobalt(2+) propionate
12. Cobalt(2+) isononanoate – Not registered
13. Fatty acids, tall-oil, cobalt salts – Not registered

Cobalt(2+) isononanoate and Fatty acids, tall-oil, cobalt salts have not been registered under REACH and therefore any historical volume and use information has been excluded from the analysis contained in this section. Collectively <50t/year of these two substances was reported in previous surveys (M/I) and therefore their data would not have made a significant difference to the tonnage analysis presented in this section. For more information on how best to interpret the data reported in this section, please refer to [Box 1](#).

6.1 Manufacture and Import

As there was a high response rate to the carboxylates survey back in 2016, the overall level of extrapolation required was limited. However, the previous survey could not factor any new registrants since 2016 who will have registered as a M/I no later than May 2018 (i.e. those producing/supplying cobalt at >1tonne per year (tpa) but less than 100 tpa) and the growth in demand for cobalt carboxylates. Based on the latest registration data that was provided by the CI-CoRC Secretariat, an additional 6 letter of access (LoA) companies were added to the total number of M/Is. These LoA companies are all assumed importers with one site in the EEA. As set out in [Table 6.1](#), these 15 companies have been further breakdown (in terms of M, I or M and I).

Table 6.1: M/I of cobalt carboxylates (total EEA market)

Number of M/Is supplying to the EEA market				Data on M/Is	
Manufacturers (M)	Importers (I)	Both M and I	Total	Total number of sites in the EEA	Total number of people directly employed in the EEA
4	9	2	15	15 - 36	7,900

Table notes:

- The total number of M/I's is based on the latest REACH registration data as of 2018 (this has been adjusted to account for known mergers since 2015). All 6 LoA companies have been assumed to all import cobalt carboxylates for internal use.
- Figures have been rounded (employment to nearest 100 tonnes)
- The total number of people employed includes all workers within the company (e.g. sales, HR and finance) and not only the number of workers involved with the manufacture/import of cobalt metal.
- Data relates to the European Economic Area (EEA)

Table 6.2 provides a breakdown of the total EEA market for the M/I of cobalt carboxylates. During the period 2012-2014, the previous carboxylates report indicated that the total market volume M/I in the EEA was estimated at around 8,200 tonnes per year. Based on the latest registration data (2015-17), the market has either grown with registered volumes increasing to approx. 10,000 (which doesn't necessary capture all internal use) or that the previous estimate for 2012-2014 was an underestimate. It has been assumed the difference is due to a mixture of new companies (e.g. the 6 LoAs who have a total reported annual tonnage of approx. 700), underestimating the volumes being used in 2012-14 and growth in the market. The total annual volume M/I for the period 2015-17 is now estimated to be 10,600 as shown in **Table 6.2**.

Table 6.2: Break-down of M/I cobalt carboxylates (total EU market)

Volumes (Annual average tonnes, 2015-2017)		Volumes used (Annual average tonnes, 2012-2014)			
Manufactured	Imported	Internally used in EU	Sold in the EU	Internally used outside EU	Sold outside the EU
7,100	3,500	4,900	5,100	-	approx. 600
TOTAL: 10,600		EU TOTAL: 10,000		EXPORT TOTAL: approx. 600	

Table notes:

- The total volumes (and breakdown) estimated is based on using respondent data and REACH registration data
- Figures have been rounded (volumes to nearest 100 tonnes).
- Data relates to the EEA

6.2 Use within the EU

Table 6.3 provides an estimated breakdown of the total volume used within the EU by each broad use category. For cobalt carboxylates, the main uses within the EEA were for adhesion, the chemicals sector, and use in driers/ paints.

Table 6.3: Broad uses of cobalt carboxylates within the EEA (total EU market)

Broad use	Annual volume used (tonnes, 2012-14)		
	Internal use	Sold	Total
Adhesion (inc. rubber adhesion agent)	2,200	3,700	5,900
Batteries	-	-	-
Biotech - animal feed and fertiliser	-	-	-
Biotech - biogas production	-	-	-
Catalysts - used as catalyst precursor	-	100	100
Catalysts - used as oxidation catalyst/for PTA and IPA	-	100	100
Chemicals	2,100	-	2,100
Driers / paints	500	1,100	1,600
Electronics	-	-	-
Magnetic alloys	-	-	-
Pigments (inc. Decolourising (glass))	-	-	-
Surface treatment	-	-	-
Other	-	100	100
Total	4,800	5,100	10,000

Table notes:

- Figures have been rounded (volumes to nearest 100 tonnes) - The total volume used in the EEA (10,000) is slightly different to sum of the individual broad use volumes sold and internally used due to rounding.
- Within this table, the symbol "<" refers to less than 50 and "<<" refers to significantly less than 50 (i.e. <10).
- Data relates to the EEA

The breakdown shown in **Table 6.3** is largely based on the same approach used previously (eftec and wca, 2016), which was based on several data sources and agreed upon with the CI-CoRC secretariat.

6.3 Uses of volumes exported

Table 6.4 provides a breakdown of respondent data for volumes exported outside of the EU by each broad use category.

Table 6.4: Broad uses of cobalt carboxylates exported outside of the EEA (total export market)

Broad use	Annual volume exported (tonnes, 2012-2014)		
	Internal use	Sold	Total
Adhesion (inc. rubber adhesion agent)	-	400	400
Batteries	-	-	-
Biotech - animal feed and fertiliser	-	-	-
Biotech - biogas production	-	-	-
Catalysts - used as catalyst precursor	-	<<50	<<50
Catalysts - used as oxidation catalyst/for PTA and IPA	-	100	100
Chemicals	-	-	-
Driers / paints	-	200	200
Electronics	-	-	-
Magnetic alloys	-	-	-
Pigments (inc. Decolourising (glass))	-	-	-
Surface treatment	-	-	-
Other	-	<<50	<<50
Total	-	700	700

Table notes:

- Figures have been rounded (volumes to nearest 100 tonnes). The total estimated volume of 700 tonnes is slightly higher than the estimates shown in **Table 6.2** due to rounding and how the totals are derived
- Within this table, the symbol "<" refers to less than 50 and "<<" refers to significantly less than 50 (i.e. <10).
- Data relates to the EEA.

6.4 Substance summary

Figure 6.1 provides a visual summary of the EU cobalt carboxylates value chain. It is estimated that 10,600 tonnes per year of cobalt carboxylates is manufactured/imported into the EEA. The vast majority (approx. 94%) of this volume is used within the EEA and the remainder (approx. 6%) exported outside of the EEA. For cobalt carboxylates, the main uses within the EEA were for adhesion, the chemicals sector, and use in driers/ paints.

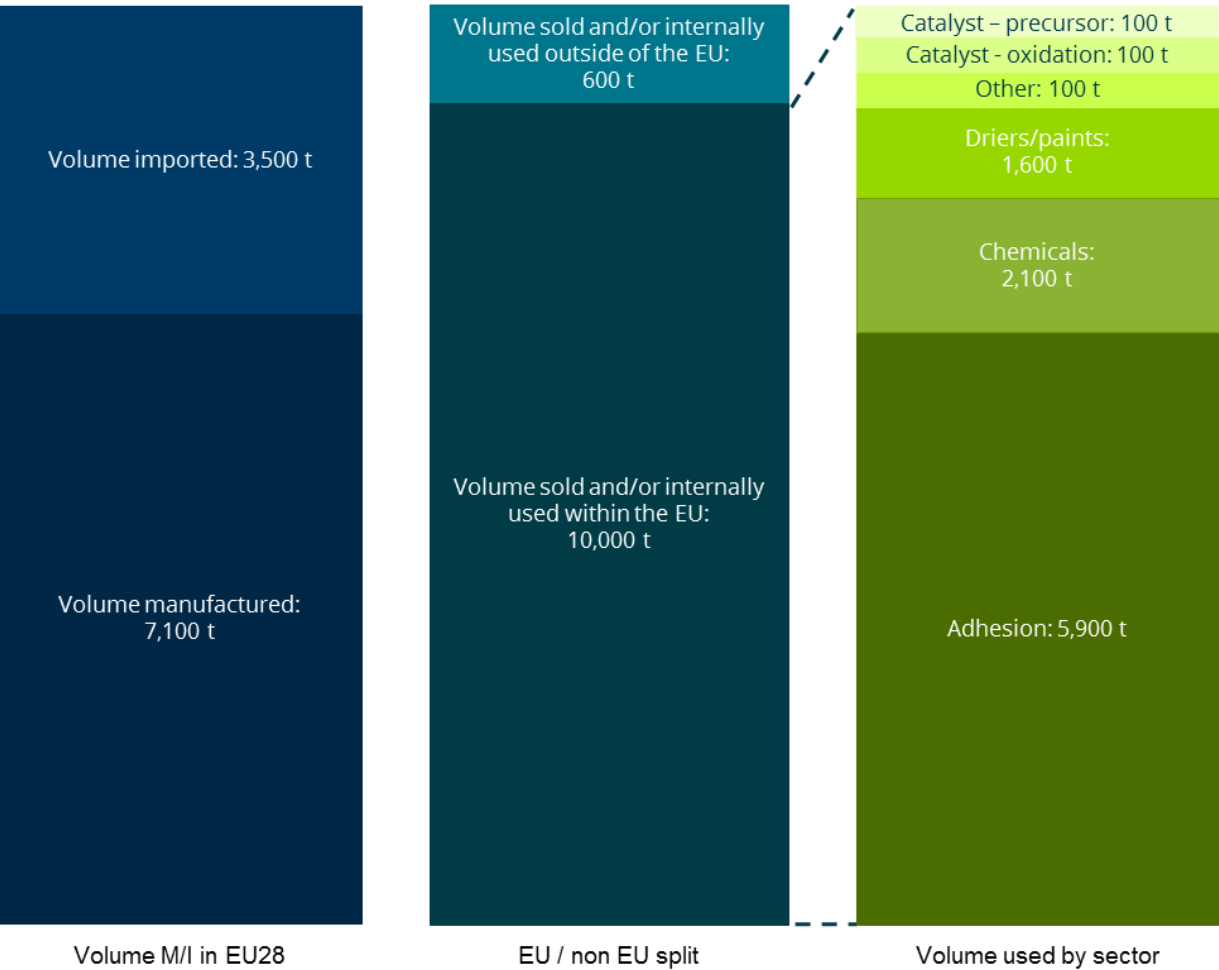


Figure 6.1: EEA value chain for cobalt carboxylates (tonnes per year)

7. Collated dataset

7.1 Manufacture and Import (M/I)

As set out in **Table 7.1** this study was able to collate data on 22 cobalt compounds M/I and used in the EU. For more information on how best to interpret the data reported in this section, please refer to [Box 1](#).

Table 7.1: Cobalt substances

Blue Consortium	Green Consortium	Red Consortium
Cobalt Metal	Cobalt (II) 4-oxopent-2-en-2-olate	Cobalt carbonate
	Cobalt oxalate	Cobalt dichloride
	Cobalt, borate 2-ethylhexanoate complexes	Cobalt dinitrate
	Cobalt, borate propionate complexes	Cobalt sulphate
	Resin acids and Resin acids, cobalt salts	Cobalt sulphide
	Fatty acids, tall-oil, cobalt salts *	Cobalt oxide
	Naphthenic acids, cobalt salts	Tricobalt tetraoxide
	Cobalt di(acetate)	
	Cobalt bis(2-ethylhexanoate)	
	Cobalt ⁽²⁺⁾ isononanoate *	Dicobalt trioxide
	Neodecanoic acid, cobalt salt	Cobalt trihydroxide
	Stearic acid, cobalt salt	Cobalt dihydroxide
	Oleic acid, cobalt salt *	Cobalt hydroxide oxide
	Cobalt ⁽²⁺⁾ propionate	Reaction mass of cobalt, copper and iron
	Cobalt, borate neodecanoate complexes	Cobalt lithium dioxide
		Reaction mass of cobalt sulphide, nickel sulphide and trinickel disulphide

Note: * these cobalt substances have been transferred to the inactive list of the consortium agreement (as of June 2018).

Based on communications with CI-CoRC Secretariat these 22 compounds included in this study include those compounds M/I or used in the largest quantities. Therefore, these compounds provide a good basis for characterising the entire EU cobalt compounds M/I process.

The study was built on several previous substance-specific studies carried out for CI-CoRC (see Section 2 for more details). These studies collected data on the number of M/I companies for the substance(s), and the broad uses these substance(s) are used in - both within the EU and exported outside the EU. These numbers have been refined to account for changes in the market since the previous studies have been carried out (e.g. mergers and acquisitions) and the latest registration data available to the CI-CoRC Secretariat for the period 2015-17. This latest data also accounts for those cobalt compounds that were recently registered in lower volumes.

On an individual substance level, the underlying data collected presents an excellent picture and represents the best industry dataset available to the CI-CoRC Secretariat. However, when combining the datasets, care is required to avoid double counting effects. For example, as set out in **Table 7.2** a company may manufacture/import cobalt metal as well as one of the five cobalt salts and employing the same workers at the same site. Therefore **Table 7.2** deliberately does not include a 'total' row as it may not be appropriate to sum up the number of companies, sites, or employees. Instead the highest number reported is presented instead.

Table 7.2: Number of companies M/I cobalt compounds – by 4 cobalt compound groups

Cobalt compounds	Number of M/Is supplying to the EU market				Data on M/Is	
	Manufacturers (M)	Importers (I)	Both M and I	Total	Total number of sites in the EU	Total number of people directly employed in the EU
cobalt metal	6	58	7	71	84	20,100
5 cobalt salts	22	8	3	33	33+	5,300
5 cobalt oxides	9	36	8	53	62	13,400
11 cobalt carboxylates	4	9	2	15	15 - 36	7,900
highest value from any cobalt compound group	22	58	8	71 (sum = 88)	84	20,100

Table notes:

- Employment figures have been rounded to the nearest 100 employees.
- The total number of people employed includes all workers within the company (e.g. sales, HR and finance) and not only the number of workers involved with the manufacture of the cobalt compound(s).

The highest numbers of an individual compound could represent a minimum estimate for the total number of companies, sites and people employed with the EU. Based on **Table 7.2** this would be cobalt metal, indicating that there are at least 71 companies M/I cobalt compounds in the EU, from 84 sites and directly employing at least 20,100 workers. Alternatively, as reported, the highest value from any group of cobalt compounds provides another estimate of the total number of M/I cobalt compounds in the EU, with an estimate of 88 companies. Either approach however is likely to underestimate the total EU cobalt M/I supply chain.

To derive a potentially better estimate, the total number of unique respondents across all the different surveys were collated (accounting for known mergers and acquisitions). In total there were 107 unique respondents of which 62 respondents were only downstream users whilst the remainder (45) at least manufactured or imported one of the 22 compounds assessed in this study. As set out in **Table 7.3** there are 26 out of 45 companies (58%) who only make one type of cobalt compounds (i.e. either: cobalt metal, cobalt salts, cobalt oxides, or cobalt carboxylates). Around a quarter of all respondents (11) made two types of cobalt compounds, while 8 companies made three or all four types of cobalt compounds.

Table 7.3: Breakdown of M/I of cobalt compounds (respondent data)

Number of types of cobalt compounds M/I in the EU	Number of respondents	%
1 type	26	58%
2 types	11	24%
3 or 4 types	8	18%
TOTAL	45	100%

Table notes:

- Based on respondent data only – There are more than 45 unique M/I of cobalt compounds in the EU
- The four possible types of cobalt compounds are: cobalt metal, cobalt salts, cobalt oxides (including Co sulphide), and cobalt carboxylates

The information shown in **Table 7.3** suggests that using the highest numbers of M/I's reported for a type of cobalt compound would significantly underestimate the total EU market since over half of M/I respondents only reported on one type of cobalt compound. The underlying data also reveals some other interactions:

- Most companies that manufacture/import three types of cobalt compound involve the M/I of cobalt metal + salts + oxides. Therefore, it would be double counting to aggregate data for these three types of cobalt compounds. A more conservative approach would be to take the highest value reported across these three types of cobalt compounds.
- Most companies that manufacture/import two types of cobalt compounds relate to the M/I of cobalt salts and oxides. This is not unsurprising as cobalt oxides are made using certain cobalt salts. Therefore, it would be double counting to aggregate data for cobalt salts and oxides.
- Accounting for those that manufacture / import all four types of cobalt compounds, there were no cobalt metal respondents who also M/I cobalt carboxylates. Therefore, it was possible to aggregate data from cobalt metal with cobalt carboxylates (factoring for those companies that M/I all four types of cobalt compounds) with minimal risk of double counting.

Based on these observations, as a best estimate the total M/I chain is set out in **Table 7.4**. Some of the totals have been rounded to avoid the impression of false accuracy meaning that the total number of M/Is within the EU (all cobalt compounds) is 100, sited across 120 sites, and directly employ 28,000 people within the EU.

Table 7.4: Total number of M/I of cobalt compounds (best estimate)

Number of M/Is supplying cobalt compounds to the EU market				Data on these M/Is	
Manufacturers (M)	Importers (I)	Both M and I	Total (rounded)	Total number of sites in the EU	Total number of people directly employed in the EU
26	67	9	100	120	28,000

Table notes:

- The number of (M) is estimated by taking the highest number of M from metal, salts and oxides (22) and adding the number of M of cobalt carboxylates (4) = 22+4
- The number of (I) is estimated by taking the highest number of M from metal, salts and oxides (58) and adding the number of M of cobalt carboxylates (9) = 58+9
- The number of (I) is estimated (total = 9) by taking the highest number of M/I from metal, salts and oxides and adding the number of M of cobalt carboxylates less the companies that makes all compounds
- The number of sites is estimated by taking the highest number of sites across metal, salts and oxides (84) and the number of sites for cobalt carboxylates (36) = 84+36
- The number of employees is estimated by taking the highest number of employees across metal, salts and oxides (20,100) and the number of employees for cobalt carboxylates (7,900).
- Employment figures have been rounded to the nearest 100 employees and total number of companies rounded to the nearest 10 companies. This is to avoid the impression of false accuracy.
- The total number of people employed includes all workers within the company (e.g. sales, HR and finance) and not only the number of workers involved with the manufacture of the cobalt compound(s).

Table 7.5 sets out the total annual average volume M/I of these 22 cobalt compounds. A “total” row is deliberately excluded at this stage as it would not factor that within the EU for example some cobalt salts are used to make cobalt oxide. These connections are however considered in the next sub-sections, with regards to total volumes used in the EU versus those exported from the EU; as it is only possible to factor such complexities when looking at the volumes at a broad use level.

Table 7.5: Total volume of cobalt compounds M/I (annual average)

Cobalt compounds	Annual average volumes		Annual average volumes used (sold + internal use)	
	Manufactured within the EU	Imported into the EU	Within the EU	Exported outside the EU
cobalt metal	13,500	14,600	15,700	12,400
5 cobalt salts	36,800	600	30,000	7,400
5 inorganic cobalt compounds	15,600	9,700	approx. 15,700	approx. 9,700
11 cobalt carboxylates	7,100	3,500	10,000	600

Table notes: Tonnage figures have been rounded to the nearest 100 tonnes

Overall approx. 70% of cobalt compounds M/I within the EU are subsequently used by downstream users within the EU (note that a M/I may also be a downstream which is shown in the subsequent tables as ‘internal use’) and the remaining 30% is exported outside the EU. However, this does vary as for example the vast majority of cobalt carboxylates that are M/I in the EU are also used within the EU.

7.2 Volumes used within the EU

Table 7.7 breaks down the aggregated volume of cobalt compounds used within the EU by broad use category, which has tentatively been estimated at approx. 47,500 tonnes per year. For most broad uses it is appropriate to sum up the total volumes by use across the four broad cobalt compounds. The exceptions are the use of cobalt compounds when: (i) used as catalyst precursor, and (ii) used in the chemical broad use categories. Typically for these two broad use categories the

cobalt compound is used as an intermediate for the manufacture of other compounds. Therefore, rather than summing up the tonnage data across the four types of cobalt compounds, a better approach was to take the maximum tonnage used for any broad type of compound. This avoids the risk of double counting the volumes from a 'value chain perspective' presented on a tonnage basis. The percentages shown could also be viewed as a representative breakdown of uses of cobalt.

Table 7.6: Breakdown of the use of cobalt compounds within the EU

Broad uses	Annual volumes used in the EU (tonnes)					%
	Metal (2011-13)	Salts (2011-13)	Oxides (2011-13)	Carboxylates (2012-14)	TOTAL	
Adhesion (inc. rubber adhesion agent)*	-	-	100	5,900	6,000	12.6
Batteries*	1,600	-	100	-	1,600	3.4
Bespoke/Niche Applications	-	<50	-	-	<50	0.1
Biotech - animal feed and fertiliser	200	300	<<50	-	500	1.0
Biotech - biogas production	-	100	-	-	100	0.2
Biotech - fermentation, biotech processes, health and medicine	-	<<50	-	-	<<50	0.1
Carbide Diamond Tools	1,900	-	-	-	1900	4.0
Catalysts - used as catalyst precursor	1,100	1,200	1,600	100	(1,600)	3.4
Catalysts - used as oxidation catalyst/for PTA and IPA	200	1,200	-	100	1500	3.2
Chemicals*	7,800	26,700	11,500	2,100	(26,700)	56.2
Driers / paints	500	-	-	1,600	2,100	4.4
Electronics	-	-	<50	-	<50	0.01
Magnetic alloys	900	-	<50	-	900	1.9
Metallurgical alloys	1,300	-	-	-	1,300	2.7
Pigments (inc. Decolourising (glass))	200	-	2,200	-	2,400	5.0
Surface treatment	200	500	100	-	800	1.7
Other	-	-	-	100	100	0.2
Total	15,700	30,000	15,700	10,000	approx. 47,500	100%

Table notes:

- Figures have been rounded (volumes to nearest 100 tonnes). Within this table, the symbol "<" refers to less than 50 and "<<" refers to significantly less than 50 (i.e. <10). The numbers reported for the animal feed sector could potentially be overestimated due to changes made to comply with Regulation (EC) no 1831/2003 on additives for use in animal nutrition.
- * Due to the data collection and confidentiality, volumes used for 'Batteries' and 'Adhesion (inc. rubber adhesion agent)' is underreported in this table, as these uses are included within the chemicals sector. For example, estimates reported in the market overview note (eftec, 2018b) and JRC report (Alves et al., 2018) indicate a higher proportion of cobalt compounds being used in the batteries sector.

Table 7.6 illustrates that within the EU cobalt compounds are used for a variety of uses and sectors. The proportion of the volumes attributed to catalyst and the chemicals sector is thought to ultimately end up being used for high specialist applications where the requirement is purity and

very specific compositions (e.g. batteries and metallurgical alloys). For the Roskills value chain which is ultimately being presented in monetary terms, here it may be possible to factor the 'value added' within the EU from the transformation process (e.g. where very specific purity/quality of cobalt compounds are produced from the transformation process).

7.3 Volumes used outside the EU

Table 7.7 breaks down the volume (30,100 tonnes / year) of cobalt compounds exported outside of the EU by broad use category. Unlike with the volumes being used within the EU, it is not necessary to account for any subsequent transformations between cobalt compounds (e.g. use of cobalt salts to make cobalt oxide) since any transformation will occur outside of the EU and therefore would not affect the net total volume being exported. For example, it is estimated that around 2,300 tonnes of cobalt salts are exported outside of the EU for use as a catalyst precursor. Some of this volume may be used to make cobalt oxides but this would not affect the fact that around 1,300 tonnes of cobalt oxide are estimated to also be exported outside of the EU for use as a catalyst precursor.

Table 7.7: Breakdown of the use of cobalt compounds exported outside the EU

Broad uses	Annual volumes exported outside of the EU (tonnes)					
	Metal (2011-13)	Salts (2011-13)	Oxides (2011-13)	Carboxylates (2012-14)	TOTAL	%
Adhesion (incl. rubber adhesion agent)	-	-	100	400	500	1.7
Batteries	6300	400	6,100	-	12,800	42.5
Bespoke/Niche Applications	-	300	-	-	300	1.0
Biotech - animal feed and fertiliser	-	300	-	-	300	1.0
Biotech - biogas production	-	-	-	-	-	-
Biotech - fermentation, biotech processes, health and medicine	-	-	-	-	-	-
Carbide Diamond Tools	2,400	-	-	-	2,400	8.0
Catalysts - used as catalyst precursor	200	2,300	1,300	<<50	3,800	12.6
Catalysts - used as oxidation catalyst/for PTA and IPA	<<50	-	-	100	100	0.3
Chemicals	2,300	3,800	800	-	6,900	22.9
Driers / paints	400	-	-	200	600	2.0
Electronics	-	-	300	-	300	1.0
Magnetic alloys	200	-	<<50	-	200	0.7
Metallurgical alloys	600	-	-	-	600	2.0
Pigments (inc. Decolourising (glass))	<50	<<50	1,100	-	1,100	3.7
Surface treatment	<50	300	<<50	-	300	1.0
Other	-	-	-	<<50	<<50	0.2
Total	12,400	7,400	9,700	700	approx. 30,100	100%

Table notes:

- Figures have been rounded (volumes to nearest 100 tonnes). Within this table, the symbol "<" refers to less than 50 and "<<" refers to significantly less than 50 (i.e. <10).

Unlike within the EU, the main uses of cobalt compounds outside of the EU are for use in batteries. This is not surprising given that there are more battery manufacturers located outside of the EU

than within the EU. However, this is expected to change in the future due to increased capacity within the EU to make batteries for electric vehicles (a market that is expected to rapidly grow).

7.4 Summary

Figure 7.1 illustrates the overall EU cobalt value chain. It includes details of the number of EU manufacturers (M) and importers (I), how many M/I sites there are in the EU and the number of persons these M/I's employ (as set out in **Table 7.4**).

It also includes a best estimate of the total volume of cobalt (based on 22 cobalt compounds) used in the EU, the total volume of cobalt exported outside of the EU, and what sectors (broad uses) are using these cobalt compounds (See **Table 7.6** & **Table 7.7**).

It was beyond the scope of this study to:

- Monetise the value chain – This is being carried out through the Roskills study following a method that has already been applied for other metal substances; and
- Estimate the downstream user supply chain – Whilst this study sets out how many tonnes are being used downstream on a sectoral basis, there is insufficient data on the total number of downstream users (and employment data) using these 22 cobalt compounds (both within the EU and outside the EU). This aspect will also be covered in the Roskills study, using a method already applied for other metal studies.

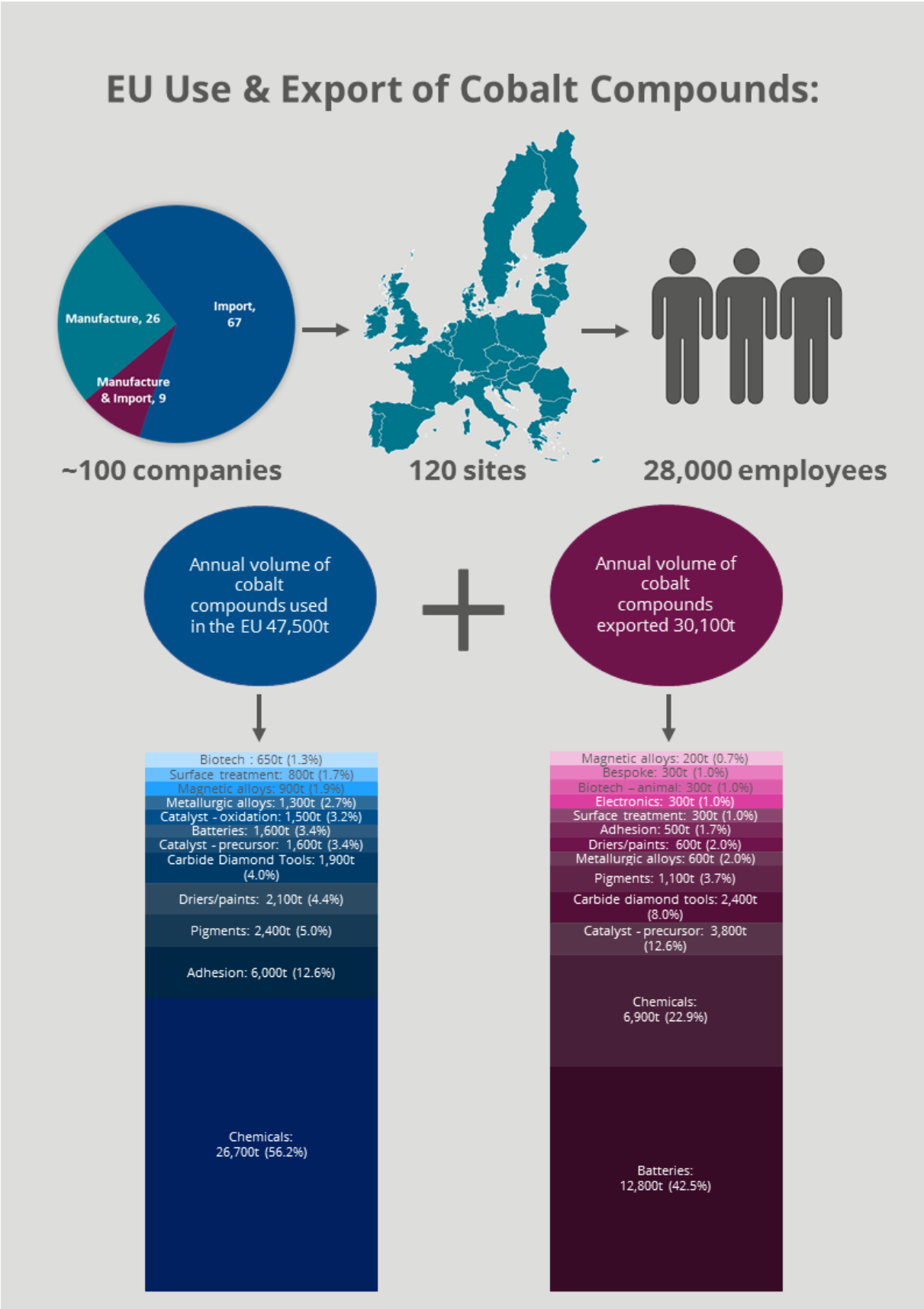


Figure 7.1: EU Cobalt value chain summary

References

EC (2006). REGULATION (EC) No 1907/2006 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC

This study also builds on data collected and reported within four confidential reports for the Cobalt REACH Consortia (CoRC):

eftec and wca (2015) – “WP2: Cobalt metal and cobalt salts value chains” - confidential report

eftec (2015) – “Uses of Tricobalt Tetraoxide” – Confidential final report for the CoRC

eftec (2016a) – “Uses of three cobalt oxides” – Confidential final report for the CoRC

eftec (2016b) – “Cobalt carboxylates supply chain report” - Confidential final report for the CoRC

And additional supplementary notes developed for regulatory submission:

eftec (2018a) – “Supplementary note related to the number of companies, workers exposed to the five cobalt salts and workers employed in the EU-28” – Confidential note submitted to ECHA

eftec (2018b) – “Annex G: Supplementary note on market demands and trends of five cobalt salts” – Note submitted to ECHA during cobalt salts Annex XV dossier public consultation

Further information about the current volumes of cobalt can be viewed in:

Alves Dias P., Blagoeva D., Pavel C., Arvanitidis N. (2018) – “Cobalt: demand-supply balances in the transition to electric mobility” EUR 29381 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-79-94311-9, doi:10.2760/97710, JRC112285.

Appendix 1 – Cobalt conversion factors

This report provides volume data in tonnes per year. The following table provides the conversion factors required to convert the tonnage data reported into the amount of cobalt contained within each type of compound.

Cobalt Substance	Cobalt Content (%)	Conversion Factor (to calculate cobalt contained)
Cobalt Metal	100	1
Cobalt carbonate	45	0.45
Cobalt dichloride	24	0.24
Cobalt dinitrate	32	0.32
Cobalt sulphate	20	0.2
Cobalt sulphide	65	0.65
Cobalt oxide	72	0.72
Tricobalt tetraoxide	73	0.73
Cobalt (II) 4-oxopent-2-en-2-olate	23	0.23
Cobalt oxalate	40	0.4
Cobalt, borate 2-ethylhexanoate complexes	27	0.27
Cobalt, borate propionate complexes	39	0.39
Resin acids and Resin acids, cobalt salts	9	0.09
Naphthenic acids, cobalt salts	15	0.15
Cobalt di(acetate)	21	0.21
Cobalt bis(2-ethylhexanoate)	29	0.29
Neodecanoic acid, cobalt salt	15	0.15
Stearic acid, cobalt salt	9	0.09
Cobalt ⁽²⁺⁾ propionate	29	0.29
Cobalt, borate neodecanoate complexes	20	0.2

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