Roskill Consulting Group Ltd

International Antimony Association

Socio-economic analysis of the antimony industry in the EEA

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1. Introduction

The antimony industry represents a small, but important sector that ensures the availability of a little-known but widely-used raw material. Although added in small quantities, antimony supports the production of a range of applications used in daily life. In its largest application, antimony is an important synergist component of some of the most performant flame retardants, providing a critical societal and life-saving role that help delay the ignition and spread of fire, and reduce risks of catastrophic incidents by increasing the window of opportunity for containment and emergency response. High-purity antimony trioxide is also the major antimony chemical used in the catalysis of PET. As regards antimony metal, its major application is in hardening of lead metal in a number of very cost-efficient applications such as lead-acid batteries. Other lower volume applications include technology glass, friction and lubricant products, ceramics, functional pigments, explosives, and medical treatments.

As such, the antimony industry contributes an important raw material to the world economy. But in an increasingly interconnected world, methods of production are as important as the value of the products produced. Antimony is no exception to this, and the sustainability of the industry will be vital to the sector's longevity and viability within the EEA.

Already, the production of antimony within the EEA benefits from a large reliance on recycling, with significant volumes of antimony sourced from spent lead-acid batteries. Recycling rates may increase further, owing to developments in the possible recycling of antimony from different recycled polymers, as well. While such recycled materials are supplemented by imports of mined material, this report finds that owing to the high recycling rate, companies involved in the production of antimony generally have a low carbon footprint, compared to other companies within the chemical and metal processing industries.

But sustainable development and industrial activity goes beyond mere environmental impacts and encompasses the full spectrum of social and economic effects. This report seeks to provide an initial contribution by mapping out several of these, exploring the sector's contribution to economic activity and value addition, but also its contribution to research and investment, employment, labour income, tax revenues, and support to small and medium enterprises.

With new legislative and environmental challenges ahead, particularly surrounding the EU's REACH and CLP legislation, the antimony industry has continued its active effort to ensure the collection of scientific data, conduct appropriate studies, and disseminate information concerning the safety and benefits of antimony compounds. However, as this study observes, the small size of the industry – and its slim profit margins – compared to other, larger metal and processing industries in the EEA means that the costs of such compliance are significant to the producers involved, and that care must be exercised in ensure the proportionality of the cost of implementation, to the overall size, value and profitability of the industry.

2. Acronyms and definitions

2.1 Acronyms

CLP	Classification, Labelling and Packaging
EBITDA	Earnings before interest, taxes, depreciation, and amortisation
EEA	European Economic Area
EU	European Union
GHG	Greenhouse gas
NACE	Nomenclature des Activités Économiques dans la Communauté Européenne
OECD	Organisation for Economic Co-operation and Development
PET	Polyethylene terephthalate
PTFE	Polytetrafluoroethylene
PVC	Polyvinyl chloride
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals

2.2 Units

CO_2	Carbon dioxide
kt	Kilotonne
M	Million
ppm	Parts per million
Sb	Antimony
t	Tonne

2.3 Definitions

Allocation factor

The use of antimony supports various downstream sectors and applications that depend on it, but at the same time antimony is only one of many essential components, accounting for a small portion of the total value of inputs. To determine the number of jobs, the amount of value addition, and other socio-economic effects that are attributable to antimony in such downstream factors, an allocation factor will be used.

Input-based

The primary allocation factor used in this study is defined as the *value of antimony* as a percentage of *output minus value addition,* hence representing providing a share of the total cost of inputs. If antimony accounts for 1% of the total cost of inputs, 1% of the value addition or job positions and other effects would be attributed to antimony.

Revenue-based

An alternative allocation factor used in this study is defined as the *value of antimony* as a percentage of *output*, before subtraction of value addition. This method would, implicitly, not attribute any of the value addition that occurs in downstream stages to the contribution of the various inputs used. This approach results in a slightly lower allocation factor and is explored in the discussion section.

Compounds	Chemical substances of antimony, including antimony oxides, sodium antimonate, antimony trisulfide, and others.
Direct effects	Any effects that occur *on site* of a company. This includes, for instances, employees involved with the operation itself, as opposed to positions created by an operation's sourcing of its various inputs and materials.
Double count	Term referring to the risk of accounting for the same effect more than once; for instance, counting a single employee who produces a chemical product and its finished downstream product twice, once to produce the chemical, and once to produce the finished product. This study aims to identify such double counting where it occurs and makes appropriate adjustments.
Employment	This includes regular employees, as reported by companies, as well as on-site contractors (assumed at 25% of the regular workforce if not reported explicitly).
End use of antimony	Consumer or industrial end products that contain antimony, via applications based on antimony, such as flame retardants or lead-acid batteries.
First use of antimony	Direct applications of antimony products, including flame retardants and lead-acid batteries, directly purchasing antimony.
Halogenated flame retardants	Flame retardants based on bromine and chlorineiwhich may contain additions of antimony to act as a chemical synergist for the halogen.
Indirect effects	Any effects that occur *off site* of a company. This includes, for instance, employment effects created by an operation in the surrounding economy.
Type I	Indirect effects relating specifically to effects resulting from its demand for local goods and services, such as chemical products, building materials, legal and financial advice, etc.
First-round effect	Effects resulting from the demand for local goods and services by the company itself.
Industrial support effect	Effects resulting from the demand for local goods and services by the company's immediate suppliers, and their own supply chains.
Type II	Indirect effects resulting from the income earned by employees working on or off-site the operation; reinvested labour income (which may be spent on food, apparel, housing, entertainment and other) re-enters the economy and requires additional supporting jobs.

Income effect	Same as Type II effect.
Induced consumption effect	Same as Type II effect.
Labour income	Defined as the total cost of labour to employers, therefore including social taxes and contributions.
Masterbatch	A pre-mixture of pigments and additives, which may include flame retardants, into a polymeric matrix, that are added during the production of plastics, textiles, etc.
Polyester/PET catalysis	Refers to the use of antimony (mostly high-purity antimony trioxide or antimony tris (ethylene glycolate) as a catalyst in the production of PET resin and textile polyester.
Output	A measure of turnover or revenue.
Total taxes on products and production	Including various taxes ranging from VAT, to corporation taxes and environmental levies, but not including taxes relating to employment.
Value addition	The difference between the cost of inputs and revenue but including labour costs. In the study, value addition has been calculated as EBITDA plus labour costs where derived from company financial reports, or from Eurostat for the sectoral analysis used in the study.

3. Executive summary

3.1 Antimony industry

Antimony is produced both via mine production (120kt Sb in 2018) and recycled sources (62-67kt Sb in 2018), with all production in the EEA from recycling and imported material (see section 4.1).

The EEA is the second-largest producing region of antimony oxides and compounds, as well as of lead. Production of antimony oxides amounted to an average 23ktpy Sb over the years 2010-2018, accounting for 22% of the world total, with Belgium and France the main producing countries. Production of antimony in antimonial lead averaged 11ktpy Sb over the same period, corresponding to 21% of the world total, with significant production in at least 18 European countries.

The two most important applications of antimony are in flame retardants and lead-acid batteries (see section 4.3). In flame retardants, antimony is added as part of a "masterbatch" of various fillers and additives. While antimony itself has no flame retardant properties, when used with halogenated compounds the mixture creates the desired synergistic effect. The resultant flame retardants are used primarily in various types of plastics and polymers, as well as in rubber and textiles.

In lead-acid batteries, antimony is added as part of the battery grid along with lead, forming an electric cell when immersed in sulphuric acid. Most of the use of lead-acid batteries is in the automotive and other transport sectors, but other applications include telecommunication and data networks that need back-up power supply.

3.2 Study methodology

To determine the socio-economic contribution of the production and use of antimony within the EEA, a bespoke study has been undertaken by Roskill on behalf of the i2a, which included the following components:

1. A company-by-company analysis covering 32 production sites as well as 34 downstream operations to assess levels of output, employment, labour income, research and expenditure, emissions, profit margins, and taxation (see section 5.2.1).

2. A material flow analysis to assess the usage of antimony in different direct and indirect applications, both globally and specifically within the EEA (see sections 4.2 and 5.2.2).

3. A sectoral analysis reliant on EUROSTAT data for different NACE industries, to assess the overall footprint of several of antimony's downstream and more fragmented applications (see section 5.2.3).

4. The determination of antimony allocation factors, to assess the relative importance of antimony in each application as a percentage of cost of inputs, to determine the portion of each sector's footprint deemed to be attributable to antimony (see section 5.6.2).

5. The use of input/output data from EUROSTAT to assess indirect effects, including so-called "Type I" effects resulting from operations' requirements for various inputs in the forms of goods and services from other sectors, and "Type II" effects related to the reinvestment of labour income by employees involved in the sector. This data was used to assess the sector's contribution to employment, output, value addition and other effects via associated industries (see section 5.3).

3.3 Key conclusions

The primary results of the study may be summarised as follows:

- The total value of the industry, estimated as the value of the antimony products produced, is estimated by Roskill at €1.26Bn in 2018, of which the EEA accounted for around €300M.

- Taking into account the downstream use of antimony, the production and use of antimony generated a total of €837M directly and €1,219M indirectly per year over the years 2010-2017.

- Value addition by in the production of antimony, incorporating adjustments to avoid double-counting and providing a better direct comparison to GDP, amounted to €250M per year, including both direct and indirect effects. Downstream sectors reliant on antimony added a further €454M in value addition per year attributable to antimony.

- Among the producers of antimony themselves, falling prices of antimony have led to low margins, at an average of 5%, corresponding to less than €14M per year. Owing to these slim margins, regulatory compliance costs have represented a disproportionately large burden to the antimony industry.

- Total employment attributable to antimony in the EEA is estimated at 12,182 jobs, of which around 21% are directly employed by producers and downstream consumers of antimony, with the remainder in roles in supporting sectors.

- Average labour costs per employee in the antimony industry, the production of flame retardants and lead-acid batteries are estimated in the €40,000-€45,000 range. Total labour contributions by the antimony value chain amounted to an average of €118M per year, with a further €212M in indirect labour costs among supporting industries.

- On an annual basis, Roskill estimates that the antimony industry directly and indirectly contributed €8.5M in taxes per year over the years 2010-2017, with direct and indirect contributions via downstream industries adding a further €13.3M per year.

- The companies reviewed in the study, and reporting relevant data, spent an average of 0.5% of their revenues on research and development, with cumulative spending over the eight years from 2010 to 2017 having amounted to an estimated €17.6M.

- Albeit limited data was available on emissions by companies in the sector (and keeping in mind that most companies are diversified and produce a range of different products) median emissions by those companies reporting such data fell from 214t CO_2 equivalent in 2014 to 176t in 2017, considerably below average emissions in key reference sectors such as the chemical processing industry, possibly because of the high recycling rate of antimony.

- Most companies involved in the production of antimony are not categorised as small and medium enterprises, but Eurostat data suggests that as much as 93% of the businesses in the main sectors supporting the production of antimony would be classified as such, suggesting that the antimony value chain indirectly supports a substantial number of such enterprises.

4. The antimony industry

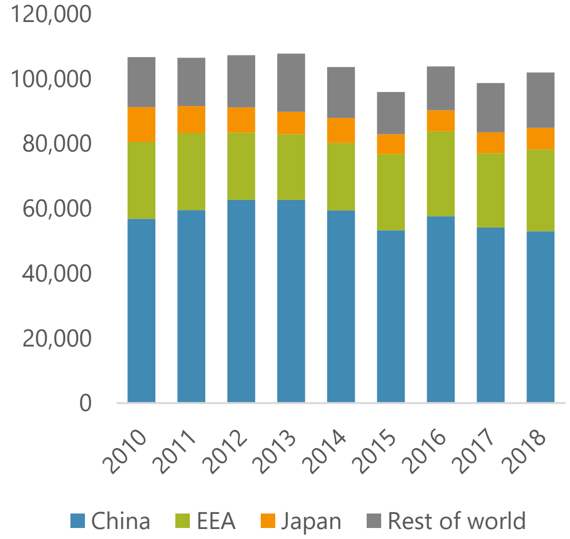
4.1 Production of antimony

Antimony is produced from two main sources – mine production, and recycling of lead-acid batteries and, to a lesser extent, of chemical contents. Globally, in 2018, mine production accounted for around 120kt of contained antimony, compared to 57kt from the recycling of lead-acid batteries, and 5-10kt from the recycling of other chemical compounds.

In the EEA, no mine production of antimony takes place, and all production of antimony is from recycling or imports of antimony intermediates from China, but also from Tajikistan, Russia, Vietnam and Thailand.

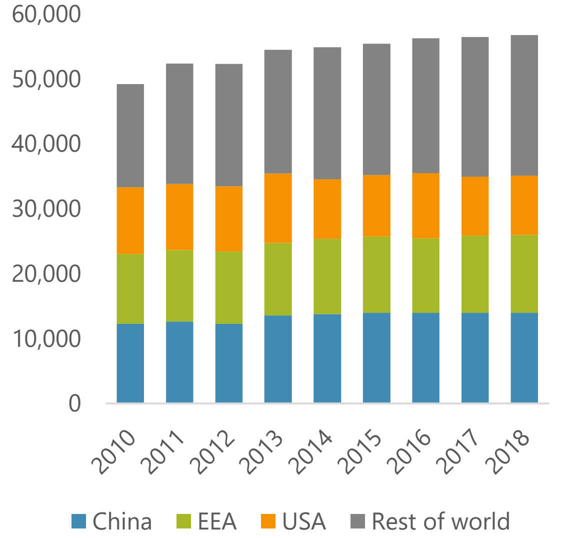
The EEA is, however, an important producer of antimony oxides and masterbatches (used in flame retardants and other non-metallurgical applications) and of antimonial lead (used in lead-acid batteries and other metallurgical applications).

Figure 1: Production of antimony oxides and equivalent, 2010-2018 (t Sb)



Source: Roskill

Figure 2: Production of antimonial lead, 2010-2018 (t Sb)



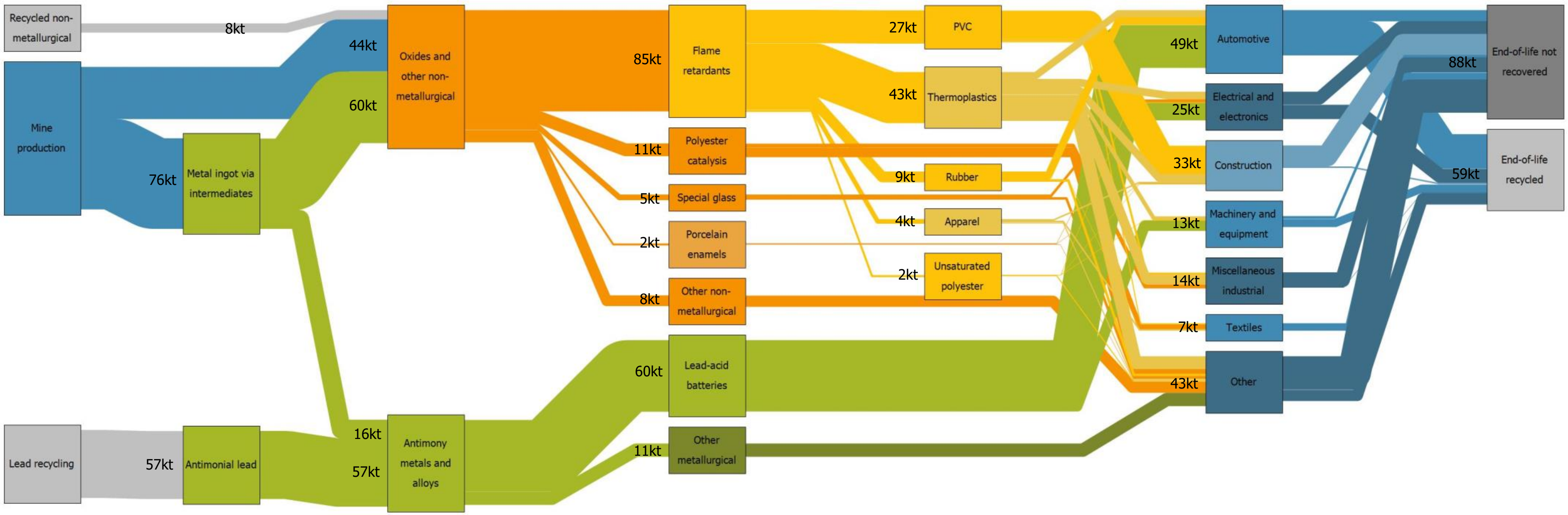
Source: Roskill

4.2 Material flowchart

The figure below provides a schematic overview of the structure of the global antimony industry. Production of antimony is separated between primary production from mine material, and recycled material from lead-acid batteries and non-metallurgical applications. Mined and recycled units of antimony are processed into oxides and metal.

The largest use overall is in flame retardants, used in a variety of plastics, textiles and rubber products. In metallurgical applications, usage is dominated by lead-acid batteries. A variety of smaller uses account for smaller volumes of antimony. Via these various routes, antimony ends up in a variety of consumer and industrial sectors, ranging from household furniture to emergency power systems and electrical devices. Substantial volumes of antimony are recycled, primarily on the metallurgical side of the industry.

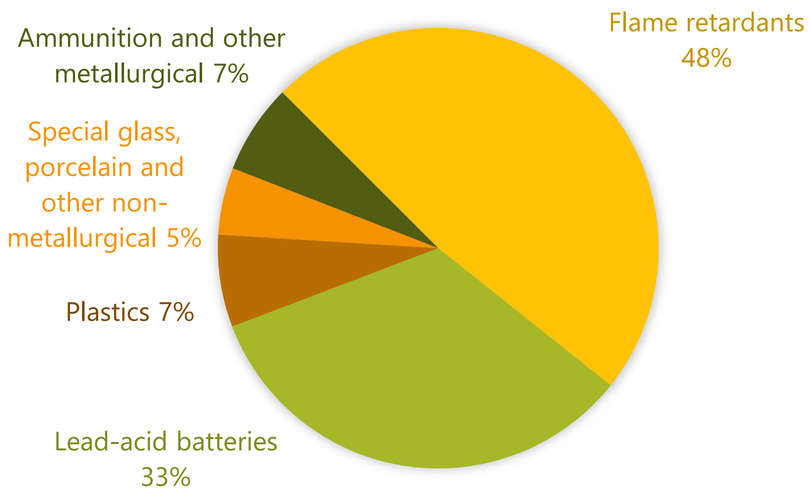
Figure 3: Estimated global flows of antimony by volume, 2018 (kt Sb)



4.3 Applications of antimony

Antimony consumption is split into non-metallurgical and metallurgical applications. The largest end use for non-metallurgical antimony is in flame retardants, whilst for metallurgical applications, the major use of antimony is lead-acid batteries.

Figure 4: Applications of antimony, 2018 (% of contained Sb)



Source: Roskill; Note: Use in plastics only includes antimony use as a catalyst and heat stabiliser; flame retardant uses of antimony in plastics are included under flame retardants

4.3.1 Use in flame retardants

In **halogenated flame retardants**, antimony is predominantly used in the form of oxides, and mainly used as a synergist. Antimony is added during the compounding process of plastics in the form of a flame retardant "masterbatch", along with fillers and property enhancing additives such as pigments, brighteners and stabilisers. It is estimated that globally 85kt of antimony, or 48% of total consumption, is used for this purpose.

Whereas flame retardants and lead-acid batteries represent the immediate applications (or "first uses") of antimony, the antimony used in these sectors ultimately ends up in range of different sectors and end products, that may be purchased by consumers or be employed in industrial sectors.

Flame retardants, for instance, are used in a variety of plastics, textiles and rubber products. Plastics and other materials that are by their nature potentially flammable are used in a wide variety of applications in homes, work places, schools, hospitals and transportation. They present a risk of flammability which can be alleviated through adding flame retardant while maintaining the utility, comfort and aesthetic they provide.

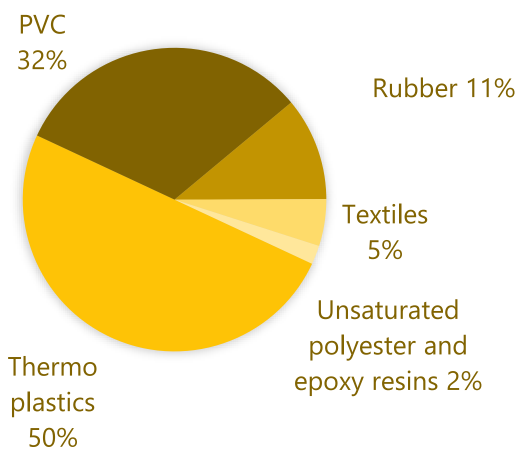
Materials used in buildings need to have a good level of fire resistance and safety. The main types of plastics used in buildings are PVC and thermoplastics, used in for example insulation, water pipes, though additionally paints. Most types of flame retardant, including antimony-based, are used in building and construction applications. Additionally, the textiles and fillers used in furniture and furnishings, such as curtains and carpets need to be fire resistant.

Home appliances and electrical devices such as televisions, vacuum cleaners, kettles, computers and associated containers and cables contain significant amounts of combustible plastic. Ignition sources from wiring faults and overheating, combined with the flammable material, increase the risk of fire.

Outside of buildings, flame retardants play an important role in making transportation safer. Combustible items in vehicles are the seats, dashboard, bumpers, tires as well as the fuel and lubrication oil. Faulty electrical wiring can provide an ignition source.

The exact breakdown of the use of flame retardants is difficult to track with any degree of precision, particularly on a regional basis, but a rough breakdown between the main applications of antimony-based flame retardants is shown in Figure 5.

Figure 5: Modelled use of flame retardants, by application (%)



Source: Roskill, German Federal Environment Agency

4.3.2 Use in lead-acid batteries

In **lead acid batteries** antimony is added to lead used in the battery grids, which form an electric cell when immersed in sulphuric acid, and the resulting chemical reactions generate electricity. These lead alloy grids contain up to 10% antimony, to improve strength, corrosion resistance and castability. In maintenance-free, valve-regulated lead-acid (VRLA) batteries, lower additions of antimony are used in the grid itself, where tin is used instead, but a 3% antimony-lead alloy is still used in posts and battery connectors.

Lead-acid batteries are primarily used in the automotive sector. Batteries are used in vehicles to store electrical energy that is used to start and provide ignition for the engine, and support lighting functions. Lead-acid batteries are the most widely used for this purpose as they tend to be reliable, robust, relatively inexpensive on a per unit of power delivered, and highly recyclable and effectively collected and recycled.

Other applications of lead-acid batteries include telecommunication and data networks that need back-up power supply. The design of these batteries is slightly different from automotive batteries with thicker plates. These types of batteries are also used for providing an uninterruptible power supply (UPS) to protect equipment such as computers, critical medical equipment and data centres from unexpected interruptions to the power source. They provide low level steady power for a long duration though they are not intended to be used for extended periods.

Other stationary battery applications are spread across a range of sectors including security, control and switchgear, emergency lighting, etc. An emerging stationary battery application is in renewable energy storage and load levelling for utilities. In all these applications, lead-acid batteries are under threat from lithium-ion and other battery technologies but have retained market share owing to their comparatively low cost and recyclability.

Lead acid batteries accounted for an estimated 59kt Sb in 2018, or 33% of overall consumption of antimony. Most of the antimony used in this application is derived from recycled material, benefiting from a highly-organised collection and recycling system for this type of battery.

4.3.3 Use in other applications

In **plastics**, antimony is used as a catalyst for the polymerization of polyester or polyethylene terephthalate (PET). The amounts of antimony oxide used are small, at around 200-300ppm, but owing to the scale of the industries, these applications of antimony accounted for an estimated 12kt Sb in 2019, or 7% of overall consumption.

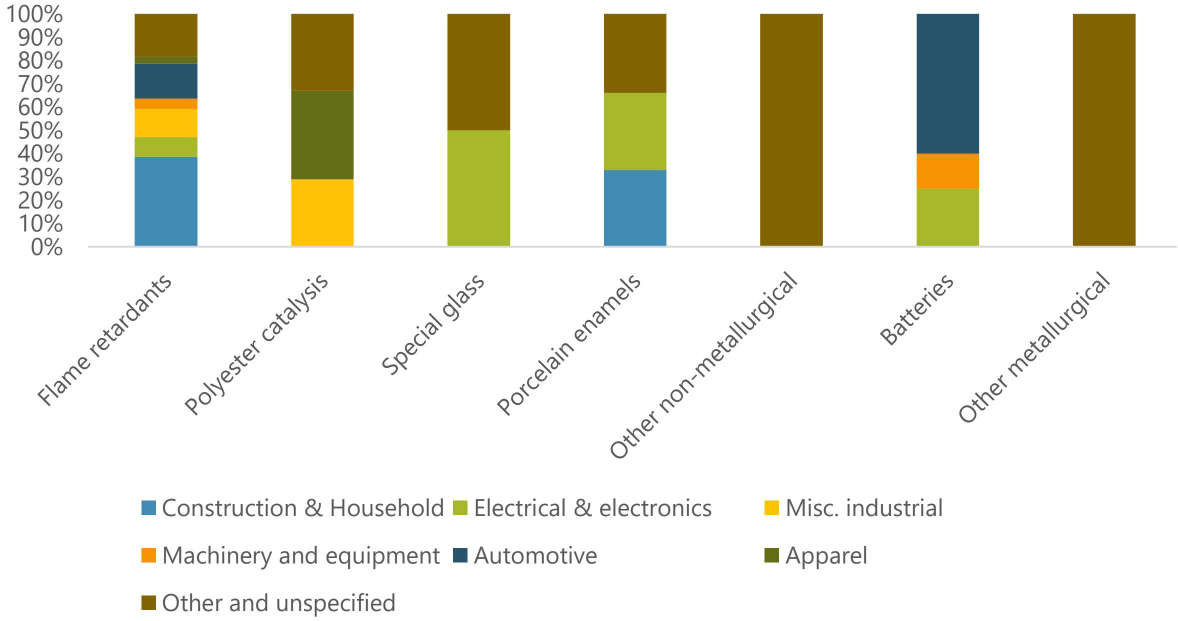
Other non-metallurgical applications include the use of antimony as an ingredient of special glass (including photovoltaic glass), contributing to the increased visual purity and light diffraction potential of the glass. Antimony is also used in ceramics to improve acid resistance and as an opacifier. Smaller applications include use in functional pigments, lubricants, medical treatments against leischmaniasis, fluorescent light bulbs, fireworks, and the catalysis of the synthetic polymer PTFE. These various applications account for around 6% of global consumption or 11kt Sb.

Other metallurgical applications primarily include the use of antimony as a hardening additive in lead alloys for small arms and sporting ammunition, with antimony trisulfide also used as a primer for guns, and as an alloy with tin in various bearing metals and sheathed cabled. Jointly, these applications account for a further 12kt or 6% of global consumption.

4.4 End sector demand

Through the various applications described in section 4.3, antimony is used directly and indirectly in a range of industry sectors. This includes use in construction and household industries, electrical equipment, the automotive industry, apparel, and miscellaneous other sectors. An approximate breakdown of such end use of antimony is provided in Figure 6.

Figure 6: Modelled use of antimony in end sectors, by main application (%)



Source: Roskill

4.5 Consumption of antimony in the EEA

Asia is the dominant consuming region across both metallurgical and non-metallurgical end uses.

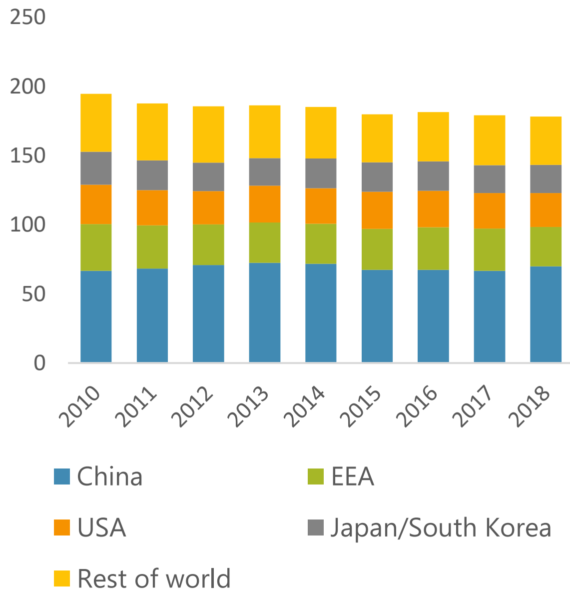
It is difficult to estimate consumption in metallurgical applications, because not only is a large portion of the demand accounted for by secondary antimonial lead, but also trade of metal ingots tracks demand for converting ingot to other antimony compounds: mainly trioxide. For example, Belgium and France import large amounts of antimony metal, over 80% of which is used in the production of antimony trioxide used in flame retardants.

It is easier to determine the split of regional demand for non-metallurgical applications by looking at apparent consumption and trade statistics of antimony oxides and other compounds.

An alternative means of estimating the breakdown of demand is based on a comparison of the regional share in some of the main markets for antimony, such as the production of plastics, batteries, textiles, and others, which allows for a more detailed regional split by application but assumes a similar intensity of use of antimony between regions within each application.

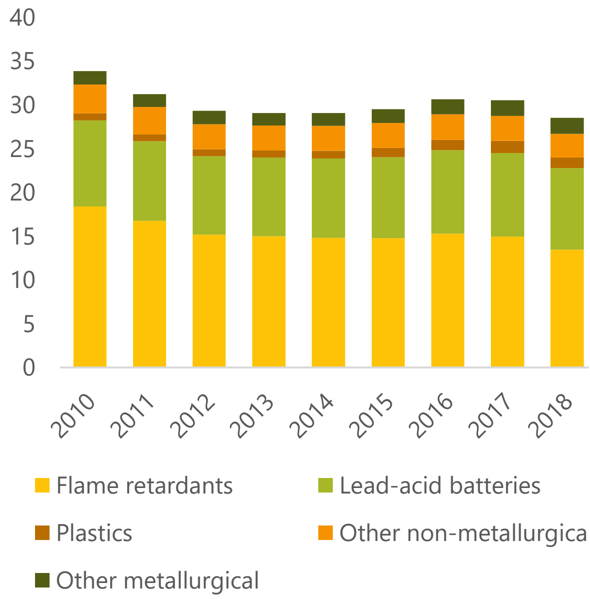
The two approaches (using apparent consumption versus an analysis of downstream sector breakdowns) are complementary, with the former offering a better analysis of country-by-country consumption, while the latter offers a better insight into breakdowns by application. A combination of the two approaches thus results in the best results, presented in Figure 7 and Figure 8.

Figure 7: Consumption of antimony by region, 2010-2018 (kt Sb)



Source: Roskill

Figure 8: EEA: Consumption of antimony by application, 2010-2018 (kt Sb)[1]



Source: Roskill

4.6 Value of the antimony industry

The value of the antimony industry may be estimated through a comparison of production volumes and changes in annual, published prices. The method is imperfect, as prices achieved by producers may differ from such published price series owing to premiums and discounts secured for material grades, as well as the unique contracting terms between each producer and customer. Nonetheless, the estimate provides a useful insight into overall industry trends.

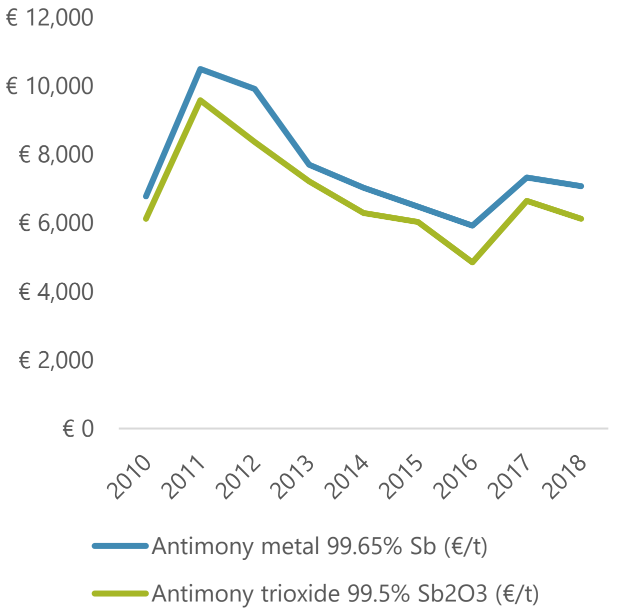
[1] Use in plastics only includes antimony use as a catalyst and heat stabiliser; flame retardant uses of antimony in plastics are included under flame retardants

Roskill estimates the total value of the antimony industry to have amounted to approximately €1.26Bn in 2018 and having averaged €1.38Bn over the years from 2010 to 2018. This figure includes only the production of antimony oxides and antimonial lead, with mine production and production of metal ingot, which act as feedstocks to these products not included to avoid double counting.

This figure also does not include the additional value generated using antimony in downstream industries, which is explored more fully in the section outlining the findings of the socio-economic study in section 6, and thus merely relates to the production of antimony *itself*.

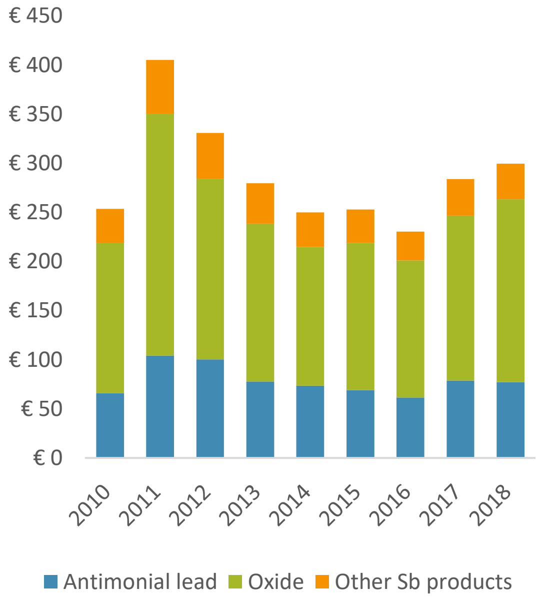
The overall value of the antimony produced has fallen, owing both to weakness in demand, as well as a fall in average prices of antimony metal, antimonial lead, and antimony trioxide. Roskill estimates that the EEA accounted for just under €300M of the total in 2018, or around 24% of the value of the global industry (Figure 10).

Figure 9: Prices of antimony metal and trioxide (€/t)



Source: Roskill, Metal Bulletin, Asian Metal

Figure 10: EEA: Consumption of antimony by use, 2010-2018 (kt Sb)



Source: Roskill

5. Methodology

5.1 Overview

This study seeks to employ a straightforward and intuitive methodology to quantify the socio-economic footprint of the production and use of antimony within the EEA. Figure 11 provides a simplified, schematic overview of the analytical process employed to derive the results described in this report, which is described in more detail below. The methodology may, analytically, be divided into separate parts:

1. Company-by-company analysis and sectoral data were used to estimate *direct* socio-economic effects of the antimony industry itself, and of its downstream applications, described in section 5.2.

2. A material flow analysis was undertaken to quantify the specific volumes and value of antimony used in each downstream application, and to calculate *allocation factors* determining which percentage of socio-economic effects to attribute to antimony, as described in sections 5.2.3 and 5.6.2.

3. Input/output data from Eurostat was used to estimate the reliance of the antimony industry and its downstream applications on other supporting industries, via their demand for goods and services from these other sectors. This input/output data was used to calculate *indirect* socio-economic effects, occurring offsite elsewhere in the EEA's economy. This is described in section 5.3.

5.2 Direct effects

This study distinguishes between so-called direct and indirect socio-economic effects. Direct effects may be thought of as occurring "on site" at an antimony-producing company, or a downstream business directly reliant on antimony or antimony-containing products. Indirect effects, on the other hand, relate to the impact of such operations on the wider, surrounding economy, supporting industrial sectors, and the personal spending of the employees that they employ.

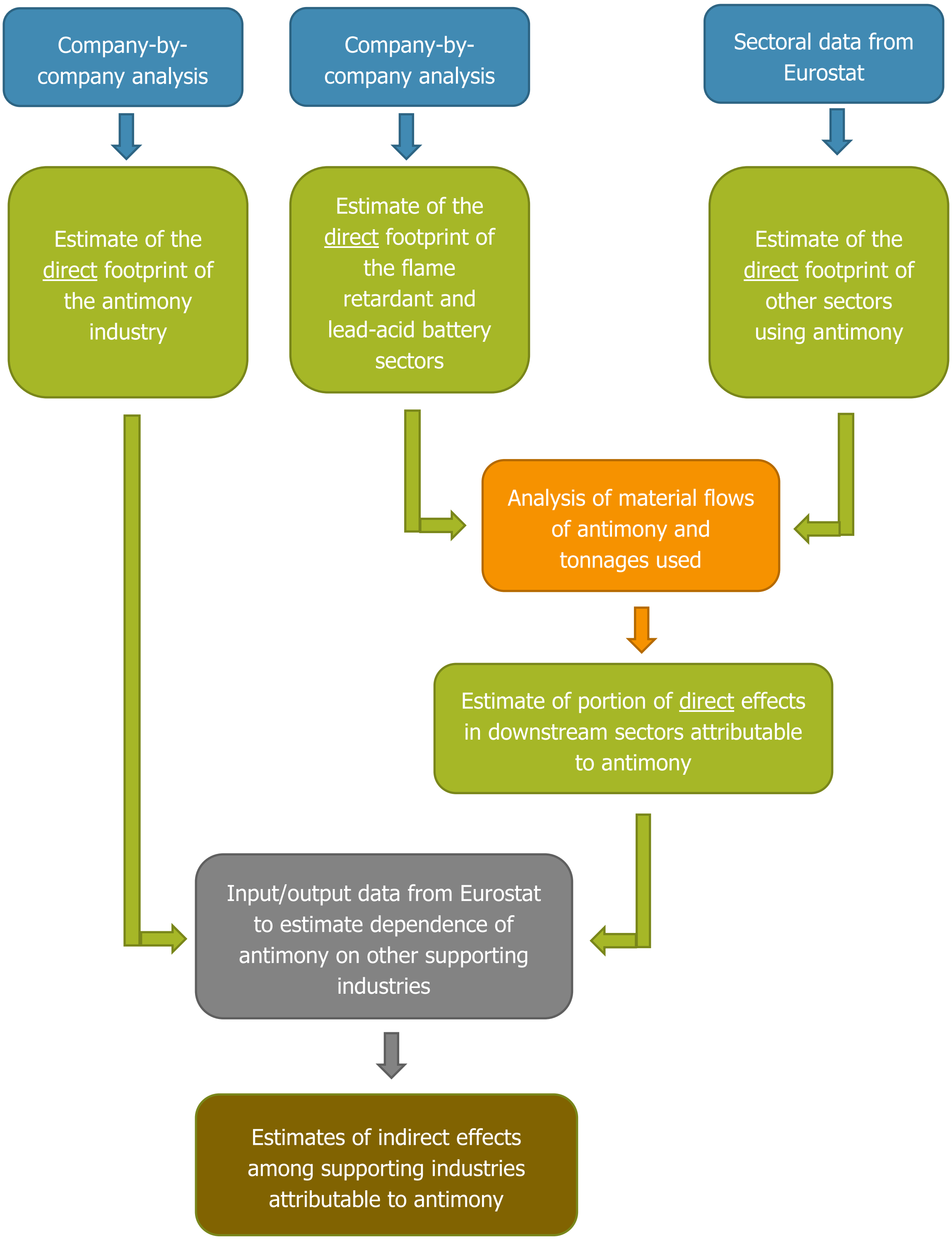
Direct effects can be tracked more readily than indirect effects. Direct effects such as the number of employees employed in the antimony industry or the amount of revenue reported may be derived from published, company reports, or industry statistics. In this study, a detailed company-by-company analysis has been undertaken for all producing companies of antimony in the EEA, as well as an industry-level analysis for the various downstream applications.

5.2.1 Analysis of the antimony industry

To assemble data on the antimony industry itself, a detailed analysis was undertaken for all the identified producers of antimony products in these countries, including battery recycling plants, as well as producers of antimony oxides and compounds.

Data was sourced primarily from these companies' own financial reports, as well as from ORBIS – a subscription-only database containing key information on over 300 million companies worldwide. Where no figures were formally reported, additional data was sourced from websites, press releases or news articles, with any gaps estimated using ratios derived from other peer companies with more published information.

Figure 11: Schematic, simplified overview of the study's methodology



Source: Roskill

In total, data was collected on 32 operations directly involved in the production of antimony, as well as 34 operations involved in the production of flame retardant masterbatches and lead acid batteries. Data collected covered information on basic financials, such as sales, EBITDA, and assets, as well as data on the number of employees, overall labour costs, and spending on research and development. Where possible, data was also collected on CO_2 emissions, but such data was also reported by six producers, and mostly related to larger business segments or the company, rather than the specific production of antimony.

For this study, this analysis set out to assess not only the overall footprint of antimony-producing companies, but more specifically the footprint of their antimony segment, specifically. Many of the companies reviewed represented diversified companies, with interests in other raw materials or revenues from unrelated businesses. Indeed, in the EEA specifically, there are very few companies that solely produce antimony, with antimony in the EEA usually produced as a by-product along with other products.

Table 1: Example of company-based analysis and attribution to antimony

	Unit	2010	2011	2012	2013	2014	2015	2016	2017
Business segment									
Sales	€ M	401.4	419.1	433.6	425.4	441.8	393.2	349.7	406.2
EBITDA	€ M	10.1	11.8	14.7	-17.8	0.1	0.5	8.5	20.7
Assets	€ M	261.7	216.3	207.7	203.9	175.8	124.9	135.4	180.4
Employees	#	628	591	627	661	666	642	605	595
Labour expenses	€ M	42.3	40.4	41.3	45.6	47.7	46.0	40.3	40.5
R&D	€ M	0.97	0.91	0.43	0.78	0.10	0.53	0.37	0.48
Antimony output									
Lead/lead alloys	kt	94.7	107.4	110.6	102.8	98.9	90.4	89.7	105.7
Antimony contained	kt Sb	0.85	0.97	1.00	0.93	0.89	0.81	0.81	0.95
Estimated sales	€ M	7.7	14.1	12.7	9.5	8.3	5.8	5.3	7.9
% of revenue	%	1.9%	3.4%	2.9%	2.2%	1.9%	1.5%	1.5%	1.9%
Attributed to antimony									
Sales	€ M	7.67	14.11	12.68	9.46	8.31	5.85	5.29	7.87
EBITDA	€ M	0.19	0.40	0.43	-0.40	0.00	0.01	0.13	0.40
Assets	€ M	5.00	7.28	6.07	4.53	3.31	1.86	2.05	3.49
Employees	#	12	20	18	15	13	10	9	12
Labour expenses	€ M	0.81	1.36	1.21	1.01	0.90	0.68	0.61	0.78
R&D	€ M	0.02	0.03	0.01	0.02	0.00	0.01	0.01	0.01

Source: Roskill

To derive estimates for antimony, specifically, allocation factors were calculated for these companies. Allocation factors were defined as the portion of sales accounted for by antimony as a percentage of sales of the wider segment, or the company, depending on the granularity of reporting. Antimony sales themselves, if not specifically reported, were estimated based on known or estimated production figures (sourced from Roskill's 2018 Antimony Market Outlook report and Roskill's internal database) and multiplied by market prices for the relevant antimony product.

These allocation factors were then used to estimate antimony-specific footprints. For instance, where the raw material segment of a company had 1,000 employees, with antimony accounting for 5% of the sales of the segment, 50 employees would have been attributed to antimony. While this methodology is obviously imperfect, as exact labour intensity may differ between different types of operations within the company, the result is both transparent and – at an industry, aggregated level - a fair approximation of antimony's societal importance.

5.2.2 Analysis of material flows

The second step in the analysis involved the detailed accounting of flows of antimony through different first use applications (such as flame retardants and lead-acid batteries) and end uses in sectors such as transport, engineering, construction, etc.

The result of this analysis, showing the flow of antimony through the global and the EEA economy, has been discussed in section 4 of this report. Section 4.1 discussed the production of antimony in its various forms, section 4.3 explored its various first use applications, and section **Error! Reference source not found.** reviewed the sectors where finished products containing antimony end up.

Estimates for this analysis were derived from Roskill's antimony database and 2018 Antimony Market Outlook report. This latter report is now in its 13th edition, with the first edition dating back to the 1970s, and draws on decades of research into the industry, tracking usage of antimony and historical trends. For the purpose of the study, this data was reviewed in its entirety, which resulted in a more detailed breakdown of demand by application.

Roskill's statistics generally track usage by application on a global basis. Roskill, additionally, maintains estimates of consumption of antimony at a country level, based on apparent consumption – a measure of consumption derived from reported production, exports, and imports. For the purpose of this study, the use of antimony in its different applications was broken down geographically with the aid of additional datasets – such as the global production of plastics, textiles and ceramics. This resulted in a more detailed dataset estimating consumption broken down.

5.2.3 Analysis of first and end use sectors

Akin to the analysis of the socio-economic footprint of the antimony industry itself, this study also aims to assess the impact of the downstream *use* of antimony. This analysis relied on three separate steps:

1. The determination of the overall size and socio-economic indicators of each of the first use and end use sectors where antimony is used.

2. The determination of the amount of antimony used in these sectors (as described in section 5.2.2).

3. The combination of these two estimates to estimate the socio-economic footprint *attributable* to antimony.

This analysis is illustrated in the tables on the following pages. For each of the first use and end use sectors for antimony, industry statistics were compiled for each of the five countries, identifying aggregate sales, value addition, and employment indicators. These estimates were derived using two distinct approaches.

In the case of lead acid batteries and flame retardants, a company-by-company analysis was once again undertaken, similar to the analysis for the antimony industry described in section 5.2.1. In total, 34 companies from these sectors were profiled in this manner.

In the other sectors, a company-by-company analysis was impractical owing to the many thousands of companies involved in, for instance, the production of pigments or glass. Owing to this reason, and the lesser importance of these sectors to antimony generally, an industry-level analysis was relied on instead. For this analysis, for each of the first and end use sectors of antimony, the relevant codes from the Nomenclature des Activités Économiques dans la Communauté Européenne (NACE) were identified that encapsulated these industries. NACE industries are generally broader industry groupings, relating, for instance, to the "manufacture of batteries and accumulators", rather than specifically to *lead-acid* batteries. For each sector, the most specific industry category was identified, where possible on a "four-digit" level, but on a two-digit level for some of the broader end sectors, such as related to the use of antimony in automotive applications.

Drawing on these NACE codes, basic indicators on the aggregate size of each industry were sourced from Eurostat, providing details on output, establishments, employment, and labour cost. These statistics were used to calculate industry-average ratios, such as the amount of value addition, number of employees and labour cost, per million Euros of output. Antimony-specific figures were then estimated by estimating the value of antimony used in each industry, drawing on the analysis of flows of antimony and market prices of the individual antimony products, and multiplied by these ratios. An adjustment factor was also applied, to consider that the total amount of output generated in each sector exceeds the aggregate value contributed by antimony, other raw materials and other inputs, owing to value addition.

Table 2: Overview of overarching industries of selected antimony applications and end sectors

	Contained within	
	NACE code	NACE description
First uses		
Flame retardants	C2059	Manufacture of other chemical products N.E.C.
-Plastics	*C222*	*Manufacture of plastics products*
-Rubber	*C221*	*Manufacture of rubber products*
-Textiles	*C1310*	*Preparation and spinning of textile fibres*
PET catalysis	C2016	Manufacture of plastics in primary forms
PVC heat stabilisation	C2016	Manufacture of plastics in primary forms
Special glass	C2319	Manufacture and processing of other glass
Ceramic opacifying	C233/4	Manufacture of ceramic products
Other non-met. (mainly pigments)	C2012	Manufacture of dyes and pigments
Other met. (mainly ammunition)	C2540	Manufacture of weapons and ammunition
Lead-acid batteries	C2720	Manufacture of batteries and accumulators
End sectors		
Electro & Electronic	C26/7	Manufacture of electrical equipment, computer, electronic and optical products
Misc. industrial	C	Manufacturing
Machinery and equipment	C28	Manufacture of machinery and equipment n.e.c.
Construction & Household furniture	C31	Manufacture of furniture
Automotive	C29	Manufacture of motor vehicles
Textiles	C131/139	Manufacture of other textiles
Other	C	Manufacturing

Source: Roskill, European Commission

Table 3: EEA: Multipliers for value addition, employment and labour costs for selected sectors

	Per €M of revenue			Value of Sb	Output as % of	Value of Sb units		
	Value addition	Employees	Labour cost	units	factor inputs	Value addition	Employees	Labour cost
	€	#	€	€ M	%	€ M	#	€ M
First uses								
Flame retardants	271,073	2.30	144,267	134.4	137%	50	425	27
-Plastics	*300,900*	*5.53*	*200,481*	*113.1*	*143%*	*49*	*894*	*32*
-Rubber	*348,276*	*6.03*	*237,665*	*5.3*	*153%*	*3*	*49*	*2*
-Textiles	*232,512*	*5.83*	*156,000*	*16.0*	*130%*	*5*	*121*	*3*
PET catalysis	167,840	1.38	93,770	8.0	120%	2	13	1
PVC heat stabilisation	167,840	1.38	93,770	0.8	120%	0	1	0
Special glass	444,654	6.80	302,434	7.6	180%	6	93	4
Ceramic opacifying	379,527	7.39	264,622	1.9	161%	1	23	1
Other non-met.	287,836	2.80	168,574	4.6	140%	2	18	1
Other met.	371,801	4.35	247,611	12.2	159%	7	84	5
Lead-acid batteries	214,777	3.42	165,954	71.3	127%	20	311	15
End sectors								
Electro & Electronic	313,446	4.52	221,342	18.8	146%	9	123	6
Misc. industrial	258,368	4.06	167,957	9.3	135%	3	51	2
Machinery and equipment	330,636	4.56	230,103	8.3	149%	4	57	3
Construction & Household furniture	321,613	8.81	238,096	3.6	147%	2	47	1
Automotive	220,086	2.98	149,386	31.3	128%	9	119	6
Textiles	268,954	5.49	185,556	3.6	137%	1	27	1
Other	258,368	4.06	167,957	22.3	135%	8	122	5

Source: Roskill, Eurostat

5.3 Indirect effects

Indirect effects are generally separated into two types:

I. Type I effects relate to socio-economic effects resulting from the dependence of a sector on other, supporting industries. This includes both the immediate requirements for inputs from the sector – for items such as construction materials, energy and services – as well as the additional requirements that the providers of such goods and services themselves require, thus creating a lengthy chain of inputs and outputs leading to the finished product. These effects are discussed in section 5.3.1 and 5.3.2 below.

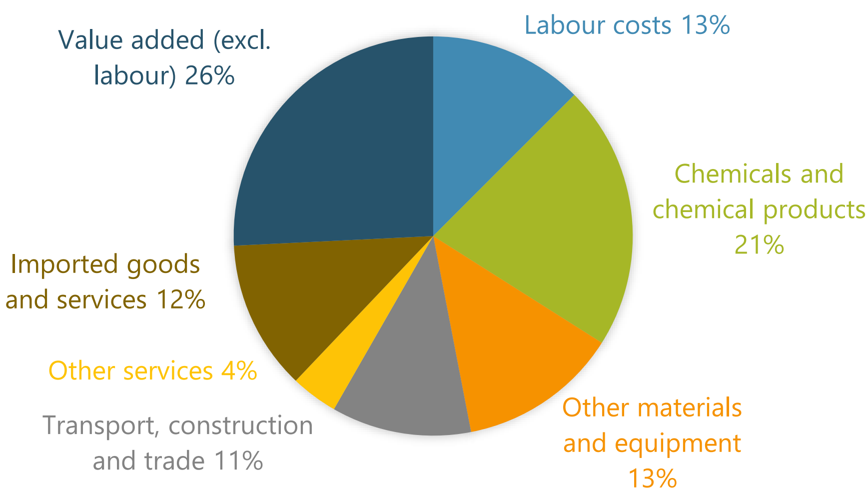
II. Type II effects relate to *income* effects, resulting from employment and the generation of labour income, part of which is reinvested in local economies. As employees spend part of their salaries on various consumer products and services, the contribution to local demand by an industrial or mining operation does not only result from its own requirements, but also from the demand generated by its employees. These effects are discussed in section 5.3.3 below.

5.3.1 First-round requirements for inputs

Like other industries, chemical and metal processing industries rely on a large amount of inputs to produce their output. Estimates for the inputs into a given industry such as chemical production, are recorded in so-called Input-Output tables, sourced from Eurostat, that track the amount of goods and services sourced from various supporting industries per Euro of output by a sector.

An example of such requirements is shown in Figure 12, for the chemical industry in the EU. On average, for every Euro of output, European chemical processors spend €0.13 on labour. They also spend €0.21 on other chemical inputs, and €0.13 on other raw materials and equipment. In addition, they spend a further €0.15 on transport, construction, trade and other services, and source €0.12 in goods and services from outside the EU. The remaining €0.26 is accounted for by the inherent value addition of the production process.

Figure 12: EU: Average composition of output in the chemical industry (% of output)



Source: Roskill, Eurostat Input-Output tables

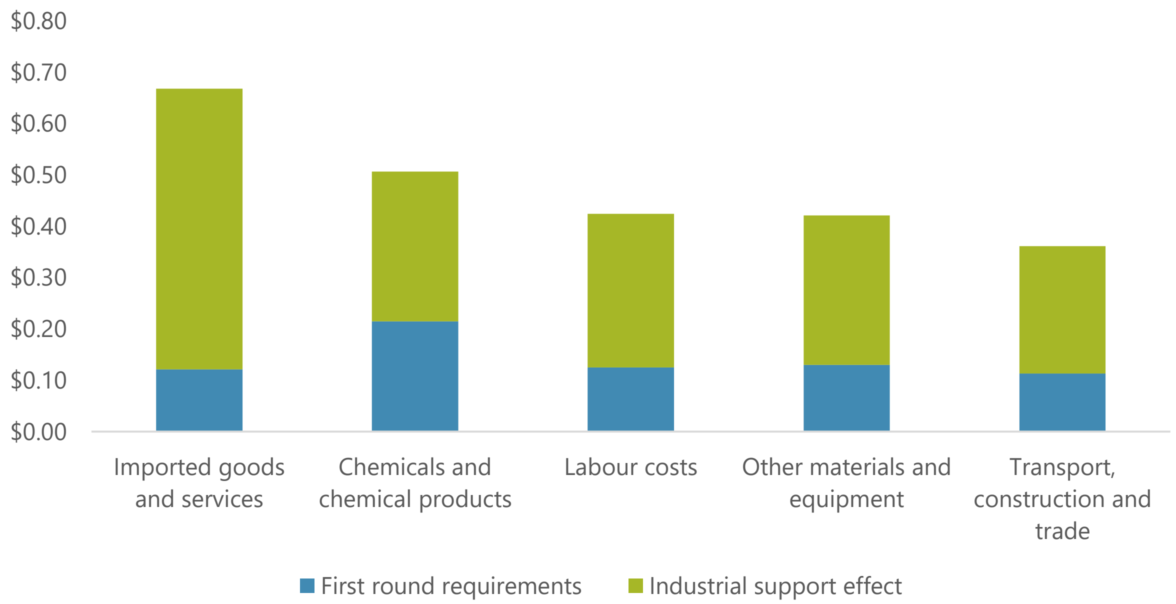
These requirements are, in this study, referred to as "first-round" requirements, and relate to the specific goods and services required by a chemical processing itself. They do not include, therefore, the further inputs required by the *suppliers* of such goods and services, which are discussed in section 5.3.2.

These requirements are an important contributor to the overall socio-economic footprint of an antimony business. The demand for chemicals, equipment and other inputs indirectly contributes to the economic activity and employment opportunities in those supporting businesses. As such, the disappearance or emergence of a chemical or metal industry does not only affect the industry itself but has an extensive knock-on effect throughout the wider economy.

5.3.2 Industrial support effect

The industrial support effect is closely related to the effects described in section 5.3.1, and form part of the so-called "Type I" effects that are related to the indirect demand for various goods and services created by an operation. Such goods and services include the requirements by the operation itself (referred to as the first-round effect) as well as all the additional, upstream inputs required for the various suppliers to produce these.

Figure 13: EU: Direct and indirect impact on economic sectors, per € in chemical output (€)



Source: Roskill, OECD Input-Output tables

The production of any given product, in other words, should be viewed as the result of a long chain of inputs of goods, services, and labour, combined with the value addition that occurs at each step of the value chain. There is, as such, no fundamental difference between the first round and industrial support effect, with the two separated in this analysis only for intuitive ease of understanding.

The figure above provides an indication of the types of inputs required per Euro of chemical processing in the EU. Notably, the total inputs add up to €2.56, exceeding the one Euro of output created at the end of the value chain. The reason for this is that to produce one Euro of chemical output, that same Euro may pass hands multiple times.[1] The net effect acts as an important multiplier, where the existence of a

[1] For an intuitive example to understand why the aggregate value of inputs can exceed the value of the output, consider the purchase of a €100 piece of furniture from a furniture shop. That shop may buy the piece from a local craftsman for €80, who may himself have paid €60 for wood supplies

mining industry (or any other industry) can foster significant economic activity well beyond the scope of its own operation.

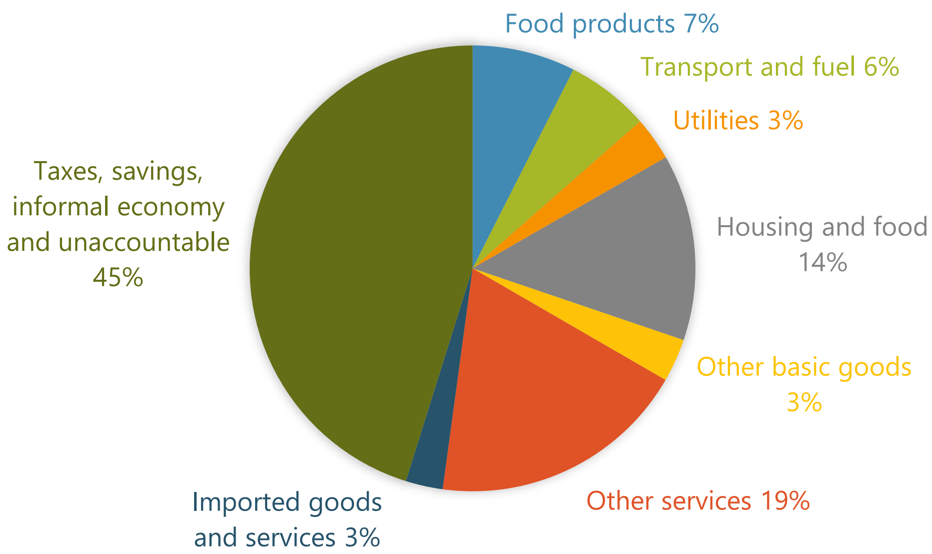
5.3.3 Income effects

Income or "Type II" effects relate to the additional impact on economic activity resulting through employment. The cost of labour accounts, in most sectors, for a substantial share of overall costs of production. Such labour costs, however, do not merely end up in the pockets or saving accounts of employees, but often flow back into a local economy – through the rental of real estate, purchases of food, clothing and consumer products, and entertainment expenses.

Once again, Eurostat data provides some insight into aggregate household spending. When taken as a percentage of overall household income, this provides an estimate of the portion of labour income that is reinvested. In the case of the EU, just over half of household income has been modelled to flow back into known sectors, with most of the spending accounted for by various necessities such as housing, food and transport.

A large portion of income cannot be specifically accounted for – resulting from discrepancies between estimates for household income and spending, the effect of taxes, savings, and the informal economy. Only the traceable portion (55%) from the figure below has been included in the analysis, to ensure that the study errs on the safe side and does not overestimate the size of this income effect.

Figure 14: EU: Household spending as a percentage of growth domestic product (%)



Source: Roskill, OECD Input-Output tables

As income flows back into the economy, it once again contributes to further economic activity and job creation, in housing, food, transport, textile and other industries. Once again, such activity sets in motion a chain of further indirect effects – highlighting the complexity of the "ripple effect" of a single operation and the dynamic nature of economic ecosystems.

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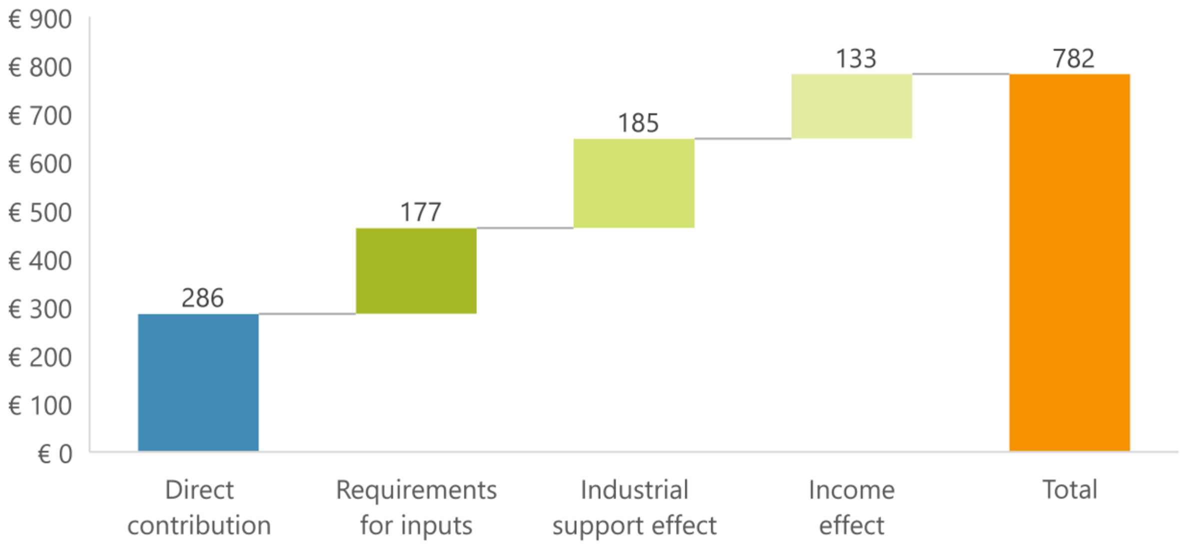
and paint. The €100 purchase thus supported €140 in economic activity, as part of the amount passed hands multiple times. Such "double counting" is intentional, as it relates to economic activity. Measures relating to *value addition* instead of output, on the other hand, generally avoid such double counting. Both output and value addition measures are included in this study.

5.4 Direct, Type I and Type II effects

The various indirect effects described in section 5.3 are often substantial. The figure below shows estimates for the net contribution to output or economic activity attributable to the antimony industry. The antimony industry itself accounted for average revenues of €286M over the years from 2010-2017, but indirect effects meant that the true economic impact of the industry amounted to more than €782M (Figure 15).

As discussed in the various country sections in this study, when it comes to employment, indirect effects related to the chemical and metal processing industries may often exceed the direct component. Owing to the higher labour intensity in supporting industries such as transport and construction, compared to capital-intensive chemical and metal processing industries, more jobs are often created through the requirements of an antimony operation for goods and services, than it may create on-site. This underlines the importance of need for studies such as the present one, as ignoring such effects would underestimate the true economic significance of antimony industry, and many other industrial sectors.

Figure 15: EU: Estimates for average direct and indirect contributions to output from the antimony industry, 2010-2017 (%)



Source: Roskill

5.5 Methodological challenges

5.5.1 Data gaps

The preceding sections have outlined the various methodologies and data sources used to compile the report. However, the antimony industry is comparatively opaque, with only some companies publicly reporting production figures, and only limited information being available for the various private companies. Similarly, for countries such as Kazakhstan, macroeconomic data is more limited.

Data gaps were addressed through several estimation methods. In the case of company data, Roskill's estimates of antimony production and published information on market prices were used to estimate antimony revenues. Industry ratios – derived from other peer companies with more published information – were used to fill in any gaps in employment, value addition, EBITDA, labour costs, etc. Where data was available for some years but not others, annual figures were extrapolated either using production and revenue as a proxy, using average growth trends, or using flat-line growth as a last resort.

With respect to industrial statistics in Eurostat's database, some gaps were also apparent, with more limited data available for some countries and some years. Where appropriate, gaps were filled by reference to the more basic but more comprehensive data at the "two-digit" rather than "four-digit" industry level.

Owing to these various estimation methods, the figures presented in this report should be considered *indicative*. Wherever possible, the report has sought to err on the conservative side, to avoid any risk of overestimation.

5.5.2 Double-counting

The methodology employed by the study has taken note of potential risks of double counting and implemented necessary adjustments to address these.

The main problem creating a risk of double counting concerns the issue of *vertical integration* in flame retardants. In this sector, some of the producers of antimony oxides and compounds also produce antimony-based flame retardant *masterbatches*. As part of the company-by-company analysis described in section 5.2.1. The additional employees, value addition, and labour cost associated with this processing step has already been accounted for under the production of antimony. As such, counting these companies "again" as producers of flame retardant masterbatches would result in double counting. To adjust for this, Roskill estimates that 50% of antimony-based masterbatches in the EEA are produced by vertically-integrated producers, with estimates for the socio-economic footprint of flame retardants thus reduced by this amount, by producers such as Campine and AMG.

5.6 Model parameters

The methodology used in this study is a well-established one, based originally on the work by the Russian-American Nobel-prize winning economist Wassily Leontief. The various Type I and Type II indirect described in section 4.2 were first explored by Leontief and are now commonly used in socio-economic impact analysis across sectors. The figures presented in the country sections of this report therefore include both effects, by default. However, several variations of the data offer slightly different interpretations of the socio-economic footprint of the antimony industry and are included in the report.

5.6.1 Inclusion of indirect effects

In some instances, it may be of interest to assess socio-economic impact without indirect effects. For instance, the "Type II" or "labour income" effect relates to the economic activity resulting from the reinvestment of employees' labour income into the local economy. This factor, however, may be deemed less important in economies with a shortage of labour, where such employees may be expected to readily find re-employment elsewhere, so that it may be desirable to assess effects both with and without this effect included.

For this reason, chapter 6.6 presents alternative estimates for the main figures presented in the report including and excluding such various indirect effects.

5.6.2 Antimony allocation factors

Another main interpretative consideration relates to the calculation of antimony *allocation factors.* Consider a hypothetical industry sector with 100 employees, and total revenue of €10M, composed of the cost of inputs of €8M and value addition of €2M, with the cost of antimony accounting for €500,000.

In this example, antimony accounts for 5% of the overall output of the sector, but for 6.25% of the cost of inputs, excluding the sector's value addition. In determining the number of employees attributable to antimony, Roskill typically relies on the latter figure, which would result in an estimate of 6.25 employees, which implicitly attributes part of the value addition taking place within the sector to the use of antimony, whereas the lower 5% figure (corresponding to 5 employees) would not take such value addition into account. The former approach - taking value addition into account and attributing part of it to the use of antimony – is the default one adopted in this report, and is illustrated in the table in section 5.2.35.2.3. In chapter 6.6, however, the alternative measure is also shown, for comparison.

6. Socio-economic footprint of the antimony value chain

6.1 Contribution to output

This section and section 5.2 consider the contribution of antimony to output and value addition, respectively. Output refers to the revenue generated by a company. To create that revenue, a company would have had to purchase goods and services from other suppliers, so that the same one million Euros of revenue generated by a company, leads to additional revenue elsewhere in the value chain.

In measures of output, as explored in this section, such double counting is acknowledged and intentional, being indicative of overall economic activity. In section 5.2, which considers value addition, only the increase in value at each part of the value chain is considered, which reduces the amount of double counting, and provides an alternative insight into the economic significance of antimony in the EEA's economy.[1]

Roskill estimates that antimony contributed an average of nearly €837M billion *directly* to the EEA's economic output over the years 2010-2017.

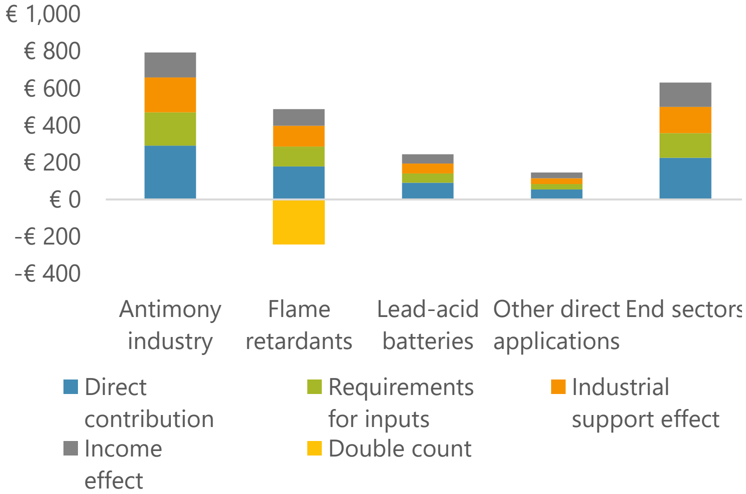
Of this amount, €290M was accounted for by the direct contributions of the antimony industry, calculated as the market value of the antimony products produced. A further €547M is accounted for by the use of antimony in downstream applications, including in flame retardants and lead-acid batteries.

In addition to these direct effects, however, a substantial part of antimony's economic contribution is accounted for by *indirect* effects. Both the production of antimony and its downstream products rely on substantial amounts of other inputs of goods and services from other sectors (direct requirements), which in turn depend on their own supply chains and contributions from other industries (industrial support effect). Finally, the contribution to employment that these various industries generate leads to substantial labour income, part of which is reinvested in the local economy to drive further economic activity. These dynamics are explained in further detail in the methodology section.

In the EEA, the indirect effects of the antimony value chain are estimated to contribute a further €1,219M in output to the EEA's economy, for a total contribution of €2,056M (Figure 16 and Figure 17).

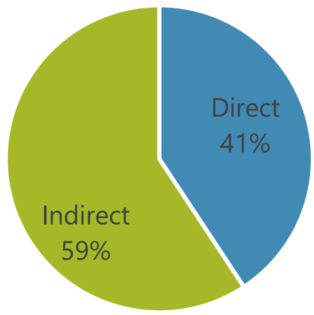
[1] See also footnote 1 on page 14 for an additional explanation of the difference in these two approaches.

Figure 16: EEA: Average annual contribution to output by sector and type of effect, 2010-2017 (€ M)



Source: Roskill

Figure 17: EEA: Breakdown of output by direct and indirect effects (%)



Source: Roskill

6.2 Contribution to value addition

Value addition relates to that portion of revenue not accounted for by the cost of other goods and services. It represents the intrinsic value that is added as part of the manufacturing process, with the finished product being more valuable than the sum of its individual inputs. Part of this value addition is accounted for by the costs of *labour*, which is generally included within the definition of value addition.

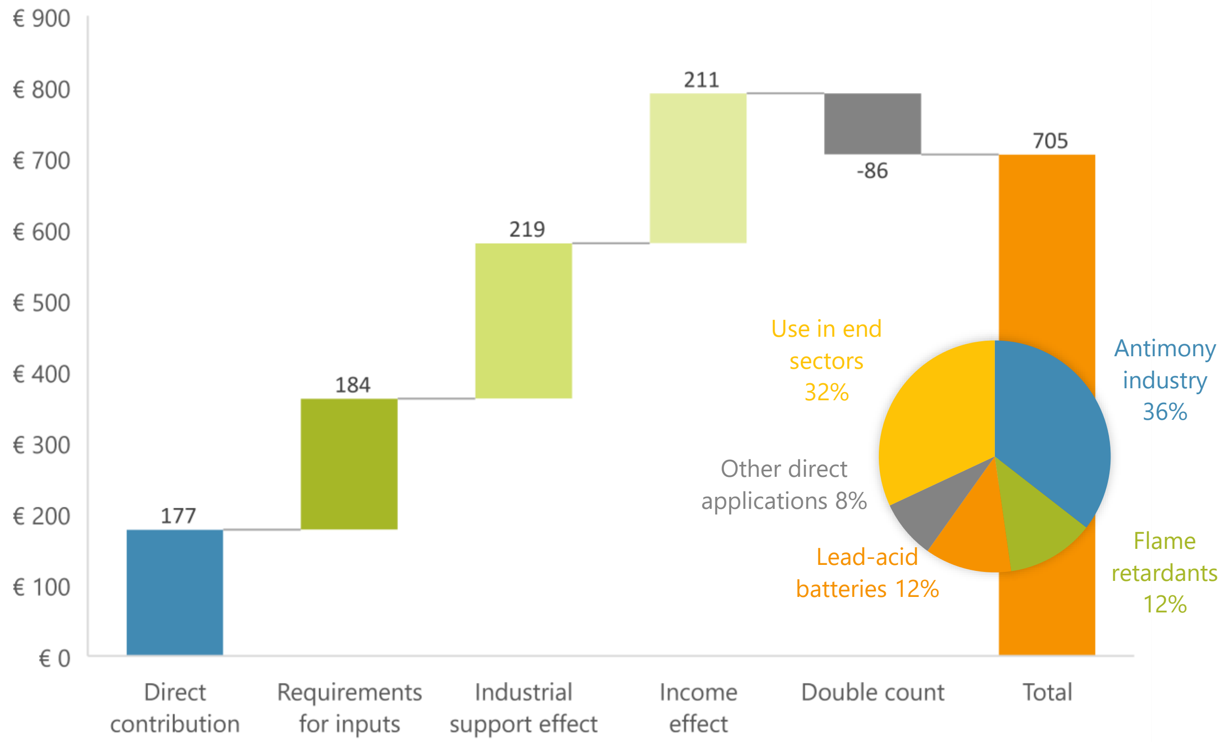
Value addition often represents the better indicator compared with output, by reducing risks of double-counting.

In the EEA, the antimony industry itself is estimated to have contributed €42M in value directly, and a further €208M indirectly, through its demands on suppliers of goods and services.

In the downstream use of antimony, flame retardants, lead-acid batteries and other applications, a further €135M of value was added that was directly attributable to antimony (based on the percentage of the cost of inputs accounted for by antimony). An additional €319M was created indirectly in these parts of the value chain, after adjustment for double counting of vertically-integrated companies (see section 5.5.2).

The total contribution of antimony to value addition in the EEA thus amounted to €705M over the years 2010-2017 (Figure 18).

Figure 18: EEA: Average annual contribution to value addition, by sector and type of effect, 2010-2017 (€ M)



Source: Roskill

6.3 Industry EBITDA

The antimony industry has faced several challenges of the years, including high regulatory and compliance costs, and competition from lithium-ion batteries and non-halogenated flame retardants. This, combined with high prices of antimony in the early 2010s, contributed to some fall in demand.

Prices of antimony have since fallen, to a level no longer justifying substitution but as a result margins for producers in the industry – which were slim to begin with – have fallen further.

Based on its company-by-company analysis described in section 5.2.1, Roskill estimates that the aggregate EBITDA in the industry in 2017 amounted to only €11M, compared to output of €284M, or a margin of just 4%. Over the years from 2010 to 2017, the industry EBITDA averaged only slightly higher at €14M, compared to turnover of €286M, or a margin of 5% (Figure 19).[1]

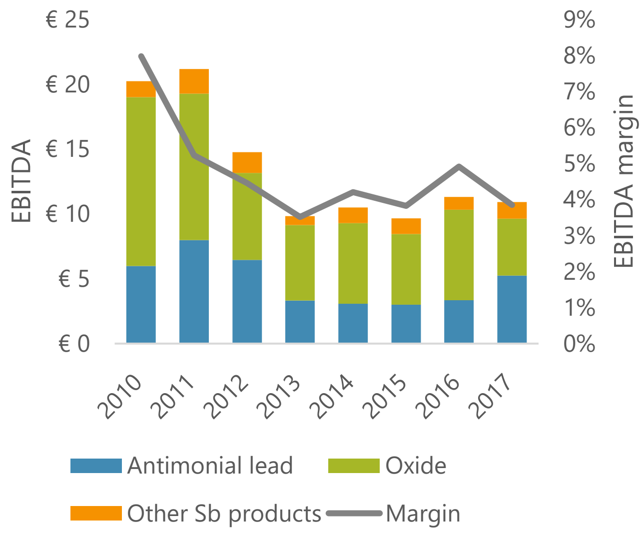
The second figure below compares the industry's estimated EBITDA to that of nickel, for which Roskill has undertaken a similar socio-economic analysis, covering the EEA, for the years 2010-2014. During these years, the nickel industry in the EEA had an average annual EBITDA of €137M, with the EBITDA in more recent years estimated at a similar figure of €131M (Figure 20).

While the margin during these eight years was an average 5%, comparable to antimony, the industry's profit margin in absolute terms was thus nearly 10 times higher than for antimony.

[1] Note that these figures only relate to the antimony industry, and not its downstream applications in flame retardants, lead-acid batteries, etc. Estimates are based on company-by-company analysis, and where possible draw on segmental financial reports from each company. Antimony is usually produced alongside a range of other products. As financial reports generally do not split financial performance by product, the EBITDA margin cited may reflect a varying range of chemical products for different companies, although antimony represents the common link between these.

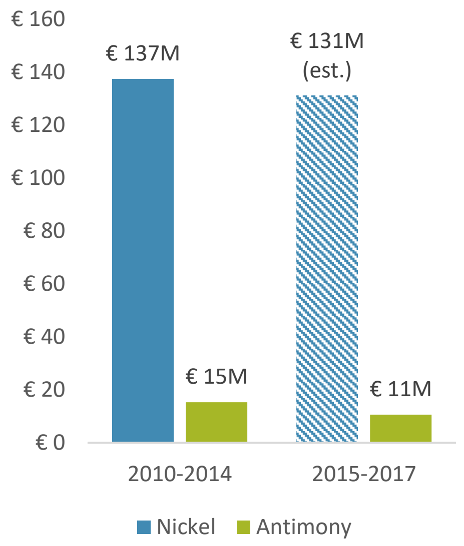
The comparatively small size of the antimony industry poses a challenge to its producers, as it increases the relative cost of regulatory performance, for instance in the case of REACH, where larger industries may be able to more easily fund the costs of research and public communication.

Figure 19: EEA: Estimated EBITDA in the antimony industry, 2010-2017 (€ M)



Source: Roskill

Figure 20: EEA: Comparison of industry EBITDA to nickel (annual € M)



Source: Roskill

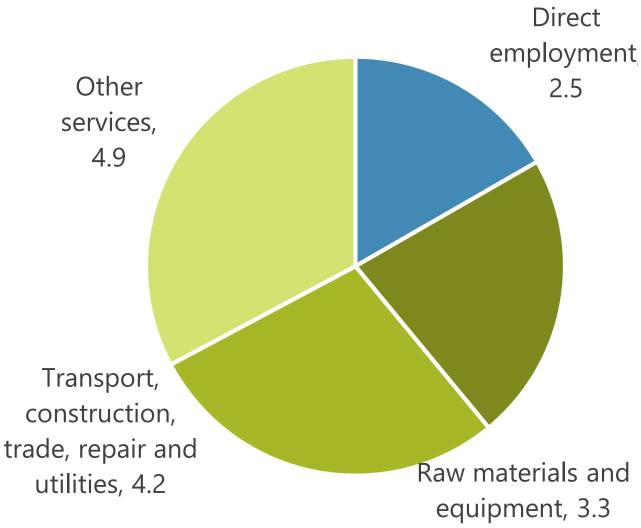
6.4 Contribution to employment

Chemical and metal processing industries, as a general rule, are comparatively capital intensive, and the high degree of mechanisation and/or automisation means that such operations generally contribute a meaningful, but modest number of direct employment opportunities.

However, at the same time, these operations rely on goods and services supplied by industries where labour intensity is dramatically higher. This includes, for instance, sectors such as transport services (such as trucking), construction and various trade services.

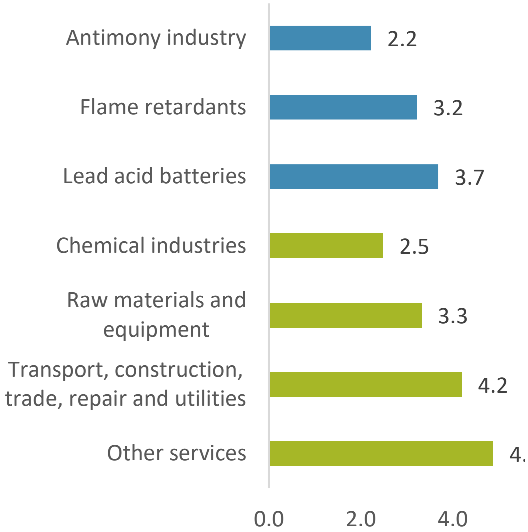
As a result, when it comes to employment, more jobs will generally be created off-site a processing plant (whether this is a chemical or metallurgical operation) than on-site. On average, for instance, a chemical processing operation would be expected to contribute around 15 jobs to the local economy per million Euros of output, of which only 2.5 would be generated on-site (Figure 21).

Figure 21: EEA: Typical contribution to employment by a chemical processing facility (number of employees/€M)



Source: Roskill

Figure 22: EEA: Typical labour intensity by sector (employees/€M)

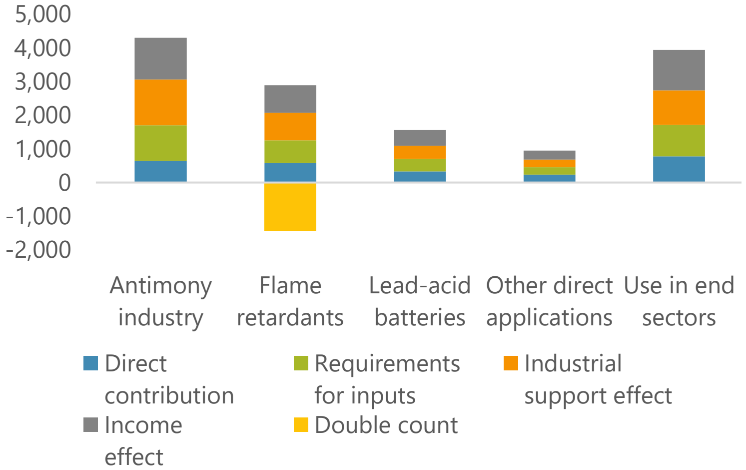


Source: Roskill

With respect to the antimony industry, the same conditions apply. Roskill's company-by-company accounting of employees and contractors at chemical and metal processing plants in the antimony industry, suggests there are approximately 642 employees and contractors employed directly in the production of antimony products, with a further 1,919 employees attributable to antimony in its downstream applications (this once again represents a small share of the total number of employees in all the various downstream sectors, with only a portion of these attributed to antimony based on the relative value of antimony as a share of inputs).

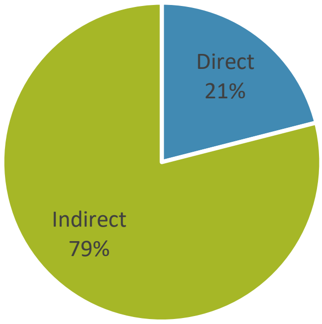
Such direct employment opportunities thus add up to around 2,561 positions. Owing to the points made above, related to the much higher labour intensity among some of the industries that *supply* the antimony industry, a much larger amount of jobs is created via indirect means. Drawing on input-output models and employment statistics sourced from the OECD, Roskill estimates that these indirect positions to amounted to 9,621 additional jobs over the years 2010-2017 (Figure 23 and Figure 24).

Figure 23: EEA: Average annual contribution to employment by sector and type of effect, 2010-2017 (number of employees)



Source: Roskill

Figure 24: EEA: Breakdown of employment by direct and indirect effects (%)



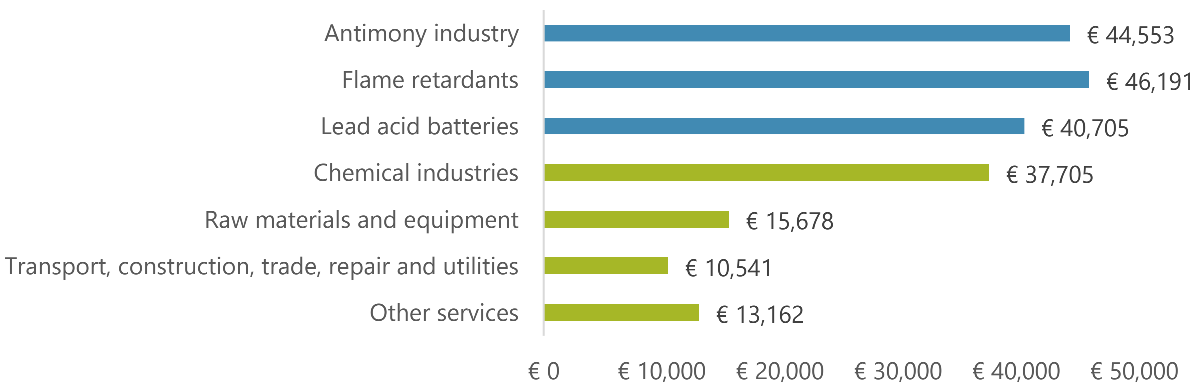
Source: Roskill

6.5 Contribution to labour income

In determining the contribution to labour income, an important qualifying consideration is the variation in pay between different sectors of the economy. Whereas it has been previously noted that the metal and chemical industries are relatively capital intensive and rely on fewer employees per Euro of output than other more labour-intensive sectors, salaries in the mining and processing industries are generally substantially higher. This, of course, reflects the comparatively higher labour productivity, or the amount of revenue that each employee can contribute.

Owing to the higher salaries in these sectors, labour income received in metal and chemical processing is disproportionately higher than in other sectors. Despite direct on-site employment at such plants accounting for only 21% of the number of jobs created by antimony, Roskill estimates that these positions accounted for 32% of the total labour cost linked to the production and downstream use of antimony.

Figure 25: EEA: Average labour costs per employee in selected sectors, 2010-2017 (€/employee)

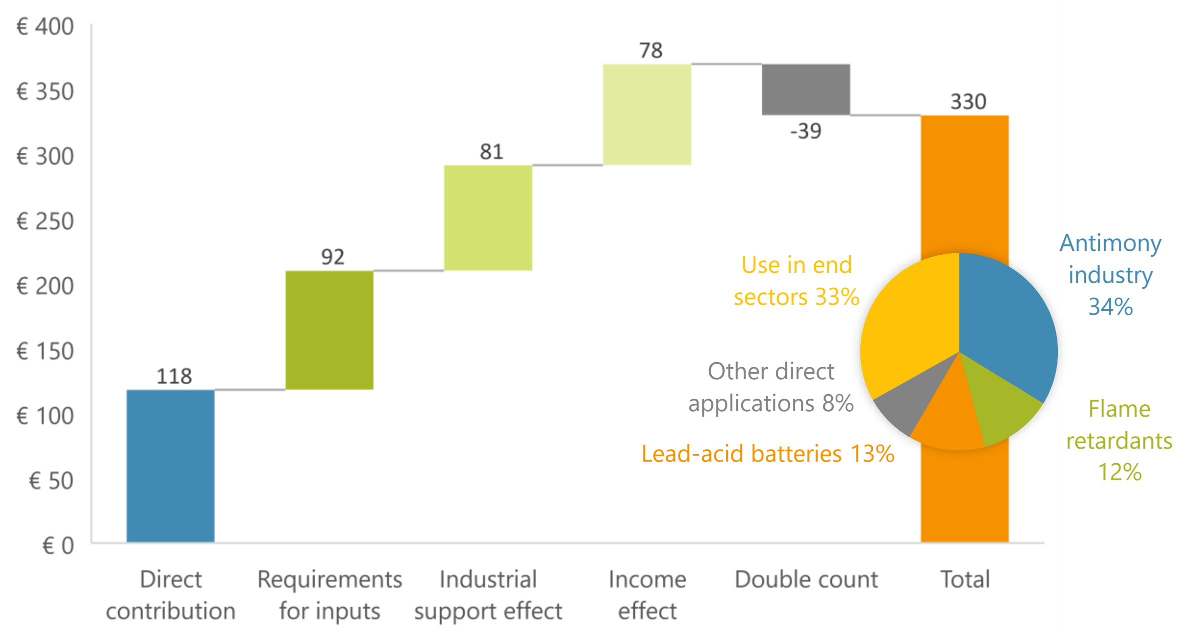


Source: Roskill; Note: some figures may include part-time workers so that figures may not be directly comparable

In total, labour costs associated with direct employment at chemical and metal processing plants and downstream operations amounted to an average of €118 over the years 2010-2017. Indirect labour costs, among upstream suppliers as well as in positions supported through the reinvestment of this labour income accounted for a further €212M, for a total contribution of €330M (Figure 26).

Of this amount, the antimony industry itself accounted for around 34%, with most labour costs incurred in the downstream use of antimony in flame retardants, lead acid batteries and other uses, and the downstream end sectors for those applications.

Figure 26: EEA: Average annual contribution to labour income, by sector and type of effect, 2010-2017 (€ M)



Source: Roskill

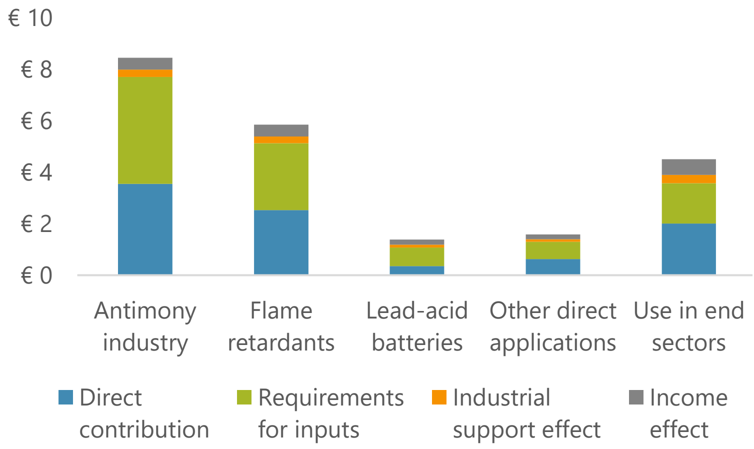
6.6 Contribution through taxation

The previous section outlined the contribution of antimony to the generation of employment opportunities and labour income. Indirectly, such labour income leads to the generation of tax income, but the antimony sector also contributes to local and national revenue more directly, through taxes on products produced, as well as other taxes on production.

On average, producers of antimonial lead reported spending 26% of their EBITDA on local and national corporation tax, employer contributions, and other taxes. On average, over the years 2010-2017, producers of antimony contributed €3.6M in taxes directly, with a further €4.9M in taxes generated by the various suppliers and indirect economy activity resulting from the production of antimony. Producers of flame retardants, lead-acid batteries and other downstream users of antimony contributed €5.5M in taxes directly, and €6.5M in indirect taxes (Figure 27 and Figure 28).

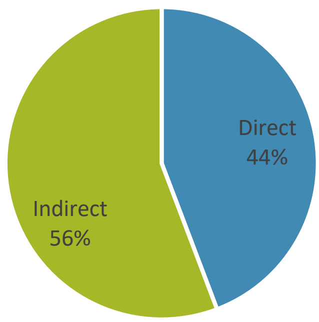
Total contributions attributable to the antimony industry therefore amounted to an estimated €20.5M per year, or a cumulative total of €164M over the eight years reviewed in the study.

Figure 27: EEA: Average annual contribution to taxation on products and production, 2010-2017 (€M)



Source: Roskill

Figure 28: EEA: Breakdown of contribution to taxes by direct and indirect effects (%)



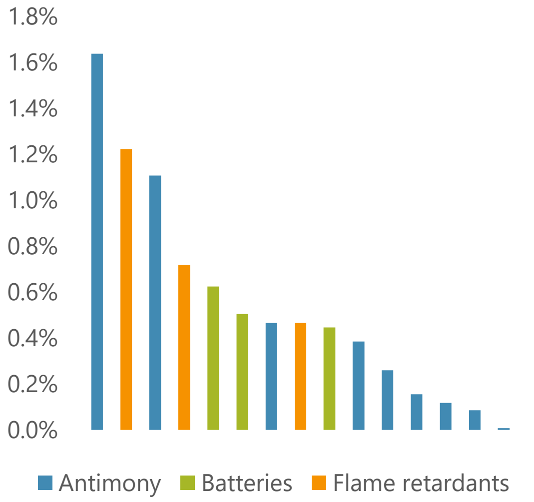
Source: Roskill

6.7 Contribution to research and development

The antimony sector is a small but dynamic and responsive industry, which has maintained an active research programme to support the continuous evolution of the use of antimony in society. Investment in R&D programmes has, for instance, focuses on enhancing the effectiveness of flame retardants, assessing and minimising their environmental and safety risks, and improving the efficiency of production processes. Producers of antimony who reported their spending on R&D, spent an average of 0.5% of their revenues on R&D, at a similar level to reported spending by battery manufacturers, while those producers of flame retardants for whom R&D spending information was available dedicated 0.8% of their revenues to research.

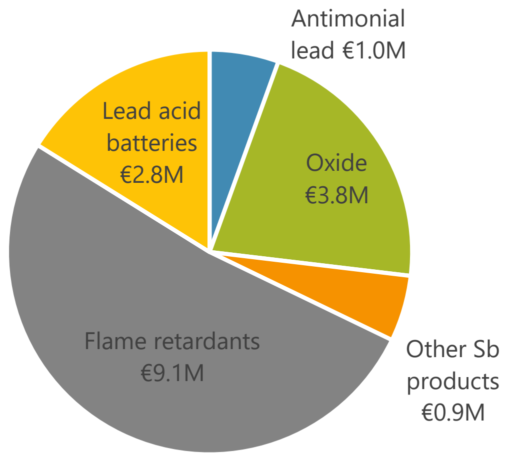
In total, Roskill estimates that R&D expenditure attributable to antimony amounted to €17.6M over the eight years from 2010-2017 (Figure 29 and Figure 30). This figure only includes the spending attributable to antimony by producers of antimony, and the main users of antimony in battery and flame retardant industries. The figure does not include additional spending on R&D that would have been triggered indirectly, by upstream suppliers and industries supporting the antimony value chain, or in some of the smaller applications of antimony. As such, actual spending on R&D within the EEA linked to or otherwise dependent on the production and use of antimony was likely substantially higher.

Figure 29: EEA: Spending on R&D by selected companies (% of revenue)



Source: Roskill

Figure 30: EEA: Spending on antimony R&D by sector, 2010-2017 (total €M spent)



Source: Roskill

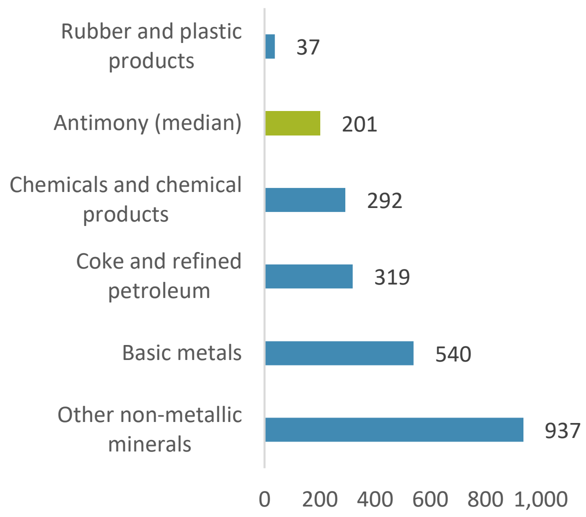
6.8 Environmental performance

Of the companies reviewed by Roskill, four producers explicitly reported their levels of greenhouse emissions. Figures reported on greenhouse emissions generally relate to overall emissions by the company or business segment, rather than the specific production of antimony. As a result, levels of emissions may vary widely between companies, depending on their product mix and involvement in other industries or value chains, producing products that may be associated with a higher or lower energy intensity and environmental footprint.

However, some indication of the relative size of the environmental footprint of producers of antimony may be obtained by taking the median level of emissions reported by these producers. Over the years from 2014 to 2017, median emissions for these four companies averaged 201 tonnes per million Euros of revenue. This figure compares favourably with typical emissions among companies producing chemicals (at 292 tonnes) and basic metals (at 540 tonnes) – the two industry sectors most closely related to the production of antimony. As such, despite the limited number of companies for which data could be collected, the production of antimony appears to have a comparatively small environmental footprint within the EU (Figure 31).

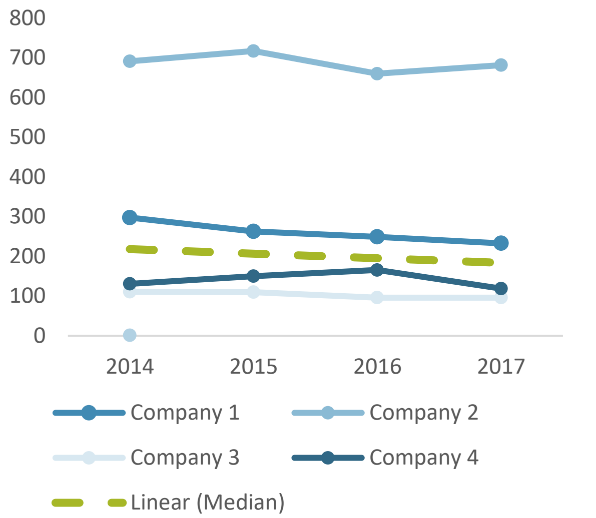
Moreover, all the four companies for which data was available reduced their level of emissions from 2014 to 2017, with median emissions falling from 214 tonnes to 176 tonnes per million euros of output (Figure 32).

Figure 31: EU: Greenhouse emissions for selected sectors (t CO_2-equivalent per million Euros of revenue)



Source: Roskill

Figure 32: Greenhouse emissions reported by producers of antimony (t CO_2-equivalent per million Euros of revenue)



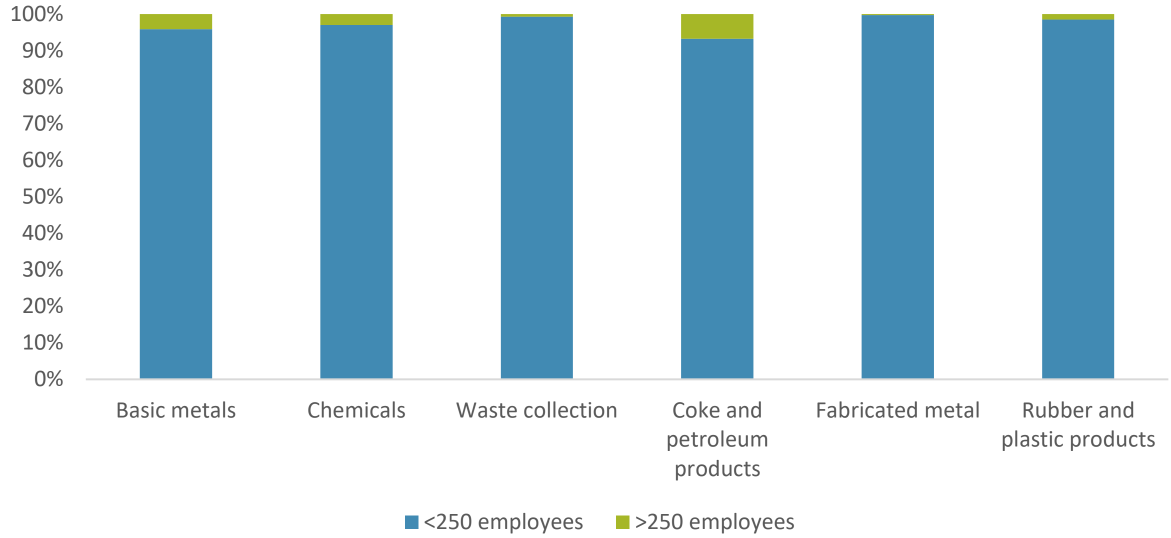
Source: Roskill

6.9 Small and medium enterprises

Among the producers of antimony reviewed as part of this study, four out 26 producers reviewed were deemed to be classified as a small or medium enterprise, with 250 or fewer employees, and turnover below €50 million euros. However, while the production of antimonial lead, antimony oxides, and compounds is mainly dominated by larger producing companies, the industrial inputs relied on by these companies are sourced largely from sectors where small and medium enterprises account for most of the economic activity.

The figure below shows the estimated number of enterprises with more than or less than 250 employees, respectively, for six of the main sectors of relevance to the production of metal and chemical products such as antimony. Eurostat data suggests that SMEs account for more than 93% of the number of companies in each of these six sectors (Figure 33). While it cannot be precisely determined which individual companies provide products and materials used by producers of antimony, or downstream companies involved in the production of flame retardants or batteries, it is therefore likely that the production and use of antimony support many SMEs and their employees.

Figure 33: Percentage of small and medium enterprises in six of the main industries supporting the production of antimony, 2011-2017



Source: Eurostat

7. Discussion

The tables on the following two pages provide a more detailed breakdown of five of the main indicators discussed in chapter 6, including total output, value addition, labour income, contributions through taxation, and employees.

The two tables differ in one key characteristic, related to the allocation of socio-economic effects in the downstream applications of antimony, to the use of antimony itself:

- Table 4 shows the baseline figures used throughout the rest of this report and includes estimates for the footprint of the antimony industry, as well as including an allowance for the further economic activity generated using antimony in the rest of its value chain. The allocation of these effects is based on the value of antimony as a percentage of the total cost of inputs in downstream sectors. This approach is deemed by Roskill to be the most reasonable estimate for antimony's overall contribution to economic activity.

- Table 5 shows similar figures but uses an alternative method for the calculation of the portion of effects that is deemed to be attributable to antimony. As mentioned in the previous paragraph, the baseline figures attribute such effects by determining an allocation factor, defined as the value of antimony as a percentage of overall inputs. In the second table, conversely, the allocation factor used is the value of antimony as a percentage of total output. This approach is not deemed, by Roskill, to be preferable, but results in slightly lower estimates, which are included for reference purposes and transparency. The discussion of the calculation of different allocation factors is discussed further in section 5.6.2.

Each table also breaks down the figures between: (1) the footprint of the production of antimony itself; (2) the footprint associated with the direct use of antimony in its immediate applications in flame retardants, lead-acid batteries, and others; (3) the further use downstream, in final consumer or industrial end products.

For each part of the industry, figures are, additionally, broken down between *direct* effects, *first round requirements*, *industrial support effects* and *income effects*, which have been explained in the definitions.

Table 4: Summary of results, baseline[1]

	Output	Value addition	Labour income	Taxes	Employees
	€M	€M	€M	€M	#
Antimony industry					
Direct effect only	290	42	29	4	642
First-round reqs. (Type I)	180	64	31	4	1,060
Industrial support effect (Type I)	188	78	28	0	1,363
Direct-effect + Type I	**658**	**185**	**88**	**8**	**3,065**
Income effect (Type II)	135	65	24	0	1,237
Direct effect + Type I and Type II	**793**	**250**	**112**	**8**	**4,302**
Batteries, flame retardants and other applications					
Direct effect only	321	81	52	4	1,140
First-round reqs. (Type I)	189	71	35	4	1,263
Industrial support effect (Type I)	196	82	30	0	1,435
Direct-effect + Type I	**706**	**233**	**118**	**8**	**3,838**
Income effect (Type II)	170	82	30	1	1,553
Direct effect + Type I and Type II	**876**	**315**	**148**	**9**	**5,391**
Adjustment for double count	-243	-86	79	-3	-1,443
Downstream use					
Direct effect only	226	55	37	2	779
First-round reqs. (Type I)	132	49	25	2	926
Industrial support effect (Type I)	142	58	23	0	1,030
Direct-effect + Type I	**499**	**162**	**85**	**4**	**2,736**
Income effect (Type II)	131	63	23	1	1,197
Direct effect + Type I and Type II	**630**	**225**	**109**	**5**	**3,932**
Total					
Direct effect only	837	177	118	9	2,561
First-round reqs. (Type I)	501	184	92	10	3,249
Industrial support effect (Type I)	525	219	81	1	3,828
Direct-effect + Type I	**1,863**	**580**	**291**	**20**	**9,638**
Income effect (Type II)	436	211	78	2	3,987
Direct effect + Type I and Type II	**2,300**	**791**	**369**	**22**	**13,625**
Adjustment for double count	-243	-86	79	-3	-1,443
Total	**2,056**	**705**	**448**	**19**	**12,182**

Source: Roskill; Note: 1) effects attributed to antimony calculated in downstream sectors based on the value of antimony as a percentage of cost of inputs.

Table 5: Summary of results, alternative[1]

	Output	Value addition	Labour income	Taxes	Employees
	€M	€M	€M	€M	#
Antimony industry					
Direct effect only	290	42	29	4	642
First-round reqs. (Type I)	180	64	31	4	1,060
Industrial support effect (Type I)	188	78	28	0	1,363
Direct-effect + Type I	**658**	**185**	**88**	**8**	**3,065**
Income effect (Type II)	135	65	24	0	1,237
Direct effect + Type I and Type II	**793**	**250**	**112**	**8**	**4,302**
Batteries, flame retardants and other applications					
Direct effect only	241	59	38	3	826
First-round reqs. (Type I)	142	53	27	3	944
Industrial support effect (Type I)	147	62	23	0	1,078
Direct-effect + Type I	**530**	**173**	**87**	**6**	**2,847**
Income effect (Type II)	127	61	23	1	1,158
Direct effect + Type I and Type II	**656**	**234**	**110**	**7**	**4,006**
Adjustment for double count	-184	-65	-30	-2	-1,083
Downstream use					
Direct effect only	165	40	27	1	565
First-round reqs. (Type I)	96	36	18	1	675
Industrial support effect (Type I)	103	42	16	0	752
Direct-effect + Type I	**365**	**118**	**62**	**3**	**1,991**
Income effect (Type II)	95	46	17	0	872
Direct effect + Type I and Type II	**460**	**164**	**79**	**3**	**2,863**
Total					
Direct effect only	696	140	93	8	2,032
First-round reqs. (Type I)	418	153	76	8	2,679
Industrial support effect (Type I)	438	182	68	1	3,192
Direct-effect + Type I	**1,552**	**476**	**237**	**17**	**7,903**
Income effect (Type II)	358	173	64	2	3,267
Direct effect + Type I and Type II	**1,910**	**649**	**301**	**18**	**11,171**
Adjustment for double count	-184	-65	-30	-2	-1,083
Total	**1,725**	**584**	**271**	**16**	**10,088**

Source: Roskill; Note: 1) effects attributed to antimony calculated in downstream sectors based on the value of antimony as a ***percentage of total output***

8. Conclusion

This report has sought to provide a succinct overview of the role of the antimony industry within the global economy, and more specifically within that of the EEA.

Although it lacks any of its own mine production, the EEA accounts for around 23% of the global production of antimony in oxides and antimonial lead, with most of its production derived from recycling or imported metal. It is also a major consumer of antimony, accounting for an estimated 16% of global consumption.

While smaller than some other metal and chemical industries, this study has estimated that the antimony value chain on average contributed €837M to the EEA's economy over the years 2010 to 2017, with indirect effects – via the industry's requirements for process inputs and labour – increasing this amount to €2,056 in economic activity, with total value addition estimated at €705M per year. In total, the study estimates that more than 12,000 jobs are dependent on antimony within the EEA, even after adjustments for double counting. These workers were estimated to have generated gross labour income of around €330M per year.[1]

In addition, the sector generated additional contributions in the form of research and investment, with a cumulative total of €17.6M in research spending found to have been linked to the production and use of antimony in the EEA over the years 2010 to 2017. Total contributions through taxes on products and production amounted to an annual average of €20.5M during the same period.

Despite these significant contributions, this report has also highlighted that compared to some larger raw material industries EEA, antimony is produced in considerably smaller volumes and has struggled with falling prices and weak demand. The aggregate EBITDA of producers of antimony was estimated at less than of €14M per year, representing a mere 5% margin.

Given these slim margins and the modest size of the sector, legislative pressure and requirements for extensive research and reporting on environmental and health risks has represented a challenge to the industry. New legislation such as REACH has required investment in extensive dossiers, public communication and compliance, which poses a disproportionately high cost to smaller industries. Subsequent classification, workplace restriction or product restriction requirements further add to the initial and on-going REACH efforts.

Nonetheless, the antimony industry remains an innovative part of the overall economy. The large percentage of production accounted for by recycling in the EEA makes it an exemplar case for a transition to a circular economy, characterised by the re-use of materials rather than dependence on mine output. In part for this reason, the environmental footprint of producers of antimony appears to be smaller than that of other peers, with average (and falling) emissions of 201kt per million Euros of output from 2014 to 2017, compared to 291kt for the chemical industry, and 540kt for producers of basic metals. This, together with antimony's life-saving properties as a flame retardant contribute to the sector's overall profile and socio-economic role.

[1] For a more comprehensive overview of these various conclusions, based on the findings in Chapter 6, see also section 3.3 in the Executive Summary,