
Association Connecting Electronics Industries



# Research report for IPC entitled

# '*Supply Chain Traceability of Substances of Concern Across the Electronics Sector Supply Chain*'

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Version FINAL

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# List of Abbreviations

| Term | Meaning | Term | Meaning |
|---|---|---|---|
| ACS | American Chemical Society. | IoT | Internet of Things. |
| ACEA | European Automobile Manufacturers Association. | IPC | Institute of Printed Circuits. |
| AD | Aerospace and Defence. | IRIS | Integrated Risk Information System (US EPA IRIS). |
| AD-DSL | Aerospace and Defence – Declarable Substance List. | ISTAR | Intelligence, Surveillance, Target Acquisition and Reconnaissance. |
| ADAS | Advanced Driver Assistance Systems. | IT | Information Technology. |
| AIA | Aerospace Industries Association. | IVDR | In-Vitro Diagnostic Regulation. |
| AIAG | Automotive Industry Action Group. | JEITA | Japan Electronics and Information Technology Industries Association. |
| B | Billion. | KG | Kilo Gram. |
| BEV | Battery Electric Vehicle. | LBS | Pounds. |
| BOM | Bill of Materials. | LCD | Liquid Crystal Display. |
| BSL | Basic Substance List. | LED | Light Emitting Diode. |
| CAMDS | China Automotive Material Data System. | M | Million. |
| CAP | Canada-wide Action Plan. | MDR | Medical Device Regulation. |
| CARACAL | Competent Authorities on CLP and REACH. | MRO | Manufacture Repair and Overhaul. |
| CAS | Chemical Abstract Service. | MSCA | Member State Competent Authority. |
| CBI | Confidential Business Information. | MSDS | Material Safety Data Sheet. |
| CCME | Canadian Council of Ministers of the Environment. | Mt | Million Tonnes. |
| CEFIC | The European Chemical Council. | NAS | National Aerospace Standard. |
| CII-OSH | Cross-Industry Initiative on Better Regulation in Chemicals Management. | NGO | Non-Governmental Organization. |
| CMMI | Capability Maturity Model Integration. | ODM | Original Design Manufacturer. |
| CMR | Conflict Mineral Reporting. | OEM | Original Equipment Manufacturer. |
| CMRT | Conflict Mineral Reporting Template. | PACE | Platform Accelerating the Circular Economy. |
| CRM | Critical Raw Material. | PCB | Printed Circuit Board. |
| CTA | Consumer Tech Association. | PCBA | Printed Circuit Board Assembly. |
| DG Env | Directorate-General for the Environment. | PCS | Producer Compliance Schemes. |
| DG Grow | Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs. | PGM | Platinum Group Materials. |
| DSL | Declarable Substance List. | PHEV | Plug-In Hybrid Electric Vehicle. |
| DVD | Digital Versatile Disk. | POST | Parliamentary Office of Science and Technology. |
| EC | European Commission. | PPAP | Production Part Approval Process. |
| ECHA | European CHemicals Agency. | RFID | Radio Frequency Identification. |
| ECHA MSC | ECHA Member State Committee. | RISL | Railways Industries Substance List. |
| ECHA RAC | ECHA Risk Assessment Committee. | RM | Responsible Minerals. |
| ECHA SEAC | ECHA Committee for Socio-Economic Analysis. | RoHS | Restriction of Hazardous Substances. |
| ECHA SCIP | ECHA Substances of Concern In articles as such or in complex objects (Products) database. | SAE | Society of Automobile Engineers. |
| EEA | European Economic Area. | SBO | Standards Body Organization. |
| EEE | Electrical and Electronic Equipment. | SCRM | Supply Chain Risk Management. |
| ELV | End-of-Life Vehicle. | SDO | Standards Development Organization. |
| EMS | Electronics Manufacturing Services. | SEC | Securities and Exchange Commission. |
| EOL | End of Life | SIA | Semiconductor Industry Association. |
| EPA | Environmental Protection Agency. | SIN List | Substitute It Now! List. |
| EPR | Extended Producer Responsibility. | SME | Small Medium Enterprise or Subject Matter Expert. |

| Term | Meaning | Term | Meaning |
|---|---|---|---|
| EU | European Union. | | |
| EU SRR | EU Ship Recycling Regulation. | T | Trillion. |
| FMD | Full Material Declaration. | TV | Television. |
| FSD | Full Substance Declaration. | UAE | United Arab Emirates. |
| GADSL | General Automotive Declarable Substance List. | UK | United Kingdom. |
| GHG | Green House Gases. | UN | United Nations. |
| GLAPS | Global Automotive Process Chemicals. | UNIFE | The Association of the European Rail Industry. |
| IEC | International Electrotechnical Committee. | US | United States. |
| IHM | Inventory of Hazardous Materials. | XML | eXtensible Mark-up Language. |
| IMA | International Magnesium Association. | WEEE | Waste Electrical and Electronic Equipment. |
| IMDS | International Material Data System. | WEF | World Economic Forum. |
| IMO | International Maritime Organization. | WFD | Waste Framework Directive. |

## Executive Summary

This research focuses on the completion of priority 1 tasks from a research proposal (Takhar, 2019) created by the report author, which was subsequently reviewed, and priorities assigned by IPC. The research enables effective decision-making to be undertaken and will aid any further research in to the same topic area.

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## Document Version History

| Version | Date | Comments | Changed by |
|---|---|---|---|
| 0.1a | 1st November 2019. | Draft version issued for review. | Raj Takhar. |
| 0.2a | 21st November 2019. | Updated following Noam El Mrabet (Interel) and Kelly Scanlon (IPC) peer review comments. | Raj Takhar. |

# 1. Introduction

## 1.1 Introduction to IPC

IPC is a trade association that brings together electronics manufacturing companies at the global scale: designers, board manufacturers, assembly companies, suppliers, and original equipment manufacturers. More than 5,600 companies around the world depend on IPC programs and services to further their competitive excellence and financial success. As a member-driven organization and leading source for industry standards, training, market research and public policy advocacy, IPC supports programs to meet the needs of an estimated $2T global electronics industry (IPC, 2019a).

## 1.2 Purpose

The purpose of this study involves examination of how to identify and trace chemicals across the entire lifecycle of a product classed as being part of the Electronics sector.

## 1.3 Scope

Priority 1 tasks assigned within the research proposal (Takhar, 2019), are shown in Table [1], below:

Table 1: Research tasks in scope of report

| # | Task Details | Relevant report section(s) |
|---|---|---|
| 1 | Identify internal and external stakeholders which impact the electronics sector supply chain. | 2.8 Action plan for when substances becoming more controlled. |
| 2 | Define different industry sectors to benchmark against. | 2.5 Review of industry approaches towards chemical substance reporting. |
| 3 | Benchmark different industry sector approaches. | |
| 4 | Review global chemical regulations. | 2.3.3 Regulatory measures to handle e-waste.<br>2.4 Chemical regulations. |
| 10 | Define what chemicals of concern means. | 2.6 Development of a chemicals of concern list for the electronics sector. |
| 19 | Assess any product stewardship activities which may impact supply chain traceability of chemical substances | 2.7 Reporting and analyzing data using product stewardship |

# 2. Findings

## 2.1 Products and supply chains

A product can be described as physical item such as a chemical substance, mixture, material, semi-component, component, product which are either manufactured for sale on their own, or collated with other substances, mixtures, materials, semi-components, components and products to produce assemblies or higher-level finished products (Takhar and Liyanage, 2018a; Takhar and Liyanage, 2018b).

The term supply chain refers to a collection of actors (organizations) selling / flowing products and / or services from one actor to another, until such state that the products and / or services are at the intended end consumers. The term '*Article Transformation Cycle*' describes the process of taking raw materials, processing substances and mixtures to produce finished articles. Figure [1] depicts the article transformation cycle (Takhar and Liyanage, 2017a).

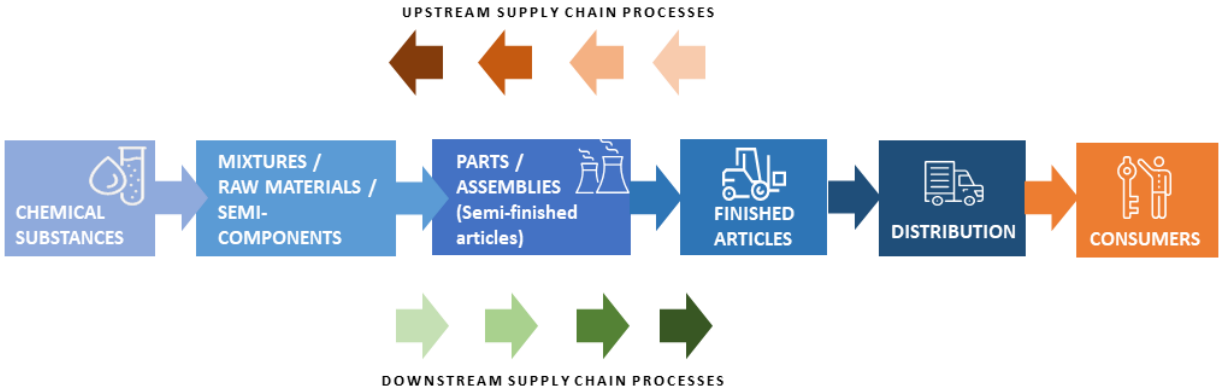


Figure 1: The 'Article Transformation' Cycle

Traditional manufacturing chains focused on: (a) procuring products from regional supply chains at the lowest prices; (b) producing high quality products in the highest volume amounts at the lowest cost price, to generate continual growths in profits. Increasing technological advancements such as modern computers, the internet, and smartphones have augmented the modern marketplace and have enabled chemical substances, mixtures, materials and products to be purchased 24/7 from around the world (Porter, 1980; Woinaroschy, 2016; Dias and Ierapetritou, 2017).

## 2.2 Review of the global electronics sector

### 2.2.1 Definition of electronics

Electronics is defined as '*The branch of physics and technology concerned with the design of circuits using transistors and microchips, and with the behaviour and movement of electrons in a semiconductor, conductor, vacuum, or gas*.' (Lexico 2019).

### 2.2.2 Product examples within the electronics sector

The term electronics sector covers a very broad range of supply chain actors manufacturing products that contain PCBs for a diverse set of markets. Appendix One shows the sectors analysis of different product examples served by the electronics sector. Figure [2] depicts the diversity of products produced by the electronics sector.

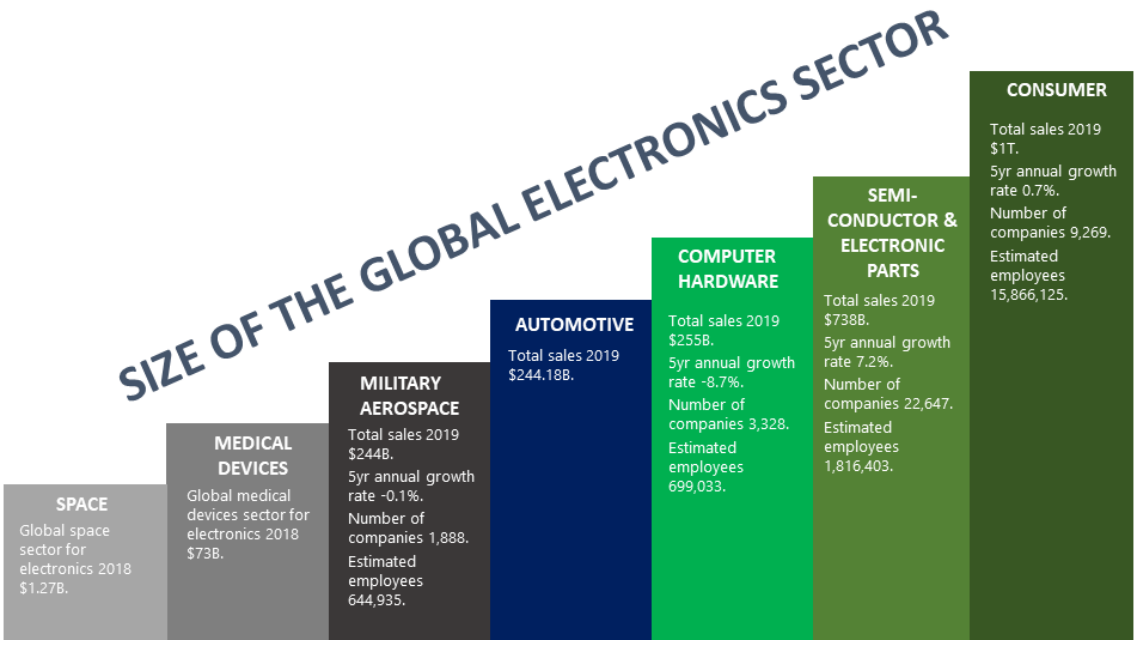


Figure 2: Global electronics sector (example industries)
Source: See Appendix One.

### 2.2.3 Global scale of the electronics sector

Using the product type manufacturers identified in section 2.2.2, additional analysis was conducted in Appendix Two, to identify the regional scale of companies manufacturing and utilizing electronic products. Figure [3] depicts regions with the highest density of manufacturers and users of electronic products.

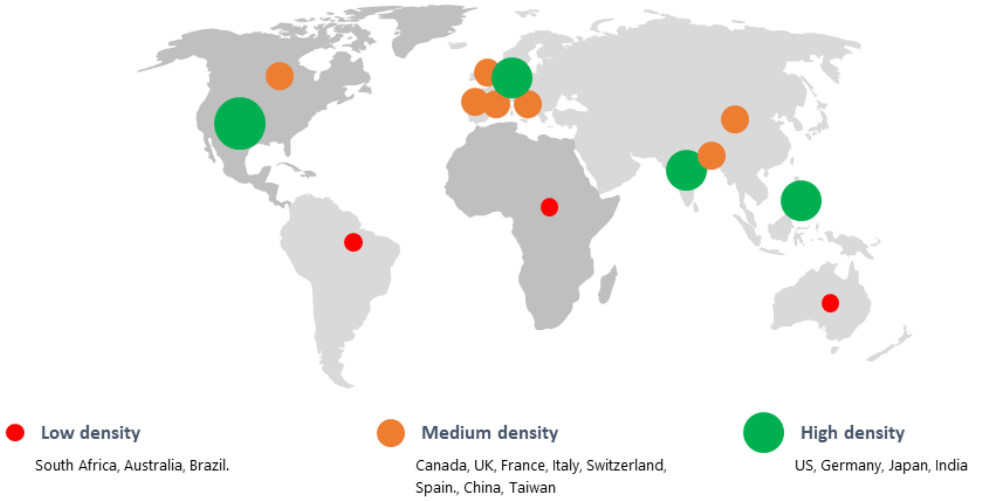


Figure 3: Electronic product density by region
Source: Appendix Two.

Note – This is a non-exhaustive list of companies which will require review and further expansion as deemed necessary. The data has been included to derive an initial hotspot list of electronics consumptions shown in the figure above.

### 2.2.4 CRMs for the electronics sector

CRMs are key materials that an industry relies on in order to manufacture products. CRMs are defined as materials which: (1) cannot easily replaced with other materials; (2) materials which could large scale supply chain disruption; (3) materials which could impact national security. A list CRMs identified as being used within the electronics sector was generated based on: (1) EC CRM list 2017 (European Commission, 2017); (2) US CRM list (Commerce.gov, 2019), and; (3) TTI! list of raw materials (TTI!, 2019). The findings are detailed in Appendix Three. Table [2] presents the list of CRMs for electronics:

Table 2: List of critical raw materials (CRM) for the electronics sector

| CRM Name | Application(s) of use within electronics | Source(s) of supply |
|---|---|---|
| Aluminum | RF connectors; aluminum capacitors; resistors. | Australia; Canada; China; Russia; |
| Antimony | Microelectronics; lead-acid batteries. | China; Belgium; Bolivia; Vietnam. |
| Arsenic | Semiconductors. | Belgium; China; Morocco. |
| Baryte / Barite | Shielding; TV screens. | China; India; Mexico; Morocco. |
| Bauxite | See Aluminium. | Brazil; Guinea; Guyana; Jamaica. |
| Beryllium | Telecommunications; computers; battery contacts. | Brazil; China; Japan; Kazakhstan; UK; US. |
| Bismuth | Replacement for lead in solder. | China; Belgium; Japan; Mexico; Peru. |
| Borate | Flame retardant in electronics. | Argentina; Turkey; US. |
| Chromium | Insulation wiring for cables. | Kazakhstan; Russia; South Korea. |
| Cobalt | Semi-conductors; solar panels; fuel cells; rechargeable batteries used in portable electronic | Canada; China; DRC; Finland; Japan; Norway. |

| CRM Name | Application(s) of use within electronics | Source(s) of supply |
|---|---|---|
| | devices; batteries used in electric / hybrid cars; medical devices; wind turbines. | |
| Copper | PCBs; connectors; cables; capacitors; resistors; inductors; ferrites; fuses. | Australia; Chile; DRC; Indonesia; Mexico; Peru; Russia; US, Zambia |
| Fluorspar | Electrical and electronic appliances; lithium batteries. | China; Mexico; Mongolia; South Africa; Vietnam. |
| Gallium | Microwave circuits; high-speed switching circuits; infrared circuits. | China; Germany; Kazakhstan; UK; Ukraine. |
| Germanium | Semi-conductors. | Belgium; Canada; China; Finland; Germany; Russia; US. |
| Gold | 91% of Gold is used in Electronic products. | Australia; Canada; DRC; Russia; South Africa. |
| Hafnium | Electronic equipment; light bulbs; nuclear power industry. | France; Russia; Ukraine; US. |
| Helium | Semi-conductor manufacturing process. | Algeria; Qatar; US. |
| Indium | Semi-conductors. | Canada; China; France; Japan; South Korea.. |
| Lead | Solder (subject to approval); mica capacitors; resistors. | Australia; Canada; China; US. |
| Lithium | Batteries. | Argentina; Chile; China. |
| Magnesium | Light weight metal used for shielding parts and products. | Australia; China; Canada; Gabon; Georgia; Israel; South Korea; UK; US. |
| Natural Graphite | Electrodes; batteries; solar panels. | Brazil; Canada; China; India; Mexico. |
| Natural Rubber | Shock protection; electromagnetic interference; chemical intrusion; others. | India; Indonesia; Thailand; Vietnam. |
| Nickel | Connectors; capacitors; resistors; inductors; ferrites; fuses. | Australia; Brazil; Canada; Finland; Madagascar; New Caledonia. |
| Niobium | Passive electronic components. | Brazil; Canada; Russia. |
| Oil | Connectors; film capacitors. | Brazil; Canada; China; Kuwait; UAE; Iran; Iraq; Russia; Saudi Arabia; US. |
| Palladium | Connectors; ceramic capacitors; SMD resistors, varistors. | Canada; Russia; South Africa; US; Zimbabwe. |
| Platinum / PGM | Ceramic capacitors; tantalum capacitors. | Italy; Russia; South Africa; UK. |
| Rare Earths | Widely used within electronics. | China; Estonia; France; Japan. |
| Rhenium | Electrical contacts | Belgium; Bolivia; Chile; Germany; Poland. |
| Scandium | Electronics; lasers. | China; Russia; Ukraine. |
| Silicon Metal | Solar cells; microchips. | Brazil; China; France; Norway; US. |
| Silver | capacitors; resistors; ferrites; fuses; varistors. | Australia; Bolivia; Mexico; Peru; Poland. |
| Steel | Metal circular connectors; resistors; inductors; ferrites. | Australia; Brazil; Canada; China; India; Iran; Kazakhstan; Russia; South Africa; Sweden; Ukraine; US. |
| Strontium | Cathode ray tubes; magnets and; for refining Zinc. | China; Germany; Mexico. |
| Solvents and gases | Cleaning; degreasing; removing impurities. | |
| Tantalite (tantalum) | 40% of Tantalite is used in Electronic products. | Australia; Brazil; Canada; DRC; Rwanda. |
| Tellurium | Used in solar cells; semi-conductors; phase change memory chips. | Belgium; Canada; China; Philippines. |
| Tin | 64% of Tin is used in Electronic products. | Bolivia; China; Indonesia; Malaysia; Peru. |
| Titanium / Titanium Mineral concentrates | Titanium electronic circuits where titanium metal is used generate a complete electronic circuit. | Australia; China; Canada; Japan; Kazakhstan; Mozambique; South Africa; Ukraine. |
| Tungsten | 70% of Tungsten is used in Electronic products. | Australia; Austria; Brazil; Bolivia; Canada; China; Germany; Mongolia; North Korea; Poland; Portugal; Russia; Spain; South Korea; UK; US; Vietnam. |
| Uranium | Material for nuclear industry, power generation and military application. | Australia; Canada; Kazakhstan; Russia. |

| CRM Name | Application(s) of use within electronics | Source(s) of supply |
|---|---|---|
| Vanadium | Low-power electronics, communication systems | Austria; Canada; China; Czech Republic; Russia; South Africa; South Korea. |
| Zirconium / Zirconium mineral concentrates | Reactor fuel rods for nuclear industry. | Australia; China; Germany; Japan South Africa; Senegal. |
| Zinc | Varistors. | Canada; Chile; Honduras; Mexico; Peru. |

Increasing consumption of electronic products has resulted in a decline in available CRMs, thereby increasing the cost of available CRMs. Changing geopolitical tensions could result in supply chain shortages of key CRMs between nations which enter trade wars with one another.

## 2.3 Recycling within the electronics sector

Section 2.2.2 identified product market types for electronic products, in section 2.2.3, the regions producing electronic products were examined.

### 2.3.1 Typical life spans for products with a high level of electronics content

Table [3] highlights typical life spans for products that have a high levels of electronic product content. The actual life span of a product will depend on technological advancements and end consumer desire to update existing products to the latest models. The data does highlight the products which contain a high level of electronic components do remain in use for extended periods of time.

Table 3: Typical life span products with a high level of electronic product content

| Product Category | Product examples | Estimated life | Source(s) |
|---|---|---|---|
| Consumer | Smartphone. | 2.5yrs. | CoolBlue, 2019. |
| | Tablet. | 6.72yrs. | Statista, 2019. |
| | LCD Television. | 30,000 to 60,000 hours, estimated life at 6 hours daily use is 28yrs. | Techwalla, 2019. |
| | LED Television. | 60,000 to 100,00 hours, estimated life at 6 hours daily use is 46yrs. | Your4ktvguide, 2017. |
| | Fridge Freezer. | 14 to 17yrs. | Homeguides, 2018. |
| | Electric oven. | 13 to 15yrs. | DigitalTrends, 2017. |
| | Dishwashers. | 9 to 13yrs. | |
| | Microwaves. | 9 to 10yrs. | |
| | Washing machine. | 10 to 14yrs. | |
| | Light bulbs. | Incandescent - 750-2,000hrs; Fluorescent - 24,000-36,000hrs; Halogen - 2,000-4,000hrs; LED - 35,000-50,000hrs. | TheLightBulb, 2019. |
| Automotive | Traditional. | Older vehicles – 8yrs+; Modern vehicles – 10yrs+ | CardealPage, 2018. |
| | Electric. | Car batteries estimated at 8yrs. | Energy.gov, 2019. |
| Military / Aerospace | Aircraft. | Airframe for commercial flights 20-30yrs. Boeing 747 – 27yrs; Lockheed Tri-Star – 24yrs | Flexport, 2016. |
| | | Aero engine 30-50 years dependent on size. | GE, 2010. |
| Medical Devices | Connected medical devices. | 7-10yrs. | CyberMDX, 2019. |
| | MRI scanner. | 11-22yrs+. | GE Healthcare, 2017. |

| Product Category | Product examples | Estimated life | Source(s) |
|---|---|---|---|
| Computer hardware | Desktop | Typically, last between 3-5yrs. Well maintained desktops can last up to 10 years. | YourBusiness, 2019. |
| | Server | 3yrs+. | TechRepublic, 2013. |
| | Laptop | 3-5yrs+. | SmallBusiness, 2018. |
| Space | Satellites | Originally lasted 10-15yrs now being implemented to last 5yrs+. | SpaceNews, 2018. |

### 2.3.2 What is E-Waste?

EEE waste at the EOL state is termed as e-waste. Technological innovation has led to ever increasing new product innovations. The globally generated amounts of e-waste have been increasing sharply over time: (1) 2012, 42Mt of e-waste (OSU, 2013); (2) 2016, 44.7Mt of e-waste (The Global E-waste Monitor 2017); (3) 2018, 50Mt (UN, 2019). By 2021, 52-57Mt of e-waste are expected to be generated (PACE, 2019; Panda Security, 2019). The predicted amount of e-waste for 2050 is expected to reach 120Mt. Only 20% of e-waste are currently being recycled (UN, 2019), the remainder 80% is defined as undocumented and consider statistically as ending up in landfill sites. E-waste product contain toxic metals which are dangerous to the environment, particularly Beryllium (*Carcinogenic, Skin sensitising*), Cadmium (*Carcinogenic, Possibly Mutagenic, Possibly Toxic to Reproduction*) and Lead (*Toxic for reproduction, Possibly Carcinogenic)* (ECHA, 2019b). When toxic metals enter into undocumented / landfill sites, there has been scientific concern expressed over the release of toxins into the environment which: (1) enter in the food chain via water and soil; (2) animals could then potentially consume vegetation and other animals affected by the toxins; (3) human could then potentially consume water, vegetation and / or animal infected with the toxins. Table [4] highlights the continents which generate e-waste and the levels of recycling undertaken. The data depicts as expected, that the Oceania, Americas and Europe generate the highest levels of waste in KG per inhabitant, with varying levels of documented e-waste collection and recycling. This data contrasts with Figure [3] showing the flows of finished product e-waste from consuming countries to countries that receive the e-waste.

Table 4: Global E-Waste Data (2017)

| Region | Countries | Inhabitants | KG waste per inhabitant | e-waste generated | e-waste documented waste collected & recycled |
|---|---|---|---|---|---|
| Africa | 52 | 1.2B | 1.9 | 2.2Mt (5% of global) | - |
| Americas | 35 | 1B | 11.6 | 11.3Mt (25.3% of global) | 1.9Mt (17% collection rate) |
| Asia | 49 | 4.4B | 4.2 | 18.2Mt (40.7 of global) | 2.7Mt (15% collection rate) |
| Europe | 40 | 0.7B | 16.6 | 12.3Mt (27.5 of global) | 4.3Mt (35% collection rate) |
| Oceania | 13 | 0.04B | 17.3 | 0.7Mt (1.6% of global) | 0.04Mt (16% collection rate) |

Source: The Global E-waste Monitor 2017

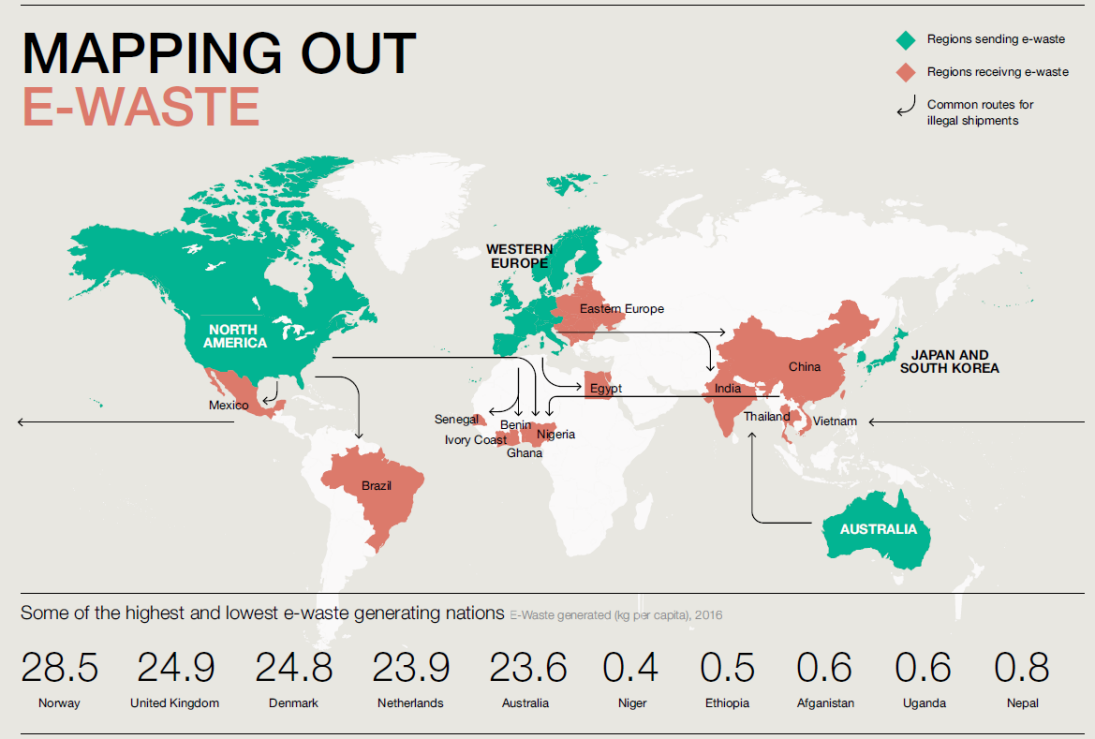


Figure 4: E-Waste flows
Source: PACE, (2019)

In summary a lot of e-waste is being generated annually which is potentially affecting regions where un-documented recycling is being undertaken.

### 2.3.3 Regulatory measures to handle e-waste

#### 2.3.3.1 Europe

Regulatory control measures to handle e-waste first appeared within the EU RoHS (2002/95/EC) and EU WEEE (2002/96/EC) Directives. EU RoHS (2002/95/EC) set out an objective to enable the environmentally sound recovery and disposal of waste electrical and electronic equipment. The EU WEEE (2002/96/EC) and EU WEEE (2012/19/EU) Directives set out collection, recycling and recovery of electrical products. The EU Waste Framework Directive (2008/98/EC) established the concept of (i) a waste hierarchy focusing on reducing waste via reduce, reuse and recycling; (ii) setting initial targets for waste recycling and recovery; (iii) established the concept of EPR schemes. A limitation to EU member states exchanging and processing e-waste recycling in an efficient manner comes from the Hazardous Waste Directive (91/689/EEC) which places control measures on the movement of hazardous waste. The EU Waste Framework Directive 2018/851 revised existing EPR schemes, updated targets for recycling and recovery, and established the need for all producers of products that contain any

SVHC substance >0.1% w/w threshold level at the lowest article (component) level to report into the ECHA SCIP database from 5th January 2021.

#### 2.3.3.2 Americas

Canada-wide Action Plan for Extended Producer Responsibility (2009), introduced several EPR schemes. California Electronic Waste Recycling Act 2003, introduced a consumer pays approach towards funding the collection and recycling of e-waste products. Brazil introduced Politica Nacional de Residuos Solidos n.12305 (PNRS) in 2010.

#### 2.3.3.3 Asia

Japan implemented the Law for the Recycling of Specified Kinds of Home Appliances (2001), which states consumers are responsible for the cost of recycling home appliances. China has been implementing several recycling schemes under a five-year plan (2015-2020) covering EPR schemes, defining principles from design, use of materials, recycling and publishing information.

### 2.3.4 E-Waste and the circular economy?

Moving from closed-loop manufacturing systems towards the circular economic model has shown the potential to use recycling and reprocessing to ensure the supply of critical CRMs, used in electronics, for example 1 million smart phones could potentially be utilised and recycled to generate: (i) 35,000lbs of copper; (ii) 772lbs of silver; (iii) 751bs of Gold; (iv) 32lbs of Palladium (Panda Security, 2019). Industry adopting greener 'non-toxic' chemicals will aid the ability to recycle products to generate secondary raw materials. The UK government strategy for CRMs is still being developed (POST, 2019), the US has developed its strategy (Commerce.gov, 2019). Based on the data from Table [2], further analysis of CRMs was conducted in Appendix Four identified the following CRMs which are considered as currently being recycled: Aluminum, Cobalt, Copper, Gallium, Germanium, Gold, Lead, Lithium, Magnesium, Natural Graphite, Natural Rubber, Nickel, Niobium, Oil, Palladium, Platinum / PGM, Rhenium, Silver, Steel, Tantalite (tantalum), Tellurium, Titanium / Titanium Mineral concentrates, Tungsten, and Zinc. The EU Circular Economy Package (EC, 2015; EC, 2019a) laid down a common framework strategy to enable the recycling of products reaching the EOL stage, recovering raw materials to enable continued future prosperity against a backdrop of reduced global availability of CRM. The EU Plastics Strategy (EC, 2018a) identified a

consumption rate of 49 million tonnes of plastics within the EU in 2015 of which 5% was attributed to being used within the electronics sector. A key driver to being able to implement circularity to enable products to be continually reused is the removal of hazardous substances from design and manufacturing cycles for products, which is where the use of chemical regulations can play a pivotal role. The current state practice for e-waste recycling operators is to focus on recycling CRMs which yield the highest financial value as opposed to other CRMs, this imbalance needs to be addressed by further research and education activities as it impacts the sectors ability to recycle products in a truly circular manner. The European Commission has recognized that there is a disparity between existing regulations andvarious regulations

#### 1.1.1 Understanding potential supply chain disruption risks

The EU circular economy package (European Commission, 2019a) has s.

## 2.4 Chemical regulations

### 2.4.1 New chemical substances are being created at a rapid pace

Chemical substances are the lowest level ingredient which can be used on their own or combined with other chemical substances to produce mixtures or materials. New chemical substances are created at a very rapid pace, for example, the number of registered substances in the CAS database index have grown from 129M, in 2017 (Takhar and Liyanage, 2017a), to 156M, in 2019 (CAS, 2019).

### 2.4.2 The role of chemical regulations

Regulations exist to impose a consistent set of norm/behaviours upon society. Chemical regulations exist to control and limit the use of hazardous chemicals, to prevent any future environmental degradation. Chemical regulations establish: (1) frameworks for industry to manage the manufacture, use and disposal of hazardous chemicals; (2) establish risk assessment measures to guide industry on assessing the use of hazardous substances; (3) reporting mechanisms to collect data for known uses of chemical substances which may then be used to enable further control of the most hazardous substances, as well as providing details on safer alternative chemical substances; (4) ensure appropriate labelling and disposal of hazardous chemical substances; (5) ensure appropriate flows of information occur across a supply chain,

from (i) chemical manufacturers, (ii) downstream users, (iii) end consumers, and (iv) waste stream operators relating to hazardous chemicals; (6) allow enforcement bodies / regulators certain powers to enforce industrial control measures (Tickner, et al, 2015; Krimsky, 2017; Takhar and Liyanage, 2017b; Botos, Graham, Illés, 2018).

### 2.4.3 Types of chemical regulations

Over 50 different types of chemical regulations, reporting standards and DSLs, applicable to the electronics sector were reviewed in Appendix Five and then categorised into five categories (note – some appeared in more than 1 category) (1) product labelling regulations – 20 occurrences ; (2) product safety regulations – 22 occurrences; (3) consumer regulations – 26 occurrences; (4) industrial regulations – 36 occurrences , and; (5) others – 22 occurrences.

### 2.4.4 Numbers of chemical substances under regulatory radars

Figure [5] depicts chemical substance information recorded against the main databases and defined in substance lists against various chemical regulations.

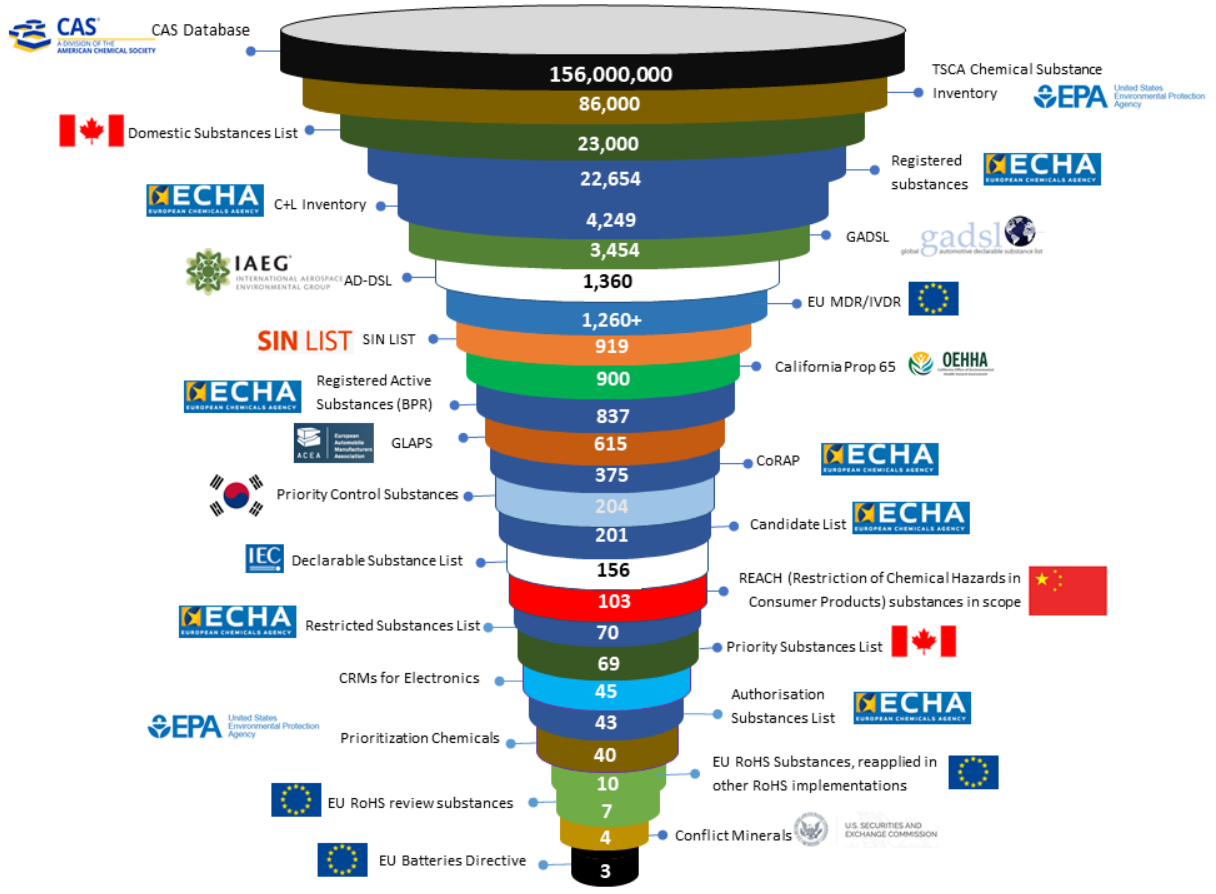


Figure 5: Chemical substances identified from regulations and standards (October 2019)
Sources: ACEA, 2019; Canada.ca, 2019a; Canada.ca, 2019b; CAS, 2019; Chemsec, 2019; CIRS-REACH, 2019; EC, 2006b; EC, 2019b; ECHA, 2019c; ECHA, 2019d; ECHA, 2019e; ECHA, 2019f; ECHA, 2019g; ECHA, 2019h; ECHA, 2019i; EU, 2017a; EU, 2017b; GADSL, 2019; IAEG, 2019; IEC, 2019; OEHHA, 2019; Oko-Institut, 2019; SEC, 2012; TSCA, 2019a; TSCA, 2019b.

The key findings from Figure [5] suggest that whilst many chemical substances exist, the numbers of hazardous chemicals which are closely monitored and controlled under chemical regulations are a much-reduced number.

### 2.4.5 ECHA SCIP database

EC WFD 2008/98/EC (EC,2008) was originally implemented to protect environmental and human health by preventing or reducing the adverse impacts of waste generation and management. One of the key issues was that it resulted in a significant burden on waste stream operators having to develop methods for identification of hazardous substances, when EOL products were entering waste streams. EC WFD 2008/98/EC established the concept of a waste hierarchy and establishment of EPR schemes which were further developed under EU WEEE Directive 2012/19/EU (EU, 2012). Consultations reviewing the efficacy of EC WFD 2008/98/EC (EC,2008), identified several concerns expressed by waste stream operators relating to the identification of hazardous chemicals in EOL products entering waste streams. In order to obtain details of hazardous materials contained on EOL products, waste stream operators had to develop testing criteria and methods to identify hazardous substances, to ensure employee and environment protection or risk having permits to process waste being revoked. The EU WFD 2018/851 (EU, 2018) introduced two key criteria, as show in Figure [6].

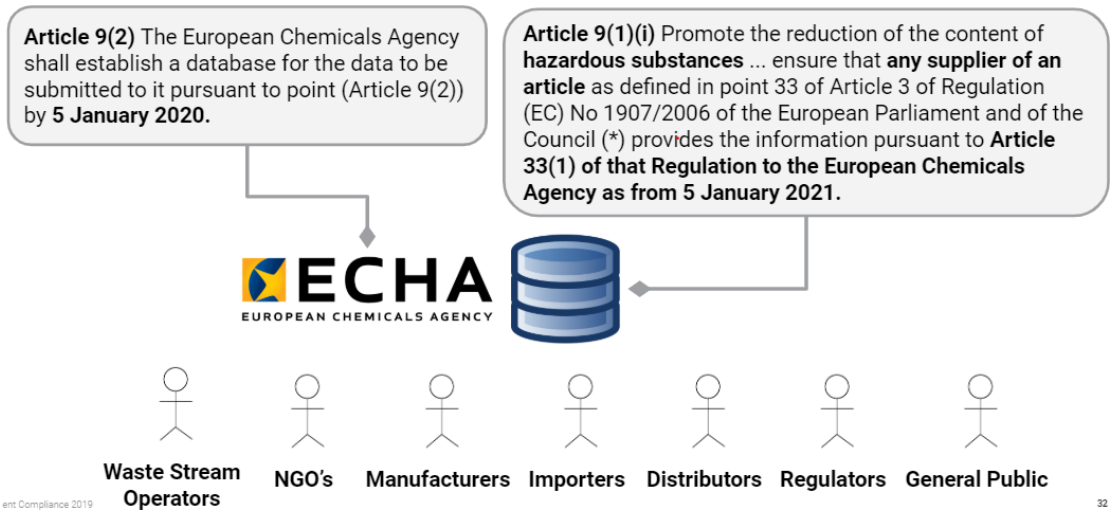


Figure 6: EU WFD 2018/851 Article 9

In developing the initial design for the ECHA SCIP database, ECHA made some key decisions based on a number of legal rulings relating to the EU REACH 1907/2006 (EC, 2006a) and the reporting requirements for the waste stream operators for whom the database was originally

intended to be used, these included: (1) new duty holder role, where different actors within a supply chain ("suppliers of articles") are obliged to provide SVHC reporting information into the ECHA SCIP database; (2) if an article is manufactured outside the EU, the expectation is that the importer of the article (or an Only Representative) will need to request and collate the data from their respective supply chains and report into the ECHA SCIP database; (3) additional reporting fields encompassing information on tariff codes applicable to the article being reported against, which could potentially be the lowest level piece component within a PCBA; (4) information on how a hazardous substance / mixture or material containing the hazardous substance has been applied to a given product. The current design (October 2019) is shown in Figure [7].

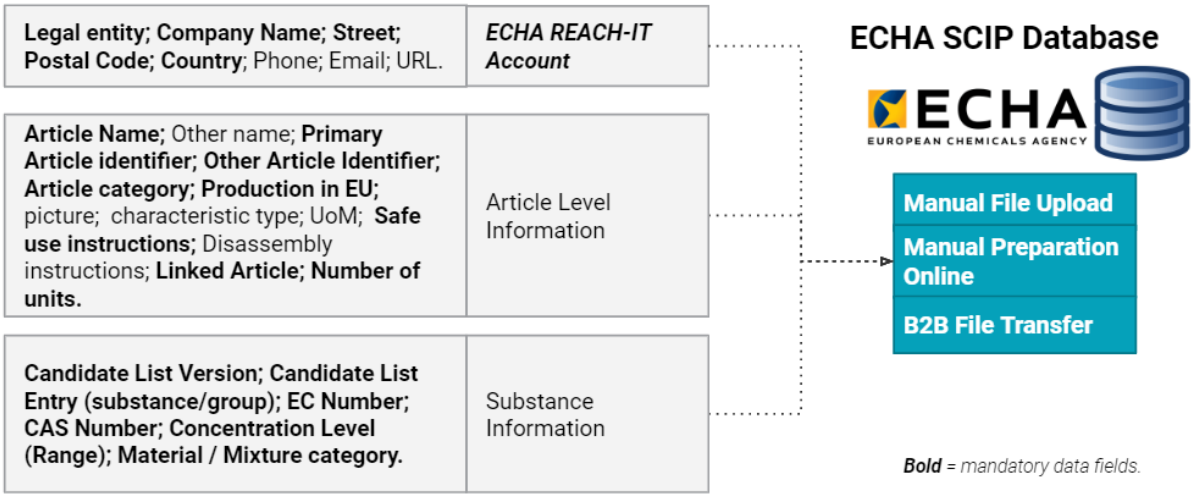


Figure 7: ECHA SCIP database fields (October 2019)

EU WFD 2018/851 (EU, 2018) legally mandates the use of the ECHA SCIP database from 5th January 2021 by all duty holders placing products onto the EEA. Concern expressed by industry: (1) additional data fields which require a significant amount of data collection; (2) collating the additional data fields is likely to impact existing systems which collate EU REACH data; (3) reporting requirements are seen as being significantly more than those which are required today under EU REACH 1907/2006 (EC, 2006a) article 33 requirements; (4) concerns over how CBI data will be protected within the ECHA SCIP database; (5) fears over the potential access given to various stakeholder groups and potential adverse media which may result. The current system design shows several different stakeholders being able to connect and access data in the ECHA SCIP database as shown in Figure [8], which ECHA is currently stating is data that has to be provided to waste stream operators and therefore is classed as being in the public domain.

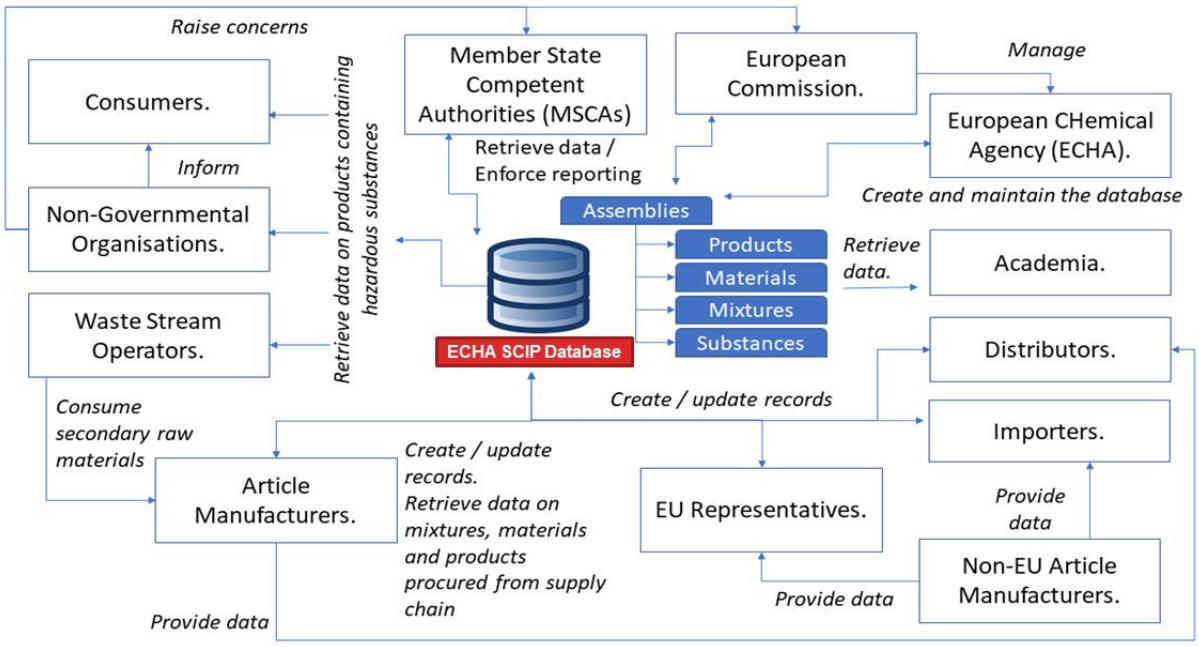


Figure 8: ECHA SCIP database data flow design

To meet the reporting needs of the ECHA SCIP database, IPC-1754 and IEC62474 standards are developing the additional reporting fields required, whilst IPC-1752B has been drafted to meet the new reporting needs as IPC-1752A lacked the required BOM level reporting and additional data fields. The key concern from the ECHA SCIP database implementation is the additional reporting burdens being placed on both EU and non-EU manufacturers to collate data from the lowest article that contains an SVHC substance and reporting this data into the ECHA SCIP database with many more fields that existing EU REACH reporting tasks, from 5th January 2021.

### 2.4.6 The costs of compliance

CEFIC estimated the costs for the compliance reporting to regulations averaged €9.5 billion yearly with the EU, about 2% of annual industry turnover between 2004 to 2014 (Maroulis, et al., 2016). Using data on product examples shown in section 2.2.2, the costs of compliance can be roughly calculated based on 2% of annual turnover as: (1) space $25.4M ($1.27B); (2) medical devices $1.46B ($73B); (3) military aerospace $4.88B ($244B); (4) automotive $4.8B ($244.18B); (5) computer hardware $5.10B ($255B); (6) semi-conductor and electronic parts $14.76B ($738B); (7) consumer products $20B ($1T). The largest cost areas in relation to regulatory compliance were identified as: (1) emissions and industrial processes (33%); (2) chemicals (29%), and; (3) worker safety (24%), with; (4) product-specific regulations account

for 1% of these legislations (0.6%) (EC, 2016). It was suggested that once the initial reporting was developed, compliance costs would be expected to decrease over time. However, regulations such as California Prop 65, EU REACH, EU BPR, EU RoHS (OEHHA, 2019; ECHA, 2019h; ECHA, 2019i; EC 2002b) have seen increased substances appearing thereby increasing reporting obligations upon industry.

### 2.4.7 Future realignment of EU Regulations

### 2.4.8 Understanding potential supply chain disruption risks

Supply chain disruption as a result of chemical regulations arises from: (1) not clearly understanding any hazardous chemicals being consumed and taking the appropriate safety control measures; (2) loss of access to a market if no data on hazardous chemicals can be provided, for example under EU REACH, there is the principle of 'no data, no market access'; (3) potential financial penalties for not identifying regulated hazardous chemical substance(s) in a timely manner, and notifying a regulator; (4) potential financial penalties for not providing appropriate information to downstream users, consumers and waste stream operators; (5) supply chain disruption if raw material(s) / components / parts cannot be sourced as they contain the more controlled substance(s), for example substances which fall under the EU REACH Authorisation or Restricted substance lists; (6) potential product failures if a supplier has changed a material / formulation, which affects the performance of a product, which may not have been recorded correctly within existing systems; (7) additional product redesign, testing and certification as a result of a supplier changing a substance / mixture in a supplied product; (8) chemical formulators may not obtain authorizations for all uses of chemical substances and mixtures, they rely on downstream users providing information on uses not detailed in a SDS/ESDS which may be alleviated using supply chain chemical substance reporting and then validating the information; (9) neglecting to identify chemical substances used as process substances, which could potentially lead to products being withdrawn, preventing the manufacture of products (Takhar and Liyanage, 2018b).

## 2.5 Review of industry approaches towards chemical substance reporting

The approaches taken by industry to perform chemical substance reporting vary from one industry to another, and even one company and another company within same sector. The current practices include: (1) custom reporting templates adopted with a list of regulations or DSL listing chemicals to be reported against; (2) creation of data exchange standards as the means of exchanging data between different systems using (i) an XML schema to define data fields and rules for data collection; (ii) a reporting template which enables data to be transmitted between a requestor and responder (based on the XML schema), and; (iii) a DSL defining the list of substances which need to be reported against. Different industry approaches have been examined in terms of the: (1) automotive; (2) electronics; (3) aerospace; (4) medical devices; (5) railway, and (6) shipbuilding sectors:

### 2.5.1 Automotive sector

The Automotive industry impacted by chemical regulations much earlier than other sectors as a result of initial EU ELV, EU WEEE, EU RoHS, EU REACH, CMR, EU BPR regulations (EC, 2000; EC, 2002a; EC, 2002b; EU, 2006a; EU, 2012; ECHA, 2019h; SEC, 2012). In order to meet new regulatory reporting requirements, as a sector, automotive adopted a top-down approach towards chemical substance reporting. IMDS, the main chemical reporting system was first established in June 2000 (IMDS wiki, 2018). IMDS was originally established by EDS, then HP and is currently managed by DXC Technology. IMDS formed a fundamental step change in the way the higher tier companies (OEM/ODM) interacted with lower tier suppliers (assembly/part/component/semi-component/raw material suppliers). Figure [9] depicts the data flow requests from the OEM/ODMs to the lowest supply chain tiers and back again:

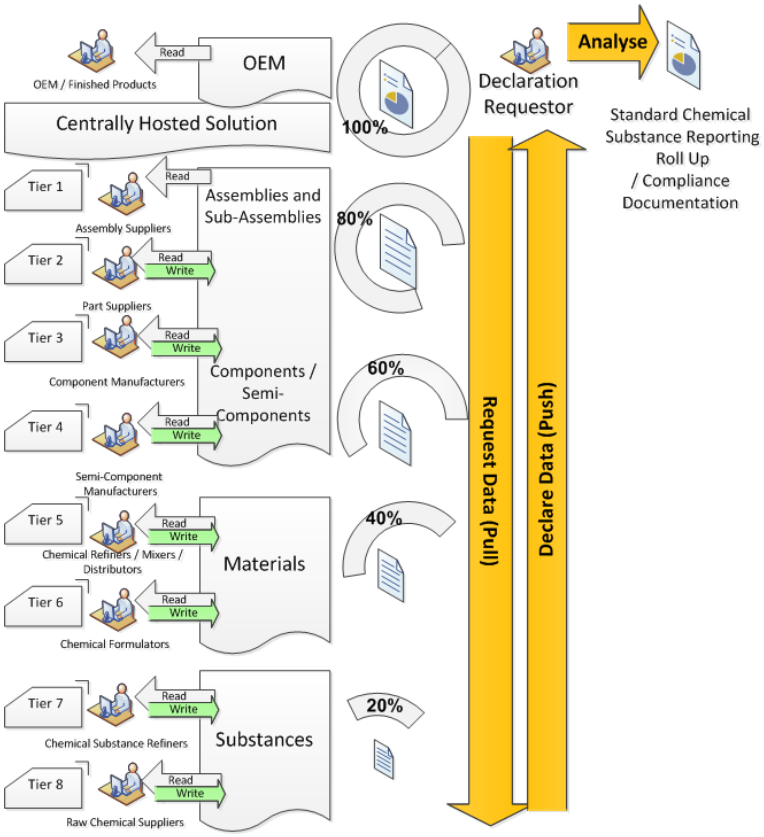


Figure 9: Centrally hosting reporting solution
Source: Takhar and Liyanage (2017b).

Prior to the inception of IMDS, different automotive manufacturers would have requested and received information across their supply chains in an ad-hoc and inconsistent manner. IMDS works by having a centralised reporting system, with common formats for data reporting and an Automotive chemicals of concern list known as GADSL (GADSL, 2019). IMDS, overtime has enabled reporting of substance information to be embedded within buyer-supplier relationships within the automotive sector. Suppliers complete IMDS declaration requests as part of: (1) normal part deliveries, and; (2) as part of the PPAP process where new parts require a valid IMDS material declaration before acceptance (PPAP wiki, 2019). Funding for IMDS is made by the top tier OEM/ODMs who finance DXC Technologies to maintain the system. In 2017, a process chemicals substance list was created called GLAPS (ACEA, 2019). Issues with IMDS have included: (1) the initial standard reporting templates were augmented between different OEM/ODMs resulting in complex reporting for lower level supply chain tiers, data has to be entered differently depending on the OEM/ODMs the data is being reported to; (2) DXC Technologies is the single service provider for the solution maintaining both the codebase and limiting competitor access to IMDS (unless fees are paid); (3) changes to the IMDS system take

a long time to be agreed prior to implementation; (4) reporting to IMDS is different to other systems as it is a proprietary system for the automotive sector, there is a long learning curve which takes time to embed with an organisation; (5) some of the logic in what a process chemical under GLAPS and how it is to be reported under IMDS is debatable for example fuel used to test an engine which remains in the fuel sump is not classed as a process chemical; (6) recent Rec019 changes have caused an issue with electronic product suppliers as the reporting of chemical substances is changing (October 2019) from a aggregated data view towards an FMD approach. A variant of IMDS exists in China called CAMDS (CAMDS, 2010) which was implemented in 2009, reporting is like IMDS, using a different DSL called BSL, applicable to automotive sector in China.

### 2.5.2 Electronics sector

The electronics sector is affected by the following chemical regulations EU WEEE, EU RoHS, EU REACH, CMR, EU BPR regulations (EC, 2002a; EC, 2002b; EU, 2006a; EU, 2012; ECHA, 2019h; SEC, 2012). The electronics sector developed two open data exchange reporting formats which can be used by industry and multiple solution providers to support IPC-1752A (IPC-1752, 2019) and IEC62474 (IEC, 2019). Where IPC-1752A allows for multiple substance lists via implementation list, IEC has a defined substance list based on EU REACH, both standards allow for FMDs. IPC-1752A is widely used in the Americas, whereas as the user base for IEC62474 is more widely used in Asia and Europe. There are still a few differences between the two standards which need to be resolved to allow data from one standard to be 100% parsed against another. There is no single provider of a service to both standards like IMDS, the Electronics industry assumes all service providers will compete not just on the basic data transmission, storage and retrieval process, rather organisations will compete against each other on price and value-added services (deeper supply chain reporting, deeper value-added analytics, etc.). Organizations can adopt internally managed reporting based on developing their own reporting templates using the IPC and IEC standard data fields.

### 2.5.3 Aerospace and Defence sector

The AD industry can be described as a synergy of electronics and automotive type articles. Regulations in scope of the AD sector include most of the same regulations as the automotive sector (except for EU RoHS) plus additional DSLs specific to defence customer requirements such as NAS-411 (AIA, 2016) and IAEG AD-DSL (IAEG, 2019). There was an initial attempt

to launch an AD specific declaration standard and DSL in the form of AS9535 in 2008, (SAE, 2008). The AD sector has refrained from developing a centrally hosted solution in the same manner as the automotive IMDS solution, primarily due to: (1) stringent data security requirements from defence clients, data must be stored and maintained on secure defence certified systems, and; (2) fear of CBI data being potentially viewed by industry competitors. AS9535 adopted a 'Top Down' data flow, without a centrally hosted solution managing all the requests, and data on behalf of the entire AD sector. AS9535 faltered due: (1) a cumbersome set of data elements, and; (2) an additional charge of $1000 for users of the standard to view the DSL to report against. IPC-1754 was developed by AD companies and expanded to include companies from multiple industries. IPC-1754 enables multiple industries to use a common data exchange standard, with their own industry specific declarable substance lists (IPC-1754, 2019). The AD sector has developed its own sector specific DSL known as the AD-DSL which has been collated by reviewing all potential regulations which may affect the AD sector and then categorizing chemical substances into short-term, medium-term and long-term impacts (IAEG, 2019). IPC-1754 reporting for the AD sector includes reporting of chemical substances (1) at a trace 0% threshold as opposed to 0.1% threshold to simplify supply chain reporting; (2) identification of chemical substances used in manufacturing processes, and; (3) identification of chemical substances used in maintenance activities, which are viewed as being a unique impact to the AD sector. IPC-1754 is currently being rolled out within the AD sector today (October 2019). Prior to the full adoption of IPC-1754 companies within the AD sector will be using a mixture of IPC-1752A, IEC-62474 and other custom solutions to request and collate supply chain chemical substance reporting information.

### 2.5.4 EU Medical device sector

The medical devices sector is impacted by EU WEEE, EU RoHS, EU REACH, CMR, EU MDR, EU IVDR, and FDA regulations (EC, 2002a; EC, 2002b; EU, 2006a; EU, 2012; SEC, 2012). The EU MDR (EU, 2017a) and IVDR (EU, 2017b) regulations require the generation of a DSL based on specific regulations EU CLP, EU BPR and EU REACH for CMR 1a, CMR 1B and ED substance types, within just these two regulations the generated DSL exceeds 1260 substances. The typical reporting formats for the medical devices sector are IPC-1752A and IEC62474, transmitted either by OEM/ODMs or third-party solution providers across supply chains.

### 2.5.5 Railway sector

UNIFE has developed an excel based reporting template with a DSL named RISL (UNIFE, 2019). The RISL is based on EU REACH (EU, 2006a), with references to regulations in Canada, China, US. The reporting template has not been widely adopted outside the rail sector, in general application IPC-1752A data exchange formats have been used with the RISL. Data is transmitted either by OEM/ODMs or third-party solution providers across supply chains.

### 2.5.6 Shipbuilding sector

Two regulations cover the reporting needs for the shipping industry, based on a minimum sized ship, the ship builders have to collect substance data based for all products installed onto a ship which is > 500 gross tonnes and the reporting is based on; (2) ship is owned by non-EU owner then IMO IHM (IMO, 2015) substance list and reporting template becomes applicable, or (2) ship is owned by a EU based owner in which case the EU SRR (EU,2013) substance list is applicable. The default reporting template is the IMO template with EU SRR or IMO IHM substances. The reporting consists of identifying all parts on a ship by the ship builder which contain the defined substances, this data is then passed onto a ship owner who must maintain the data until a point in time where the ship needs to be recycled at an approved recycling facility. Data is transmitted either by OEM/ODMs or third-party solution providers across supply chains.

### 2.5.7 Sector reporting summary

A summary of the different sector approaches towards chemical substance reporting is shown in Table [5].

Table 5: Summary of sector approaches to chemical substance reporting

| Industry sector | Use | Data exchange format / tools | Multiple providers | DSL | Efficacy rates | Description |
|---|---|---|---|---|---|---|
| Automotive | Global | IMDS | No | GADSL GLAPS | High | Single centrally hosted solution provider portal (except for China). |
| | China | CAMDS | No | BSL | High | Single centrally hosted solution provider portal for China. |
| Electronics | Global | IPC-1752A | Yes | Multiple | Medium | XML schema with multiple DSLs either managed internally within the standard as implementation lists or externally via third parties. Data transmitted and receipted using templates / forms. Reporting is focused on one tier requester and one tier supplier responses, no ability to manage BOM structures. |
| | Global | IEC62474 | Yes | Multiple | Medium | XML schema with multiple DSLs either managed internally within the |

| Industry sector | Use | Data exchange format / tools | Multiple providers | DSL | Efficacy rates | Description |
|---|---|---|---|---|---|---|
| | | | | | | standard as implementation lists or externally via third parties. Data transmitted and receipted using templates / forms. |
| Aerospace | Global | Custom format | No | Ad-hoc | Low | Custom reporting templates which usually consist of aerospace company internal interpretations of required data fields and custom DSL for reporting. Ad-hoc data structure with varying degrees of supply chain responsiveness. |
| | Global | IPC-1752A | Yes | Multiple | Medium | Currently adopted format for some solution providers and / or aerospace companies until IPC-1754 is established across the sector. |
| | Global | IEC62474 | Yes | Multiple | Medium | Currently adopted format for some solution providers and / or aerospace companies until IPC-1754 is established across the sector. |
| | Global | IPC-1754 | Yes | Multiple | TBD *(High when used)* | Designed to manage complex product BOM structures.. XML schema, with DSLs managed outside of the standard by users of the standard – they must conform to the structure defined in the standard. Data transmitted and receipted using templates / forms. |
| Medical devices | Global | IPC-1752A | Yes | Multiple | Medium | |
| | Global | IEC62474 | Yes | Multiple | Medium | |
| | Global | Custom format | No | Ad-hoc | Low | |
| Railway | Regional | Custom format | Yes | RISL | TBD | Rail industry reporting template, usage rates are unknown. |
| | Regional | IPC-1752A | Yes | RISL | TBD | |
| Shipping | Global | IHM | Yes | IMO | Medium | IHM template. |
| | Europe | IHM | Yes | EU SRR | Medium | EU SRR does not define a template – DSL is adopted against IHM template. |
| Conflict Mineral reporting | Widespread | CMRT | Yes | Yes | High | Initially used by companies listed on the US stock exchanges but has gained adoption across companies globally as a corporate social responsibility initiative. |
| | Widespread | IPC-1755 | Yes | Yes | Low | |
| Japan | Japan | ChemSherpa | No | Yes | High | Used the main reporting standard for products manufactured and imported into Japan. Design is based on IEC62474 XML format. |

Source: Adapted from Theret, 2019

Whilst reporting sector specific information meets the requirements of the sector, it can lead to issues for some manufacturers that provide products for different sectors. Issue arise may due to: (1) the structure of a DSL and the naming conventions for a chemical substance which may vary from a regulatory list versus an industry name for a chemical substance; (2) industry specific interpretation of mandatory and optional data fields used with a data exchange standard may also vary. The activities of the Proactive Alliance (Proactive Alliance, 2019) are progressing towards the development of multi-industry data exchange standard and use of

common data structure within a DSL which can be used by all current data exchange standards to enable easier data sharing to take place. Within IPC, work of the activities of the E-31-AT-DSL (IPC, 2019b) committee have begun to investigate the development the common format for DSL based on the Proactive Alliance activities.

## 2.6 Development of a chemicals of concern list for the electronics sector

A chemicals of concern substance list is a single DSL which defines substances considered to be relevant for a sector in terms of a range of different chemical regulations. Appendix Six defines how ECHA have defined a general chemicals of concern list for the EU. To define a chemicals of concern list relevant regulations that need to be identified which may affect all the different industries the electronics sector supports. Table [6] defines an example of an initial list of chemical regulations in scope for the electronics sector. The list defines 9,832 chemical substances which may become a smaller group when duplicate substance names are removed but may increase if substance groups are broken out with lower level substance names.

Table 6: Initial list of chemical regulations potentially in scope for the electronics sector

| Region | Sector(s) | Regulation / Industry DSL | Substance numbers | Applicability | Source(s) |
|---|---|---|---|---|---|
| Global | Automotive | GADSL | 3,454 | Yes. | GADSL, 2019. |
| | | GLAPS | 615 | Yes. | ACEA, 2019. |
| | Aerospace and Defence | AD-DSL | 1,360 | Yes. | IAEG, 2019. |
| | Electronics | CRMs for electronics | 45 | Yes. | See section 2.2.4. |
| | | IEC62474 DSL | 156 | Yes. | IEC, 2019. |
| | Shipping | IMO IHM | 218 | Yes. | IMO, 2015. |
| | All | CMRT | 4 | Yes. | SEC, 2012. |
| US | All | California prop 65 | 900 | Yes – consumer products. | OEHHA, 2019. |
| | All | Prioritization chemicals list | 40 | Yes – where applicable to electronics | TSCA, 2019b. |
| Canada | All | Priority substance list | 69 | Yes | Canada.ca, 2019b; |
| Europe | All | EU REACH Candidate list | 201 | Yes, applicable to all articles place onto the EEA. | ECHA, 2019i. |
| | All | EU REACH Authorisation list | 43 | Yes, applicable to all articles place onto the EEA. | ECHA, 2019f. |
| | All | EU REACH Restricted substances list | 70 | Yes, applicable to all articles place onto the EEA. | ECHA, 2019g. |
| | Electronics | EU RoHS* | 10 | Yes. | EC, 2002b, EC, 2019b |
| | Electronics | EU RoHS review substances | 7 | Yes. | Oko-Institut, 2019. |
| | All | EU BPR | 837 | Yes, when protective coatings applied to electronic products. | ECHA, 2019h. |
| | Medical Devices | EU MDR, EU IVDR | 1,260 | Yes, must be checked against all articles within medical devices and the | EU, 2017a, EU, 2017b. |

| Region | Sector(s) | Regulation / Industry DSL | Substance numbers | Applicability | Source(s) |
|---|---|---|---|---|---|
| | | | | use of a substance justified. | |
| | Batteries | EU Batteries | 3 | Yes – identification and labelling of batteries and accumulators. | EC, 2006b. |
| | Shipping | EU SRR | 233 | Yes. | EU, 2013. |
| China | All | Restriction of chemical hazards in consumer products | 103 | Yes | |
| South Korea | All | Priority control substances | 204 | Yes. | CIRS-REACH, 2019. |
| **Total potential substances** | | | **9,832** | | |
| Other potential regulations / standards / lists | | | | | |
| US | All | TSCA Chemical inventory list | 86,000 | | TSCA, 2019a; |
| Canada | All | Domestic substances list | 23,000 | | Canada.ca, 2019a; |
| Europe | All | Registry of SVHC intentions until outcome. | 286 | Maybe potential additions to the EU candidate list. | Registry of SVHC Intentions until outcome. |
| | | Registry of Submitted Recommendations for Authorisation. | 31 | Maybe potential additions to the EU Authorisation list. | Registry of Submitted Recommendations for Authorisation. |
| | | Previous Authorisation Consultations. | 419 | Maybe potential additions to the EU Authorisation list. | Previous Authorisation Consultations. |
| | | Current authorisation consultations. | 46 | Maybe potential additions to the EU Authorisation list. | Current Authorisation Consultations. |
| | | Substances awaiting inclusion onto the EU REACH Restricted substances list | 12 | Maybe potential additions to the EU Restricted substances list. | Registry of restriction intentions until outcome. |
| | | CLP | 4,249 | Maybe – applicable to substances and mixtures. | ECHA, 2019d. |
| | | Registry of CLH intentions until outcome. | 177 | | Registry of CLH intentions until outcome. |
| | | CoRAP | 375 | Maybe – potential additions in scope of being under review to be added to EU REACH Candidate list. | |
| **Total potential substances** | | | **114,595** | | |

Note: EU RoHS has been chosen as the baseline RoHS regulations, several variations of RoHS regulations have been implemented, based on reporting against either the current 10 substances, or the earlier 6 substances. The differences between EU RoHS and variants lies mainly within product groups in scope of the regulation.

## 2.7 Reporting and analyzing data using product stewardship

Utilization of: (1) a chemicals of concern list for the electronics sector together with; (2) a data exchange standard, will allow organizations within the electronics sector to flow data requests, (3) using a standard template format across a respective supply chain. Having the data

transmitted and collated in a standard format will ease the burden on a supply chain against having to respond to similar multiple format requests from other companies within the electronics sector. This resultant data reporting will enable organizations to identify substances which require internal review and action(s) to be undertaken. This review process should be undertaken as part of product stewardship activities. Product stewardship involves the examination of the health, safety, environmental and social risks of a product across its lifespan from manufacture, use, disposal and more recently encompassing aspects of sustainability and the circular economy. Table [7] defines the steps required in order embed a product stewardship culture within an organization.

Table 7: Conceptual framework of how to embed product stewardship

| # | Task | Task Details |
|---|---|---|
| 1. | Identify internal actors. | Engage with all internal stakeholders such as design, purchasing, manufacture, quality, sales, etc. All relevant stakeholders within an organization need to be engaged. See Table [15] for examples of internal actors. |
| 2. | Agree actors. | Clearly identify who will be part of the product stewardship panel. Actors need to be committed to attend, product stewardship panel review meetings, and support the product stewardship process. |
| 3. | Establish initial objectives | Review product stewardship, chemical regulations, sustainability and circular economy literature. Brainstorm and set high-level initial goals. |
| 4. | Embed and engage to create a product stewardship culture. | Embed product stewardship panels in as many business decisions making processes as possible. This will require the actors supporting the product stewardship process to engage with all related functions explaining the new product stewardship culture being adopted. |
| 5. | Define more detailed objectives. | Develop a more thorough set of objectives. This will include setting clear targets: (1) on the use of regulated chemicals with a potential shift towards the use of non-toxic chemicals; (2) developing products which are more sustainable (materials and resources) and can feed into the circular economy. These objectives should result in clear targets. |
| 6. | Gap analysis | Analyze the current state organization. Identify gaps which exist today, which prevent the objectives from being completed. |
| 7. | Roadmap | Develop a roadmap of activities. |
| 8. | Action plan. | Define action plan that defines required tasks and task owners. |
| 9. | Identify external stakeholders. | Identify key external stakeholders to your organization who will be impacted by changes required by the action plan. Engage with stakeholders to provide insights of the proposed changes. Understand impacts of changes on external stakeholders. Review initial feedback, adjust the action plan as required. See Table [15] for examples of external actors. |
| 10. | Establish gated reviews. | Establish gated review process for key business processing stages. Establish key milestones for different functional areas within an organization to engage with the product stewardship panel for a review. These reviews will cover all aspects of business operations:<br>• Purchasing - Apply criteria which assess supply chains in terms of sustainability and the circular economy. Engage with your suppliers to get them to meet the criteria, who can help deliver sustainability and circular economy goals for your organization.<br>• Design – Understand chemical substances in use for product design.<br>• Manufacturing – Ensure products are manufactured to meet your chemical regulation, sustainability and circular economy targets. |

| # | Task | Task Details |
|---|---|---|
| | | • Business operations – Ensure business operations perform (sales, back-office, warehousing) operations to meet your chemical regulation, sustainability and circular economy targets. |
| 11. | Enforce gated reviews. | Ensure all relevant business decisions are reviewed by the product stewardship panel. This should cover reviewing existing products as well as reviewing new products as the move from design, manufacture, testing prior to being placed onto a marketplace. |
| 12. | Continuous improvements | Regularly monitor the changes reviewed by the product stewardship panel. Adjust decisions and actions to align with chemical regulation, sustainability and circular economy targets. |

Source: Takhar and Liyanage, 2019.

Actions which can be undertaken as part of the product stewardship process include:

- Assessments of existing chemical substances, mixtures, materials, semi-components and components used to create a product, this will include a review of:
    - Substances and mixtures physically held on hand within an organization, cross checking against relevant MSDS/SDS/eSDS data to identify chemical substances;
    - Reviewing existing product definitions from geometry definitions and checking information against material and process specifications to identify substances likely to appear on finished products and those chemicals used in the manufacturing cycle;
    - Performing supply chain outreach via reporting template and chemicals of concern substance list;
- Assessing and implementing recycling activities of all waste materials used in the manufacturing cycle;
- Phasing out the use of toxic chemicals within products to enable products to be more easily recycled and reused as part of any sustainability and circular economy initiatives.
- Assessing the use of potential alternative substances, where substances have been identified via  have been identified as becoming potentially more controlled, this may include the use of tools such as Greenscreen to identify hazards posed different alternative substances, to avoid any regrettable substitution activities.
- Assess and establish EPR schemes to collect products at EOL stage (where applicable) to recycle materials as part of circular economy activities;
- Repeat the cycle of tasks dependent of the topic(s) listed here, identifying any continuous improvement activities.

## 2.8 Action plan for when substances become more controlled

Having identified: (1) a chemicals of concern substance list for the electronics sector; (2) conducted supply chain reporting, identifying any potential; issues; (3) the issues then being addressed via a product stewardship process, further actions may then arise if chemical regulators decide to further control chemical substances identified as being the most hazardous. In such circumstances action plans should be developed specifically to address the impact(s) of the specific chemical substance upon the sector, identifying the specific needs of an industry sector, consulting relevant stakeholders and presenting the data in any consultations, to ultimately enable the sector to obtain exemptions or continued permits to use the chemical substance until such time that suitable alternative substances can be validated and used across the sector. Given the diversity of products across the electronics sector, for some product types such as consumer products, the impacts of chemicals becoming more controlled may have minor impacts in comparison to military, aerospace and medical device sectors where product design, validation and certification activities can result in long lead times. All relevant stakeholders need to be identified in relation to the specific chemical of concern, as shown in Figure [10]:

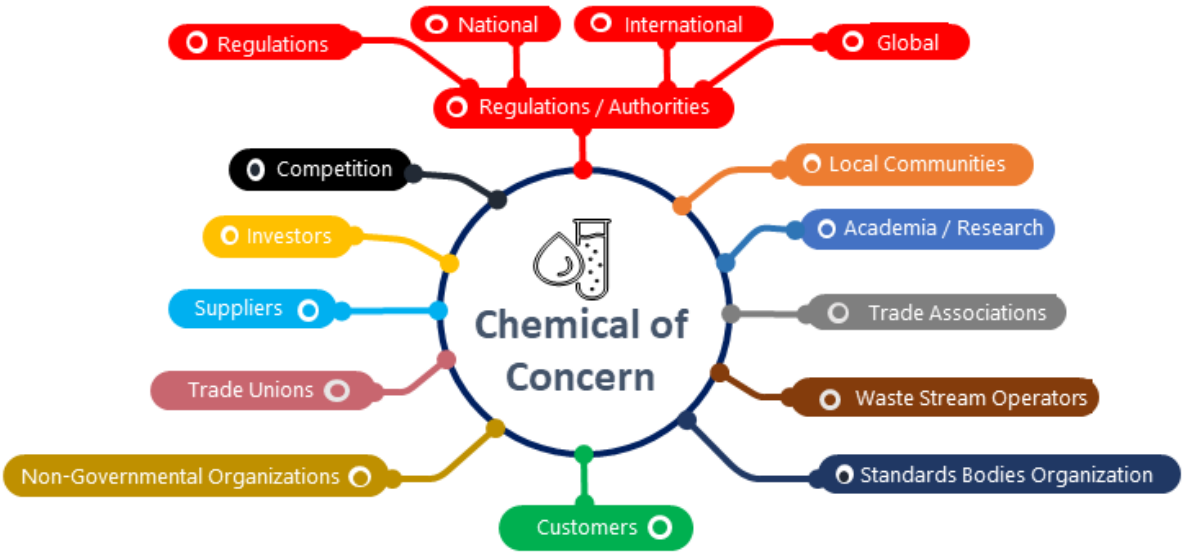


Figure 10: Identification of stakeholder map in relation to a chemical of concern

An initial table of stakeholders is shown in Appendix Seven. Actions which need to be undertaken are shown in Figure [11], these actions are based on requirements capture and management concepts utilized in the procurement and IT sectors.

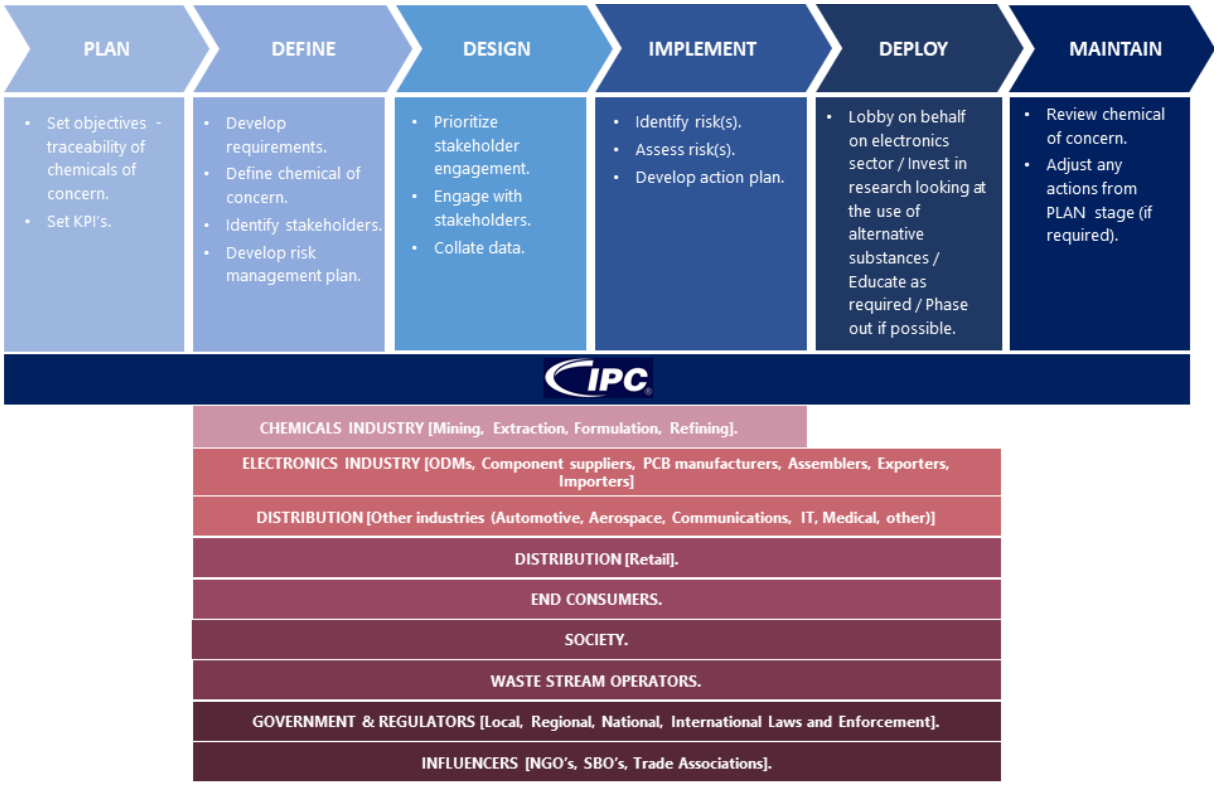


Figure 11: Stakeholder engagement and risk management (high-level)
Adapted from: CMMI Wiki, 2019; Porter, 1980.

The underlying methodology aims: (1) to identify relevant stakeholders; (2) engage with identified stakeholders; (3) raise awareness of potential issues with the identified chemical; (4) define requirements; (5) implement the desired outcomes, in the case of a chemical becoming more controlled, these activities may include: (i) analysis reports, (ii) action plans; (iii) socio-economic analysis to be used in public consultations, political lobbying, etc.

## 2.9 Other topic areas which may potentially impact the electronics sector

Table [8] identifies potential key top areas which may require further investigation by IPC.

Table 8: Key topic areas and potential risks posed

| Topic | Description of potential risk | Estimated impact(s) | Action(s) | Source(s) |
|---|---|---|---|---|
| Trade disputes | On-going tariff charge hikes between the US and China. Increasing the cost of both raw materials and import / export of associated components. | CTA estimated the impact of the initial rounds of tariff charges impacted the electronics sector by $10B in terms of components and parts. List 4a was originally scheduled for 1st September 2019, this was expected to have an impact $52B to finished consumer products (desktop computers, digital cameras, fitness trackers, lithium batteries, | Lobby against the increased charges and likely impact to the electronics sector. | CNBC.com, 2019; USTR, 2019. |

| Topic | Description of potential risk | Estimated impact(s) | Action(s) | Source(s) |
|---|---|---|---|---|
| | | smartwatches, TVs, etc.). Apple estimated the impact of the tariff charge liabilities at $500M. List 4a has now been delayed until December 2019. CTA has estimated the impact of List 4b will impact $115B of finished consumer goods (laptops, smartphones, tablets, video game consoles, etc.) | | |
| Circular Economy | Designing products to be both more durable, nut also recyclable, enabling the reuse of components and easier reprocessing of products into secondary raw materials. | (i) Anticipated annual material savings of US$70M within the consumer goods sector; (ii) US$550B reduction in health care costs from the food sector; (iii) potential €3,000 increases in disposable income for EU households | Investigate the use of: (i) non-toxic substances in new products to enable better recycling; (ii) better quality recycling to enable higher quality secondary raw materials created for use within the electronics sector. | Ellen MacArthur Foundation, 2019; Panda Security, 2019. |
| Automotive | Removal of recommendation 0019 to move from a need to report aggregated substance information for electronics in automobiles, towards FMD reporting of all substances with components. | New rules, update IMDS software and re-submittal of FMD data from suppliers of electronic components to the automobile industry. | | |
| EU Eco-Design | Implemented a ban on halogenated flame retardants from the casing and stand of electronic displays in a non-REACH/RoHS type regulation. | | | Assent Compliance Blog, 2019. |
| EU CLP | Borate Acid and Borate | Currently being investigated. | Investigate the potential impacts on the electronics supply chain. | CLP Borate, (2019). |
| EU CLP | Cobalt Metals | Expected to be added to the EU CLP Annex VII list in 2021 as a CMR type 1B, likely to be followed by an entry onto the EU Candidate list. | Investigate the potential impacts on the electronics supply chain. CLP will require clear product labelling. | CLP Cobalt Metal, 2019. |
| EU CLP | Silver | Currently under a review cycle, proposal is to classify as Repro 1B, expectation is that it may be added to the CLP list in 2021. | Widely used in electronics, CLP listing may invoke an EU Candidate list update later. | CLP Silver, 2019. |
| EU REACH | Cobalt salts - cobalt sulphate cobalt dinitrate cobalt dichloride cobalt carbonate cobalt di(acetate) | Going through a review process to potentially be added to the EU Restricted substances list around 2021. | Investigate the potential impacts on the electronics supply chain. | REACH Cobalt salts, 2019. |
| EU REACH | Lead Metal | Currently being assessed for inclusion onto the EU Authorised substance list. | Investigate the potential impacts on the electronics supply chain. | Lead REACH consortium, 2019. |

| Topic | Description of potential risk | Estimated impact(s) | Action(s) | Source(s) |
|---|---|---|---|---|
| EU REACH | Microplastics | Restrictions on use of microplastics currently being reviewed by the EC. | Investigate the potential impacts on the electronics supply chain. Liable to affect PCB housings and certain components. | REACH Microplastics, 2019. |
| EU RoHS | Beryllium | Currently under review for RoHS 3. | Investigate the potential impacts on the electronics supply chain. | Oko-Institut, 2019. |
| EU RoHS | Indium | Currently under review for RoHS 3. | Investigate the potential impacts on the electronics supply chain. | Oko-Institut, 2019. |
| TSCA | Chemical substances undergoing prioritization. | 20 high and 20 low chemical substances undergoing prioritization. | Investigate the potential impacts on the electronics supply chain. | TSCA, 2019b. |
| UK | Use of virgin materials. | New tax regime to be implemented which imposes a tax for companies that maintain use of virgin materials as opposed to using plastics containing recycled materials. Other regions EU and UAE are considering similar taxes. | Investigate the potential impacts on the electronics supply chain. | EU and UK plastic regulations. |

# 3. Conclusions and recommendations

## 3.1 Summary

Chemical regulations will continue to regulate more and more hazardous chemical substances. Industry must develop reporting systems to avoid potential business continuity risks. IPC as the leading trade association for the electronics sector can take positive steps towards enabling the electronics sector to respond, report and act to the different needs of different chemical regulations.

## 3.2 Recommended actions that IPC should consider

### 3.2.1 CRMs

- Validate the CRMs identified in section 2.2.4. This validation may occur internally or via a survey conducted with IPC members.
- Engage with the RMI to understand which CRMs are in scope of countries being assessed as part of the EU CMR review process, as some of these are likely to impact the electronics sector supply chain.

### 3.2.2 E-Waste

- Conduct further research related to understanding evolving e-waste technologies, specifically in how it can engage with waste operators to promote more recycling of low value CRMs as opposed to current practices in the recycling industry of targeting high-value CRMs.

### 3.2.3 Chemical regulations

- Develop a process of monitoring chemical regulations on a regular basis.
- Identify actions that may arise as a result of changing chemical regulations
- Liaise with IPC membership to illicit feedback in relation to changing chemical regulations.
- Liaise with IPC membership on any applicable consultations in relation to chemical regulations.
- Become an accredited stakeholder with ECHA to enable participation in the applicable committees for topics which may affect the electronics sector.

### 3.2.4 Approaches towards chemical substance reporting

- Understand how the activities of the Proactive Alliance may impact existing IPC standards. As an output of Proactive Alliance activities is to develop closer harmonization across different industry data exchange.
- Promote the work of the IPC E-31-AT-DSL harmonization committee as being an activity aiding the work being done undertaken as part of the Proactive Alliance activities.
- Consider working with other standards body organisations such as IEC and ISO to develop a harmonized approach towards the collection of supply chain data in consistent manner, to aid industry. A collaborative approach for data fields in data exchange standards would aid industry and align global standards.

### 3.2.5 Chemicals of concern list

- Review the list of regulations defined in Table [7], making any necessary additions and / or removals.

- Engage with its membership to confirm the list of regulations is valid and fit for purpose.
    - IPC may decide to add or remove regulatory lists from the other section in Table [7].
    - Regulations may be assigned a classification number based on priority for example:
        - Level 1: The requirement to report substance usage is immediate (the substance appears on a reportable list or it is on a authorised / restricted list);
        - Level 2: The substance is on a list considered as medium-term reporting applicability;
        - Level 3: The substance is on a future state list (others).
- Engage with a chemical list service provider such as chemadvisor, to produce a chemical of concern list based on the list of regulations identified.
    - The service provider then generates the applicable chemicals of concern list, breaking out substance groups and substances.
    - All substances should be identified in terms of a unique reference ID for example as used in AD-DSL or GADSL.
    - For each substance the applicable CAS number; EC number; substance name; applicable regulation; date of inclusion; IPC priority number, and; optionally a last updated date (useful when substances move between different lists for example going from EU REACH candidate list to authorised / restricted substance lists)
    - The service provider then maintains the chemicals of concern list on the behalf of IPC.
    - The list is periodically reviewed for correctness by the service provider, IPC and its membership.
- Liaise with membership to regularly revalidate the list of regulations, with the service provider then updating the list as applicable.
- IPC may decide to either charge a fee for the IPC defined chemicals of concern list for the electronics sector or allow membership to use the list in conjunction with desired method of data exchange.

- Understand how the activities of the Proactive Alliance will impact IPC standards, as an output of the work is to develop closer harmonization across different industry data exchange.
- Identify representatives to participate in Proactive Alliance discussions, to present the views the of the electronics sector.
- Actively promote the work of the IPC E-31-AT-DSL harmonization committee as being an activity aiding the work being done undertaken as part of the Proactive Alliance activities.

### 3.2.6 Product stewardship

- Engage and review with membership on industry best practices relating to product stewardship.
- Assess a potential data feed from the IPC connected factory initiative to provide data which could be used covering: (a) energy, material waste data which could potentially be encompassed into LCA analysis; (b) consider the potential for getting material information from the connected factory which may aid potential users to identify chemical substances consumed in existing chemical substances, mixtures, materials, semi-components and components used to manufacture products.

### 3.2.7 Action plan

- Review the outline process, develop stakeholder maps applicable to the specific chemical substance, then perform stakeholder engagement activities to enable documents to be generated to support consultations and lobbying activities on behalf of the electronics sector.

### 3.2.8 Other topics

- Review the other topics and assess potential impacts to the electronics sector.

# 4. Appendix

## 4.1 Appendix One: Global electronics sector data

Table 9: Global electronics sector data

| Sector | Examples of Electronic products | Application of products | Comments |
|---|---|---|---|
| Consumer electronics | Digital cameras; DVD; mobile phones; musical instrument amplifiers; public address systems; stereo equipment; speaker systems; TVs; video cameras, video games consoles. | Audio visual products; telephones and mobile devices; other consumer related products. | Global revenue August 2019 $1T; 5yr annual growth rate 0.7%; number of businesses 9,269; Industry employees 15,866,125 (IBISWorld, 2019a). Note report included mobile phone devices but excluded computer hardware. |
| Semi-conductor and electronic parts manufacturing | Analog semi-conductors; bare printed circuit boards; electronic connectors and inductors; logic semi-conductors; memory semi-conductors; printed circuit assembly; others. | Bare printed circuit board and printed circuit assembly manufacturing; capacitor manufacturing; connector manufacturing; resistor manufacturing; semiconductor manufacturing; others. | Global revenue January 2019 $738B; 5yr annual growth rate 7.2%; number of businesses 22,647; Industry employees 1,816,403 (IBISWorld, 2019b). Global sales have decreased by 15% in August 2019 compared to August 2018 (SIA, 2019). |
| Military aerospace | Aircraft parts and electronics; complete aircraft; missiles; MRO and other services; others. | Air. | Global revenue Jul 2019 $244B; 5yr annual growth rate -0.1%; number of businesses 1,888; Industry employees 664,935 (IBISWorld, 2019c). |
| Computer hardware | Desktops; laptops; storage devices; systems and servers; parts and attachments; others. | Computer manufacturing; peripheral equipment manufacturing; storage manufacturing; others. | Global revenue May 2019 $255B; 5yr annual growth rate -8.7%; number of businesses 3,328; Industry employees 699,033 (IBISWorld, 2019d). |
| Automotive | 40% components in standard automobiles are electronic components. This number increases with the Electric / Hybrid vehicles. | | |
| | Audio; control unit; current carrying devices; display; navigation; night vision; sensors; others. | ADAS, body electronics; communication systems; infotainment, safety systems, and powertrain | Global market size 2018 estimated at $230.38B (Grand view research, 2019a). |
| | Lithium-Ion, Lead-Acid, Nickel-Metal Hydride, Sodium-Ion type batteries. | Passenger Vehicles, Commercial Vehicles as BEV or PHEV. | Global market size 2018 estimated at $13.38B (Grand view research, 2019b). |
| Medical devices | Batteries; cardioverter-defibrillators; displays; memory devices; microcontrollers; microprocessors; pacemakers; MRI scanners; respiratory care devices; surgical robots; ultrasound devices, X-rays devices; others. | Diagnostic, medical implants and endoscopy patient monitoring, therapeutic. | Global market size 2018 estimated at $73B, (BusinessWire, 2019). |
| Global space systems. | Analog and mixed signals; discrete semiconductors; electrical power system; integrated circuits; memory; | | Global space electronics valued at $1.27B in 2018 (Global Newswire, 2019). |

| Sector | Examples of Electronic products | Application of products | Comments |
|---|---|---|---|
| | sensors; optoelectronics; others. | | |

## 4.2 Appendix Two: Industry sectors and regions producing electronic products

Table 10: Regions and nations supplying manufactured electronic products

| Region | Countries | # | Product types likely to contain electronics |
|---|---|---|---|
| Africa | South Africa. | 1 | Biomedical (United Scientific (Pty) Ltd), |
| Asia | China. | 10 | Consumer electronics (Lenovo), Home appliances (Haier), Renewable energy companies (Suntech), Aerospace (AviChina Industry & Tech), Automotive manufacturers (SAIC), Solar (Trina Solar, Jinko Solar, JA Solar, Yingli Green, SFCE, ReneSolar) |
| | Taiwan. | 15 | Consumer electronics (HTC), Electronic components (Mediatek), Semi-conductors (TSMC, ASE semiconductors, Nuvoton Technology Corporation), EMS providers (Hon Hai (Foxconn)), ODM manufacturers (Foxconn (Hon Hai), Pegatron, Quanta Computer, Compal Electronics, Wistron, Asustek Computer, Inventec, Chimei Innolux, Lite on Technology) |
| | South Korea. | 10 | Consumer electronics (Samsung Electronics, LG Electronics, Daewoo), Automobile manufacturers (Hyundai), Renewable energy companies (Kyocera, Sharp Solar), Aerospace (Korea Aerospace Industries), Solar (Hanwha Q CELLS), Electronic components (Samsung Semi-conductors, SK Hynix) |
| | Japan. | 52 | Consumer electronics (Sony, NEC, Panasonic, Hitachi, Ky Kyocera, Mitsubishi, Panasonic, Toshiba, Fujitsu), Home appliances (Sharp), Automobile manufacturers (Honda, Isuzu Motors, Mazda, Mitsubishi Motors, Nissan, Subaru, Suzuki, Toyota), Rolling stock manufacturers (Hitachi, Kawasaki, Mitsubishi), Electric power companies (Tokyo Electric Power Company, Tohoku Electric Power, Okinawa Electric Power Company, Hokkaido Electric Power Company, Chubu Electric Power, Shikoku Electric Power, Kansai Electric Power Company, Kyushu Electric Power, Chugoku Electric Power Company, Hokuriku Electric Power Company), Biomedical (Astellas Pharma, Chugai Pharmaceutical Co., Daiichi Sankyo, Eisai, Hisamitsu Pharmaceutical, Mitsubishi Pharma, Shionogi, Takeda Pharmaceutical Co.), Aerospace (Mitsubishi Heavy Industries Aerospace, Oshkosh Defense, IHI Aerospace, Kawasaki Aerospace and Gas). Electronic Components (TDK Corporation), Semi-conductors (Toshiba, ARM, NEC, Sony Semiconductor, Renesas Electronics) |
| | India. | 37 | Home appliances (Bajaj Electricals, Havells, Anchor, Preethi, Premier), Lighting Products (Bajaj Electricals), Automobile manufacturers (Mahindra & Mahindra, Tata Motors, Maruti Suzuki, Ashok Leyland, Eicher, Force, Bajaj Automobile, Hero, Vespa), Aerospace (Hindustan Aeronautics Limited), Renewable energy companies (Suzlon, NHPC), Electric power companies (KEC International, KPIT Cummins, TATA power, NTPC, Adani Power, Reliance Power), Biomedical (Sun Pharmaceutical, Cipla, Lupin Limited, Cadila Healthcare, Dr. Reddy's Laboratories, Ranbaxy Laboratories, Biocon, Orchid, Bharat Biotech International, Panacea, Serum Institute of India, Torrent Pharmaceuticals, Mankind Pharma, Ipca Laboratories, Alembic Pharmaceuticals, Suven life sciences, Aurobindo pharma, Ajanta Pharma, Strides arcolab) |
| | Pakistan. | 3 | Aerospace (Pakistan Aeronautical Complex), Electric power companies (WAPDA, K-Electric, Kapco) |
| | Singapore | 3 | EMS providers (Flextronics, Venture Mfg). Aerospace (Singapore Technologies Engineering Ltd.) |

| Region | Countries | # | Product types likely to contain electronics |
|---|---|---|---|
| Australia and Oceania. | Australia. | 1 | Biomedical (CSL Limited) |
| Europe. | Germany. | 50 | Consumer products (Siemens, AEG, Loewe, Medion), Home appliances (Bauknecht, Miele, BSH, Neff, Gaggenau), Automobile manufacturers (BMW, Daimler, Porsche, Volkswagen, Audi, Opel, Rolls-Royce, Bosch), Rolling stock manufacturers (Siemens, Vossloh), Rolling stock manufacturers (Leszczynski Group), Aerospace (Airbus, EADS, Eurocopter, MTU Aero Engines), Renewable energy companies (Conergy, Enercon, Nordex, Q-Cells), Electric power companies (E.ON, RWE), Biomedical (Bayer, Boehringer-Ingelheim, Merck KGaA, Ratiopharm), PCB (Würth Gruppe, Schweizer Electronic, KSG GmbH + Co KG, Mektec Europa, Unimicron Germany, hmp Macroprint, European Electronic Systems, Polytron Print GmbH, Schaltungsdruck Storz, TW Elektronik Horst Muller, Elekonta Marek GmbH, Precoplat, Jenaer Leiterplatten, Ilfa) |
| | Holland. | 6 | Consumer electronics (Philips), Home appliances (Philips), Lighting Products (Philips), Biomedical (Akzo Nobel), PCB (Elco Group), Electronic components (NXP semiconductors) |
| | Switzerland | 17 | Consumer electronics (Logitech), Home appliances (Jura), Rolling stock manufacturers (Stadler Winterthur AG), Aerospace (Pilatus), Renewable energy companies (SunOpta), Biomedical (Hoffmann-La Roche, Novartis, Nycomed, Serono), PCB (GS SwissPCB AG, Dyconex AG, Varioprint AG Electronic, Optiprint AG, Cicor Group, Asetronic AG), Electronic components (TE Connectivity, STMicroelectronics) |
| | Spain | 10 | Home appliances (Fagor), Automobile manufacturers (Seat), Rolling stock manufacturers (Construcciones y auxiliar de ferrocarriles, Talgo), Aerospace (EADS-CASA), Renewable energy companies (Abengoa, Acciona, Gamesa), Electric power companies (Endesa, Iderbola, Union Fenosa) |
| | France. | 18 | Home appliances (Groupe SEB, Tefal, Moulinex), Rolling stock manufacturers (Alstom, Arbel Fauvet Rail, Lohr Industries, Socfer, Veoila Transport (CFTA)), Aerospace (Airbus, Dassault Aviation, EADS, Eurocopter, Socata), Electric power companies (EDF, SNET), Biomedical (Sanofi-Aventis), PCB (Elvia Group, Cimulec Group) |
| | Italy. | 15 | Home appliances (Indesit, Candy), Automobile manufacturers (Fiat, Lamborghini), Rolling stock manufacturers (Ansaldo, Fiat), Aerospace (Alenia Aeronautica), Electric power companies (Enel), PCB (Elco Group, SoMaCis, Cistelaier-Group, Eleprint srl, Tecnomaster SpA, Silga SpA, OMR Italia SpA, |
| | Sweden. | 5 | Home appliances (Electrolux), Automobile manufacturers (Volvo), Aerospace (Saab), Electric power companies (Vattenfall), Biomedical (Camurus), |
| | Austria. | 3 | Lighting Products (Zumtobel), PCB (AT&S), Electronic components (EV Group) |
| | United Kingdom. | 17 | Automobile manufacturers (Bentley), Aerospace (Rolls-Royce, Augusta Westland, BAE Systems, Babcock International, GKN Aerospace, Meggitt, Cobham), Biomedical (AstraZeneca, GlaxoSmithKline, Napp, Shire plc), PCB (Amphenol-Invotec, Graphic plc, Spirit Group, Merlin (Falcon) Group), Electronic components (Dynex) |
| | Belgium | 4 | Rolling stock manufacturers (La Brugeoise et Nivelles), Electric power companies (Electrabel), Biomedical (Solvay), PCB (ACB N.V.) |
| | Czechoslovakia | 1 | Aerospace (Aero Vodochody) |
| | Denmark | 2 | Renewable energy companies (Vestas), Biomedical (Novo Nordisk) |
| | Portugal | 1 | Electric power companies (Electricidade de Portugall) |
| | Estonia | 1 | Biomedical (Quattromed) |
| | Ireland | 2 | Biomedical (MedTronic, Boston Scientific) |

| Region | Countries | # | Product types likely to contain electronics |
|---|---|---|---|
| | Israel | 2 | Aerospace (IAI industries), Biomedical (Teva Pharmaceutical Industries) |
| | Turkey | 1 | Aerospace (Aselsan A.S.) |
| | Norway | 1 | Electronic components (Elkem) |
| North America. | US. | 128 | Consumer electronics (Apple, Microsoft, Google, Emerson Radio, General Electric, IBM, Hewlett-Packard, Dell), Home appliances (General Electric, Maytag, Whirlpool), Lighting Products (Artcraft Fluorescent Lighting Corporation, Genlyte, Lightoiler, Maglite, Universal Lighting Technologies), Automobile manufacturers (Ford, General Motors), Rolling stock manufacturers (Baldwin, Brookville, Electro-Motive Diesel, General Electric, Whitcomb), Aerospace (Aerojet Rocketdyne Holdings, AAR Corp, Bell Helicopter, Boeing, CAE Inc, Cessna Aircraft Company, General Dynamics, Hexcel Corp, Eaton Aerospace, Engility, Lockheed Martin, Maxar Technologies, Mooney Airplane Company, GE Aerospace, Northrop Grumman, Parker Hannifin Aerospace, Piper Aircraft, Raytheon, Spirit AeroSystems, Sikorsky Aircraft, Collins Aerospace, Triumph Group, L3, Harris Corp, Woodward Aerospace, Wesco Aircraft, ManTech Int'l Corp, KLX Inc, Cummins), Renewable energy companies (Ausra, General Electric, SunPower), Electric power companies (GE Energy, Southern California Edison, Pacific Gas & Electric, San Diego Gas & Electric, Commonwealth Edison, Consolidated Edison, Pepco, Dynegy, NSTAR, Reliant Energy, Southern Company, Hawaiian Electric Industries, Arizona Public Service), Biomedical (Abbott Laboratories, Abbvie, Alcon, Allergan, Amgen, Amylin Pharmaceuticals, Bausch & Lomb, Baxter International, Biogen Idec, Bristol-Myers Squibb, Celgene, Cephalon, Eli Lilly and Co., Forest Laboratories, Genentech, Genzyme, Gilead Sciences, ImClone, Johnson and Johnson, Stryker, MedImmune, Merck & Co., Mylan Laboratories, Pfizer, Procter & Gamble, Schering-Plough, Teva Pharmaceutical Industries, Valeant Pharmaceuticals International, Vertex Pharmaceuticals, Watson Pharmaceuticals, Wyeth), EMS providers (Jabil Circuit, Sanmina, Plexus, Benchmark Elec), Semi-conductor manufacturers (Intel, Nvidia, AMD, Texas Instruments, Micron Technology, Analog Devices, Microchip Technology, Skyworks Solutions, Inc, Maxim Integrated Products, Inc, Xilinx, Inc, ON semiconductors, Qualcomm, Broadcom, Applied Materials, Microchip, Cadence Design Systems Inc, Crocus Technology, GlobalFoundries, Praxair, IM Flash, Cisco, Palo Alto, Qorvo), Solar (First Solar, SunPower Corp). |
| | Canada. | 19 | Rolling stock manufacturers (Bombardier Inc), Aerospace (Bombardier Inc), Electric power companies (BC Hydro, Manitoba Hydro, Hydro Ottawa, Yukon Electrical Company, Northland Utilities, Nova Scotia Power, SaskPower, Toronto Hydro, Toronto Electric Light Company, Hydro One, EPCOR, Qulliq Energy Corporation, Hydro-Québec, Bullfrog Power), Biomedical (Therapure BioPharma Inc), EMS providers (Celestica), Solar (Canadian Solar), |
| South America | Brazil. | 2 | Aerospace (Embraer, Helibras), Electric power companies (Electrobras) |

Source: Custer Consulting Group, 2018; Companies Portal, 2019, Electronics and You, 2019.

## 4.3 Appendix Three: Critical raw materials for the electronics sector

Table 11: Key materials used in the electronics sector

| Material | Where used in electronics | Comments | Source(s) |
|---|---|---|---|
| Aluminum | (1) RF connectors; (2) aluminum capacitors; (3) resistors. | Prices have been on the decline for the past 2 years. Tariff charges have increased the cost in the US. | TTI!, 2019 |
| Antimony | Microelectronics | | International Antimony Association, 2019. |
| Arsenic | Semiconductors | | Commerce.gov, 2019. |
| Baryte / Barite | (1) Shielding; (2) TV screens. | | Barytes.org, 2019. |
| Bauxite | See Aluminium – Bauxite is ore used to manufacture aluminum | | Commerce.gov, 2019. |
| Beryllium | (1) Telecommunications; (2) computers; (3) battery contacts. | | Beryllium, 2019. |
| Bismuth | Replacement for lead in solder. | | Bismuth, 2019. |
| Borate | Flame retardant in electronics. | | Borax, 2019. |
| Cesium | | Indirect, powers atomic clocks used by GPS systems | Commerce.gov, 2019. |
| Chromium | Insulation wiring for cables. | | Chromium, 2019. |
| Cobalt | (1) Semi-conductors; (2) solar panels; (3) fuel cells; (4) rechargeable batteries used in portable electronic devices; (5) batteries used in electric / hybrid cars; (6) medical devices; (7) wind turbines. | Defined as a responsible mineral by OECD. Optional reporting. | CRM alliance, 2016. |
| Copper | (1) PCBs; (2) connectors; (3) cables; (4) capacitors; (5) resistors; (6) inductors; (7) ferrites; (8) fuses. | Prices have been on the decline for the past 2 years. | TTI!, 2019 |
| Fluorspar | (1) Electrical and electronic appliances; (2) lithium batteries. | | CRM Alliance, 2017. |
| Gallium | (1) Microwave circuits; (2) high-speed switching circuits; (3) infrared circuits. | | Gallium Wiki, 2019. |
| Germanium | Semi-conductors. | | Germanium, Wiki, 2019. |
| Gold | 91% of Gold is used in Electronic products. | Defined as a responsible mineral by OECD. Dodd–Frank Act 2010 implemented the need to report sourcing in annual accounts filed with US SEC. Will form part of EU CMR from 2021. | EPRM, 2018 |
| Hafnium | (1) Electronic equipment; (2) light bulbs; (3) nuclear power industry. | | Livescience, (2018). |
| Helium | Semi-conductor manufacturing process. | | SumitSourceFunding, 2016. |
| Indium | Semi-conductors. | | Indium Wiki, 2019. |
| Lead | (1) Solder (subject to approval); (2) mica capacitors; (3) resistors. | Prices have been rising and declining sharply for the past 2 years. | TTI!, 2019 |
| Lithium | Batteries. | | Lithium Wiki, 2019. |

| Material | Where used in electronics | Comments | Source(s) |
|---|---|---|---|
| Magnesium | Light weight metal used for shielding parts and products. | | IMA, 2019. |
| Natural Graphite | (1) Electrodes (2) batteries; (3) solar panels. | | Graphite wiki, 2019. |
| Natural Rubber | (1) Shock protection; (2) electromagnetic interference; (3) chemical intrusion; (4) others. | | Minor Rubber, 2019. |
| Nickel | (1) Connectors; (2) capacitors; (3) resistors; (4) inductors; (5) ferrites; (6) fuses. | Prices have been rising and declining sharply for the past 2 years. | Nickel Wiki, 2019; TTI!, 2019 |
| Niobium | Passive electronic components. | | Niobium Wiki, 2019. |
| Oil | (1) Connectors; (2) film capacitors. | Prices have been rising and declining for the past 2 years. | TTI!, 2019 |
| Palladium | (1) Connectors; (2) ceramic capacitors; (3) SMD resistors, (4) varistors. | Prices have been rising sharply for the past 2 years. | TTI!, 2019 |
| Platinum / PGM | (1) Ceramic capacitors; (2) tantalum capacitors. | Prices have been rising and declining sharply for the past 2 years. | TTI!, 2019 |
| Rare Earths | Widely used within electronics. | | |
| Rhenium | Electrical contacts | | Chemicool, 2019. |
| Scandium | (1) Electronics; (2) lasers. | | Scandium Wiki, 2019. |
| Silicon metals | (1) Solar cells; (2) microchips. | | Silicon Metals Wiki, 2019. |
| Silver | (1) capacitors; (2) resistors; (3) ferrites; (4) fuses; (5) varistors. | Prices have been rising and declining sharply for the past 2 years. | TTI!, 2019; Silver mining Wiki, 2019. |
| Steel | (1) Metal circular connectors; (2) resistors; (3) inductors; (4) ferrites. | Tariff charges have increased the cost in the US. | TTI!, 2019 |
| Strontium | (1) Cathode ray tubes; (2) magnets and; (3) for refining Zinc. | | Strontium Wiki, 2019. |
| Solvents and gases | (1) Cleaning; (2) degreasing; (3) removing impurities. | | |
| Tantalite (tantalum) | 40% of Tantalite is used in Electronic products. | Defined as a responsible mineral by OECD. Dodd–Frank Act 2010 implemented the need to report sourcing in annual accounts filed with US SEC. Will form part of EU CMR from 2021. | EPRM, 2018 |
| Tin | 64% of Tin is used in Electronic products. | | EPRM, 2018; Tin Mining Wiki, 2019. |
| Tungsten | 70% of Tungsten is used in Electronic products. | | EPRM, 2018 |
| Tellurium | (1) Used in solar cells; (2) semi-conductors; (3) phase change memory chips. | | Tellurium Wiki, 2019. |
| Titanium / Titanium Mineral concentrates | Titanium electronic circuits where titanium metal is used generate a complete electronic circuit. | | Titanium Wiki, 2019. |
| Uranium | Material for nuclear industry, power generation and military application. | | |
| Vanadium | Low-power electronics, communication systems | | ScienceDaily, 2019. |
| Zirconium / Zirconium | Reactor fuel rods for nuclear industry. | | Zirconium Wiki, 2019. |

| Material | Where used in electronics | Comments | Source(s) |
|---|---|---|---|
| mineral concentrates | | | |
| Zinc | Varistors. | Prices have been rising and declining sharply for the past 2 years. | TTI!, 2019; Zinc Mining Wiki, 2019. |

## 4.4 Appendix Four: CRM materials recycling

Table 12: CRM recycling rates

| CRM Name | Recycling rates | Source(s) |
|---|---|---|
| Aluminum | One of the most widely recycled materials. 75% of all aluminum produced in history is still being used. | Aluminium Wiki, 2019. |
| Antimony | Limited options, Antimony can be recovered from ELV recycling activities from used lead-acid batteries. | Umicore, 2019a. |
| Arsenic | Limited. | |
| Baryte / Barite | No technology available | |
| Bauxite | See Aluminum | |
| Beryllium | Long life time material, limited recycling. | Berrylium.eu, 2016. |
| Bismuth | Difficult to recycle as it is used in a wide range of uses. | |
| Borate | Limited. | |
| Chromium | Limited, recycled into other super alloys. | |
| Cobalt | Recoverable from manufacturing processes and from used EOL NiMH, Li-ion batteries and catalysts / alloys used in aerospace applications. | Umicore, 2019b. |
| Copper | 50% of copper is recycled. | European Copper Institute, 2018. |
| Fluorspar | Consumed in use, not recyclable. | |
| Gallium | Recycling takes place from scrap manufacturing material, not from EOL products. | ElectronicDesign, 2016. |
| Germanium | Recycling takes place from scrap manufacturing material, not from EOL products. | Umicore, 2019c. |
| Gold | Variable 70% to 90% of industrial uses recycled. 10% to 15% from electronic products. | Sustainable Businesses, 2019. |
| Hafnium | Recycled in similar manner to Zirconium | |
| Helium | Technology available, cost of technology versus price of helium currently makes it not an economically viable option. | |
| Indium | Recyclable from conductive coatings. | Umicore, 2019d. |
| Lead | Widely recycled. | International Lead Association, 2014. |
| Lithium | Widely recycled, EU WEEE directive placed obligations on producers to finance lithium battery collection schemes for recycling. | Battery recycling wiki, 2019. |
| Magnesium | Widely recycled. | International Magnesium Association, 2019. |
| Natural Graphite | Recycling via fusion with synthetic graphite. | Graphite Wiki, 2019. |
| Natural Rubber | Recyclable. | |
| Nickel | 68% recycled from consumer products. | Nickel Institute, 2018. |
| Niobium | Increased recycling rates 60% recycling rate expected in 2025. | MDPI, 2019. |
| Oil | Recyclable. | |
| Palladium | Widely recycled. | Umicore, 2019e. |
| Platinum / PGM | Widely recycled. | Umicore, 2019f. |
| Rare Earths | Limited. | |
| Rhenium | Recovered from super-alloy blades used in aerospace. | Umicore, 2019g. |

| CRM Name | Recycling rates | Source(s) |
|---|---|---|
| Scandium | Limited data. | |
| Silicon Metal | Limited data. | |
| Silver | Widely recycled. | |
| Steel | Highly recycled. | ASM, 2018. |
| Strontium | Limited data. | |
| Solvents and gases | Limited data. | |
| Tantalite (tantalum) | Recyclable from tin smelting, waste from capacitor manufacture and EOL capacitors. | Umicore, 2019h. |
| Tellurium | Recyclable from copper refining. | Umicore, 2019i. |
| Tin | Low recycling rates 8%. | ASM, 2018. |
| Titanium / Titanium Mineral concentrates | Highly recycled | Takeda & Okabe, 2018. |
| Tungsten | 30% of scrap tungsten is recycled. | Metalpedia, 2019. |
| Uranium | Recycled. | Whatisnuclear, 2019. |
| Vanadium | Limited data. | |
| Zirconium / Zirconium mineral concentrates | Limited data. | |
| Zinc | 30% to 40% of global zinc is sourced from scrap metal. 70% of EOL products are recycled. | ASM, 2018. |

## 4.5 Appendix Five: Categorized chemical regulations

Table 13: Chemical regulations categorized

| # | Regulation Name | Product label | Product safety | Consumer | Industrial | Others |
|---|---|---|---|---|---|---|
| 01. | Directive 92/42/EEC efficiency requirements for new hot-water boilers. | | x | x | | |
| 02. | Directive 94/62/EC packaging and packaging waste | | | | | x |
| 03. | Directive 98/79/EC in vitro diagnostic medical devices. | | x | | | |
| 04. | Directive 2000/53/EC end-of-life vehicles. | | | | | x |
| 05. | Regulation (EC) No 850/2004 persistent organic pollutants. | | | | | x |
| 06. | Directive 2006/42/EC machinery | | | | x | |
| 07. | Directive 2006/40/EC emissions from air conditioning systems in motor vehicles. | | | | | x |
| 08. | Directive 2006/66/EC batteries and accumulators and waste batteries and accumulators. | | x | x | x | |
| 09. | Regulation (EC) No 1907/2006 EU REACH. | x | x | x | x | |
| 10. | Regulation (EC) No 1272/2008 classification, labelling and packaging of substances and mixtures. | x | x | x | x | x |
| 11. | Directive 2009/48/EC safety of toys. | | x | x | | |
| 12. | Regulation (EC) No 661/2009 type- approval requirements for the general safety of motor vehicles, their trailers and systems, components and separate technical units. | | x | x | | |
| 13. | Directive 2009/125/EC framework for the setting of ecodesign requirements for energy-related products. | x | x | x | x | |

| # | Regulation Name | Product label | Product safety | Consumer | Industrial | Others |
|---|---|---|---|---|---|---|
| 14. | Regulation (EC) No 1005/2009 substances that deplete the ozone layer. | | x | x | x | |
| 15. | Regulation (EC) No 66/2010 Ecolabel. | x | x | x | | |
| 16. | Regulation (EC) No 850/2004 persistent organic pollutants. | x | x | x | | |
| 17. | Directive 2011/65/EU restriction of the use of certain hazardous substances in electrical and electronic equipment. | x | x | x | x | |
| 18. | Regulation (EU) No 528/2012 biocidal products. | x | x | x | x | x |
| 19. | Directive 2012/19/EU waste electrical and electronic equipment (WEEE). | x | x | x | x | x |
| 20. | Regulation (EU) No 167/2013 approval and market surveillance of agricultural and forestry vehicles. | | | | x | x |
| 21. | Regulation (EU) No 168/2013 market surveillance of two- or three-wheel vehicles and quadricycle. | | | | x | x |
| 22. | Directive 2013/29/EU harmonisation of the laws of the Member States relating to the making available on the market of pyrotechnic articles | | | | x | x |
| 23. | Directive 2014/30/EU harmonisation of the laws of the Member States relating to electromagnetic compatibility | | | | x | x |
| 24. | Directive 2014/32/EU harmonisation of the laws of the Member States relating to the making available on the market of measuring instruments. | | | | x | x |
| 25. | Directive 2014/33/EU harmonisation of the laws of the Member States relating to lifts and safety components for lifts. | | | | x | |
| 26. | Directive 2014/34/EU harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres. | | | | x | |
| 27. | Directive 2014/35/EU harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits. | | | | x | x |
| 28. | Directive 2014/53/EU making available on the market of radio equipment. | | | | x | |
| 29. | Directive 2014/68/EU pressure equipment. | | | | x | |
| 30. | Directive 2014/90/EU marine equipment. | | | | x | |
| 31. | Regulation (EU) No 517/2014 fluorinated greenhouse gases. | | | x | x | x |
| 32. | Regulation (EU) 2016/424 cableway installations. | | | | x | |
| 33. | Regulation (EU) 2016/425 personal protective equipment. | | | | x | |
| 34. | Regulation (EU) 2016/1628 gaseous and particulate pollutant emission limits and type-approval for internal combustion engines for non-road mobile machinery. | | | | x | |
| 35. | Regulation (EU) 2017/745 MDR. | x | x | x | x | |

| # | Regulation Name | Product label | Product safety | Consumer | Industrial | Others |
|---|---|---|---|---|---|---|
| 36. | Regulation (EU) 2017/746 IVDR. | x | x | x | x | |
| 37. | Regulation (EU) 2017/852 mercury. | | | | | x |
| 38. | Regulation (EU) 2017/1369 framework for energy labelling. | x | | | | x |
| 39. | Regulation (EU) 2018/858 approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles. | x | x | x | x | |
| 40. | California proposition 65 | x | | | | |
| 41. | Smartlabel | x | | x | | x |
| 42. | EU GPSD no 2001/95/EC | | x | | | |
| 43. | UN GHS | x | | | | |
| 44. | AskREACH! | x | | | | |
| 45. | EPEAT | x | x | | x | |
| 46. | US TSCA | | | x | x | x |
| 47. | Canada CEPA | x | x | x | x | x |
| 48. | ECHA SCIP Database | | x | x | x | x |
| 50. | Canada WHIMS | x | | | | |
| 51. | Korea Priority Control Substances | | | x | x | x |
| 52. | IEC Declarable Substances List | | | x | x | x |
| 53. | China – restriction of chemical hazards in consumer products | x | x | x | | |
| 54. | GADSL | | | | x | |
| 55. | Chemsec SIN LIST | | | x | x | |
| 56. | IAEG AD-DSL | | | | x | |
| | **Totals** | **20** | **22** | **25** | **36** | **22** |

## 4.6 Appendix Six: ECHA definition of generating a chemical of concern list

ECHA (ECHA, 2019a) defines a chemical of concern as being (1) a substance falling into EU REACH regulatory control, or (2) a substance falling under EU CLP regulatory control. Note EU REACH focuses on identifying hazardous substances, ensuring appropriate measures are taken to monitor, control or restrict substances where applicable, EU CLP implements the UN GHS, to ensure substances are classified and labelled to identify any hazards. The Figure [12] below depicts the EU identification of substances of concern:

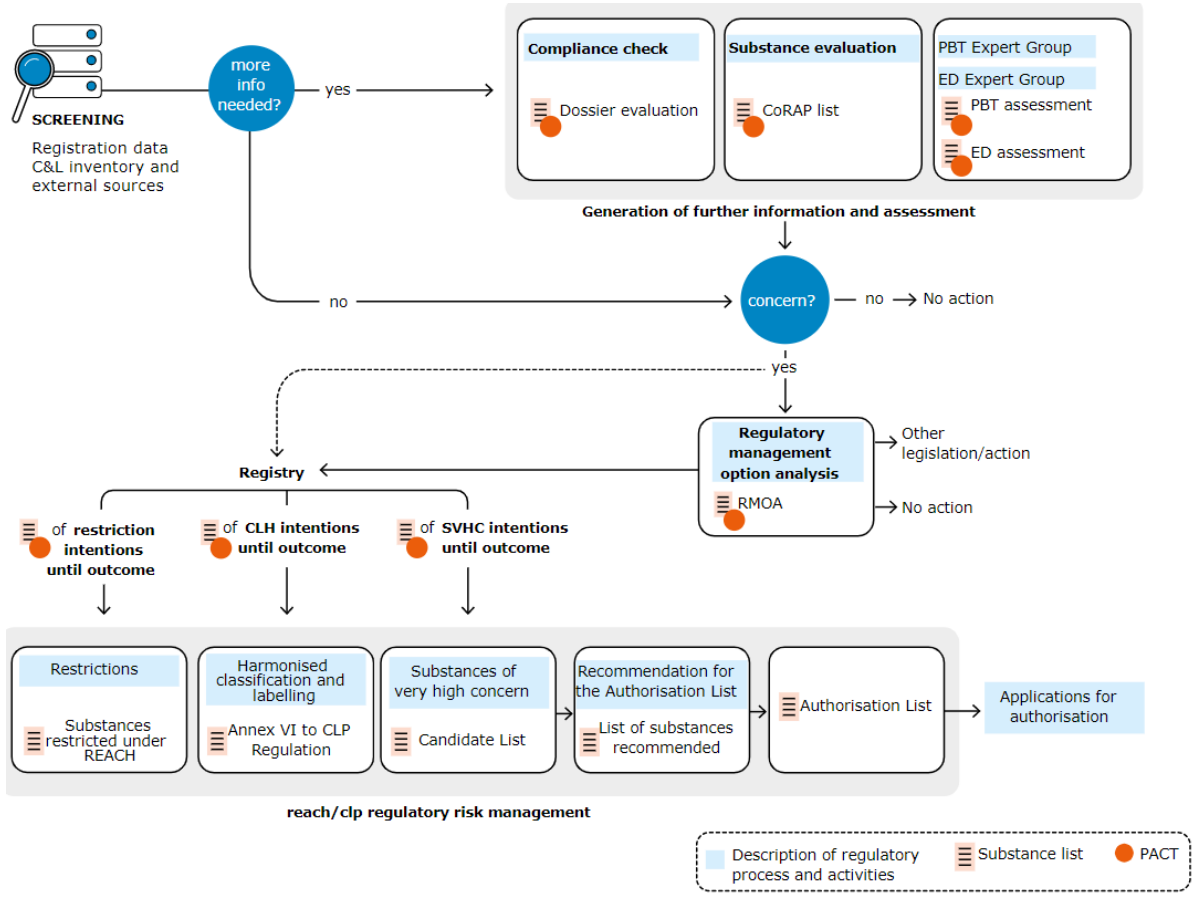


Figure 12: ECHA Addressing Substances of Concern

Source: [https://echa.europa.eu/substances-of-potential-concern]

The list of chemical substances in scope as per ECHA's defined chemical substances of concern are shown in Table [14]

Table 14: ECHA Defined chemical of concern list

| Table reference | Details | Reference URL | Current number of substances (*) |
|---|---|---|---|
| Substances restricted under EU REACH. | Annex XVII under EU REACH. | Substances restricted under EU REACH. | 70 substances |
| Registry of restriction intentions until outcome. | Review and extract substances in scope of future addition to the Annex XVII (Opinion development; Intention; Submitted) | Registry of restriction intentions until outcome. | 12 substances. |
| Annex VI to EU CLP. | | Table of harmonised entries in Annex VI to CLP. | 4249 substances. |
| Registry of CLH intentions until outcome. | Review and extract substances in scope of future addition to the CLH (Opinion development; Intention; Public Consultation; Submitted) | Registry of CLH intentions until outcome. | 177 substances. |
| Substances of Very High Concern. | | Candidate list of substances of very high concern for Authorisation. | 201 substances |

| Table reference | Details | Reference URL | Current number of substances (*) |
|---|---|---|---|
| Registry of SVHC Intentions until outcome. | Review and extract substances in scope of future addition to the Candidate List (Intention; Identified SVHC; Submitted). | Registry of SVHC Intentions until outcome. | 286 substances |
| Substances requiring Authorisation under EU REACH. | Annex XIV. | Substances requiring Authorisation under EU REACH. | 43 substances. |
| Registry of Submitted Recommendations for Authorisation. | Review and extract substances in scope of future addition to the Authorisation List (Recommended for inclusion in Annex XIV; Identified SVHC; Submitted). | Registry of Submitted Recommendations for Authorisation. | 31 substances. |
| Previous Authorisation Consultations. | Review and extract substances in scope of future addition to the Authorisation List (Opinion Development; Pending Decision). | Previous Authorisation Consultations. | 419 substances. |
| Current Authorisation Consultations. | | Current Authorisation Consultations. | 46 substances. |
| **Estimated substances in scope (note – duplicate substance names need to be removed)** | | | **5534 substances** |

*Substances identified as of 27th August 2019.

Factors to consider when using the ECHA substances of concern list:

- Covers REACH and CLP substance lists
- Electronics Sectors has additional regulations to adhere to EU RoHS, EU Batteries Directive, EU ELV, EU Biocides; EU Nanomaterials.

## 4.7 Appendix Seven: Example lists of stakeholders

Table 15: Examples of internal stakeholders

| Stakeholder Name | Stakeholder Description |
|---|---|
| Materials function. | Define chemical substances, mixtures and materials which can be used to design and manufacture products. |
| Engineering design function. | Design products fit for purpose which can be manufactured. |
| Purchasing function. | Procure materials for the organisation, potentially encompassing manufacture internally (make) or outsource product manufacture (buy) decisions. |
| Manufacturing function. | Manufacture products using defined materials. |
| Testing function. | Test product meets required functional design and safety parameters. |
| Warehouse function. | Package, store and distribute products to consumers. |
| Sales and marketing function. | Promote products and engage with customers. |
| Health and safety function. | Ensure safety of employees and the environment. |
| Quality function. | Ensure products are manufactured to be safe and of high quality. |
| Employees. | Provide time, labour and resources to support the business. |
| | Direct and indirect employees, require safe working environments. |

Table 16: Examples of external stakeholders

| Stakeholder Name | Stakeholder Description |
|---|---|
| Investors. | Desire organization to perform on a financially sound basis, generating yearly increasing profit returns. |
| Unions. | Desire protection of employee rights. |
| Local communities. | Desire a reduction in: (i) noise pollution; (ii) air pollution; (iii) waste emissions,; (iv) GHGs. |
| Customers. | Desire products that are: (i) safe; (ii) free from hazardous substances; (iii) do not impact the environment. |
| Chemical Trade Associations | Adhesive and Sealant Council, Inc.; American Chemistry Council; American Chemical Society; ACS Green Chemistry Institute; American Cleaning Institute; American Composites Manufacturers Association; Center for the Polyurethanes Industry; Chlorine Institute; The Fertilizer Institute; International Association of Chemical Distributors; Personal Care Products Council; Plastics Industry Association; Polyurethane Foam Association; Society of Chemical Manufacturers and Affiliates; Vinyl Institute. |
| Chemical Companies | 3M; BASF; Covestro; Haas Group International; Henkel; |
| Local | Local government member; local regulators. |
| Regional | Regional government member; regional regulators. |
| Canada | *[TBD].* |
| China | *[TBD].* |
| European Level | Member of European Parliament; CARACAL; Council of ministers – Environment council; Council of ministers - Health Attachés; DG Grow Unit DDG1.D1 REACH; DG Grow Unite DDG1.B Single Market Policy, Regulation and implementation; DG Grow Unit DDG1.C Industrial Transformation and Advance Value Chains; DG Grow Unit DDG1.D Consumer, Environmental and Health Technologies; DG Grow Unit DDG1.F Innovation and Advanced Manufacturing; DG Grow Unit D.2 Chemicals; DG Grow Unit DDG3.I Space Policy, Copernicus and Defence; DG Grow Unit DDG3.J EU Satellite Navigation Programmes; DG GROW Unit D.4. Health Technology and Cosmetics; DG ENV Unit B.2. Sustainable Chemicals; DG ENV Unit B.3. Waste Management and Secondary Materials; DG SANTE Unit E.4. Pesticides and Biocides; ECHA RAC; ECHA SEAC; ECHA Secretariat; ECHA MSC; EU parliament ENVI Committee; *[TBD].* |
| Japan Level | *METI; [TBD].* |
| South Korea Level | *[TBD].* |
| US Level | *[TBD].* |
| Others | *[TBD].* |
| Cross-Industry Initiatives | CII-OSH; Cefic cross-industry platform on microplastics; Eurometaux - Cobalt Institute Cobalt Metal Taskforce; CES Silicones Europe Downstream User Forum; Cross-Industry RoHS Coordination Group; RoHS Umbrella Project; Plastics Europe PC/BPA Group |
| SBOs / SDOs | BSi; IEC; IPC; ISO, (Japanese one), Japanese Industrial Standards Committee; Japanese Industrial Standards; |
| NGOs (digital rights) | Consumers International; Access Now; Association for Technology and Internet; BEUC – The European Consumers Organisation; Bits of Freedom; CILD – Coalizione Italiana Libertà e Diritti Civili; Chaos Computer Club; Digitalcourage; Electronic Frontier Norway; Electronic Frontier Finland; Epicenter.works; European Digital Rights; Fitug; Frënn vun der Ënn; Homo Digitalis; Hermes Center; Initiative for Network Freedom; IT-Pol; Open Rights Group; The Panoptykon Foundation; Privacy International; Xnet. |
| Trade associations (based purely on CRMs) | International Antimony Association; Beryllium Science and Technology Association; The Baryte Association; European Borates Association; Cobalt Institute; Copper Development Association; International Copper Alliance; Chinese Kings (Fluorite Association); Minor Metals Trade Association; LBMA; World Gold Council; Swiss Better Gold Association; International Lead Association; International Magnesium Association; China Graphite Industry Association; European Carbon and Graphite Association; China Carbon Industry Association; British Rubber and Polyurethane |

| Stakeholder Name | Stakeholder Description |
|---|---|
| | Products Association; British Tyre Manufacturers Association; Rubber Trade Association Singapore; The Polymer and Composites Industry Association; The Rubber Trade Association of Europe; Nickel Institute; Surface Engineering Association; International Nickel Study Group; Tantalum and Niobium International Study Center; The global oil and gas trade association; European Petroleum Industry Association; The London Platinum and Palladium Market; International Platinum Group Metals Association; Euroalliages; The Silver Institute; Precious Metals Association of North America; The International Steel Trade Association; Make UK; The World Steel Association; European Steel Association; Steel Construction; American Tin Trade Association; International Tin Association; European Precious Metals Federation; Vanitec; International Zinc Association; International Zinc Association Europe; American Zinc Association. |
| Trade associations (Manufacturers) | International Association for Soaps, Detergents and Maintenance Products; Aromatics Producers Association; Technical Committee of Petroleum Additive Manufacturers in Europe; Liaison Office of Rubber Industries; European Bromine Transportation Safety; Centre Européen d'Etudes des Polyphosphates; Centre Européen d'Etude des Silicates; CEFIC; European Council of the Paint, Printing Ink and Artists' Colours Industry; Confederation of European Paper Industries; Centre Européen des Silicones; Euro Chlor; Cosmetics Europe; Comité Technique Européen du Fluor; European Association for Textile Polyolefins; European Brominated Flame Retardant Industry Panel; European Council for Plasticizers and Intermediates; European Fluorocarbon Technical Committee; European Fuel Oxygenates Associations; European Industrial Gases Association; European Petrochemical Association; European Solvents Industry Group; Ecological and Toxicological Association of Dyes and Organic Pigments Manufacturers; EUROMETAUX European Association of Metals; European Association for Bioindustries; European Petroleum Industry Association; Food Contact Additives Sector Group; Human and Environmental Risk Assessment on ingredients of household cleaning products; European Diisocyanate and Polyol Producers Association; PetroChemical Europe; PlasticsEurope. |
| Automotive trade associations | ACEA; AIAG; Motorcycle Industry Association; SAE; SMMT; *[TBD]*. |
| Consumer trade associations | *[TBD]*. |
| Military trade associations | *[TBD]*. |
| Aerospace trade associations. | ADS; AIA; AIAA; ASD; IAEG; SAE; *[TBD]*. |
| Medical Devices trade associations | AdvaMed; COCIR; MedTech Europe; MedTech; *[TBD]*. |
| Semi-Conductor trade associations | IEC; IPC; *[TBD]*. |
| Electronic product trade associations | IEC; IPC; *[TBD]*. |
| Computer trade associations. | BCS; *[TBD]*. |
| Engineering trade associations | IET; *[TBD]*. |
| Rail industry trade associations | UNIFE; *[TBD]*. |

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