



Chemicals of Concern in Electronics

Review of Legislative and Regulatory Approaches



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1 Background, aims and scope

Chemicals in products and hazardous substances within the life cycle of electrical and electronic products have been longstanding emerging policy issues under the Strategic Approach to International Chemicals Management (SAICM). To further advance these issues, a GEF-funded project on “Global best practices on emerging chemical policy issues of concern under SAICM” has been launched in 2019, running through 2022. Amongst others, the activities under the project aim at increasing the ambition of different stakeholders to track and control chemicals along the value chains of electrical and electronic products.

To provide a strategic overview of the capacity and models that exist for sustainable management of electronics, the project includes the development of a review of legislative and regulatory approaches for prohibiting the use of Chemicals of Concern (CoC) in electronics including the transposition of the EU Directive on Restriction of Hazardous Substances (RoHS). This report provides this overview.

The regulatory landscape relevant for the use of CoC in electronics is complex and multidimensional (Figure 1). On an international level, several chemicals and chemical groups with documented uses in electrical and electronic equipment have been designated for global elimination by Multilateral Environmental Agreements (MEAs). Examples for this are the listing of polybrominated diphenyl ethers or short-chain chlorinated paraffins in Annex A of the Stockholm Convention or the global agreement on the elimination of mercury for a variety of uses under the Minamata Convention. On a national level, several different types of laws or regulations may be relevant for the use of CoC in electronics. The most apparent are laws and regulations that stipulate explicit chemicals-related provisions that are specific for electrical and electronic products, such as the EU directive on the restriction of certain hazardous substances in electrical and electronic products (RoHS). This type of regulation also includes mandatory standards that are specific for electronic products. In addition to these specific laws and regulations, overarching framework laws on chemicals or products can contain provisions that are not specific, but nevertheless relevant for the use of CoC in electronics. In the EU for example, the REACH regulation sets obligations for suppliers to provide consumers with sufficient information, if their products contain Substances Of Very High Concern (SVHC). These obligations apply to suppliers of all products, including suppliers of electronics. Similarly, the US Consumer Product Safety Improvement Act sets limit values for lead in all products designed or intended primarily for children age 12 or younger, which also includes electronic products. Lastly, specific regulations that address the use of individual chemicals or groups of chemicals independent of their use, may also be relevant for the issue of CoC in electronics. For example, the Argentinian Resolution 451/2019 from the Ministry of Environment prohibits chemicals listed under the Stockholm convention including their use in domestically manufactured and imported products including electronics.

All of these types of laws or regulations can exist alone or in parallel, and the nature of the regulatory landscape relevant for the use of CoC in electronics is highly specific on national contexts. Due to this complexity and the time constraints under the project, the scope of this analysis only covers **regional and national laws and regulations stipulating explicit chemicals-related provisions that are specific for electrical and electronic products**. Any other regulatory approaches that may not be specific, but nevertheless relevant to the use of CoC in electronics are not considered. Regulatory approaches explicitly only addressing batteries were also not considered.

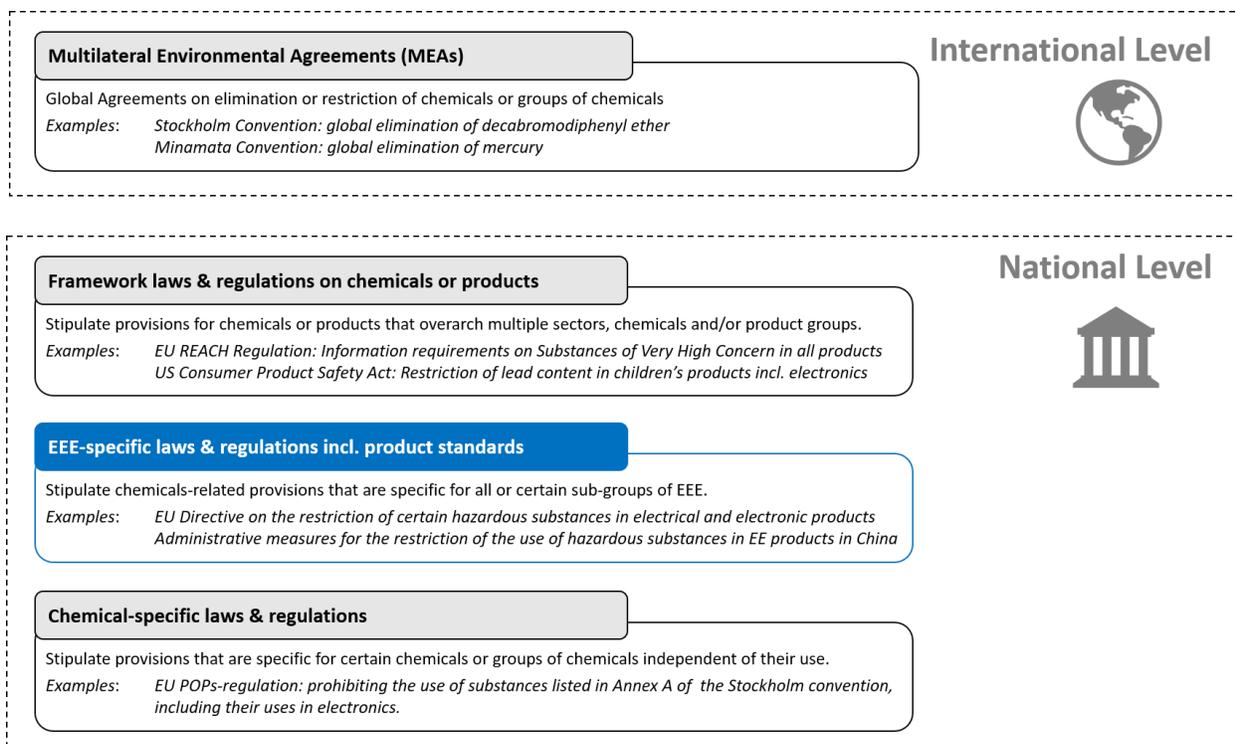


Figure 1: Regulatory landscape relevant for the use of chemicals of concern in electronic products.

As the EU RoHS directive has, to some extent, served as reference for some of the relevant laws and regulations across the globe, the second chapter of the report provides a brief summary of this approach. The third chapter provides an extensive overview of various regulatory approaches for the use of CoC in electrical and electronic products across the globe.

The compilation of this overview is based on publicly available documents and reports identified through online research. Wherever possible, regulatory texts were used as primary sources, but secondary sources, such as news articles, press releases or publicly available industry information were also considered. The research was conducted mainly in English and French. Documents only available in other languages were accessed with the aid of machine-based translation tools where possible. Although extensive efforts were undertaken to find relevant regulations, the research approach is limited to the public and online availability of documents in the respective search languages and it is possible that relevant regulatory approaches were not captured in the analysis. The report therefore provides a comprehensive but not necessarily exhaustive overview of the various regulatory approaches for CoC in EEE. Further inputs from the international community are welcomed to complement the research, especially with regards to relevant regulations that are not yet captured in the report.

2 The EU RoHS Directive

2.1 Directive 2002/95/EC – RoHS 1

The “directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment” (Directive 2002/95/EC) [1] was adopted in February 2003 by the European Union. Sometimes referred to as “RoHS 1”, this directive was closely linked to the directive 2002/96/EC on waste electrical

and electronic equipment (WEEE directive) and restricted the use of six hazardous substances in the following categories of electrical and electronic equipment

1. Large household appliances
2. Small household appliances
3. IT and telecommunications equipment
4. Consumer equipment
5. Lighting equipment
6. Electrical and electronic tools (with the exception of large-scale stationary industrial tools)
7. Toys, leisure and sports equipment
8. Medical devices (with the exception of all implanted and infected products)
9. Monitoring and control instruments
10. Automatic dispensers

Table 1 summarizes the regulatory provisions for the substances addressed under the original RoHS directive.

Table 1: Summary of regulatory provisions of Directive 2002/95/EC ("RoHS 1").

| Substance | Maximum allowable concentration in homogenous* materials |
|--|--|
| Lead | 0.1 % by weight |
| Mercury | 0.1 % by weight |
| Hexavalent chromium | 0.1 % by weight |
| Cadmium | 0.01 % by weight |
| Polybrominated biphenyls (PBB) | 0.1 % by weight |
| Polybrominated diphenyl ethers (PBDE) | 0.1 % by weight |
| *a homogenous material is defined as "a material of uniform composition throughout or a material consisting of a combination of materials that cannot be disjointed or separated into different materials by mechanical actions [...]" | |

In its latest version, the directive contained 79 specific exemptions from the restrictions.

2.2 Directive 2011/65/EU – RoHS 2

In 2011, the RoHS Directive was recast in order to reduce the administrative burden and ensure coherency with newer EU policies and legislation, such as the Regulation on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) or the new legislative framework for the marketing of products in the EU. The recast RoHS directive (Directive 2011/65/EU) [2], also referred to as "RoHS 2", was published on 1 July 2011 and fully replaced RoHS 1. Most notably, RoHS 2 decoupled its scope from the WEEE directive, introduced a methodology for the assessment of new hazardous substances in EEE and stipulated clearer and more transparent rules for exemptions [3]. It also streamlined specific product markings by integrating RoHS compliance into the requirements for CE-marking of products.

In 2015 RoHS was amended to include provisions for the restriction of four ortho-phthalates [4] which entered into force in July 2019. This amendment is sometimes referred to as "RoHS 3"¹. Table 2 summarizes the general provisions of RoHS currently in force in the EU [5].

Annexes III and IV of the EU RoHS Directive furthermore provide more than 100 specific exemptions for certain applications. Box 1 provides further information and illustrations of these exemptions.

Conformity assessment of products with the provisions of the directive is based on self-declaration. Companies are required to compile the relevant technical documentation for conformity assessment but must provide them to authorities only upon request.

Table 2: Summary of the general provisions of RoHS currently in force in the EU.

| Scope | Excluded from scope | Restricted substances & max. allowable content* |
|---|---|--|
| 1. Large household appliances. 2. Small household appliances. 3. IT and telecommunications equipment. 4. Consumer equipment. 5. Lighting equipment. 6. Electrical and electronic tools. 7. Toys, leisure and sports equipment. 8. Medical devices. 9. Monitoring and control instruments including industrial monitoring and control instruments. 10. Automatic dispensers. 11. Other EEE not covered by any of the categories above. | <ul style="list-style-type: none"> • Military equipment • Space equipment • Large-scale industrial tools • Large-scale fixed installations • Vehicles • Mobile machinery • Active implantable medical devices • Photovoltaic panels • R & D equipment • Pipe organs | <ul style="list-style-type: none"> • Cadmium: 0.01% • Mercury: 0.1% • Lead: 0.1% • Hexavalent chromium: 0.1% • Polybrominated biphenyls (PBB): 0.1%; • Polybrominated diphenyl ethers (PBDE): 0.1% • Bis(2-Ethylhexyl) phthalate (DEHP): 0.1% (added in 2015); • Benzyl butyl phthalate (BBP): 0.1% (added in 2015); • Dibutyl phthalate (DBP): 0.1% (added in 2015); • Diisobutyl phthalate (DIBP): 0.1% (added in 2015). |
| * In homogenous materials, is defined as "a material of uniform composition throughout or a material consisting of a combination of materials that cannot be disjointed or separated into different materials by mechanical actions [...]" | | |

Box 1: Exemptions under the RoHS directive

For situations where

- the elimination or substitution of regulated substances is scientifically or technically impracticable; or
- the reliability of substitute is not ensured; or
- the substitution's total negative environmental, health and consumer safety impacts are likely to outweigh the total environmental, health and consumer safety benefits,

¹ With these extensions being an amendment instead of a recast of the directive, "RoHS 3" has not been used in the terminology of the European Commission and will therefore not be further used in this report.

exemptions from the RoHS provisions be granted by the European Commission for specific applications. These exemptions are included in the Annex III and Annex IV of the RoHS directive. The Full list contains more than 90 specific applications and an additional 43 exemptions for applications specific to medical devices and monitoring and control instruments. Many of these exemptions are time-limited with the possibility of renewal upon request by industry stakeholders. Existing exemptions for which a renewal request has been submitted remain valid until a decision on the request is taken by the European Commission [6]. The listed specific exemptions include, for example:

- *Lead in high melting temperature type solders (i.e. lead-based alloys containing 85%w or more lead) for the following scope and timeframe*
 - o Products falling in the scope categories 1-7 and 10 until 21 July 2021
 - o Products falling in the scope categories 8 and 9 other than in-vitro diagnostic medical device and industrial monitoring and control instruments until 21 July 2021
 - o In vitro diagnostic medical devices until 21 July 2023
 - o Industrial monitoring and control instruments and for all other EEE not captured by any of the scope categories 1-10 until 21 July 2024.

2.3 Implementation and enforcement of RoHS within the EU Member States and other European countries

With RoHS being an EU directive, it has no direct binding legal force, but it lays down certain results that must be achieved by the Member States. Its provisions and procedures for enforcement, therefore have been transposed into the respective national laws of the 27 Member States.

Beyond the EU, other countries in Europe and in the European Economic Area (EEA) have also transposed the EU RoHS Directive into their national law. These countries include Norway, Liechtenstein and Iceland (EEA Member States) as well as Switzerland (EFTA Member State).

3 Overview of regulatory approaches outside of Europe

Since its first introduction the term "RoHS" has increasingly been used to describe chemicals-specific regulations and restrictions in electric and electronic products and many other regions and countries have introduced similar laws or regulations. While the EU RoHS directive has served as reference for some of these laws or regulations they can sometimes significantly differ in their scope and provisions due to differences in regulatory environments. While certain regulations, for example, explicitly prohibit the sale of products that contain certain substances above a maximum level, others simply require manufacturers to label their products according to whether they comply with a set of requirements. The scope of products addressed by these regulations varies from a small selection of products (e.g. only video devices) to all EEE sold on the market. The following sections provide an overview of the identified regulatory approaches. In a first section, the regulatory approaches imposing explicit restrictions on uses of certain substances in certain EE products are summarized. The second section summarizes regulatory approaches that impose any form of information requirement on the uses and/or levels of certain substances in EE products and a third section briefly summarizes regulatory actions that are under development at the date of the analysis. It is important to note that report provides a comprehensive but not necessarily exhaustive overview of the various regulatory approaches for CoC in EEE. .

3.1 Regulatory approaches imposing explicit restrictions

13 regulatory approaches could be identified that impose explicit restriction on uses of certain substances in certain categories of EE products. Table 3 gives an overview of these approaches (sorted by alphabetical order of the respective country / region).

3.1.1 State of California

In the United States of America, there is currently no regulation or law addressing CoC in EEE at a federal level. However, several States, such as California, have enacted laws addressing certain chemicals in EE products. California's RoHS law [7] is modelled after the EU RoHS 1 Directive and requires 'covered electronic devices'² sold in the state to meet the same requirements for heavy metals as those stipulated in the EU RoHS 1 directive. California's RoHS law therefore has a more limited scope than the EU RoHS Directive, addressing only four chemicals (mercury, lead, hexavalent chromium and cadmium) and one product type. Manufacturers of covered electronic devices sold in the State of California must submit an annual notice to the California Integrated Waste Management Board that includes information regarding the use of restricted substances in the devices [8].

3.1.2 China

In China, CoC in EEE are addressed by the "Administrative Measures for the Restriction of the Use of Hazardous Substances in Electrical and Electronic Products", often referred to as China-RoHS 2. It defines six chemicals and chemical groups and respective maximum allowable levels in EEE. The chemicals and respective maximum allowable levels are identical with the provisions in the EU RoHS 1 directive.

For implementation, the regulation takes a two-step approach: Since July 2016, manufacturers are required to determine the level of the six chemicals in their products and label them accordingly. Products containing one or more of the six chemicals above the allowable maximum level can therefore be sold on the market but require a special labelling as well as the disclosure of the chemical concentration within the product and the declaration of an Environment Friendly Use Period (EFUP), indicating the period of time before any of the regulated chemicals are likely to leak out of the product. Products not containing any of the six chemicals above the allowable maximum level must be labelled as such.

The second step of the regulation entered into force in November 2019 and stipulates mandatory compliance with the maximum allowable level of the six chemicals for 12 product types, set out in the "Qualification Management Catalogue for Restriction of Hazardous Substances in EEPs". Manufacture or sale of products not compliant with the maximum allowable levels of the six chemicals is prohibited. Compliance must be demonstrated by either a voluntary third-party certification or self-declaration via an online public service platform [9]. Similar to the EU RoHS Directive, the China RoHS qualification management catalogue includes a list of exemptions for cases where compliance is not technically or economically feasible. This list includes 39 exempt applications, which appear to be identical to the exemptions provided in Annex III of the EU RoHS 2 directive [10].

3.1.3 Eurasian Economic Union

The Technical Regulation of the Eurasian Economic Union TR EAEU 037/ 2016 on restriction of the use of certain hazardous substances in electrical and electronic equipment contains mandatory requirements for six chemicals and chemical groups in EEE (mercury, lead hexavalent chromium, cadmium, PBBs and PBDEs). The chemical scope and maximum allowable concentrations under the TR are identical with the provisions of the EU RoHS 1 Directive and the four ortho-phthalates addressed under the EU RoHS2

² Defined as video display devices with a screen greater than four inches, measured diagonally.

Directive are not included. Furthermore, certain aspects of the product scope differ between the two regulatory instruments.

EEE may only be placed on the market of the EAEU, if it is compliant with the requirements of the technical regulation. Conformity is demonstrated within the procedures for obtaining the EAC conformity mark.

3.1.4 India

In India the use of six chemicals and chemical groups are restricted for certain EE products through the E-Waste (Management and handling) Rules [11]. Products containing these substances above a maximum allowable concentration are banned from sale on the Indian market. The chemical scope and maximum allowable concentrations for each substance / substance group are identical with the provisions from the EU RoHS 1 Directive. However, the scope of products addressed by the Indian E-Waste (Management and handling) Rules differ significantly from the scope of EU RoHS. For example, the Indian rules do not apply to products serving micro and small enterprises. The Indian E-waste (Management and Handling) Rules provide 77 specific exemptions, which are similar to, but not identical with the ones specified by the EU RoHS Directive.

The Indian E-Waste (Management and Handling) Rules require the submission of documentary evidence of compliance to the government before a product can be sold [12] and also requires the inclusion of information on RoHS compliance in instruction manuals [13].

3.1.5 State of New Jersey

Similar to the state of California, New Jersey also enacted a regulation. The Waste Recycling Act (NJAC 13:1E-99.94 et seq.) bans the sale of new covered electronics including televisions, if the device does not comply with the requirements of the EU RoHS Directive for heavy metals. The sale of covered electronic devices that are non-compliant with these EU requirements is only permitted if the use of the heavy metals is required for compliance with certain consumer, health or safety requirements [14], [8]. Covered electronic devices are defined as video display devices (including television and computer monitors), all desktop or personal computers and portable computers sold to consumers.

Manufacturers of covered electronic devices must register their products with the New Jersey Department of Environmental Protection before placing them on the market. With this registration, manufacturers must provide a certification that their product complies with the provisions for heavy metals under the Waste Recycling Act. This registration has to be renewed on a yearly basis [15].

3.1.6 Oman

Since the end of June 2020, new radio and terminal equipment subject to the type approval process by the Omani Telecommunication Regulatory Authority (TRA) must provide evidence for compliance with the most recent amendment of the EU RoHS directive (EU Directive 2017/2120). The type approval process is mandatory for all radio and terminal equipment, before it can be imported to the Omani market [16].

3.1.7 Republic of Korea

The Act for Resource Recycling of Electrical and Electronic Equipment and Vehicles" and its Enforcement Decree [17] [18] restrict the use of six chemicals / chemical groups in EEE and four chemicals in vehicles. The six substances restricted in EEE and their respective maximum allowable concentrations are identical with the substances regulated under the EU RoHS 1 Directive. The scope of EE products addressed under the Korean Act however, differs from the EU RoHS directive by addressing nine product types from the categories of household appliances and IT products (Table 3) [19].

In contrast to EU RoHS, the Korean regulatory approach also addresses the use of four heavy metals in passenger cars, vans and truck up to 3.5 tons. The heavy metals and their respective maximum allowable concentrations are the same that are also included in the EU RoHS Directive (cadmium, mercury, lead, hexavalent chromium).

Manufacturers and importers of vehicles and EEE must make a compliance declaration either on the electrical and electronic assurance system (EcoAS)³, or on their company web-page. There is no specific certification requirement. [19]

The Republic of Korea currently considers extending the products scope addressed by its regulatory approach and including the four phthalates that are also included in the EU RoHS 2 Directive (DEHP, BBP, DBP and DIBP) [20]

3.1.8 Serbia

In Serbia, the use of certain chemicals in EEE is addressed by the "Management of Waste from and Hazardous Substances in Electrical and Electronic Equipment, Regulation" and its corresponding Rulebook [21]. It bans the placing on the market of certain EEE that contain six chemicals / chemical groups above a maximum allowable concentration. The chemicals addressed under the Serbian regulatory approach are the same six that have been addressed by the EU RoHS 1 directive, as are the maximum allowable concentrations. The product scope is similar to the EU RoHS directive but excludes medical devices and monitoring and control instruments. For each of the product categories, the rulebook provides a detailed list of products that are addressed by the regulation. The rulebook furthermore provides 73 specific exemptions which are almost identical with the exemptions under the EU RoHS 1 Directive (2002/95/EC)⁴

3.1.9 Singapore

In August 2016, the Ministry of Environment and Water Resources (MEWR) published an amendment to the Environmental Protection and Management Act that addresses chemicals in EEE and is often referred to as "Singapore RoHS" [22]. The regulation prohibits the sale of EEE containing six chemicals / chemical groups above a maximum allowable concentration. The chemicals addressed under the Singapore regulatory approach are the same six that have been addressed by the EU RoHS 1, as are the maximum allowable concentrations. In contrast, the product scope under the Singapore regulation is narrower than the one addressed by EU RoHS. It includes mobile phones, portable computers, air conditioners, panel TVs, refrigerators and washing machines and excludes all other types of EEE (e.g. medical devices or industrial use equipment) as well as spare parts [23]. Before the sale of any regulated product, local manufacturers or importers are required to submit a declaration of conformity to the National Environmental Agency [23].

3.1.10 Turkey

The Turkish "Regulation on the Control of Waste Electrical and Electronic Goods" [24] entered into force in June 2009. It is modelled on the EU RoHS 1 Directive and prohibits the sale and manufacture of certain EEE that contains one or more of six chemicals / chemical group exceeding a maximum allowable concentration. The chemicals addressed by the regulation are the same as included in the EU RoHS 1 Directive, as are the maximum allowable concentration values. The product scope is also similar to the

³ www.ecoas.or.kr

⁴ The Serbian Rulebook does not include the provisions of the Commission Decision 2011/534/EU of 8 September 2011, including Cadmium in photoresistors for analogue optocouplers applied in professional audio equipment as an exemption.

EU RoHS Directive, but does not include medical devices and monitoring and control instruments. For each of the product categories, the Turkish regulation provides a defined list of products in Annex 1.

Like the EU RoHS Directive, the Turkish regulation also provides a list of exemptions containing 29 entries. The exemptions are similar to the EU RoHS 1 Directive but not identical. For example, the Turkish regulation provides an exemption for the use of DecaBDE in polymeric applications and exemptions are generally not time-limited.

Manufacturers are obligated to compile technical documentation demonstrating compliance with the regulation's provisions and to keep these documents for ten years after the first introduction of a product to the market. Furthermore, manufacturers must submit an annual declaration of conformity to the Ministry of Environment and Urbanization.

3.1.11 Ukraine

The Ukrainian "Technical Regulation restricting the use of certain hazardous substances in electrical and electronic equipment (TR No. 139) [25] entered into force in September 2017. Its provisions are fully aligned with the EU RoHS 2 Directive as it addresses the same 10 chemicals/chemical groups and respective maximum allowable concentrations as well as an identical product scope. As the RoHS 2 Directive, the Ukrainian Technical Regulation also provides the same substance-specific exemptions from the provisions with only two exceptions: at the date of reporting, the Ukrainian regulation does not include the exemptions on DEHP in rubber components of certain engine systems and lead in solders of sensors, actuators and engine control units of certain combustion engines (Exemptions No. 43 and 44 of the EU RoHS 2 Directive⁵).

Manufacturers must label their products with a mark of conformity and draw up a declaration of conformity.

3.1.12 United Arab Emirates

In the United Arab Emirates, CoC in EEE are addressed by the provisions of the UAE Cabinet Decision No. 10 which was published in April 2017 [26] and has since then been implemented in several steps. The provisions of the UAE's regulation are, in essence, identical with the provisions of the EU RoHS 2 Directive in terms of product scope, chemicals addressed and their respective maximum allowable concentrations. The exemptions provided under the UAE regulation are also similar to the ones stipulated by the EU RoHS Directive, with the exception that the respective provision in the UAE regulation are not time limited.

The UAE regulation's provision on the obligation of suppliers of EEE related to the demonstration of conformity differ from the EU RoHS Directive. Suppliers of EEE⁶ must apply for a certificate of conformity under the UAE Assessment Scheme (ECAS) by use of an e-service portal. For this application, a supplier must provide amongst other things 3rd party test reports provided by an ISO 17025 accredited laboratory [27].

⁵ Amended to the EU RoHS 2 Directive by Commission Delegated Directives (EU) 2019/1845 and (EU) 2019/1864 of 8 August 2019.

⁶ Defined as "The factory, importer, agent or assembler of the product, or any main or secondary distributor whose activity affects the product properties or any commercial or legal representative responsible for the import, installation and operation of the product subject to the provisions hereof who practices his business through a company or individual establishment licensed in the State." [34]

3.1.13 Viet Nam

In Viet Nam, the use of certain chemicals in EEE is restricted by the provisions outlined in Circular No. 30/2011/TT-BCT, amended by Decision No. 4693/QĐ-BCT [28] [29]. The regulation restricts the use of six chemicals / chemical group in certain EEE. The chemicals and the maximum allowable concentrations, as well as the product scope are identical to the provisions of the original EU RoHS 1 Directive (Table 3), the product scope of the Vietnamese regulation differs in certain aspects from its European counterpart. The Vietnamese regulation also provides a list 72 specific exemptions which is similar but not identical to the exemptions included in the EU RoHS 1 Directive. Manufacturers or importers of EEE in Viet Nam must disclose the compliance of their product with the regulation either on their website, in the product's instruction documents, or directly on the product's packaging.

Table 3: Overview of regulatory approaches outside of Europe that explicitly impose restriction to the use of CoC in EEE.

| Country / Region & Name of Regulation | Restricted substances & max. allowable conc. | Product scope | Exemptions | Products excluded from scope | Ref. |
|--|--|--|---|--|----------------------|
| <p>State of California: California Restrictions on the use of Certain Hazardous Substances (RoHS) Law</p> | <p>By weight in all homogenous materials: - Cadmium: 0.01% - Lead: 0.1% - Mercury: 0.1% - Hexavalent chromium: 0.1%</p> | <p>Covered electronic devices defined as video display devices with a screen greater than four inches, measured diagonally</p> | <p>All applicable exemptions under the EU RoHS directive</p> | <p>-</p> | <p>[7]</p> |
| <p>China: Administrative Measures for the Restriction of the Use of Hazardous Substances in Electrical and Electronic Products (China RoHS 2)</p> | <p>By weight in all homogenous materials: - Cadmium & its compounds: 0.01% - Mercury & its compounds: 0.1% - Lead & its compounds: 0.1% - Hexavalent chromium & its compounds: 0.1% - Polybrominated biphenyls (PBB): 0.1 %; - Polybrominated diphenyl ethers (PBDE): 0.1%</p> | <p>Restrictions: - Refrigerators (up to 800 litres); - Air conditioners (Rated cooling capacity ≤ 14,000 watts); - Washing machine (dry clothes ≤ 10 kg); - Water heaters; Printers (≤ A3, ≤ 60 pages / minute); - Copiers (≤ A3, ≤ 60 pages / minute); - Fax machines; - TV sets; Monitors; - Microcomputers (desktop with necessary peripherals, laptops, tablets); - Mobile communication handset; - Telephones. Labelling requirements: Electrical and electronic products, defined as devices and accessory products with rated working electrical voltages of no more than 1500 volts direct current, and 1000 volts alternating current which function by means of current or electromagnetic fields, and generate, transmit and measure such currents and electromagnetic fields. This includes batteries.</p> | <p>Restrictions: 39 Exemptions including all exemptions in Annex III of the EU RoHS 2 directive (2011/8/65/EU). Only available in Chinese. Labelling Requirements: none</p> | <p>- EEE involving energy production and distribution equipment, such as power plants, transmission and distribution power stations, building supply and distribution systems and equipment used - EEE for defense and military use - EEE used in special environments or extreme environments - EEE for export - Electrical transportation equipment - Used equipment manufactured before July 1st, 2016 - Temporary entry of imported products or maintenance service, not for sale - Prototype for research / development, testing purposes - EEE for exhibition and other purposes, not for sale, etc.</p> | <p>[30] [31]</p> |

| Country / Region & Name of Regulation | Restricted substances & max. allowable conc. | Product scope | Exemptions | Products excluded from scope | Ref. |
|---|---|---|---|---|------|
| Eurasian Economic Union Technical regulation of the Customs Union 037/2016 "On restriction of use of hazardous substances in products of electrical engineering and radio electronics | By weight in all homogenous materials: - Cadmium: 0.01% - Lead: 0.1% - Mercury: 0.1% - Hexavalent chromium: 0.1% - Polybrominated biphenyls (PBB): 0.1% - Polybrominated diphenyl ethers (PBDE): 0.1% | <ul style="list-style-type: none"> - defined list of electrical devices and appliances for household uses - defined list of electronic computers and connected devices - defined list of telecommunication devices - copiers and other electrical office equipment - electrified tools - light sources and lighting equipment, including devices embedded in furniture - electronic music instruments / tools - Game and trading devices - cash registers, ticket printing machines, identification card readers, ATMs, information kiosks - cables, wires and cords intended for use at nominal voltage of maximum 500 V except of fiber-optic cables - Switches and automatic devices - Fire security equipment & detectors | | <ul style="list-style-type: none"> - Electrical devices and radio electronics intended for use at a rated voltage of more than 1000 V AC and 1500 V DC, - Electrical devices intended solely for use as components of electrical equipment not included in the list provided for in Appendix N 1 - Electric toys; - Photovoltaic panels (solar panels), which are part of the electrical products and radio electronics; - Electrical devices intended for use as part of ground and orbital space objects; - Electrical equipment intended exclusively for use in air, water, land and underground transport; - Electric batteries and accumulators, including those put into circulation on the territory of the Union as part of electrical products; - Electrical devices of second-use; - Measuring instruments; - Medical devices | [32] |
| India: E-Waste (Management and handling) Rules 2016 | By weight in all homogenous materials: - Cadmium: 0.01% - Lead: 0.1% - Mercury: 0.1% - Hexavalent chromium: 0.1% - Polybrominated biphenyls (PBB): 0.1% - Polybrominated diphenyl ethers (PBDE): 0.1% | <ul style="list-style-type: none"> - IT and telecommunications equipment: mainframes & minicomputers, personal computers, Laptops, Notebook computers, Notepad computers, printers incl. cartridges, copying equipment, electrical and electronic typewriters, user terminals & systems, facsimile, telex, telephones (pay, cordless & ceullular), answering systems.. -Large household appliances: Refrigerators, Washing | 77 specific exemptions, similar but not identical with Annex III of the amended EU RoHS 2 directive and without time limitations. | <ul style="list-style-type: none"> - Products for military and national defence - Products where electricity is not the primary power source ∴ Products where the primary function does not require electricity (e.g. talking dolls) ∴ Sub-assembly or component of exempted product category ∴ Products that serve small manufacturing and service businesses as defined under the Micro, Small & Medium | [11] |

| Country / Region & Name of Regulation | Restricted substances & max. allowable conc. | Product scope | Exemptions | Products excluded from scope | Ref. |
|--|--|---|---|---|----------------------|
| | | machines, Air-con (non-centralised air-con plants). - 'Consumer Equipment' : Television sets (all types) | | Enterprises Development Act of 2006 :: Batteries :: Radioactive waste | |
| State of New Jersey: Electronic Waste Recycling Act (Senate Bill 2144) | By weight in all homogenous materials: - Cadmium: 0.01% - Lead: 0.1% - Mercury: 0.1% - Hexavalent chromium: 0.1% | Covered electronic devices, defined as video display devices (including television and computer monitors), all desktop or personal computers and portable computers sold to consumers. | All applicable exemptions under the EU RoHS directive | - | [14] |
| Oman Technical Notice by the Telecommunications Regulatory Authority | By weight in all homogenous materials: - Cadmium: 0.01% - Mercury: 0.1% - Lead: 0.1% - Hexavalent chromium: 0.1% - Polybrominated biphenyls (PBB): 0.1%; - Polybrominated diphenyl ethers (PBDE): 0.1% - Bis(2-Ethylhexyl) phthalate (DEHP): 0.1% - Benzyl butyl phthalate (BBP): 0.1% - Dibutyl phthalate (DBP): 0.1% - Diisobutyl phthalate (DIBP): 0.1% | Radio and terminal equipment, such as radios in cars or other transport vehicles (e.g. boats), radio equipment embedded in other products like telephones or stereo systems, and modems and routers. | No information available | No information available | [16] |
| Republic of Korea The Act for Resource Recycling of Electrical and Electronic Equipment and Vehicles | By weight in all homogenous materials: - Cadmium: 0.01% - Mercury: 0.1% - Lead: 0.1% - Hexavalent chromium: 0.1% - Polybrominated biphenyls (PBB): 0.1% (only EEE, not vehicles) - Polybrominated diphenyl ethers (PBDE): 0.1% (only EEE, not vehicles) | - TV - Refrigerators - Mobile devices - Washers designed for household use - Personal computers - Audio equipment - Air conditioners - Printers & copiers - Fax machines - Vehicles including passenger cars, vans and trucks < 3.5 tons | - no information available | - spare parts and components which are sold separately | [19] [17] [18] |

| Country / Region & Name of Regulation | Restricted substances & max. allowable conc. | Product scope | Exemptions | Products excluded from scope | Ref. |
|---|---|---|--|--|--------------|
| Serbia Management of Waste from and Hazardous Substances in Electrical and Electronic Equipment, Regulation and its corresponding Rulebook | <ul style="list-style-type: none"> - Cadmium: 0.01% - Mercury: 0.1% - Lead: 0.1% - Hexavalent chromium: 0.1% - Polybrominated biphenyls (PBB): 0.1%; - Polybrominated diphenyl ethers (PBDE): 0.1% (no information available, if these requirements apply at level of homogenous materials) | <ul style="list-style-type: none"> - Large household appliances; - Small household appliances; - Information technology (IT) and telecommunications equipment; - Consumer equipment for leisure; - Lighting equipment; - Power and electronic tools (except large stationary industrial tools); - Toys, recreational and sports equipment; - Automata. | 73 specific exemptions similar but not identical with Annex III of the amended EU RoHS 2 directive | <ul style="list-style-type: none"> - Military equipment - Printer & Toner cartridges | [21] |
| Singapore Environmental Protection and Management Act (Chapter 94A) / Singapore RoHS | By weight in all homogenous materials: <ul style="list-style-type: none"> - Cadmium: 0.01% - Mercury: 0.1% - Lead: 0.1% - Hexavalent chromium: 0.1% - Polybrominated biphenyls (PBB): 0.1%; - Polybrominated diphenyl ethers (PBDE): 0.1% | <ul style="list-style-type: none"> - Mobile phones - Portable computers - Refrigerators - Air conditioners - Panel TVs - Washing machines | All applicable exemptions under the EU RoHS directive | <ul style="list-style-type: none"> - Spare parts and components which are sold separately (may be included in the future) - Batteries and accumulators used in EEE - used or second-hand EEE | [22] [33] |
| Turkey Regulation on Control of Waste Electrical and Electronic Equipment / Atık Elektrikli ve Elektronik Eşyaların (AEEE) Kontrolü Yönetmeliği | By weight in all homogenous materials: <ul style="list-style-type: none"> - Cadmium: 0.01% - Mercury: 0.1% - Lead: 0.1% - Hexavalent chromium: 0.1% - Polybrominated biphenyls (PBB): 0.1%; - Polybrominated diphenyl ethers (PBDE): 0.1% | <ul style="list-style-type: none"> - Large household items - Small appliances - Information and telecommunication equipment - Consumer equipment - Lighting equipment - Electrical and electronic equipment (excluding large and fixed industrial equipment) - Toys, entertainment and sports equipment - Medical devices - Monitoring and control instruments - Vending Machines | 29 Exemptions, similar to EU RoHS 1 but not identical. | <ul style="list-style-type: none"> - Any equipment with voltages of over 1000 V (AC) or 1500 V (DC), - Replacement parts for equipment manufactured before June 2009, - Equipment designed for integration into another piece equipment, - Weapons and other equipment used for exclusively military purposes. | [24] |

| Country / Region & Name of Regulation | Restricted substances & max. allowable conc. | Product scope | Exemptions | Products excluded from scope | Ref. |
|--|--|---|--|---|--------------|
| | | For each of the categories, a defined list of products is provided in Annex 1 of the Regulation | | | |
| Ukraine Technical Regulation Decree No. 139 | By weight in all homogenous materials: - Cadmium: 0.01% - Mercury: 0.1% - Lead: 0.1% - Hexavalent chromium: 0.1% - Polybrominated biphenyls (PBB): 0.1%; - Polybrominated diphenyl ethers (PBDE): 0.1% - Bis(2-Ethylhexyl) phthalate (DEHP): 0.1% - Benzyl butyl phthalate (BBP): 0.1% - Dibutyl phthalate (DBP): 0.1% - Diisobutyl phthalate (DIBP): 0.1% | - Major appliances. - Small appliances. - Information technology equipment and telecommunication equipment. - Household electronics. - Lighting equipment. - Electric and electronic tools. - Toys, equipment for recreation and sport. - Medical devices (including medical devices for diagnostics in vitro). - Monitoring and control devices (inclusive of industrial monitoring and control devices). - Products output and dosing automation devices. - Other electric and electronic equipment not included into the listed categories | Identical with exemptions listed in Annex III of EU RoHS Directive (2011/65/EU) except for exemptions 43 and 44. | - Military equipment - Space equipment - Large-scale industrial tools - Large-scale fixed installations - Vehicles - Mobile machinery - Active implantable medical devices - Photovoltaic panels - R & D equipment - Pipe organs | [25] |
| United Arab Emirates Cabinet's Decision No. (10) of 2017 | By weight in all homogenous materials: - Cadmium: 0.01% - Mercury: 0.1% - Lead: 0.1% - Hexavalent chromium: 0.1% - Polybrominated biphenyls (PBB): 0.1%; - Polybrominated diphenyl ethers (PBDE): 0.1% - Bis(2-Ethylhexyl) phthalate (DEHP): 0.1% - Benzyl butyl phthalate (BBP): 0.1% - Dibutyl phthalate (DBP): 0.1% | - Large household appliances - Small household appliances - IT and Telecommunication equipment - Consumer equipment - Lighting equipment - Electrical and electronic tools (except for large-scale stationary industrial tools) - Toys leisure and sport equipment - Medical devices (except for all implanted and infected products) | 39 specific examples, similar but not identical with EU RoHS 2 and without time-limitations. | - military / security equipment - equipment for outer space - specially designed equipment - large-scale stationary industrial tools - large-scale fixed installations - non-type approved means of transportation - non-road mobile machinery made available exclusively for professional use; - active implantable medical devices - professional photovoltaic panels | [26] [34] |

| Country / Region & Name of Regulation | Restricted substances & max. allowable conc. | Product scope | Exemptions | Products excluded from scope | Ref. |
|--|--|--|---|--|----------------------|
| | - Diisobutyl phthalate (DIBP): 0.1% | <ul style="list-style-type: none"> - Monitoring and control instruments - Automatic dispensers - Other EEE not covered by any of the categories above or, and falling within the definition of Article one. | | <ul style="list-style-type: none"> - research and development equipment for business-to-business basis; - and products for general lighting covered under UAE Cabinet Decision No. 24 of 2012. | |
| <p>Viet Nam Circular No. 30/2011/TT-BCT provisionally stipulating allowable limit contents of a number of toxic or hazardous chemicals in electric or electronic products; amended by Decision No. 4693/QD-BCT.</p> | <p>By weight in all homogenous materials:</p> <ul style="list-style-type: none"> - Cadmium: 0.01% - Mercury: 0.1% - Lead: 0.1% - Hexavalent chromium: 0.1% - Polybrominated biphenyls (PBB): 0.1%; - Polybrominated diphenyl ethers (PBDE): 0.1% | <ul style="list-style-type: none"> - Large household appliances. - Small household appliances. - Information technology and communications equipment. - Consumer equipment. - Lighting equipment. - Electric or electronic tools (except large-scale stationary industrial tools). - Toys, leisure or sports equipment. - Automatic measuring devices <p>Annex 2 of the circular provides a detailed list of products in scope</p> | 72 specific exemptions, similar but not identical to EU RoHS 1 directive. | <ul style="list-style-type: none"> - Electric or electronic parts; - batteries and accumulators; - Spare parts to be used for repair, reuse & upgrading of EEE; - EE products which are gifts or souvenirs or to be used for exhibition or display - hand luggage and accompanying assets of organization and individuals - Commodities temporarily imported or exported or transited; - Electric or electronic products circulated on the Vietnamese market before the effective date of the regulation. | <p>[28] [29]</p> |

3.2 Regulatory approaches imposing information requirements

Regulatory approaches imposing certain forms of information requirements for CoC in EEE were identified for 8 countries or states. All of these regulations exhibit similarities to the EU RoHS directives in terms of chemicals they address and concentration limits relevant for the requirements. In contrast to the regulatory approaches summarized in chapter 3.1, these regulations don't restrict the use of certain substances in EEE, but require that certain information are provided to either the consumers or regulatory authorities. Table 4 provides an overview of these approaches (sorted by alphabetical order of the respective country / state).

3.2.1 Japan

In Japan, chemicals related requirements for electronics are outlined in the Law for Promotion of Effective Utilization of Resources in Japan [35] and the Standard JIS C 0950 on the marking for presence of specific chemical substances in electrical and electronic equipment [36], which together sometimes are referred to as "J-MOSS". JIS C 0950 is a Japanese industry standard specifying provisions for the marking of six chemicals / chemical groups in seven specific products and its provisions are made mandatory through the Ministry ordinance on the Law. The chemicals that are addressed under J-MOSS are the same as addressed by the EU RoHS 1 Directive. Depending on whether the content of any of the chemicals exceeds the specified concentration limits, the product must be marked with an orange "R" mark (concentration limits exceeded) or a green "G" mark (no chemical exceeds concentration limit). If the content of one substance in a product exceeds concentration limit, it must furthermore be disclosed on the website in Japanese in accordance with JIS. Such a declaration is also required for products that are exempted from the regulation [37].

The concentration limits above which labelling and/or a declaration is required are identical with the maximum allowable concentrations mandated under the EU RoHS 1 Directive.

3.2.2 Taiwan, Province of China

In Taiwan, province of China, chemical uses in electronics are addressed by the "Guidance to reduction of the restricted chemical substances in electrical and electronic equipment" (CNS 15663) [38], which became law in December 2016. The chemical scope of the guidance mirrors the EU RoHS 1 directive, by specifying the same limit values for lead, mercury, hexavalent chromium, cadmium, PBBs and PBDEs. Certain EE products that contain one or more of these substances exceeding the limit values must be labelled accordingly and a table outlining the concentration of the individual chemicals is to be provided on the product body, packaging or within the instructions [39].

While the general scope of the labelling guidance is broad and very similar to the product scope of the EU RoHS directive, the labelling requirements are only mandatory for a smaller selection of products that have been specified by the Bureau of Standards, Metrology and Inspection (BSMI) [38]. For all other products, the labelling requirements for the chemicals set out under CNS 15663 are voluntary.

3.2.3 States of the United States of America

Several US states have enacted regulations imposing certain information requirements for CoC in EEE. Scope of products and chemicals addressed under these regulations vary sometimes significantly, as do the specific information requirements.

In **Illinois**, the Electronic Products Recycling and Reuse Act requires manufactures of certain EEE to register with the state's environmental protection agency. The list of products required registration is provided in Table 4 and includes computers, televisions and small-scale servers. With this registration, the manufacturer must, amongst others, provide information whether any of the products sold in the state

exceed the maximum concentration values for lead, mercury cadmium, hexavalent chromium, polybrominated biphenyls (PBBs) and polybrominated diphenyl ethers (PBDE) established under the EU RoHS Directive and identify the products that exceed the EU requirements. The registration must be renewed on a yearly basis [40] [8]

The regulations in the States of **Indiana** and **Minnesota** require manufacturers of video display devices to register with the State authorities and to provide information whether any of the products sold in the state exceed the maximum concentration values for lead, mercury cadmium, hexavalent chromium, polybrominated biphenyls (PBBs) and polybrominated diphenyl ethers (PBDE) established under the EU RoHS Directive and if the manufacturer has received any exemption of the requirements established under the EU RoHS directive by the European Commission [40] [8].

Similarly the regulations in the States of **New York**, **Rhode Island** and **Wisconsin** require manufacturers of covered electronic devices to register with the respective authorities and to provide information on compliance with the EU RoHS Directive and if any of the products have received an exemption from the EU RoHS requirements by the European Commission [14] [41] [42] [8]. However, the scope of individual products that are considered under the three regulations differ to a certain extent. Furthermore, the regulations of the States of New York and Rhode Island only mandate information on compliance with the EU RoHS requirements for the four heavy metals, PBBs and PBDES, whereas in the State of Wisconsin, the regulation mandates information on compliance on compliance with all chemicals addressed by EU RoHS, including the four ortho-phthalates.

Table 4: Overview of regulatory approaches outside of Europe that impose certain information or labelling requirements for CoC in EEE.

| Country / Region & Name of Regulation | Chemicals & limit values relevant for requirements | Product scope | Exemptions | Products excluded from scope | Information requirements imposed | Ref. |
|---|--|--|---|---|---|--------------|
| Japan Law for Promotion of Effective Utilization of Resources in Japan and Industry Standard JIS C 0950 / J-MOSS | By weight in all homogenous materials: - Cadmium: 0.01% - Lead: 0.1% - Mercury: 0.1% - Hexavalent chromium: 0.1% - Polybrominated biphenyls (PBB): 0.1%; - Polybrominated diphenyl ethers (PBDE): 0.1% | - Personal computers - Unit-type air conditioners - Television sets - Refrigerators - Washing machines - Clothes dryers - Microwaves | - Listed in Annex B of JIS C 0950:2008, not available in the public domain | - | Specific mark on the product indicating whether or not the limit values are exceeded. If concentration limits are exceeded, substances must be disclosed. | [35] [36] |
| Taiwan, province of China CNS 15663: Guidance to reduction of the restricted chemical substances in electrical and electronic equipment | By weight in all homogenous materials: - Cadmium: 0.01% - Lead: 0.1% - Mercury: 0.1% - Hexavalent chromium: 0.1% - Polybrominated biphenyls (PBB): 0.1%; - Polybrominated diphenyl ethers (PBDE): 0.1% | General scope of guidance: - Large household appliances - Small household appliances - IT and telecommunication equipment - Consumer equipment - Lighting equipment (including electric light bulbs and household luminaires) - Electrical and electronic tools (except for large-scale stationary industrial tools) - Toys, leisure and sports equipment - Automatic dispensers - Other equipment covered by CNS 3765, CNS 14408 and CNS 14336-1 Requirement mandatory for: - automatic data processing machines and others (6 items since Jul. 2017) | 54 specific examples similar but not identical with EU RoHS 2 and without time-limitations. | - military equipment - products where electricity is not the main power source - products where EE components are not needed to fulfil primary function (e.g. toys) - Batteries - Large-scale stationary industrial tools | Product labelling requirement if limit values are exceeded and requirement to disclose the concentration of the individual chemicals. | [38] [43] |

| Country / Region & Name of Regulation | Chemicals & limit values relevant for requirements | Product scope | Exemptions | Products excluded from scope | Information requirements imposed | Ref. |
|---------------------------------------|--|---|------------|------------------------------|----------------------------------|------|
| | | <ul style="list-style-type: none"> - network media players and projectors (since Jul. 2017) - water dispensers (since Dec. 2016) - Plugs and socket outlets, adapters, cord sets and other related products (since Jan. 2018) - Radio keyboard and other (92 items, since Jan. 2018) - electric blankets and others (63 items, since Jan. 2018) - self-ballasted fluorescent lamps (since Jan. 20158) - Drinking water suppliers (since Jan. 2018) - motors and others (32 items, since Jan. 2018) - Power suppliers and others (7 items, since Jan 2018) - Air conditioners, lighting and others (8 items, since Jul. 2018) - Fluorescent lamps and related electronic ballasts (since Jan 2018) - Printing or copying machines (since Jan. 2118) - Off-board charger of electric bicycles (since Jan. 2019) - Loudspeaker and others (24 items, since Jul. 2018) - Power supplies for cigar lighters in cars (since Jan. 2019) | | | | |

| Country / Region & Name of Regulation | Chemicals & limit values relevant for requirements | Product scope | Exemptions | Products excluded from scope | Information requirements imposed | Ref. |
|--|--|---|---|--|---|------|
| State of Illinois: Electronic Products Recycling and Reuse Act | By weight in all homogenous materials: - Cadmium: 0.01% - Lead: 0.1% - Mercury: 0.1% - Hexavalent chromium: 0.1% - Polybrominated biphenyls (PBB): 0.1%; - Polybrominated diphenyl ethers (PBDE): 0.1% | computers, computer monitors, printers, televisions, electronic keyboards, facsimile machines, videocassette recorders, portable digital music players, digital video disc players, video game consoles, electronic mice, scanners, digital converter boxes, cable receivers, satellite receivers, digital video disc recorders, or small-scale servers | - | - | Information on whether product exceeds the limit values required as part of yearly registration with the state authorities. | [40] |
| State of Indiana Indiana Code 2020 Title 13, Article 20.5 Electronic Waste | By weight in all homogenous materials: - Cadmium: 0.01% - Lead: 0.1% - Mercury: 0.1% - Hexavalent chromium: 0.1% - Polybrominated biphenyls (PBB): 0.1%; - Polybrominated diphenyl ethers (PBDE): 0.1% | Any video display | All applicable exemptions under the EU RoHS 1 directive (2002/95/EC) and any amendments thereof | - | Information on whether product exceeds the limit values required as part of registration with the state authorities | [44] |
| State of Minnesota Minnesota Statutes, Chapter 115A, Section 115A.1312 | By weight in all homogenous materials: - Cadmium: 0.01% - Lead: 0.1% - Mercury: 0.1% - Hexavalent chromium: 0.1% - Polybrominated biphenyls (PBB): 0.1%; - Polybrominated diphenyl ethers (PBDE): 0.1% | Any video display | All applicable exemptions under the EU RoHS 1 directive (2002/95/EC) and any amendments thereof | - | Information on whether product exceeds the limit values required as part of registration with state authorities | [45] |
| State of New York Environmental Conservation Law Article 27 Title 26 | By weight in all homogenous materials: - Cadmium: 0.01% - Lead: 0.1% - Mercury: 0.1% - Hexavalent chromium: 0.1% | Covered electronic equipment, defined as a computer; computer peripheral; small electronic equipment; small-scale server; cathode ray tube; or television | All applicable exemptions under the EU RoHS 1 directive (2002/95/EC) and any amendments thereof | any motor vehicle or any part thereof; camera or video camera; portable or stationary radio; household appliances such as clothes washers, clothes | Information on whether product is compliant with the respective requirements of the EU RoHS directive required as part of registration with state authorities | [46] |

| Country / Region & Name of Regulation | Chemicals & limit values relevant for requirements | Product scope | Exemptions | Products excluded from scope | Information requirements imposed | Ref. |
|---------------------------------------|--|---------------|------------|---|----------------------------------|------|
| | <ul style="list-style-type: none"> - Polybrominated biphenyls (PBB): 0.1%; - Polybrominated diphenyl ethers (PBDE): 0.1% | | | <p>dryers, refrigerators, freezers, microwave ovens, ovens, ranges or dishwashers; equipment that is functionally or physically part of a larger piece of equipment intended for use in an industrial, research and development or commercial setting; security or anti-terrorism equipment; monitoring and control instrument or system; thermostat; hand-held transceiver; telephone of any type; portable digital assistant or similar device; calculator; global positioning system (GPS) receiver or similar navigation device; a server other than a small-scale server; a cash register or retail self-checkout system; a stand-alone storage product intended for use in industrial, research and development or commercial settings; commercial medical equipment that contains within it a cathode ray tube, a flat panel display or similar video display device, and is not separate from the larger piece of</p> | | |

| Country / Region & Name of Regulation | Chemicals & limit values relevant for requirements | Product scope | Exemptions | Products excluded from scope | Information requirements imposed | Ref. |
|--|--|-----------------------------|---|---|---|------|
| | | | | equipment; or other medical devices | | |
| State of Rhode Island Electronic Waste Prevention, Reuse and Recycling Act | By weight in all homogenous materials: - Cadmium: 0.01% - Lead: 0.1% - Mercury: 0.1% - Hexavalent chromium: 0.1% - Polybrominated biphenyls (PBB): 0.1%; - Polybrominated diphenyl ethers (PBDE): 0.1% | Covered electronic products | All applicable exemptions under the EU RoHS 1 directive (2002/95/EC) and any amendments thereof | computer, television, or video-display device that is: (a) A part of a motor vehicle or any component part of a motor vehicle assembled by, or for, a vehicle manufacturer or franchised dealer, including replacement parts for use in a motor vehicle; or (b) Functionally or physically a part of, connected to, or integrated within a larger piece of equipment designed and intended for use in an industrial, governmental, commercial, research and development, or medical setting, (including diagnostic, monitoring, or other medical products as that term is defined under the Federal Food, Drug, and Cosmetic Act) or equipment used for security, sensing, monitoring, or anti-terrorism purposes; or (c) Contained within a home appliance, clothes washer, clothes dryer, refrigerator, refrigerator and freezer, microwave oven, conventional oven or range, | Information on whether product is compliant with the respective requirements of the EU RoHS directive required as part of registration with state authorities | [41] |

| Country / Region & Name of Regulation | Chemicals & limit values relevant for requirements | Product scope | Exemptions | Products excluded from scope | Information requirements imposed | Ref. |
|--|--|---|------------|---|---|------|
| | | | | dishwasher, room air conditioner, dehumidifier, or air purifier; or (d) A handheld device used to access commercial mobile radio service and/or commercial mobile data service, | | |
| Wisconsin Wisconsin Statutes Chapter 287 Solid Waste, Reduction and Recycling, section 287.17 Electronic waste recycling | By weight in all homogenous materials: - Cadmium: 0.01% - Mercury: 0.1% - Lead: 0.1% - Hexavalent chromium: 0.1% - Polybrominated biphenyls (PBB): 0.1%; - Polybrominated diphenyl ethers (PBDE): 0.1% - Bis(2-Ethylhexyl) phthalate (DEHP): 0.1% - Benzyl butyl phthalate (BBP): 0.1% - Dibutyl phthalate (DBP): 0.1% - Diisobutyl phthalate (DIBP): 0.1% | Covered electronic device defined as a consumer video display device, a consumer computer, or a consumer printer. | - | - | Information on whether product is compliant with the respective requirements of the EU RoHS directive required as part of registration with state authorities | [42] |

3.3 Regulatory approaches in other countries and under development

In addition to the regulatory approaches identified in chapters 3.1 and 3.2, there is evidence that regulatory approaches are in force or currently being developed in more countries and regions [47]. These include **Jordan, Tunisia, Montenegro, Kosovo, Kenya, North Macedonia** and the **Republika Srpska**. However, no information on the nature or status of these regulatory approaches could be found through the applied research methods.

Several countries have been identified, where regulatory approaches for CoC in electronics are currently being developed. The following paragraphs summarize the current state of these developments in an alphabetical order by country.

In February 2020, **Bangladesh** notified the World Trade Organisation (WTO) Committee on Technical Barriers to Trade of the draft E-Waste (electrical and electronic) Management Rules, 2019 amending the Bangladesh Conservation Act 1995 [48]. The proposed rules set out a variety of requirements related to EEE and E-waste and include provisions on threshold limits for the use of certain hazardous substances used in EEE. These proposed threshold limits differ from the ones currently in force under the EU RoHS Directive and are summarized in Table 5. The proposed product scope encompasses household appliances, monitoring and control equipment, medical equipment, automatic machines and IT and telecommunication equipment. The deadline for comments was 30 June 2020.

Table 5: Threshold limits for use of certain hazardous substances as notified for the Bangladesh Draft Hazardous Waste (E-Waste) Management Rules 2019 (Schedule-3)

| Sl. | Substance Name | Standards |
|-----|---|-----------|
| 1. | Short Chain Chloro Paraffins, Alkanes, C10-13 | ≤ 25% |
| 2. | Antimony trioxide | ≤ 1% |
| 3. | Beryllium metal/ Beryllium oxide (Beryllia) | ≤ 0.1% |
| 4. | Nickel/Cadmium/Cadmium oxide/ Cadmium sulphide | ≤ 0.1% |
| 5. | Chromium VI | ≤ 0.25% |
| 6. | Copper beryllium alloys | ≤ 3% |
| 7. | Lead/Lead oxide | ≤ 0.1% |
| 8. | Mercury | ≤ 0.1% |
| 9. | Mineral Wool: [Man-made vitreous (silicate) fibers with random orientation with alkaline oxide and alkali earth oxide (Na ₂ O+K ₂ O+CaO+MgO+BaO) content greater than 18 % by weight] | ≤ 2% |
| 10. | Octabromodiphenylether (OBDE) | ≤ 2% |
| 11. | Polychlorobiphenyls: The level of 50 mg/kg (0.005%) should be the defining threshold concentration for wastes containing PCBs and PCTs: above that concentration such waste should be considered as hazardous. | ≤ 0.25% |
| 12. | Refractory Ceramic Fibers: [Man-made vitreous (silicate) fibers with random orientation with alkaline oxide and alkali earth oxide (Na ₂ O+K ₂ O+CaO+MgO+BaO) content less or equal to 18 % by weight] | ≤ 20% |
| 13. | Liquid Crystals: Commercially available liquid crystals (LC) are mixtures of 10 to 20 substances, which belong to the group of substituted phenylcyclohexanes, alkylbenzenes and cyclohexylbenzenes. The chemical substances contain oxygen, fluorine, hydrogen and carbon. About 250 chemical substances are used for formulating more than thousand marketed liquid crystals. | ≤ 0.15% |
| 14. | Polyvinyl Chloride (PVC) | ≤ 0.15% |
| 15. | Tetrabromobisphenol-A (TBBPA) | ≤ 0.15% |

In 2018, the Ministry of the Environment of **Brazil** announced a working group undertaking first steps in the process of drafting a proposal for the control of substances in EEE [49]. The aim of the regulation is to align with the EU RoHS Directive and the draft regulations is expected to see restrictions on the same chemicals. In a next step, a draft of the regulation is expected to be sent to the country's national environment council for review [50].

In May 2018, **Kuwait**, the **United Arab Emirates**, **Bahrain**, **Oman**, **Qatar**, **Saudi Arabia**, and **Yemen** notified the WTO Committee on Technical Barriers to Trade of a draft Gulf Cooperation Council (GCC) Technical Regulation for the Restriction of the use of certain Hazardous Substances in electrical and electronic equipment [51]. The regulation aims at restricting the 10 substances currently addressed under the EU RoHS 2 Directive and would establish identical maximum permissible concentrations. The product scope of the regulation is also expected to be very similar to the current EU RoHS directive. The regulation is currently still in consultation and at the date of this report no date of adoption has been proposed. Independent of this, **Saudi Arabia** notified the WTO Committee on Technical Barriers to Trade of a draft technical regulation for the restriction of hazardous substances in electrical and electronic equipment. This regulation would restrict the 10 substances currently addressed under the EU RoHS 2 directive in eight categories of electrical and electronic equipment on the Saudi Arabian market [52]. The technical regulation is planned to enter into force in January 2021.

In July 2020, the Industrial Standards Institute of **Thailand** announced a draft industrial Standard (TIS 2368-25XX Electrical and Electronic Equipment That May Contain Hazardous Substances: Restriction Of The Use of Certain Hazardous Substances) [53] revising the existing voluntary industrial standard TIS 2368-2551. This industry standard would restrict the 10 substances currently addressed under the EU RoHS directive and the scope of product falling under this industrial standard is expected to also be similar.

In July 2020, the **United States State of Washington** published a draft report identifying 11 priority consumer products to be addressed under Pollution Prevention for Healthy People and Puget Sound Act. This list of priority products includes residential and office electric and electronic equipment with plastics that encase electric or electronic components [54]. If adopted, the law mandates the department of ecology to determine regulatory actions and adopt rules for a set of priority chemicals in these priority products. The first set of priority chemicals include per- and polyfluoroalkyl substances (PFAS), phthalates, organohalogen flame retardants and flame retardants identified as chemicals of high concern to children, phenolic compounds and polychlorinated biphenyls (PCBs) [55].

4 Discussion

4.1 Regulatory approaches across the world

In total, **31 countries in the European Union, the EEA and EFTA** have transposed the requirements of the EU RoHS 2 Directive (2011/65/EU) into their national legislation. In addition to these, our research has identified 18 other countries that have adopted regulations, that address the use of certain chemicals in EEE. **Out of the 18 non-EU/EEA/EFTA countries that have adopted regulations, 7 are classified as high-income, 7 as upper-middle income and 4 as lower-middle income countries⁷.** All countries where relevant regulations are currently in force are in the **European, Asia-Pacific or the North-American** regions.

⁷ Classification according to the World Bank list of economies (June 2019)

An additional **11 countries or states have been identified that are currently developing regulations** addressing the use of selected chemicals in EEE. Of these 11 countries, 7 are classified as high-income, 2 as upper middle-income, 1 as lower middle-income and 1 as low-income country (Yemen in the context of the Gulf Cooperation Council Technical regulation). **Most countries currently developing regulations lie in the Asian-Pacific Region and one in the Latin-American region.**

Despite extensive research, no regulatory approaches could be identified for the African region. There are indications that approaches exist or are currently being developed in Tunisia and Kenya [47], however, no further information could be found. This does not necessarily mean that no relevant regulatory approaches exist in these countries, but rather that the applied research methodology may have not been sufficiently adequate to capture these regulations. Further inputs from the international community are welcomed to complement the research, especially with regards to relevant regulations that are not yet captured in the report.

While all of the identified regulations show similarities to the EU RoHS directive, **two distinct regulatory approaches exist:**

- (i) **regulations that explicitly restrict the use of certain chemicals in EEE and**
- (ii) **regulations that impose information requirements on the use of certain chemicals in EEE.**

No systematic differences could be identified between regulations from middle-income countries and regulations from high-income countries.

In general all of the regulatory approaches identified apply only to the domestic market of their relative country / region. Articles for export are generally considered out of scope as such articles usually need to comply with the regulatory provisions of the countries they are exported to.

4.2 Analysis of scope and provisions of the existing regulations

All regulations identified in this analysis address the same or a sub-set of the chemicals that are addressed by EU RoHS Directive and the maximum concentrations triggering regulatory requirements are identical across all regulations. Table 6 provides an overview of which chemicals are addressed in which state, country or region. As far as information was available at the time of reporting, the regulatory approaches currently under development are largely expected to also address the same chemicals. An **exception to this is the Bangladeshi draft E-Waste (electrical and electronic) Management Rules, 2019,** whose proposed chemical scope is broader than the one of the EU RoHS Directive and includes certain short-chain chlorinated paraffins, antimony trioxide as well as some beryllium and nickel compounds (ref. Table 5).

Table 6: Overview of the chemicals and chemical groups that are addressed by the regulatory approaches that have been identified and are currently in force.

| State / Country / Region | Chemicals addressed under the regulation and respective maximum concentrations | | | | | | | | | |
|--|--|-----------|-----------|---------------|-------------|-------------|-------------|------------|------------|-------------|
| | Cd (0.01%) | Pb (0.1%) | Hg (0.1%) | Cr(VI) (0.1%) | PBBs (0.1%) | PBDE (0.1%) | DEHP (0.1%) | BBP (0.1%) | DBP (0.1%) | DIBP (0.1%) |
| <i>Regulatory approaches imposing explicit restrictions</i> | | | | | | | | | | |
| State of California | X | X | X | X | | | | | | |
| China | X | X | X | X | X | X | | | | |
| European Union / EEA / EFTA | X | X | X | X | X | X | X | X | X | X |
| Eurasian Economic Union | X | X | X | X | X | X | | | | |
| India | X | X | X | X | X | X | | | | |
| State of New Jersey | X | X | X | X | | | | | | |
| Oman | X | X | X | X | X | X | X | X | X | X |
| Republic of Korea | X | X | X | X | X | X | | | | |
| Serbia | X | X | X | X | X | X | | | | |
| Singapore | X | X | X | X | X | X | | | | |
| Turkey | X | X | X | X | X | X | | | | |
| Ukraine | X | X | X | X | X | X | X | X | X | X |
| United Arab Emirates | X | X | X | X | X | X | X | X | X | X |
| Viet Nam | X | X | X | X | X | X | | | | |
| <i>Regulatory approaches imposing information requirements</i> | | | | | | | | | | |
| Japan | X | X | X | X | X | X | | | | |
| Taiwan, Province of China | X | X | X | X | X | X | | | | |
| State of Illinois | X | X | X | X | X | X | | | | |
| State of Indiana | X | X | X | X | X | X | | | | |
| State of Minnesota | X | X | X | X | X | X | | | | |
| State of New York | X | X | X | X | X | X | | | | |
| State of Rhodes Island | X | X | X | X | X | X | | | | |
| State of Wisconsin | X | X | X | X | X | X | X | X | X | X |

In contrast to the chemical scope, the **product scope of the identified regulatory approaches differs sometimes quite significantly**. For example, while regulations in the EU, Viet Nam or in China stipulate rules for a large selection of EEE (ranging from household appliances to IT-equipment to lighting sources, toys, medical devices and monitoring instruments), regulations in other countries may only apply to a selected list of products, such as video displays with a certain screen size in the State of California. The Republic of Korea is the only country also including vehicles in their regulatory scope. Similarly, some countries, such as Ukraine or the United Arab Emirates, define the product scope of their regulation based on relatively broad product categories, while others, such as Viet Nam or the countries in the Eurasian Economic Union define the product scope of their regulation based on specific list of devices. Table 3 and Table 4 provide an overview of product scopes of all identified regulatory approaches outside Europe.

Similar differences exist related to the exemptions from the provisions. While almost all identified regulatory approaches foresee certain exemptions from the provisions, the **exact nature of these exemptions often differ between the regulations** likely reflecting different market conditions, regulatory systems and frequency of revisions of regulatory texts in different countries. In some countries, certain exemptions are time limited and are set to expire, while in other countries, exemptions generally do not have a time limit.

Differences between the identified approaches also exist related to the mechanisms for demonstrating compliance. While under **many regulations conformity assessment is based on self declaration**, the procedural details vary depending on the nature of the different regulatory systems: in some countries or regions, a technical documentation must be compiled and stored for a certain time upon the market entry for a product, while in other countries, a declaration of compliance must be provided to the authorities or the consumer. **A few countries**, such as the United Arab Emirates or China **may require the verification of information on compliance either through a third party or the national authorities**. Some countries and regions, such as the EU, the EEU, the United Arab Emirates or Ukraine, have **integrated the procedures for conformity declaration with their laws in existing conformity labelling schemes**, such as the CE or the EAC conformity marking. Table 7 provides a summary of the policies for demonstrating compliance under the identified regulatory frameworks.

Table 7: Summary of the policies for demonstrating compliance under the identified regulatory approaches that impose explicit restrictions on the use of certain chemicals in EEE.

| Country / Region & Name of Regulation | Provision for demonstrating regulatory compliance |
|---|---|
| State of California: California Restrictions on the use of Certain Hazardous Substances (RoHS) Law | Manufacturers must submit an annual report to the California Integrated Waste Management Board (CIWMB) that includes information on use of restricted substances in covered electronic devices |
| China: Administrative Measures for the Restriction of the Use of Hazardous Substances in Electrical and Electronic Products (China RoHS 2) | Step 1: all EEE must be labelled according to their content of regulated substances. Products containing one or more of the regulated chemicals above maximum allowable content require special labelling Step 2: compliance with maximum allowable concentration must be demonstrated either by third-party certification or self-declaration via an online public service platform |
| European Union Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment | Self declaration under the procedures for obtaining the CE marking. Companies are required to compile the relevant technical documentation for conformity assessment but must provide them to authorities only upon request. |

| Country / Region & Name of Regulation | Provision for demonstrating regulatory compliance |
|--|---|
| Eurasian Economic Union Technical regulation of the Customs Union 037/2016 "On restriction of use of hazardous substances in products of electrical engineering and radio electronics | Assessment of conformity is integrated in the process of obtaining the EAC conformity mark, which is required for placing a product on the market. The EAC certification of EEE is carried out exclusively by notified bodies. |
| India: E-Waste (Management and handling) Rules 2016 | Self declaration of compliance must be included in the product user documentation and every producer of EEE who is seeking Extended Producer Responsibility Authorisation must provide a self declaration of compliance with the chemicals-related provision of the regulation. |
| State of New Jersey: Electronic Waste Recycling Act (Senate Bill 2144) | Manufacturers of covered electronic devices must submit an annual registration to the New Jersey Department of Environmental protection which includes a declaration of conformity. |
| Oman Technical Notice by the Telecommunications Regulatory Authority | Manufacturers are required to demonstrate compliance with the regulation during the mandatory type approval process for new radio and terminal equipment. |
| Serbia Management of Waste from and Hazardous Substances in Electrical and Electronic Equipment, Regulation and its corresponding Rulebook | Not specified in the respective regulatory texts. |
| Singapore Environmental Protection and Management Act (Chapter 94A) / Singapore RoHS | Self declaration of conformity required by manufacturers, traders and importers through a company declaration letter. |
| Republic of Korea The Act for Resource Recycling of Electrical and Electronic Equipment and Vehicles | Self declaration required by producers and importers through either the electrical and electronic assurance system (www.ecoas.or.kr) or through the company's web-page |
| Turkey Regulation on Control of Waste Electrical and Electronic Equipment /Atık Elektrikli ve Elektronik Eşyaların (AEEE) Kontrolü Yönetmeliği | Manufacturers must submit a yearly declaration of conformity to the the Government and keep technical documentation demonstrating conformity of their product for five years upon the product's introduction to the market. |
| Ukraine Technical Regulation Decree No. 139 | Manufacturers must compile technical documentation demonstrating compliance and a declaration of conformity and mark their products with a marking of compliance. The technical documentation must be kept for ten years upon the product's introduction to the market and produced to the national market supervision authority upon request. |
| United Arab Emirates Cabinet's Decision No. (10) of 2017 | Compliance must be demonstrated either through (1) the Emirates Conformity Assessment Scheme (ECAS, certification valid for one year), or (2) the Emriates Quality Mark Scheme (EQM, certification valid for 3 years). Both schemes require submitting technical documentation demonstrating for verification through the Emirates Authority for Stanardization & Metrology (EASM). |
| Viet Nam Circular No. 30/2011/TT-BCT provisionally stipulating allowable limit contents of a number of toxic or hazardous chemicals in electric or electronic products; amended by Decision No. 4693/QD-BCT. | Compliancy status of products must be disclosed in product documentation, on the manufacturer's web-page or elsewhere. |

4.3 Linking to the issue of e-waste

The issue of chemicals of concern in electrical and electronic products is closely linked to the issue of e-waste. Many of these chemicals can have significant impacts on human health and the environment as they can be released from electrical and electronic products at their end-of-life stages i.e. during recycling or disposal. Regulatory approaches that **restrict the use of CoC in EEE can therefore help addressing this issue by minimizing their incorporation upstream of the value-chain.** Information requirements on the content of CoC in EEE can furthermore help minimizing impacts during recycling and disposal by providing the relevant actors with information supporting the choice of methods that are sound from an environmental and human health perspective.

Reflecting this linkage, **regulations of CoC in EEE have been found to frequently go hand in hand with regulations on waste-EEE,** i.e. the provisions on CoC in EEE are often addressed in the same regulation that also contain provisions on e-waste management, such as in the Indian E-Waste (management and handling) rules 2016, or the Turkish Regulation on Control of Waste Electrical and Electronic Equipment. One possible explanation for this could be that such a coupled approach reflects the potential of CoC to cause significant impacts on human health or the environment at the end-of-life stage of EEE.

5 Conclusions, opportunities and recommendations

The majority of regulations on CoC in electrical and electronic equipment appears to be in force in the Europe and the Asia-Pacific region. A few local regulations are in force in the North-American region and one regulation is currently being developed in Latin-America. No regulatory approaches could be identified in the African region through the applied research methodology. Any additional information for inclusion into this report would be welcomed.

All countries that were identified to have relevant regulation in place are either high- or middle-income countries. No systematic differences could be identified between regulations from middle-income countries and regulations from high-income countries.

While the chemical scope of all identified regulations is very similar, the provisions regarding the product scope, the specific exemptions from the provisions, as well as the procedures to ensure compliance vary between the regulations, likely reflecting different market conditions, regulatory systems and frequency of revisions of regulatory texts in different countries.

As outlined in the Global Chemicals Outlook II (GCO II), regulatory drivers are providing momentum for the removal of chemicals of concern from manufacturing processes and from products [56]. Regulations addressing CoC in electrical and electronic products, have been indeed an important driver for innovation and substitution in the sector. Therefore **regulation is an important tool for advancing the challenge of chemicals of concern in electrical and electronic products and supporting the goal of minimizing harmful impacts of chemicals on human health and the environment across all life cycle stages.** In addition, the content of chemicals of concern in EEE may constitute a barrier for recycling due to concerns of potential impacts during post-consumer uses of these materials. **Regulations address that barrier, and enable circularity and circular business models** [57].

Based on the current research, the following recommendation can be made for stakeholders involved in addressing the issue of CoC in the electronics sector:

- **Accelerating and streamlining regulatory action on CoC in EEE through regional and global collaboration:** While this analysis has demonstrated that there are many countries that have developed regulatory frameworks addressing CoC in electronics, there are several regions where there still is potential for respective regulatory action. A consequent and coherent set of regulations addressing CoC in EEE has the potential to minimize impacts of waste-EEE and to support the shift towards more circular business models in the electronic sector. Considering the rapid technological development and the technical and structural complexity of the electronics sector, the development and maintenance of relevant regulatory instruments can be a particularly challenging and resource intensive process, requiring considerable technical and institutional capacities. Stakeholders should explore the potential of regional collaborations as a means for sharing this burden, using potential synergies and streamlining regulatory action. Global collaboration should be explored in order to close the still significant data gaps on the presence, flow and transboundary movement of chemicals of concern throughout the life cycle of EEE.
- **Developing and implementing a coordinated and coherent regulatory approach for CoC in EEE on a national level:** The life cycle of EEE and their components are complex and in order to ensure protection from potential impacts of CoC, national regulations need to provide a coherent set of rules addressing the use of CoC in EEE. National regulatory approaches for CoC in EEE should therefore be carefully coordinated across multiple regulatory domains, such as regulation on products, chemicals, persistent organic pollutants or waste. For example certain provisions of the Stockholm Convention on Persistent Organic Pollutants (POPs) can be relevant in the context of CoC in electronics and regulators thus need to carefully coordinate national legislation on EEE with national legislation on POPs in order to ensure a coherent set of rules.
- **Development and implementation of complementary tools:** Besides regulatory action, other complementary tools, policies and instruments may have significant potential to mobilise additional actors in the sectors value chain and therefore support addressing the issue of CoC in electronics. Such tools could include voluntary schemes, such as labelling or voluntary sustainability standards, as well as initiatives like the development of sustainable public procurement programs. Stakeholders should explore the potential of developing such complementary tools including the potential of collaboration on a national and regional level.
- **Developing regulations and policies considering circular perspectives:** The continuing advances in regulations should be mindful of and support the development of concepts for circular economy and circular business models in the electrical and electronics sector. This could, for example be achieved by considering the potential of chemicals and materials to constitute significant barriers to recycling in regulatory decisions, by providing incentives for the use of materials and technologies that facilitate circular approaches or providing frameworks that ensure the communication of information on materials and potential contents of CoC along the entire value chain.
- **Developing and providing specific guidance and building capacity for substituting chemicals of concern for stakeholders along the electronics value chain:** The substitution of chemicals of concern is often a highly complex and context-specific process that requires considerable technical expertise. Therefore guidance and tools for substitution, that are applicable in different national contexts as well as in the context of the electronics sector, should be developed. It is important, that such guidance not only addresses substitution by means of one-to-one chemical replacement but also includes guidance on substitution by possible changes in product design

and materials or manufacturing processes. Stakeholders should also consider enhancing institutional capacities within the sector and companies through incentive-based government initiatives that include support for research and evaluation guidance, information on alternatives, demonstration project, technical assistance, databases training and assistance for supply chain networking [59].

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