Mercury and RoHS: the link between environmental regulations and efficiency

Michael Scholand
CLASP Europe
7 Green Bank
London, N12 8AS
United Kingdom
MScholand@clasp.ngo

Peter Bennich
Swedish Energy Agency
Box 380 69
S-100 64 Stockholm
Sweden
Peter.bennich@energimyndigheten.se

Keywords

Restriction of Hazardous Substances Directive (RoHS), lighting, compact fluorescent lamps (CFLs), LED, mercury, environmental benefits

Abstract

A European environmental regulation that addresses mercury was identified as a mechanism to capture significant energy and greenhouse gas savings for lighting products which were complementary to the existing Ecodesign regulation for those same products. The Restriction of Hazardous Substances Directive (RoHS) presented with an opportunity to expand the scope of coverage to more products, including some excluded from regulation under Ecodesign, and to accelerate the phase-out of those products due to their toxicity rather than on a basis of least life-cycle cost. The RoHS Directive was adopted in February 2003 with the intention to limit and phase-out certain hazardous substances in electrical products, including mercury. Fluorescent and high-intensity discharge lamps are currently allowed under RoHS, albeit with limits on their mercury content. While the intention is to recover and recycle these lamps at the end of life, research has shown that only 12–50 % of the lamps sold in the EU are recovered, implying considerable quantities of mercury are released to the environment (SEA-CLASP, 2019).

Mercury-free "plug and play" LED retrofit lamps have now matured to the point where they can replace fluorescent lighting in virtually all applications. Research published in 2020 demonstrated that when applying the criteria of the RoHS Directive, the justification for exempting fluorescent lamps no longer applies. The European Commission is expected to decide in 2021 whether to rescind the exemption. A socio-economic analysis published by the Commission in July 2020 shows that such a decision would generate €29.9 billion in net savings for Europe, eliminate 2.9 tonnes of mercury in lamps and avoid the need for 310 TWh of electrical energy (Öko-Institut, 2020) – which given Europe's power mix, saves a further 2.5 tonnes of mercury emissions from coal-power plants (SEA-CLASP, 2020b).

Furthermore, if Europe decides to end the RoHS exemptions for fluorescent lamps, the EU-27 will be well positioned to support similar measures to phase-out fluorescent lamps to the global community through the United Nation's Minamata Convention on Mercury which starts its fourth Conference of the Parties (COP4) in November 2021. Phasing out fluorescent lighting globally will protect public and environmental health from unnecessary mercury releases while cost-effectively reducing energy-use for lighting. This paper offers a case study of fluorescent lighting being examined by the RoHS Directive in Europe and presents the results of a global analysis of environmental benefits if the Minamata Convention were to phase out fluorescent lamps.

Introduction

Fluorescent lighting has been a mainstay of the lighting industry for over half a century, producing more than 70 % of the artificial light around the world (UNEP, 2016). Yet fluorescent lighting contains mercury, a known neurotoxin that is extremely hazardous to people and the environment. For this reason, the mercury content of fluorescent lamps was first regulated in Europe under the Restriction of Hazardous Substances (RoHS)

Directive (2002/95/EC) which limits the amount of mercury in each lamp. Fluorescent lighting is also covered and regulated under the Ecodesign Directive (2009/125/EC), which looks at establishing quality and performance requirements based on a life-cycle assessment, including cost-effectiveness and environmental sustainability aspects. This paper discusses the regulatory activities undertaken for fluorescent lighting over the last five years in Europe under these two Directives, and identifies the pitfalls and policy challenges that were encountered along the way as both Directives addressed this inefficient and toxic lighting technology.

THE BACKGROUND ON ROHS

The first RoHS Directive was originally passed in 2003 (Directive 2002/95/EC) and took effect in 2006 (EU Parliament and Council, 2003). RoHS was later revised in 2011 (Directive 2011/65/EU), establishing new more stringent limits (EU Parliament and Council, 2011). Broadly speaking, RoHS limits or bans ten substances: lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE), bis(2-ethylhexyl) phthalate (DEHP), butyl benzyl phthalate (BBP), dibutyl phthalate (DBP) and diisobutyl phthalate (DIBP). (EC, 2021). In relation to mercury content in lighting, RoHS sets a maximum amount of mercury in fluorescent lamps and high-intensity discharge (HID) lamps.

Any business that manufactures, imports or otherwise places covered products like fluorescent lamps on the EU market must ensure they are compliant with RoHS. RoHS is a CE-marking directive, meaning that all suppliers must ensure they comply with RoHS before they can apply the CE mark to their products – a pre-requisite for placing them on the market.

THE BACKGROUND ON ECODESIGN

The Ecodesign Directive was originally passed in 2005 (Directive 2005/32/EC) and was then significantly revised when it was recast in 2009 (Directive 2009/125/EC) (EU Parliament and Council, 2009). Ecodesign established a European public-participative process for developing minimum mandatory requirements on energy-efficiency and resource efficiency of covered products. Ecodesign sets harmonised requirements across the European market removing barriers to trade, improving product quality and protecting the environment.

Lighting products were first regulated under Ecodesign in 2009, with two regulations being adopted – one on non-directional lamps (EC No 244/2009) and one on professional lamps (EC No 245/2009). A few years later, the Commission adopted a regulation on directional lamps and LED lamps (EU No 1194/2012). These regulations set energy-efficiency, quality and performance requirements on the covered lighting products. Taken together with an energy labelling regulation introduced in 2012 (EU No 874/2012), these regulations helped to gradually shift the European market towards more energy-efficient lighting. These three ecodesign regulations and the energy labelling regulation were all recently amended in two new lighting policy measures that were adopted in late 2019 – Regulation (EU) 2019/2020 on ecodesign requirements for light sources and separate control gears and Delegated Regulation (EU) 2019/2015 on energy labelling of light sources.

In order to develop these various lighting policies over the years, the European Commission established a Consultation Forum of stakeholders who participate in the policy-making process on a regular basis around the studies prepared and the policy measures drafted. The members of the Consultation Forum include EU country representatives, the regulated industry as well as civil society and environmental non-profit organisations. Similar to RoHS, suppliers must ensure they comply with the requirements of ecodesign before they can affix the CE mark to their products.

DIFFERENCES BETWEEN ROHS AND ECODESIGN

RoHS is a Delegated Act, meaning that the Commission – and specifically, DG Environment – has been granted authority by the Parliament and Council to carry out the work of the regulation. In other words, decisions about which products and processes are banned, limited or exempted are made by DG Environment. To support that work, the Commission formed an Expert Group of advisors from all of the Member States, and contracts in expert advisors like the Öko-Institut to prepare studies. The Commission may also consult with other experts or industry representatives on an ad hoc basis, but unlike Ecodesign, it does not invite wide-ranging stakeholder participation in the process or implementation of the regulation. Meetings and letters or evidence submitted by Member States or other parties are treated as confidential and are only available to third parties through a Freedom of Information request. The schedule around decision-making and priorities is not disclosed to the public, and there are no mandatory deadlines or time limits by which the Commission must adopt amendments to the exemptions from RoHS.

Ecodesign, on the other hand, follows Comitology and is highly transparent and participative. Like RoHS, the Commission manages the process – through DG ENERGY, DG GROW or DG Environment – but DG ENERGY conducts the majority of the regulations, including those for lighting products. Under Ecodesign, the Commission established a Consultation Forum of stakeholders who are given an opportunity to review and comment on a draft regulation, prior to adoption, so additional evidence and analysis can be shared with all parties. And, unlike RoHS, the ultimate decision on what to adopt is the responsibility of the Regulatory Committee – a group of government officials nominated by the Member States. For the recently adopted Commission Regulation (EU) 2019/2020, the Regulatory Committee voted in December 2018 adopting requirements on lighting products, including several for fluorescent lighting technologies.

Ecodesign removes the least efficient products on the basis of least life-cycle cost, and the date for when that happens is flexible, meaning the Regulatory Committee can schedule it to take place at a time they consider appropriate. Under the RoHS Directive, the legal structure does not offer the same flexibility; rather it essentially checks to determine whether alternatives to the exempted products exist on the EU market and if they do, then the exemption for a given product (e.g., a fluorescent lamp) must be phased out either 12 or 18 months from the date of publication in the Official Journal of the European Union (OJEU). However, while it would appear DG Environment is not given flexibility around the length of a compliance period they deem appropriate, the phase-out period only starts when the delegated act(s) is published in the OJEU, and thus as long as nothing is published in the OJEU, the phase-out date for a

Table 1. Timeline of Activity on Fluorescent Lighting.

Date	RoHS Directive	Ecodesign Directive
June 2016	Öko-Institut identifies mercury-free LED alternatives and recommends phase-out of common fluorescent lamps by 2018.	Review study completed and preparation of regulation (EU) 2019/2020; launch of impact assessment.
October 2016	DG Environment announces launch of new Socioeconomic Impact Assessment.	
December 2017		DG Energy publishes first draft of regulation (EU) 2019/2020, proposing phase-out of fluorescent lamps in September 2020.
July 2018		DG Energy publishes revised draft, proposing a linear fluorescent lamp phase-out one year later, September 2021.
December 2018		Regulatory Committee meets to vote on lighting regulation, and delays the phase-out of T8 fluorescent lamps to September 2023; T5 fluorescent lamps remain on the market.
September 2019	Draft of the SEIA circulated; data on mercury-free LED alternatives is from 2013–15 and does not reflect current product offering.	
December 2019	Sweden-CLASP publish first Report (SEA-CLASP, 2019).	
February 2020	DG Environment convenes a small technical meeting including LightingEurope and European Environmental Bureau to discuss the fluorescent lamp exemptions.	
March 2020	Sweden-CLASP publish second Report, (SEA-CLASP, 2020a).	
July 2020	DG Environment publishes the final update to the SEIA (Öko-Institut, 2020); Sweden-CLASP publish third Report (SEA-CLASP, 2020b).	
May 2021	DG Environment has not yet published their draft position on the Commission's "Have Your Say" webpage.	

product is otherwise extended. In addition, it should be noted that the RoHS Directive does not impose any mandatory deadlines on DG Environment for finalising an Amendment to the exemptions – thus the Commission in practice selects the phase-out date for a product through the publication date of the amendment. As an example of this, of the amendment for fluorescent lighting was expected in 2016 and as of the time of this paper in May 2021, has yet to be published.

RECENT LIGHTING POLICY DEVELOPMENTS IN EUROPE

Exemptions for lighting products, and limits on the quantity of mercury contained in each lamp, were last made to RoHS in 2011. As RoHS has a regular five-year review cycle on exemptions, the Commission was expected to develop and publish revisions to those exemptions in 2016. A study was prepared and published (Öko-Institut, 2016), but no revision was made. Instead, DG Environment launched a new in-depth Socioeconomic Impact Assessment (SEIA).

The SEIA study that was initiated in 2016 and expected to be completed in 2017 or 2018, but was not actually finalised until July 2020. Öko-Institut, who was contracted to conduct the SEIA, reported to the authors of this paper that it experienced difficulty obtaining data on current LED retrofit products. The authors of this paper started to gather and publish data from industry sources to assist the process and bring more evidence to the policy development process, preparing a series of studies (SEA-CLASP, 2019, SEA-CLASP, 2020a; SEA-CLASP 2020b) which established a current database of available mercury-free (LED) retrofits for fluorescent lamps. One study evaluated the available mercury-free alternatives to fluorescent lamps under the exemption criteria of RoHS, demonstrating how the exemption could no longer be sustained.

Table 1 provides an approximate 2016 to 2020 timeline for both RoHS and Ecodesign. In essence, the RoHS Directive represents an opportunity for regulators to capture significant energy and greenhouse gas savings for lighting products which are complementary to the existing Ecodesign regulation for those same products. The RoHS offers the Commission an opportunity to expand the scope of coverage to lighting products which were excluded from regulation under Ecodesign, and to accelerate their phase-out relative to business-as-usual due to their toxicity rather than on a basis of least life-cycle cost.

Why Fluorescent Lighting Should be Phased-Out

The case for phasing-out fluorescent lighting is very strong, from a public-health perspective, an economic perspective and an environmental perspective.

AVAILABILITY OF MERCURY-FREE DIRECT RETROFITS

There are thousands of mercury-free LED replacement lamps available today to replace fluorescent lamps – different sizes, lengths, ballast types (i.e., magnetic/starter and high frequency electronic), colour temperatures, and regular, high output and

Table 2. Economic Analysis of T8 fluorescent vs. LED lamps in Europe.

Economic indicator description	T8 LFL	T8 LED-1	T8 LED-2	Units
Price for one lamp:	€3.68	€6.77	€12.74	*Euros/lamp*
Rated lamp wattage:	36	18	12.5	*Watts*
Rated lamp lifetime:	20,000	30,000	50,000	*Hours*
Annual electricity consumption (10 hr/day):	131	66	46	*kWh/yr*
Annual cost of electricity:	€16.48	€8.24	€5.72	*Euros/year*
Payback period in years:		0.38	0.84	*years*
Payback period in months:		4.5	10.1	*months*
Life-Cycle Cost, 13 years, net present value:	€223.40	€118.82	€87.12	*Euros (NPV, 2021)*
Life-Cycle Cost savings (net present value):		€104.58	€136.28	*Euros (NPV, 2021)*

ultra-high light output levels. Lamps are also available which are "universal" and can operate on a variety of ballasts and input power configurations. This approach to the design and marketing of the products removes barriers to upgrading to mercury-free LED lamps by enabling the end-users to continue to use the same luminaires, and simply change the lamp.

A review of published industry literature confirms the availability of easy-retrofit LED products designed as direct retrofits into existing fluorescent fixtures, avoiding the need to rewire (*N.B.* even though some of these companies also sell fluorescent tubes). Philips/Signify states that there is "No need to change drivers or rewire", noting that they offer a "plug and play solution that works straight out of the box" (Philips, 2016). OSRAM/LEDvance state that their "SubstiTUBE" product is a "Quick, simple and safe lamp replacement without rewiring." (LEDvance, 2021) Tungsram reports that in addition to "the 2.5–3× longer life (compared to T8[1] fluorescent lamps operated on electro-magnetic gear) and lower wattages, Tungsram LED T8 tubes provide lower system loss while existing fixtures remain intact." (Tungsram, 2021.)

COST-EFFECTIVENESS OF MERCURY-FREE LED REPLACEMENT LAMPS

Replacing fluorescent lamps with LED retrofit tubes is highly cost-effective. According to the website of OSRAM/LEDvance, "Replacement costs can be recouped in just four months" (LEDvance, 2021). In Table 2, the authors calculate the payback period replacing a 36 W T8 linear fluorescent lamp with two different LED retrofit lamps – an economy grade LED tube and a high quality LED tube. The results indicate that the payback period is between 4 and 10 months, even before taking into consideration the labour savings from not needing to change the LED tubes as often as the fluorescent. The service life of LED retrofit lamps in this example below is 1.5 to 2.5 times longer than fluorescent, offering further saving on replacement costs.

Considering a typical T8 fluorescent lamp installation in Europe, Table 2[2] presents the comparison of a €3.68 OSRAM 36 W T8 linear fluorescent lamp (declared 20,000 hours lifetime) with Philips' CorePro (entry-level, 30,000 hours lifetime, 18 watts) LED replacement and Philips' MasterLED (professional-grade, 50,000 hours lifetime, 12.5 watts) LED retrofit models. In a typical one-shift office operation, the lights will be on for an average of 10 hours per day – allowing for one eight-hour shift and a few hours before and after for cleaning and flexi-time. The table shows that the entry-level LED (T8 LED-1) offers a payback period of 4.5 months compared to the fluorescent (and will last 1.5 times longer than the fluorescent lamp) and the professional grade lamp (T8 LED-2) offers a payback period of 10.1 months (and will last 13 years, which is 2.5 times longer than the linear fluorescent lamp). These calculations reflect energy costs and bulb costs only, and do not incorporate labour costs to change the lamp which are avoided due to the reduced frequency of bulb changes (which would make the payback period even shorter). Considering the life-cycle costs of this installation over a 13 year period and discounted to today's net present value, end-users will save €105 with the T8 LED-1 (CorePro) or €136 with the T8 LED-2 (MasterLED) for each T8 fluorescent lamp replaced.

The same calculation was performed on an installation of 54 watt T5[3] fluorescent lamps, which have longer payback periods of 1.13–1.39 years. These calculations reflect energy costs and bulb costs only, and do not incorporate labour costs to change the lamp which are avoided due to the reduced frequency of bulb changes (which would make the payback period even shorter). Considering the life-cycle costs of this installation over a 13 year period and discounted to today's net present value, end-users will save €152 to €155 for each T5 fluorescent lamp replaced.[4]

Finally, a third category of fluorescent lamps that would be phased-out by RoHS are pin-based compact fluorescent lamps (CFLs). These CFLs do not contain a ballast, but rather are installed in luminaires where the ballast is part of the fixture, thus they are commonly called "non-integrally ballasted CFLs" or CFLni. Like the T8 and T5 linear fluorescent lamps examined, CFLni were found to offer very attractive payback periods of between 1.2 and 2.7 years for a given installation and will last 2–3 times longer than the fluorescent lamp. For European businesses and households, there is a very strong value proposi-

1. T8 is industry nomenclature for describing a certain type of fluorescent lamp. The T stands for tubular and the 8 refers to the number of eights of an inch diameter of the tube. Thus a T8 lamp is one inch in diameter.

2. For this calculation, it is assumed the lamps operate on average 10 hours per day (3,650 hours/year), electricity costs are €0.1254/kWh (EuroStat, 2021a), that there is an annual increase in electricity price of 4.0 % and a discount rate of 4.0 % (VHK, 2019).

3. T5 is industry nomenclature for describing a certain type of fluorescent lamp. The T stands for tubular and the 5 refers to the number of eights of an inch diameter of the tube. Thus a T5 lamp is five-eights of an inch in diameter.

4. Table 3: For this calculation, it is assumed the lamps operate on average 10 hours per day (3,650 hours/year), electricity costs are €0.1254/kWh (EuroStat, 2021a), that there is an annual increase in electricity price of 4.0 % and a discount rate of 4.0 % (VHK, 2019).

Table 3. Economic Analysis of T5 fluorescent vs. LED lamps in Europe.

Economic indicator description	T5 LFL	T5 LED-1	T5 LED-2	Units
Price for one lamp:	€3.54	€18.06	€21.30	*Euros/lamp*
Rated lamp wattage:	54	26	26	*Watts*
Rated lamp lifetime:	24,000	50,000	50,000	*Hours*
Annual electricity consumption (10 hr/day):	197	95	95	*kWh/yr*
Annual cost of electricity:	€24.72	€11.90	€11.90	*Euros/year*
Payback period in years:		1.13	1.39	*years*
Payback period in months:		13.6	16.6	*months*
Life-Cycle Cost, 13 years, net present value:	€327.65	€172.77	€176.01	*Euros (NPV, 2021)*
Life-Cycle Cost savings (net present value):		€155.88	€151.64	*Euros (NPV, 2021)*

tion in switching to LED, and lighting manufacturers' websites highlight the cost-effectiveness and energy savings potential of LED alternatives to fluorescent lamps.

ON-GOING FAILURE TO COLLECT USED LAMPS AT THE END OF LIFE

The majority of used fluorescent lamps are not recovered at the end of life and thus end up being disposed of in the general waste, resulting in more mercury pollution. A 2014 European Commission study (EC, 2014) on the Waste Electrical and Electronic Equipment (WEEE) Directive collection found that the European collection rate for lamps covered under WEEE was only 12 % in 2010 – when fluorescent lamps were at or around their peak shipments.[5] This study projected that the collection rate for lamps would reach 16 % in 2019 in the absence of a specific collection target for this category. For Member States seeking to reach their national collection targets of WEEE, which are based on weight, fluorescent lamps are largely irrelevant. They are light-weight and relatively difficult to collect and transport (due to their fragility, and associated risk of mercury release). Furthermore, the small size of lamps makes them easier to dispose of in the general waste than other types of WEEE covered products.

A large share of uncollected gas-discharge lamps may be compact fluorescent lamps, which are more common in residential use than T5 and T8 linear fluorescent lamps. However, according to the MELISA model developed by VHK for the EC, the share of linear fluorescent lamps in the lamps covered by the WEEE Directive was 38 % in 2009 (VHK, 2015). Considering a case in which 16 % of those lamps are collected (the aforementioned projected 2019 collection rate (EC, 2014), then the balance of those lamps (38 %–16 %) is 22 % which are not collected. And given this, 22 % of the total 38 % corresponds to 58 % of the linear fluorescent lamps are not collected. Extractions from Eurostat (Eurostat, 2021b) show that although the situation seems to have improved since 2010, the collection rate of gas-discharge lamps is estimated to still be only one-third to one-half of all gas-discharge lamps that have reached their end of life. Thus, it is understood that at least half of these mercury-containing lamps (and possibly more) are simply discarded in the general waste stream.

A 2016 study (Öko-Institut, 2016) to review the renewal applications for a number of RoHS exemptions includes reports from Member States that confirm the low levels of recovered mercury-containing lamps. In particular, Belgium and Denmark report that a significant share of mercury-containing lamps are not handled correctly. All of the data indicate that while some lighting industry reports claim the majority of Member States have met the target of 80 % for the re-use/recycling of gas-discharge lamps, the reason for these very high reported recovery rates has to do with the legal definition of the targets set out in the WEEE Directive (EC, 2012). In Article 11, Recovery Targets, paragraph 2, the regulation states "The achievement of the targets shall be calculated, for each category, by dividing the weight of the WEEE that enters the recovery or recycling/preparing for re-use facility, after proper treatment in accordance with Article 8(2) with regard to recovery or recycling, by the weight of all separately collected WEEE for each category, expressed as a percentage." In other words, the percentages are calculated as the weight of the WEEE after proper treatment by the WEEE that is separately collected for each category. Crucially, the reported percentages are not divided by the total weight of the fluorescent lamps (i.e., WEEE) placed on the market, they are only divided by the ones that are separately collected and delivered to recycling centres – thus the percentages are distorted because they ignore the larger volume of mercury-containing fluorescent lamps that are discarded in the general waste (because these lamps were not "separately collected").

Figure 1 depicts the flow of fluorescent lamps in Europe based on the data sources analysed (SEA-CLASP, 2021b). We estimate that less than half of the fluorescent lamps installed in Europe are recovered and recycled at the end of life.

The fact that more than half of the total mercury content of fluorescent lamps is not disposed of properly in Europe and ends up in the mixed municipal waste or other incorrect disposal is deeply concerning. This issue goes to the purpose of why the RoHS Directive was drafted, to try and protect the public from toxic substances like mercury, and given that direct, drop-in (mercury-free) replacement LED lamps are available for virtually all fluorescent lamp installations, it is time to phase-out the fluorescent lamp exemptions in the RoHS Directive.

RoHS Decision and Benefits

Far from being disruptive, the installation of LED retrofit lamps into existing fluorescent lamps will offer significant benefits to the EU. LED retrofit lamps completely eliminate mercury, re-

5. Commission Regulation (EC) No 244/2009 had phased out incandescent lamps, shifting the market to halogen and CFL, and LED replacements were still expensive and did not have high levels of market penetration. LED retrofit linear tubes were only entering the market in 2010.

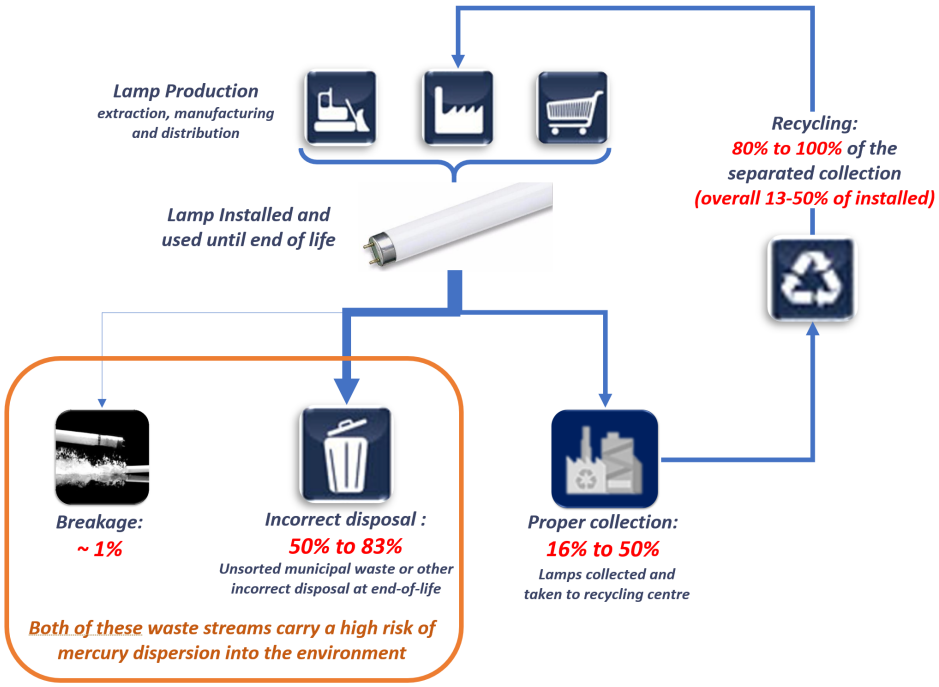

Figure 1. Life-cycle flow diagram of fluorescent lamps in the EU.

duce energy consumption and provide better, longer lasting life from the LED lamps. LED lamps use approximately 50 % less energy than their fluorescent equivalents, resulting in lower operating costs, saving consumers money over the life of the product. A study (Öko-Institut, 2020) was published that quantified the benefits that would accrue to Europe if RoHS were to phase-out the exemptions in 2021 for the fluorescent lamps that Ecodesign did not remove from the market. The savings and benefits are given below (Öko-Institut, 2020; SEA-CLASP, 2020b):

- Save European consumers €29.9 billion through 2035; cumulative net savings, accounting for bulb costs and energy savings;
- Eliminate a cumulative 2.9 metric tonnes of mercury by avoiding the sales of fluorescent bulbs while saving a further 2.5 metric tonnes of mercury emissions from coal-fired power plants[6] as a result of the greater energy-efficiency of LED bulbs;
- Avoid a cumulative 92.1 million metric tonnes of CO_2 emissions through energy savings by 2035, which is equivalent to the total combined annual CO_2 emissions of Denmark and Slovakia in 2018;

Phasing out fluorescent lighting in Europe will be good for the economy, the recovery and of course the public and environmental health of Europe.

Scaling Up – The Minamata Convention

According to the World Health Organisation (WHO), mercury can cause serious health problems, and is a threat to the development of the child in utero and early in life. Mercury has toxic effects on the nervous, digestive and immune systems, and on lungs, kidneys, skin and eyes. Indeed, Mercury is considered by the WHO as one of the top ten chemicals of major public health concern (WHO, 2021).

To eliminate this public health risk, the Minamata Convention on Mercury was launched in 2013 with the goal to "Make Mercury History" by eliminating the use of mercury in products and processes worldwide. The Convention is named after the city of Minamata, Japan, which experienced widespread mercury poisoning after wastewater from a nearby chemical plant was discharged into the sea. The Convention entered into force in August 2017 following ratification by 50 countries; as of May 2021, there were 131 parties to the Convention. Major highlights of the Convention include a ban on new mercury mines and phase-out of existing ones, the phase out and phase down of mercury use in a number of products and processes, control measures on emissions to air and on releases to land and water.

Yet despite this progress, the Minamata Convention contains exemptions for mercury-containing fluorescent lighting products, citing insufficient cost-effective alternatives across global markets. While those exemptions were justified in 2013 when the Convention was launched, thanks to the innovation and development of mercury-free LED retrofit lamps, the need to maintain fluorescent exemptions under Minamata is no longer needed nor is it justified. Just as the EU market gradually phases-out fluorescent lighting, hazardous and poor-performing mercury-based fluorescent lighting should not be traded with other countries around the world. Under the Minamata Convention, the export and trade in mercury-containing fluores-

6. Electricity savings avoids the release of mercury from power stations that burn coal. Using the Commission's estimate of an average 0.016 mg Hg/kWh of electricity generated in Europe, a further 2.5 metric tonnes of mercury emissions released to the environment in Europe would be avoided.

cent lamps could be ended, protecting public and environmental health by eliminating mercury releases.

The development and increasing accessibility and affordability of mercury-free LED lighting makes the exemptions under the Minamata Convention unnecessary. Eliminating the exemptions for fluorescent lighting at the next Conference of Parties (COP4) of the Minamata Convention could lead to a global phase-out of fluorescent lighting by 2025, accelerating a global transition to more energy-efficient, mercury-free LED lighting. On 30 April 2021, the Minamata Secretariat circulated a proposed amendment that had been submitted by 36 countries in Africa calling for the phase-out of fluorescent lamps by 2025 (UNEP, 2021). Given this development, the Parties to the Convention will be discussing and voting on the phase-out of fluorescent lamps at COP4.

The Clean Lighting Coalition (CLiC), a coalition of private sector, health authorities, mercury experts and NGOs, prepared a global lighting market model to quantify the global savings potential in terms of mercury and energy if this African amendment were to be adopted (CLiC, 2021). The Coalition reports that phasing out fluorescent lighting globally by 2025 will have widespread benefits, including:

- 232 metric tonnes of mercury pollution are removed, both from the lamps themselves as well as avoided emissions from coal-fired power plants; and
- 3.5 gigatonnes of CO_2 emissions are avoided between 2025 and 2050, the equivalent of removing all passenger cars from the road *worldwide* for one year.

Much like the global phase-out of incandescent bulbs, now is the time for the global phase-out of fluorescents – motivated not only by energy savings and cost-effectiveness, but because of the toxic metal that resides inside the bulb and the impact it has on people and the environment. The EU should be well positioned to support the African Amendment (UNEP, 2021), given that much of the fluorescent lighting is already being phased out under the Ecodesign Directive and the balance of fluorescent lamps are expected to be phased out soon under the RoHS Directive.

Conclusion

At the time of publication of this paper, the amendment to the RoHS Directive that was expected in 2016 has not yet been published. The on-going delay to this amendment has a societal cost in that it is reducing the €29.9 billion of net benefit that the Oko-Institut and VHK calculated would accrue to Europe if the phase-out happened in 2021. An EU-wide study using the same analytical tools published by Oko-Institut and VHK found that the first year of delay wipes out €5.6 billion of those savings (CLASP, 2021). A second year of delay would wipe out (compounded) €11.7 billion of the total savings (CLASP, 2021). Indeed, it is hoped that the policy process under RoHS can be initiated soon and moved through the procedural steps quickly to protect consumers and the environment, and to enable mercury-free LED lighting to contribute to the green recovery of Europe, post-pandemic.

Over the last few years, DG Energy conducted analysis of lighting products (i.e., fluorescent lighting) under the Ecodesign Directive, and found that most of fluorescent lighting should be phased-out on the basis of life-cycle cost. This finding was then adopted as an EU regulation (EU 2019/2020) and the European market is preparing now for that phase-out. There are, however, some lamp types that were exempted by Ecodesign and would otherwise remain on the EU market unless or until the RoHS Amendments are published. The expectation is that RoHS will pick-up and phase-out the remaining fluorescent lamps and in that process, generate significant mercury, energy, climate and financial benefits for Europe.

The WEEE Directive calculates the percentage of Recovery Targets for fluorescent lamps by dividing the recycled lamps by the weight of the WEEE that enters the recovery or recycling facility, rather than the total weight of the fluorescent lamps placed on the market. Thus the official reported percentages of recycled mercury lamps is artificially high, boosted by the fact that the calculation omits the larger volume of mercury-containing fluorescent lamps that are discarded in the general waste (since these lamps were not "separately collected"). This issue may warrant review, as it could mislead regulators into believing the problem of mercury contamination from lighting products is under control when it is not. Looking at the practical reality of waste handling, experts have found that 50–83 % of the fluorescent lamps placed on the market in Europe are not disposed of correctly (SEA-CLASP, 2021b).

LED retrofit lamps are widely available and will fit and operate in virtually all fluorescent fixtures across Europe according to a series of studies that prepared to support DG Environment's review of the fluorescent lamp exemptions RoHS (SEA-CLASP, 2019, SEA-CLASP, 2020a; SEA-CLASP 2020b). These studies found that it is both technologically feasible and economically justified to end the exemptions for fluorescent lamps. A socioeconomic analysis published by the Commission shows that such a decision would generate €29.9 billion in net savings, eliminate 2.9 tonnes of mercury in lamps and avoid the need for 310 TWh of electrical energy (Öko-Institut, 2020) – which given Europe's power mix, saves a further 2.5 tonnes of mercury emissions from coal-power plants (SEA-CLASP, 2020b).

The EU is a Party to the Minamata Convention on Mercury, an initiative seeking the phase-out of mercury from products and processes world-wide. Given the new awareness in Europe about the widespread availability of LED retrofit products, the Commission is well positioned to support the African Lighting Amendment to the Minamata Convention (UNEP, 2021) which calls for the phase-out of fluorescent lighting globally by 2025. In Europe, much of the fluorescent lighting is already being phased out under the Ecodesign Directive and the balance of these mercury-containing lamps are expected to be phased out soon under the RoHS Directive. It is time for the world to say "farewell to fluorescent".

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