MERCURY IN FLUORESCENT LIGHTING

Compact fluorescent lamps did not diminish mercury emission.

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CONTENTS

Preface

This paper is not yet a self-contained unit. Conflicting statements in places are included.

I preferred to give you share in the preliminary results of my study. It is up to you to correct and complete the data.

It is unendurable to base our lighting on mercury, a highly toxic metal. Immediate actions are needed. If governments do not take proper measures, consumers have to take them. Everyone can decide whenever to make exclusively an appeal on mercury free lighting and can take away all CFLs and even fluorescent tubes.

I eagerly look forward to your remarks. This study needs the contribution of many attentive readers. This is also why regularly new versions of this paper will be published.

Summary

1. It is an accepted fact that mercury and methyl mercury in particular are very dangerous to human health. An overview is given of the characteristics of mercury, the health effects and the origin of methyl mercury in fish.

2. Some facts are summed up about the reduction of the global primary mercury production, the global consumption, the emission of mercury to the atmosphere, and the average emission in some countries. The chapter ends with a short discussion about actions which have been undertaken to reduce mercury emission in power plants.

3. The global demand of mercury is inspected by region. We bring into focus the demand of the lighting sector. An answer is given to the question “Why do fluorescent lamps contain mercury?”. The directive 2002/95/EC has exempted the fluorescent lamps from the requirement for the substitution of mercury. What is the amount of mercury in fluorescent lamps and in particularly in CFLs? Are substitutes available for fluorescent lamps? We ascertain that the most suitable alternative for the CFL is the halogen lamp and the incandescent lamp but in some countries the incandescent lamp has been banned.

4. We try to answer the question if the presence of mercury in lighting does result in less mercury emission in power plants. Therefore, we investigate four calculations made by Annette Gydesen and Dorte Maimann for Denmark (1991), by Laurie Ramroth for U.S. (2008), by the Flemish Institute for Technological Research (VITO) for the E.U. (2009) and by the American Environmental Protection Agency (EPA) for the U.S. A minimum of mercury emission by (coal fired) power plants is needed to justify the presence of mercury in lamps. The value of the average mercury emission by country or region has since years not changed to justify the production of CFLs. The higher the amount of mercury emitted by power plants, the more the producers of CFLs can justify their supply of CFLs. We ascertain that producers of CFLs make hay of the unacceptable pollution by coal fired power plants

5. UNEP has given undue preference to Philips Lighting and OSRAM AG through the *en.lighten iniative*. This partnership with UNEP not only promoted CFLs over the whole world but developed also a road-map for the global phase-out of incandescent bulbs. Under the pressure of producers of CFLs, the U.S. and the E.U. took measures to ban incandescent lamps. The lobby of the private industry in the decision making in the E.U. must urgently be restrained.

6. There were serious health problems during the production phase of CFLs, in particularly in China, where most CFLs are produced. Research is going on to investigate if ultraviolet and electromagnetic radiation from CFLs is a risk factor for the aggravation of light-sensitive symptoms in some patients. Broken CFLs mean a serious danger to the health, especially for children. The measures issued by the

governments or institutions of different countries are not univocal. Not recycled CFLs are a serious problem for the environment and for health.

7. The consumer has the right to acquire the most appropriate product to meet his well-considered demands. The ban on incandescent lamps means a violation of the free market principles. Certain preferences cannot be fulfilled by CFLs. The Cradle to Cradle principle suggests that every product should have a complete cycle mapped out for each component. This is not the case with CFLs, due to the fact that most of these lamps end up in a landfill. Ethical minded consumers don't want to buy mercury containing products. This chapter ends with a small test of CFLs. The conclusion is that in the given circumstances, to buy a CFL is somehow to take part in a lottery.

8. The production of CFLs should be banned immediately. We demand an immediate lift of the ban on incandescent lamps and clear notices on the package about the content of mercury and about the dangers intrinsic to fluorescent tubes.

   We demand the publication of the rate of emission of the pollutants of all coal fired power plants. Each habitant in the region should be able to receive data about the emission of fine particles, nitrogen oxides, sulfur dioxide, mercury, etc. Especially in Europe, a lack of such information is ascertained.

A short conclusion is worked out at the end of Chapter 8.

1. Impact of mercury exposure on human health

Mercury: characteristics

Mercury is a silvery-white metal that is liquid at normal temperature and pressure. It is not inflammable and odorless.

- atomic number: 80
- relative molecular mass: 200.59
- melting point: -38.87° C
- boiling point: 356.72° C
- density: 13.534 g/ cm^3 at 25° C. (Technical2007, p. 2)

Mercury is extracted by heating cinnabar and condensing the vapor. The equation of this extraction is $HgS + O_2 \rightarrow Hg + SO_2$ (See Newworldencyclopedia.org).
Elementary mercury evaporates and forms vapors. *"Mercury vapours are colourless and odourless." "The higher temperature, the more vapours are released from liquid elemental mercury."* (Technical2007, p. 2)
Mercury can have the following states:

1. liquid metallic mercury (Hg^0)
2. mercury vapor (Hg^0)
3. monovalent (Hg^+) (exists as inorganic salts) and divalent (Hg^{2+}) mercury (may form either inorganic salts or organomercury compounds). The three groups vary in effects. (http://www.coda-cerva.be/index.php?option=com_content&view=article&id=215&Itemid=209&lang=en)

A very dangerous organometallic form is methylmercury (MeHg). It can bioaccumulate up the food chain. It can lead to high concentrations in predatory fish. Fish is a very important source of protein for human, particularly for Japanese and other Asians, as well as for people in the Arctic region. (Technical2007, p. 2)

Mercury is recognized as one of the most hazardous elements after incidents such as the Minamata disease in Japan (1956) and Iraq methylmercury poisoning in the early 1970's. (Technical2007, p. 3)

Atmospheric mercury exists mainly in the form of elemental mercury vapour (90 to 99%), particle bound mercury (< 5%) and gaseous divalent mercury (<5%). (Ambient_air_pollution2001, p. 4)

Mercury is a bioaccumulative element in the environment and retained in organisms. *"Once mercury enters into the environment, mercury permanently exists in the environment by changing its chemical forms depending on the environment."* (Technical2007, p. 3) *"It is a natural element that cannot be created or destroyed and the same amount has existed on Earth since the planet was formed."* (MercuryfateUNEP2008, p. 58)

[Bioaccumulate – the accumulation of a substance, such as a toxic chemical, in various tissues of a living organism.] (http://www.thebriefingroom.com/archives/2008/08/mercury_in_cfls.html)

"Mercury is a global pollutant. The emissions to air in Europe decreased by about 60% from 1990 to 2000, while global emissions rose by about 20% over the same period. As a result, the European share of the total global mercury emissions to air fell from about 33% in 1990 to about 10% in 2000." (Commission_staff2006, p. 85)

Health effects

What are the health effects of mercury?

- "**Elemental mercury** is not known to directly irritate the skin. However, an allergic skin reaction may develop after contact with mercury. In the long term, elemental mercury liquid and vapour can be absorbed through the skin and may contribute to the overall absorption and toxicity." (http://www.ccohs.ca/oshanswers/chemicals/chem_profiles/mercury/health_mercury.html)

- **Mercury vapor** is very dangerous because it is absorbed quite easy by the lungs. According to Wikipedia, *approximately 80% of inhaled mercury vapor is absorbed via the respiratory tract where it enters the circulatory system and is distributed throughout the body. Chronic exposure by inhalation, even at low concentrations in the range 0.7-42 µg/m^3, has been shown in case control studies to cause effects such as tremors, impaired cognitive skills, and sleep disturbance in workers.*

  The proposed limit value for Hg^0 of 0.05 µg m^{-3} (annual average for the general population) is rarely exceeded in ambient air in Europe. (Ambient_air_pollution2001, p. 2; p.3) *The WHO air quality guideline for mercury is 1 µg/m^3 (annual average).* (Technical2007, p. 6) The "Provisional Tolerable Weekly Intake" (PTWI) of Hg^0 is 5 µg/kg body weight. (http://www.coda-cerva.be/index.php?option=com_content&view=article&id=215&Itemid=209&lang=nl)

- *In the aquatic environment, elemental mercury is bioconverted into **methylmercury**.* (Technical2007, p. 4-5)
    - *Methylmercury exposure is a particular concern for women of childbearing age, unborn babies, and young children because studies have linked high levels of methylmercury to damage to the developing nervous system. This damage can impair children's ability to think and learn.*
    - *Mercury and other power plant emissions also damage the environment and pollute our nation's lakes, streams, and fish.* (Fact Sheet, Proposed Mercury and Air Toxics Standards, (http://www.epa.gov/airquality/powerplanttoxics/pdfs/proposalfactsheet.pdf)

Ingested methylmercury in the human body is readily and completely absorbed by the gastrointestinal tract, almost completely absorbed into the bloodstream and distributed to all tissues within about 4 days. Methylmercury is accumulated in the liver and kidney. (…)
Pregnant and child-bearing women are a sensitive group *because methylmercury as methylmercury-cysteine conjugate can pass not only the blood-brain barrier but also the placenta and causes the adverse effects tot the fetus.* (Technical2007, p. 4-5)
The developing brain is considered the most sensitive target organ for methyl mercury which occurs in the human diet. (Ambient_air_pollution2001, p. 2)
The estimated intake of mercury in Europe varied by country, depending on the amount and type of fish consumed. Based on the SCOOP document, national average exposures to methylmercury from fish and seafood products were between 1.3 and 97.3 µg/week, corresponding to <0.1 and 1.6 µg/kg body weight per week (assuming a 60 kg adult body weight). Hence the highest average intake estimates were just at the PTWI, thereby exceeding the US NRC recommendation. (Commission_staff2006, p. 83)
Most people in coastal areas of Mediterranean countries, and around 1 – 5% of the population in central and northern Europe (i.e. something around 3 – 15 million people in the EU), are around the RfD. (Commission_staff2006, p. 12)
(RfD: reference dose)

Remark:

- *Most people in central and northern Europe show bioindicators of exposure below the international "Provisional Tolerable Weekly Intake" (PTWI) for methylmercury (1.6 µg/kg body weight/week).* (Commission_staff2006, p. 12)
- *The US National Research Council (NRC) has established an intake "reference dose" (RfD) for methylmercury of 0.7 µg/kg body weight per week (NRC, 2000).* (Commission_staff2006, p. 79) *This would be 42 µg/week for a 60 kg adult. The equivalent amount of fish consumed would be 420 g of fish per week with 0.1 mg Hg/kg or 105 g of fish per week with 0.4 mg Hg/kg.* (Ambient_air_pollution2001, p. 144)

Research: Leonardo Trasande, Philip J. Landrigan, Clyde Schechter, *Public Health and Economic Consequences of Methyl Mercury Toxicity to the Developing Brain*, Environmental Health Perspectives, Volume 113, Number 5, May 2005.

The major findings in this analysis are
a) that exposure to methyl mercury emitted to the atmosphere by American electric generation facilities causes lifelong loss of intelligence in hundreds of thousands of American babies born each year and
b) that this loss of intelligence exacts a significant economic cost to American society, a cost that amounts to at least hundreds of millions of dollars each year.

Moreover, these costs will recur each year with each new birth cohort as long as mercury emissions are not controlled. By contrast, the cost of installing stack filters to control atmospheric mercury emissions is a one-time expense. The high costs of in utero *exposure to methyl mercury are due principally to the lifelong consequences of irreversible injury to the developing brain.*

Origin of methylmercury in fish

The mercury present in fish and seafood products is largely, but not entirely, in the form of methylmercury. (Commission_staff2006, p. 83)
The origin of methylmercury in fish is to a large extent anthropogenic emissions of mercury to air which is subjected to long-range transport, transformations and deposition to terrestrial and aquatic systems. Mercury is accumulated in forest soils from where it only slowly is transported to aquatic ecosystems. In aquatic ecosystems, a fraction of the mercury deposited directly and transported from surrounding catchments is transformed into methylmercury compounds which are readily taken up and bioaccumulates in aquatic food-chains. Industrial discharges of mercury directly to water systems will have the same effect.
(Ambient_air_pollution2001, p. 4)

Mercury occurs naturally in the ocean sediment but can also occur as contamination as a result of human activities. Micro-organisms transform the mercury in methyl-mercury and it bio-accumulates in aquatic organisms. What bio-accumulation actually means is that when a larger fish eats a smaller fish, it accumulates the level of methyl-mercury that the smaller fish contained. When it eats another smaller fish, it accumulates some more methyl mercury. The more small fish it consumes, the more methyl-mercury it accumulates and the level does not drop. Then along comes an even bigger fish and eats the fish that ate the smaller fish and that larger fish accumulates all the mercury of the fish it just ate and so the vicious circle continues.
Fish not only accumulate mercury from consuming smaller fish. All fish absorb methyl-mercury from the water that passes through their gills. The longer the fish lives, the more methyl-mercury it will bio-accumulate. Fish that are not predatory and are short lived are not

going to contain as much methyl-mercury as their predatory and long living relatives so these are the fish we want to be including in our diet. (http://www.ffc.org.au/Mercury_and_fish.html)

Wisconsin researchers found that changes in atmospheric mercury deposition can have rapid effects on the fish mercury concentrations. They found that a 10 percent decrease in mercury deposition resulted in a five percent decrease in fish tissue levels. (mercury_em_coal2003, p. 2-6).

Recent data (Murata et al, 2004) suggest that the effects of methylmercury exposure may yet extend significantly below even the US RfD. So, *there may be benefits of decreasing exposures even for populations who are below the present RfD/PTWI levels.* (Commission_staff2006, p. 80)

Conclusions

1. The damage to our health and the environment has reached an alarming level. *Most people in central and northern Europe show bioindicators of exposure below internationally accepted safe levels for methylmercury. However, most people in coastal areas of Mediterranean countries, and around 1-5% of the population in central and northern Europe, are around these levels, and large numbers among Mediterranean fishing communities and the Arctic population exceed them significantly.* (Communication from the Commission to the Council and the European Parliament, 28.01.2005)

2. *There is a significant body of mercury already released to the environment that can recirculate again and again, contaminating fish and causing other problems, until it at least reaches a long term sink. There is no prospect of an immediate solution to this problem.* (Commission_staff2006, p. 15) *A key long term aim is that levels of mercury in the environment will be reduced such that there is no longer any need for concern over methylmercury in fish. This will probably take decades, since the present levels of mercury in the environment are representative of past mercury emissions, and even without further emissions it would take some time for these levels to fall.* (Commission_staff2006, p. 16)

3. The problem cannot be solved by one country acting alone. *It is important to make progress at the global level.* (Commission_staff2006, p. 16)

4. More research has to be done on the impact of mercury on the environment and health. *For example, there is little scientific information that indicates how further cuts in mercury emissions would translate into, say, reduced levels of methylmercury in fish, or over what time period changes could be expected.* (Commission_staff2006, p. 15)

References

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2. Mercury: demand and supply

The impact of the enhanced mercury emissions, related to energy resources exploitation, especially fossil fuel consumption, is such that atmospheric concentrations have increased by a factor of three on average since pre-industrial times. (MercuryfateUNEP2008, p. xxxv)

Some facts about the phasing out of primary mercury mining

Since 2001 a remarkable progress has been made concerning the running down of primary mercury mining.

1. *Circa 2002, the EU adopted the European Mercury Strategy which is aimed to phase out the use of mercury in goods and industrial applications and reduce to the extent possible mercury emissions to the atmosphere from fossil fuels power plants and industrial facilities.* (MercuryfateUNEP2008, p. 2)
2. *Before 2003 Europe was a major exporter of mercury (around 25% of the total supply). The main production site in Europe was the mine in Almadén in Spain where primary production of metallic mercury came from cinnabar extraction. In 2003 the production of virgin mercury in Almadén stopped and the export of mercury from Europe declined significantly. Mercury mining in Slovenia (Idraje mine) and Italy (Monte Amiata) ceased several years ago (1995 in Slovenia and 1976 in Italy).* (RequirementsEC2010, p. 12-13)
3. In Algeria, mercury mining stopped in 2005. A National Action Plan on Primary Mercury Mining in Kyrgyzstan has been elaborated. The recommended actions will lead to the consideration of closing the Khaidarkan Mine. (More...)
4. The export of mercury from the EU is phased out in 2011. This creates a large surplus mercury from the chlor-alkali industry. It will be safely stored.
5. From 2012, only China will exploit mercury mining only for his own interest without exporting the substance. (UNEP_Répondre2008, p. 3) China is the world leader in mercury production. In 2010, its share reached 71% of world total while the part of Kyrgyzstan was 13%. (More...)

6. *The European chlorine industry committed itself to voluntarily phasing out the mercury-based chlorine plants or conversion to non-mercury technologies (e.g. membrane technology by 2020.* (RequirementsEC2010, p. 14)

Global production of mercury

Table 2.1.

Main sources of mercury in 2005	**Supply of mercury (tonnes)**
Primary mercury mining	1150 – 1500
Mercury from other minerals, the mercury gained from purification of natural gas inclusive	410 – 580
Mercury from (decommissioned) chlor-alkali cells	700 – 900
Stocks	300 – 400
Total	**2560 - 3380**

(1 ton = 1,000 kg) The mercury gained from recycled products is not included.

(UNEP_Répondre2008, p. 6)

Global consumption of mercury

Table 2.2.

Application	**Consumption of mercury in 2005 (tonnes)**	**Percentage**
Artisanal extraction in mining activity	650 – 1 000	22
Vinyl chloride monomer / PVC	715 - 825	20
Chlor-alkali plants	450 – 550	13
Batteries	260 – 450	9
Dental amalgam	300 – 400	13
Measuring and control equipment	300 – 350	9
Lighting	120 – 150	4
Electric and electronic devises	170 – 210	5
Other applications	200 – 420	8
Total consumption	**3165 – 4355**	**100**
Recycled and recovered mercury	(650 – 830)	
Net consumption	**2500 – 3500**	

(UNEP_Répondre2008, p. 4)

Mercury emissions to the atmosphere

The sources of mercury emissions to the atmosphere are:

- Natural sources: volcanoes, soil and water surfaces, weathering processes of Earth crust and forest fires. Natural processes contribute 68% of the global atmospheric Hg input. Without considering biomass burning, the current estimate of mercury emissions from natural sources is near 4532 tonnes per year. (One ton is 1,000 kg.) *"Much of this emitted Hg, while being emitted from a natural process has an anthropogenic origin in being originally released to the biosphere as a result of human activity."* (MercuryfateUNEP2008, p. 2; p. xxxviii)

- The contribution from industrial sources have been found ranging between 1660 and 2200 tons per year. (MercuryfateUNEP2008, p. 2; The table below is borrowed from p. 6)

Releases from mobilization of mercury impurities	**Releases from intentional extraction and use of mercury**	**Releases from waste treatment, cremation, etc.**
Coal-fired power and heat production plants	Mercury extraction	Waste incinerators
Energy production from other fuels	Artisanal gold mining	Landfills
Cement production	Caustic soda production	Cremation and cemeteries
Mining and other metallurgic activities	Use of fluorescent lamps, instruments and dental amalgam fillings	
Traffic activity (Gasoline, diesel, kerosene, biofuels)	Manufacturing of products containing mercury	

A number of studies have estimated that the yearly total global input of mercury to the atmosphere ranges between 5800-7000 tonnes. Of these emissions, somewhere between 35-60% originates from anthropogenic sources. However, if re-emission of anthropogenic mercury previously deposited on natural surfaces is taken into account, the anthropogenic portion of the total global mercury emissions may be as high as 75 percent.
(CCSD_Quantifying2004, p. i)

Worldwide release of mercury to the atmosphere is estimated to be between 2,000 and 3,000 metric tons from anthropogenic sources and 1,400 to 2,300, due to natural sources. (SCHER (Scientific Committee on Health and Environmental Risks), *Opinion on Mercury in Certain Energy-saving Light Bulbs*, 18 May 2010)

Estimated global anthropogenic emissions of mercury to air in 2005 from selected sectors

Table 2.3.

Selected sectors	**UNEP/AMAP 2008 (revised)***	**Percentage**
Coal combustion in power plants and industrial boilers	498 (339 - 657)	26
Residential heating/other combustion	382 (257 – 506)	20
Non-ferrous metals (Cu, Zn, Pb)	132 (80 – 185)	7
Large scale gold production	111 (66 – 156)	6
Cement production	189 (114 – 263)	10
Waste incineration	42	2
Other waste	74	4
Pig iron and steel, sec. steel	61 (35 – 74)	3
Artisanal and small-scale gold production	323	17
Chlor alkali industry	47 (29 -64)	2
Dental amalgam (incineration)**	27	1
Other	26	1
Mercury production	9 (5 – 12)	0,5
Overall inventory	**1921 (1221 – 2950)**	**100**

* Represents best estimates: estimate (uncertainty interval), or conservative estimate (no associated range). See UNEP/AMAP (2008) for discussion on uncertainties. (AMAP: Arctic Monitoring and Assessment Programme)

** Does not include other waste relative to production, manipulation, use and elimination of dental amalgams.

(UNEP_Etude2010, p. 19)

Of the 1921 tonnes of estimated mercury emissions, power plants and industrial boilers contribute about 500 tonnes or 26%. *Most of mercury emissions generated during the combustion process can be controlled by devices added on the installations to remove particles and acidic gasses.* (Ambient_air_pollution2001, p. 202) The question is if Best Available Techniques are used where needed.

A large percentage of the mercury emission is due to artisanal and small-scale gold mining (ASM). With the increasing prices of gold, one can expect that more mercury will be used. (UNEP_Répondre2008, p. 13;26)

China plays a singular part in the emission of mercury.

1. With its large number of coal-fired power plants, China was estimated to be the largest single emitter of mercury to air worldwide in 2005. *Emissions from the power sector in China have likely decreased since 2005.* (UNEP_Study2010, p. 18)

2. Has the highest ASM mercury consumption, with 200 to 250 tonnes consumed and released. (UNEP2006E, p. 57).
3. About 50 per cent of the estimated mercury emissions from the non-ferrous metal industries (from large-scale operations) are estimated coming from China. (UNEP_Study2010, p. 15)
4. *About 74 per cent of the total mercury emitted from the cement sector are emitted in Asia with China the main contributor, responsible for 45 per cent of total emissions to air from cement manufacturing.* (UNEP_Study2010, p. 15)

Average emission of mercury in some countries

Coal fired power plants are by far the largest source of mercury to air.

Coal represents the primary fuel in electrical power generation facilities, accounting for approximately 43% of total fuel used worldwide (EIA, 2008). The literature data indicate that the mercury concentrations in coals vary between 0.01 and 1.5 g per Mg of fuel. (MercuryfateUNEP2008, p. 7)

The other pollutants emitted as a result of fossil fuel exploitation, such as NO_x and SO_2, have an impact on the atmospheric chemistry of mercury and influence its deposition patterns. (MercuryfateUNEP2008, p. 2)

Natural gas may contain small amounts of mercury but the element is normally removed from the raw gas during the recovery of liquid constituents as well as during the removal of hydrogen sulfide. Therefore, it is assumed that mercury emissions during the natural gas combustion are insignificant (Pirrone et al. 1996; Pirrone et al.1998; Pirrone et al. 2001c). (MercuryfateUNEP2008, p. 7-8)

The pulverized coal furnace attempts to burn the finely powdered coal and air in a gaseous torch at 1700 K. Mercury can be released in a variety in forms including: elemental mercury (Hg0), mercury chloride ($HgCl_2$), mercury oxide (HgO), mercury sulphate ($HgSO_4$), mercuric nitrate [$(Hg(NO_3)_2$], and several other compounds. (Technical2007, p. 13)

Some countries with the largest mercury emissions are China, Australia, United States, Europe. (Peeters_Weem_Reduction2011, p. 10)

3.a. India:

Table 2.4.

Production from:	**Electricity (GWh)**	**Percentage**
coal	569310	68.6

oil	34148	4.1
gas	81927	9.9
biomass	1973	0.2
nuclear	14713	1.8
hydro	114295	13.8
solar PV (photovoltaic)	20	0.0
wind	13740	1.7
Total Production	**830126**	**100.0**

Source: http://www.iea.org/stats/electricitydata.asp?COUNTRY_CODE=IN

It is not clear what's the amount of mercury emission in India. If we assume the number of about 80 tonnes (UNEP_Etude2010, p. 29; UNEP_study2010, p. 22), (and an electricity production of 835,266,450,000 kWh in 2009, source: wikipedia, List_of_countries_by_electricity_production) we establish a national average of mercury emission of **0.0897 mg** per kWh. This is a very high number and should worry everyone in India! Urgent measures are needed!

3. b. China

Table 2.5.

Production from:	**Electricity (GWh)**	**Percentage**
coal	2,733,280	79.1
oil	23,411	0.7
gas	31,028	0.9
biomass	2,359	0.1
nuclear	68,394	2.0
hydro	585,187	16.9
solar PV	172	0.0
wind	13,079	0.4
Total Production	**3,456,910**	**100.0**

Source: http://www.iea.org/stats/electricitydata.asp?COUNTRY_CODE=CN

The emission of mercury by coal fired power plants in China is estimated at 195 tonnes (UNEP/PSEA 2008). (UNEP_Etude2010, p. 28; UNEP_study2010, p. 22)

With an electricity production of 3,221,798,270,000 kWh in 2008 (wikipedia, List_of_countries_by_electricity_production), the national average of mercury emission per kWh is, at a rough estimate, **0.0605 mg**!

The country is paying a too high and unjustified price for their energy requirements. This has to be remedied immediately.

3.c. Australia

Table 2.6.

Production from:	**Electricity (GWh)**	**Percentage**
coal	197622	76.8
oil	2756	1.1

gas	38507	15.0
biomass	2204	0.9
hydro	12057	4.7
solar PV	156	0.1
Solar thermal	4	0.0
wind	3941	1.5
Total production	**257247**	**100.0**

Source: http://www.iea.org/stats/electricitydata.asp?COUNTRY_CODE=AU

We ascertain that more than75% of the production of electricity in Australia relies on coal. We distinguish the production of electricity in three different states:

- Queensland where electricity is produced from relatively high-energy black coal;
- Victoria where electricity is produced from relatively low-energy "brown" coal;
- Tasmania where electricity s produced significantly from hydro-electric sources. (David Parsons, *The environmental impact of compact fluorescent lamps and incandescent lamps for Australian conditions*, in The Environmental Engineer, Vol.7, n° 2, Winter 2006.)

The emission of mercury by coal fired power plants in Australia is estimated at 8.8 tonnes (UNEP/PSEA). (UNEP_Etude2010, p. 27, UNEP_study2010, p. 21)
If this number is correct and with an electricity production of 249,914,000,000 kWh in 2008 (wikipedia), we find a national average of mercury emission per kWh of **0.035 mg**!

3.d. United States: Two different number have been found for the national average of mercury emission per kWh: 0.016 mg (1993) and **0.012 mg** (2006). Our own calculation, based on figures of Environmental Integrity Project "Dirty Kilowatts", leads to an average mercury emission of 0.009 mg/kWh for the year 2008 (see Annex B).

3.e. Europe-27: The VITO-report calculated an average of mercury emission of **0.016 mg** per kWh (See VITO2009, p. 147). As will be demonstrated, the accuracy if this number can be doubted. The number needs an update.
Apart from that, the estimates of the mercury emissions of power plants in Europe is rather uncertain. We did not found correct information about this subject.

Actions undertaken to reduce mercury emissions in power plants

a. In Europe
The following actions were issued.
- Emissions of mercury from major industrial sources are subject to the EU Directive (96/61/EC) on Integrated Pollution Prevention and Control (IPPC). Existing installations had until October 2007 to comply. (Q&A van ec.europa.eu)
- Emissions of coal fired power plants have to be reduced according to the LCP Directive (2001/80/EC). (Peeters_Weem_Reduction2011, p. 5)

- In 2013 the new Industrial Emissions Directive (IED) (2010/75/EU) will replace the LCP. (Ibidem)

For EU Members the application of BAT (Best Available Techniques) is mandatory under the current IPPC Directive and under the new Industrial Emissions Directive. BAT is aimed at reducing emissions of SO_2, dust and NO_x. The consequence is that also the emissions of mercury will be reduced.

Most current coal fired power plants in Europe will meet the proposed emission standard of 30 microgram/Nm^3 without making any additional provisions against mercury emissions. (…) If the raw gas concentration is estimated to be below 30 microgram/ Nm^3 and the overall efficiency of a combination of ESP, FGD and SCR is estimated to be 90%, the resulting emission concentration of mercury in the stack gases will be below 3 microgram/ Nm^3. This level is obtained without application of specific mercury abatement techniques.

(ESP: electrostatic precipitation to reduce emission of Particulate Matter;
FDG: flue gas desulphurization to reduce emission of SO_2;
SCR: selective catalytic reduction to reduce emission of NO_x) (Peeters_Weem_Reduction2011, p. 5)

The draft of the IED does not give ELVs for mercury emissions, but it gives ELVs for SO_2, NO_x and PM. (…) This will lead to reductions of mercury emissions with an efficiency of about 75% , or about 90% if an SCR is used. (Peeters_Weem_Reduction2011, p. 9)

It is necessary that in Europe, all coal fired power plants would obtain in practice a level below 3 microgram/Nm^3 in the near future. Further action is needed.

b. United States

- *Coal-fired power plants were estimated in 1999 to emit about 48 tons per year, or over 40 percent of the U.S. inventory from anthropogenic sources.* (mercury_em_coal2003, p. 2-1).
- *In December 2000, in the last days of the Clinton administration, the E.P.A. finally listed power plants as a source of hazardous air pollutants under the Clean Air Act.* (New York Times)
- *On February 14, 2002, the Bush Administration announced its Clear Skies Initiative for multipollutant controls.* More...
- In 2005, a controversial cap-and-trade program for mercury was instituted. In practice, this meant a delay. *The E.P.A.'s most recent data shows that from 1999 to 2005, mercury emissions from power plants increased more than 8 percent, to 53 tons from 49 tons.* (New York Times)
- *On February 21, 2011 the US EPA issued a final regulation for emissions of mercury from coal fired power plants. This regulation sets ELVs (emission limit value) for mercury emissions for new and for existing coal fired boilers. The ELVs for the mercury concentrations emitted by new and by existing installations are set at levels of about 3 mg/Nm^3 and about 5 mg/Nm^3 respectively.* (Peeters_Weem_Reduction2011p. 9)
- *About one-third of US power generating capacity was equipped with SO_2 scrubbers in 2005.* The US EPA expects that in 2015 two-thirds of the installations will equipped with FGD. (Peeters_Weem_Reduction2011p. 6)

Updated standards

Power plants are the largest source of several harmful pollutants. They are responsible for 50 percent of mercury emissions, over 50 percent of acid gas emissions, and about 25 percent of toxic metal emissions in the United States.

- *Coal-fired power plants are responsible for 99 percent of mercury emissions and the bulk the other pollutants from the power sector.*
- *EPA expects that dozens of coal-fired plants already meet at least some part of the proposed standards, however, about 44 percent of all coal-fired plants lack advanced pollution control equipment.*

The updated standards will provide certainty and level the playing field so that all power plants will have to limit their toxic emissions – ultimately preventing 91 percent of the mercury in burned coal from being emitted into the air. The rule provides up to 4 years for facilities to meet the standards. (Fact Sheet, *Proposed Mercury and Air Toxics Standards,* (http://www.epa.gov/airquality/powerplanttoxics/pdfs/proposalfactsheet.pdf)

Conclusions

1. *The most important need is to reduce anthropogenic mercury releases to the environment, either through measures relating directly to the control of emissions, or through measures at earlier stages of the mercury cycle such as supply and use.* (Commission_staff2006, p. 16)

2. *The largest proportion of mercury emissions is released to air, much of which is subject to long distance movement. Hence, from a short term perspective*, reducing emissions is the most important means of reducing the deposition of mercury. (Commission_staff2006, p. 16)

3. Power plants are the largest source of mercury emissions to the air. Once mercury from the air reaches water, microorganisms can change it into methylmercury, a highly toxic form that builds up in fish. People are primarily exposed to mercury by eating contaminated fish. (Fact Sheet, *Proposed Mercury and Air Toxics Standards,* (http://www.epa.gov/airquality/powerplanttoxics/pdfs/proposalfactsheet.pdf)

4. *A range of widely available, technical and economically feasible practices, technologies, and compliance strategies are available to power plants to meet the emission limits, including wet and dry scrubbers, dry sorbent injection systems, activated carbon injection systems, and baghouses.* (Fact Sheet, *Proposed Mercury and Air Toxics Standards*)

5. The amount of all noxious emissions from each coal burning plant has to be controlled and published without delay. This should lead to a constant concern to reduce drastically the mercury releases during the production of electricity.

6. Each citizen has the right to clean electricity.

7. Cutting the use of mercury (e.g. in lighting) will help to reduce demand.

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3. Mercury in fluorescent lighting

Why do fluorescent lamps contain mercury?

Mercury lamps are efficient light sources, typically consuming 3-5 times less energy than incandescent (filament) lamps of comparable light output. Further, their useful life is typically 10 times the average 1000 hours lifetime of incandescent lamps (ELC2004. (Options2008, p. 27)

CFLs were first launched in the early 1980s. It was then 20 to 30 times more expensive to produce them than incandescent lamps. *They now retail for about four times the price of an incandescent lamp.* (http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=651&ArticleID=6847&l=en&t=long) or (http://www.rona.unep.org/documents/news/20101201_PR_Enlighten.pdf (Cancun, 1 December 2010))

A typical mercury lamp consists of a phosphor coated glass tube with electrodes at both ends. The tube is filled with mercury vapour that is excited to a higher electronic state when electricity is passed through the lamp. As the mercury is energized it emits ultraviolet radiation (UV), which is absorbed by the phosphor-coated glass, causing it to fluoresce and emit visible light (Kuiken 2002). According to the Illuminating Engineering Society of North America, it would be possible to produce a fluorescent lamp without mercury, but the lamp would be some 70% less efficient (Lightfair 2002). (Options2008, p. 28)

Mercury-containing lamps include primarily

- fluorescent lamps (tubes and compact fluorescent lamps (CFLs)),
- high-intensity discharge (HID) lamps
    - mercury vapour,
    - (ceramic) metal halide,
    - (most) high-pressure sodium,
    - mercury short arc,
    - mercury capillary. (UNEP_Report2008, p. 85)

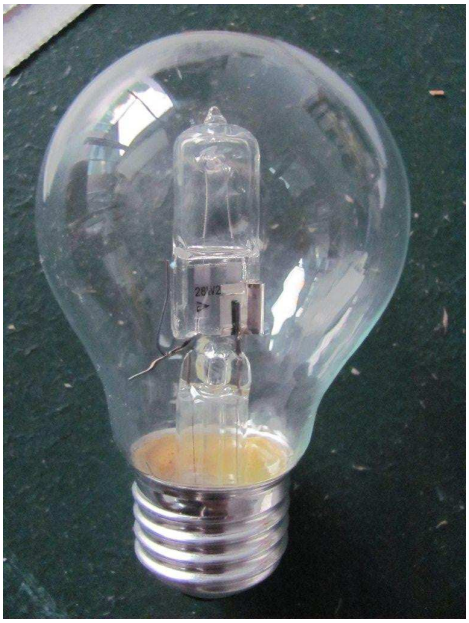
- cold cathode (ultraviolet and (some) “neon” light sources. (Options2008, p. 28)

These mercury-containing lamps are used in a wide variety of applications including: residential, commercial and industrial lighting; outdoor lighting and street lamps; automobile headlamps; and backlighting for liquid crystal displays (LCDs). (UNEP_Report2008, p. 79)

An incandescent bulb produces about 5% light and 95% heat. CFLs are said to produce 25% light and 75% heat. (http://greenwashinglamps.wordpress.com/category/cfl-analysis/)

Incandescent, compact fluorescent, and high-intensity discharge lamps

http://greencomplianceplus.markenglisharchitects.com/interviews/energy-efficient-lighting-beautiful/



Halogen EcoClassic lamp 28W of Philips

Disadvantages of compact fluorescent lamps

- *They contain mercury and therefore should be recycled and special care should be taken when cleaning up broken lamps.*
- *The life of CFLs is reduced when the lamps are subject to frequent on and off switching. GE Lighting recommends leaving CFLs on for a minimum of fifteen minutes before turning them off.*
- *Fluorescent lamps sometimes produce a light that flickers and the light quality is not suitable for all applications.*
- *Fluorescent lamps have reduced light output in cold temperatures.*
- *Many CFLs are not compatible with dimmer switches, electronic timers, photocells or motion detectors.*
- *CFLs should not be used in locations subject to vibration, high humidity or extreme temperatures.* (UNEP_Report2008, p. 81)

We can add that *one of the most common complaints of customers is premature failure after only a few hours, days, weeks or years, way short of the life rate stated on the package.* The New York Times brought attention to this problem: http://www.nytimes.com/2009/03/28/business/energy-environment/28bulbs.html?_r=1 . (http://greenwashinglamps.wordpress.com/category/cfl-analysis/)

Global mercury demand by sector by region

In 2000 (MercuryfateUNEP2008, p. 20)
Table 3.1.

Mercury use category	**EU-15 consumption (Mg)**	**US consumption (Mg)**	**Rest-of-the-world consumption (Mg)**	**Global consumption (Mg)**
Chlor-alkali industry	95	72	630	797
Small-scale gold/silver mining	0	0	650	650
Batteries	15	16	1050	1081
Dental	70	44	158	272
Measuring & control	26	35	105	166
Lighting	21	17	53	91
Electrical control & switching	25	50	79	154
Other uses	50	50	75	175
Total	**302**	**284**	**2800**	**3386**

In 2005 (UNEP_Répondre2008, p. 21)

Table 3.2.: Global consumption of mercury by region and primary use

Application	**Mercury (tonnes)**	**Region with the largest consumption**
Artisanal extraction in mining activity	825	East and South-east Asia (464)
Vinyl chloride monomer / PVC	770	East and South-east Asia (750)
Chlor-alkali plants	500	EU_25 countries (175)
Batteries	355	East and South-east Asia (240)
Dental amalgam	350	EU_25 countries (90)
Measuring and control equipment	325	East and South-east Asia (129)
Lighting	135	East and South-east Asia (47)*
Electric and electronic devises	190	East and South-east Asia and North America (60)
Other applications	310	EU_25countries (109)
Total	**3760**	**East and South-east Asia (1831)**

East and South-east Asia encompass the following countries:
Brunei Darussalam, Cambodia, China et Taiwan, Indonesia, Japan, Malaysia, Mongolia, Myanmar, Papua New Guinea, The Philippines, North Korea, South Korea, Laos, Singapore, Thailand, Vietnam.

* *In China alone, mercury used in the production of (mostly) fluorescent tubes and CFLs (compact fluorescent lamps) was estimated at 55 tonnes for 2004 (SEPA 2008), which may be an underestimate. Many of these lamps were exported.* (AMAP/UNEP, 2008. *Technical Background Report to the Global Atmospheric Mercury Assessment.* Arctic Monitoring and Assessment Programme / UNEP Chemical Branch., p. 12)

This 135 tons of mercury for lighting is divided under the following countries (only the 7 largest users are borrowed from the UNEP Report (2008). Not all figures are showed.

Table 3.3.

Country	**Estimated Mercury Demand/Quantity Used (metric tons/year)**
China	63.94 (2005)
Philippines	25.7
United States	17.6
Russia	7.5 (2001)
Japan	4.72 (2005)
Canada	1.839
Germany	1 (tubes only)

The Philippines reported a demand of 25.7 metric tons per year which was the second highest demand reported.

A 2007 study by NRDC estimated China's mercury use for lighting at 63.94 metric tons in 2005. (NRDC, 2007) (UNEP_Report2008, p. 92) (See also: In China alone, mercury used in the production of (mostly) fluorescent tubes and CFLs was estimated at 64 tonnes for 2005. Since then, the production has increased.) (UNEP_Répondre2008, p. 16 (own translation))

These 63.94 tons of mercury demand in China is divided as follows in 2005:

Table 3.4.

Name of product	**Output (100 million sets)**	**Mercury consumption (ton)**	**Average content of mercury per lamp (own calculation)**
Straight tube-type fluorescent lamp	10.56	42.24	40
Compact fluorescent lamp	17.64	14.11	8
Circle fluorescent lamp	0.56	2.24	40
High pressure mercury lamp	0.71	4.26	60
High pressure sodium lamp	0.304	0.61	20
Metal halide lamp	0.24	0.48	20
Total	**30.01**	**63.94**	**21**

Source: http://www.zeromercury.org/UNEP_developments/UNEP-Bangkok-Side-Event-November-2007.pdf

What is striking is the large amount of mercury that is needed in fluorescent tubes: 40 mg per tube! If fluorescent tubes would be banned, about 94 tons of mercury would be prohibited to flood the market. Alternatives are urgently needed.

It is generally accepted that the dispose of fluorescent tubes is performed on the right manner and that during the incineration no noxious gases can escape. This is certainly not the case with CFLs. One thinks that it is a 'green' lamp and that it can be left it in a dustbin. If one should know that this lamps contain toxic metals, it should not be purchased so easily.

While the demand for fluorescent lamps is increasing, the amount of mercury used for lamps/lighting is not increasing at the same rate. (UNEP_Report2008, p. 96)

United States Mercury Demand for Lamps/Lighting

United States Mercury Demand for Lamps/Lighting (UNEP_Report2008, p. 93)

Table 3.5.

Lamp Type	**Mercury Demand**
Fluorescent tubes	6.2 metric tons
Fluorescent compact bulbs	0.9 metric tons
High-intensity discharge lamps	1.7 metric tons
Short arc lamps	0.0018 metric tons

Lamp Type	Mercury Demand
Neon and other miscellaneous lighting	0.0227 metric tons

Hg content per fluorescent lamp

Table 3.6.: Historic mercury content of fluorescent lamps (Options2008, p. 29 (partially reproduced))

Lamp type	**Mercury content of lamp (mg Hg/item)**	**Country/-region for data**
Fluorescent (double end)	30 - 40 (1993) 15 (1997) 10 (2002) 10 - 22 23 - 46	European Union USA Canada
Compact fluorescent (CFL, single end)	5 (1997) 5 (2002)? 10	European Union Canada

Linear fluorescent lamps

A 2008 Northeast Waste Management Officials Association (NEWMOA) report states that the average mercury content of a 4 foot lamp was 8 milligrams in 2001.

A 2007 Natural Resources Defense Council (NRDC) report on the use of mercury in China's lighting industry estimated that the production of straight fluorescent tube lamps consumed an average of 40 milligrams of mercury per lamp in 2005. (NRDC, 2007) (UNEP_Report2008, p. 79)

Compact fluorescent lamps

A 2007 NRDC report on the use of mercury in China's lighting industry estimated that the production of compact fluorescent lamps consumed an average of 8 milligrams of mercury per lamp in 2005. (NRDC, 2007) (UNEP_Report2008, p. 82)

* * * * *

*The mercury content for lamps representing best available technology decreased from **about 30 mg/lamp in 1994 to about 8 mg/lamp in 2000** (ELC 2008b).* (ELC: European Lamp Companies Federation)

ELC has stated that in 2006 the "approximate volume of Hg containing lamps sold on the EU market (EU 27 and EFTA countries) by ELC Member Companies result[ed] in a**pproximately 5 tonnes of Hg**." *No details of the supporting calculation were provided, except that*

- *50% of the total was allocated to fluorescent tubes,*
- *25% to CFLs and*
- *25% to HIDs.*

According to ELC information,

- *a fluorescent tube may now be produced with less than 10 mg mercury,*

- *a CFL may have less than 5 mg, and*
- *HID lamps still have up to 30 mg on average.* (Options2008, p. 30 (emphasis added))

EU: Directive 2002/95 exempts fluorescent lamps from the requirement for substitution of mercury.

The ***directive on the restriction of hazardous substances in electrical and electronic equipment*** (2002/95/EC), in short RoHS directive, generally forbids mercury in electronic and electronic equipment with some exemptions in duly motivated cases, such as CFLs.

The mercury tolerance for Compact fluorescent lamps is currently set at 5 mg per lamp and is subjected to reviewed on a regular basis.

Note: It is scheduled to be gradually lowered to 3.5 mg in 2012 and 2.5 mg from 2013 on with some variations depending on the specific lamp type.
(http://ec.europa.eu/health/scientific_committees/opinions_layman/mercury-in-cfl/en/mercury-cfl/l-2/1-mercury-tolerance.htm#0)

Total Hg content in fluorescent lamps in the EU

Table 3.7.

EU27 consumption for mercury-containing lamps (2006) (Comext + PRODCOM data)	**Units (million)**	**Hg content (g/unit)**	**Hg content (tonnes)**
Fluorescent tubes	389	0.010	3.89
CFLs	447	0.005	2.23
HID lamps	42	0.030	1.27
Other lamps	75	0.025	1.86
TOTAL	**953**	**0.010**	**9.26**

*Considering various uncertainties in these numbers, the total mercury consumption within the EU is estimated at **8-11 tonnes in 2006**.* (Options2008, p. 31 (emphasis added))

The 2007 EU mercury consumption is for lighting is estimated at **about 11-15 tonnes**. (See Q & A in http://ec.europa.eu/environment/chemicals/mercury/index.htm)

Mercury in lamps accumulated in Europe

ELC has stated that when it made a calculation for 2006, it counted approximately 3.3 billion lamps that had been sold by its member companies installed in the EU27 and EFTA at that time.

*ELC has estimated that those lamps contain an inventory of some **25 tonnes of mercury**, which implies an average mercury content per lamp of 7-8 mg. Due to the significant decline in the mercury content of fluorescent tubes and CFLs during the last 10 years, and little or no decline in the mercury content of HIDs, ELC has estimated that*

- *60% of that Hg inventory is likely to be in fluorescent tubes,*
- *25% in CFLs*
- *and about 15% in HID lamps.*

In calculating the accumulation of mercury lamps and mercury in society, one should recall that there are significant imports to the EU other than those produced by ELC member companies. (Options2008, p. 32 (emphasis added))

Table 3.8.: Status 2006 – Accumulation of lamps and mercury in the EU (Options2008, p. 33 (table partially reproduced))

	Lamps consumed assuming 3% market growth (millions)
2002	847
2003	872
2004	898
2005	925
2006	953
Accumulated lamps 2002-2006	**4,495**
Accumulated mercury 2002-2006	**46.9**

With regard to the mercury content of these lamps, it is obvious that those lamps installed in 2002 had a higher average mercury content than those installed in 2006. The evolution of the EU mercury content is assumed to be in line with, although somewhat lower than, calculations made for the US market, where the average mercury content in 2000 was estimated at 13.34 mg, and declined to 11.5 mg by 2005. Following this reasoning, the accumulated mercury in lamps in use in the EU is likely in the range of 45-50 tonnes. (Options2008, p. 33)

Hg content of CFLs in the EU 27

In 2007, 353 million CFLs were sold in the EU27. Their content of mercury averaged 4 mg. If no CFL should be recycled, the emission of mercury to the air of these lamps should be (353 million x 0.000004 kg =) 1,412 kg! We assume that 20% of the lamps were recycled, what still leads to the amount of 1,130 kg. (SCHER (Scientific Committee on Health and Environmental Risks), *Opinion on Mercury in Certain Energy-saving Light Bulbs*, 18 May 2010)

Another rough estimate is found on the website *www.health.belgium.be*.
The expected quantity of mercury in energy-saving bulbs for domestic use can be estimated as follows: 4 mg × 200 106 households in the European Union × 20 energy-saving bulbs on average per household = 16 tons. Assuming that the average life of the energy-saving bulb is 5 years, this would result in 3.2 tons of additional mercury consumption a year (of which a part is recycled).

(http://www.health.belgium.be/eportal/Environment/Products/Electricalandelectronicequipme/energysavingbulbs/Mercuryinenergysavingbulbs/index.htm?fodnlang=en)

Summary of mercury content in lighting

	China	EU_25	North-America	Global
Consumption of mercury (2005)	1400 - 1750	420	347	3760
Consumption of mercury for lighting (2005)	60 - 70	14 11-15 (EU_27 2007)	27	135 (120-150)
Mercury consumption for CFLs	14	2.23 (EU_27 2007)	1 (U.S.) 10 ? (Canada)	*25-30*

Table 3.9. (Mercury consumption in metric tons)
(UNEP_Répondre2008, p. 4, 21-22 ; China: table p. 24; EU, table p. 26-27; US: table p. 25)

The figures concerning the US and Canada have to be taken cautiously.
The amount of global mercury consumption for CFLs is based on the assumption that 20% of total consumption for lighting purposes is needed in CFLs.

Substitutes for mercury containing lamps?

Let us first examine if substitutes exist for mercury containing lamps.

A. Alternatives for linear fluorescent lamps

- Linear LED lamps: *The linear LED lamps utilize a series of LEDs arranged in a tube, which is the same size as the equivalent linear fluorescent lamp.*

Advantages of linear LED lamps over linear fluorescent lamps.

- *They do not contain mercury and therefore do not require special end-of-life treatment.*
- *The lamps have a durable construction and do not contain fragile glass like the fluorescent lamps or fragile filaments like incandescent lamps.*
- *They can be used in cold temperatures without a decrease in light output.*
- *The light from LEDs does not flicker like the light from some fluorescent lamps.*
- *Linear LED lamps are available in a range of color temperatures, from warm white to daylight white.*
- *Manufacturers of linear LED lamps state that their products are 10-20% more efficient than equivalent fluorescent lamps and they expect the efficiency to improve significantly over the next five years.*
- *The long life of LEDs translates into a lamp life of 50,000 hours or more. The life is not shortened by frequent on-and-off switching.*

Disadvantage: high cost, e.g.: a 4-foot lamp for $92.00 (EdisonLED, 2008) (UNEP_Report2008, p. 80)

B. Alternatives for compact fluorescent lamps

1. Incandescent Lamps: *General Electric announced in February 2007 that it was developing high efficiency incandescent lamps, which would be two to four times as efficient as current incandescent bulbs. General Electric expects the new technology to be as efficient as CFLs but with a lower price. The light quality and instant-on convenience would be the same as current incandescent lamps. These high efficiency lamps would be replacements for 40 to 100 watt household incandescent lamps. They are expected to reach the market by 2010.* (UNEP_Report2008, p. 82) Meanwhile, GE has suspended the development of the high efficient incandescent (HEI) lamp.
2. Philips, Osram and other producers have developed new halogen lamps. (Philips: halogen EcoClassic, Osram: halogen Eco Classic, TDII: halogen New Generation, etc.) These lamps save up to 30% energy and are not expensive.

- *Mean life span: 2,000 hours compared with 1,000 hours of standard incandescent lamps*
- *No warm-up time*
- *Colour rendering: very good (R_a = 100)*
- *Colour temperature: approximately 2,900 K*
- *Simple operation on line voltage without a transformer*
- *Does not contain mercury or other harmful substances - can be thrown away with normal household waste.*

(http://www.produits-economiques.com/produkt.php?lang=en&pm_id=1342&cat1_name=Halogen-Glühlampen&cat2_name=Tropfenform)

(http://www.osram.com/osram_com/Professionals/General_Lighting/Halogen_lamps/Why_halogen_lamps/index.html) (R_a = color rendering index)

3. *LED Lamps*
   Light-emitting diodes (LEDs) are solid-state semiconductor devices that emit light when electricity is passed through them. This technology is now being used to produce lamps for general lighting applications, including alternatives to certain compact fluorescent lamps. The LED lamps covered in this section are alternatives to CFLs with the screw-type Edison base, in either the twist- or reflector-type configuration.

   An individual LED does not produce sufficient light for typical applications so LED lamps incorporate multiple LEDs. These LEDs produce a light that is directional, unlike compact fluorescent lamps that emit light in all directions. To achieve the desired light dispersion, LEDs are placed in specific patterns on the lamps. Some LED lamps also incorporate diffusers and lenses to disperse the light.
   Advantages:
   - *long life (50,000 hours),*
   - *warm light color similar to incandescent lamps,*
   - *low heat generation, and*
   - *the ability to work with dimming switches in certain lamps.*
   - *LED lamps are energy-efficient and*

- *have the potential to be more efficient than CFLs for some applications.*
- *They do not emit ultraviolet or infrared light.*

The disadvantages of LED lamps are that

- *they are currently expensive and available for only limited applications.*
- *Light output of the available lamps is typically low which limits the use to applications such as task lighting, accent lighting or low level ambient lighting.* (UNEP_Report2008, p. 83)

4. LED Downlight Lamps

Light-emitting diode (LED) downlights are a replacement for CFL reflector lamps used in recessed light fixtures. The LED downlights covered in this section include not only the lamp but also the recessed lighting trim. These products are intended for new construction or remodeling where new recessed light fixtures will be installed. They are compatible with standard recessed housing fixtures.

Advantages of the LED downlights include:

- *long life (50,000 hours),*
- *warm light color similar to incandescent lamps,*
- *low heat generation,*
- *and they are dimmable.*
- *LED downlights are energy-efficient,*
- *and in some cases, they consume less energy than equivalent CFL lamps.*
- *LED lamps do not emit ultraviolet or infrared light.*

LED lamps emit light in a specific direction and this directional light is well suited for downlight applications. Fluorescent and incandescent lamps are bulb shaped and emit light in all directions and, in the case of downlight applications, as much as 50 percent of the light is emitted back into the fixture and lost.

Disadvantage:

- *LED downlights are a relatively new technology and therefore prices are high and availability is limited.*
- *Another potential disadvantage is that a light failure may require the replacement of the entire unit, which is much more costly than replacing a CFL lamp.* (UNEP_Report2008, p. 84)

Conclusions

- In 2005 the lighting industry needed about 150 tonnes of mercury globally: about 65 tonnes in China, about 30 tonnes in North America and about 15 tonnes in the EU. At this moment, an alternative to linear fluorescent lamps and to High-Intensity Discharge Lamps hardly exists.
- In 2005, about 25-30 tonnes of mercury was needed to produce CFLs.

- Mercury containing compact fluorescent lamps were supported and promoted by governments in several countries, not always with much success.
- As we have already concluded earlier, a healthy environment is of paramount importance. It is outrageous to store profits using 'more efficient' (as several studies claim) fluorescent lights containing mercury and at the same time to poison the environment by the use of electricity and by the distribution of the mercury in the lamps. If politicians are so eager to reduce CO_2, then they should not use fossil fuels for the generation of electricity. Instead of taking measures at the source, i.e. in the electricity production, they prefer to intervene in the energy consumption by incandescent lamps.

The supporters of CFLs will argue that these lamp types will help to reduce the problem of mercury emission from coal fired power plants. This will be the subject of our investigation in the next chapter.

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4. Does mercury in lighting result in less mercury in the environment compared to traditional light bulbs?

A. *Study of Annette Gydesen and Dorte Maimann (1991)*

Country: Denmark

Share of coal-fired plants in electricity generation: 95%

Average mercury emission: 0.059 mg/kWh

Source: *Life Cycle Analyses of Integral Compact Fluorescent Lamps versus Incandescent Lamps, Energy and Emissions*.
(http://www.iaeel.org/iaeel/Archive/Right_Light_Proceedings/Proceedings_Body/BOK1/200/1411.PDF)

A 60W (730 lumen) incandescent lamp is compared with a 15W (900 lm) CFL. *"As the two types of lamps do not have the same luminous intensity, the energy consumption and the emissions are calculated per 10^6 lumen hours"*. (p. 3)

Table 4.1.

	Incandescent lamp 60W	**CFL 15W**
National Average Mercury Emissions in Denmark circa 1990 (mg/kWh)	0.059	0.059
Lifetime (hours)	1,000	8,000
Luminous intensity (lumen)	730	900
Energy consumption during lifetime of lamp	60 kWh	120 kWh
Number of lumen hours during one lifetime	730,000	7,200,000
Number of lamps necessary to produce 10^6 lumen hours	1.37	0.14
Energy consumption in 10^6 lumen hours	82.2 kWh	16.7 kWh

Content of mercury in the lamp	0 mg	5 mg
Mercury content in lamps per 10^6 lumen hours	0 mg	0.69 mg
Mercury emission into the air during operation per 10^6 lumen hours	4.86 mg	1.0 mg
Assumption: lamp ends up in a landfill. Emission of mercury	0 mg	0.69 mg
Total mercury emissions	**4.86 mg**	**1.69 mg**

The authors assert that in coal fired power plants, *about 60% of the mercury emission is attached to the fly ash, and is gathered with this. The rest of the mercury emission is gaseous and very difficult to purify from the air.*
The conclusion is clear: *The use of compact fluorescent lamps leads to reduced emissions of both gaseous mercury and mercury attached to the fly ash.*

Remark

- In the 1990s, Denmark was hard hit by the large amount of mercury emissions: 0.059 mg/kWh! Fortunately, in comparison with the year 1991, the share of coal in the generation of electricity is reduced to 48% (www.iea.org, CODE=DK)

Conclusion

- We can consider the difference between the total of mercury emissions of a CFL and of an incandescent lamp in the previous calculation, as a kind of litmus test. A large difference between them means that the generation of electricity is accompanied with too much emission of mercury. In that case, we ascertain that the power plants are unclean and they should be remediated without delay. If the electricity should be clean, only the CFLs should emit mercury.
- It is strange that the pro-CFL camp needs countries with a high percentage of coal fired power plants to justify the production of mercury containing CFLs.

B. *Calculation of Laurie Ramroth*

Country: United States
Share of coal-fired plants in electricity generation: 50%
Average mercury emission: 0.016 mg/kWh

The environmental impact of mercury from CFLs is compared to the impact of mercury from incandescent lamps. The following qualification is made. (Ramroth2008, p. 13)
Table 4.2.

	Incandescent lamp 100W	**CFL 23W**
National Average Mercury Emissions	0.016	0.016

(mg/kWh)		
Number of lamps used during the 10,000 hour period	10	1
Lifetime (hours)	1,000	10,000
Effective luminous efficiency (lumen)	1,600 (10 lamps)	1,600 (1 lamp)
Mercury emission into the air during operation	16 mg	4.6 mg
Content of mercury in the lamp	0 mg	5 mg
Assumption: lamp ends up in a landfill. Emission of mercury	0 mg	5 mg
Total mercury emissions	**16 mg**	**9.6 mg**

In another report, the following calculation was found.
Electrical Generation in the United States totaled 2,825,023,000,000 kilowatt hours (kwh) in 1991. The Mercury Report To Congress estimates mercury emissions from coal-fired utility boilers as 46.3 megagrams per year (Mg/yr) from 1990 through 1993. We developed an emissions factor in milligrams per kwh by dividing the 46.3 Mg/yr of emissions by the electric generation of 2,825,023,000,000 kwh, which resulted in an emissions rate of 0.016 mg/kwh. (Source: *Mercury emissions from the disposal of fluorescent lamps, final report*, Office of Solid Waste, U.S. Environmental Protection Agency, June 30, 1997, p. 2-8)

Has the emission of mercury not changed since 1993? See further.

C. *The study made by VITO*

Region: Europe-27
Share of coal-fired plants in electricity generation: 31%
Average mercury emission: 0.016 mg/kWh

The VITO-study is named: "Final Report. Lot 19: *Domestic lighting. Study for European Commission DGTREN unit D3*, October 2009".

VITO (Flemish Institute for Technological Research) was commissioned to explore the European lighting market before the regulation 244/2009[1] was proclaimed. The key argument

[1] On 18 March 2009, the Commission adopted a regulation (Commission Regulation 244/2009) on non-directional household lamps which would replace inefficient incandescent bulbs by more efficient alternatives (such as improved incandescent bulbs with halogen technology and compact fluorescent lamps) between 2009 and 2012.

used in the adoption of the alternative CFL was the calculation made by VITO on Life Cycle Cost.

The principle of Life Cycle Cost *measures the total material and energy consumption of a product from its production phase, distribution phase, use phase, end of life phase and the environmental impact of these phases.* (Excerpt of the Master thesis of Halldor Steinn Steinsen, *Architectural lighting design*, Royal Institute of Technology, Stockholm, Sweden)

On page 174 of the VITO-report, the conclusion is striking: "***Regarding environmental impacts, the CFLi is, not surprisingly, the best lamp choice and incandescent lamps the worst choice."***
Let us inspect how the authors came to that conclusion. We will limit our inquiry to three types of lamps (instead of six). (See VITO2009, p. 172).

Remark:
1. In all calculations, the assumption is made that in the EU **the generation of 1 kWh emits 0.016 mg mercury to air**. For this value, reference is made to the DG Joint Research Centre, that assumed electricity is produced from an EU fuel mix of 31% coal, 21% gas and oil, and 48% non-fossil fuels (of which 32% of nuclear). The years for which this calculation is valid, is not mentioned. (VITO2009, p. 147)
2. The assumption is made that 20% of the CFLi's (Compact Fluorescent Lamps with integrated ballast) from households are collected in the end-of-life phase. *Collected CFLi's at end of life are crushed in a closed installation and sieved. The mercury containing fraction is distillated at 600°C to separate the mercury. The pure, metallic mercury is used again by lamp industry.* (p. 134) This distillation process requires a substantial amount of energy. Is it taken into account? Is the transportation from recycling stations to the reprocessing factories and from the reprocessing factories back to the lamp factories taken in consideration? http://greenwashinglamps.wordpress.com/category/cfl-analysis/
3. Due to the electrical losses in the ballast, the 'real' electricity consumption is assumed to be 13.65 Wh/h. instead of 13W. (p. 143)

Table 4.3.: Mercury emissions to air for each base-case per lumen per hour (p. 172)

Percentage of coal in the fuel mix to produce electricity	**31%**		
Mercury emitted to air for the production of 1 kWh (mg)	**0.016 mg**		
Percentage of collected CLFi's	**20%**		
.	**clear incandescent lamp 54W**	**Frosted (or coated) incandescent lamp 54W**	**CLFi 13W**
Average wattage	54W	54W	13.65W
Lifetime (h)	1000	1000	6000

Total kWh during lifetime	54 kWh	54 kWh	81.9 kWh
Effective luminous efficiency (lm per watt)	11 lm	10.6 lm	43 lm
Mercury emitted during the use phase (mg)	0.86 mg	0.86 mg	1.31 mg
Mercury content in lamp	0	0	4 mg
Mercury emitted during the end-of-life (mg)	0	0	3,2 mg
Total mercury emission per lamp	0.86 mg	0.86 mg	4.51 mg
Mercury emitted over lifetime per lumen per hour (nanogram)	**1.45 ng**	**1.51 ng**	**1.34 ng**
Result of the calculation of the total mercury emission	**Regarding environmental impacts, the compact fluorescent lamp is the best lamp choice.**		

Conclusions of this calculation

- Despite having the same power output, the luminous efficacy of a clear incandescent lamp is higher than a frosted incandescent lamp for the same wattage. (p. 139)
- Compared to the CFLi, the 'clear' incandescent lamp emits 8% more mercury during its lifetime while the frosted incandescent emits 12% more mercury.

Discussion of the basic assumptions of this study

As we have already concluded earlier, a healthy environment is of paramount importance. Therefore, in this discussion we will not examine the luminous efficacy of compact fluorescent lamps. A healthy environment is primordial. It is outrageous to store profits using 'more efficient' (as several studies claim) fluorescent lights containing mercury and at the same time to poison the environment by the use of electricity and by the distribution of the mercury in the lamps.

It is surprising to see that the difference in the amount of mercury emissions between the three lamps, is only 12%. This means that the assumptions have to change very little to render a different solution. There are 5 assumptions:

a. In Europe, the generation of 1 kWh emits 0.016 mg of mercury to air.
   → Change it to 0.014 mg and the clear incandescent lamp is better than the CFL regarding the environmental impact of mercury
b. The mercury emission is averaged over a significant region: here Europe-27.
   → If one considers it on the level of a country with less or no coal fired power plants, one will establish that the incandescent lamps will be better.
c. 20% of the CFLi's (Compact Fluorescent Lamps with integrated ballast) from households are collected.

→ Change it to 10% and the clear incandescent lamp begins to be better than the CFL.

d. The wasted heat generated by lighting is considered as pure energy loss.
e. The lifetime of the CLF is 6000 hours while the lifetime of the incandescent lamp is only 1000 hours.
→ Change the number of hours in 5300, and the clear incandescent lamp is better.

We will complete the study and apply the VITO-calculation to the new halogen lamps. (See later on.)

a. In Europe, the generation of 1 kWh emits 0.016 mg of mercury to air

As indicated earlier, for this statement, the author refers to the DG Joint Research Centre, that assumed electricity is produced from an EU fuel mix of 31% coal, 21% gas and oil, and 48% non-fossil fuels (of which 32% of nuclear). The years for which this calculation is valid, is not mentioned. (VITO2009, p. 147)
According to my calculation for 2008, based on the website of the International Energy Agency (IEA), electricity in the EU is produced from a mix of 27.9% coal, 23.3% gas, 3.1% oil, (26.4% gas and oil) and 45.7% non-fossil fuels. (See Annex A.)

Remarks

- Thanks to the effort of the European Union, the mercury emission in fuel plants has been reduced drastically. *Emissions of mercury from coal-fired plants in Europe (total 25 EU member states) were estimated at around **29 metric tons/year** in 2005, having declined from 52 metric tons/year in 1995.* (UNEP, *Process Optimization Guidance Document for Reducing Mercury Emissions from Coal Combustion Power Plants*, Geneva, July 2010, p. 8.) (emphasis added)
  And: *While Asian emissions increased in the period 1990 to 2005, emissions in North America and Europe decreased during the same period.* (UNEP_Study2010, p. 2)
  Example: In Poland, a rapid emission decrease started around 1997. In comparison to 1995, the emission decrease in 2002 was of ca. 38%. (Urszula Lorenz, Zbigniew Grudzinski, *Mercury emission and its content in hard and brown coal*, Gospodarka Surowcami Mineralnymi, 2008).

- As was shown on p. 36, the result of the calculation by EPA in 1997 was the same emission rate as here: 0.016 mg/kWh. It would be very strange that in a country where 50% of electricity was produced by coal, the emission rate would be the same as in a region where 31% of electricity is generated by coal. (Source: *Mercury emissions from the disposal of fluorescent lamps, final report,* Office of Solid Waste, U.S. Environmental Protection Agency, June 30, 1997)
  I made the following calculation for Europe for the year 2005:

    - EU electricity demand: about 3,000 TWh (http://www.wind-energy-the-facts.org/en/scenarios-and-targets/chapter-3-contribution-of-wind-power-to-electricity-generation-and-generation-capacity-in-the-eu-27/)
    - Mercury emission from coal-fired plants: **29 tons**.
    - The resulting mercury emission rate would be 0.010 mg per kWh.
      I agree that also the mercury emission of other fuels have to be reckoned with, but the contribution is not as large as of coal.
- The E-PRTR database estimated the emissions of mercury from coal fired power plants to be **21.2 tons** in 2008 in the EU. (André Peeters Weem, *Reduction of mercury emissions from coal fired power plants*, Working Group of Strategies and Review, 48th Session, 2011, Informal document No. 3)
- If this figure of 21.2 tons is correct, we would get (with an electricity production of 3,372,565 GWh) an average for EU-27 of 0.006 mg/kWh! (See Annex A.)

So, one can assert in all probability that the value of 0.016 mg per kWh is not valid today. The consequences are huge. Change in the calculation the amount of mercury emitted to air for the production of 1 kWh (mg) into 0.013 mg and the incandescent lamps become the best choice! There are indications that this figure is even too high.

The conclusion from the technical study was obvious: *"From a life-cycle perspective, the Regulation is in any case the most eco-efficient solution. Indeed, according to the technical study ordered by the Commission to prepare for the regulation on household lamps (www.eup4light.net), even in the worst possible case that a CFL goes to the landfill, during its lifetime it will have saved more mercury emissions from electricity production in coal power plants (compared to the mercury emissions related to the conventional incandescent bulbs' electricity need) than is contained in the CFL itself, so the overall mercury pollution balance will be positive."* (http://ec.europa.eu/energy/lumen/doc/full_faq-en.pdf *Frequently asked questions on the regulation phasing out conventional incandescent bulbs*, p. 33)

After our investigation, we should read: "From a life-cycle perspective, the Regulation is in several cases a **bad** eco-efficient solution. (…) in the worst possible case that a CFL goes to the landfill, during its lifetime it will have saved **less** mercury emissions from electricity production in coal power plants than is contained in the CFL itself, so the overall mercury pollution balance **will be negative**."

It is sad to have to establish that the word 'eco-efficient' is used for a lamp that bears in it such a pollutant matter. 'Eco-efficiency' is *a strategy that calls for using fewer resources, generating less pollution and waste, and minimizing industry's adverse impacts on human health and the environment.* (http://www.mcdonough.com/writings/hope_human.htm)

Conclusions

- The whole intention of the producers of CFLs is burden the incandescent bulbs with the noxious effects of coal fired electricity production and to obscure the presence of a

pollutant in CFLs by naming it 'eco-efficient'. The production of a CFL needs more resources than the production incandescent bulbs, generates more pollution and waste and has an adverse impact on health and the environment. Coal fired power plants have a disastrous impact on environment. One cannot saddle the incandescent bulb with the noxious effects of a certain type of electricity production.

- In 2008, the average of the share of coal in the generation of electricity in EU-27 was - according to my calculations - 27.9% (See Annex A)
- The amount of emission of mercury and of other noxious substances of each power plant should be available. If the mercury emission exceeds the fixed level, the power plant has to be shut down.
- By declaring that CFLs (with a content of 4 mg mercury) have only a narrow advantage in comparison with incandescent lamps, VITO agrees that CFLs with more mercury – as earlier – have caused in the past decades serious damage to the environment. From typical amounts of 20-40 mg of mercury per lamp [20 or 30 years ago], lamps with only 3 mg of mercury are commercially available today. (UNEP2002E, p. 145) An investigation has to be performed to establish the damage through the introduction of CFLs, especially in the 1980s and 1990s.

b. The mercury emission is averaged over a significant region

The market of electricity in Europe is not yet unified. Meanwhile, a regional strategy is promoted as an interim stage towards a single electricity market in Europe. *Interconnection capacity is scarce across Europe and little progress has been made.* (Leonardo Meeus, Ronnie Belmans, *Electricity Market Integration in Europe*, University of Leuven)

Despite a 50% reduction in emissions from power plants above 50MW_{th} between 1995 and 2000, Poland still accounted for the largest proportion of such emissions (26.6%). The second biggest was Spain (14%), then Germany (13.7%), the UK (8.9%), France (5.4%) and the Czech Republic (4.5%). Together, these countries were responsible for 73% or total mercury emissions from coal combustion in power plants above 50 MW_{th}. (Commission_staff2006, p. 114)

The countries with the largest share of coal in the fuel mix for the generation of electricity in EU-27 for the year 2008 are:
Poland (91.8%), Estonia (91.2%), Czech Republic (59.6%), Greece (52.3%), Bulgaria (51.6%), Denmark (48.0%), Germany (45.6%). The amount of mercury emission depends on the measures taken to clean the exhaust fumes.

Countries where coal is less than 10% in the fuel mix for power plants are: (Information was found on the website http://www.iea.org/stats/electricitydata.asp?COUNTRY_CODE=LT for Lithuania and putting the right country code for other countries.)

- Lithuania, Latvia, Luxemburg, Malta, Cyprus: 0.0% coal used for the generation of electricity.

- Sweden and France: less than 5%.
- Belgium: 8.5% coal.

A survey of the mix of fuels for the 27 countries of the EU is given in annex A.

What will be the consequences of the distribution of CFLs in a country where no coal fired exist or that obtains its electricity entirely from renewable sources. Example of the last case: Iceland.

Table 4.4.: Mercury emissions to air for each base-case per lumen per hour in a region with no mercury emission from the production of electricity

Percentage of coal in the fuel mix to produce electricity	**0%**		
Mercury emitted to air for the production of 1 kWh (mg)	**0.000 mg**		
Percentage of collected CLFi's	**20%**		
.	**clear incandescent lamp 54W**	**Frosted (or coated) incdandescent lamp 54W**	**CLFi 13W**
Average wattage	54W	54W	13.65W
Lifetime (h)	1000	1000	6000
Total kWh during lifetime	54 kWh	54 kWh	81.9 kWh
Effective luminous efficiency (lm per watt)	11 lm	10.6 lm	43 lm
Mercury emitted during the use phase (mg)	0.00 mg	0.00 mg	0.00 mg
Mercury content in lamp	0	0	4 mg
Mercury emitted during the end-of-life (mg)	0	0	3.2 mg
Total mercury emission per lamp	0.00 mg	0.00 mg	3.2 mg
Mercury emitted over lifetime per lumen per hour (nanogram)	**0.00 ng**	**0.00 ng**	**0.95 ng**
Result of the calculation of the total mercury emission	**Regarding environmental impacts, the clear incandescent lamp is the best lamp choice.**		

Conclusions

- We ascertain that the incandescent lamps cause no emission of mercury at all, while only compact fluorescent lamps pollute the environment with their content of mercury.
- When the government regulators promote solar panels, the production of electricity cannot be clean enough. When the same regulators promote CFLs, the production of electricity must have an certain degree of pollution in order to justify the sale of these mercury containing lamps! The environment polluting power plants are an

indispensable condition to replace incandescent lamps with compact fluorescent lamps. Take the pollution away and the CFLs become obsolete.

- The here mentioned 'total mercury emission' by CFLs is not complete. Mercury has to be exploited in mercury mines and CFLs have to be produced. This will be dealt on later.
- It is unjustified to describe a CFL as a green product. Products that contain mercury don't earn that epitheton.
- It is shameful that the producers of lighting promote their mercury containing lamps even in regions or countries untarnished by coal fired power plants, e.g. Iceland, Brazil, California, Sweden, etc. The net result will be an enhanced pollution of mercury in the environment and ultimately more mercury in the blood of the inhabitants. The declared eco-friendly CFL is in fact a polluting product that endangers the environment and species.

c. 20% of the CFLi's (Compact Fluorescent Lamps with integrated ballast) from households are collected.

We establish that, if we substitute the percentage ‘20%’ with ‘0%’ (no CFLs recycled), then the incandescent bulbs are better than the CFL: the clear incandescent lamp emits 8% less mercury and the frosted lamp 4,7% less.
If only 20% of CFLs are deposed, an effective pollution of environment takes place of 3,2 mg mercury per lamp. But, according to the study, this damage is more than compensated by the lower consumption of (polluting) electricity (in comparison with incandescent bulbs)!

Why is it so difficult to collect end-of-life CLFs? There are two reasons.

a. *Luminaries and ballasts contain high amounts of aluminum, steel and copper and prices offered for these materials are quite high, giving the incentive to collect them after use; even rag-and-bone men are eager for buying scrap metals.*
   This is different for CFLi’s. Notwithstanding the fact that many components (glass, metal parts, phosphors and mercury) can be recycled, recycling doesn’t seem to be very profitable.
   As a consequence, many people don’t know what to do with their used lamps, moreover they don’t even know that CFLi’s are containing mercury. (VITO2009, p. 105)
b. Consumers are used to recycle fluorescent tubes because these don’t fit in a standard dustbin or trash can. On the other hand, incandescent bulbs are thrown away more easily. Because CFLs have the same compact volume, they are put without much questioning in a dustbin.

EU legislation to restrict the use of hazardous substances in electrical and electronic equipment and to promote the collection and recycling of such equipment has been in force since August 2004. More than four years later only about a third of electrical and electronic waste is reported to be treated in line with these laws and the other two thirds is going to

landfill and potentially to sub-standard treatment sites in or outside the European Union. (Europa Press Releases, *Environment: Commission proposes revised laws on recycling and use of hazardous substances in electrical and electronic equipment,* 2 December 2008: "Environment: Commission proposes revised laws on recycling and use of hazardous substances in electrical and electronic equipment")

Mercury control in waste incineration is thus closely related to the issue of mercury in e.g. household products and medical devices, a fraction of which may end up in waste streams. Substitution of mercury containing products or introduction of effective systems for collection and safe disposal of mercury are thus alternative measures to avoid mercury emissions from waste incineration. (UNEP_Study2010, p. 51)

Conclusions

- The government and the producers of lighting promote CFLs as a green product and warn insufficiently against the presence of mercury in these lamps. If consumers only receive the message that CFLs are in *any case the most eco-efficient solution,* they are not inclined to dispose of the CFL at end of life.
- It is not wise to put a new burden, i.e. the recycling of CFLs, to private individuals.

d. The heat generated by lighting is considered as pure energy loss.

The 'FAQ on the regulation phasing out conventional incandescent bulbs', p. 34, has a discussion of this question. (http://ec.europa.eu/energy/lumen/doc/full_faq-en.pdf)
Though it is accepted that conventional incandescent lamps emit heat, their primary purpose is lighting and not heating, therefore their design and installation make them by definition a less efficient method of heating a room than dedicated heating appliances. This means that less energy is needed for dedicated heating appliances to achieve the same temperature increase. More specifically,

- *the bulbs' location on the ceiling is inefficient,*
- *electrical heating itself is inefficient compared to other forms of heating (e.g. gas or heat pumps),*
- *the heating is unnecessary in the summer period and may even result in increased cooling needs, and*
- *not all rooms needing lighting need also heating.*

Because of all these factors, heat from lighting is considered as energy loss rather than useful energy.
However, this is an important mark of an incandescent lamp. During summer, the sun shines until the late evening in most countries of the northern hemisphere and no supplemental light is needed. During winter evenings, it is dark from 5 or 6h p.m. and the heat emission of an

incandescent lamp, together with the warm spectrum, is very welcome. The given arguments can be easily countered.

- the more the lamp is near the individual, the better it is perceptible. E.g. a desk lamp.
- it is not always cost-effective to start the heating system. E.g. during months preceding or following the winter.
- some rooms need both light and heat. It is known that only four rooms are important: the living room, the kitchen, the reception room and the study for the kids. A CFL in a cellar or a toilet is hardly efficient, in terms of cost-efficiency. In terms of pollution, it is absolutely to avoid.

Other studies are less unfavorable towards the heat replacement effect.

- Market Transformation Programme, *BNXS05: The Heat Replacement Effect*, version 9.0, 15-3-2010. If these effect is factored in, the energy savings have to be reduced with 25%, the cost savings with 8% and the CO_2 emissions with 12%.
- Letter from *Planbureau voor de Leefomgeving* to *Ministerie van Infrastructuur en Milieu* (31 May 2011) (http://www.pbl.nl/publicaties/2011/effect-van-voorgenomen-beleid-voor-verlaging-van-de-broeikasemissies-van-de-niet-ets-sectoren)
  The Ecodesign Directive is basic for the ban of incandescent lamps. Ecodesign aims at reducing the environmental impact of products, including the energy consumption throughout their entire life cycle.
  "The continued implementation of the Ecodesign Directive will lead to an increase of the efficiency of office equipment. The efficiency gain is largely the consequence of less production of 'waste heat' (printers produce heat, etc.). This reduction in 'waste heat production' in offices, leads to some increase in heat demand in these offices and therefore to more demand for gas. This results, according to the above ECN data, to an increase in emissions [of CO2] of 0.05 Megaton in 2020." (Own translation)
  ECN: Energieonderzoek Centrum Nederland (Energy research Centre Netherlands)

e. The lifetime of the CLF is 6000 hours while the lifetime of the incandescent lamp is only 1000 hours.

For incandescent lamps, the typical declared operational lifetime t_{life} is 1000h and for halogen lamps, operational lifetimes from 2000 till 5000h are declared by manufacturers. For CFLi's, different declared operational lifetimes can be found on the market: e.g. 6000, 8000, 12000 and 15000h. (VITO2009, p. 129)

According to several consumers' organizations, the tested lifetime of a lamp does not always match the promised lifetime.

We know well that Howard Brandston, an award-winning lighting designer, has stepped out of retirement and went into the debate over energy-efficient lighting. He answered the question: *Are you saying that if people like incandescents, it's the smarter choice in terms of efficiency?*

"I'm saying that in all probability, in a residential application, I think they would be more efficient. Using my home system as an example, I have literally dozens of incandescent lights in here. The quality of light in this house is superb, as one would expect from a lighting designer like me, but the interesting thing is, since I put a 1,250 square foot addition on here 12 years ago, I've been tracking the life of the lamps. And in that 12 years I've replaced 3 lamps. This is under normal residential use, and a fully occupied dwelling."
(http://green.blogs.nytimes.com/2009/04/24/a-defense-of-the-incandescent-light-bulb/)

The behavior of the consumers has not been fully recorded by the Commission. A Swedish study on user behavior in lighting by M. Bladh and H. Krantz, published in 2008, *showed that energy used for lighting is an interplay of various factors. The importance of the three most used lamps in a household is established. It also showed that people's cost consciousness in relation to lighting in very low, except for older people. The lights that are not needed are simply turned off. This possibly suggests that user behaviour is more important than previously thought.* (Excerpt of the Master thesis of Halldor Steinn Steinsen, Architectural lighting design, Royal Institute of Technology, Stockholm, Sweden)

Also, conversion to efficient lighting often leads to an increase in the use of light. To some degree, this can be a positive effect, as it can increase comfort and your well-being. But it can also lead to wasting light, such as leaving lamps on when there is no need to (e.g. when you leave the room). (http://www.greenpeace.org/usa/en/multimedia/goodies/green-guide/in-your-home/electricity-lighting/)

f. A comparison between an incandescent bulb, a new halogen lamp and a CFL

Let us make a comparison between an incandescent lamp, a new halogen lamp and a CFL.
The halogen lamp of 42W replaces an incandescent lamp of 55W.
The equivalences are:
Table 4.5.

New halogen lamp	Incandescent lamp
18W	20W
28W	35W
42W	55W
53W	70W
70W	92W
105W	135W

(http://www.osram.com/osram_com/Consumer/Home_Lighting/Halogen_lamps/Product_overview/Screw_bases/HALOGEN_ECO_CLASSIC/HALOGEN_ECO_CLASSIC_A/index.html)

Table 4.6.: A new calculation of three lamps.

Percentage of coal in the fuel mix to produce electricity	**31%**
Mercury emitted to air for the production of 1 kWh (mg)	**0.016 mg**

Percentage of collected CLFi's	**20%**		
.	**Clear incandescent lamp 54W**	**New halogen lamp 42W**	**CLFi 13W**
Average wattage	54W	42W	13.65W
Lifetime (h)	1000	2000	6000
Total kWh during lifetime	54 kWh	84 kWh	81.9 kWh
Effective luminous efficiency (lm per watt)	11 lm	15 lm	43 lm
Mercury emitted during the use phase (mg)	0.86 mg	1.34 mg	1.31 mg
Mercury content in lamp	0	0	4 mg
Mercury emitted during the end-of-life (mg)	0	0	3,2 mg
Total mercury emission per lamp	0.86 mg	1.34 mg	4.51 mg
Mercury emitted over lifetime per lumen per hour (nanogram)	**1.45 ng**	**1.07 ng**	**1.34 ng**
Result of the calculation of the total mercury emission	**Regarding environmental impacts, the new halogen lamp is the best lamp choice.**		

We ascertain that the effective luminous efficiency (lm per watt) is most favorable for the CFL (43 lm/W), followed by the halogen lamp and the incandescent lamp. But the lifetime of 6000 hours is **not** enough to recuperate the mercury in the lamp.

The supporters of the CFL will argue that a longer lifetime (e.g. 10.000 hours) and a smaller content of mercury in the lamp (e.g. 3 mg) will make the CFL competitive again. On the other hand, I assume that the amount of the emitted mercury to air from power plants is nowadays about 0.009 mg/kWh (see Annex B). So, the calculation will remain valid.

This calculation is a proof that lighting without mercury is perfectly possible and even with better results, regarding the environmental impacts. It is self-evident that the halogen technology has a much better quality of light than that of CFLs. Nevertheless, from the beginning, lighting producers have almost exclusively mobilized on the CFL technology. Politicians are also responsible for this evolution towards the misuse of mercury for lighting purposes. Alternatives without mercury were in the making: General Electric had plans to develop efficient incandescent bulbs but no time was left to the producer. Incandescent bulbs were phased out faster than the industry could deliver alternatives!

This means that the careful built construction by the EU experts to defend the CFL production is collapsing like a house of cards. Instead of the statement "***Regarding environmental impacts, the CFLi is, not surprisingly, the best lamp choice and incandescent lamps the worst choice.***", one had to write " ***Regarding environmental impacts, this halogen lamp is,***

not surprisingly, the best lamp choice followed by the CFLi and the clear incandescent lamp."

The importance of this finding can hardly be overestimated. CFLs are just needless. They are only carriers of mercury and should be prohibited at all costs. They should be banned immediately. Halogen lamps should be promoted. Incandescent lamps of low wattages should remain available. Some producers have at this moment lamps of 18W (what corresponds with an incandescent lamp of 20W). The need of incandescent lamps of 5W, 15W, 25W and 40W must be supplied.

D. *The study made by EPA*

The American Environmental Protection Agency (EPA) gives the following figures in the publication: *Frequently Asked Questions. Information on Compact Fluorescent Light Bulbs (CFLs) and Mercury*, November 2010, p. 1.

Table 4.7.: EPA calculation of mercury emission

National Average Mercury Emissions (mg/kWh)	**0.012 mg**	
Light Bulb Type	**Incandescent**	**CFL**
Watts	60W	13W
Lifetime	1000 h	8000 h
Hours of Use	8000 h (1000 h x 8)	8000 h
kWh Use	480 kWh	104 kWh
Mercury from Electricity Use (mg)	5.5 mg	1.2 mg
Mercury From Landfilling (mg)	0	0.44 mg
Total Mercury (mg)	5.5 mg	1.6 mg
Result of this calculation concerning mercury emission	**Regarding environmental impacts, the compact fluorescent lamp is the best lamp choice.**	

Discussion

- The same number can be found on the website *popularmechanics.com* (http://www.popularmechanics.com/home/reviews/news/4217864). *In 2006, coal-fired power plants produced 1,971 billion kilowatt hours (kwh) of electricity, emitting 50.7 tons of mercury into the air. (…) Approximately 0.0234 mg of mercury – plus carbon dioxide, sulfur dioxide and nitrogen oxide – releases into the air per kwh of electricity that a coal-fired power plant generates.* Because about 50% of the electricity in the U.S. is from coal, the average mercury emission, according to the mentioned calculation, is about 0.012 mg per kWh. This contrasts with the calculation of 1997

(on p. 36), where found an amount of 0.016 mg/kWh. (Report *Mercury emissions from the disposal of fluorescent lamps, final report,* Office of Solid Waste, U.S. Environmental Protection Agency, June 30, 1997, p. 2-8.)

- As yet indicated, I made a calculation based on the data of "Dirty Kilowatts" of the Environmental Integrity Project (EIF). For the year 2008, I have calculated a mercury emission of about 0.009 mg/kWh. (See Annex B)
- The average amount of mercury in a CFL is about 4 mg. How came EPA to the amount of only 0.44 mg for a CFL that ends up in a landfill?
  EPA: *Most mercury vapor inside fluorescent light bulbs becomes bound to the inside of the light bulb as it is used. EPA estimates that the rest of the mercury within a CFL – about 11 percent – is released into air or water when it is sent to a landfill, assuming the light bulb is broken.*

  Therefore, only (4 mg x 11% =) 0.44 mg mercury remains! As if by magic, 89% of the mercury content has disappeared! The argumentation proceeds. *Therefore, if all 272 million CFLs sold in 2009 were sent to a landfill (versus recycled, as a worst case) – they would add 0.12 metric tons, or 0.12 percent, to U.S. mercury emissions caused by humans.*
  However, not all authorities agree with this view.
  - *Also, electricity generation emits mercury in metallic form and in low concentration because dissipated over a large area. Metallic mercury doesn't easily become part of the food chain. However, when a CFL bulb breaks in a landfill, there is much less dissipation and bacteria convert metallic mercury into methyl-mercury which is 100 times more soluble in fat.* (Commission Staff Working Document, *Accompanying document to the Commission Regulation implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirement for non-directional household lamps,* 18-3-2009, p.79)
  - Ramroth writes: *Recycling one CFL prevents 5 mg of mercury from entering the environment and reduces the amount of virgin material extracted for a new lamp.* (Ramroth2008, p. 18) And it is known that not all bulbs on a landfill have reached the provided end of life. E.g.: If the ballast is malfunctioning, the mercury is not bounded.
  - *EU legislation to restrict the use of hazardous substances in electrical and electronic equipment and to promote the collection and recycling of such equipment has been in force since August 2004. More than four years later only about a third of electrical and electronic waste is reported to be treated in line with these laws and the other two thirds is going to landfill and potentially to sub-standard treatment sites in or outside the European Union. Apart from losing out on valuable secondary raw materials, this is especially worrisome since inadequately treated products pose major environmental and health risks.* (Europa Press Releases, *Environment: Commission proposes revised laws on recycling and use of hazardous substances in electrical and electronic equipment,* 2

December 2008: “Environment: Commission proposes revised laws on recycling and use of hazardous substances in electrical and electronic equipment”)

- *Approximately 620 million fluorescent bulbs are discarded yearly. Despite the existence of recycling programs, it is estimated that only about 20% of discarded bulbs are recycled nationally. It is probable that most of the bulbs that are not recycled are broken during disposal. Extrapolation of the results of this study suggests that discarded fluorescent bulbs release approximately 2 to 4 tons/year of mercury in the U.S.* (Release_merc2004, p. 3)
- *Dr Michelle Bloor, of Ports mouth University, said: “If thousands of CFL bulbs were sent to landfill this could pose a problem. Mercury could leak and get into the food chain.”* (http://www.express.co.uk/posts/view/89185)

Control of emission of mercury in the U.S.

- *EPA also concluded that the use of available pollution controls aimed at reducing soot and smog pollution could reduce mercury by 70 percent, to 15 tons per year, and that even stricter cleanup requirements could reduce mercury by 90 percent, to 5 tons per year. The bottom line: Power plant mercury emissions remain unnecessarily high; emissions are significantly higher than the levels that would be achieved if power plants were required to install currently available pollution control technology like bag-houses, scrubbers, and sorbent controls.* (Environmental Integrity Project, *Dirty Kilowatts. America’s Top Fifty Power Plant Mercury Polluters*, March 2010. http://www.environmentalintegrity.org/news_reports/documents/DirtyKilowatts-Top50MercuryPowerPlantReport.pdf)
- Texas is the state with the largest mercury emission. (Environmental Integrity Project, Dirty Kilowatts. America’s Top Fifty Power Plant Mercury Polluters, March 2010.) *“Texas harbors five of the 10 largest power plant mercury air pollution sites in the U.S. Glen Hooks, regional director, Sierra Club Beyond Coal Campaign said:* "Texans and other Americans do not need to live with the dangerous risks posed by mercury pollution from power plants. Pollution controls that dramatically reduce mercury emissions are widely available, and are already being used at many power plants. But, until the public and policymakers hold the electric power industry to its promises to shut down or clean up the nation's oldest and dirtiest plants, Americans will continue to bear unnecessary health and environmental costs."” (http://www.environmentalintegrity.org/news_reports/news_03_17_10.php , where you can find the full Environmental Integrity Project report.)
- In the United States, the website http://www.epa.gov/cleanenergy/energy-and-you/how-clean.html gives information on the share of coal in the generation of electricity for each region.

Conclusions

- *For all existing and new coal-fired EGUs* [electric utility steam generating units], *the proposed standards would establish numerical emission limits for mercury, PM*

[particulate matter] *(a surrogate for toxic non-mercury metals), and HCl (a surrogate for toxic acid gases).* (Fact Sheet, *Proposed Mercury and Air Toxics Standards*)

- The removing from fly ashes and the cleaning in the exhaust pipe of the emitted gasses are highly important as well. The fixing of ELVs (emission limit values) for mercury emissions will guarantee a more healthy solution.
- Coal fired power plants emitting mercury must be remediated or closed. This can certainly never imply a permit to the production of mercury containing lamps.

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5. UNEP and EU intertwined with private interests

A. The sake of the en.lighten initiative

It was very inconvenient to me to learn how intensely the United Nations Environment Program (UNEP) was intertwined with private companies. The *en.lighten initiative* has been established to promote, accelerate and coordinate global efforts to push for efficient lighting. It is a GEF (Global Environment Facility) Earth Fund (Public Private Partnership) initiative implemented by UNEP in partnership with Philips Lighting and OSRAM AG. (http://www.enlighten-initiative.org/)

The first US$30 million operational Platform was approved by the Council in May 2008, and is currently being managed by the IFC. A second US$5 million Platform proposal, "Global Market Transformation for Efficient Lighting," to be managed by UNEP, was submitted for Council approval in May 2009. Other Platform proposals are currently being prepared for submission to the Council for approval during 2009, which will complete the initial funding allocation of US$50 million. (http://www.thegef.org/gef/node/1293)
IFC: International Finance Corporation (World Bank Group)

Monique Barbut, CEO and Chairperson of the Global Environment Facility*: "En.lighten is the latest initiative funded by the GEF in partnership with UNEP and leading global lighting manufacturers to accelerate market transformation of efficient lighting technologies on a global scale. Through this initiative, we hope to build a strong partnership with the private sector to encourage innovation and to help those who need our help the most build brighter futures today and for the next generation."*

1. The assessments analyze the benefits of shifting the obsolete incandescent lamp technology to compact fluorescent lamps (CFLs).
(http://www.rona.unep.org/documents/news/20101201_PR_Enlighten.pdf)

To endorse their mission, en.lighten writes: *Shifting to efficient lighting technologies would cut the world share of electricity used for lighting from 19 to 7%. This would save enough electricity to close 705 of the world's 2 670 coal-fired plants. (…) Few actions can cut carbon emissions more easily than the phase-out of inefficient lighting, making it one of the most effective and economically advantageous means to combat climate change.* (http://www.enlighten-initiative.org/)

- They say that diminishing the world share of electricity for lighting with 12%, would save enough electricity to close 26,4% of the coal-fired plants! This is only a mask to veil their argument that a certain amount of coal fired power plants is needed to make CFLs more cost-effective in comparison with incandescent bulbs. Meanwhile, more coal fired power plants are in the make!
- The EU-27 electricity consumption in 2007 of non-directional light sources in all sectors was about 112.5 TWh (VITO 2009). This is approximately 4 % of the EU-27 total electricity consumption with 2.95% being used by the domestic sector and 1.05% in the non-domestic sector. (SCHER (Scientific Committee on Health and Environmental Risks), *Opinion on Mercury in Certain Energy-saving Light Bulbs*, 18 May 2010)
- When large power plants are responsible for 27% of mercury emission in the air (Commission_staff2006, p. 93), then one need to act on the production side and not on the consumption side. The problem with mercury cannot be resolved through more mercury.
- One knows that in the U.S., only 3.6% of total energy is consumed by incandescent lamps. (Source of the figure '3.6': Howard Brandston, March 11, 2011 http://smart-grid.tmcnet.com/news/2011/03/11/5371427.htm)

Let us retrieve the reasoning in the webpage of UNEP. See: http://www.rona.unep.org/documents/news/20101201_PR_Enlighten.pdf (Cancun, 1 December 2010)

It is clear that the producers of CFLs see an enormous market for their lamps over the whole world. They managed to acquire the support of UNEP to execute their plans. This means that a public organization is used by private companies! Their profits will be enlarged through their action in the so called '100 countries'.

The main arguments are:
- you can save billion dollars a year by switching to energy-saving bulbs;
- you can cut greenhouse gas emissions by several tonnes of CO_2 annually.

What do they mean with 'energy saving bulbs'? The answer is given: "*The initiative, which today launched detailed market assessments of the environmental and economic potential of a switch to efficient lighting in 100 countries, is supported by the Global Environment Facility*

under its Earth Fund. The assessments analyze the benefits of shifting the obsolete incandescent lamp technology to compact fluorescent lamps (CFLs)."

To which countries do the advocates of CFLs refer? The countries who generate electricity with fossil fuel could reduce their emission of CO_2. The other countries could at least save money.
Examples given in the article:

- Indonesia: (41% coal, 29% oil, 17% gas) could save $*1 billion a year and cut its greenhouse gas emissions by eight million tonnes of CO_2 annually.*
- South Africa: (93% coal) *might save US$280 million a year and* cut its greenhouse gas emissions by two and a half million tonnes of CO_2 annually.
- Mexico: (8% coal, 19% oil, 50.6% gas) *would save US$900 million, reducing 5 million tonnes of CO_2 emissions a year.*
- Brazil: (3% coal, 4% oil, 6% gas, 80% hydro power) *will save US$2 billion a year and 4 million tonnes of CO_2.* How can they save so much CO_2 when 80% of electricity is generated by hydropower? It is a shame that in a country with clean energy, mercury containing bulbs will be distributed. The net result will be an enhanced pollution of mercury in the environment and ultimately more mercury in the blood of the inhabitants.
- Ukraine: (36% coal, 12% gas and oil, 47% nuclear) *the cost savings could be US$210 million per annum with greenhouse gas reductions of 2 million tonnes of CO_2 a year.*

That the CFLs contain mercury is described in the article, but rather concise: *"But some critics have pointed to the health hazardous mercury, used in CFLs, as an issue that raises a question mark over the technology's environmental credentials."*
What is the answer of UNEP?
(http://www.rona.unep.org/documents/news/20101201_PR_Enlighten.pdf (Cancun, 1 December 2010))

1. *Like all fluorescent lamps, CFLs contain mercury, which complicates their disposal. Mercury is a hazardous substance in fluorescent lamps.*
   - *The average mercury content in a CFL bulb is about 3 milligrams - roughly the amount it would take to cover the tip of a ball-point pen. By comparison, older thermometers contain 500 milligrams of mercury - the equivalent of more than 100 CFLs.*
   - *Experts emphasize that mercury is also emitted from coal-fired power stations. Studies indicate that the level of emissions from power stations linked with lighting the world's old bulbs are far higher than those linked with the disposal of energy efficient bulbs.*
   - *Some manufacturers have voluntarily reduced the mercury content in CFLs by about 80 per cent in the past decade, to as little as 2 mg per bulb. Research is ongoing to achieve further mercury reductions.*
2. *Take-back schemes and the safe disposal of CFLs.*

3. *Meanwhile, other mercury-free technologies are also being promoted including Light Emitting Diodes (LEDs).*
4. *Nevertheless given that the main source of new mercury emissions world-wide is from the burning of coal, estimates indicate that overall it is far more environmentally-friendly to switch from old bulbs to new ones.*
5. *The world needs quick wins to show that climate change can be controlled. A global transition to efficient lighting is perhaps the easiest method. If achieved swiftly, this victory would generate the momentum needed to achieve greater CO_2 reductions in other sectors and assist towards stabilizing the climate below 2 degrees.*

Discussion

1. They argue that mercury is *also emitted from coal-fired power stations* (item 1). So, if others drown their selves, why not us? We ascertain again that there is no motive in their reasoning to reduce the mercury emission by power plants so that mercury containing lamps will become obsolete. They only repeat that, due to the fact that most power plants emit mercury, we, from our side, can take advantage of this abuse. The producers of lamps can make profits and the consumers can reduce their electricity bill. So, money is more valuable than the environment.

2. "*The level of emissions from power stations linked with lighting the world's old bulbs are far higher than those linked with the disposal of energy efficient bulbs."* We have seen that the new halogen lamp is more eco-efficient than the CFL. We have to generate a world with no mercury emission and with no need of a disposal unit for bulbs. The use of CFLs stand in the way of this ambition.

3. "*Some manufacturers have voluntarily reduced the mercury content in CFLs by about 80 per cent in the past decade, to as little as 2 mg per bulb."* But the mercury is still present and has to be avoided with all means. And if today, 2 mg per bulb is the standard, then they admit that in previous years the mercury content was much too high, and consequently, with damaging consequences to the environment. The question is, who will pick up the check?

4. Only at the end of the reasoning, when no other argument can be given, they producers of lighting refer to LEDs, a mercury free alternative.

5. "*The world needs quick wins to show that climate change can be controlled."* Why do they support the thesis of a manmade global warming? Why are they advocates of a significant CO_2 reduction? Because they want to sell their mercury containing bulbs and the CO_2 reduction is a welcome opportunity. It is known that the avoidance of pollution is of paramount importance. CO_2 is not a pollutant. Particulate matter, NO_x, SO_2, mercury, phosphor, and other toxic metals are pollutants and must be avoided as much as possible. The quick wins will only come if the electricity by power plants will be clean.

2. In parallel to the assessment work, en.lighten is convening experts from over 30 developing and developed countries and various sectors, including; governments, civil society and private sector, to develop a draft road-map for the global phase-out of inefficient lighting.

UNEP expects the draft road map to be tabled for global consultation in the second half of 2011. (…) Efficient lighting systems is one path that is literally available at the flip of a policy switch". (http://www.rona.unep.org/documents/news/20101201_PR_Enlighten.pdf (Cancun, 1 December 2010))

Definitely, imagine that all incandescent would be banned all over the world! It would mean a billion-dollar turnover for the lighting producers! And what is the final justifying step according to the producers of CFLs? The mercury emission through coal fired power plants is worldwide already so high that the production of a more mercury intended for lamps, will reduce even their emission! This is just the way we should keep off!

We have proven that not CFLs but the new halogen lamps are the best choice. Also, we have to take into account that the used figures of the average amount of mercury emission through generation of electricity by coal, are overestimated. With a clean energy, only CFLs become obsolete.

We have to react with all means against the demolition of our right on quality concerning lighting. Howard M. Brandston gives the right significance of a possible energy reduction through the use of CFLs.

Will some energy be saved? Probably. The problem is this benefit will be more than offset by rampant dissatisfaction with lighting. We are not talking about giving up a small luxury for the greater good. We are talking about compromising light. Light is fundamental. And light is obviously for people, not buildings. The primary objective in the design of any space is to make it comfortable and habitable. This is most critical in homes, where this law will impact our lives the most. And yet while energy conservation, a worthy cause, has strong advocacy in public policy, good lighting has very little.
(http://online.wsj.com/article/SB10001424052970203706604574377171050647330.html)

I found this a remarkable description of the good old incandescent bulb.

But, having said all this, if I were forced to choose the best lighting for residential overall, it would have to be incandescent. I feel that we as humans have a deep connection to flame for many thousands of years. It's almost like it's in our DNA. It's interesting that as time moves on, people are still drawn to sitting around the camp fire, a fireplace, even a barbecue. Think of Yule log. It's just that this particular quality of light is ingrained in us. You can even get a screen saver of log flames.
Incandescents with their glowing filaments are a form of flame and are thus an extension of this inborn affinity that we have for fire.
(http://greencomplianceplus.markenglisharchitects.com/interviews/energy-efficient-lighting-beautiful/
)

B. The ban of incandescent bulbs in the U.S.

Congress, by setting new, elevated lighting efficiency (lumens-per-watt) requirements in 2007's EISA *legislation, has basically banned the incandescent lamp (as we have known it for decades). Sales of lamps that don't meet the LPW minimums will stop (on a schedule) in the 2012-2014 period.* (http://www.tedmag.com/news/news-room/special-report/Special-Report/Special-Report--6-4-2009.aspx)
(EISA: Energy Independence and Security Act)

C. The ban of incandescent bulbs in the E.U.

On 18 March 2009, the Commission adopted a regulation (Commission Regulation 244/2009) on non-directional household lamps which would replace inefficient incandescent bulbs by more efficient alternatives (such as improved incandescent bulbs with halogen technology and compact fluorescent lamps) between 2009 and 2012.
The request to phase out conventional incandescent bulbs was made by the European Council in 2007 and further reinforced by the European Parliament and by the Council of Energy Ministers in 2008. (*Frequently asked questions on the regulation phasing out conventional incandescent bulbs,* p. 10)
100W clear conventional incandescent bulbs started to be phased out at the same time as all frosted bulbs, in September 2009. Only the lower wattage clear bulbs were spared momentarily, with the 75W banned in 2010, the 60W in 2011, and the 40W and less in 2012. (p. 9)
The decision process in the EU is too much intertwined with private interests. Most private companies prepare a well founded file to support their aims. Lighting companies not only have succeeded to force a positive decision to trade their mercury containing lamps, they obtained to let ban the incandescent bulbs as well!
This was not the first blunder of the EU. I mention here also the obligation to use biofuels in cars. One of the consequences is a rise of food prices, with all the disastrous effects linked with it. *European companies are frequent land grabbers, seeing a large guaranteed market back home as European Union regulations now require biofuels to be blended with fuel sold at forecourt pumps.* (International Federation of Red Cross and Red Crescent Societies, *World Disasters Report*, 2011, p. 110) The first aim was to reduce the emission of CO_2 but most reports deny that this will be the case.

Conclusions

- We conclude that the partnership from two lighting companies with UNEP must be stopped immediately. The interests of Philips and Osram companies are to make more profit replacing cheap incandescent lights with more expensive CFLs. It was remarkable that right on the last day the lamps of 60W were tolerated in Europe (31 August 2011), the price of CFLs rose with about 25% (the increase in price earlier this

year included) (De Standaard, 1 September 2011 (Belgium)). It is a shame that a public organization not only allows but also supports the two companies in their performance to spread mercury containing bulbs over the whole world. I thought that UNEP had the aim to reduce mercury emissions in our environment but I was naïve.

- The lobby of the private industry in the decision making in the EU must be restrained.
- The EU has to withdraw the ban of incandescent bulbs immediately. This will lead to a more competitive lighting market. The trade of CFLs has to be stopped because of the content of mercury in these lamps.

6. Health problems during production phase, use and disposal of fluorescent lighting

A. Problems with the production of CFLs in China

China is a leading manufacturer of mercury-containing lamps and reported the highest use of mercury for lighting. In 2005, it produced more than 30 billion units using nearly 64 metric tons of mercury. Eighty-percent of the manufacturers of fluorescent lamps in China use liquid mercury in the manufacturing process (drip method). The production of lamps using liquid mercury results in a significantly higher use of mercury than methods using mercury pellets or amalgam. Upgrading the manufacturing facilities with systems using less mercury per lamp and releasing less mercury to the environment will require a significant investment. Higher mercury prices and mercury content limits set by the RoHS Directive[2] have reportedly motivated manufacturers to reduce mercury use in recent years. (NRDC, 2007)
(UNEP_Report2008, p. 96)
'Drip filling' is a cheap but inaccurate method of mercury filling *that seems to be very common in most small far eastern production plants.* (VITO2009, p. 123)

Extracts of the article of The Times on line dated May 3, 2009:
(http://www.timesonline.co.uk/tol/news/world/asia/article6211261.ece)
Large numbers of Chinese workers have been poisoned by mercury, which forms part of the compact fluorescent lightbulbs. A surge in foreign demand, set off by a European Union directive making these bulbs compulsory within three years, has also led to the reopening of mercury mines that have ruined the environment.

[2] RoHS: The directive on the Restriction of Hazardous Substances in electrical and electronic equipment (2002/95/EC)

The government shut all the big mercury mining operations in the region in recent years in response to a fall in global mercury prices and concern over dead rivers, poisoned fields and ailing inhabitants.

But The Sunday Times found that in this remote corner of a poverty-stricken province, the European demand for mercury had brought the miners back.

In one case, Foshan city officials intervened to order medical tests on workers at the Nanhai Feiyang lighting factory after receiving a petition alleging dangerous conditions, according to a report in the Nanfang Daily newspaper. The tests found 68 out of 72 workers were so badly poisoned they required hospitalisation.

A specialist medical journal, published by the health ministry, describes another compact fluorescent lightbulb factory in Jinzhou, in central China, where 121 out of 123 employees had excessive mercury levels. One man's level was 150 times the accepted standard.

It also reported a survey of 18 lightbulb factories near Shanghai, which found that exposure levels to mercury were higher for workers making the new compact fluorescent lightbulbs than for other lights containing the metal.

Reaction of E.U.

The European Environmental Bureau is involved in the RoHS exemption process. They have considered the whole life cycle of lamps and support a 2 mg target for mercury content. The issue of waste is also critical and in relation to this, they are particularly concerned by a production process involving the dripping procedure with high mercury losses. (Commission Staff Working Document, *Accompanying document to the Commission Regulation implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirement for non-directional household lamps*, 18-3-2009, p.79)
(RoHS directive: directive on the restriction of hazardous substances in electrical and electronic equipment (2002/95/EC))

The VITO (2009) report is unclear about the inclusion of possible Hg release during the production phase of the lamps in the assessment. Considering the industrial and local nature of lamp production, the SCHER assumes that these potential Hg emissions will be strictly controlled and managed. (SCHER (Scientific Committee on Health and Environmental Risks), *Opinion on Mercury in Certain Energy-saving Light Bulbs*, 18 May 2010, p. 12)

The only suitable reaction of the politicians should be to stop immediately all import of CFLs from China and to lift the ban on incandescent lamps!

Movement of jobs in the U.S.

http://en.wikipedia.org/wiki/Phase-out_of_incandescent_light_bulbs : *General Electric closed their incandescent light bulb factory in Winchester, Virginia, while the CFL bulb market share is dominated by Chinese manufacturers. Ironically, the increase in demand for Chinese CFLs has driven an expansion in the number of facilities manufacturing the bulbs, which in turn has spurred an increase in the construction of coal-fired power plants in China, to*

supply power to the additional factories. Reduction in atmospheric mercury and greenhouse gases in some parts of the world are therefore being offset to some extent by increases in these emissions from the additional Chinese plants.

B. Research is performing to assess whether the symptoms of some diseases could be aggravated by energy saving lamps.

Some of these questions have to scrutinized further. Not all medical effects of CFLs are treated here.

- Today's conventional CFLs have a high proportion of blue in their spectrum, in comparison with incandescent lamps. This blue light is a trigger for the body clock during the day. If the blue is present during the night, this is a wrong signal to the body clock. Disturbances of the body clock lead to disturbances of the body. We know that it has an impact on cancer, but also to heart attack, depression and other diseases. (http://www.diagnose-funk.org/technik/energiesparlampen/report-forscher-warnen-vor-eu-gluehlampenverbot.php)
  Most of the research evidence concerning adverse effects of lighting on human health concerns circadian rhythm disruptions and breast cancer. The blue portion of the spectrum is known to interfere most strongly with the human endocrine system mediated by photoperiod, leading to reduction in the production of melatonin, a hormone shown to suppress breast cancer growth and development. (http://docs.darksky.org/Reports/IDA-Blue-Rich-Light-White-Paper.pdf)

- Do single-envelope compact fluorescent lamps emit UVB and traces of UVC radiation? Can blue and ultraviolet radiation be identified as *"as a potential risk factor for the aggravation of the light-sensitive symptoms in some patients with such diseases as chronic actinic dermatitis and solar urticaria"*. These questions have to be scrutinized further.
  (http://ec.europa.eu/health/scientific_committees/consultations/public_consultations/scenihr_consultation_14_en.htm)

- *Do people who suffer from Lupus report a flare-up of their condition through CFLs? In certain cases, they are housebound because they cannot be exposed to light. Dr Robert Sarkany, consultant dermatologist at Kings College London, said: "Reactions to fluorescent lights are not well understood. But I am seeing regular handfuls of patients who are complaining of skin allergies when exposed to them, as are my colleagues.* (http://www.express.co.uk/posts/view/89185)

C. Mercury vapours spread in the air from broken CFLs

A safe precautionary measure is not to use CFLs or fluorescent tubes in the vicinity of children. See also: http://www.wnd.com/index.php?fa=PAGE.view&pageId=72133 (Study of Maine Department of Environmental Protection).

Which steps are to be taken to reduce exposure to mercury vapor from a broken bulb?

1. US (EPA)

On average, a compact fluorescent bulb has somewhere between 2.3 milligrams and 5 milligrams of mercury inside. That probably sounds like a lot, considering it's about 500 times the maximum ingestion amount recommended by the U.S. Environmental Protection Agency (EPA). But here's the thing: By running a CFL, you're not ingesting any mercury at all. The only time you even have a chance of inhaling the mercury vapor in a CFL is if it breaks, and even then, your risk is very limited. If you clean it up thoroughly and quickly (with a broom, not a vacuum, since vacuums can expel it into the air), seal all the debris in a plastic bag, and dispose of it at an approved site (see sidebar), there's barely any risk at all of inhaling a damaging dose of mercury.
http://science.howstuffworks.com/environmental/green-science/cfl-mercury2.htm

1. Before cleanup
a. Have people and pets leave the room.
b. Air out the room for 5-10 minutes by opening a window or door to the outdoor environment.
c. Shut off the central forced air heating/air conditioning system, if you have one.
d. Collect materials needed to clean up broken bulb.
2. During cleanup
a. Be thorough in collecting broken glass and visible powder.
b. Place cleanup materials in a sealable container.
3. After cleanup
a. Promptly place all bulb debris and cleanup materials outdoors in a trash container or protected area until materials can be disposed of properly. Avoid leaving any bulb fragments or cleanup materials indoors.
b. If practical, continue to air out the room where the bulb was broken and leave the heating/air conditioning system shut off for several hours.

Vacuuming of carpeting or rugs during cleanup is not recommended unless broken glass remains after all other cleanup steps have been taken. [NOTE: It is possible that vacuuming could spread mercury-containing powder or mercury vapor, although available information on this problem is limited.]
(http://www.epa.gov/cfl/cflcleanup.pdf)

A video of the Foxnews gives the following advice.
(http://video.foxnews.com/v/3939582/save-the-light-bulb)
How to clean up your fluorescent bulbs if they break?
1. Before clean-up, air the room
2. Have people and pets leave the room
3. Shut off central air heating/air conditioning system

4. Carefully scoop up glass pieces & powder using stiff paper or cardboard and place them in a glass jar with metal lid
5. Use tape to pick up any remaining small glass fragments
6. Wipe the area clean with damp paper towels
7. Place towels in the glass jar
8. Immediately place all clean-up materials outdoors in a trash container
9. Wash your hands after disposing of the jars containing clean-up materials.

2. United Kingdom
(http://www.hpa.org.uk/web/HPAweb&HPAwebStandard/HPAweb_C/1207293983993)

1. *Take care to prevent injury from broken glass.*
2. *Vacate the room and keep children and pets out of the affected area. Shut off central air conditioning system, if you have one.*
3. *Ventilate the room by opening the windows for at least 15 minutes before clean up.*
4. *Do not use a vacuum cleaner, but clean up using rubber gloves and aim to avoid creating and inhaling airborne dust as much as possible.*
5. *On hard surfaces sweep up all particles and glass fragments with stiff cardboard and place everything, including the cardboard, in a plastic bag. Wipe the area with a damp cloth and then add that to the bag. Household cleaning products should be avoided during clean up despite the very small amount of mercury involved. See the next section for cleaning carpeted surfaces.*
6. *Use sticky tape to pick up small residual CFL pieces or powder from soft furnishings and then add that to the bag.*
7. *The plastic bag should be reasonably sturdy and needs to be sealed, but it does not need to be air tight. The sealed plastic bag should be double-bagged to minimise cuts from broken glass.*

The bags can then be discarded through your local council.

3. The European Union

SCHER, The Scientific Committee on Health and Environmental Risks, gives the following assessment of the risks of a broken CFL.

- *When the tube of a fluorescent light bulb breaks, the mercury vapour inside is released into the air. In an average room, the amount of vapour could briefly be well above the limits allowed in the general environment, and could exceed the levels allowed in the workplace. However, these limits are designed to protect adults who are exposed to such levels regularly during a 40-year work life, so they are not applicable for a very short-term exposure.*
- *Most of the mercury released from the CFL turns liquid very quickly so, shortly after the breakage, the level of mercury vapour becomes too low to cause any harm to adults, even those who are particularly sensitive.*

- *Children breathe in more air in proportion to their size than adults and tend to be more active, so children could be exposed to comparatively higher levels of mercury than adults.*
- *The spilt mercury that has turned to liquid can stick to surfaces and dust, particularly if the room is not aired sufficiently or cleaned up thoroughly. This is particularly relevant for young children because they bring their fingers and objects to their mouth and may thus swallow contaminated dust.*
- *At present there are no estimates on the amount of mercury that children are likely to swallow after a lamp has broken and the SCHER recommends that this research be carried out and that customers be given instructions on how to deal with a CFL breakage.* (www.greenfacts.org: *Mercury in Compact Fluorescent Lamps, Level 2 - Details on Mercury in Compact Fluorescent Lamps*)
  SCHER: Scientific Committee on Health and Environmental Risks "Opinion on Mercury in Certain Energy-saving Light Bulbs".

In addition, the Commission asked the Scientific Committee on Health and Environmental Risks (SCHER) for an opinion on mercury in certain energy-saving light bulbs. The SCHER concluded that compact fluorescent lamps (CFLs) offer a net, although limited, decrease in total mercury emissions from the lamps and from coal-fired power plants providing electricity for lighting as compared with the other light bulbs considered. The SCHER was also of the opinion that a human health risk for adults due to breakage of such lamps was unlikely. <u>For children SCHER could not conclude on the risk, since data on exposure are missing</u>.
("*Communication from the Commission to the European Parliament and the Council on the review of the Community Strategy Concerning Mercury*, 7 December 2010", emphasis added)

The external peak exposure to Hg^0 by inhalation in adults after a CFL breakage is not translated into a sharp peak exposure of the foetus. Transfer of Hg^0 from the maternal circulation to the foetus is limited. Therefore, foetal exposure is expected to be negligible.
(http://ec.europa.eu/health/scientific_committees/environmental_risks/docs/scher_o_124.pdf)

4. Belgium

- Doctor Geert Verstegen (Poisons Advice Centre): "Exposure to a broken CFL is not really damaging to health." (De Morgen, 5 August 2011).
- The website www.gezondheid.be gives relevant information. "When a CFL is broken, the mercury vapor in the air can exceed 0.3 µg/m³ during a certain time, with peak loads of 25 µg/m³, sometimes more than 50 µg/m³ and occasionally more than 100 µg/m³ (at the ground) (source)." (*The WHO air quality guideline for mercury is 1 µg/m³ (annual average).*
(Technical2007, p. 6)

5. The Netherlands

On 11 December 2008, Jeroen Bartels, the principal of LightRec, an organization dedicated to the recycling of lighting equipment, said that the mercury that is released through a broken CFL is so small that there are no noxious consequences for health. This was based on a study by TNO. (Unfortunately, I did not find this study.)
(http://www.nu.nl/algemeen/1880788/gebroken-spaarlamp-geen-risico-gezondheid.html)

6. Study of Yadong Li and Li Jin, *Environmental Release of Mercury from Broken Compact Fluorescent Lamps*, in Environmental Engineering Science, Number 10, 2011.

According to Johnson et al. (2008), the release of 1 mg of Hg vapor into a 500 m³ room can yield an Hg level 10 times the children's exposure limit (0.2 µg/m³) recommended by the Agency for Toxic Substances and Disease Registry. Thus, in most cases, one broken CFL could cause the Hg vapor concentration in such a room to exceed the safe level for children if the room is not vented. (…)
The emission can last weeks even months and the total amount of Hg that can be released in vapor from new CFLs can often exceed 1.0 mg. Since vapor Hg can be readily inhaled by people, rapid removal of broken CFLs and sufficient ventilation of rooms by fresh air are critical to prevent people from potential harms.

Conclusions

- It is regrettable that in most countries of the EU no official guidelines exist concerning broken CFLs and that no warnings are affixed on or inside packages informing people what to do with breakages. (http://www.ceolas.net/#li19x)
- It is shameful that the European Commission risks the health of young children. Without a complete investigation of the problem, the sale of risky CFLs is forced through and the harmless incandescent bulbs are banned.
- The ban of CFLs is the most elegant solution. No research is needed when mercury is excluded in domestic lighting.

D. End of life

1. CFLs

CFLs are less recycled than fluorescent tubes. Tubes are larger and cannot be hided in a dustbin. Incandescent bulbs can be putted in a dustbin without problems. As has been said (p. 43), the recycling of CFLs does not seem very profitable.

Collected CFLi's at end of life are crushed in a closed installation and sieved. The mercury containing fraction is distillated at 600°C to separate the mercury. The pure, metallic mercury is used again by lamp industry. (VITO2009, p. 134)

The problem of not recycled CFLs will only grow in the future. "'*We estimate that it will double or triple within a few years now that the incandescent bulb is banned', says Magnus Frantzell. 'This would mean that about 10 to 15 million CFLs per year will be sold. If recycling remains on the same level as today, this means that up to 10-15 kilograms will not be recycled.'* Magnus Frantzell speaks about Sweden, a country where only 20% of CFLs do not get recycled." (http://greenwashinglamps.wordpress.com/category/cfl-analysis/mercury-cfl-analysis-2/)

Also, electricity generation emits mercury in metallic form and in low concentration because dissipated over a large area. Metallic mercury doesn't easily become part of the food chain. However, when a CFL bulb breaks in a landfill, there is much less dissipation and bacteria convert metallic mercury into methyl-mercury which is 100 times more soluble in fat.

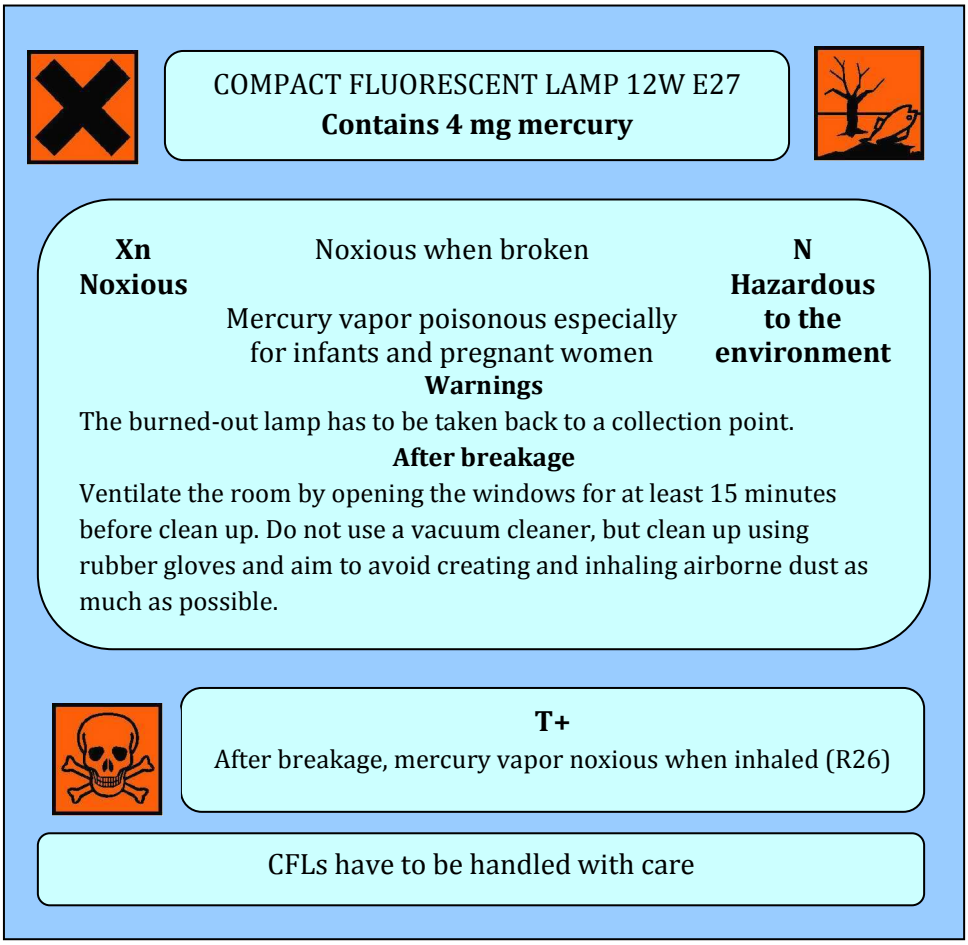
BEUC (…) added that they do not share the Commission's views that energy savings from CFLs will outweigh the increase in mercury. A solution to the waste issue is needed. (Commission Staff Working Document, *Accompanying document to the Commission Regulation implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirement for non-directional household lamps*, 18-3-2009, p.79)

Conclusions

- Swedish environmental expert Minna Gillberg, adviser to Commissioner Margot Wallström, says all CFL bulbs should be marked with a skull-&-bones label to increase awareness among consumers.

(http://www.nyheterna.se/1.824048/2009/01/26/expert_varnar_for_lagenergilampor?commentId=19.85504) Consult the interesting website http://greenwashinglamps.wordpress.com/category/cfl-analysis/mercury-cfl-analysis-2/ .

I made this example of a possible CFL label.

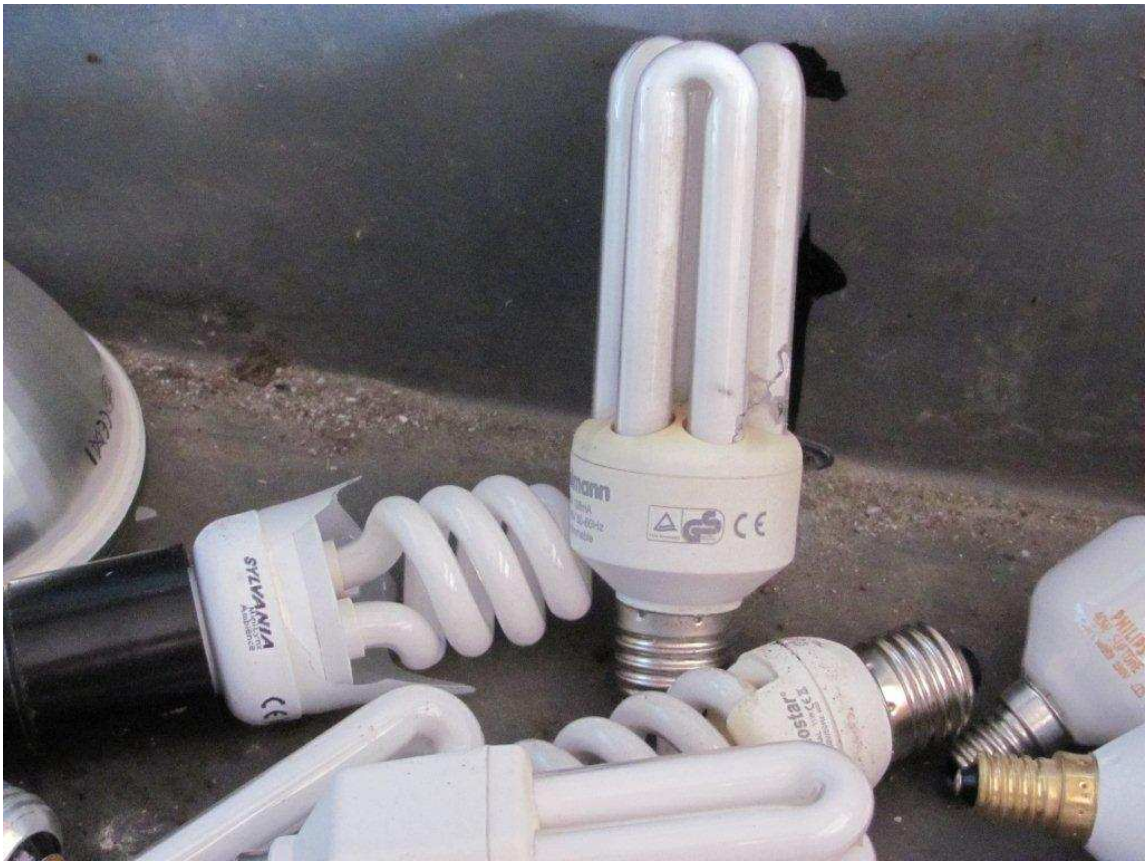


In many countries, the danger of a broken CFL is underestimated. The study of Yadong Li and Li Jin has indicated that the emission of mercury vapor after a breakage can last weeks and even months. Sufficient ventilation of room by fresh air is critical.

- A ban on the use of mercury in lighting bulbs has to be executed and the alternatives without mercury have to be allowed immediately. Products free of mercury, such as incandescent light bulbs, have to be promoted again. It was ill-advised to proclaim a ban on incandescent bulbs while these lamps contain no mercury. In a green economy the producers of lamps will not overwhelm consumers with mercury products while incandescent lamps which contain no mercury, are banned.
- *Banning the most popular lamp type on the market with the possible negative side effects shown in this research is questionable public policy.* (Excerpt of the Master thesis of Halldor Steinn Steinsen, *Architectural lighting design*, Royal Institute of Technology, Stockholm, Sweden)
- In Europe, the exemption for mercury content in CFLs must be lifted from the RoHS directive on hazardous substances in electrical and electronic equipment (2002/95/EC). The regulation 244/2009 permitting the phasing out of incandescent lamps, leads to an unacceptable emission of mercury in the environment during the production phase of fluorescent lamps, during the use (if a lamp is broken) and at end-of-life. This regulation has to be abolished.

Two examples of broken CFLs in the recycling station in my municipality (30 September 2011).


MEMOSTAR
IKEA


SYLVANIA

References

- (VITO2009): *Final Report. Lot 19: Domestic lighting. Study for European Commission DGTREN unit D3*, VITO, October 2009.
- (UNEP_Report2008) : UNEP, *Report on the major mercury-containing products and processes, their substitutes and experience in switching to mercury-free products and processes*, July 2008)

7. Ethical consuming and freedom of choice

The phasing out of incandescent lamps

In 2005:

- **Cuba**: In 2005, in response to the energy crisis, traditional bulbs were banned. To every home, volunteers were send armed with new substitutes. (http://www.dailymail.co.uk/news/article-1107290/Revolt-Robbed-right-buy-traditional-light-bulbs-millions-clearing-shelves-supplies.html)
- **Venezuela**: Incandescent bulbs were banned in 2005. (ibidem) *The government will revamp its two year-old "Energy Revolution" light bulb exchange program by replacing 74 million incandescent light bulbs with fluorescent, energy-saving bulbs.* (November 5, 2009) (http://venezuelanalysis.com/news/4919)
- **Brazil**: Incandescent bulbs were banned in 2005. (ibidem)

In 2007: Ban signed in U.S. ; Delay voted during the first year of the ban (2012)

- **U.S.** : The energy bill, signed in December 2007, took the incandescent bulbs away from the U.S. market. The changeover will be gradual, to begin from 2012 and phased out through 2014. (http://money.usnews.com/money/business-economy/articles/2007/12/19/faq-the-end-of-the-light-bulb-as-we-know-it). The House of Representatives Lawmakers passed an amendment *to the energy- spending legislation for fiscal year 2012 barring the Energy Department from implementing or enforcing lighting-efficiency standards set by 2007 legislation. The law would effectively push the traditional bulbs off store shelves, starting with the 100-watt version next year.* (http://www.bloomberg.com/news/2011-07-15/house-votes-to-save-traditional-light-bulbs.html)

The House has voted to delay the de facto ban on incandescent light bulbs for at least a year. It is the first step in restoring consumer choice and ending government intrusion into our homes. (Rep. Joe Barton (R-Arlington/Ennis http://joebarton.house.gov/NewsRoom.aspx?FormMode=Detail&ID=673)

In 2008: Ban lifted in New Zealand

- In 2008, the government of **New Zealand** decided to lift the originally planned ban on incandescent bulbs. *"We are committed to energy efficiency in the home and efficient lighting has an important role to play in helping us reduce the amount of energy we use, but this Government believes it is a matter of consumer choice.", said Mr Brownlee.* (http://www.national.org.nz/Article.aspx?ArticleID=29097)

In 2009:

- **Switzerland**: Incandescent bulbs were banned in 2009.
- **Australia**: *The first stage of the phase-out plan was the introduction of an import restriction on inefficient incandescent general lighting service light bulbs from 1 February 2009.* (http://www.climatechange.gov.au/en/what-you-need-to-know/lighting.aspx)
- **E.U.**: On 18 March 2009, the Commission adopted a regulation (Commission Regulation 244/2009) on non-directional household lamps which would replace inefficient incandescent bulbs by more efficient alternatives (such as improved incandescent bulbs with halogen technology and compact fluorescent lamps) between 2009 and 2012.
  The request to phase out conventional incandescent bulbs was made by the European Council in 2007 and further reinforced by the European Parliament and by the Council of Energy Ministers in 2008. (EU_FAQ, p. 10) (Source: *Frequently asked questions on the regulation phasing out conventional incandescent bulbs*)
  100W clear conventional incandescent bulbs started to be phased out at the same time as all frosted bulbs, in September 2009. Only the lower wattage clear bulbs were spared momentarily, with the 75W banned in 2010, the 60W in 2011, and the 40W and less in 2012. (EU_FAQ, p. 9)

In 2011:

- **Argentina**: From January 1, 2011, no import or sell of incandescent lamps is permitted.

In 2012: Delay of ban in Canada

- **Canada**: A ban of incandescent bulbs was proposed by 2012. *The federal government wants to delay by two years its deadline requiring all new light bulbs sold in Canada to be energy efficient. Canadians have the next 75 days to comment on the proposal.*

CFLs contain small amounts of mercury and are not readily recycled.
(http://www.cbc.ca/news/canada/story/2011/04/15/cv-election-bulbs-deadline.html)

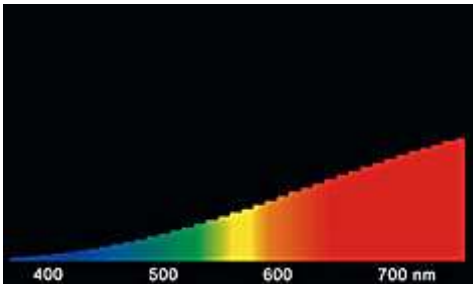
The rights of the consumer

Barry Schwarz begins his article "The Paradox of Choice: Why More is Less", with a clear statement.
When people have no choice, life is almost unbearable. As the number of available choices increases, as it has in our consumer culture, the autonomy, control, and liberation this variety bring are powerful and positive. There is no denying that choice improves the quality of our lives. It enables us to control our destinies and to come close to getting exactly what we want out of any situation. (http://www.scribd.com/doc/13260167/The-Paradox-of-Choice)

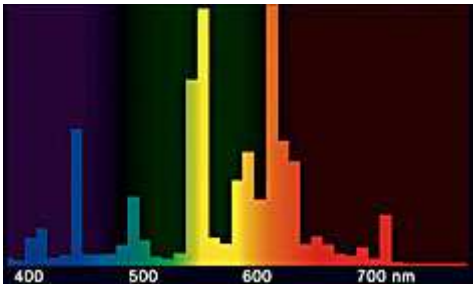
Let us apply this principle to the choice of a lamp. *None of the alternatives to the incandescent lamp produce light with the same spectral characteristics. An incandescent lamp approximates a black body spectral distribution. All the proposed alternatives use phosphors to produce light and have significantly irregular spectral distributions, which can result in colour casts in photography and failures of colour matching when compared to incandescent produced light or daylight.* http://en.wikipedia.org/wiki/Phase-out_of_incandescent_light_bulbs

The warm spectrum of incandescent lamps and halogen lamps cannot be matched by CFLs and LED lamps.

Here are spectral distribution charts (from Osram) for different light sources, which illuminate the quality differences very clearly:

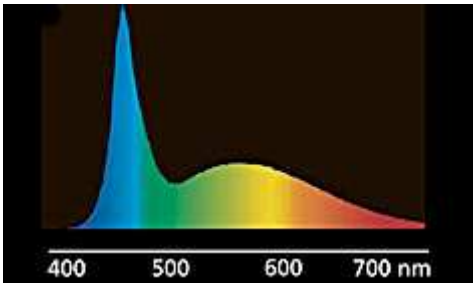


Incandescent light with continuous spectrum and full colour rendering (CRI 100).



Example of standard FL/CFL with uneven spectrum & limited colour rendering (CRI 82-85).

We see the irregular spectral distribution. The consequence is that some colors are not visible at all. The red color is poorly occupied.



White LED, a smoother curve but peaking in the blue end of the spectrum instead of the red. (http://greenwashinglamps.wordpress.com/category/cfl-analysis/)

Let us list some justified preferences of the consumer.

- The wakeful consumer looks for lamps which are pleasing for his eyes. After the ban of incandescent bulbs, it has become very difficult to find them. His justified wishes cannot be fulfilled anymore.
- The incandescent lamp is banned before there was a good alternative.
- A desk lamp that is very near to the eyes, must meet several requirements: warm light spectrum, no flickering, no delivery of UV and electromagnetic radiation, no noise.

  "Although the amount of UV emitted by CFLs poses no problem for the average person, some people are extremely sensitive to UV and may be affected by the amount of UV produced by CFLs. Those who have Lupus or another auto-immune disease and certain skin conditions can be sensitive to the UV from CFLs, in the same way they would be sensitive to sunlight and other light bulbs that emit UV." (http://www.hc-sc.gc.ca/hl-vs/iyh-vsv/prod/cfl-afc-eng.php) Research has shown that a cover surrounding the lamp absorbs part of the emitted UV.

  "The flickering caused by some fluorescent lights can make it difficult for eyes to keep focused. Eyes have cells that activate when hit by light, and to pick up flickers these

cells must activate constantly, often with little opportunity to rest and clean the waste they produce. This produces a large amount of eyestrain in some people and can lead to migraines or damage to the eyes of those who already have eye problems." (http://www.ehow.com/about_6605819_cfl-light-bulbs-migraines.html)

- Apart from the content of mercury, CFLs are not cost-effective when used in rooms that are not visited frequently: cellar, toilet, guest room, attic, etc. Frequent on and off switching reduces the life of CFLs. In cold temperatures the light is dimmer. In this matter it should be appropriate to make an analysis of the use of energy per point of light. In most cases, a cheap incandescent bulb is much more cost-effective than an expensive CFL.
- In locations subject to high humidity or extreme temperatures, consumers are advised against using CFLs, e.g. in a bathroom.
- The same holds for rooms where children are playing: day-care centers, pediatrics, schools, playrooms, etc.
- Antique chandeliers need the appropriate lamps in the right form that spread a warm light spectrum.

Cradle to Cradle

In their book *"Cradle to Cradle: Remaking the Way We Make Things"* by architect William McDonough and chemist Michael Braungart, they suggest that every product (and all packaging they require) should have a complete "closed-loop" cycle mapped out for each component - a way in which every component will either return to the natural ecosystem through biodegradation or be recycled indefinitely. (http://en.wikipedia.org/wiki/Recycling)

William McDonough declared that he was guided by The Hannover Principles as he was working to change the design of the world. The 5th and 6th principle was:

- ***Create safe objects of long-term value.*** *Do not burden future generations with requirements for maintenance or vigilant administration of potential danger due to the careless creation of products.*
- ***Eliminate the concept of waste.*** *Evaluate and optimize the full life-cycle of products and processes, to approach the state of natural systems, in which there is no waste.*
(http://www.mcdonough.com/writings/new_design.htm)

Diverse forms of ethical consumerism

Ethical consumerism is the intentional purchase of products and services that the customer considers to be made ethically. This may mean with minimal harm to or exploitation of humans, animals and/or the natural environment.
(http://en.wikipedia.org/wiki/Ethical_consumerism)

It is unreasonable to prohibit the sale of a product that is not dangerous, that is cheap and contains no mercury. It is market disturbing and leads to an almost monopole to the CFL producing companies.
Will consumers have to buy incandescent lamps on the black market? Will they have to order them with internet? Will they buy them in countries where incandescent lamps are still available?

Howard M. Brandston

I firmly believe that the restrictions put on incandescent lamps will have a significant negative impact on almost every residence in our country. I believe how one lives in their home is a decision that rests with the occupant and is not the purview of the government. I believe this violates the very principles upon which this nation was founded and I, as a devoted citizen, am most proud of, our freedom of choice in our personal lives. (…)
Although lamp manufacturers are developing new sources to compete with the incandescent lamp, if they are so superior they should be able to compete in the open marketplace where price will be a factor. Alternative lighting to the incandescent lamp will have to be worth price differential. (http://smart-grid.tmcnet.com/news/2011/03/11/5371427.htm)

A small test of CFLs

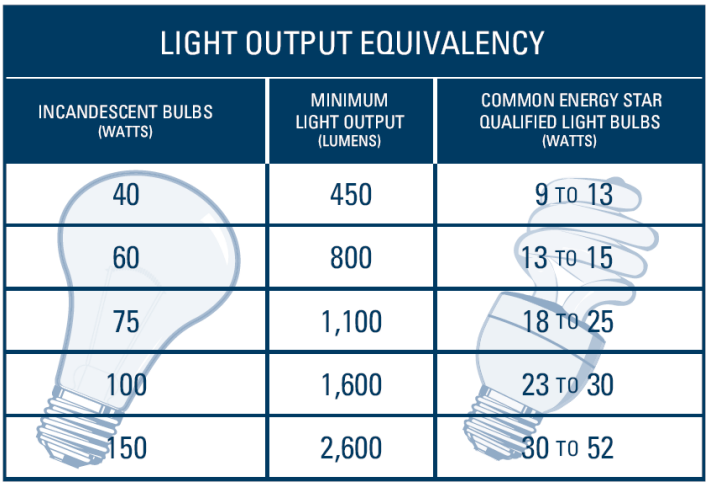
To make a mature comparison of the CFLs in a shop, the consumer has to know some elementary features. On the packaging he must see the amount of mercury in the bulb, how long the lamp will give light, how many watt en lumen the lamp has. I controlled three lamps in a local shop. The results were:

	Brand A	**Brand B**	**Brand C**
Average wattage	15	15	11
This is the same as the average wattage of an incandescent bulb of … watt	75	75	60
Lumen	Not mentioned	900	570
Amount of mercury	Not mentioned	< 4.6 mg	Not mentioned
Lifetime	5,000 h	10,000 h	15,000 h

Remarks

1. It is indicated that an incandescent lamp of 60W should be replaced by a CFL of 11W. According to the VITO-study, one should better choose the "rule of thumb" for an equivalence of 4:1. So, a 60W incandescent lamp should be replaced by a 15W CFLi. *This requirement compensates for the lower real life performance of the CFLi compared to GLS due to lower LLMF (ageing factor, (…)), temperature effects, potential influence from lamp position and a compensation for the low start performance due to warm-up time.* (VITO2009, p. 112-113)

The light output equivalence, prescribed by Energy Star Qualified Light Bulbs, 2006 Partner Resource Guide, "http://www.energystar.gov/ia/partners/manuf_res/CFL_PRG_FINAL.pdf" gives the following equivalences:



LIGHT OUTPUT EQUIVALENCY

INCANDESCENT BULBS (WATTS)	MINIMUM LIGHT OUTPUT (LUMENS)	COMMON ENERGY STAR QUALIFIED LIGHT BULBS (WATTS)
40	450	9 TO 13
60	800	13 TO 15
75	1,100	18 TO 25
100	1,600	23 TO 30
150	2,600	30 TO 52

2. The amount of lumen is not indicated on each bulb!
3. Only one bulb gives an indication of the presence of mercury. The exact amount is not mentioned, only that the amount is less than the 4.6 mg.
4. The lifetime of the bulbs changes in steps of 5,000 hours. This is rather suspicious. Several official reports let know that the tested lifetime is not always the same as the promised lifetime.

The conclusion is that the consumer who wants to buy a CFL, has to buy it without knowledge of the amount of mercury and of the exact lifetime. Moreover, the consumer is mislead about the equivalence of incandescent and compact fluorescent lamps. This means, to buy a CFL is somehow to take part in a lottery.

An important feature is that the cheaper price for the consumption of CFLs leads to more consumption. Most consumers, except older people, are unconscious in relation to the cost of lighting. Because CFLs are economical, they are more on, even if one leaves the room. Sometimes, lights are on when the house is left, to deter thieves. The result is more wasting light and in this way, the consumption of energy for lighting does not diminish.

Conclusion

- In a number of countries, a ban on incandescent lamps has been ordered. The reason why this ban has been implemented, is saving energy. With an unprecedented vigor, the old bulbs have been substituted by CFLs. The eyes of the politicians saw only money with their eyes but were blind for the mercury that has been brought in the interior of each home. Is money more valuable than the planet? Is the depression making light of CFLs more valuable than the happiness of the people?

- An important point of irritation is the whitish spectrum of CFLs. An incandescent bulbs has the spectrum of the setting sun.
- The justified demands of the consumer cannot be fulfilled without the supply of incandescent lamps.
- That many CFLs are not compatible with dimmer switches, etc. is not told. Dimmable CLFs cost more and it is not sure they will work as desired on the dimmers.
- The conclusion is that the consumer who wants to buy a CFL, has to buy it without knowledge of the amount of mercury and of the exact lifetime. Moreover, the consumer is mislead about the equivalence of incandescent and compact fluorescent lamps. This means, to buy a CFL is somehow to take part in a lottery.

References

- (VITO2009): *Final Report. Lot 19: Domestic lighting. Study for European Commission DGTREN unit D3,* VITO, October 2009.
- (EU_FAQ): http://ec.europa.eu/energy/lumen/doc/full_faq-en.pdf *Frequently asked questions on the regulation phasing out conventional incandescent bulbs.*

8. A critical view

Follow the track of the mercury

The track of the mercury	Impact on environment and health

Ban on incandescent bulbs and substitution by CFLs in some countries

U.S.: *General Electric closed their incandescent light bulb factory in Winchester, Virginia, while the CFL bulb market share is dominated by Chinese manufacturers.* (Wiki)

Reduction in atmospheric mercury and greenhouse gases in some parts of the world (Wiki)

Reopening of mercury mines in China

This surge in foreign demand is set off by a European Union directive making these bulbs compulsory within three years. (The Times on line)

Some reopened mercury mines have ruined the environment:
- *dead rivers,*
- *poisoned fields*
- *ailing inhabitants.*

Expansion in the number of facilities manufacturing CFLs in China

In a CFL factory, 121 out of 123 employees had excessive mercury levels. One man's level was 150 times the accepted standard.

Increased construction of coal-fired power plants in China, to supply power to the additional factories.

Reduction in atmospheric mercury and greenhouse gases in some parts of the world are therefore being offset to some extent by increases in these emissions from the additional Chinese plants. (Wiki)

Retail trade of lighting with mercury content and use

E.g.: Situation in a region with a mercury emission of 0.016 mg/kWh and 20% of CFLs recycled (see p. 37).

	CFLs 13W
Mercury content	3.20 mg
Mercury emission during use (6000 h)	1.31 mg
Total mercury emission	4.51 mg

- The high proportion of blue in CFLs has a negative impact on health. This whitish light can be a trigger for depression.
- Several CFLs emit UV-radiation. Some persons are allergic to it.
- Broken CFLs spread mercury vapor in the air.
- Only a small part of the CFLs are deposed (20- 30%). This leads to a new pollution of the environment. These lamps can leak and get into the food chain.

Transportation from the waste collect centers to the reprocessing factories

Distillation process at 600°C to separate the mercury.

This distillation process requires a substantial amount of energy. If the electricity is supplied by coal fired power plants, a new emission of mercury will take place.

Transportation from the reprocessing factories back to the lamp factories

- (Wiki): http://en.wikipedia.org/wiki/Phase-out_of_incandescent_light_bulbs
- (The Times on line): (May 3, 2009) (http://www.timesonline.co.uk/tol/news/world/asia/article6211261.ece)

Conclusion: short version

Comparison between three lamps

	Incandescent bulb 54W	**CFL 13W**	**New halogen lamp 42W**
Mercury content	0 mg	3.20 mg	0 mg
Mercury emission during use (6000 h)	5.16 mg	1.31 mg	4.02 mg
Total mercury emission	5.16 mg	4.51 mg	4.02 mg

See further explanation on p. 46 - 48.

We ascertain that the difference concerning mercury emission between the incandescent lamp and the CFL is 0.65 mg. But the difference between the CFL and the halogen lamp is 0.49 mg in the advantage of the halogen lamp. It is unwise to produce lamps which need yearly about 25-30 tons of mercury. These lamps cannot compensate their content of mercury with a lesser consumption and, as a consequence, with a lesser emission of mercury through power plants. But this calculation shows only one side of the picture. We have also to reckon in the mercury losses during the exploitation of the mercury mines and during the production of CFLs.

1. Power plants are the largest source of mercury emissions to the air. Once mercury from the air reaches water, microorganisms can change it into methylmercury, a highly toxic form that builds up in fish. People are primarily exposed to mercury by eating contaminated fish. (Fact Sheet, *Proposed Mercury and Air Toxics Standards*, (http://www.epa.gov/airquality/powerplanttoxics/pdfs/proposalfactsheet.pdf)
2. The first action that has to be undertaken is the reduction of mercury emissions in power plants. *A range of widely available, technical and economically feasible practices, technologies, and compliance strategies are available to power plants to meet the emission limits, including wet and dry scrubbers, dry sorbent injection systems, activated carbon injection systems, and baghouses.* (Fact Sheet, *Proposed Mercury and Air Toxics Standards*) An emission standard below 3 microgram/Nm^3 would provide, I guess, a reduction of mercury emission of at least 200 tons (of the total of about 600 tons from coal combustion in power plants and industrial boilers). If we want to built a safer world, where one will no longer have to be concerned over methyl mercury in fish, then we have to enact these measures.
3. Instead of taking measures at the source, i.e. in the electricity production, politicians preferred to intervene in the energy consumption by incandescent lamps. It is known that the portion of energy consumed by incandescent lamps is only 3.6% of the total energy consumed in the U.S. (Source of the figure '3.6%': Howard Brandston, March 11, 2011 http://smart-grid.tmcnet.com/news/2011/03/11/5371427.htm) If one does consider the

heat of incandescent bulbs as useful (not as pure energy loss), hardly any difference with CFLs can be ascertained.

4. Some studies throw serious doubts upon the statement that substituting incandescent bulbs for CFLs, will reduce CO_2. (see Letter from *Planbureau voor de Leefomgeving* to *Ministerie van Infrastructuur en Milieu* (31 May 2011), p. 45 of this paper.)
5. Regarding environmental impacts, a comparison between the mercury emission of CFLs, incandescent and halogen lamps during use and disposal, let see that the halogen lamp was the best choice, followed by the CFLi and the clear incandescent lamp. Because there are valid alternatives, mercury is not needed at all in lamps. It is incomprehensible that CFLs are promoted by authorities in such extent, despite the fact that they contain mercury. Mercury containing lamps cannot be imposed on us.
6. The so called 'mercury emission' of the considered incandescent lamp and the halogen lamp is only a consequence of the use of them and must be entirely attributed to the emission of the power plants.
7. The mercury emission of a CFL is the consequence of several factors:
    - Mercury has to be extracted in mercury mines (exploitation phase).
    - CFls have to be produced in factories, where the public health legislation is not always respected.
    - When CFLs are broken, the content of mercury in the lamps becomes free. The amount of mercury vapor depends on the number of hours that the lamp has already shined. The more the lamp is old, the more the mercury is in a bound form.
    - Pollution in landfills: if 20% of the CFLs are recycled, 80% of the mercury content of the lamp pollute the landfills.
    - During a distillation process, the mercury is extracted from the CFLs. This process requires a lot of electricity. If coal fired power plants are used, this is a new source of mercury emission.

    It is abundantly clear that CFLs are a source of pollution in every step of the cycle, from cradle to grave.
8. For this reason, we demand a total ban of the CFL. This lamp is a product of a wrong outline. Mercury has not to be used in the housekeeping. The gains would be immediate:
    - a decrease in the demand of mercury with 25-30 tons;
    - a clean production cycle of lamps;
    - a more pleasant quality of light in our homes;
    - no UV and electromagnetic radiation from the lamps;
    - no dangers of mercury particles in the air, on the floor or on curtains when lamps are broken, especially for young children;
    - no pollution on landfills by broken CFLs;
    - no recycling of CFLs is needed: no disposal of CFLs in waste collect centers and no distillation process to extract the mercury.

- The actions to reduce mercury emission in power plants must be pursued. A minimum content of mercury emitted to air for the production of electricity is no longer needed to justify the production and use of CFLs.
- We will not saddle up future generations with the noxious waste of CFLs on landfills and elsewhere.
- Lighting producers will develop attractive alternatives without mercury. Innovation will be encouraged. The new halogen lamps (as other halogen lamps that were not the subject of this study) are even better, regarding the environmental impacts, than CFLs.

9. In 2005, about 25-30 tons of mercury was needed to produce CFLs. Most of this mercury will pollute the environment. A ban on CFLs can prevent this. *UNEP estimates that every kilogramme of mercury taken out of the environment can trigger up to $12,500 worth of social, environmental and human health benefits.* (http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=562&ArticleID=6090&l=en)
10. UNEP must stop his partnership with the two lighting companies (Philips and Osram) immediately. They have not the right to spread mercury containing bulbs over the planet.
11. In order to let possible a minimum of choice of lamps with different qualities and wattages, the ban on incandescent bulbs should be lifted immediately.
    a. Lighting producers have for years neglected to develop attractive alternatives.
    b. The need of incandescent lamps of 5W, 15W, 25W and 40W must be supplied.
12. The lobby of the private industry in the decision making in the EU must be restrained.

Conclusion: extended version

1. Mercury: a damage to our health

1. The damage to our health and the environment has reached an alarming level. *Most people in central and northern Europe show bioindicators of exposure below internationally accepted safe levels for methylmercury. However, most people in coastal areas of Mediterranean countries, and around 1-5% of the population in central and northern Europe, are around these levels, and large numbers among Mediterranean fishing communities and the Arctic population exceed them significantly.* (Communication from the Commission to the Council and the European Parliament, 28.01.2005)
2. *There is a significant body of mercury already released to the environment that can recirculate again and again, contaminating fish and causing other problems, until it at*

least reaches a long term sink. There is no prospect of an immediate solution to this problem. (Commission_staff2006, p. 15) *A key long term aim is that levels of mercury in the environment will be reduced such that there is no longer any need for concern over methylmercury in fish. This will probably take decades, since the present levels of mercury in the environment are representative of past mercury emissions, and even without further emissions it would take some time for these levels to fall.* (Commission_staff2006, p. 16)

3. The problem cannot be solved by one country acting alone. *It is important to make progress at the global level.* (Commission_staff2006, p. 16)
4. More research has to be done on the impact of mercury on the environment and health. *For example, there is little scientific information that indicates how further cuts in mercury emissions would translate into, say, reduced levels of methylmercury in fish, or over what time period changes could be expected.* (Commission_staff2006, p. 15)
5. *The most important need is to reduce anthropogenic mercury releases to the environment, either through measures relating directly to the control of emissions, or through measures at earlier stages of the mercury cycle such as supply and use.* (Commission_staff2006, p. 16)

2. Reduce mercury emission from coal fired power plants

1. Each citizen has the right to clean electricity.
2. *The largest proportion of mercury emissions is released to air, much of which is subject to long distance movement. Hence, from a short term perspective,* reducing emissions is the most important means of reducing the deposition of mercury. (Commission_staff2006, p. 16)
3. Power plants are the largest source of mercury emissions to the air. Once mercury from the air reaches water, microorganisms can change it into methylmercury, a highly toxic form that builds up in fish. People are primarily exposed to mercury by eating contaminated fish. (Fact Sheet, *Proposed Mercury and Air Toxics Standards,* (http://www.epa.gov/airquality/powerplanttoxics/pdfs/proposalfactsheet.pdf)
4. *A range of widely available, technical and economically feasible practices, technologies, and compliance strategies are available to power plants to meet the emission limits, including wet and dry scrubbers, dry sorbent injection systems, activated carbon injection systems, and baghouses. (…) For all existing and new coal-fired EGUs* [electric utility steam generating units], *the proposed standards would establish numerical emission limits for mercury, PM* [particulate matter] *(a surrogate for toxic non-mercury metals), and HCl (a surrogate for toxic acid gases).* (Fact Sheet, *Proposed Mercury and Air Toxics Standards*) The more the mercury emission will be reduced, the more mercury containing lamps will become obsolete.
5. The amount of all noxious emissions from each coal burning plant has to be controlled and published without delay. If the mercury emission exceeds a fixed level, the power plant has to be shut down. This should lead to a constant concern to reduce drastically the mercury releases.

6. In the United States, the website http://www.epa.gov/cleanenergy/energy-and-you/how-clean.html gives information on the share of coal in the generation of electricity for each region.
7. Texas is the state with the largest mercury emission. (http://www.environmentalintegrity.org/news_reports/documents/DirtyKilowatts-Top50MercuryPowerPlantReport.pdf) "*Texas harbors five of the 10 largest power plant mercury air pollution sites in the U.S. Glen Hooks, regional director, Sierra Club Beyond Coal Campaign said:* "Texans and other Americans do not need to live with the dangerous risks posed by mercury pollution from power plants. Pollution controls that dramatically reduce mercury emissions are widely available, and are already being used at many power plants. But, until the public and policymakers hold the electric power industry to its promises to shut down or clean up the nation's oldest and dirtiest plants, Americans will continue to bear unnecessary health and environmental costs."" (http://www.environmentalintegrity.org/news_reports/news_03_17_10.php , where you can find the full Environmental Integrity Project report.)
8. In 2008, the average of the share of coal in the generation of electricity in EU-27 was - according to my calculations - 27.9% (See Annex A)
9. The proponents of the CFL argue that most electric power is derived from coal. They consider the fact that the production of electricity spreads the deadly mercury into the air as a matter of course. Their solution is: use more mercury in order to reduce the emission of power plants! Instead of adopting the logic of an unavoidable mercury emission, one has to look for measures to reduce the emission of mercury at all levels.
10. This view does not take into account the level of mercury emission by power plants by region, state or country. In Iceland, the emission of mercury through power plants is zero. Several states, countries or regions exist where clean electricity is generated. It is almost criminal to distribute mercury containing CFLs in these unpolluted regions.
13. Is it arguable to blame a type of lamp for a reason that has nothing to do with it: the harmful emission of a power plant?
14. One is expecting that the number of coal-fired plants will not diminish in the near future.

3. Lighting industry

1. In 2005 the lighting industry needed about 150 tonnes of mercury globally: about 65 tonnes in China, about 30 tonnes in North America and about 15 tonnes in the EU.
2. A large amount of mercury is needed in fluorescent tubes: 40 mg per tube! If fluorescent tubes should be banned, about 94 tons of mercury (on a total of 150 tons for lighting) should be prohibited to flood the market (figures of 2005). Alternatives are urgently needed. Cutting the use of mercury (e.g. in lighting) will help to reduce demand.
3. For HID lamps and fluorescent tubes, no affordable alternatives are available at present.

4. All packings of these products have to indicate clearly the amount of mercury and the dangers intrinsic to it.
5. In 2005, about 25-30 tonnes of mercury was needed to produce CFLs. Alternatives are available. A cheap and practical alternative for CFLs was available in the shape of incandescent bulbs but several governments have phased out these lamps. The new halogen lamps are the best alternative. Other more expensive alternatives are LED lamps and LED downlight lamps. However, there are presently no signs of a rapid influx of LEDs to replace CFLs.
6. The only suitable reaction of the politicians to the damage of health and environment in the CFL industry in China is to stop immediately all import of CFLs from China and to lift the ban on incandescent lamps.

4. CFLs versus incandescent lamps

4.a. General comment

1. As we have already concluded earlier, a healthy environment is of paramount importance. **The poisonous substance mercury has to be avoided at any cost.** It is outrageous to store profits using 'more efficient' (as several studies claim) fluorescent lights containing mercury and at the same time to poison the environment by the use of electricity and by the distribution of the mercury in the lamps. Health has no price and must always be considered first! It cannot be permitted that capital is more important than our health! This is contrary to the actual trend giving more attention to the cost-effectiveness of lamps or to the reduction of CO_2 emission than to their content.
2. Instead of taking measures at the source, i.e. in the electricity production, politicians prefer to intervene in the energy consumption by incandescent lamps. It is known that the portion of energy consumed by incandescent lamps is only 3.6% of the total energy consumed in the U.S. (Source of the figure '3.6%': Howard Brandston, March 11, 2011 http://smart-grid.tmcnet.com/news/2011/03/11/5371427.htm) If one does consider the heat of incandescent bulbs as useful (not as pure energy loss), (see p. 44-45) hardly any difference with CFLs can be ascertained.
3. Several studies designate CO_2 as a pollutant. It is certainly not a pollutant but a basic element of life. It is needed in greenhouses to stimulate the growth of plants. If politicians are so eager to reduce CO_2, then they should not use fossil fuels for the generation of electricity.
4. Some studies throw serious doubts upon the statement that substituting incandescent bulbs for CFLs, will reduce CO_2. (see Letter from *Planbureau voor de Leefomgeving* to *Ministerie van Infrastructuur en Milieu* (31 May 2011), p. 45 of this paper)

5. It is strange that the pro-CFL camp needs countries with a high percentage of coal fired power plants to justify the production of mercury containing CFLs. The lighting producers profit from the environment devastating generation of electricity. Producers are misusing a blameworthy situation to make profit of mercury containing lamps.
6. When the government regulators promote solar panels, the production of electricity cannot be clean enough. When the same regulators promote CFLs, the production of electricity must have an certain degree of pollution in order to justify the sale of these mercury containing lamps! The environment polluting power plants are an indispensable condition to replace incandescent lamps with compact fluorescent lamps. Take the pollution away and the CFLs become obsolete.
7. The whole intention of the producers of CFLs is to burden the incandescent bulbs with the noxious effects of coal fired electricity generation and to obscure the presence of a pollutant in CFLs by naming it 'eco-efficient'. It is unjustified to describe a CFL as a green product. Products that contain mercury don't earn that epitheton.
8. The production of a CFL needs more resources than the production incandescent bulbs, the use and deposal of CFLs generates more pollution and waste and has an adverse impact on health and the environment.
9. The legislation has ordered that such toxic products may have a place in our houses. Every place in our residents can be poisoned with mercury. This is opposite to the public health and to a clean environment.
10. Fluorescent lamps have a low quality of light.
11. By declaring that CFLs (with a content of 4 mg mercury) have only a narrow advantage in comparison with incandescent lamps, VITO agrees that CFLs with more mercury – as earlier – have caused serious damage to the environment. From typical amounts of 20-40 mg of mercury per lamp [20 or 30 years ago], lamps with only 3 mg of mercury are commercially available today. (UNEP2002E, p. 145) An investigation has to be performed to establish the damage through the introduction of CFLs, especially in the 1980s and 1990s.

4.b. CFLs promoted in countries or regions with clean electricity

1. It is shameful that the producers of lighting promote their mercury containing lamps even in regions or countries untarnished by coal fired power plants, e.g. Iceland, Brazil, California, Sweden, etc. The net result will be an enhanced pollution of mercury in the environment and ultimately more mercury in the blood of the inhabitants. The declared eco-friendly CFL is in fact a polluting product that endangers the environment and species. The method of them is obvious: they look for regions where CFLs are 'cost-effective' (i.e. with more coal fired power plants) and extend this interpretation to regions with less coal fired power plants where CFLs are not 'cost-effective'.
2. It was ill-advised to acclaim the CFL as the best choice in all circumstances of electricity generation, even in regions where only renewable sources are used.

Producers are misusing a blameworthy situation to make profit of mercury containing lamps.

4.c. The disposal of CFLs

1. The government and the producers of lighting promote CFLs as a green product and warn insufficiently against the presence of mercury in these lamps. If consumers only receive the message that CFLs are in *any case the most eco-efficient solution*, they are not inclined to dispose of the CFL at end of life.
2. It is not wise to put a new burden, i.e. the recycling of CFLs, to private individuals.
3. An important part of the population thinks that it is a 'green' lamp and that it can be left it in a dustbin. Even in commercials to advice consumers to bring CFLs to a waste collect center, the word 'mercury' is not used!
4. We cannot burden future generations with the mountain of waste left by a generation that was obliged to buy mercury containing lamps.

4.d. Broken CFLs

1. It is regrettable that in most countries of the EU no official guidelines exist concerning broken CFLs and that no warnings are affixed on or inside packages informing people what to do with breakages. (http://www.ceolas.net/#li19x)
2. It is shameful that the European Commission risks the health of young children. Without a complete investigation of the problem, the sale of risky CFLs is forced through and the harmless incandescent bulbs are banned.
3. In many countries, the danger of a broken CFL is underestimated. The study of Yadong Li and Li Jin has indicated that the emission of mercury vapor after a breakage can last weeks and even months. Sufficient ventilation of room by fresh air is critical.

4.e. CFLs (and other fluorescent lamps): lack of information on the package

1. The conclusion is that the consumer has to buy a CLF without knowledge of the amount of mercury and of the exact lifetime. Moreover, the consumer is mislead about the equivalence of incandescent and compact fluorescent lamps. This means, to buy a CFL is somehow to take part in a lottery.
2. That many CFLs are not compatible with dimmer switches, etc. is not told. Dimmable CLFs cost more and it is not sure they will work as desired on the dimmers.

5. CFLs versus new halogen lamps

1. The careful built construction by the EU experts to defend the CFL production is collapsing like a house of cards. Instead of the statement "***Regarding environmental***

impacts, the CFLi is, not surprisingly, the best lamp choice and incandescent lamps the worst choice.”, one had to write " ***Regarding environmental impacts, this new halogen lamp is, not surprisingly, the best lamp choice followed by the CFLi and the clear incandescent lamp.”***

2. A CFL does not merit the designation 'eco-efficient lamp'. The halogen lamp merits the designation 'eco-efficient', because it contains no mercury and is, regarding environmental impacts, the best choice.
3. Incandescent lamps of low wattages should remain available. Some producers have at this moment lamps of 18W (what corresponds with an incandescent lamp of 20W). The need of incandescent lamps of 5W, 15W, 25W and 40W must be supplied.

6. Ban of CFLs, lift of ban of incandescent bulbs

1. A ban on the use of mercury in lighting bulbs has to be executed and lamps without mercury have to be allowed immediately. The production of CFLs should be banned immediately because they contain mercury. Alternatives without mercury are available: halogen and incandescent lamps and LEDs. Incandescent lamps must be available again, if it was only to have the low wattage lamps at one's disposal.
2. It was ill-advised to proclaim a ban on incandescent bulbs while these lamps contain no mercury. In a green economy the producers of lamps will not overwhelm consumers with mercury products.
3. *Banning the most popular lamp type on the market with the possible negative side effects shown in this research is questionable public policy.* (Excerpt of the Master thesis of Halldor Steinn Steinsen, *Architectural lighting design*, Royal Institute of Technology, Stockholm, Sweden)
4. In the U.S., the ban of the incandescent lamps, approved in 2007, has to be lifted immediately. In recent years, alternatives, e.g. halogen lamps, are available for the environment damaging CFLs.
5. If one factors in the 'lost' heat of incandescent lamps, the efficiency is not very different of that of CFLs!
6. Several articles deal with incandescent lamps as 'old technology'. Is it really an improvement to switch to a lamp with 'toxic technology'?
7. In Europe, the exemption for mercury content in CFLs must be lifted from the RoHS directive on hazardous substances in electrical and electronic equipment (2002/95/EC). The regulation 244/2009 permitting the phasing out of incandescent lamps, leads to an unacceptable emission of mercury in the environment during the production phase of fluorescent lamps, during the use (if a lamp is broken) and at end-of-life.
8. It is unreasonable to prohibit the sale of a product that is not dangerous, that is cheap and contains no mercury. It is market disturbing and leads to an almost monopole to the CFL producing companies.
9. The conversion to CFL lighting can lead to an increase in the use of light.

7. Relation public private sector

1. We conclude that the partnership from two lighting companies with UNEP must be stopped immediately. The interests of Philips and Osram companies are to make more profit replacing cheap incandescent lights with more expensive CFLs. It was remarkable that right on the last day the lamps of 60W were tolerated in Europe and Switzerland (31 August 2011), the price of CFLs rose with about 25% (the increase in price earlier this year included) (http://www.tagesanzeiger.ch/wirtschaft/60WattGluehbirnen-verboten--Osram-erhoeht-Preis-fuer-Sparlampen/story/31157654 , De Standaard, 1 September 2011 (Belgium)).
2. It is a shame that a public organization not only allows but also supports the two companies in their performance to spread mercury containing bulbs over the whole world. I thought that UNEP had the aim to reduce mercury emissions in our environment but I was naïve.
3. The lobby of the private industry in the decision making in the EU must be restrained.
4. The EU has to withdraw the ban of incandescent bulbs immediately. This will lead to a more competitive lighting market.
5. Mercury containing compact fluorescent lamps were supported and promoted by governments in several countries, not always with much success.

Advice

1. Do not buy CFLs. They use a 'toxic' technology. These lamps must be taken out of circulation.
2. Do not buy fluorescent tubes. The lighting of a new house must be mercury free!
3. In many countries, incandescent lamps are still available. Store up a lot of bulbs with the wattage you will need.
4. The new halogen lamps are a more eco-effective than CFLs.
5. If the government should not ban the CFLs, several actions are still possible to reduce the sale of CFLs. One can organize a boycott or let know the suggestion to ignore these lamps.
6. ***"My house is mercury free"*** is not always attainable in the short run because fluorescent tubes have no cheap substitute. Mercury is also found in batteries, LCDs (liquid crystal displays) used in televisions, desktop computer monitors, and laptop computers. (UNEP_Report2008, p. 89) But it would be quite a step if all conscious consumers should substitute their CFLs for halogen type lamps, incandescent bulbs or LEDs.

Meanwhile I replaced all my CFLs with incandescents and halogens and brought my CFLs to a collection point, even if they were not end-of-life. Now I can say, "my house is ***CFL free***" and I love it! I enjoy of the warm spectrum on every place in my home. I asked myself how I

could so stupid to believe the propaganda of the politicians. Earlier, I was a supporter of CFLs. Now, I am a strong proponent of a mercury free lighting. I have made rid of the CFLs and its disadvantages. Now, I have the feeling that my home is again my private residence and not the territory of strange thinking politicians.

Should it be possible that CFLs cause or aggravate a depression? If one wakes up under the light of a CFL with its limited colour rendering, and its nervous making slow warm-up time, and sometimes its flickering and noise, I am convinced that this could lead to low spirits. The moment I replaced my CFLs, I was surprised by the warm and agreeable quality of the light.

We end this paper with some remarkable statements of Mr. Howard Brandston

The quality of light from the compact fluorescent is about the worst of the major light sources manufactured today. And, aside from that, they don't say anything about the problems of disposing of these lamps, nor do they talk about the additional power that it costs to manufacture these lamps. When you look at how they work, the entire process they are suggesting is filled with errors. And it's misleading.
(http://green.blogs.nytimes.com/2009/04/24/a-defense-of-the-incandescent-light-bulb/)

Will some energy be saved? Probably. The problem is this benefit will be more than offset by rampant dissatisfaction with lighting. We are not talking about giving up a small luxury for the greater good. We are talking about compromising light. Light is fundamental. And light is obviously for people, not buildings. The primary objective in the design of any space is to make it comfortable and habitable. This is most critical in homes, where this law will impact our lives the most. And yet while energy conservation, a worthy cause, has strong advocacy in public policy, good lighting has very little.
(http://online.wsj.com/article/SB10001424052970203706604574377171050647330.html)

The Energy Independence and Security Act of 2007 ignores the fundamentals of good lighting practice and intrudes on our ability to choose how we live. Please respect the privacy of our homes, allow people their indispensable right to choose how they live and light their homes and eliminate the restrictions on the incandescent lamp.
(http://smart-grid.tmcnet.com/news/2011/03/11/5371427.htm)

Annex A

Based on http://www.iea.org/stats/electricitydata.asp?COUNTRY_CODE=DK (adapting the country code).

Year 2008

Country	Electricity production (GWh)	Production from coal (GWh)	Percentage production from coal	Percentage production from fossil sources
Austria	67101	6898	10.3	28.8
Belgium	84930	7235	8.5	38.0
Bulgaria	45037	23220	51.6	57.4
Cyprus	5078	0	0.0	99.7
Czech Republic	83517	49823	59.7	63.3
Denmark	36391	17457	48.0	70.1
Estonia	10581	9645	91.2	98.1
Finland	76930	14310	18.6	33.8
France	574868	27231	4.7	9.6
Germany	637232	290645	45.6	60.8
Greece	63749	33356	52.3	89.6
Hungary	40025	7205	18.0	56.8
Ireland	29685	8018	27.0	87.0
Italy	319130	48591	15.2	79.2
Latvia	5274	2	0.0	39.1
Lithuania	13912	1	0.0	18.6
Luxemburg	3557	0	0.0	67.5
Malta	2312	0	0.0	100.0
Netherlands	107645	26797	24.9	85.7
Poland	156177	143369	91.8	95.3
Portugal	45969	11196	24.4	66.4
Romania	64956	25882	39.8	56.2
Slovakia	28962	5149	17.8	25.7
Slovenia	16399	5323	32.5	35.5
Spain	313746	49973	15.9	60.4
Sweden	150036	2235	1.5	2.5
United Kingdom	389366	126699	32.5	79.5
Total EU_27	**3372565**	**940260**	**27.9**	**54.3**

The information about the emission of mercury by power plant or country is not found.

Annex B

Table 3: Mercury Emissions (in Pounds) by State (Source: Dirty Kilowatts)			Appendix B: All TRI 2008 Electric Utilities Reporting At Least 2,000 Gigawatt-hours (Source: Dirty Kilowatts, reduced and adapted representation)			
State		**2008 Hg (lbs)**	**2008 Hg (lbs)**	**Hg tons**	**metric tons**	**Electric Generation (GWh)**
Alaska	AK	18				
Alabama	AL	4229	4050	2.03	1.81	83483.34
Arkansas	AR	1300	1300	0.65	0.58	27230.53
Arizona	AZ	1732	1727.8	0.86	0.77	47161.06
California	CA	61		0.00	0.00	0,00
Colorado	CO	899	700.6	0.35	0.31	30382.16
Connecticut	CT	75	26.34	0.01	0.01	3018.71
District of Columbia	DC	0		0.00	0.00	0.00
Deleware	DE	271	262.1	0.13	0.12	6666.47
Florida	FL	1539	1347.14	0.67	0.60	107592.44
Georgia	GA	3776	3671.9	1.84	1.64	90417.77
Hawaii	HI	48		0.00	0.00	0.00
Iowa	IA	2425	1725.8	0,86	0.77	33756.32
Illinois	IL	4482	4118.95	2.06	1.84	92594.14
Indiana	IN	4471	4311	2.16	1.92	122528.18
Kansas	KS	1926	1655.2	0.83	0.74	32231.18
Kentucky	KY	3055	2940.8	1.47	1.31	91587.72
Louisiana	LA	1770	1770.2	0.89	0.79	27754.39
Massachusetts	MA	97	56	0.03	0.03	8372.23
Maryland	MD	1339	1159	0.58	0.52	25703.30
Maine	ME	0		0.00	0.00	0.00
Michigan	MI	3448	2743.17	1.37	1.22	58937.45
Minnesota	MN	1193	918.65	0.46	0.41	26527.20
Missouri	MO	4198	3941.98	1.97	1.76	72072.87
Mississippi	MS	669	601.11	0.30	0.27	17267.42
Montana	MT	1063	910	0.46	0.41	17533.04
North Carolina	NC	1961	1376.5	0.69	0.61	57399.38
North Dakota	ND	2741	2638.9	1.32	1.18	29724.05
Nebraska	NE	1227	1069	0.53	0.48	19541.70
North Hampshire	NH	170	160	0.08	0.07	3008.72
New Jersey	NJ	137	101.7	0.05	0.05	11021.28
New Mexico	NM	792	727	0.36	0.32	27467.60
Nevada	NV	125	97	0.05	0.04	7542.36
New York	NY	678	521.8	0.26	0.23	17171.61
Ohio	OH	5680	5211.2	2.61	2.33	131710.39

Oklahoma	OK	1373	1246.36	0.62	0.56	39340.45
Oregon	OR	262	261.8	0.13	0.12	4264.59
Pennsylvania	PA	5659	4667.77	2.33	2.08	102397.36
Puerto Rico	PR	246		0.00	0.00	0.00
Rhode Island	RI	0		0.00	0.00	0.00
South Carolina	SC	800	588	0.29	0.26	37133.29
South Dakota	SD	241	222.3	0.11	0.10	3729.11
Tennessee	TN	2000	2000	1.00	0.89	60207.59
Texas	TX	11722	11722.42	5.86	5.23	159114.27
Utah	UT	433	406.04	0.20	0.18	37961.23
Virginia	VA	1007	600	0.30	0.27	25537.02
Virgin Islands	VI	0		0.00	0.00	0.00
Washington	WA	313	312.9	0.16	0.14	9449.49
Wisconsin	WI	2312	2152.4	1.08	0.96	37004.97
West Virginia	WV	3740	3385	1.69	1.51	92505.79
Wyoming	WY	1719	1691.6	0.85	0.76	46735.77
		89422	**81097.43**	**40.55**	**36.20**	**1,982,785.94**

The table on the right comprehends +/- 90% of Hg emission by coal fired power plant. We ascertain a national average of mercury emission by coal fired power plants of 0.018 mg/kWh produced by this plants. Averaged over all electricity generation facilities, we calculate for the year 2008 a mercury emission of about 0.009 mg/kWh.

Source: (Environmental Integrity Project, *Dirty Kilowatts. America's Top Fifty Power Plant Mercury Polluters*, March 2010.
http://www.environmentalintegrity.org/news_reports/documents/DirtyKilowatts-Top50MercuryPowerPlantReport.pdf)