Energy "Saving" Lamps = Energy Wasting Lamps

A Research on the ecological overall balance of the so-called energy saving lamps.

On behalf of Greenpeace/ Hamburg

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Fluorescent lamps have been subject to criticism ever since they were introduced in the 1930's. Physicians, ergonomists and trade unionists repeatedly reported various forms of discomfort of employees who constantly had to work under fluorescent light: eyestrain, inflammations, headaches, and loss of performance.

The lighting industry have always rejected this criticism and continued the distribution of these lamps. In the 1980's they even managed to put through the use of fluorescent lamps in residential use – without much objection by those affected.

Essentially this was accomplished on the basis of one single argument: the customers could save money. Elaborate marketing campaigns demonstrated that they should pay more than twenty times more per lamp, but this would still be cheaper if the lifetime and energy consumption of the lamps would be considered. It was fatal that this targeted and expensive campaign also reached customers whose ecological conscience motivated them to try and save energy. Through a clever information strategy Osram and other lamp manufacturers convinced many newspapers and magazines to print their argumentation, and they gained the support of Stiftung Warentest [equivalent to "Which?"], "Globus" (a TV programme on environmental issues), the German Federal Environmental Agency, and even critical organisations such as the B.U.N.D. (German Association for the Preservation of the Environment and Nature). By now the ministries even prompt their

admistrative offices to install “energy saving lamps”. These fluorescent lamps were not even assessed by others than the manufacturers themselves.

It was not until late towards the end of the 1980’s that criticism evolved. In 1989, German Power Stations published their own measurement results on compact fluorescent lamps and stated that they were less economical than claimed by the lighting industry [1)]. In our 1989 book “Zwielicht – Ökologie der künstliche Helligkeit” (“Twilight – Ecology of Artificial Brightness”) we criticised the adverse visual properties and the great load of waste [2)]. In 1990 the Munich Environmental Institute identified radioactive radiation in the installed starters [3)].

This did not put an end to the selling success of the reputed “eco lamps”. On the German market alone about 100 different compact fluorescent lamps are available. In 1999, again at least 10 million of them were sold.

What is actually ecological about the “eco lamps”?

It is true that in certain situations compact fluorescent lamps consume less energy than incandescent lamps. But it is wrong to assume that buying these lamps means you are doing something good for the environment or the energy balance. It is verifiable that this is wrong!

An ecological evaluation of these lamps must start with an overall look at the effort of manufacture, the running properties, and the consequences for waste disposal, as well as the effects these lamps have on living beings. This evaluation is particularly difficult because the main source of information on these highly complicated technical lamps is the manufacturers. Despite this hitch, sufficient details are known for coming to an overall evaluation.

To begin with, the general principal of how light is generated:

Fluorescent lamps (other than incandescent lamps) do not have a filament, but a gas filling which is excited to radiate by current passing through. This gas filling consists of noble gases with added mercury. Electricity is applied to the cathodes on both ends of the lamp tube, causing a discharge in the gas. The gas discharge displays a band spectrum with the main radiation being 254nm UV-C light, which is characteristic for mercury. Phosphors which are applied to the inner surface of the glass tube are excited to shine by this UV-C radiation. The combination of these phosphors (halophosphate, rare earths, etc.) determines the spectral properties of visible light. Generally all fluorescent lamps must be run by additional electric devises, the control gear. They contain a choke coil for metering the current, and, among other things, a starter which provides for the correct ignition. Over the last

couple of years electronic control gears have been distributed to replace the coil and starter system.

Compact fluorescent lamps are a sub-group of fluorescent lamps. The multiple bends of their tube and a one-sided base allow for a squat shape. For years lamps with a common GLS-like screw base have been very popular which have the control ballast integrated into the bottom.

As compact fluorescent lamps cannot be run without an adequate control gear, an overall ecological balance has to deal with both devises at once. (As a reference: incandescent lamps do not require a control gear.)

1. Manufacture

It is only at first glance that producing a fluorescent lamp and an incandescent lamp would seem to be comparable. Both lamps require a glass bulb with a specific gas filling, a metal base, and small curled filament (the electrodes of the fluorescent lamps). But in contrast to incandescent lamps, fluorescent lamps additionally contain a complex mixture of phosphors which are indispensable for the production of light. They contain phosphor compounds, zinc beryllium silicates, cadmium bromides, vanadium compounds, rare earths (europium, terbium, etc.) – depending on the model. Sourcing these elements and chemically processing them requires substantial technical facilities and according energy consumption. But it is the indispensable control gear that makes a fluorescent lamp particularly adverse.

With every single lamp (respectively two lamps in Duo circuits) comes a set of electric control devices for ignition, current limitation, stabilisation, assembled in the so called control gear which is usually housed within the luminaires. There are compact fluorescent lamps which house the control gear in their own lamp base; with other models it comes as a separate device. Older models contain a starter with bimetal electrodes, an ignition coil (partly with radioactive krypton 85), a choke coil with an iron core and copper windings, and capacitors (often still containing polychlorinated biphenyl). The more recent electronic control ballasts contain a series of diodes, resistors, capacitors, a commentator, a chopper, a transformer and a filter for radio-interference suppression [4)].

Each of these components is being produced under high energy consumption. The fabrication of the circuit boards alone requires a substantial amount of electricity. And each further module has to go through a series of steps until the semiconductors are ready, the insulation layers have the right shape, the contact wires fit, etc.

Thus, producing a compact fluorescent lamp (with all its associated control parts) involves a lot more than to fabricate an incandescent lamp – when considering the

use of materials and energy. Recently (in 1991) the German Electrical and Electronic Manufacturers' Association, ZVEI, published a calculation of the energy consumption of lamp production [5]. It states the energy consumption for the production of one incandescent lamp to be 150 watt-hours, and 1400 watt-hours for a compact fluorescent lamp – i.e. almost ten times as high. Probably these figures need to be squared, as queries with lamp manufacturers have shown. The following need to be considered: electricity and gas consumption for assembling the prefabricated modules (glasses, electrodes, phosphors, bases, insulation, mounting components, as well as all parts of the complicated control gears); but also the share of energy for the prefabrication of all modules (capacitors, diodes, choppers, electrodes, glass bulbs, etc.); energy for processing the actual materials (glass, metal, noble gases, phosphor compounds, semiconductors, etc.); as well as energy consumed by transportation and packaging of prefabricated materials. The figures by ZVEI (150 and 1400 watt-hours) are also wrong in their relation to each other (1:9.3). Producing compact fluorescent lamps – with all pre-fabrication steps for the control gears taken into consideration – will require at least 40 times the energy. This is why the compact fluorescent lamp deserves to be called **"energy wasting lamp"**. To some limitation, this relation also reflects in the sales price: Compact fluorescent lamps cost 25 DM to 40 DM, an incandescent lamp is available for less than 2 DM. But didn't the manufacturers promise you could save when using these lamps?

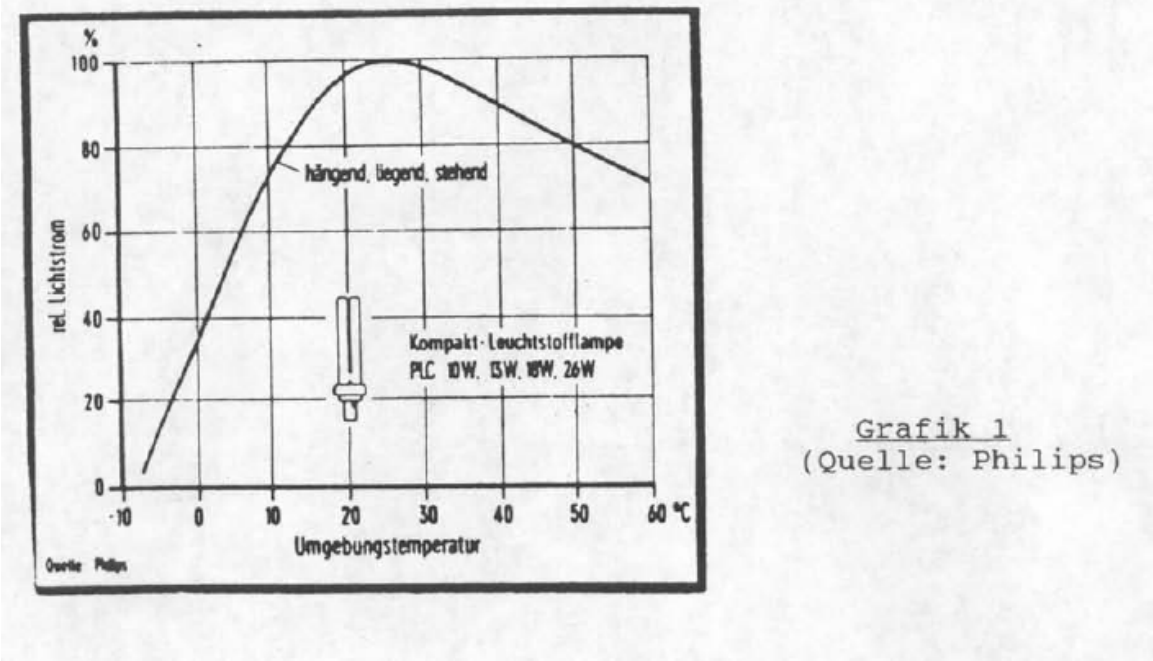
2. Energy consumption during application

For years it has been promoted that these lamps would have up to eight times the lifetime and would shine at least five times as bright. So you would save energy and get away cheaper in the end although you have to spend about 20 times the money as for incandescent lamps.

It is worth taking a closer look at this. What this alluring calculation is keeping secret is the fact that incandescent lamps are much less affected by ambient factors than fluorescent lamps. The most striking aspect is the influence of the ambient temperature around the lamp.

2. a) Ambient temperature

Compact fluorescent lamps reach their full performance at and ambient temperature of 20°C to 30°C; higher or lower temperatures cause the light output to drop drastically. In cool interior spaces such as corridors or basements the luminous efficacy remains way below the optimum (see graphic 1).



Grafik 1
(Quelle: Philips)

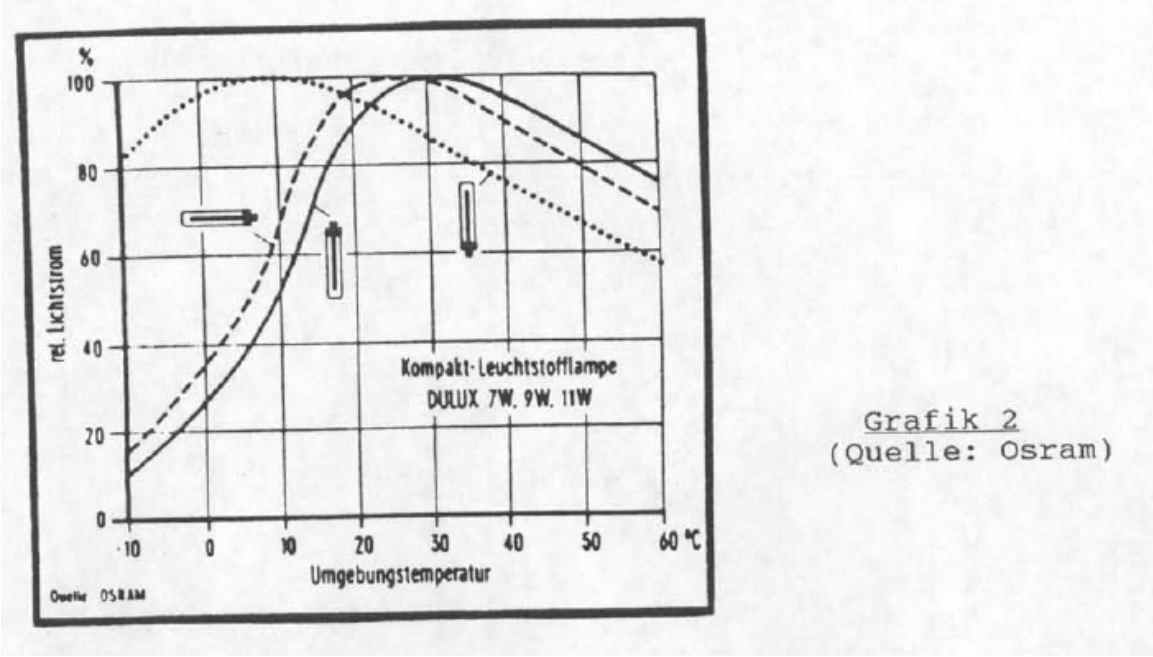
[x-axis: ambient temperature; y-axis: relative luminous flux; note on graph: hanging, horizontal, standing]

Of course with exterior lighting installations the dependency of ambient temperature carries even more weight. With exterior temperatures in the evening and in the night hardly reaching 20°C even during the summer months, a cool evening with say 5 degrees Celsius causes the much-acclaimed luminous efficacy of the energy wasting lamp to drop to less than 50 percent of its maximum value. For this reason the power company RWE fundamentally dissuades from using these lamps for exterior lighting [1)]. The lighting industry's answer to this is that appropriate envelopes, i.e. luminaires, would reduce the dependency of ambient temperature. Measurements have shown though that those luminaires which provided a more stable interior climate at the same time reduced the light output ratio.

Then again incandescent lamps shine no matter what the ambient temperature.

2. b) Lamp position

Another parameter is the orientation of the lamp. Lamps pointing upwards have a completely different luminous efficacy than lamps hanging from the ceiling or facing downwards within table lamps. However, the maximum performance does not correlate with the usual room temperatures (see graphic 2).

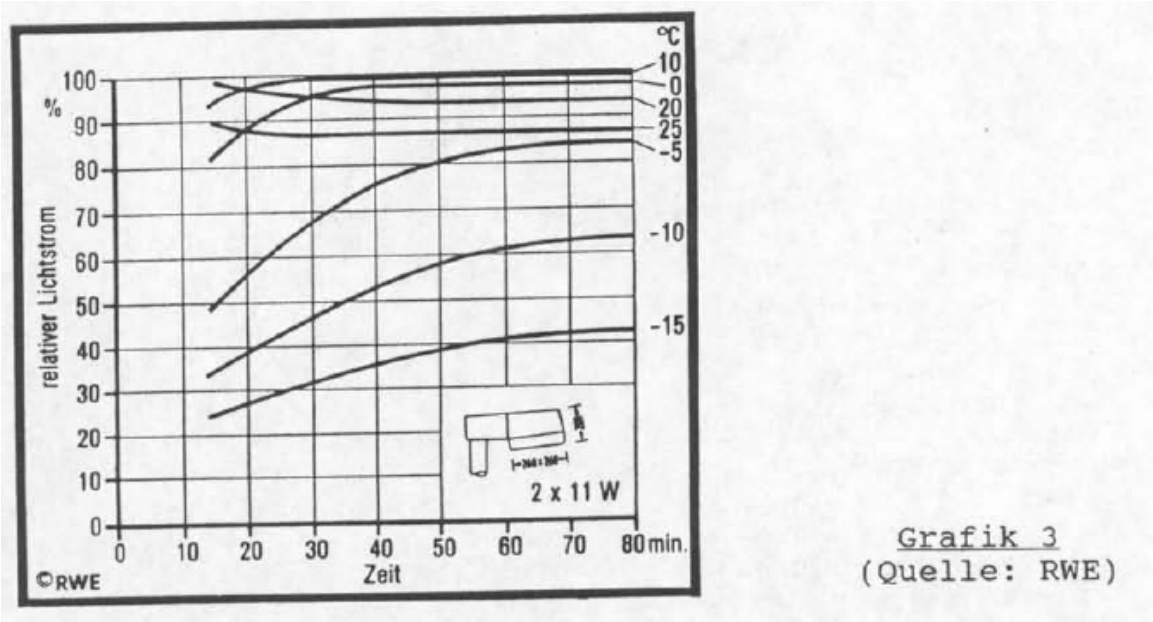


Grafik 2
(Quelle: Osram)

[y-axis: relative luminous flux; y-axis: ambient temperature]

2. c) Lead time

Energy wasting lamps take substantial time to reach their individual optimum luminous efficacy. They run specifically sparse and unstable during the first 15 minutes. It is only after 25 to 40 minutes of running time that they reach their greatest brightness (see graphic 3).

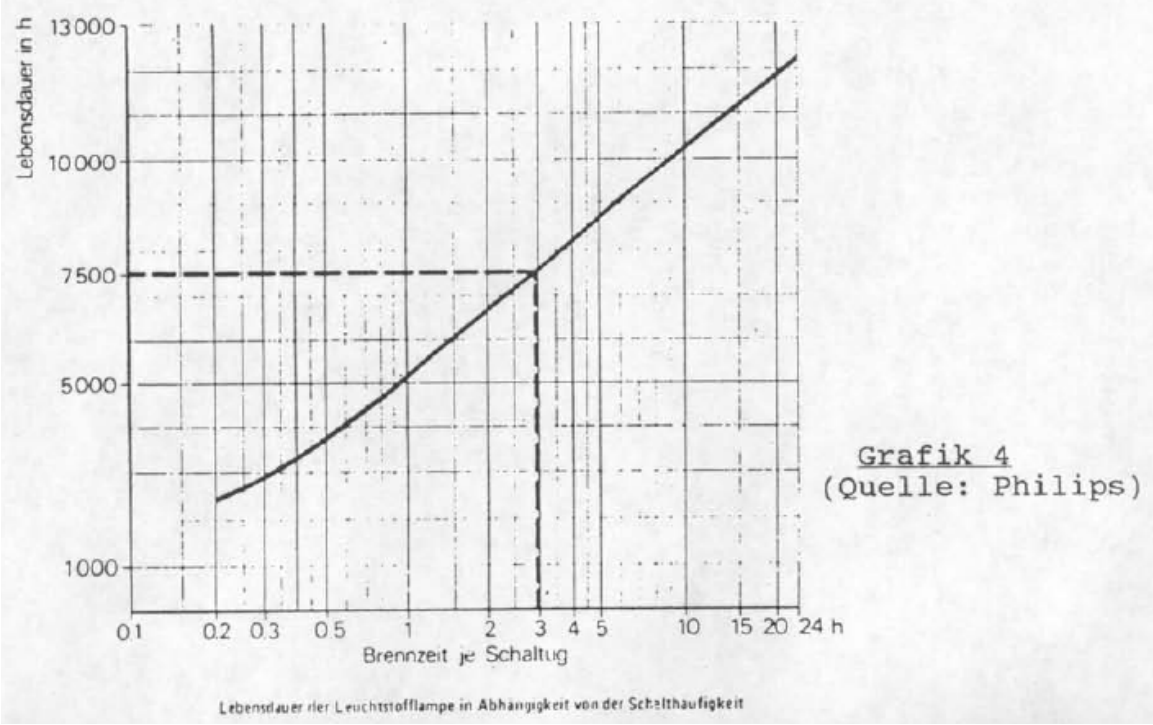


Grafik 3
(Quelle: RWE)

[y-axis: relative luminous flux]

2. d) Switching frequency

Frequent switching does not affect the lifetime of incandescent lamps. The contrary is the case with energy wasting lamps: Their lifetime drops rapidly with more frequent switching. (see graphic 4).



Grafik 4
(Quelle: Philips)

[Lifetime of fluorescent lamps in relation to switching frequency; x-axis: running time per activation; y-axis: lifetime in h]

Lamps which run uninterruptedly most likely reach the 8000 hours of lifetime as stated by the manufacturer. But if you would let it run for one hour in the morning and another one hour in the late afternoon – e.g. at an office desk – the lifetime drops to 5000 hours due to the “high” switching frequency. Or if it is repeatedly being switched on and off in a corridor it gets into the area of incandescent lamps (halogen lamps reach 2000 hours!).

Again these lamps are economical only in very constrained circumstances: that is if they are run without a break.

2. e) Interim balance

Manufacturers argue on the base of running costs. They contain the following main factors: lifetime, luminous efficacy (luminous flux per watt), lamp costs, and energy

costs. However, the manufacturers do not go by everyday conditions, but they rigorously calculate with optimum values even though these only apply in specific situations.

As an example, the LUMINOUS OUTPUT of a 15 watt compact fluorescent lamp (with integral control gear) is supposed to be the equivalent of that of a 75 watt incandescent lamp. It is alleged to shine five times as brightly. This is not normally the case. For this calculation a compact fluorescent lamp was run under rare optimum conditions while being compared to a specifically weak incandescent lamp. Halogen incandescent lamps perform at up to 25 lumens per watt of luminous efficacy. Compact fluorescent lamps deliver their optimum of 60 lumens per watt at an upright orientation with an ambient temperature of 10 degrees Celsius, and only approximately 30 minutes after switching them on. The typical luminous efficacy is substantially below that; it may be at an average of half of that, i.e. 30 lumens per watt – depending on the conditions.

Regarding the LIFETIME similar measures are being applied. Incandescent lamps are said to last for 1000 hours, whereas compact fluorescent lamps would reach 6000 to 8000 hours. Firstly, halogen incandescent lamps have a lifetime of 2000 hours; with a cool beam mirror they even reach 3000 hours. And there are incandescent lamps (Merkur Extra) with a lifetime of 5000 hours. Secondly, compact fluorescent lamps only reach this age if they are left to run permanently. Once the average running time is approximately 45 minutes they only last for 4000 hours. At least still four times as long as conventional incandescent lamps! But the retail price – the third factor in the running costs – of 40.00 DM is twenty times that of a simple incandescent lamp (which is 2.00 DM; the long lasting Merkur lamp also costs only 1.95 DM).

Thus: double the luminous efficacy and four times the lifetime at twenty times the price!

The power companies have examined this “lighting calculation” on the basis of their own test series and came up with the following significant results:

“Compact fluorescent lamps are twice as economical as incandescent lamps at a low switching frequency. At a running time of less than 45 minutes per activation it is more costly to run compact fluorescent lamps than incandescent lamps.”

This interim balance only takes the material costs into account. In order to achieve an overall comparison it is not enough to look at the expenses of production, but also the visual properties, the load of non-visual radiation, and the problems of disposal.

3. The visual properties

Over millions of years, the biogenetic evolution of the whole human visual perceptive system, the hormone system, the skin, as well as of all properties of the organism happened under the conditions of the alternation of natural daylight and night. It is understood that this allows assuming that the genetic endowment of man is adapted to the properties of sky light. The healthy functioning of a living organism is not guaranteed though if permanently exposed to artificial light which does not match natural daylight. The most important criteria for the quality of artificial light are not efficacy of lifetime, but its similarity to natural light. Lighting biologists in the whole world agree on this [7)]. Any plant breeder or stock farmer knows of the strong influences of types of artificial light on growth, fertility, productivity, and mortality of living creatures. Today also a vast number of studies give detailed proof that variances of the quality of natural light impair ones health [2)].

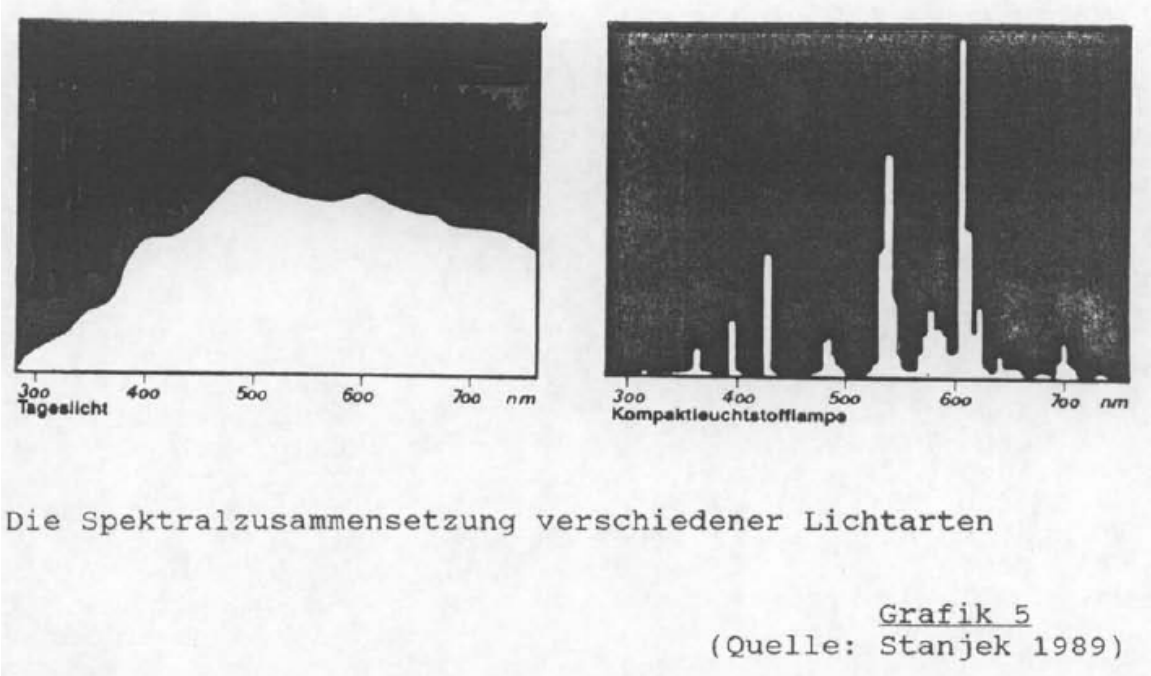
Daylight can be characterised by a number of properties: continuous radiation, colour spectrum containing UV and infra-red, spatiality, brightness, and variability. Artificial light shares only very few of these aspects.

In contrast to daylight, compact fluorescent lamps do not produce a continuous spectrum but only emit strong brightness at specific wavelengths, whereas other spectral areas are reduced or not represented there at all. It is fatal that the bare eye cannot distinguish light with such a “band spectrum” from light with a continuous spectrum because visual perception can be tricked. Band spectra make the lamp appear brighter, but cause stress to the visual process. This becomes apparent when you consider that the lens of the eye causes different refraction to different colours of light so that blue rays are mapped in front of the retina, and red rays behind. If the complete spectrum of daylight is given, the eye can continuously overlay the level of imaging. However, the band spectrum of a fluorescent lamp causes several discrete retina images behind one another, which makes it very demanding for the eye to focus, thus resulting in vegetative disorders such as headaches.

The parts of the spectrum which are missing in between the given intense bands are by no means of less importance to the organism. A whole series of physiological processes rely on light of very different wavelength, causing ideal performance of the corresponding biochemical processes. If those wavelengths are missing in the prevailing light, these processes are limited or even inhibited.

Whatever ultraviolet light would be contained in normal daylight is almost completely missing in fluorescent light. But these parts are especially important for human health. While there is no doubt that short wavelengths of UV light (UV-C: 100 – 280 nanometres) are deleterious for humans and can usually not be found in daylight, longer wavelengths of UV light (280 – 380 nanometres = UV-A + UV-B)

have various positive effects on the organism as long as the dose is adequate. Several systematic studies have compared the effect of everyday lighting at a reduced band spectrum and at a full spectrum. Repeatedly the influence on tenseness and tiredness as well as general health have been proven (see graphic 5).



Die Spektralzusammensetzung verschiedener Lichtarten

Grafik 5
(Quelle: Stanjek 1989)

[The spectral composition of different types of light – daylight – compact fluorescent lamp]

4. Non-visual load of radiation

Compact fluorescent lamps produce electromagnetic disturbances of various frequencies which lie outside the visual spectrum. Experiments on plants have demonstrated that this radiation impaired the regular growth. These lamps create radio wave emissions over the length of the discharge arc. This is supplemented by the effects of the high voltage for ignition and the magnetic effects of the choke coil in the control gear. Radio frequencies are being emitted by all fluorescent lamps, and they are known to cause imprecise displays with very sensitive devises, e.g. scanners in hospitals, or some computers. A Russian article has it that an EEG recorded not only human brain waves, but also radio frequencies of fluorescent tubes [8)].

The effect of technical noise fields have only been examined properly over the last couple of years. Several studies showed noise fields to cause an increase of specific types of cancer, e.g. leukaemia, as well as an increased percentage of

malformations of newborn. But probably they also affect human health in an unspecific way, causing cells […].

The hazardousness of radioactive radiation has been common currency for a long time. But it was not until 1990 that radioactive substances in “eco lamps” were discovered. In order to reduce flickering at start-up, the starters of some types contain radioactive substances such as krypton, promethium, tritium, and thorium, which, according to measurements by the Munich Environmental Institute, amount to as much as 1100 Becquerel [3].

5. Problematical disposal of the lamps

Energy “saving” lamps are highly poisonous. The gas filling contains mercury vapour, the phosphor mix consists of a number of hazardous substances, the starter and control modules contain all the usual pollutants of “electronic scrap”. According to the Waste Bill of 1986 fluorescent lamps are to be treated as “special waste”. Still, there is no regulation for the control gears, which are at least equally poisonous. So far these lamps are not apt for recycling because of the combination of lighting elements with circuit boards, the components of which are subject to wearing. Burt-out compact fluorescent lamps – currently ten million of them per year – thus impose a great burden to the environment. These of all lamps, which everyone thought to be ecologically sensible.

Almost the only source of information on what these pollutants actually are is the industry. Various sources state that the lamps contain at least mercury, yttrium, vanadium, arsenic, antimony, and the radioactive elements thorium, krypton, promethium, and tritium. On top of this, the control gears contain asbestos, cadmium, lead, and halogenated compounds. Mostly the amounts per lamp (e.g. approximately 10mg of mercury) are small, but when summed up to 10 million lamps per year this is an unjustifiable imposition on the environment.

The industry claims that apart from the mercury all poisonous substances were bound to the glass surface or the electrodes and thus barely soluble in water [9]. After 24 hours of agitation in CO_2 they were merely soluble in seepage water and thus not relevant for the environment! A strange logic, which apparently points towards landfill, accepting the immense growth of garbage dumps without the shadow of a doubt.

The recommendations for disposal by the industry (e.g. ZVEI: “Entladungslampen und Umwelt” – “Discharge Lamps and the Environment”, Bonn 1990) does not touch the disposal of the corresponding control gears at all, although there is 150,000 tons of new electronic scrap every year [10], meaning that landfill as special waste has almost become impossible.

If compared to the disposal of incandescent lamps it becomes clear that energy wasting lamps create a much larger garbage problem. Incandescent lamps do not require electric and electronic waste of a control gear to be disposed of. The lamp base, the insulation mass, the glass bulb and the filament are dumped. Strictly speaking, the filament consists of hazardous heavy metals, and a closer look reveals that this is also not quite harmless garbage. But compared to a compact fluorescent lamp with all its control gear and poisonous components the incandescent lamp is environmentally by far more compatible.

6. Balance

The evaluation of compact fluorescent lamps under ecological criteria clearly shows negative results.

The production of the lamps and its corresponding control gears requires large amounts of energy and material. In practice they show a high dependency on external factors such as ambient temperature, position, frequency of switching, etc. Their efficiency (brightness in relation to the energy consumed, lifetime and initial cost) is significantly lower than claimed in the campaigns. If switched often they are even more expensive to run than incandescent lamps. The emitted light is based on a very incomplete spectrum. From a physiological point of view it is the worst of all artificial light sources commonly used for residential purposes. Additionally, these lamps emit various kinds of non-visual radiation (radioactivity, UHF radiation, etc.), the negative effects of which on the human body have repeatedly been described. Once burnt out, the lamps and their control gears become a substantial burden for the environment as they contain highly hazardous substances. So far, the lamps cannot be recycled and must be treated as special waste. Once again it is valid that the way to solve the garbage problem is to avoid garbage in the first place.

Thus the use of compact fluorescent lamps, which have become popular as “eco lamps”, should be discouraged from.

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