The Social Implications of Light at Night (LAN)

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Revised: March 14th, 2017

Summary

It has been shown that Light at Night (LAN) has serious implications for both the environment and human health. What is considered here are the social implications that arise from these problems, and what needs to be done to redress these issues.

Introduction

Light at Night is a serious environmental problem whose environmental and medical implications have been seriously underestimated. If no action is taken the problem will become progressively worse and may reach a point where nothing can be done about it. The issues arising from it need to be identified and

appropriate action taken to mitigate these issues as far as possible. Hopefully this can be done amicably by self regulation within communities, but if this fails then stringent anti-light pollution legislation will have to be enacted. Some countries and local authorities have already begun to make faltering steps in this direction[1], but so far the measures taken have been minimal and largely ineffective. Light at Night (and the light pollution resulting from it) therefore remains a problem and continues to get worse despite the measures already taken to reduce it. Domes of scattered light continue to hang above our cities, killing off our wildlife and endangering public health. Attitudes need to change and urgent measures need to be taken in order to reduce or eliminate its impact.

So what and where are the problems?

These can be listed as follows:

1) ***Effects on human behaviour.***
2) ***Neighbour disputes.***
3) ***The Lighting Industry and Municipal Lighting Authorities.***

4) ***Vanity Lighting.***

5) ***Human Health.***

6) ***Environmental Issues.***

7) ***The Economics of Light at Night.***

1) <u>Effects on human behaviour</u>

Diurnal-nocturnal behaviour patterns may change in the general population. During the hours of darkness people tend to stay in their homes. However, if places are "well" lit, people will tend to behave at night more as they would during the day. Most crime of the kind we fear occurs during the hours of daylight, ergo criminals need light, consequently crime rates in well illuminated urban areas will increase. If light was truly a deterrent then there would be little or no crime during the day[2]. The increase in crime has mirrored the increase in street-lighting since the 1950's. <u>Rather than reduce crime, increased street and security</u> <u>lighting actually encourages it</u>[3]. This fact is now well established[4], but business interests prevent it being widely recognised by local authorities. Economic constraints

have recently forced some local authorities to cut back on street lighting and where this has happened, crime has decreased by as much as fifty percent[5]. One recent study[6] claimed that increased lighting actually reduced crime. This study was based on an earlier study[7] financed by a well-known manufacturer of lighting, as were all similar studies in the U.K. However independent assessments found the study's findings were flawed and it was subsequently discredited[8]. All lighting can do is reduce the fear of crime[9], and unfortunately this will be exploited as a marketing tool by the lighting industry[10,11]. To address those concerns the industry will stir up the fear of crime in order to promote and sell more lighting. Consequently we see the installation of more and brighter lighting with inevitable consequences for both human health and the environment. However this becomes pointless if the crime rate is going to increase. The fact remains that people are safer under a blanket of darkness, which is further supported by the fact that during power failures criminality drops to zero or nearly so[12]. Obviously

then, criminals need light in order to perpetrate crimes and for the past century or more this has been abundantly provided by municipal lighting authorities. Public lighting makes the criminal's job so much easier, but in the absence or near absence of lighting, criminals would have to provide their own and this would increase their chances of being caught. Anyone seen flashing a torch around in an unlit property will inevitably attract attention.

As part of an aid project, street lighting was recently re-introduced into Mogadishu, Somalia after years of internal conflict, in order to re-establish the traditional night-life that prevailed in the city[13]. It did have obvious benefits, but was any attention paid to the environmental effects the street lighting would have? Almost certainly, none at all. Chinese solar-powered lighting was installed without due regard to the environment. In addition, the local police spouted out the age old beliefs as to how the lighting would reduce crime[14]. It will be interesting to see how much crime will increase as a result of its

re-introduction. With people becoming more active at night, the rate of criminality will inevitably rise. Aid agencies should always review the environmental impact of street lighting before its implementation in order to avoid an inappropriate knee-jerk response to third world lighting problems.

The problem of crime is not a lighting problem[15]. Society has got to be more pro-active in addressing the issues that cause crime, such as poverty, unemployment, drugs and family breakdown. The presence or absence of street lighting does not have any effect on these.

2) <u>Neighbour disputes</u>

Light pollution is in some ways similar to noise pollution. Excessive noise has long been recognised as being anti-social and local authorities have in many cases enacted measures to deal with it. If a resident or business causes excessive noise, then neighbours may suffer lack of amenity through the absence of peace and quiet. They will be unable to enjoy the privacy of their own homes, and will be entitled to raise this with municipal

environmental health departments. Light pollution is just as offensive yet is rarely seen as a problem. It effects are not immediately life threatening so local authorities don't see any need to do anything about it. Few people see it as a problem. However to those affected by anti-social lighting it can be very distressing, yet they have little recourse to legislation that can do anything about it. Some countries have included blatant light pollution in local authority bye-laws, but these are often so emasculated by exceptions that they are reduced to the status of a paper tiger. The plaintiff needs to secure reasonable redress within the law, but so far this has evaded him. As with noise pollution, neighbour disputes over antisocial lighting can become very ugly as the delinquent party is frequently totally insensitive to the needs and feelings of the plaintiff. This can cause undue stress on the plaintiff leading to unpredictable consequences.

By marketing bad and unnecessary lighting, the lighting industry is actually encouraging the abuse of lighting, thereby fermenting disputes between neighbours. Examples of this would

be various forms of security lighting, and vanity lighting such as garden lighting. If it only produced dark sky compliant lighting then this problem would be less likely to occur. The industry may further divest itself of all responsibility for the behaviour of the end user in the same way as arms manufacturers when firearms have been involved in homicides.

3) <u>The Lighting Industry and Municipal Lighting Authorities</u>

Most of the problems of light pollution are caused by the lighting industry and municipal lighting authorities. Many of the people involved are members of professional bodies promoting the industry. Companies manufacturing lighting are simply in the business to maximise profits and to a large extent couldn't care less about the environmental issues involved. Municipal lighting departments pander to the understandable fears of the general public over criminality after having been conned by the industry into believing that more and brighter lighting reduces crime, increases security and improves safety. They are delinquent because they seem to think they have a divine right to

install lighting outside homes without consulting individual residents. Those who don't want lighting outside their homes should not be forced to endure it. A resident's right to darkness should never be violated. If they protest against it they risk being branded as "over-sensitised" nerds and eccentrics whose needs can be trampled upon with impunity, and at worst as being mentally unbalanced. One could counter this by arguing that road users also have the right to see where they are going, and this is not disputed. However, in areas where all-night lighting is not appropriate, such as rural, residential and suburban areas, the onus should be on them to provide their own lighting by using a torch. As for motor vehicles, it may a truism, but they have headlights. If adaptive high beam headlights were more widely adopted, then drivers would be able to see better at night without the need to install more lighting[16]. Local authorities are not actually under any obligation to provide lighting (but only to maintain it in good working order if they do)[17] nor should they be liable to injury claims if people don't take appropriate care when

moving around at night. If people suffer injury through not taking appropriate care, then they only have themselves to blame.

The problem of light pollution is twofold. There are those who desire polluting lights for selfish reasons and those who seek to profit from it by creating and perpetuating the problem. The interests of both complement each other. The first group simply want to draw attention to themselves by virtue of the fact one cannot ignore a bright light any more than one can ignore a loud noise. Such people see no reason to minimise their light pollution by installing dark-sky compliant lighting nor by applying it only when needed. The second group seeks to expand demand in order to maximise and perpetuate their profits. They bear the most responsibility because of what they do in order to achieve this end. This is actually achieved by producing lights that make it more difficult to see. If a luminaire is directly visible it forces a change in visual acuity that makes anything less than 1% as luminous appear black. Thus areas not immediately adjacent to the light appear dark, creating what is known as "artificial

darkness;" (Kniffen 2012)[18]. This creates a positive feedback cycle that encourages demand for more and brighter lighting in order to overcome it. Creating artificial darkness is therefore a deliberate attempt to interfere with our vision. In developed areas lots of lights display contrasting areas of brightness and darkness, however dark sky compliant lighting would eliminate artificial darkness by rendering only illuminated areas visible, without revealing the source of the illumination. Outdoor lighting over the past few decades has expanded for only one reason, and this is due to the deliberate policy by the lighting industry of marketing lighting that actually makes it harder to see, thereby motivating demand for more and brighter lighting.

Consequently the standards imposed by the lighting industry, associated professional bodies and municipalities are totally inappropriate and to the detriment of both the environment and human health. The message about bad lighting and how to reduce it has been out for at least twenty years, yet manufacturers continue to churn out vast quantities of bad

lighting that only makes the situation worse. This is despite the fact that better designs have long since been available. Again, those who protest against it are variously dismissed as over-sensitised eccentrics and nerds. If a householder requires darkness within the confines of his/her own property but doesn't get it because of the insensitivity of a municipal lighting authority, then he or she has every right to be over-sensitised. Such cases should always be viewed sympathetically to the satisfaction of the householder, whose needs should take priority.

The intrusion of new lighting schemes into areas previously unlit or dimly lit consequently negates any improvements in lighting design that have already been made. Often, they try to compensate by installing full cut-off lanterns on taller poles, often in clusters, further negating any benefits the new designs provide. The lighting industry and those connected with it are therefore out of control and need to be reined in. It is not disputed that lighting is necessary, but <u>it should only be applied sparingly, on a needs must basis, where needed, when needed, in</u>

the correct amounts, and using appropriate smart lighting technology. New, stringent legislation needs to be enacted to reduce light nuisance and to provide an effective avenue of redress for those adversely affected by it. A consultative body needs to be set up to oversee all lighting schemes, and this needs to be composed of people without any vested interest in the industry, and to redress the needs of those who might be adversely affected.

Fig 1. Solar powered lighting threatens remote areas that would not otherwise be lit. Credit: Greenshine New Energy Ltd., http://www.streetlamp-solar.com/supera-series.html

The introduction of solar powered lighting[19] (fig 1) means that lighting can now be introduced into remote, sensitive rural areas that never otherwise would have been lit. This trend should be discouraged at all costs in order to prevent the environmental degradation of these areas and subsequent loss of biodiversity that will result. Unfortunately local populations living in these areas are ignorant of the adverse environmental effects such lighting would cause. Therefore these areas need to be protected by the creation of dark-sky reserves that proscribe the introduction of indiscriminate lighting, and local populations advised as to how outdoor lighting can be deployed responsibly. They should also be informed about the available options that minimise impact on the environment. Aid organisations working in such areas should also be made aware so that they don't over-react in situations where exterior lighting may be needed. The appeals for street lighting in Mogadishu and after the 2010 Haïtian earthquake are notable examples[20].

One possible solution has recently emerged from the

Netherlands and may well result in conventional street lighting becoming obsolete with the elimination of the T-shaped towers[21] that are such a familiar sight on motorways in the U.K. and elsewhere. This innovation involves smart road lighting developed by Daan Roosgaarde[22,23]. The technology involves the application of high-tech photo-luminescent paint that charges up during the day and then turns on during the night (fig 2). An alternative idea is similar to motion operated lighting that only switches on when vehicles approach, leading to savings in energy when there isn't any traffic. Much of this technology will be applied at ground level, obviating the need for lighting on tall poles that is responsible for much of the obtrusive lighting that exists at the moment. If these ideas catch on then many of the problems created by urban light pollution will be eliminated. The downside of this technology is that the paint deteriorates over time and gets dirty, and does not perform too well in rain or snow[24]. However if these teething problems can be overcome it

Fig 2. Smart Road Lighting: Credit: Studio Roosegaarde. Note: no street lights.

still has great potential. An alternative solution are solar powered LED road studs[25] (fig3). These are totally sustainable, reliable and don't require any maintenance. They can be applied in a


Fig 3. Solar Powered LED road studs. These are very reliable and offer and alternative solution to street lighting in areas where it is not appropriate. Credit: Astucia Traffic Safety Systems.

range of colours and again have the potential to render conventional street lighting obsolete. They could be motion operated, coming on only when traffic is in the immediate vicinity, thereby further reducing any environmental impact.

Before lighting is installed planners should always ask if there are any suitable alternatives. As revealed above, such alternatives are available, but are rarely ever applied because the general consensus of opinion is that lighting is the best solution for road safety and other issues. This view will be encouraged by the lighting industry, so alternative solutions are rarely considered to the detriment of human health and the environment. In many situations road safety can be improved further without naïve recourse to lighting and this can be achieved in the following ways:

a) Cat's eyes (fig 4) and similar reflective devices: (fig 5). Cat's eyes have been around since 1933[26], and once installed will last for many years. They are more effective if the road is not illuminated.

b) Reflective road signs and lane markers. Highly reflective paints for road signs have been around at least since the late 1950's, and can be very striking when illuminated by car headlights. They are very effective and can obviate the need for lighting in many cases.

Fig 4. Cat's Eyes, with their inventor, Percy Shaw. Image: Reflecting Roadstuds Ltd., http://www.percyshawcatseyes.com/history

Fig 5. The reflective devices on this rural road in Saudi Arabia improve road safety substantially and obviate the need for street lighting in these areas. Image: C. Henshaw.

c) Diagonal concrete baffles (fig 6) on the central reservations of motorways, to eliminate the glare of oncoming traffic. Alternatively, crash barriers can be raised to a similar height so they can have the same effect. When combined with the other methods outlined above, the need for lighting on motorways can be eliminated.

Fig 6: Concrete baffles intended for use on a motorway in Egypt. Credit: World Highways. http://www.worldhighways.com/categories/road-markings-barriers-workzone-protection/features/safety-barriers-deliver-valuable-road-user-protection/

d) Speed limits and speed humps in the vicinity of a hazard may also be effective.

All of these methods have advantages. They do not consume energy once installed so they are not wasteful of fossil fuels, nor will they require much maintenance after installation. So, in the

Fig 7. Anti-Light Pollution Street Light suitable for Urban Areas.

This light is motion operated so it only comes on when it is needed.

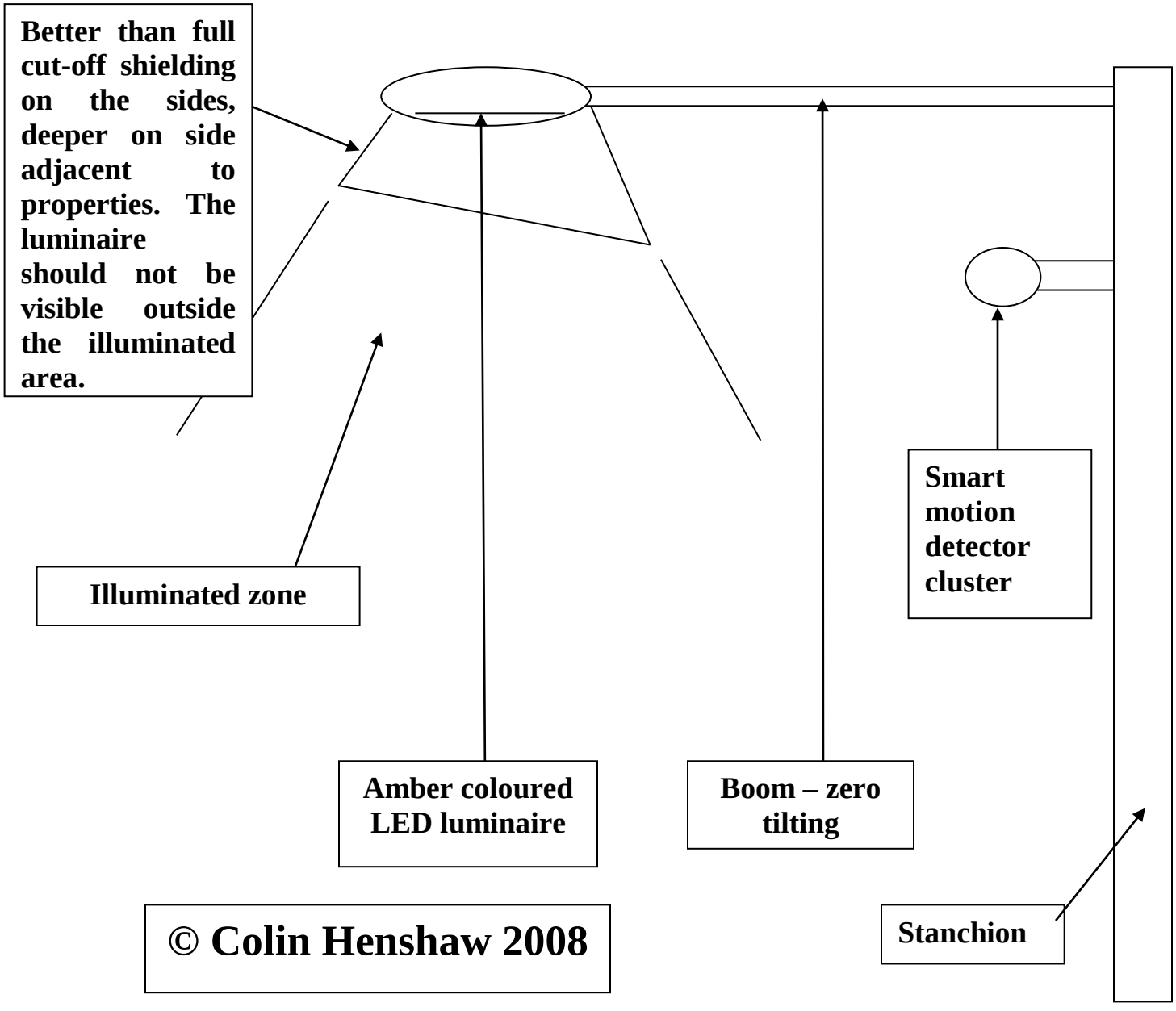
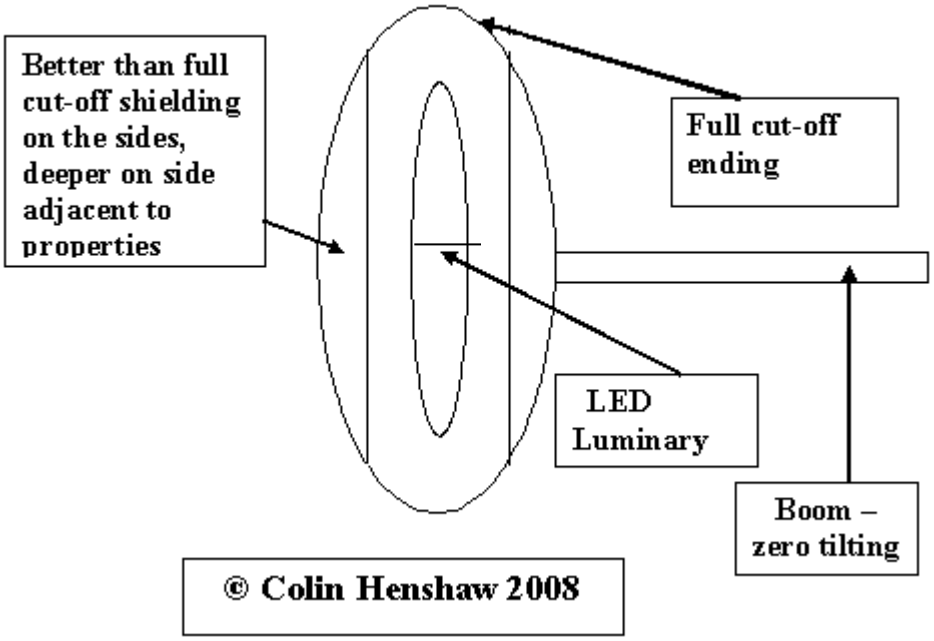


Fig 8. Anti-Light Pollution Street Light suitable for Urban Areas

Underside View of the Luminaire and its Housing



The countersunk amber coloured LED luminaire is split so as only to illuminate the area occupied by the pedestrian. This is controlled by the smart motion detector. The luminaire is fitted perpendicular to the boom and co-axial with the road to fan as much light as possible onto the road surface with minimal leakage outside the target area.

Fig 9. Motion Operated Bollard Light
Front View

Height: no more than three feet (1m). **The light should be vandal-proof but should fall over if involved in a collision with a vehicle.**

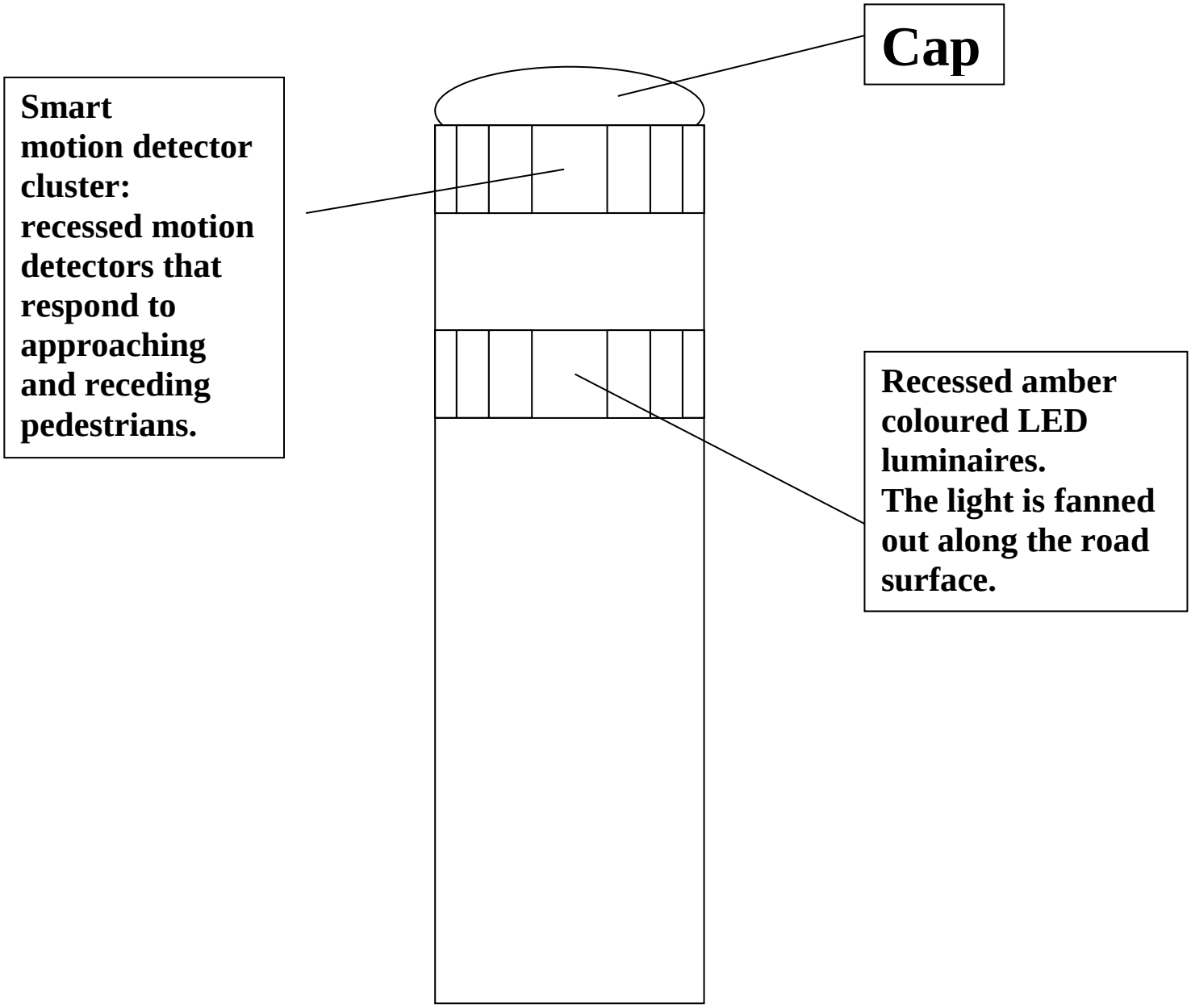
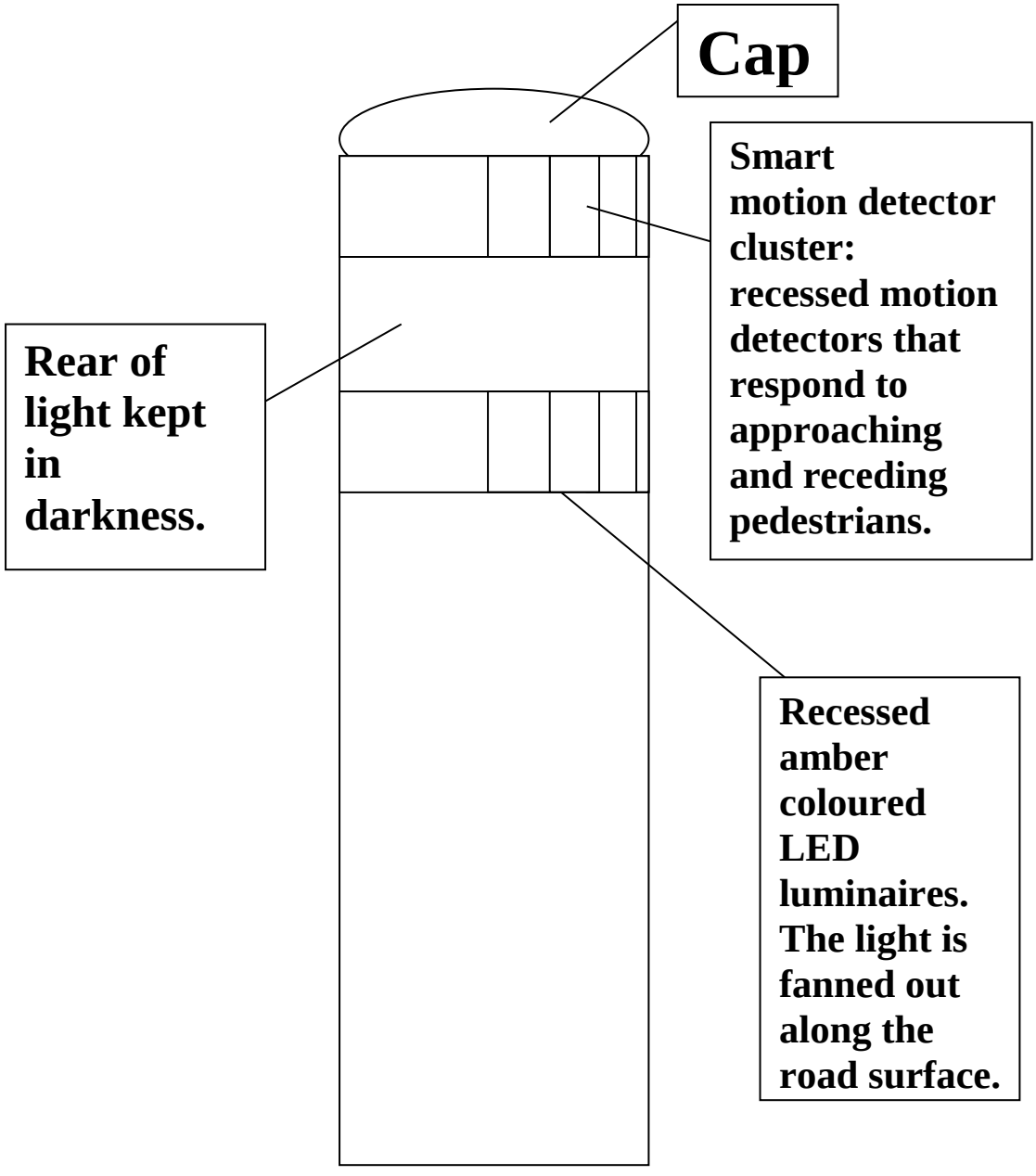


Fig 10. Motion Operated Bollard Light

Side View

Height: no more than three feet (1m)



event that lighting does need to be applied, what is the best option? City centres are best lit up with forty-five degree full cut-off lighting in which the luminaire is countersunk within its housing so it is not visible beyond the illuminated area. Light will not intrude above the horizontal, and unlike ninety degree full cut-off lighting will not illuminate the cloud ceiling that becomes exposed as a result of the Earth's curvature[27]. The luminaire is boomed out over the area to be illuminated in order to reduce the scattering of light off the stanchion. Possible designs are illustrated. (Figs 7 and 8).

In residential and suburban areas, lighting should be <u>subject to curfew and motion operated</u>. It should never exceed first floor height, to prevent intrusion into bedrooms. In areas where vandalism is not a serious issue, robust, low level, motion operated bollard lighting may be more appropriate. (Figs 9 and 10). Individuals adversely affected by public lighting, such as amateur astronomers, should be able to insist on <u>the removal of any public lighting that intrudes onto their properties</u>.

With the possibility of intelligent lighting[28], lighting needs can be personalised. If one has a street light shining into one's bedroom at night and one wants to go to sleep, it should be possible to send an S.M.S. text message that switches it off. This will certainly solve a lot of problems.

One lighting manufacturer[29] is already promoting a lighting solution that addresses many of these issues by incorporating some of the ideas mentioned above. Hopefully their ideas will catch on and light pollution will be substantially reduced in years to come.

4) <u>Vanity Lighting</u>

This is a problem that is again encouraged by the lighting industry as they stand to profit from it. Such lighting includes floodlit buildings (fig 11) and monuments, urban regeneration follies, skybeams and lasers. As opposed to utility lighting that may be construed as useful, this type of lighting does not serve any useful purpose <u>at all</u>. Its apparent function is purely decorative and because it does not serve any useful purpose it

Fig 11. Floodlight municipal building, Istanbul, Turkey. Image: C. Henshaw, September 2013.

adds further to the ecological damage caused by existing lighting and is wasteful of energy and fuel. It is therefore in direct contravention of the environmental mission statements of most local authorities that aim to reduce their impact on the environment. Such lighting is encouraged by the general level of ignorance of business people and elected officials about science and environmental issues, and this leads to the abuse of lighting without them actually being aware of it. Others couldn't care less, being motivated by greed, profit and their own self aggrandisement. Add to this the so-called artists and contractors

drafted in to design and construct such ill-conceived projects. Constituents will not want their hard-earned taxes squandered by ignorant elected officials and business executives on an ego trip. These projects are often construed as "regenerating" depressed areas when in fact they do just the opposite, often degenerating into eyesores after a short period of time. They are frequently expensive, yet local authorities are always expected to cut back on essential services such as health, education, welfare, care for the elderly and state pensions. To redress this problem elected officials should be fully conversant with environmental issues and be accountable for any abuses during their term in office. Those serving on municipal planning committees should be environmentally aware, fully conversant with the environmental impact of lighting, and be prepared to forestall any abuses before they arise. They should also question the cost of such projects to avoid any future embarrassment about squandering money. Public art in itself is not a problem, and there is no attempt here to discourage genuine artistic expression, however it

must be environmentally friendly and this precludes its use of light at night. This is particularly true in residential, suburban, and rural areas where natural darkness should be conserved.

5) <u>Human Health</u>.

It is now recognised that light at night has serious implications for human health[30,31]. It can suppress the production of the hormone melatonin by the pineal gland. Melatonin is a known anti-oxidant that is oncostatic, meaning that it suppresses cancer. It has been shown that the incidence of breast and prostate cancer is lower in areas that are naturally dark, and that blind women show a substantially lower incidence of breast cancer. Low pressure sodium (SOX) lighting is least damaging in this respect, while LED and other forms of lighting with a substantial blue component are the most damaging. The impact of such lighting can be substantially reduced, if in residential and suburban areas it is 45 degree full-cut off, aimed downwards, motion operated and subject to an 11p.m. till dawn curfews. The blue component can be reduced by installing low

colour temperature (ideally not exceeding 2,000K) amber coloured LEDs: (fig 12).

Fig 12. Amber coloured LED light. Credit: A.W. Direct. **http://www.awdirect.com/grommet-mount-led-warning-light-aw-direct-oval-6-1-2quotl-x-2-1-4quoth-amber-lens-ledwic3a/flush-mount-warning-lights/**

The situation was expressed very simply by Guzauskas when he said "Current lighting practice causes Circadian Disruption, and Circadian Disruption causes a much higher incidence of cancers. And cancers can often cause death. So current lighting practice causes death….[32]"

In sensitive individuals lighting can mimic increased summer day-length, causing cravings for carbohydrates leading to obesity and cardiovascular disease.

In urban areas, lighting can interfere with the chemical reactions that clear the air of pollutants discharged by factories and motor vehicles. Nitrates are responsible for breaking down ozone and smog, but lighting destroys them leaving the pollutants

unaffected. Consequently they accumulate in the atmosphere and exacerbate conditions such as asthma, bronchitis, emphysema and cystic fibrosis.

One recent development concerns the formation of nanoparticles through the combustion of fuels used in energy production. One of the worst sources of nanoparticles is energy production through the combustion of organic waste in municipal incinerators. In cities at least nineteen percent of this energy is consumed by outdoor lighting. Consequently lighting must be responsible for a proportionate amount of nanoparticle formation. Nanoparticles are particles about 10μ across that can enter the body through the lungs and the digestive system. Evading the body's defence mechanisms, they can penetrate cell membranes and cross the blood-brain barrier and the placenta. They are capable of carrying toxins to all parts of the body, and have been implicated in cardiovascular disease, asthma, lung fibrosis and Alzheimer's disease. Biomass incinerators also produce carbon monoxide, and oxides of sulphur and nitrogen

that can cause scaring in the lungs. They produce carcinogens such as polycyclic hydrocarbons and dioxin. As with cigarettes these can aggravate respiratory and cardiac conditions. If public lighting is cut back, then the need to produce energy from this source likewise becomes less, resulting in a reduction in nanoparticle formation, associated pollutants and the health problems they cause.

Street lights shining into the bedrooms of children can cause the children to become myopic. Bedroom windows should be fitted with thick, dark curtains and children encouraged to sleep in total darkness. In residential areas any street lighting should not exceed first floor height to prevent light intrusion into houses, even better if it is under curfew and motion operated.

Vanity lighting can also be a problem if residential properties are illuminated, possibly leading to an increase in breast cancer through circadian disruption.

The expansion of lighting systems, particularly in the developing world, will kill off large quantities of insects upon

which the majority of bats feed. Bat populations will then decline. Bats also feed on large numbers of mosquitoes that are not attracted to lighting. As bat populations decline, mosquitoes will then increase in numbers, thereby encouraging the spread of mosquito-borne diseases such as malaria, dengue fever, and Japanese encephalitis in areas where they had previously been eradicated or where they had never existed before.

Unfortunately, avian dinosaurs, usually pigeons, have a propensity to roost on the horizontal booms connecting street light stanchions with their lanterns. This results in an accumulation of guano at the base of every stanchion which at best is unsightly. Pedestrians will not want to walk through middens of guano (fig 13) located under every street light. As opposed to dog fæces that eventually get cleaned up, middens of guano are easily overlooked. This problem may pose a health hazard to road cleaners[33], though the risk is probably minimal if they take proper precautions. The installation of anti-roosting spikes[34] on the horizontal boom will discourage roosting and

therefore minimise the problem .

6) <u>Environmental Issues</u>

The environmental effects of lighting are now well established[35,36], but why should this be a concern? According to industry sources, around nineteen percent of all energy

Fig 13. Midden of guano underneath a street light. Grange Road, Bowdon, Cheshire, England. Image: C. Henshaw, August 2013.

consumption is taken up by municipal lighting, so this will therefore be responsible for a corresponding amount of carbon dioxide emissions. This could well be an under-estimate. In the

Tuscany town of Certaldo, more than 60% of all electricity produced is consumed by street lighting, (Fiaschi et al, 2010)[37]. Other towns and cities are going to be similar or worse, especially in the Middle and Far East, where environmental concerns are of little or no consequence.These increased emissions of carbon dioxide are responsible for climate change that will in turn lead to rising sea levels that will adversely affect coastal communities. Of all the man-made problems affecting the environment, that of unnecessary lighting will be the easiest to solve. Improved smart lighting design, curfews, and motion operated systems will all contribute, as well is legislation to control lighting abuse. In response to energy concerns the lighting industry develops more efficient, brighter lighting in order to appear sensitive to concerns over excessive energy consumption. CFL light bulbs are cheaper to run than incandescents and LEDs are even cheaper[38]. Consequently, incandescents have been largely phased out. However, this in itself does not resolve the issue of light pollution. The

replacement fixtures are often brighter, and if lights become cheaper to run then consumers may be tempted to operate more and brighter lights for the original cost of running one. This is a manifestation of Jevon's Paradox[39], in which there is a tendency to use more of a product and not less as the cost of production goes down. Consequently the demand for cheap lighting outstrips supply causing communities to become increasingly more illuminated[40], to the detriment of the environment. Clarke (2012)[41] again emphasised the negative effects of this improved technology. There is no point in campaigning on the grounds of energy efficiency when it is now possible to save money and energy while simultaneously creating the same or substantially more light pollution as one did before[42]. Despite this, energy wastage still remains a serious concern, and recently the French Government has mandated that all lights inside and outside public buildings, shops and offices should be switched off between 01.00hrs and dawn. In this way they hope to boost France's energy efficiency by 20% by 2020. The proposal

will apply to all French towns, cities, and villages, and is intended to save money and energy, and show "sobriety.[43]" This is a very bold step on behalf of the French Government, and sets a precedent for the rest of the world.

Insects are frequently attracted to lights and will spiral around them until they are too tired either to feed or to procreate. They will then die and their decline in numbers will have concomitant effects on higher order consumers leading to a

Fig 14. The Gegenschein: sunlight reflected from dust particles diametrically opposed to the Sun, located in the plane of the Earth's orbit. It is the very faint glow seen slightly off centre in this image. It is virtually extinct from England due to light pollution, consequently few people have ever seen it. This image was taken from a dark location in Saudi Arabia. Image: C. Henshaw, November 2013.

reduction in biodiversity. Many insects are also important as pollinators. As lighting systems continue to wipe out insect populations, there will be fewer insects available to pollinate crops and other plants. This will cause reduced plant populations and diversity, which will initiate a positive feed-back cycle in which fewer plants will further exacerbate the already declining insect population. Since many crops are dependant on insects, the threat of crop failures becomes worrying especially at a time when the human population is increasing rapidly.

Excessive and unnecessary lighting is annoying amateur and professional astronomers who find it increasingly difficult to operate in or near cities. Even low levels of light pollution will eliminate natural phenomena such as the Milky Way, Zodiacal Light, and Gegenschein, (fig 14), that should always be visible on any dark moonless night. Astronomers, therefore, are like the proverbial canaries in a coal mine, and if they are experiencing difficulties making observations through excessive light pollution, then the world has a serious problem. Municipal

lighting authorities are rarely sympathetic to their needs and will not take the action required when obtrusive lighting violates their homes. This needs to be rectified and any obtrusive lighting removed on request. Condescending attempts to placate astronomers by baffling or shading offending street lights are largely ineffective as scattered light reflected off the ground and adjacent buildings is still going to penetrate. No amount of shading is going to help if a street light is on the opposite side of the road to a property. If municipal lighting authorities continue to remain obstructive over the issue of intrusive street lighting, then the protection of astronomers' observing sites must be enshrined in legislation. This should be applicable as much to an amateur astronomer with a pair of binoculars as it is to a major observatory. However, if common sense prevails and the needs of astronomers accommodated, then this will engender a considerable degree of goodwill amongst the astronomical community, sooth any feelings of resentment and obviate the formation of militant pressure groups. Astronomical observation

is a perfectly justifiable reason for prohibiting obtrusive lighting adjacent to a property. Therefore requests for the removal of obtrusive lighting for this purpose are not unreasonable. The number of active amateur astronomers in the community to whom this applies is actually quite small, so no local authority is going to be overwhelmed with requests to remove lighting. However, when asked to do so they should comply. Astronomers have never suggested that all lights be removed or switched off, but if they ask that their homes and properties should not be illuminated, then this should be respected. The protection of the civil rights of minority interests is nothing new, as has already happened with women, gays, disabled people, and racial and religious minorities, so there is no reason why they cannot be accommodated. Unpolluted darkness at night within the confines of one's property should therefore be regarded as a universal human right. When this right is denied by the lighting industry, municipalities, business interests, or even inconsiderate neighbours, then a human rights violation has occurred. Human

rights violations occur when governments or non-state actors deny or ignore basic human rights including civil, political, cultural[44], social and economic rights. Astronomy has been an integral part of human culture for thousands of years, so the right to participate in it should be protected. This right is inhibited by the unrestricted behaviour of a lighting industry that has been flooding the market with inappropriate lighting for decades. Municipalities are equally culpable through their inappropriate lighting policies and unacceptable lighting standards, and contemptuous attitudes towards complaints. This was seen recently when a plaintiff's complaint was rejected on the grounds of "over-sensitisation.[45]" He was accused of having a history of complaining and the complaint was rejected on the grounds that they are unable to take into account such sensitivities and that they would have to assess the situation "to determine what the average person would find objectionable." They failed to define what an "average" person was. In all probability there is no such thing as everyone is different, so the

term becomes meaningless. The municipality added that any action taken by their part may well be appealed, and if this is subsequently upheld, any appeal lodged would result in a waste of resources and tax-payers' money. Yet they don't seem to have any problem in wasting tax-payers' money on excessive, unnecessary lighting, and crass illuminated art projects. Over-sensitisation is often used a get-out clause to justify inaction and inertia by local authorities, so references to it should be eliminated from any future recommendations and guidelines, as should any other forms of legalistic jargon that mean the same thing. Any challenges to action taken by municipalities to combat light pollution should be denied on environmental grounds alone and appellants made to realise that current levels of lighting are no longer acceptable. If we fail to prevent the next asteroid strike due to all-pervading global light pollution then we will only have ourselves to blame. It is only a matter of time: not a question of if, but when. The apocalypse is out there, so we can't afford to be complacent. The dinosaurs and Chelyabinsk bear witness to that.

Unfortunately campaigning against light pollution on the grounds of energy wastage ultimately becomes a waste of time. As municipalities, industry and consumers become more aware of the environmental concerns of energy wastage, the demand increases for more and more energy efficient lighting. The lighting industry responds by producing more efficient, and brighter forms of lighting that consume less energy. The demand for lighting will increase as the operating costs of lighting go down, so consumers can afford more lights (Jevon's Paradox). Consequently the degree of light pollution increases and this perpetuates its environmental impact. In order to make an impact on the degree of light pollution, public education needs to focus on ecological concerns, public health issues, artificial darkness, wastage of money, and the degradation by outdoor lighting of a range of quality of life issues both for individuals and communities.

Environmental organisations that campaign on behalf of endangered species and against climate change should become

fully aware of the environmental implications of light at night. They should realise that by devastating insect populations it is having a concomitant effect on higher order consumers and plants, so if they really concerned about preserving wildlife they should take a more militant stand against it. Unfortunately many of them fail to appreciate the importance of preserving the night sky. They may pay lip-service to it, but when it comes to taking appropriate action, they fail miserably. They should

Fig 15. Credit: http://www.openairphilly.net/concept

realise that the night sky should be afforded the same kind of protection as any endangered species. Environmental organisations, like the Audubon Society in the United States, should be taking exactly the same stand against light pollution as astronomers. In 2012, their Philadelphia branch was particularly culpable, when instead of condemning it outright, it offered advice to the organisers of a light show (fig 15) that deliberately polluted the skies over the city[46]. The concerns of astronomers are being undermined by the indifference of major environmental groups, which are larger in number and have more clout. Greenpeace and Friends of the Earth are a case in point. They are very vociferous about protecting the environment and combating climate change, but when approached on dark-sky conservation issues they don't want to know. They should realise that light at night is just as much a pollutant as any form of toxic waste. Light pollution is a major contributor to climate change, yet they fail to realise that and do nothing about it.

7) The Economics of Light at Night

One industry source states that street lighting takes up thirty-eight percent of a municipality's budget[47] while another says it is as high as sixty percent, amounting to around 59,760TWh per year in Europe[48]. This does not include commercial lighting or lighting from other sources. Obviously then, current lighting practices are very wasteful, both in financial terms, and in terms of fuel efficiency. Improved fuel efficiency translates into reduced carbon dioxide emissions. Savings can be made by the installation of more efficient, smart light fittings that throw all the light on the area intended to be illuminated, rather than up into the sky. If such technology could be universally implemented, then lower wattage lighting can be installed and much of this waste eliminated without causing lack of amenity. This will lead to considerable financial savings, and the money redeployed into essential areas frequently exposed to cut-backs such as health, education, welfare, pensions and sensible urban regeneration.

One of the causes of increased light pollution is economic growth. However, economic growth such as we see now is unsustainable as the planet's natural resources are finite. Unfortunately economists and governments fail to realise that and continue to base their economic policies on economic growth in the erroneous belief that it stimulates development and alleviates poverty. Economists don't see any limit on economic growth, while governments fear anything that threatens it. They pour thousands of millions of pounds, euros or dollars into a failing financial system that continues to jump from one economic crisis to another. With economic growth and the population explosion continuing as they are, the two feed back on each other to the continued detriment of the environment. Unfortunately green values seem unable to compete against the myopic capitalist ethic of fast returns[49]. A steady state economic solution[50] is therefore required that does not consume the Earth's resources faster than the Earth can provide them. Some even advocate degrowth[51] in order for this objective to be

achieved. If nothing is done we will travel headlong into an environmental disaster and the curse of poverty will remain along with the potential for conflict in the future.

In the U.K. a petition has been set up[52] campaigning to get illuminated signs switched off at midnight, on the grounds of light pollution and wastage of fossil fuels. A single illuminated advertising hoarding at a bus stop consumes 491,000 kWh of electricity per annum, releasing 257 tonnes of carbon dioxide[53] into the atmosphere. This begs the question as to why they should be illuminated in the first place as all they do is damage the environment. The money spent in keeping them lit up could better spent elsewhere. Instead of switching them off, they should be totally replaced with hoardings that don't consume energy. Businesses can't complain as they will all be on a level playing field.

One way in which commercial and domestic outdoor lighting could be curtailed is to levy and outdoor light tax[54], similar in principle to the window tax that was introduced in

Victorian times. A sliding scale could be applied depending on the wattage and luminance of the lighting installed. The municipality would then benefit from the extra revenue. However, to avoid paying the tax the Victorians bricked up surplus windows. If people had to pay a tax on outdoor lighting, they would certainly think twice about installing more than is absolutely necessary. Inessential lighting could be reduced further if municipalities required planning permission to install an outside light. The application would then have to go before a planning committee that would assess the environmental impact of the light. The committee would have to decide whether or not the light complies to environmental standards and whether or not it is actually needed. If planning permission is required then people would again think twice and this would forestall the frivolous abuse of lighting.

In recent years, efforts have been made to promote judicious energy usage through the world-wide celebration of Earth Hour[55]. Earth Hour was initiated by the World Wildlife

Fund in 2007, starting with Sydney, and is held every year on the last Saturday in March. Municipalities undertake to switch off all non-essential lighting between 20.30 and 21.30 local time. In

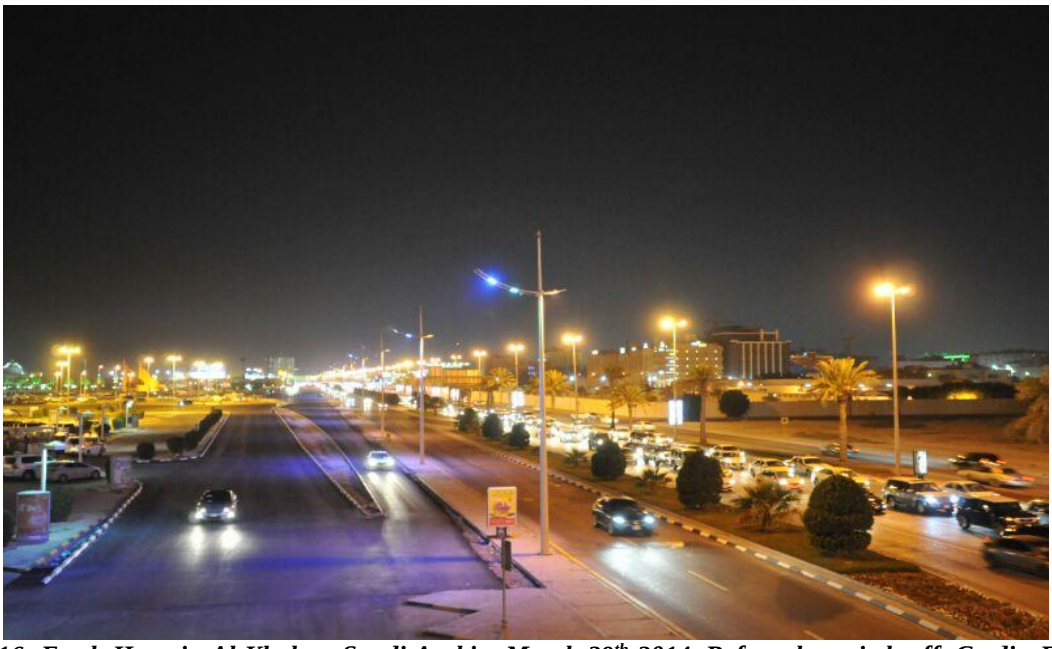


Fig 16: Earth Hour in Al Khobar, Saudi Arabia. March 29th 2014. Before the switch-off. Credit: Esam Al Mulla, Al Khobar Municipality President.

Fig 17: Earth Hour in Al Khobar, Saudi Arabia. March 29th 2014. After the switch-off. Credit: Esam Al Mulla, Al Khobar Municipality President. This image demonstrates that if excessive lighting can be switched off for one hour without loss of amenity, then it can be switched off indefinitely.

2014 in Saudi Arabia, ten thousand street lights were switched off in Dhahran and a further seven thousand in Dammam (figs 16 and 17). Other cities that participated included Jizan, Yanbu, Ha'il, Riyadh and Jeddah[56]. Though good in principle, Earth Hour actually demonstrates that if we can survive without this inessential lighting for an hour without loss of amenity, then it further demonstrates that all this excessive lighting was never necessary in the first place[57,58]. In the interests of the environment and our own ultimate well-being we should strive to make Earth Hour permanent.

Crass vanity projects proposed by incompetent municipalities and commercial interests often cost hundreds of thousands of pounds/dollars/euros. Constituents will not want to see their taxes spent on such projects when they see essential services such as health, education, welfare, care for the elderly and state pensions repeatedly threatened with cut-backs. In addition such ill-conceived projects bring local authorities into disrepute and public ridicule. Fortunately these projects are often

publicised in the local media and several have been overturned by a groundswell of public opinion.

Conclusions

It has been clearly demonstrated that Light at Night, (and the light pollution resulting from it) has serious social implications that must be redressed in order to improve the quality of life of communities both large and small. It has serious environmental and health implications, but apart from a few enlightened individuals, few perceive it as a threat. Those who try to act against it are up against powerful commercial, business and municipal interests that are reluctant to change their behaviour in spite of the evidence. The Institution of Lighting Professionals recently referred to the Essex street lighting switch-off as "a knee-jerk response to climate change and energy cost increases, which could decrease road safety and public security – and court unpopularity from the local electorate[59]." Here they are continuing to exploit fears about safety and security in order to maintain the status quo. Clearly, the profit motive continues to

override efforts to protect of the environment. Lighting intended for outdoor use should always meet standards that minimise its environmental impact. Such lighting, outlined above, has been around for about twenty years, though it is rarely applied, and bad lighting continues to be manufactured. The lighting industry should only manufacture outdoor lighting that meets these environmental standards, and if it does not self-regulate then legislation will need to be enacted. Hopefully new smart lighting technology emerging from the U.K. and Netherlands will revolutionise road lighting and eliminate many of the light pollution problems caused by conventional street lighting, and render it obsolete.

Unfortunately for those campaigning against the problem 99.99% of the population couldn't care less if they can see stars or not. Furthermore, it is now known that street lighting is expanding globally at a rate of 6% per annum[60]. In the United States, shipments of LED lights for use in street lighting and other applications that require a higher brightness are

expected to rise by a compound annual growth rate of 14%[61] between 2014 and 2017. As more and more LED lighting comes online, the rest of the world will follow. Before the situation can improve, a universal culture change is required in public attitudes towards outdoor lighting. This will only come through education and public outreach campaigns, backed up by legislation. Emphasis should be laid more on ecological damage, medical implications, artificial darkness, wastage of money and quality of life issues, though the wastefulness of current lighting practices in terms of energy efficiency still remains a serious concern. This will not be impossible to achieve, though the road ahead will be difficult. The French Government has already made significant steps in this direction that set an excellent example for the rest of the world. In the Shetland Islands[62], the local authority is already removing street lights, not only to save money, but also in response to popular demand. Similar paradigm shifts have already been seen in public attitudes towards drink-driving, the wearing of seat-belts and crash

helmets, vivisection and blood sports, though it took many years of campaigning and parliamentary debate before success was achieved. One can only hope in this case the tide can be turned soon, before it is too late to repair the damage to the environment that will inevitably occur. Significant numbers of people need to be convinced about the rectitude of arguments against excessive municipal, security and commercial lighting otherwise campaigns against it may be construed as tyranny by a minority[63]. This is often cited as an argument against lighting management and it should be avoided at all costs.

As less lighting becomes necessary through the judicious application of lighting, some lighting companies may fold and municipal lighting departments will need to be downsized. This will inevitably cause some unemployment. However those currently employed by the industry will have skills that are marketable elsewhere, so it shouldn't take too long for them to find alternative employment. They should also consider the ethics of working in an industry that has such a cavalier attitude to the

environment, human health and human rights.

Though night-time lighting is an essential part of the urban scene, it must be applied in such a way that it does not impinge adversely on the environment and individuals. The way forward has been clearly demonstrated but if the advice offered here is not universally adopted then all communities are going to suffer in the long term. Now that the magnitude of the problem has been revealed, those in power cannot claim plausible deniability. Instead of promoting international conferences that achieve little, governments and municipalities concerned about energy wastage and carbon emissions can do no better than to eliminate all unnecessary lighting and legislate against abuse. Only then can they claim to be making progress. Developing countries desirous of providing amenity lighting for their citizens should do so in such a way that it has minimal impact on the environment, otherwise pristine natural environments may be compromised that otherwise would have remained dark.

If global light pollution is not substantially reduced then we

may miss the next major asteroid strike, possibly with disastrous consequences. Though largely beyond present human experience, geological evidence indicates that these have occurred numerous times in the past, and it is only a matter of time before it happens again. We need to be able to detect these objects before they arrive so appropriate remedial action can be taken. Inertia by local and national governments should not be allowed to impede the work of astronomers, (both amateur and professional) who are in a position to detect and monitor these objects before they arrive.

Light pollution is clearly a symptom of a sick planet with humans being the ætiological agents responsible. We may never eliminate it entirely, but we have the means at our disposal to mitigate its worst effects and restore curative darkness to the natural world where it belongs. Massive outpourings of wasted energy are taking their toll right across the ecological spectrum. Inter-governmental procrastination may lead to disaster and if we don't seize the opportunity to rectify it now, the environment

and the universe may pay us back in ways we cannot imagine[64].

Acknowledgements:

The author is indebted to Doug Kniffen for his invaluable contribution over the issue of artificial darkness.

Declarations:

Funding: none.

Competing Interests: three declared;

1) The Lighting Industry: if they consider the findings compromise their profits and jobs.

2) Municipal councils: since their lighting practices are called into question.

3) Businesses involved in the marketing and application of unnecessary and inappropriate forms of lighting.

Ethical approval: none required.

References:

1) Clean Neighbourhoods and Environment Act 2005. Statutory Nuisance: Lighting.
http://www.legislation.gov.uk/ukpga/2005/16/section/102

2) Light Pollution Endangers Our security and Our Safety.
http://physics.fau.edu/observatory/lightpol-security.html

3) Clark, B. A. J. Outdoor Lighting and Crime, Part 2: Coupled Growth. Version of 2003-05-23.
http://asv.org.au/downloads/Outdoor%20Lighting%20and%20Crime,%20Part%202.pdf

4) Burglars afraid of the dark? Crime falls when Bristol street lights are turned off. http://www.thisisbristol.co.uk/Burglars-afraid-dark-Crime-falls-Bristol-street/story-13952633-detail/story.html

5) Usborne S., Galaxy Quest: The Search for Britain's Darkest Skies. The Independent, January 5th., 2010.
http://www.independent.co.uk/travel/uk/galaxy-quest-the-search-for-britainrsquos-darkest-skies-1857687.html

6) David P. Farrington and Brandon C. Welsh. Home Office Research Study 251. August 2002.
http://www.delscope.demon.co.uk/information/lightpollution.htm

7) Painter, K. A. and Farrington D. P., Evaluating Situational Crime Prevention Using a Young People's Survey.
http://bjc.oxfordjournals.org/content/41/2/266.abstract

8) Private Eye No. 1142, p28, 30 Sept 2005.
http://www.radstats.org.uk/no091/PrivateEye.pdf

9) Atkins S., Husain S., and Storey A., The Influence of Street Lighting on Crime and Fear of Crime.
http://www.celfosc.org/news/southampton.htm

10) Marchant, P., What is the contribution of street lighting to keeping us safe? An investigation into a policy.
http://www.radstats.org.uk/no102/Marchant102.pdf

11) Koninklinjke Philips Electronics NV. 2008 White Light – Transforming your urban nightscape.
http://www.lighting.philips.com/pwc_li/main/shared/assets/downloads/PHIPR006-03_53621_White%20Light%20BR%20A4_UK_def.pdf

12) Mitchell, John, quoted by Lilley, Ray. The Columbian, 03-08-1998. Criminals take a break in blacked-out Auckland.
http://www.highbeam.com/doc/1P1-5702801.html

13) Streetlights bring normality to Mogadishu.
http://www.bbc.co.uk/news/world-africa-22492135

14) Welcome to the Somali Police.
http://www.police.somaligov.net/Community%20Policing%20.html

15) Mizon, R., Re: [CFDS] Rugby lights switch off.
http://tech.groups.yahoo.com/group/CFDS/message/13795

16) Bullough, J., "Adaptive high-beam headlamps could allow drivers to see at night without a need for as much roadway lighting"
http://www.drivingvisionnews.com/news/news-home/51-editorial/2430-adaptive-high-beam-headlamps-could-allow-drivers-to-see-at-night-without-a-need-for-as-much-roadway-lighting

17) Street Lighting - Questions and Answers (PDF 149KB).
http://www.cheshireeast.gov.uk/transport_and_travel/highways_and_roads/streets_and_traffic/street_lighting.aspx

18) Kniffen, D. DarkSkies Communities Forem, April 2012.
http://groups.yahoo.com/group/DarkSkyCommunities/message/2538

19) Shenzhen Century Sunshine Lighting Co., Ltd.
http://www.chinacsky.com/product/1620946/high_power_solar_led_street_light_5_years_warranty.htm

20) Padgett, T., and Ferreira, S., Haiti Three Years After The Quake: There's Good News, Too.
http://world.time.com/2013/01/12/haiti-three-years-after-the-quake-theres-good-news-too/

21) Glow in the dark roads to debut in 2013

http://www.telegraph.co.uk/motoring/motoringvideo/9788107/Glow-in-the-dark-roads-to-debut-in-2013.html

22) Smart Highway http://www.studioroosegaarde.net/project/smart-highway/info/

23) Smart Highway http://www.studioroosegaarde.net/project/smart-highway/photo/#smart-highway

24) Pas, F. Re: 19285 [OL Forum Glow in the dark road.]

https://groups.yahoo.com/neo/groups/OutdoorLighting-Forum/conversations/messages/19285

25) Astucia Traffic Systems. SolarLite F Series Flush Road Studs.

http://www.clearviewtraffic.com/astucia/products-astucia/art/22/solarlite-f-series-flush-road-studs.htm

26) West Yorkshire's role in history, http://news.bbc.co.uk/local/bradford/hi/people_and_places/history/newsid_8454000/8454492.stm

27) Henshaw, C., The Medical Implications of Light at Night (LAN) (unpublished).

28) Winterman, D., Light Pollution: Is there a Solution?

http://www.bbc.co.uk/news/magazine-16470744

29) Tvilight Intelligent Lighting. http://www.tvilight.com/skylite/ ,

http://youtu.be/Vt6iVS0zqZ4

30) as 27)

31) Council of Europe Parliamentary Resolution 1776. http://assembly.coe.int/Main.asp?link=/Documents/AdoptedText/ta10/ERES1776.htm

32) Guzauskas, R., The IDA is out of focus. Yahoogroups DarkSky Communities. March 17th 2013.
http://groups.yahoo.com/group/DarkSkyCommunities/message/2966

33) Control of Health Hazards Associated with Bird and Bat Droppings.
http://www.cdc.gov/niosh/nas/rdrp/appendices/chapter6/a6-133.pdf

34) Cleaning – How important is it? Pigeons & Disease.
http://www.pigeoncontrolresourcecentre.org/html/cleaning-pigeon-droppings.html

35) Henshaw, C., The Ecological Consequences of Light at Night. (Unpublished). https://independent.academia.edu/ColinHenshaw

36) as 31.

37) Fiaschi, D., Bandinelli, R., Conti, S., A case study for energy issues of public buildings and utilities in a small municipality: Investigation of possible improvements and integration with renewables. Applied Energy, *97*, 101 – 114, September 2012.
http://www.sciencedirect.com/science/article/pii/S0306261912002012

38) The True Cost Of Light Bulbs: LED vs CFL vs Incandescent.
http://greenlivingideas.com/2015/02/19/the-true-cost-of-light-bulbs-led-cfl-incandescent/

39) York, R., Ecological Paradoxes: William Stanley Jevons and the Paperless Office.
www.humanecologyreview.org/pastissues/her132/york.pdf

40) International Dark Sky Association: 5 Popular Myths About LED Streetlights. 2016. http://darksky.org/5-popular-myths-about-led-streetlights/

41) Clark, P., Beware technology bearing gifts; turn off the light.
http://www.eetimes.com/electronics-news/4391981/Beware-technology-bearing-gifts

42) Citro, G. Re: new champion in Chicago for Starlight preservation.
http://groups.yahoo.com/group/DarkSkyCommunities/message/2607

43) France to mandate turning off lights at night to save energy. http://www.foxnews.com/world/2012/12/29/france-to-mandate-turning-lights-off-at-night-to-save-energy/?intcmp=obinsite

44) The United Nations International Covenant on Economic, Social and Cultural Rights. http://www.hrweb.org/legal/escr.html

45) Edwards, Mark. Rejected Light Nuisance Complaint, CfDS Yahoogroups Forum. 03-01-2012. http://tech.groups.yahoo.com/group/CFDS/message/13237

46) Open Air. http://www.openairphilly.net/concept

47) USAID/India. http://eco3.org/wp-content/plugins/downloads-manager/upload/Energy%20Efficient%20Street%20Lighting%20Guidelines.pdf

48) E-Street Project Report: Intelligent Road and Street Lighting in Europe. http://www.e-streetlight.com/Documents/Homepage/E-street%20Project%20Report%2005_157.pdf

49) Special report: How our economy is killing the Earth. http://www.newscientist.com/article/mg20026786.000-special-report-how-our-economy-is-killing-the-earth.html

50) Steady State Economy http://www.investopedia.com/terms/s/steady-state-economy.asp

51) Ashton, G. What is Economic Degrowth? http://en.demagazine.eu/sharing-ideas/what-economic-degrowth

52) Lambeth Friends of the Earth. Switch illuminated advertisements off after midnight. http://www.change.org/en-GB/petitions/switch-illuminated-advertisements-off-after-midnight

53) Pickles, E. We want illuminated advertisements to be switched off between midnight and 5am. http://www.foe.co.uk/campaignhubs/index.php?topic=2108.0

54) Edwards, Mark. Will you turn your lights off on March 29th? https://groups.yahoo.com/neo/groups/cfds/conversations/messages/14049

55) http://www.earthhour.org/

56) http://sabq.org/Q0Vfde

57) Henshaw, C. https://groups.yahoo.com/neo/groups/CFDS/conversations/messages/14043

58) Henshaw, C. https://groups.yahoo.com/neo/groups/CFDS/conversations/messages/14046

59) Institution of Lighting Professionals News Archive: Don't Switch Off – Invest to Save Energy. http://www.theilp.org.uk/index.php?mact=News,cntnt01,detail,0&cntnt01articleid=50&cntnt01returnid=51

60) Street lights disrupt ecosystem, says beetle study. http://www.google.com/hostednews/afp/article/ALeqM5jbaDdyziBgWN2bVUZgLqzzXxocuQ?docId=CNG.95ec130f9bc7e13b1b72c5bf3e9e0349.741

61) SSL Design News Staff. Streetlights to Power Demand for High-Power LED Shipments Through 2017, according to NPD DisplaySearch. http://www.lightimes.com/documents/view/generic.php?id=124195#top

62) Marter, H. J., Lights out, Shetland News, June 26th, 2013. http://www.shetnews.co.uk/newsbites/7010-lights-out

63) Guzauskas, R., New champion in Chicago for Starlight Preservation. http://groups.yahoo.com/group/DarkSkyCommunities/message/2608

64) Schwartz, P., and Randall, D. 2003. An Abrupt Climate Change Scenario and Its Implications for United States National Security http://www.futurebrief.com/dod-climate.pdf