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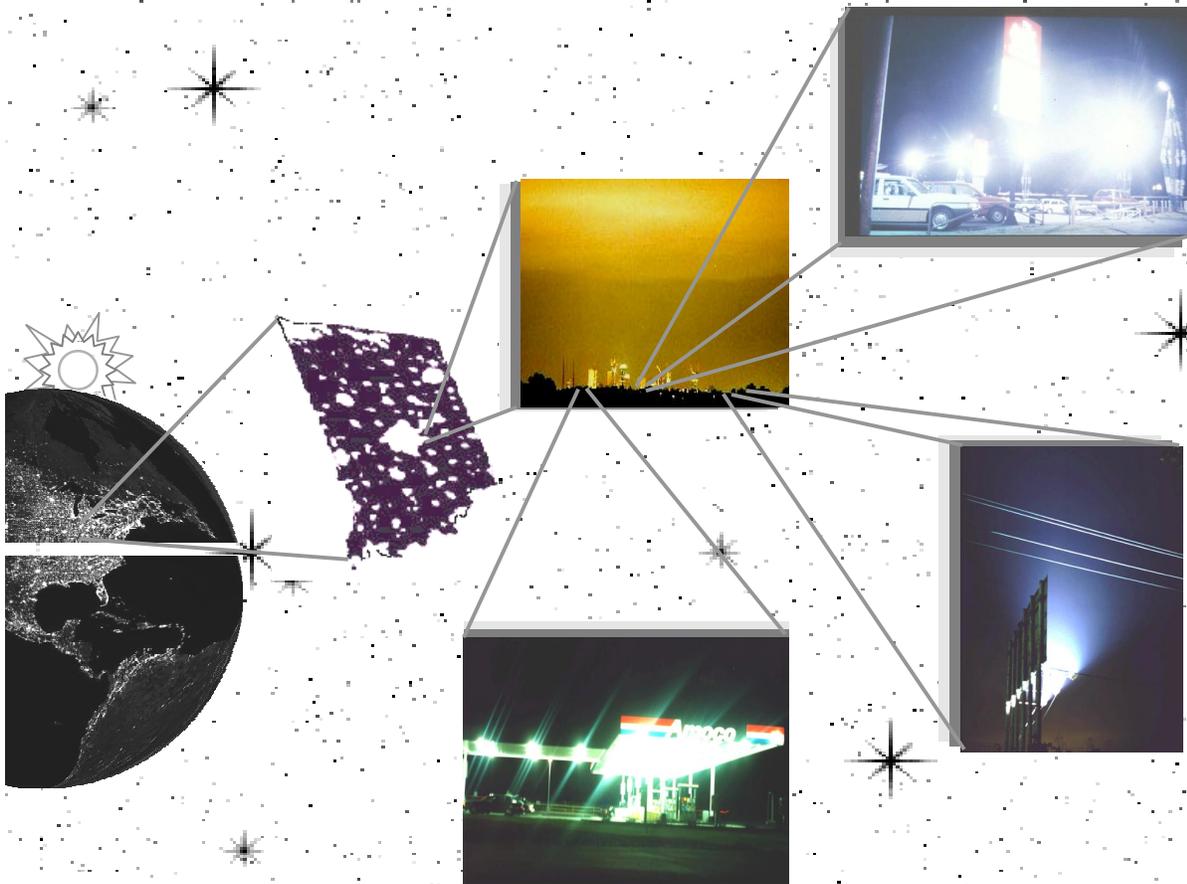
THE INDIANA COUNCIL ON OUTDOOR LIGHTING EDUCATION

ICOLE

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Outdoor Lighting Practices in the State of Indiana:

*Opportunities to Save Millions of Dollars, Reduce Nuisance, Improve Safety,
Protect the Environment, and Preserve our Natural Heritage, Through the
Effective Use of Outdoor Lighting.*



"Perhaps the sentiments contained in the following pages, are not yet sufficiently fashionable to procure them as general favor; a long habit of not thinking a thing wrong, gives it a superficial appearance of being right, and raises at first a formidable outcry in deference of custom. But the tumult soon subsides. Time makes more converts than reason."

*Introduction to Common Sense
by Thomas Paine
February 14, 1776*

Outdoor Lighting Practices in the State of Indiana

Introduction

- A. Outdoor Lighting and Night Vision**
- B. The Ratcheting of Commercial Site Lighting**
- C. Roadway Lighting**
- D. Illuminated Signs**
- E. Effectiveness of Lighting on Crime**
- F. Myth-driven Use of Outdoor Lighting (more on lighting and crime)**
- G. Impacts on the Environment and Human Health.**
- H. Impacts on Quality of Life**

CONCLUSIONS AND RECOMMENDATIONS

Appendix

References

Introduction

In the last half of the twentieth century, outdoor lighting slowly became an integral part of nighttime in Indiana. Few locations in the state host nighttime views void of at least one shining outdoor luminaire. Paralleling this growth in lighting is a growing discussion among lighting engineers and researchers, lighting manufactures, community planners, environmentalists, neighborhood groups, medical researchers, and increasingly in the media, about trends in outdoor lighting's use and the impacts of those trends.

The discussions reflect growing awareness that the indiscriminant use of poorly planned, poorly designed outdoor lighting creates many problems. The cost savings available by addressing inefficient, wasteful outdoor lighting practices dwarfs that which daylight savings time advocates say would result from a one-hour time shift, for one-half of the year, for some of the state. Dusk-to-dawn, statewide, year-around, misdirected and excessive outdoor lighting costs Indiana taxpayers and electric ratepayers over \$100 million annually in wasted electricity (Appendix) and adds commensurate tons of pollution emissions generated by electricity production (Appendix, Table A.) Discomforting or disabling glare exacerbated by sprawl and retailer competition for driver attention threatens public safety, harms flora and fauna, and creates nuisance. Local ordinances sometimes contain provisions intended to provide relief from "light trespass," occurring when illumination is directed across property lines. Recent research into night lighting's affects on humans suggests serious health concerns.

Indiana astronomers recognized a problem on our nocturnal horizon many years ago.¹ Poor directional control of excessively bright lamps, in luminaires often too numerous for the task result in the illumination of the atmosphere, creating "urban sky glow." Its impact is proportional to the intensity of the misdirected light and its proximity to the observer. In a 1971 article² in the Indianapolis Star, Dr. Martin Burkhead, professor emeritus, Indiana University Astronomy Dept., raised concerns about urban sky glow's negative impact on IU's astronomy facilities. Since then scientific research, academic standing, high tech investment, and high tech jobs left Indiana as a direct result of our growing light pollution.³

In 1998 IU Astronomy chair Dr. Kent Honeycutt remarked in a newspaper article that many incoming astronomy students had never seen the Milky Way.⁴ The flag of the state in which they study contains stars, while the stars in its sky continue to disappear in an ever-brighter night sky. It begs the question, will our heritage of starry night skies always be reflected in our poetry, literature, and music, and will we always be inspired to ponder the stars and our place among them. If not, how will that affect us?

Satellite images (Appendix, Image 1) reveal the problem. It is pervasive and without boundaries. Many other states and nations are acting on this problem, which still awaits greater awareness in Indiana. This report details ICOLE's continuing observations of outdoor lighting practices in our communities and on our roadways, and problems sometimes associated with those practices. It discusses methods for minimizing unwanted impacts while providing needed lighting, cost reduction, preservation of the environment and our quality of life, and public health and safety. It proposes better ways to use outdoor lighting through which everyone wins.

A. Outdoor Lighting and Night Vision

Outdoor lighting is often simultaneously beneficial and detrimental to our vision at night. Human eyes are designed to see very well in low light and in a very wide range of illumination. Bright sunlight is up to one trillion times brighter than the minimum light required for human vision.⁵ But adapting to changes within this range requires time. Finding our way upon entering a dark movie theatre for the matinee on a bright sunny day is much more difficult than finding the exit because our eyes adapt to the lower light level during the movie. Departing the theatre, we feel eye strain as our pupils constrict like a camera lens guarding against over-exposure and as the light-sensitivity promoting photopigment rhodopsin recedes, or is "bleached," from our retinas by a flood of photons from the sun. This same adjustment process occurs in the night environment when we encounter intense lighting such as at a gas station. We depart such an area with desensitized eyes, entering a road that appears dark until we regain sensitivity. Re-adapting to low light takes time even for young eyes. Older people can require several hundred feet of roadway.⁶

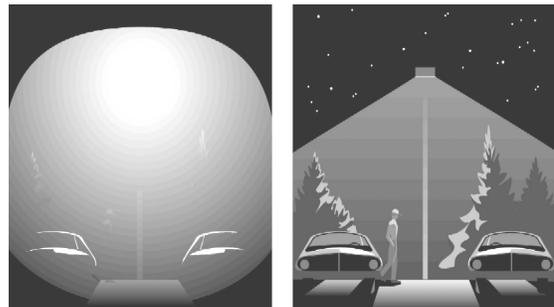
We adapt to a wide range of illumination but we have a limited ability to process visual information simultaneously from areas illuminated at differing levels. For example, bright stage lights make actors highly visible to each other, but make the audience practically invisible to the actors. Bright gas stations also create this effect. To a lesser extent, a typical porch light also improves a homeowner's vision of a visitor nearing his home but reduces the distance at which the approaching visitor can be seen. Nighttime illumination from outdoor light fixtures make the area near the fixture more visible (if located or shielded so as to not create excessive glare) but make the surrounding area less visible. This presents a dilemma for roadway illumination. A street light providing better vision of a section of roadway can diminish driver vision beyond that section, down intersecting roads, and of potential roadside obstacles such as pedestrians or deer. Accordingly, rural street lighting is usually not beneficial.

Optometrists and illuminating engineers refer to the counterproductive effect from an excessively bright light source as "veiling luminance" or "disability glare." Kathleen Ryan and Michael Munson write in the *Outdoor Lighting Manual for Vermont Municipalities*:

Disability glare (sometimes called veiling luminance) occurs when stray, misdirected light enters the eye and passes through the vitreous humor, a liquid in the inner eye. This medium contains impurities which scatter incident light and spread it across the retina like a veil, reducing contrasts and thereby reducing the visibility of images. As with sunlight on a computer screen, contrasts become washed out and images become hard to see. As the eye ages, disability glare becomes more of a problem. This is one reason older people sometimes find it difficult to drive at night.

Glare and Veiling luminance

Intense unshielded light sources create a veiling effect upon vision. A photograph cannot cause the discomfort we experience when viewing an intense light source. We can stare at photos of the sun. Photographs of scenes that include a bright light source also reveal details obscured to an observer by veiling luminance, such as in the illustration on the left. The illustration on the right shows that shielding drastically reduces glare, revealing details barely visible without the shielding.



Illustrations courtesy Bob Crelin, Branford, CT

Cinergy PSI has also provided information that warns consumers about glare. It distributed a brochure to 600,000 customer addresses, called "Be Aware, Think About Glare." It states in part:

Outdoor lighting may, under certain circumstances, create unique problems many of us fail to realize. Neighbors may be bothered by light spillage from your property or business. Improperly designed lighting may also diminish a driver's night vision.



Lighting designs often lack consideration for veiling luminance. It is particularly noticeable with globe type streetlights ironically referred to as "pedestrian" lights. Unfortunately, many communities have installed globe type "acorn" luminaires that were fashionable decades ago. Frequently such a fixture is chosen for historic authenticity, nostalgia, or to achieve a period look. These fixtures can be quite attractive by day but tend to be very expensive per unit. According to Loogootee Mayor Brian Ader, the installation of similar lights in his city cost approximately \$700,000 in a small area of the center of town, with each luminaire costing an incredible \$5,000 each, installed.



Acorn fixture

They provide such poor light distribution angles that visibility is terrible if the poles are not spaced quite closely, resulting in an even more costly installation and energy inefficiency. A state-of-the-art, high intensity discharge lamp installed in these "antique" luminaires can be as overpowering as a racing engine in a Model T. Substantial glare and veiling luminance are the result. These fixtures should only be used for decorative purposes with very low intensity lamps and accompanied with well-designed full cutoff fixtures to address any illumination needs. They are best suited for use indoor such as at a shopping mall. Due to concerns about liability, the city of Lawrenceburg decided to order special internal shields for the acorn street lights it installed. Such shields reduce a portion of the excess glare from a fixture of this design.



The acorn lamp is easy to see, but do you see the person standing beside it?

B. The Ratcheting of Commercial Site Lighting

Commercial lighting applications have historically included the use of colored accent lighting; neon tube lighting, colored panels such as for signs, and lighting that flashes or simulates motion, all to attract attention. Many local ordinances restrict such lighting to reduce nuisance, driver distraction, and diminished community aesthetics.

In recent years a trend referred to by lighting professionals⁷ as "ratcheting" has emerged regarding commercial use of non-colored outdoor light. The intensity, or brightness, of parking lot lighting, floodlighting, area lighting, and security lighting has greatly increased. There is also a much greater use of floodlighting to illuminate building facades, often by a luminaire inappropriately called a "directional" fixture by some (see Appendix, Image 9.) Security is often the reason cited for this ratcheted illumination. The evidence does not support the claim that brighter lighting reduces crime (see Section E.) Gas stations/convenience stores (front cover bottom image) are the most prominent example of ratcheted lighting, some spurring the adoption of local ordinance.⁸ The country's foremost authority on lighting design, the Illuminating Engineering Society of North America (IES), recommends that the illumination level of an exterior area should not exceed that of its surroundings by more than a factor of ten.⁹ Typically, gas station/convenience stores grossly exceed that recommendation. Neighboring businesses are required to follow suit, lest they be cast in relative darkness, and streets require brighter, tax-funded street lights.

Marketing literature¹⁰ often promotes brighter lighting as a means to increase store "profile." In effect, a floodlit building facade bearing a company's name or marketing slogan is a very large illuminated sign. A community may wish to illuminate some buildings of unique significance, such as a courthouse, and minimize outdoor advertising intrusiveness. The routine bright illumination of commercial building facades undermines both of those goals.

Research shows light affects our mood and behavior. Seasonal Affective Disorder, or SAD, is a condition characterized by depression and low energy during winter's short daylight hours. SAD patients have responded favorably to doses of artificial light. In his presentation at the lighting industry's premier trade show in 2000, LightFair International, Italian lighting designer Walter Amort spoke of high intensity lighting's tendency to exert pressure on customers to shop faster and generate higher revenues. The president of the Ohio section of the IES stated at a 1998 Columbus, OH, lighting forum that retailers refer to consumer attraction to bright light as "the moth effect."

As discussed in Section A, bright outdoor lighting inherently conflicts with human visual acuity in nighttime's low light levels. When illumination levels are increased, the eye becomes desensitized to light, substantially defeating the intended affect of brighter illumination. The cost of ratcheted lighting reflected in consumer prices adds yet another cost of poor lighting practices.

Lighting such as this is useful only for advertising purposes. Many businesses leave such lighting on all night long. Area homeowners and passing drivers would find this lighting a terrible nuisance and an impediment to good night vision.



C. Roadway Lighting

In Indiana and elsewhere, the most frequent sight atop roadside light poles is this luminaire (fixture) referred to in the lighting industry as a "cobrahead." The cobrahead's design creates a pattern of illumination conforming to the roadway's ribbon-like shape -- narrow width and extended length -- achieved by covering the lamp (bulb) with a lens shaped like a stretched bowl. The lens refracts the light, and thereby it becomes the light source. Its shape and prismatic facets direct illumination up and down the length of the road and reduces the amount of light cast beyond the width of the road. These cobrahead fixtures are called "drop lens" or "sag lens" cobras.



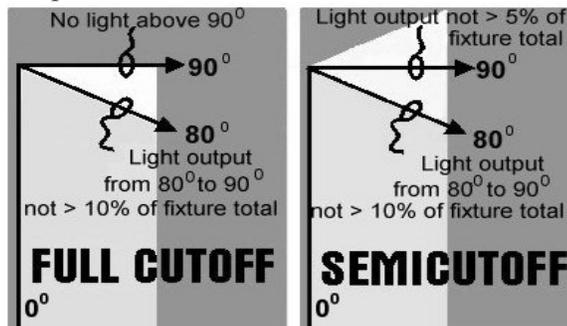
The sag lens has disadvantages. Its shape creates a large surface that is glaring for drivers, pedestrians, and nearby residents. Some light is wastefully directed above the horizontal plane and into the sky or at downward angles too high, causing light to spill beyond the right of way, because the lens extends well below the fixture's opaque housing.



Manufacturers also offer cobraheads with a flat lens that faces the roadway surface, as shown in this picture. Flat lens cobras have a faceted reflective liner installed above the bulb that provides directional control of light. This design dramatically reduces glare, eliminates wasteful direct uplight and minimizes illumination beyond the right-of-way.

The IES establishes roadway lighting practices in its publication RP-8, and are adopted by the American National Standards Institute (ANSI.) The lighting standards of the American Association of State Highway Transportation Officials (AASHTO,) which the Indiana Dept. of Transportation (INDOT) has indicated it uses, are also from RP-8, according to Carl Burkett, chairman the AASHTO Task Force for Highway Lighting Committee. The flat lens cobra is a "full cutoff," so defined by the IES as a luminaire which directs no light above horizontal and not more than 10 percent of its total light output between horizontal and 10 degrees below horizontal. IES recently revised RP-8, and issued two technical memoranda identifying urban sky glow, glare, and light trespass as undesirable and requiring re-mediation with full cutoffs.

The largest manufacturer of cobrahead fixtures, General Electric, stated ¹¹ in 1997 that it had begun to manufacture more flat lens than drop lens cobras. Connecticut Statute 13a-110 requires full cutoff roadway lighting, as do statutes in Maine, New Mexico, Arizona, and Texas. ICOLE has determined that Colorado, Massachusetts, Pennsylvania, Virginia, Iowa, New York, Wyoming, New Hampshire, Rhode Island and Maryland have either pending bills or study committee proposals introduced in their state legislatures regarding the use of full cutoff lighting. Hundreds of municipalities have passed ordinances requiring full cutoff luminaires.¹²



IES with revisions

Evansville and Fort Wayne extensively use full cutoff roadway lighting. Indianapolis still installs "semi-cutoff" drop lens cobraheads, as does INDOT except in rare cases such as near airports, including Indianapolis International. It is important to shield drivers from glare as it is pilots, and upward projection of light by drop lens cobras is seemingly acknowledged where a flat lens is chosen near runways. INDOT responded to an Indianapolis neighborhood group

association's request for full cutoff roadway lighting with a claim doing so would require 50 percent more fixtures and therefore more energy consumption. Analysis with General Electric's Aladan® lighting design software indicates that for a given street light layout, flat lens cobras provide essentially the same level of roadway illumination as the drop lens when the proper fixture is chosen. But the full cutoff's lower glare translates into better vision with less illumination. Bulb downsizing and commensurate energy conservation is in fact attainable, especially for non-continuous lighting applications such as those at intersections. Opportunities for energy conservation, better vision, and more livable neighborhoods are at hand.

D. Illuminated Signs

Scenic preservation groups, neighborhood groups, and environmentalists often seek to limit billboard proliferation. When illuminated, billboards are also a problem for astronomy. As the lower image on the cover shows, they create an extensive amount of urban sky glow on a per-luminaire basis. Typical two-sided billboard lighting includes four upward-pointed luminaires on each side. On hazy nights, it is easy to see that a large majority of the light misses the sign and beams directly skyward (front cover, Appendix, Image 2.) This problem is easily fixed with downward-pointed luminaires mounted on top of the sign and by fixtures that provide better directional control.



Although our informational road signs have a highly reflective surface, INDOT illuminates many signs installed over the roadway. Motorists routinely encounter such signs with non-functioning luminaires. But the high reflectivity of these signs, and contrasting light letters on the dark green background make them easy to read with light from headlights, as with the sign in this picture on the left. Texas and Michigan are among a number of states that normally do not illuminate informational road signs.

In spite of the high reflectivity of road signs INDOT uses many more light fixtures (mounted below the signs in the picture at right) per square foot of sign area than are used for non-reflective billboards. The billboard pictured below is on a section of a major arterial road that is largely residential, and uses only a single light fixture. The picture of INDOT signs on the right also shows that the middle light fixture is illuminating the truss more than the sign. This sign set is using at least three more fixtures than are needed. Fixtures mounted on the bottom pointed up at the signs send much illumination directly into the sky, creating additional urban sky glow. Road signs in Illinois and Arizona are illuminated by a single luminaire, in Arizona from atop the sign.



This billboard is about the size of the two illuminated roadway signs combined, pictured above. They are highly reflective. The billboard is not. Yet the roadway signs have about five times as many fixtures per square foot.

E. Effectiveness of Outdoor Lighting on Crime

There is a widely held perception that outdoor lighting provides protection against crime. It is the central marketing theme of outdoor lighting. At times when lighting is not required, the reason cited for its continual operation is "for security." Many parking lots are lit all night every night at businesses that closed hours earlier. Many lights are simply called security lights. Some seem intended not to illuminate any particular surface or object, but rather to stand as a luminous sentry guarding against the unknown.

In 1977, the U.S. Justice Dept. released a study¹³ that found no statistically significant evidence that street lighting reduces the level of crime. In the early 1990s a British government agency, the Home Office, released the *Police Research Papers*,¹⁴ containing the results of a study which also determined no correlation between street lighting and crime. And, in 1995 a criminology team at the University of Maryland undertook a study¹⁵ for the National Institute of Justice that was presented to Congress. The criminologists' finding from this exhaustive study was that outdoor lighting's impact on crime is inconclusive.

Reports of anecdotal evidence also seem to indicate that lighting is not effective against crime. On March 8, 1998, an Associated Press article reported on a power blackout that had been affecting New Zealand's largest city, Auckland, for two weeks. The first three sentences stated:

"Even criminals have deserted the darkened streets of downtown Auckland, where two weeks of power blackouts have made elevators risky, spoiled food and frustrated residents. 'It's been almost a crime free zone,' Inspector John Mitchell said Saturday. 'The normal level of muggings, violence, fights, burglary and robbery have just not happened.'"

F. Myth-driven use of Outdoor Lighting (more on lighting and crime)

Too few consumers are aware of how outdoor nighttime lighting functions and what it will and will not do. Usually their only source of information is from the sellers of lighting products. For a large portion of lighting installations the same people design the layout, sell the product, and install it.

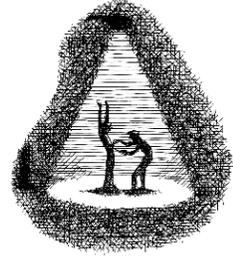
The types of autos we find on roadways would be different if consumers let salesmen decide what car they needed. We understand it's the salesman's job to sell us pricier models, and that auto makers try to appeal to our emotions by marketing an association to their product with freedom, independence, sex appeal, etc. Awareness helps guide us to rational choices.

Darkness meant danger for early man. Fire kept predators at bay. Superstition and ritualistic beliefs reinforce the association of the darkness, danger, and dreaded events throughout our history. It is in our literature and movies. Scenes meant to provoke fear nearly always occur at night, in contrast with FBI statistics which indicate more violent crime occurs during the day than at night.¹⁶ The "dark ages" and "enlightenment" are two terms among many that convey deeply engrained positive and negative associations with the light and the dark.

Such prevailing ideas are often evident in the media. Crime or traffic accidents are often matter-of-factly attributed to a lack of lighting, whereas it is rare, if ever, to encounter a report that lists badly designed lighting as the possible cause. An Indianapolis TV station reported in March 2000 that a nighttime fatality occurring when a driver struck a concrete bridge was probably due to the lack of street lighting. The police report did not mention street lighting. In

fact, the driver's direction of travel was toward an unshielded street light that made the bridge more difficult to see. Another Indianapolis TV station reported on the nighttime robbery of a patron of an outside automatic teller machine. The reporter seemed to share the puzzlement she said bank management felt, since, as she noted, the ATM was "well-lighted." The previously mentioned 1995 University of Maryland crime study states:

...The problematic relationship between lighting and crime increases when one considers that offenders need lighting to detect potential targets and low-risk situations (Fleming and Burrows 1986). Consider lighting at outside ATM machines, for example. An ATM user might feel safer when the ATM and its immediate surrounding area are well lit. However, this same lighting makes the patron more visible to passing offenders. Who the lighting serves is unclear.



The marketing of outdoor lighting often appeals directly to our uneasiness about nighttime darkness and helps reinforce these myths. Slogans such as "light the night" and claims such as "criminals hate bright lights" are common sales themes. Product names "security lighting" and "protective lighting" unambiguously reinforce the concept. Lack of consumer awareness about lighting and crime statistics makes such appeals to emotion more effective. Rather than making rational decisions to use the right amount of light where and when it is needed, we often operate under the single-minded idea that the more and brighter the light, the better. Usually "well-lighted" means brightly lighted rather than correctly lighted.

At a recent meeting at Hanover College¹⁷ attended by ICOLE representatives, a lighting manufacturer's rep lit a candle in a room illuminated by overhead fixtures and daylight coming in through windows. He described the lighted candle as equivalent to "one footcandle," which could have created the impression that the 77 footcandles of illumination he planned for a nearby gas station was minimal. Actually, a candle is roughly equivalent to a light source of one candela. An attempt to demonstrate the gas station's nighttime illumination from its twenty-four, high intensity discharge canopy fixtures would have required lighting over 60,000 candles in a darkened room approximating nighttime's low light -- but only after giving observers several minutes to achieve dark adaptation. Lack of awareness causes extensive misuse of outdoor lighting.

G. Impacts on the Environment and Human Health

Nearly 96 percent of Indiana's electricity comes from coal-burning power plants.¹⁸ Typical lighting used on a single billboard requires the burning of more than seven tons of coal annually. Doing so creates 46,400 pounds of carbon dioxide, a greenhouse gas; 356 lbs. of sulfur dioxide which creates acid rain; 215 lbs. of nitrogen oxide which creates ground level ozone; and about .03 gram of mercury. Some health agencies report that from 0.1 parts per million to as little as .001 ppm of mercury vapor in the air causes long term ill-health effects. Indiana is 4th in the U.S. in nitrogen oxide emissions, 3rd in sulfur dioxide, 4th in carbon dioxide, and fifth in mercury. Indiana's population ranked 14th in the U.S. according to the 1990 census.¹⁹ (Also see Appendix, Table A)



Coal combustion by-products also include uranium and other heavy metals. Alex Gabbard, principal investigator for the Nuclear Energy Program at the U.S. Dept. of Energy's Oak Ridge National Laboratory writes in ORNL Review:

The emissions by coal-fired power plants of greenhouse gases, a vast array of chemical by-products, and naturally occurring radioactive elements make coal much less desirable as an energy source than is generally accepted.

Later he writes:

The amount of uranium-235 alone dispersed by coal combustion is the equivalent of dozens of nuclear reactor fuel loadings. In short, naturally occurring radioactive species released by coal combustion are accumulating in the environment along with mercury, arsenic, silicon, calcium, chlorine, and ...lead, sodium, as well as metals such as aluminum, iron, lead, (sic) magnesium, titanium, boron, chromium, and others that are continually dispersed in millions of tons of coal combustion by-products.

Life has evolved on Earth through periods of daylight faithfully followed by nighttime darkness in a 24-hour cycle, except near the poles. Many life forms have a dependence on the dark. Sea turtle hatchlings have received protection in some coastal areas because of their fatal tendency to be confused by lighting and lose their way to the sea. Species of moths and fireflies are on the decline. The March/April 2000 issue of Audubon Magazine reported on migratory birds' fatal attraction to tower lighting. Smithsonian Magazine, November 2000, reported on the Cincinnati Zoo's inability to mate rare cats until moving them away from bright night lighting.

Satellite images (Appendix, Image 1) capture what the International Dark-sky Association estimated several years ago to be \$2 billion wasted annually in the U.S. by misdirected outdoor light. Humans also pay a health cost associated with the previously discussed environmental consequences of wasted electricity. Increasingly, it appears that health impacts include more than from fouled air and water. Not until the last half of the 20th century were large numbers of people in developed nations exposed to a continual alteration of the natural 24-hour daylight-dark cycle. Dr. David Avery, University of Washington psychiatrist specializing in sleep problems and circadian rhythms recently stated, "In a sense, we have this huge experiment going on ... and we don't know what the consequences are."²⁰

This unintended experiment has begun to show signs that the dark may be vital to our health. The onset of evening triggers physical responses such as a lowering of core body temperature and increased production by the pineal gland of melatonin, which promotes sleep. But nighttime lighting alters this human circadian rhythm.²⁵ A link between excessive night light and insomnia has been proposed as one of the results.

A suspected link between melatonin suppression and cancer has also emerged. In lab experiments, rats with their pineal glands removed developed numerous malignant breast tumors. Another group's pineal glands were also removed, but also given melatonin supplements and developed far fewer cancers. Studies that followed showed that constant light had the same effect as removing the pineal gland: numerous malignant breast tumors.²¹

Studies of blind women in the United States, Sweden and Finland appear to support the theory that blind women experience lower rates of breast cancer. Further analysis of the Finnish data involving 10,935 women even showed a correlation between degree of visual impairment and incident of cancer. Oncologist Dr. David Blask of Bassett Research Institute, Cooperstown,

NY, and colleagues, transplanted tumors to two groups of rats. One group was exposed to small amounts of night light, such as with street light filtering in through curtains. That group's tumors grew far faster than the group that was kept in complete darkness.²¹

Professor Charles Czeisler of Harvard University's medical school is in no doubt about the disruptive role night light can play in human lives. Writing in a recent edition of the U.S. journal *Science* he makes the remarkable statement, "If light was a drug the government wouldn't approve it."²²

H. Impacts on Quality of Life

During the early 1990s, the public's focus on a struggling economy faded with yearly economic growth through the end of the decade. Changes that paralleled the growth gave rise to such phrases as "urban sprawl" and "quality of life." "Visual clutter" is another new phrase that describes excessive visual stimulation that bombards the eyes along the gauntlets of commercial corridors. Outdoor lighting has increasingly become the primary tool of outdoor advertising, whether on billboards, on-site signs, whole-building illumination, search lights, glaring parking lot lights far brighter than needed, and other ways conceived in the fertile minds of advertisers and lighting product sellers. Many neighborhood groups seek restraint in the growth of visual clutter in the urban environment.

Urban sky glow continues to creep beyond metropolitan areas and grow in intensity over smaller communities. The unnaturally bright sky over the city of Indianapolis is visible from Shades State Park, about 50 miles away. All of Indiana's state parks, forests, and nature preserves are experiencing growing levels of urban sky glow. The National Park Service has begun implementing policy to reduce light pollution in our national parks from sources in and outside the parks.²³ The Indiana Sierra Club adopted a resolution²⁴ calling on the Indiana Legislature to address light pollution created by state agencies. In areas such as Brown County great effort is taken to protect the natural environment, which provides an economic payoff. Light pollution from Indianapolis, Greenwood, Columbus, Bloomington, and Seymour is becoming increasingly visible in Brown County State Park.

CONCLUSIONS AND RECOMMENDATIONS

Policy changes by the state and municipalities and new state and local laws are needed to address the problems caused by light pollution. In the absence of legal standards for directional control of outdoor illumination, little remedy is available in Indiana to Hoosiers subjected to intrusive, excessive lighting. The ratcheting of illumination levels for advertising purposes has escalated into "glare wars" for customer attention. Business lacks awareness that excess light borne by the costly "brighter is better" philosophy that stokes these wars, also obscures the vision that profitable returns on its costs are ultimately long term losses. Nature provided us with night vision that lighting should compliment, not attempt to overpower. The higher the bar is raised with brighter light, the more the eye adapts. Nothing is gained. Increased energy demand, pollution, nuisance, diminished safety, environmental damage, potential risks to human health, higher taxes, higher consumer costs, and lowered quality of life are the result.

A variety of policy initiatives and provisions in state statute and local ordinance would begin to address light pollution:

- A maximum allowable level of illumination spilling inside residential property lines should be created. ICOLE recommends 0.1 (one-tenth) footcandle.
- A directional control provision to minimize glare from lighting when viewed from other property should be established for all lighting provided or maintained by state funding, or by grants administered by the state. ICOLE recommends a provision that a lamp or lamps in a fixture with an output of more than 2000 lumens should be so located and designed with an opaque enclosure, as to be shielded from view beyond any property where installed. All lighting used to illuminate state and federal highways should be full cutoff, providing the minimum illumination necessary.
- Protection zones should be created around astronomical observatories of academic institutions, state parks, forests, nature preserves, and other environmentally sensitive areas. Such zones should establish graduated lighting standards within selected radial zones, limiting or prohibiting illuminated billboards, lighted towers, and commercial lighting.
- No person, business, or organization should be held liable for accidents alleged to be caused by insufficient lighting, as long as any installed lighting provides illumination not less than the minimum recommendations of the IESNA. No person, business, or organization should be held liable for accidents occurring on private or public property after normal hours of operation, if the victim had no reasonable expectation of after-hours lighting or lacked good cause to be on the property.
- Communities adopting comprehensive outdoor lighting standards equal to or higher than those created by state statutory provisions should receive an increased share of selected state tax distribution or riverboat gambling funds. Property tax exemptions should be granted for the replacement of installed lighting which becomes non-conforming, with conforming lighting.
- The use of illumination on reflective roadway information signs should be discontinued unless uniquely required, in which case a single luminaire should be top-mounted on the sign. The use of high-mast cluster lighting on roadways should be eliminated except when it can be installed at a height no greater than three times the distance in any direction to the right-of-way boundary line. Homeowners should be compensated for excessive light trespass from existing high-mast cluster lighting. Michigan does not use high-mast cluster lighting.
- Electric utilities should be required to offer full cutoff lighting for each type of outdoor lighting they offer, at no greater margin above cost and at equal cost for equal electrical consumption. Provisions in electric utility tariffs and contracts should not provide a discount for additional use of electricity. The installation of any outdoor lighting fixture producing more than 2000 lumens should include a means for the customer to turn off such a light. The marketing of luminaires as "security lights," "protective lights," or similar terms should include a disclaimer stating that extensive, authoritative studies do not support a claim that outdoor lighting reduces crime.
- An informational resource should be established to provide objective information and guidance for state and local officials about outdoor lighting.

APPENDIX



Image 1. This is a composite image of the U.S. at night from military defense satellite images.

Estimating Electricity Lost by Wasteful Outdoor Lighting Practices and Designs

The International Dark-sky Association (IDA) estimated a total U.S. annual cost of \$2 billion in wasted electricity due to misdirected outdoor lighting from information pertinent in the mid-1990's. Two significant factors make that estimate far too conservative now. The ratcheting of retail lighting discussed in Section B has led to much greater use of lighting in and outside stores. Glare (misdirected light) is much more prevalent, as is late-night/all-night retailing. As discussed in Section A, lighting tends to beget more lighting because of veiling luminance and dark adaptation issues. The second factor is an extended period of very strong economic growth. Both factors have resulted in added street lighting as well. Although many states and communities are addressing light pollution, in most cases problem lighting will be replaced via attrition. It is likely that the total annual U.S. cost has risen to \$4 billion or more. Indiana's total electric generation in 1999 was 3.2 percent of the U.S. total. Accordingly, 3.2 percent of \$4 billion of wasted U.S. electricity equals \$128 million in total annual waste in Indiana.

Japanese scientist Dr. Syuzo Isobe proposes waste calculations based upon satellite measurements of light from selected urban areas. See <http://www.skykeepers.org/usenergy.htm> and <http://neowg.mtk.nao.ac.jp/night/paper/index.html>. Work is also underway at the University of Wisconsin to produce similar calculations. While precisely calculating the cost of bad lighting is obviously difficult, it is easy to recognize this unproductive and counterproductive use of energy is poor public policy.

Table A

Electricity Generation Emission By-Products

| | U.S./ Indiana figures: Lbs. Per 1000 kwh | | 1999 Indiana Emission lbs. |
|----------------|--|----------------------|-------------------------------|
| | <u>Generated kwh</u> | <u>Delivered kwh</u> | |
| Carbon dioxide | 380 / 2080 | 1605 / 2419 | 249.6 billion |
| Nitrogen oxide | 4.44 / 8.30 | 5.12 / 9.65 | 996 million |
| Sulfur dioxide | 7.54 / 13.62 | 8.77 / 15.82 | 1.634 billion |
| Mercury | 0.000032 / 0.000050 | 0.00004 / 0.00006 | 6,000 lbs. |

By George Nickas, PhD. from data from the Energy Information Agency, U.S. Dept. of Energy.



Image 2 left. Bottom-mounted sign lighting puts more light in the sky than on the sign.



Image 3 right. There are many outdoor lighting fixtures available which impart an elegance of times past that also provide good directional control of light.

Image 4 and 5 below. Light fixtures referred to as wall packs are often attached to the sides of buildings and if not properly designed, direct high intensity illumination into the eyes of drivers and pedestrians, creating obvious visual hazards. Images courtesy RAB Lighting.



Image 6 and 7 below. Forrest Hamilton created this 180 degree panorama from photos he took at a location about nine miles due south of Logansport. The center view is toward the northeast. In Image 7 he adds labels indicating each source of the light pollution along the horizon. No nighttime view, even in the most rural locations in Indiana, is free of encroaching urban sky glow.

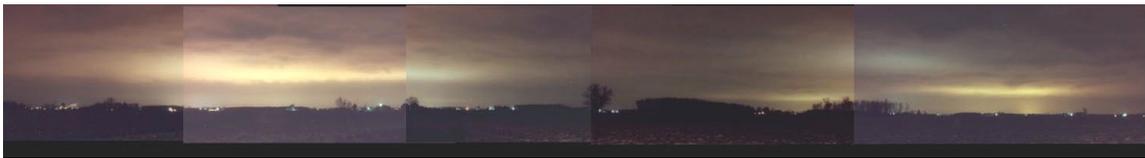




Image 8 above left. INDOT installed flat lens cobrahead street lights long ago near the airport in Indianapolis. Since less glare means better vision for drivers as well as airplane pilots, why not use them everywhere?

Image 9 above right. Flood lighting is often used to light parking lots with these poor results. Diagonally aimed floodlights with intense light sources broadcast glare far beyond property lines. Observers on the wrong side of a tilted luminaire get an eye full of glare and see little. Photo by Patric Johnston, Tulsa, OK.



Image 10 above left. This gas station at the Meijer store in Greenwood has glare free lighting under the canopy and full cutoff fixtures illuminating entryways.

Image 11 above right. Greenwood also has a school with an excellent lighting design. Every light source in view is shielded.

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Images

Cover: Top and bottom photos by Kevin Fleming. Car lot photo courtesy the International Dark-sky Association. Urban sky glow photo courtesy Geoff Dudley. Cover by Kevin Fleming.

Section A photo of pedestrian under acorn fixture, section D all photos, section G photo, and appendix images 2, 3, 8, 10, and 11 by Kevin Fleming.

Other images and photos by authors as noted or on the web by authors unknown.

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