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Dark Skies, Bright Future

Dark Skies, Bright Future

City policies throw shade on light pollution.

By Allen Best

Back in January, I returned home one night to the disconcerting spectacle of my front yard bathed in harsh light, as if something had gone wrong. Living in metro Denver, I never expect to see a truly dark sky. Polaris and the dippers, big and little, can still be seen, but it's usually like looking through a dirty window.

This was different, though. The owner of the parking lot across the street had installed energy-efficient light-emitting diodes, or LEDs, with brighter light to ensure safety for patrons. But the light that spilled into my yard was bright enough for reading a newspaper. Instead of secure, I felt accosted, as if a stranger had begun loitering on my porch.

Light trespass has been a problem since the arrival of electricity allowed us to banish the night. Many jurisdictions have codes that seek to limit it. Some are better than others, but all succeed only to the extent that they're enforced. Other regulations seek to tackle the broader problem of man-made light blotting out the stars, what many call light pollution.

Some places, including Flagstaff, Arizona, home to two astronomical observatories, have proven that you can have it all: stars in the sky and safety and commerce. Regulations adopted there nearly 60 years ago enjoy broad support. Mass retailers, accustomed to few restraints, soon learn that things are different in Flagstaff.

The two observatories make darker skies part of the local economy — 102 people work there, and dark skies are a nuanced component of the tourism business. The U.S. Naval Observatory, which has a mission of delivering information useful to U.S. defense, makes dark skies patriotic. "It really does a lot for our quality of life," says Dan Folke, aicp, the planning director in Flagstaff.



Composite image of North America at night assembled from data acquired by the Suomi NPP satellite in 2012 using the Visible Infrared Imaging Radiometer Suite, which detects light in a range of wavelengths and uses filters to observe dim signals such as city lights. Source: NASA.

LED growing pains

Technological development of lighting has had a growth spurt lately. But after Edison patented the first incandescent bulb in 1879, the next big thing was fluorescent bulbs, unveiled at the New York World's Fair in 1939. Later came mercury, high-pressure vapor bulbs, and so on. But now technology is moving fast, especially since LEDs began arriving in the market in the early 2000s.

LEDs can deliver robust cost savings and reduce energy use, an important element in ambitious climate-action plans. Edison's incandescent bulbs delivered 10 lumens for every watt of power; LEDs can deliver more than 100 lumens per watt. Lumens measure the level of brightness. Although they cost more than incandescents, manufacturers have promised LEDs can last as much as 25 times longer than some of the older lighting technologies.

But communities have also stumbled as they rushed to curb costs and realize energy savings. California's college town of Davis is something of a living laboratory, says Mitch Sears, the city's sustainability program manager. "You learn by mistakes as much as you learn by success," he says.

Davis, at the cutting edge, tested LED lights in street fixtures in 2011. Getting no pushback, the city set out to replace all of its streetlights with LEDs. That's when emails and phone calls flooded city offices. After the city council halted the retrofit, the city staff consulted with the California Lighting Technology Center at the University of California-Davis and engaged with several manufacturers.

Davis officials had missed something at the outset. Many others have, too. The LEDs delivered a different kind of light than the older high-pressure sodium fixtures they replaced. Some have likened it to being under the torch of an arc welder. Its intensity enhances blues and whites, whereas older lights enhance reds and yellows. To understand it, you have to understand color temperatures, which are described on the Kelvin scale.

For some of us non-physicists, it's bizarre. The scale's range is based on what a piece of metal would look like if heated. At 2,000 to 3,000 Kelvin, you get light that is white but warm, such as you might want for your bedroom. At higher Kelvins, the light "cools" and brightens. At 4,600 to 6,000 K, it's whitish to blue, more like daylight — or, as in my front yard in January, like a police lineup.

In Davis, after the first stumble, city officials surveyed residents, the majority of whom preferred the warmest LED lights in the spectrum, says Sears. That gave Davis officials enough confidence to replace the 650 LEDs originally installed, at a cost of \$350,000, and begin the methodical replacement of other streetlights. They don't save quite as much energy, but they're easier on the eye.

Then came another phase: lights for the parks and paths connecting neighborhoods. On shorter poles, the upward globes that imitate the gas lamps of old, sending light skyward, were replaced by a cobra-headed fixture to more efficiently direct light downward. And these LEDs were dimmer, too — much dimmer than the 2011 test lights.

Residents soon adjusted to lower levels of light. Sears says energy savings have exceeded 90 percent. "It's part science, part how-does-it-feel?" he says. "That's what lighting is all about."



Blue wavelengths from the sun are beneficial during the day, but blue light at night may cause health problems. Photo courtesy darksky.org (CC0 1.0).

Overexposure

A large body of research conducted in recent decades points to adverse effects in the natural world from extravagantly lit human ecosystems. Newly hatched turtles in coastal areas, for example, will get drawn inland to lights instead of plodding out to the sea. In doing so, they risk becoming prey.

Humans can also suffer from too much light and the wrong light. The American Medical Association last year issued a report warning that blue-rich LED streetlights operate at wavelengths that adversely suppress melatonin at night. Too-bright residential lighting is associated with reduced sleep times, dissatisfaction with sleep quality, excessive sleepiness, impaired daytime function, and obesity. The AMA-recommended street lighting should have a color temperature of no greater than 3,000 K. For reference, an incandescent bulb has 2,400 K, meaning it contains far less blue and far more yellow and red wavelengths.

Peter Strasser, technical director at the International Dark-Sky Association, describes it as still a fledging technology. Most existing lighting regulations never anticipated LEDs. He describes development and adoption of regulations as moving "at the speed of government" while the adoption of the new technology is proceeding "blazingly fast."

Manufacturers overemphasized the cost and energy benefits of LEDs, Strasser charges. "They were really dangling carrots in front of communities, saying the chips (in LEDs) lasted 100,000 hours. That's 20 years of not having to service the products," he says. LEDs can last a long time, but not nearly so long: evidence is coming in at six to eight years, he says. Further, the effectiveness of the lights depends on their cleanliness. LEDs must be wiped occasionally to remove grime. LEDs still deliver a big bang, but not quite so much as advertised.

Tucson, where the Dark-Sky Association is based, has had lighting ordinances since 1972. The amount of illumination is limited, and importantly, lights must also be directed downward, to where the light can be used. It's foolish, says Strasser, to point lights upward to illuminate the bellies of passing airplanes. The upshot of these regulations in Tucson, says Strasser, is that he can still see the Milky Way from the driveway of his home eight miles from a city center of one million people.

Stars and planets aside, says John Barentine, the Dark-Sky Association's program manager, the bottom line for planners and elected officials is what's good for dark skies also saves money, by making sure light is used most efficiently — including the most effective ways to improve public safety. More lighting is not always the answer. In fact, additional public lighting often has an inverse relationship with public safety, say dark-sky advocates.

Bob Parks, the director of a Virginia-based nonprofit called the Smart Outdoor Lighting Alliance, says the fallacy of increased lighting is demonstrated by metropolitan Washington D.C., where he lives. The city has straight edges, dating to the original founding in the late 18th century. Those borders are well defined by the night lights photographed from 249 miles in space by the International Space Station commander Scott Kelly early this year.

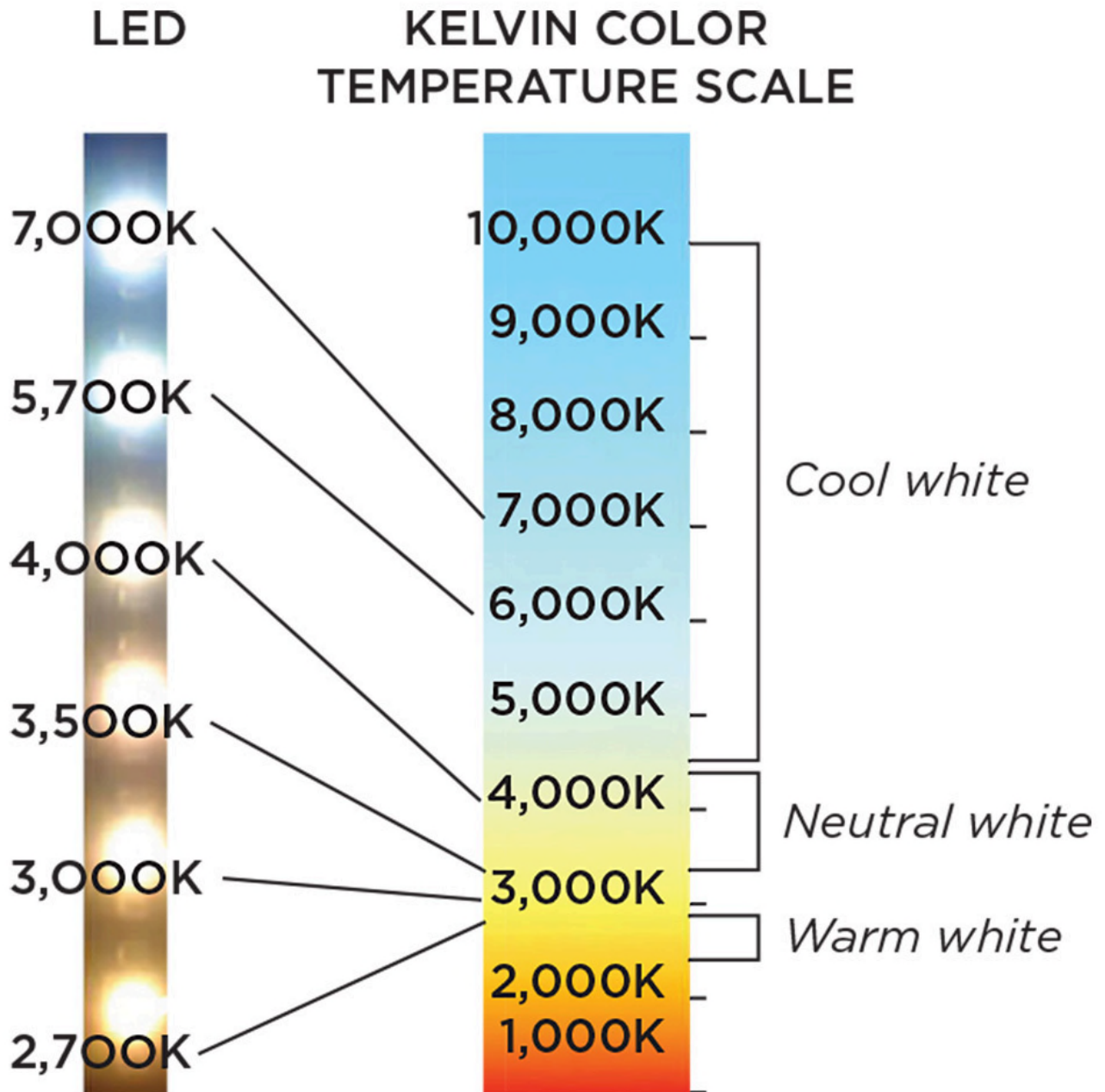
Washington is lit more brightly, as satellite images show. One reason, says Parks, is because many policy makers believe that lighting deters crime. A study he commissioned several years ago, when he was still with the International Dark-Sky Association, found no correlation.

"We found that with few exceptions the DC side had similar or higher overall crime than Maryland or Virginia and two to three times the average lighting levels," he says. The study was abandoned before being published because funding was withdrawn, says Parks, so he can point to no numbers for examination.

Evidence about the value of lighting in deterring crime is surprisingly thin. A 2007 review of studies prepared for the Swedish Council for Crime Prevention found mixed results in eight American studies. Four of the studies found that improved street lighting was effective in reducing crime, while the other four found no effect, according to the report, "Improved Street Lighting and Crime Prevention." Five studies from the United Kingdom, however, were clear that improved lighting led to decreases in crime. What may matter most, however, is the perception that improved lighting reduces crime.

Colors by Number

The Kelvin temperature scale assigns a numerical value to the color of a light source.



Source: Complete Facilities Supply.

A different kind of preservation

In Flagstaff (pop. 68,000), four hours north of Tucson, dimmed lights are part of the culture, even on the old Route 66. Recent images comparing cities of about the same size show that Cheyenne, Wyoming, is nearly 14 times brighter than Flagstaff. Flagstaff is divided into zones, with maximum lumens per acre in each zone. Some areas must have fully shielded fixtures, and others just partially shielded fixtures. There are also classes of light. An informed citizenry, including astronomers, is on board.

"Once you start pushing the envelope, people start getting it," says Brian Kulina, AICP, zoning code manager for Flagstaff. "It's my experience that our lighting standards are pretty well set in stone. None of our planners here negotiate. Either you hit it [the standard] or you don't."

Businesses will arrive, informing the city that they have certain standards, such as for canopies on chain gas stations. Flagstaff tells them to comply with the regulations. A developer arrived recently with a proposal for 1,300 houses — and agreed to create more restrictive standards than the city's standards for that area, near the Naval Observatory.

In Massachusetts, Cambridge has other concerns. It's a city of just over 100,000 people, and officials want to balance needs of the many users in mixed use developments: ground-floor merchants, upper-floor residents, maybe a life sciences company next door. An outdoor lighting task force met 18 times over two

years to forge regulations. The goal, says Lisa Hemmerle, director of economic development, was to create requirements that developers can pass to the electricians they contract with.



Camping under the stars in Utah's Canyonlands National Park, an International Dark Sky Park, is a rare experience. The park's goal is to make visitors and neighbors aware of its fragile night sky. Photo courtesy NPS/Emily Ogden via Flickr (CC By 2.0).

If you examine a satellite photograph of the U. S. taken at night, the coasts and the more densely populated East are heavily lighted. Lights dim at the Great Plains. "The East will only get lighter over time, but that just underscores the need to preserve the few places with dark skies," says Barentine. "And they are vanishing rapidly."

Greater hope remains in the more thinly settled West, and there are already many dark-sky designations associated with national parks.

In Idaho, there's ambition for something more: the first dark-sky reserve in the U.S. and the 12th in the world recognized by the International Dark-Sky Association. The Idaho Conservation League is pushing for the designation in the Sun Valley-Ketchum area, which has wilderness on three sides. The towns adopted lighting regulations in the late 1990s but do not necessarily enforce them.

In Utah, Janet Muir retired to the mountain town of Eden after a career in New York City. Eden is on the shadowy side of the Wasatch Range, away from the lights of Ogden. She works to protect the dark sky of her mountain valley. "Your nightscape is a very big part of placemaking," she says.

Muir is cofounder of the University of Utah's recently formed Consortium for Dark Sky Studies. It is described as the first academic center in the world dedicated to discovering, developing, communicating, and applying knowledge pertaining to the quality of night skies.

Stephen Goldsmith, who was the director of planning in Salt Lake City when the Olympics were held there in 2002, is now associate professor of city and metropolitan planning at the university. He grew up in Salt Lake City just a few blocks away from the university, and it was a different place then. As a boy, he could see the Milky Way from his backyard.

"I would just fall asleep staring at the sky and I remember seeing the Milky Way and thinking, 'What is that?'" he says. That sense of wonder gave him a grounding that he says is lost when the night sky is obscured. Restoring the night sky — harnessing our energy flows that have hidden the stars — is a vital task in making cities more livable, he thinks. To see the stars, he says, is to feel like a speck of dust on earth, itself a speck of dust in the cosmos. He finds that comforting. It keeps a lot of other stressful questions in perspective.

Allen Best writes about energy and other topics from his home base in the Denver area. He is a frequent contributor to Planning.

RESOURCES

The International Dark-Sky Association and the Illuminating Engineering Society of North America offer a model ordinance and standards communities can use to reduce glare, light trespass, and skyglow.

darksky.org/our-work/public-policy/mlo (<http://darksky.org/our-work/public-policy/mlo>).

[A recent study](http://advances.sciencemag.org/content/2/6/e1600377) (<http://advances.sciencemag.org/content/2/6/e1600377>) finds that 80 percent of the world's population lives under a light-polluted sky. It's even worse in the U.S. and Europe, where 99 percent of residents experience nighttime skyglow. To see how bad light pollution is in your area, download the New World Atlas of Artificial Sky Brightness from the Cooperative Institute for Research in Environmental Sciences. cires.colorado.edu/artificial-sky (<http://cires.colorado.edu/artificial-sky>).



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