Figures at a Glance:

Outdoor Lighting Energy Use and the Cost of Light Pollution

23 April, 2009 - International Dark-Sky Association

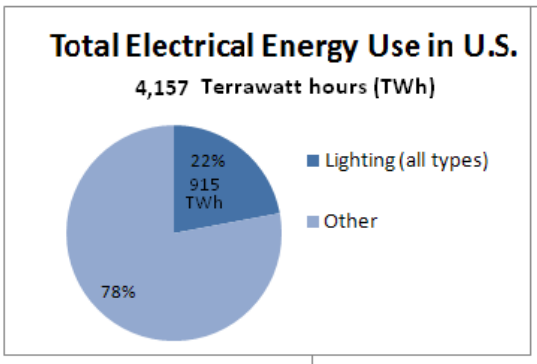
NOTE: This analysis (2009) assumes that the energy use values from the original referenced baseline report[1] published in 2002 are likely low; but that the percentage breakdowns (such as the 8% value for outdoor lighting energy use at a percentage of all lighting) have not changed substantially.

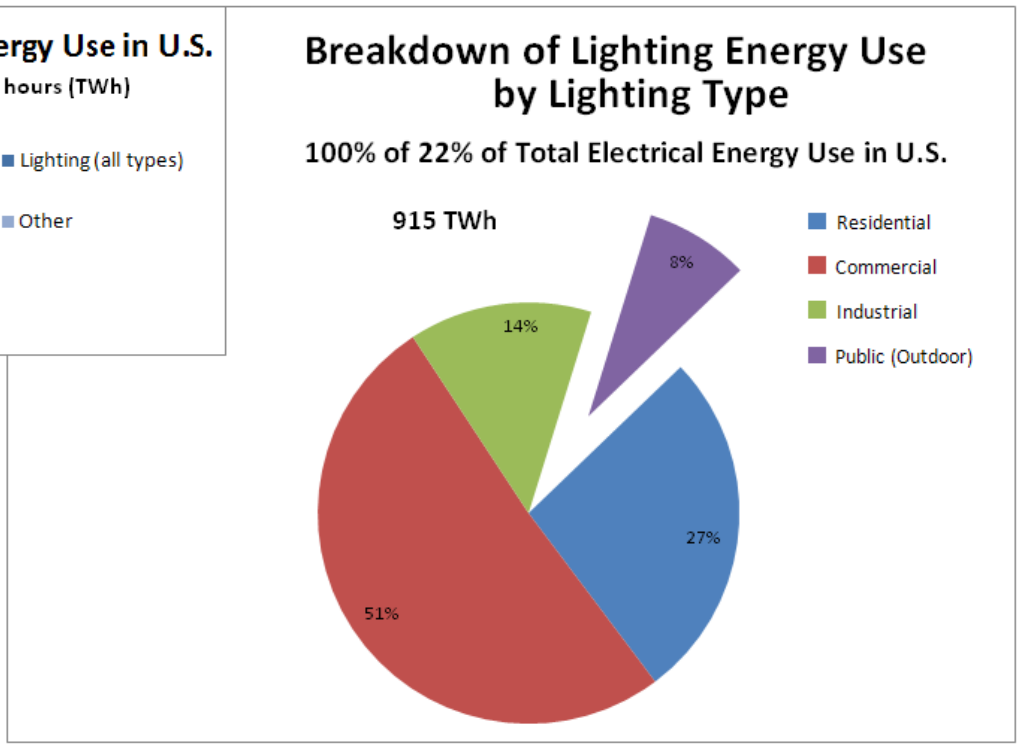
Electrical energy use is measured by the Kilowatt hour (kWh). 1 kWh is the electrical energy used by a power flow of 1000 watts for one hour or 100 watts for 10 hours. The average cost of 1 kWh ranges from 9-13 cents, depending upon the type of electrical service[2].

In 2002, total electrical energy use in the U.S. was approximately 3,295 Terawatt hours[*]. In 2007 that usage had increased to **4,157 TWh.**

In 2007, electric lighting used **22%** of the total electricity generated in the U.S., or approximately 915 Terawatt hours.

Of that 22%, total lighting energy use breaks down as: Residential = 27%; Commercial = 51%; Industrial = 14%; Outdoor = 8% (27+51+14+8=100%).

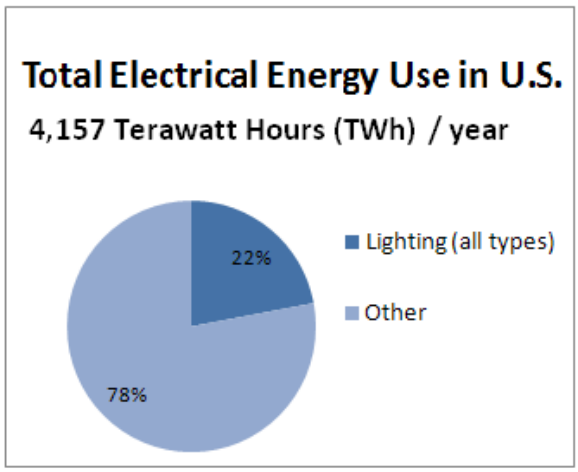


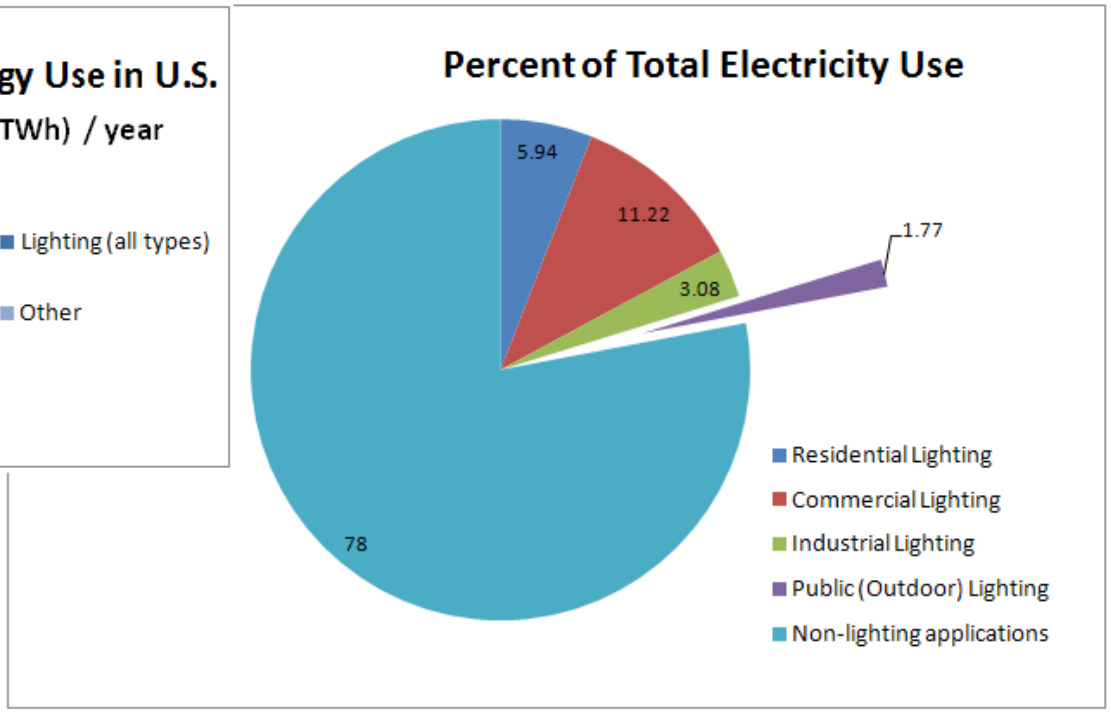


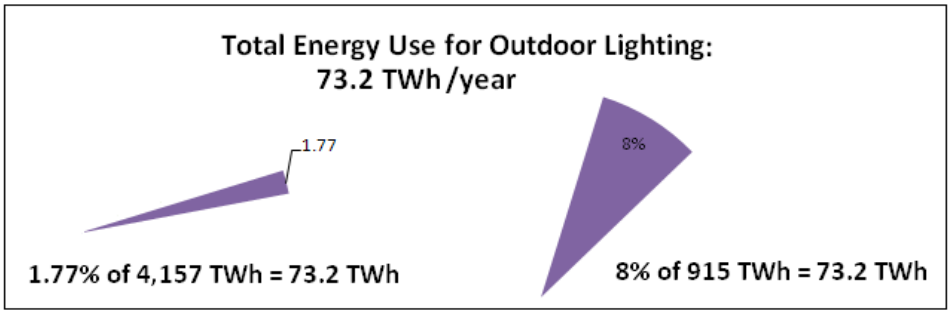
[*] One terawatt hour (TWh) is equal to 1 billion kilowatt hours (kWh), or 10^9 kWh. Therefore 3,295 TWh equals 3,295,000,000,000 (3.295 trillion) kWh.

In 2007, outdoor lighting, which used **8%** of the total electrical energy used for all lighting applications, amounted to some 73.2 TWh.

Of the total electricity generated in the U.S., outdoor lighting accounts for 1.77% (8% of 22%). The figure is a large number and has, of course, grown: 58 TWh in 2002 to **73.2 TWh in 2007**.







93% of the 73.2 TWh of lighting energy used for outdoor lighting, or 7.4%, is used for roadway and parking area lighting. These are the major lighting application sources of light pollution. That light comes mainly from 60 million "cobra-head" luminaires which constitute 82% of all outdoor lighting sockets installed.

Not included in the outdoor lighting category in the report[1] (where it's called "Outdoor Stationary Lighting") are the following uses:

- Sports Lighting
- On-premise Signs
- Building Floodlighting
- Landscape/Decorative Lighting

Such lighting is included in the "commercial" category, but it's not broken out. The unaccounted lighting costs accrued by these additional categories make the 73.2 TWh/year (2007) a low value for outdoor lighting energy used in the U.S.

The Hunter/Crawford paper (1988)[3] defines "wasted light" as light that is not reflected from any surface, such as roadway pavement, but sent directly into the sky. Photometric analyses of luminaires determined that "wasted light" from outdoor lighting was, on average, **30%** of the total light emitted by public lighting.

30% of 73.2 TWh/year = 22 TWh/year

The wasted uplight therefore amounts to 22 TWh/year of wasted electrical energy.

At $.10 per kWh (close to the national average), the cost of that energy is about **$2.2 billion per year.**

Generation of one KWh of electricity with coal creates 1.34 pounds of carbon dioxide waste (CO2). Lighting the sky with wasted uplight **creates 14.7 million tons of CO2** annually.

More Conversion Figures

The average American household uses 1,946 kWh/year in lighting energy. The uplight from outdoor public lighting fixtures, light that essentially shines up into the sky, could therefore **light over 11 million homes**.

1 Ton of Coal = 20,754,000 BTU. 22 TWh = over 75 trillion BTU. So, the coal needed to generate the wasted light would use **about 3.6 million tons of coal** per year.

and 1 Barrel of Petroleum = 42 U.S. Gallons = 5,800,000 BTU. If oil is used to generate the electricity, about **12.9 million barrels of oil** per year are required for the wasted light.

According to the Bureau of Transportation Statistics, the average car in the U.S. consumed approximately 700 gallons of petroleum per year (or 16.6 barrels) in 2002. Oil used to generate the electricity used unnecessary outdoor lighting could **power over 770,000 cars** for a year.

One tree on the equator absorbs 21 kilograms of carbon dioxide annually. It would take **702 million trees to absorb the 14.7 million tons of CO2** produced by the wasted light.

Both the monetary and energy estimates represent baseline figures. The statistics do not take into consideration the growth of lighting since 2007, the excluded applications (sports lighting, signs, or commercial and private building lighting), or the wasted light from building interiors such as skyscrapers that

are illuminated all night. When all these factors are considered, the cost of total energy expenditure for wasted lighting in the US is billions of dollars per year.

End notes

[1]Numbers presented are derived from the U.S. DOE "Lighting Market Characterization Vol.1 National Lighting Inventory and Energy Consumption Estimate" 9/02. http://www.netl.doe.gov/ssl/PDFs/lmc_vol1_final.pdf

[2]Energy production data is from the Energy Information Agency, http://www.eia.doe.gov/

[3]Hunter, T. and Crawford, D. "Economics of Light Pollution". International Astronomical Union Colloquium No. 112. 1988.

References

U.S. DOE "Lighting Market Characterization Vol.1 National Lighting Inventory and Energy Consumption Estimate" 9/02. http://www.netl.doe.gov/ssl/PDFs/lmc_vol1_final.pdf

The electric energy of that wasted light can be translated into fuel resources using the Energy Information Administration Calculator at: http://www.eia.doe.gov/kids/energyfacts/science/energy_calculator.html#eleccalc

Unit conversion by http://www.onlineconversion.com/energy.htm

From DOE Web site: http://www.eia.doe.gov/

Table 5-21: National Lighting Energy Use Summary

Sector	Lighting Energy use per Building (kWh/yr)	Number of Buildings	Site Energy		Primary Energy (quad/yr)	Percent of Total
			(TWh/yr)	(quad/ yr)		
Residential	1,946	106,989,000	208	0.7	2.2	27%
Commercial	83,933	4,657,000	391	1.3	4.2	51%
Industrial	475,063	227,000	108	0.4	1.2	14%
Outdoor Stationary	n/a	n/a	58	0.2	0.6	8%
Total			765	2.6	8.2	100%