

Useful\_Early\_Lighting\_Notes\_1999.txt

Florescent glow pigment at a high luminosity with long decay time

<http://proglow.com/pigment.htm>

Attenuation Diagram

<http://proglow.com/diagram.htm>

If we had some plastic products with this pigment manufactured as part of it, we will find some interesting uses after the PS. It is a bit expensive to buy in this raw form. Florescent fishing lures and light switches, flash light cases, and florescent tape could have many uses. Painting the inside of a survival quarters, dome would be one use. Would need to use a water sealer, moisture will degrade the florescent effect. I think plastic products that are florescent to be more practical. You can buy at most toy stores animals, stars and planets to put on your wall at night that glow. From this plastic one can make other things as they are needed. Markers for places to find in the dark would be the primary use.

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Sent: 18 April 99

Light Measurement Handbook,

<http://www.intl-light.com/handbook/index.html>

Light Sources

<http://www.intl-light.com/handbook/ch05.html>

Basic Principles

<http://www.intl-light.com/handbook/ch06.html>

Measurement Geometries

<http://www.intl-light.com/handbook/ch07.html>  
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Special Meters

<http://www.elexp.com/tst-spec.htm>

Model: LX - 101 --- \$65.95

[http://www.elexp.com/tst\\_lx01.htm](http://www.elexp.com/tst_lx01.htm)

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Model: LX-02 ----- \$39.00

[http://www.elexp.com/tst\\_lx02.htm](http://www.elexp.com/tst_lx02.htm)

Light meters

<http://204.127.238.82/visiblelight.htm>

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LED Flashlight Bulbs source

Sent: 18 April 99

100,000 - Hour LED Flashlights, Electronic Strobes and Replacement Bulbs (flash lights)

<http://www.americaworks.net/lighting/index.html>

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Safety Lights!

<http://www.shopthegroove.com/stgbrightideas.html>

Lights

<http://bikeusa.com/accessories/lights2.htm>

LED lighting is now available for indirect and direct lighting applications. The can flash, strobe, change colors, and a host of other functions while consuming very little power and they generate almost no heat compared to incandescent lighting.

<http://wagnersign.com/leds.htm>

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Outdoor

WATTS	Lumens	Hours	Cost/year	
2x120	3460	2000	105.12	Incondesent standard
4x120	6960	2000	210.24	incondesent standard
70	6300	24000	35.92	Sodum high pressure
90	1280	2000		Philips Halogen flood

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100	4500	24000	51.68	Mercury
125	6000	24000	67.45	Mercury
175	7900	24000	89.79-73.58	Mercury
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13	60w equil	10000		Compact Fluorescent Quad Lite
40	400	2466		Deluxe Extralife (130V)
40	460	1500		Bonus Brand Standard
40	490	1000		GE soft white
40	495	1250		Philips soft white longerlife
53	444	15000		Feit Electric Rough Service (130v rating, 120V operation)
60	600	5000		Feit Electric Rough Service (130V)
60	840	1250		Philips soft white longerlife
60	850	1000		Action Tungsram
75	1210	750		Bonus Brand Standard
100	1630	750		Feit Electric (120V)
100	1750	750		Bonus Brand Standard
150	2780	750		GE soft white
200	3910	750		Ge Soft white

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subject: Useful Light intensity  
Sent: 6 feb 99

Roger wrote:

>  
> \*\*\* Troubled Times forum mailing list \*\*\*  
> Wow Mike, I didn't know there was going to be a quiz (lol).

No quiz intended. The data was given for those who do not have access to a light meter, to indicate some of the factors to take into account in calculating light intensity. I realize with your physics background you are quite aware of these factors.

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> I was  
> trying to understand how a 6 watt bulb could provide enough light for  
> plants within a square meter. I don't think this is correct. Your  
> postulate below certainly accounts for this. But do we need to do these  
> calculations, or has someone already done so, and if so, what is the  
> bare minimum wattage of light needed for the average plant within a  
> square meter?

I didn't originally understand this as your purpose. But, now that I do -  
Initially, I agree it doesn't sound like much light or that it is correct.  
However, in looking more deeply into it I have found the following.

One candle = 12.5 Lumen = amount of energy (as light) a light source emits.  
Light bulbs some times are rated in this way. You can look on some bulb  
packages and get watts and number of Lumen or amount of light it puts out.

Lux = is the rate of energy falling on a surface as a result of light hitting  
it. One can think of it as the amount of light hitting a given square area of a  
surface.

I found the following Equivalents:

One foot-candle (foot-candle)= One Lumen per SQ. Ft. = 10.76 Lumens per Sq.  
Meter (or LUX) = .00176 Lumen per sq. Cm. (Phot)

One Lumen (at 5,550 Angstroms) = .00147 Watts  
one Sq. Ft. = .0929 Sq. Meters

Thus at 5,550 Angstroms of light:  
on foot-candle = .00147 watts per Sq. Ft. = .0158 Watts per Sq. Meter  
Or, one Lux = .000136 Watts per sq. ft = .00147 watts per sq. meter  
or, one watt per Sq. meter = 680 Lux  
or, one watt per sq. ft. = 7320 Lux

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Brightness Values: (electronics reference (Magnavox))

light source	Lux	Watts/ft2	Watts/m2
Office fluorescent Lighting	300-500	.04-.07	.44-.73
Halogen lamp	750	.102	1.10
Sunlight, 1 hour before sunset	1000	.136	1.47
Daylight, Cloudy sky	5000	.680	7.35
Daylight, Clear sky	10,000	1.36	14.7
Bright Sunlight	> 20,000	2.72	29.4

Note that the above watts/sq. ft and watts/sq. meter is the amount of energy in the light and not the amount of watts that it took to make the light. Many light bulbs are inefficient. Typically only 10% of the energy goes to make light in vacuum tungsten filament light or possibly up to 20% with halogen bulbs. Florescent are about 70-90% efficient.

I pulled the following quotes from link:  
<http://www.litemanu.com/lightingqa.html>

"Under natural conditions, maximum rates of Photosynthesis are attained in single leaves of many species at 25-35% of full sunlight intensity and in some shade species at even lower intensities."

If one now takes 25-35% of 14.7-29.4 watts/sq. meter one gets 3.7 to 10.3 watts/sq. meter or an average of 7 Watts/sq. meter. Note that this is very close to 6 watts/sq. meter. Thus I believe Steve is correct.

Now lets start from scratch and calculate an estimate amount of light hitting your plants.

From "Handbook of Engineering Fundamentals" by Eshbach second edition.  
Efficiency of light sources table 4 page 10-33.

Light source                      efficiency (lumens/watt)

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tungsten gas filled	20
tungsten vacuum lamp	10
Fluorescent: (includes ballast loss)	
standard cool white	46.5
standard warm white	51.2
de luxe cool white	29.0
de luxe warm white	31.0
daylight	41.3

Depending on the bulb used you could be putting out 29lumens/watt\*40watts= 1160 lumens or 51.2\*40= 2048 lumens of light.

We now will calculate the Lux using the formulas following table 1 in the following link:

Environmental Effects of Roadway Lighting  
<http://www.darksky.org/ida/info125.html>

Street lamps are designed to direct a high percentage of their light toward the street (45%). Let assume your lamps are less efficient say 30-40% of the light generated falls with in the .39 area of useable space. Lets assume we can keep the bulbs clean and that aging is the only factor of say about (.8).

Illuminance of 4 (40 watt florescent tubes) =  
 $(L*CU*LLF)/(S*W)=$   
 $[4*(1160 \text{ to } 2048 \text{ lumens})*(.3 \text{ to } .4)*.8]/(.39 \text{ sq. meters})$   
= 2855 Lux to 6721 Lux. (Or an average of 4788 Lux)

What should we expect to need? (7 watt)\*(680 Lux/watt per Sq. meter) = 4760 Lux would be the minimum from above.

Steve says: Tomatoes grow best at 4000 Lux, 18 hours a day. If the hrs decrease to 12 hrs that 22% decrease in time and now if we add 22% to 4000 Lux we get 4880 Lux. Very close to the same result.

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Bottom line: Depending on the bulb you are using and the actual efficiency of light delivered to the useable area of .39 sq. meters you both are talking about the same order of magnitude of light.

More information on definition of terms can be found at:

FAQ: Lighting and Illumination

<http://www.ie.psu.edu/courses/ie408W/lectures/lightingfaq.html>

Feel better now? I know I do it took quite a while to get this subject straight in my mind. This is one subject we may need at least one person proficient at understanding the calculations in each community after the PS. So as to not waste energy.

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Subject: Light efficiency of metal halide bulbs

While we are at it we might as well determine how the following recommendation was arrived at for metal halide 1000 watt lights.

<http://www.litemanu.com/lightingqa.html>

"Q: How much Light do I need?" (was for growing plants)

"A: 20-40 watts per sq. ft. is a general guideline. The more efficient the Light source, the less watts per sq. ft. needed. For example using 1-1000 watt metal halide light, in a 50 sq. ft. area would give you 20 watts per sq. ft. and a total of 120,000 lumens."

Solving the equation given in the following link for "CU" or the coefficient of utilization of light:

See Environmental Effects of Roadway Lighting

<http://www.darksky.org/ida/info125.html>

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We get:

$$Cu = (E*S*W)/(L*LLF) =$$
$$(4760\text{Lux}*50\text{sq.ft.}*.0929\text{sq.meter/sq.ft})/(120,000\text{lumens}*.8)=$$

.23 or 23% efficient.

In other words we need at least 23% efficient reflector to direct the light to this 50 sq. ft. area to get our minimum 4760 Lux amount of light to grow plants for 12 hrs/day.

Now what about the electrical efficiency of the 1000 watts converted to 120,000 lumens.

Recall that: One Lumen (at 5,550 Angstroms) = .00147 Watts.

Actual light energy in wattage =  $120,000\text{lumen}*.00147\text{watts/lumen}= 176$  watt of light from a 1000 watts consumed. The difference is emitted as heat.

Thus the electrical Light efficiency =  $176\text{watt}/1000\text{watt} = .176$  or 17.6% efficiency.

Summary: This setup converts 17.6% of it's energy to light of which 23% will need to fall with in the 50 Sq. ft. to make plants grow.

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Subject: Light or Lux meters

Looks like to minimize calculations and guessing and to maximize reflected light to our plants, one will need a light intensity (Lux or foot-candle) meter of one type or another. We will ultimately need a table of minimum to optimum Lux for a given hours per day for each class of plants we intend to grow. To balance the red and blue intensity, some of us will need to measure to an extent color, chromaticity, or Kelvin temperature.

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The following is a review on one type of Lux Meter product.

<http://www.animalnetwork.com/fish/aqfm/1998/june/product/>  
An Inexpensive Light Meter and Its Application to Reefkeeping

Where to buy a Lux meter? The following is some of the alternatives.

[http://www.omnicontrols.com/lists/n\\_extech84.html](http://www.omnicontrols.com/lists/n_extech84.html)  
Extech Model 401025 \$119

<http://www.bhphotovideo.com/photo/meters/sekonic/lux.html>  
SEKONIC L-246LX \$149

<http://www.central-camera.com/SEKONIC.HTM>  
Sekonic L-158 \$59

<http://www.cameratradersltd.com/usedmeters.htm>  
Used Light Meters \$69 and up

<http://northcoastmarines.com/lightmtr.htm>  
ACQUAMARINE LIGHT METER \$45

I know that a light intensity or Lux meter can be built out of a simple solar cell and a digital current meter for less than \$20. The question is if one did this without a reference meter as a standard, how does one calibrate it? All I can think of right now is a candle one foot away for the low end and the sun for the high end. Aside from there being no sun after PS, both are not a good stable, non-variable source. Building a color or Kelvin meter is another story. Possibly using the same Lux meter with some color filters would serve our purpose. Any ideas?

Roger, did you find a more cost effective product (light meter)?

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> > Did you take in to account the wasted light that escapes hitting the  
> > plants?  
> >  
> > One way to estimate how much light your plants are actually getting: 4  
> > ft florescent tubes radiate light cylindrically mostly. Thus if one  
> > determines a cylinder of diameter (average distance to center of the  
> > plant) and about 5-6 ft long. Assuming your plant is not too far away.  
> > Determine this surface area of this cylinder and the percentage of the  
> > area used by the plants at this distance. This becomes the same % of  
> > the wattage of the original bulb. Subtract about 10-20% from the  
> > wattage of the bulb due to inefficiency of conversion from electricity  
> > to light. There will be some reflection from the back reflector on the  
> > light. Assume this to add approximately 50% to 100% more light on the  
> > plant area. Take into to account the multiple florescent tubes you have  
> > in close proximity. The result is an estimate of the number of watts  
> > actually hitting the plant which can then be divided by the area of  
> > light the plant actually uses to get the watts/area.  
> >  
> > hope this helps.  
> >  
> >

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Look for red diode array and a gas discharge bulb centered on the blue spectrum.

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subject: LEDs  
<http://www.elexp.com/opt-led.htm>

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subject: LED Flashlights are coming  
Sent: 27 sep 98

Keep you eyes open for LED Flashlights. They should become more and more commonly available as we approach the PS. 100,000 hr bulb life is more than 11 years running 24/day 7 days/week. Battery life is greatly extended due to bulb efficiency. Some examples of what is currently available.

THREE "AA" ALKALINE WHITE LED FLASHLIGHT - The light lasts at a super bright level for a continuous 48 hours  
<http://ccrane.com/ledflash.htm>

Photon Micro-Light key chain flashlight - The BRIGHTEST for its size personal flashlight!! Shines bright for 124 hours with one battery.  
<http://www.photonlight.com/main.htm>

How to convert and existing flash light to work with a Red super bright Radio Shack LED - Battery lasts 20 times or more longer - Cost \$3.00  
<http://athos.rutgers.edu/~watrous/ledlite.html>

comtrad industries has a eternalight pocket flashlight that lasts 700 hrs using 3 AA batteries. Has various modes of operation. Cost is a bit high \$59.95. call 800-704-1211.

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Light energy is rather different from heat energy, though it is given out by things that are very hot. Boiling water is 100°C, a red-hot electric radiator is about 1000°C, a light bulb filament is about 3500°C and the surface of the sun is about 6000°C. (Some

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things however, such as the phosphors in fluorescent lights or in the screens of television sets, give out light by electrical processes at room temperature.)

<http://www.science.org.au/nova/037/037box03.htm>

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Subject: Electric lighting

sent: 29 Nov 97

Found this while looking for something else:

From: HOW THINGS WORK

By: Louis A. Bloomfield, Professor of Physics, The University of Virginia

[http://www.phys.virginia.edu/Education/Teaching/HowThingsWork/home\\_nov\\_1996.html](http://www.phys.virginia.edu/Education/Teaching/HowThingsWork/home_nov_1996.html)

"Electric discharge lamps are between 2 and 5 times as energy efficient as normal incandescent light bulbs. The hot filament of an incandescent lamp delivers only about 10% of its electric power as visible light. In contrast, a florescent lamp delivers about 25% of its electric power as visible light and some gas discharge lamps (particularly low-pressure sodium vapor) deliver as much as 50% of their electric powers as visible light."

How much life is consumed each time you turn on a fluorescent lamp? -- BL, San Jose, CA

"The starting process erodes the electrodes of a fluorescent tube through a phenomenon called sputtering. A typical fluorescent tube will last about 50,000 hours if left on continuously but only 20,000 hours if it's turn on for just 3 hours at a time. From that tidbit, I think its fair to say that a fluorescent tube can only start about 10,000 times. If the tube costs \$5, you are spending about 0.005 cents per start. If the electricity to operate that tube costs about 0.2 cents per hour, then turning the tube off for about 1.5 minutes saves the

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same amount of money in electricity as it costs in tube life when you turn the tube back on. In short, if you turn the lamp off for less than about 1 minute, you're wasting money. But if you turn it off for more than 10 minutes, you're saving money. In between, it's not so clear. There is a myth that turning on a fluorescent lamp consumes a huge amount of electricity so that you shouldn't turn the lamp off and on. There is simply no basis to that myth."

My comments on this - based on the data above if a fluorescent lamp is left on for over 7 hr. each use, then should get maximum life.

What are the different types of light bulbs and how do they work? - BS

"An incandescent light bulb works by heating a solid filament so hot that the filament's thermal radiation spectrum includes large amounts of visible light. A fluorescent tube uses an electric discharge in mercury vapor to produce ultraviolet light, which is then transformed into visible light by fluorescent phosphors on the inner surface of the tube. A gas discharge lamp uses an electric discharge in a gas inside that lamp (often high pressure mercury, or sodium vapor, or even neon) to produce visible light directly."

What is the composition of the phosphors used in fluorescent light bulbs? - M

"The exact composition depends on the color type of the bulb, with the most common color types being cool white, warm white, deluxe cool white, and deluxe warm white. In each case, the phosphors are a mixture of crystals that may include: calcium halophosphate, calcium silicate, strontium magnesium phosphate, calcium strontium phosphate, and magnesium fluorogermanate. These crystals contain impurities that allow them to fluoresce visible light. These impurities include: antimony, manganese, tin, and lead.

Do regular fluorescent lights emit ultraviolet light? If so, how does the ultraviolet level compare to what we would receive if we were outside? -- GF, Barstow, CA

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"While the electric discharge in the tube's mercury vapor emits large amounts of short wavelength ultraviolet light, virtually all of this ultraviolet light is absorbed by the tube's internal phosphor coating and glass envelope. As a result, a fluorescent lamp emits relatively little ultraviolet light. I think that the ultraviolet light level under fluorescent lighting is far less than that of outdoor sunlight."