e-GRO Edible Alert

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Online tool to aid greenhouse lighting fixture selection

Selecting a light system is one of the most difficult capital expense decisions for greenhouses. While there are many considerations (including lifespan, maintenance, warranty, installation costs, etc.) two of the biggest factors are the upfront cost of the lighting fixtures and the annual electricity cost to operate lights. In this article I'll describe a simple spreadsheet tool I developed to estimate lighting fixture upfront costs and electricity costs based on some information. The calculator tool was developed as part of the USDA Specialty Crop Research Initiative, Project LAMP (lighting approaches to maximize profit) and is available here.

Fill in yellow highlighted boxes	
200	Target instantaneous light intensity (µmol/m^2/s PA
1090	Lamp power consumption (W)
43560	Area to light (square feet), note that there are 10.7
1.80	Photosynthetic photon efficacy (PPE, µmol/J), usua
10%	percent light lost from edge effects
2000	total hours lights are on per year
$0.160	cost of electricity ($/kWh)
$350	cost of individual light fixture ($/fixture)

Figure 1. Input parameters for the light calculator tool. Download here.

In the calculator tool you will provide inputs about your crop/greenhouse such as target light intensity, area you will be lighting, and your cost of electricity per kilowatt hour (kWh). You will also need to supply some information that you can obtain from a lighting supplier (cost for lighting fixture, photosynthetic photon efficacy and power consumption). A helpful resource to identify possible lights is also the Design Lights Consortium (DLC) Qualified Product List. DLC is a third-party certifier for horticultural lights that meet certain standards for efficacy (energy efficiency), operating hours, and warranty. Many utility companies require fixtures to be listed by the DLC to qualify for energy efficiency incentives.

Warning, before we begin let me note a couple major **disclaimers** 1) the calculator tool makes a big assumption that the lighting fixture has uniform light coverage across its area 2) we assume we can adjust the height of a fixture to achieve a given light target. These assumptions are definitely not true in the real world – however in the real world we typically adjust spacing between light fixtures to achieve decent light uniformity (taking advantages of overlapping light between fixtures. Therefore, the calculations we do here should be thought of as rough estimates for the number of fixtures to light an area. In practice, you should always consult lighting suppliers who can provide detailed maps of how the fixtures should be installed and provide contour maps showing light distribution throughout the greenhouse.

	A	B
17	**Calculations**	(don't modify these boxes)
18	**4,047**	Square meters to light (note 1 square meter = 10.7639 square feet)
19	**1,962**	Lamp output µmol/s
20	**413**	Light fixtures needed without edge effects
21	**459**	Light fixtures needed with edge effects
22	**$160,650**	Total cost of light fixtures (assuming edge effects)
23	**1,000,620**	kWh of electricity to light this many lamps for the given number of hours
24	**$160,099**	electricty cost ($/area in cell A8/yr)
25	**$3.68**	electricity cost ($/square foot/yr)
26	**$39.56**	electricity cost ($/m^2/yr)

Figure 2. Output parameters for for the calculator tool.

Let's get started! The underlying math behind the calculator tool is pretty straightforward and you can read all about it in a previous eGro Alert here. Okay, first download a copy of the spreadsheet tool, by accessing the link here and then clicking on "File" and "Download a Copy" to your computer. After downloading the Excel Spreadsheet and opening it you may need to click "Enable Editing" at the top so you can input your own data.

The yellow highlighted boxes (Figure 1) are information that you will need to input. A few pieces of information you will need to get directly from the lighting supplier 1) the power consumption of the fixture in Watts, the Photosynthetic photon efficacy (PPE) in µmol/J (a measure of light output per unit energy, higher is better), and the cost of the individual light fixture.

The red highlighted boxes are automatically calculated based on your inputs (Figure 2). **Don't** modify or type anything into the red boxes or the calculations will be messed up. As you can see the tool estimates how many light fixtures we need (including with and without an estimate for light loss to the edges of the greenhouse). Based on the fixture power consumption, the hours that you operate the lights, and your electricity cost the calculator tool also calculates the annual electricity costs.

What about comparing a couple of fixtures? This is where it gets fun! You can use a couple tabs at the bottom of the spreadsheet "Lamp 1" and "Lamp 2" to compare two different fixtures. In this case you'll provide the input data for each lamp in the yellow highlighted area, while keeping the other information the same (such as area to light, hours on per year, and electricity cost). Then the bottom of the "Lamp 1" tab provides summary information on the cost to purchase lamp 1 vs. lamp 2 (in $/square foot) and the cost of electricity per year (in $/square foot). Finally, a simple payback in years for purchasing lamp 2 vs. lamp 1 is calculated. This is the difference in upfront cost divided by the different in annual electricity cost. Assuming lamp 2 is more expensive up front but has higher energy efficiency you'll see how many years you need to operate the light to payback the different in upfront cost. Note that this number does not account for installation costs, maintenance costs or declines in light output over time.

Let's run through a hypothetical example. In this example we assume we are lighting lettuce in the Northeast U.S. and have a target instantaneous light intensity of 200 µmol·m-2·s-1, we are lighting a 1 acre greenhouse and we'll have 10% light loss to edges. The first lamp we'll consider is a high-pressure sodium lamp with a power consumption of 1090 W, PPE of 1.8 µmol/J and a cost of $350 per fixture. The second lamp we'll consider is an LED lamp with a power consumption of 581 W, PPE of 3.1 µmol/J and a cost of $950 per fixture. Let's assume we have access to a relatively affordable electricity rate of $0.08 per kWh. Using the tool, we find the comparison table given in Figure 3.

	A	B	C	D
28	**Summary statistics comparing Lamp 1 vs. I**			
29	**$3.69**	Cost to purchase Lamp 1 ($/sf)		
30	**$10.90**	Cost to purchase Lamp 2 ($/sf)		
31	**$1.84**	Electricity cost Lamp 1 ($/sf/yr)		
32	**$1.07**	Electricity cost Lamp 2 ($/sf/yr)		
33	**9.36**	Simple payback in years for Lar		
34				

Figure 3. Comparing two lamps with electricity at $0.08 / kWh

Summary statistics comparing Lamp 1 vs.	
$3.69	Cost to purchase Lamp 1 ($/sf)
$10.90	Cost to purchase Lamp 2 ($/sf)
$3.68	Electricity cost Lamp 1 ($/sf/yr
$2.13	Electricity cost Lamp 2 ($/sf/yr
4.68	Simple payback in years for La

Figure 4. Comparing two lamps with electricity at $0.16 / kWh

You'll notice the cost to purchase lamp 1 is cheaper ($3.69 per square foot) vs. lamp 2 ($10.90 per square foot). However, the electricity cost of lamp 2 is cheaper ($1.07/sf/yr vs. $1.84/sf/yr) this means there is a simple payback time period of 9.36 years if you were to purchase lamp 2 (i.e. how many years of electricity savings it would take to make up for the difference in upfront cost of the lamps. Most operations look for a 3-5 year (or less) payback to make energy efficiency upgrades.

Now, let's consider how the cost of electricity changes the picture. Let's assume the exact same scenario with the only difference being electricity is now more expensive at $0.16 per kWh. Check out the comparison in Figure 4. The upfront cost to purchase the lamps hasn't changed but the annual electricity cost has. No surprise, the annual electricity cost has now doubled and it's $3.68/sf/yr for lamp 1 and $2.13/sf/yr for lamp 2. Because lamp 2 has double electricity cost savings (under the $0.16/kWh scenario), the simple payback This means when electricity is expensive, is now 4.68 years.

paying more upfront for a more energy efficient fixture can make sense. It's worth noting that you may be able to get incentives from your utility provider or potentially from your state to help pay for a portion of the upfront cost of energy efficient lighting.

Further information:

Design Lights Consortium. Qualified Product List for Horticultural Lighting. https://www.designlights.org/our-work/horticultural-lighting/

Mattson, N. 2017. How many light fixtures do I need? e-Gro Edible Alert 2(5). 4 pp. http://www.e-gro.org/pdf/E205a.pdf

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Purdue University

The Ohio State University

NC State University

In cooperation with our local and state greenhouse organizations

Maumee Valley Growers — Choose the Very Best.

Metropolitan Detroit Flower Growers Association — Metro Detroit Flower Growers Association

NC Flower Power

Western Michigan Greenhouse Association

Connecticut Greenhouse Growers Association

Indiana Flower Growers Association

LIFGA

Cincinnati Flower Growers Association

Michigan Greenhouse Growers Council

NYSFI — New York State Flower Industries, Inc.