Energy Calculation Mat

SIDE 1

Start here

You will use the information on this page and the results from counting the squares on the city grid to determine the energy, cost, and carbon footprint of the lights from this city.

Bulb Type 1: Metal Halide

Wattage of the bulbs: 250

Lumens of light: 22,000

Number of squares:

Bulb Type 2: High Pressure Sodium

Wattage of the bulbs: 250

Lumens of light: 24,000

Number of squares:

Bulb Type 3: High Pressure Sodium

Wattage of the bulbs: 150

Lumens of light: 16,000

Number of squares:

For all bulbs:

Cost of electricity per kilowatt-hour:

$0.08

This will depend on how your region produces electricity. For Houston, the average is $0.08 per kWh.

All bulbs will be turned on for **11 hours** per night.

There are **2,000,000 bulbs** in this city.

The total number of squares on the grid is **1,344**.

Note: In this document, a comma (,) is used for the thousands (or millions) place in large numbers and a period (.) is used for the decimal place. In many countries, this is reversed. Don't let this confuse you!

Number of squares of Bulb Type 1 +

Number of squares of Bulb Type 2 +

Number of squares of Bulb Type 3 +

Number of Lit Squares

Bulb Type 1

Use the numbers in the colors above to complete the next section of this worksheet. Repeat these steps for each type of bulb.

For this first set of calculations we will use **Bulb Type #1**. First we will find the efficacy of each bulb. The efficacy is the ratio of lumens to watts. The efficacy is related to the efficiency, but they are not the same thing. A larger efficacy means the bulb is more efficient. Which of the bulbs has the highest efficacy?

Step 1: Lumens of Type 1 ÷ Wattage of Type 1 = Efficacy of Type 1

We want to determine what percent of all lights are of Type 1. To do this, we'll take the number of squares of Type 1 and divide it by the total number of lit squares.

Step 2: Number of squares of Type 1 ÷ Total number of lit squares = Percent of lights that are Type 1

Now we want to determine how many bulbs of Type 1 are in the city. To do this, we'll take the percent of Type 1 and multiple it by the total number of lights in the city (2,000,000).

Step 3: Percent of lights that are Type 1 × 2,000,000 = Number of bulbs on Type 1 in the city

In this next step, we will find the energy used in one night. Electric utility companies measure energy in a unit called watts. For example, if you have a 100-watt bulb and the light is on for 11 hours it uses 100W*11 hours or 1,100Wh. To calculate the amount of energy used, the wattage (in watts) of the bulb is multiplied by the number of hours the light is on per night. Watts is a unit of power which is the rate of energy over time. By multiplying by time (e.g., 11 hours), you end up with energy.

Step 4: Wattage of Type 1 × 11 = Energy used in one night by one bulb of Type 1

Bulb Type 1

Now let's take a closer look at energy, cost, and carbon footprint.

Because of how quickly watt-hours add up, the term kilowatt-hour is used to represent 1000 watt-hours. You can convert the number of watt-hours to kilowatt-hours by dividing the number of watt-hours (or energy) by 1000. This is the amount of energy used in one night.

Step 5: Energy used in one night by one bulb of Type 1 ÷ 1000 = Kilowatt-hours used in one night for one bulb of Type 1

An important part of light pollution is the enormous cost that is required to keep the lights turned on. Electric utility companies charge for electricity by the kilowatt-hour (kWh). Next we will calculate how much it costs to light up one bulb of Type 1 for one night.

Step 6: Kilowatt-hours used in one night for one bulb of Type 1 × $0.08 (Cost per kilowatt-hour) = Amount spent on one bulb of Type 1 in one night

Electricity is most commonly produced from coal, natural gas, or nuclear power. When chemicals are burned, greenhouse gases are emitted that contribute to air pollution and climate change. The final important aspect of light pollution is the amount of greenhouse gases that are emitted during the production of electricity. Greenhouse gases are measured by the mass of the carbon dioxide gas. The amount of greenhouse gases produced depends on the type of fuel used to produce electricity. Because that's hard to know exactly, we're going to use an average of 0.84 kg per kilowatt-hour. To calculate how much greenhouse gas is produced, you need to multiply the kilowatt-hours used in one night by 0.84kg/kWh.

Step 7: Kilowatt-hours used in one night for one bulb of Type 1 × 0.84 $\frac{kg}{kWh}$ = Amount of greenhouse gas (kg) produced by one bulb of Type 1 in one night

Now let's determine how much energy, cost, and carbon footprint is used for the entire city in one night. To do this, we'll multiply the results from the previous page for one bulb by the total number of bulbs we calculated in Step 3.

Step 8: Kilowatt-hours used in one night for one bulb of Type 1 × Number of bulbs on Type 1 in the city = Kilowatt-hours used in one night for all bulbs of Type 1

Step 9: Amount spent in one night for one bulb of Type 1 × Number of bulbs of Type 1 in the city = Amount spent in one night for all bulbs of Type 1

Step 10: Amount of greenhouse gas produced in one night for one bulb of Type 1 × Number of bulbs of Type 1 in the city = Amount of greenhouse gas (kg) produced in one night for all bulbs of Type 1

Now let's determine how much light is being wasted by shining up into the sky. Roughly 30% of the light used is wasted. We'll multiply the results from the above steps by 30% or 0.3 to determine the wasted light.

Step 11: Kilowatt-hours used in one night for all bulbs of Type 1 × 0.3 = Kilowatt-hours wasted in one night for all bulbs of Type 1

Step 12: Amount spent in one night for all bulbs of Type 1 × 0.3 = Amount spent wasted in one night for all bulbs of Type 1

Step 13: Amount of greenhouse gas produced in one night for all bulbs of Type 1 × 0.3 = Amount of greenhouse gas (kg) wasted in one night for all bulbs of Type 1

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