

## Investigation Backpack 01

### Enlightenment 2020: Earth, Moon, and Mars

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We introduced this investigation in "Investigation Backpack" in *The Oregon Mathematics Teacher (TOMT)*, September 2007. We tried to pique your interest with a brief description, replicated here.



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**Level and Subject:** Middle school through high school

**The Hook:** The investigator plays the role of a habitat lighting designer in Earth years 2007 to 2020. She or he can opt to design lighting for habitats on Earth, in Earth-orbiting space stations, or for future habitats on the Moon and Mars.

**Earth Year 2007:** Earth habitats are switching from energy-gobbling **incandescent light bulbs** to energy-miserly **compact fluorescent lamps (CFLs)**. **Light-emitting diodes (LEDs)** are displacing other light sources in traffic lights, flashlights, camp lanterns, et cetera, et cetera. NASA is using LEDs as the source of light for growing plants in space farms. Designers of future habitats on Earth, Moon, and Mars plan to use LEDs as the primary light source.

**Earth Year 2020:** LEDs have become the preferred standard for habitat lighting on Earth, replacing CFLs. Designers of future habitats on Earth, Moon, and Mars plan to use LEDs as the standard light source, and are investigating new lighting technologies.

**Your Task.** Investigate the above claims. Are the claims for 2007 true? If yes, why is this happening? Are there cost benefits? Are there environmental benefits? Are the claims for 2020 reasonable? If yes, explain why. Compare the cost of lighting using incandescent bulbs, CFLs, and LEDs in 2007. Use credible projections to do the same for the year 2020 and beyond.

This unit points to Internet sources of information about:

- Habitat lighting: incandescent and CFL
- Data from the **Energy Information Administration (EIA)**
- Data from **Energy Star**

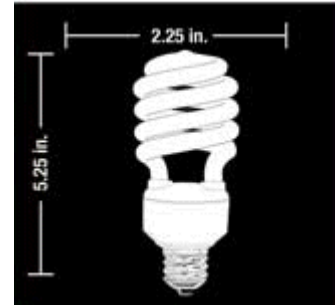
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Go to **www.curriki.org** and search for **investigation**

## Habitat lighting: incandescent and CFL

**2007:** People living in Earth habitats are switching from **incandescent light bulbs** to **compact fluorescent lamps (CFLs)**. **Investigate** incandescent light bulbs and CFLs at:

- Incandescent light bulb – Wikipedia ([http://en.wikipedia.org/wiki/Incandescent\\_light\\_bulb](http://en.wikipedia.org/wiki/Incandescent_light_bulb))
- Compact Fluorescent Light Bulbs: ENERGY STAR ([www.energystar.gov/index.cfm?c=cfls.pr\\_cfls](http://www.energystar.gov/index.cfm?c=cfls.pr_cfls))
- Find an Energy-Saving Light Bulb ([www.environmentaldefense.org/page.cfm?tagID=632](http://www.environmentaldefense.org/page.cfm?tagID=632))
- Compact fluorescent lamp – Wikipedia ([http://en.wikipedia.org/wiki/Compact\\_fluorescent\\_lamp](http://en.wikipedia.org/wiki/Compact_fluorescent_lamp))
- Lighting Types ([www.lightsofamerica.com/light-level.htm](http://www.lightsofamerica.com/light-level.htm))
- Fluorescent vs. Incandescent ([www.lightsofamerica.com/light-cfl.htm](http://www.lightsofamerica.com/light-cfl.htm))



CFL picture is from [www.lightsofamerica.com](http://www.lightsofamerica.com)

The **cost of electricity** is given in cents or dollars per **kilowatt-hour (kWh)**.

- One **kilowatt (kW)** equals 1000 **watts (W)**.
- Light bulbs are rated in watts. Divide the rating in watts by 1000 to get the rating in kilowatts. A 60-watt bulb is a 0.060-kilowatt bulb.
- One **kilowatt-hour (kWh)** equals one kilowatt used for one hour. A 60-watt (0.060 kW) bulb consumes 0.06 kWh every hour it is lit.
- In 2007, a typical residential electric rate for the USA is 10 cents (0.10 dollar) per kilowatt-hour.
- Light output is measured in **lumens**. A CFL emits approximately four times as many **lumens per watt** as an incandescent bulb. Therefore, the cost of electricity of a CFL is approximately one-fourth as much as an equivalent incandescent bulb.

**Investigate** watt, kilowatt, watt-hour, kilowatt-hour, and lumen at:

- Watt – Wikipedia (<http://en.wikipedia.org/wiki/Watt>)
- Watt-hour – Wikipedia (<http://en.wikipedia.org/wiki/Watt>)
- How much does electricity cost? What is a kilowatt-hour? (<http://michaelbluejay.com/electricity/cost.html>)
- Lumen (unit) – Wikipedia ([http://en.wikipedia.org/wiki/Lumen\\_%28unit%29](http://en.wikipedia.org/wiki/Lumen_%28unit%29))

## Data from the Energy Information Administration (EIA)

You can browse a deluge of data at the **Energy Information Administration's** web site.

- Energy Information Administration – EIA – Official Energy Statistics from the U.S. Government ([www.eia.doe.gov/](http://www.eia.doe.gov/))

Click on **Electricity** and go to:

- EIA – Electricity Data, Electric Power Capacity and Fuel Use, Electric Surveys and Analysis ([www.eia.doe.gov/fuelectric.html](http://www.eia.doe.gov/fuelectric.html))

Lots of links! Explore them. In the **U.S. Data** column (left side of the page), investigate:

<b>Sales, Revenues &amp; Prices</b>	<b>Data for years 1994 - 2005</b>
Retail Price to Customers	Average price of electricity Residential: 9.45 cents per kilowatt-hour in 2005
Retail Sales	Sale of electricity to all customers Residential: 1,359,227,107 megawatt-hours in 2005
<b>Generation</b>	
by Energy Source	Coal, petroleum, gas, nuclear, hydroelectric, other Coal: 2,013,179 thousand megawatt-hours in 2005
<b>Fuel Used in Electric Generation</b>	
Consumption of Fossil Fuels	Coal, petroleum, natural gas, other gas Coal: 1,045,878 thousand tons in 2005
<b>Environmental</b>	
Emissions	Carbon dioxide, sulfur dioxide, nitrogen oxides Carbon dioxide (CO <sub>2</sub> ): 2,513,609 thousand metric tons in 2005 [1 metric ton = 1,000 kilograms]
<b>Electricity Databases</b>	Download Excel Worksheets for states and entire U.S.

Explore more links at EIA – Electricity Data, Electric Power Capacity and Fuel Use, Electric Surveys and Analysis ([www.eia.doe.gov/fuelectric.html](http://www.eia.doe.gov/fuelectric.html)).

Under **Reports** in the center column, click on **Electric Power Annual** and go to:

- EIA – Electricity Data, Analysis, and Surveys ([www.eia.doe.gov/cneaf/electricity/epa/epa\\_sum.html](http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html))

On the right side of the page, you will see links to chapters in this report and tables of data. You can view a table in web format (html) or download it as a Microsoft Excel file (xls) or Portable Document File (pdf).

Data from several individual sources listed above are collected into two pages of tables at:

- Summary Statistics for the United States ([www.eia.doe.gov/cneaf/electricity/epa/epates.html](http://www.eia.doe.gov/cneaf/electricity/epa/epates.html))

Back to EIA – Electricity Data, Electric Power Capacity and Fuel Use, Electric Surveys and Analysis ([www.eia.doe.gov/fuelectric.html](http://www.eia.doe.gov/fuelectric.html)). In the **References** box on the right side of the page, click on **Electricity Basics 101** and go to:

- EAI – Energy Basics ([www.eia.doe.gov/basics/electricity\\_basics.html](http://www.eia.doe.gov/basics/electricity_basics.html))

In this page explore these links:

- Electricity Basic Statistics (under **Basic Electricity Data** on the left side of the page)
- Energy Conversions (in **References** box on the right side of the page)

In the energy conversions page ([www.eia.doe.gov/basics/conversion\\_basics.html](http://www.eia.doe.gov/basics/conversion_basics.html)), investigate U.S. and metric units for energy:

- U.S. units: British thermal unit (Btu), calorie (cal), and kilowatt-hour (kWh)
- Metric units: joule (J) and megajoule (MJ)

Under **Not Just for Kids**, click on **U.S. Energy Units Calculator** and go to:

- EIA Energy Kids Page ([www.eia.doe.gov/kids/energyfacts/science/energy\\_calculator.html](http://www.eia.doe.gov/kids/energyfacts/science/energy_calculator.html))

Calculate! Calculate! Calculate!

## Data from Energy Star

**About ENERGY STAR** ([www.energystar.gov/index.cfm?c=about.ab\\_index](http://www.energystar.gov/index.cfm?c=about.ab_index))

ENERGY STAR is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy helping us all save money and protect the environment through energy efficient products and practices. Americans, with the help of ENERGY STAR, saved enough energy in 2006 alone to avoid greenhouse gas emissions equivalent to those from 25 million cars while saving \$14 billion on their utility bills.

### Useful Facts & Figures: ENERGY STAR

([www.energystar.gov/index.cfm?c=energy\\_awareness.bus\\_energy\\_use](http://www.energystar.gov/index.cfm?c=energy_awareness.bus_energy_use))

- Energy to carbon emissions: 1.55 pounds CO<sub>2</sub> per kWh.

We think this means that producing one kilowatt-hour of electric energy by, say, a coal-burning or petroleum-burning power plant produces 1.55 pounds of carbon dioxide emissions.

Information paraphrased from Useful Facts & Figures: ENERGY STAR:

- In the United States, approximately 6.6 tons (almost 15,000 pounds carbon equivalent) of greenhouse gases are emitted per person every year. [6.6 tons equals 13,200 pounds. How did they get 15,000 pounds carbon equivalent from 13,200 pounds of greenhouse gases? Investigate!]
- Eighty-two percent of greenhouse gas emissions are from burning fossil fuels to generate electricity and power cars.
- About 2,700 pounds of carbon per person per year (18% of total emissions) come from operating our homes, and most of that is from the energy used to power electrical appliances. [Verify: Are 2,700 pounds 18% of 15,000 pounds?]
- Individuals can affect the emissions of about 4,800 pounds of carbon equivalent, or nearly 32% of the total emissions per person, by the choices you make in three areas of your life. [Verify: Are 4,800 pounds 32% of 15,000 pounds?]

At Useful Facts & Figures, you can click on **EPA Greenhouse Gas Calculators** and go to:

- EPA : Global Warming : Resource Center : Tools : Calculators  
(<http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterToolsCalculators.html>)

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