

Consumer Preferences

August 18, 2013

What is Power?

- Power is the rate at which work is performed.
- Equations:

$$Force = mass * acceleration$$

$$Work = Force * \Delta distance$$

$$Power = \Delta Work / \Delta Time$$

What are the units of Force, Work, and Power?

- Force: Newton (N)
 $1 N = 1 kg \cdot m / s^2$

- Work: Joule (J)
 $1 J = 1 N \cdot m$

- Power: Watt (W)
 $1 W = 1 J / s$

where kg=kilogram, m=meter, s= second

What is a Watt?

- Example:

Suppose a man, who has a mass of 70 kg, needs to climb a 5-meter high wall in 6 seconds. How much work would he do and how much power would he need to accomplish this feat?

Hold on! What is energy?

- Energy is Work.
- One way to measure Energy is to measure the amount of power in a certain time period.
 - kWh is the most common unit used to express the amount of electricity, especially for billing purposes.
 - 1 kWh = 1000 W-h
 - 1 kWh = 3.6 MJ
 - MWh are sometimes used when describing energy from a power plant.

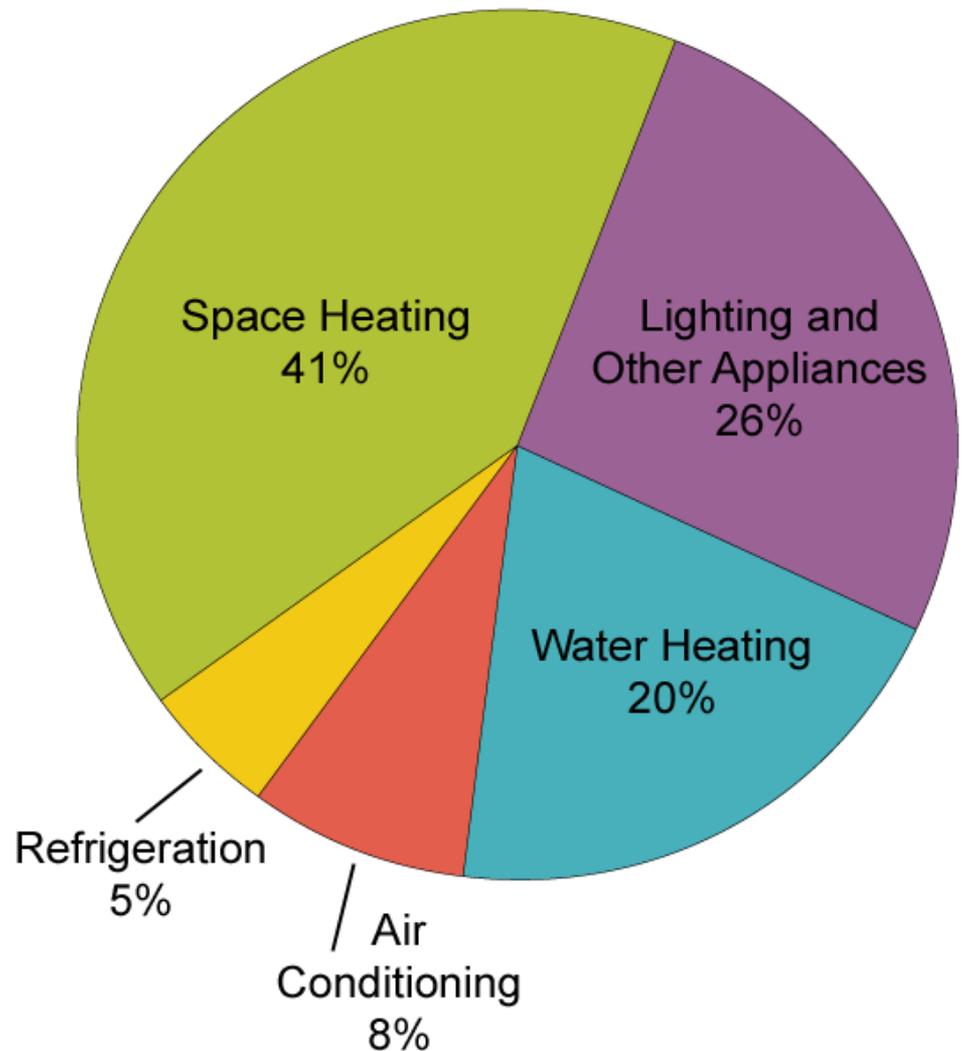
Example: How much electricity is consumed by a 60 W light bulb operating for one hour?

US v.s. World Energy Use

On average, how much electricity is used per person per year in the US? How about in other countries?

US Residential Energy Usage

Lighting accounts for 10 to 15 % of residential Energy usage!



* 2005 is the most recent year for which data are available.

Source: U.S. Energy Information Administration, *Residential Energy Consumption Survey 2005*.

Lighting Experiment

- Compare the light bulbs

How is our lighting produced?

- Incandescence
 - Light emitted due to high temperature
 - Color of the light is determined by the temperature of the object.



Figure Courtesy of 123rf



- Fluorescence
 - Highlighter
 - UV light at museums, etc.



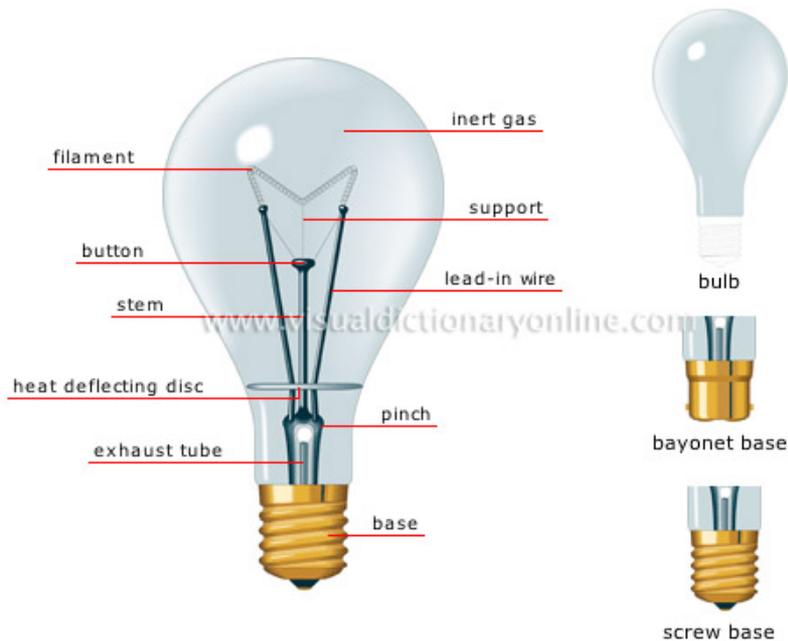
Figure Courtesy of NASA

Let's have a look at light bulbs

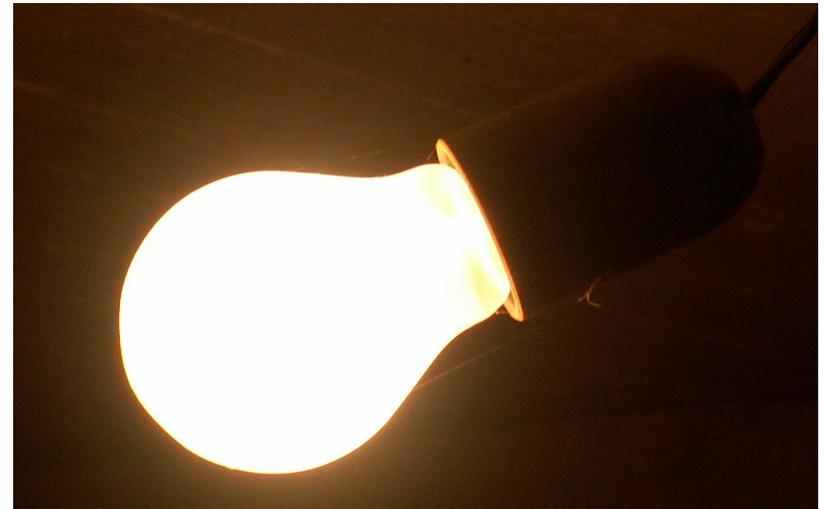
- Incandescent vs. Compact Fluorescent Light
 - Heat
 - Brightness (Lux)
- Color comparison
 1. Soft white (2700K)
 2. Bright white (3500K)
 3. Daylight (5000K)

Lighting technologies

- Incandescent lamp



Less than \$1



Lighting technologies

- Fluorescent lamp



Tubular Fluorescent Lamp

Around \$2



Compact Fluorescent Lamp (CFL)

Lighting technologies

- Light Emitting Diode (LED)



Around \$20 ~\$40

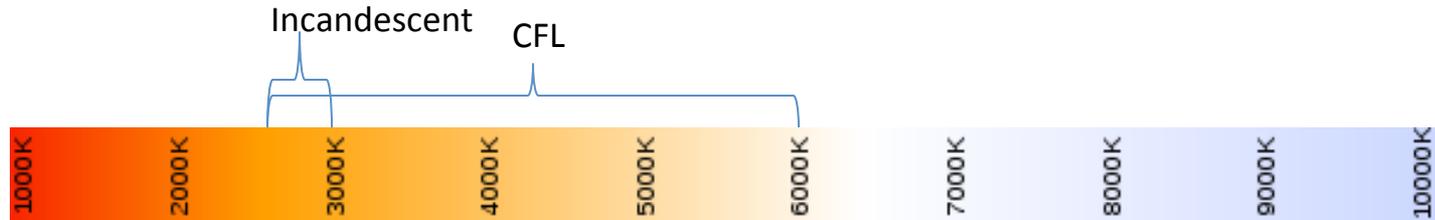


Source: <http://www.gadgetvenue.com/geobulb-led-light-bulb-costs-120-03305214/>
<http://www.metaefficient.com/bicycles/bright-led-bike-light.html>

How are they similar?

Incandescent vs. Compact Fluorescent Lamp (CFL)

- Overlapping range of color



- Almost identical in terms of brightness
 - Ranging from 350 lm to 1800 lm
 - Luminous flux (Lumen, lm)
 - Total light output from a source
 - Illuminance (Lux, lx)
 - From the perspective of a receiver
 - Light input per unit surface area ($1 \text{ lx} = 1 \text{ lm/m}^2$)

How are they different?

CFLs, compared with incandescent lamps,

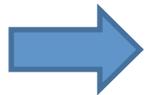
- last about **nine to ten** times longer.
- use less energy.
 - Incandescent: About 5% of input energy is converted to light.
 - CFL, LED: About 20% is converted to light. (4x)
 - The rest is wasted as heat.
- are more expensive.
- contain mercury.

Which is better? - Economics

High price and low energy cost (CFL)

vs.

Low price and high energy cost
(Incandescent)



Lifetime matters!

Which is better? – Mercury risk

- Mercury
 - It can damage the central nervous system, kidneys, and liver.
 - CFLs contain small amount of mercury (4~5mg).
 - Largest source: coal-fired power plants (50% of total in the U.S.)

Lighting Experiment

- Compare the light bulbs

Additional Choice Task #1

If these were your only options for light bulbs, which would you choose?

Choose by clicking one of the buttons below:

| | | | |
|------------------------------------|------------------------------------|-----------------------------------|-----------------------------------|
| Type: Incandescent | Type: Incandescent | Type: CFL | Type: CFL |
| Unit price: \$0.70 | Unit price: \$1.50 | Unit price: \$4.00 | Unit price: \$6.00 |
| Energy use: 40W | Energy use: 60W | Energy use: 14W | Energy use: 23W |
| Annual energy cost: \$13/yr | Annual energy cost: \$18/yr | Annual energy cost: \$5/yr | Annual energy cost: \$2/yr |
| Lifetime: 1,500 hours | Lifetime: 750 hours | Lifetime: 10,000 hours | Lifetime: 8,000 hours |
| Brightness: 500 lumen | Brightness: 850 lumen | Brightness: 750 lumen | Brightness: 1800 lumen |
| Shape: Round | Shape: Round | Shape: Round | Shape: Spiral |
| Color: Soft White | Color: Soft White | Color: Soft White | Color: Daylight |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

Please answer these three questions and write what you think during the process. For example, Was it hard because of too many factors? Did you look at just a couple things and ignore others?

Additional Choice Task #2

If these were your only options for light bulbs, which would you choose?

Choose by clicking one of the buttons below:

| | | | |
|--------------------------------------|-----------------------------------|------------------------------------|-----------------------------------|
| Type: CFL | Type: Incandescent | Type: Incandescent | Type: CFL |
| Unit price: \$4.00 | Unit price: \$0.70 | Unit price: \$1.50 | Unit price: \$4.00 |
| Energy use: 9W | Energy use: 100W | Energy use: 60W | Energy use: 9W |
| Annual energy cost: \$3.50/yr | Annual energy cost: \$8/yr | Annual energy cost: \$18/yr | Annual energy cost: \$2/yr |
| Lifetime: 8,000 hours | Lifetime: 1,500 hours | Lifetime: 1,000 hours | Lifetime: 15,000 hours |
| Brightness: 350 lumen | Brightness: 1800 lumen | Brightness: 850 lumen | Brightness: 650 lumen |
| Shape: Spiral | Shape: Round | Shape: Round | Shape: Spiral |
| Color: Soft White | Color: Soft White | Color: Soft White | Color: Soft White |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

Additional Choice Task #3

If these were your only options for light bulbs, which would you choose?

Choose by clicking one of the buttons below:

| | | | |
|------------------------------------|-----------------------------------|-----------------------------------|------------------------------------|
| Type: Incandescent | Type: CFL | Type: CFL | Type: Incandescent |
| Unit price: \$1.50 | Unit price: \$6.00 | Unit price: \$4.00 | Unit price: \$0.70 |
| Energy use: 100W | Energy use: 9W | Energy use: 14W | Energy use: 100W |
| Annual energy cost: \$13/yr | Annual energy cost: \$2/yr | Annual energy cost: \$5/yr | Annual energy cost: \$13/yr |
| Lifetime: 750 hours | Lifetime: 10,000 hours | Lifetime: 15,000 hours | Lifetime: 750 hours |
| Brightness: 1200 lumen | Brightness: 500 lumen | Brightness: 950 lumen | Brightness: 1200 lumen |
| Shape: Round | Shape: Round | Shape: Spiral | Shape: Round |
| Color: Soft White | Color: Soft White | Color: Daylight | Color: Soft White |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

U.S. legislation on lighting efficiency

- Energy Independence and Security Act of 2007 (EISA)
 - Mandates that all light bulbs be 30% more efficient in 2012 and 60% more efficient in 2020
 - Incandescent bulbs will be subject to higher energy efficiency standards
- Better Use of Light Bulbs (BULB) Act
 - Tried to repeal EISA but was not successful
 - The House voted it down on 7/12/2011.
 - “A massive Big Brother intrusion into our homes and our lives.” - Member of the U.S. House of Representatives