Introduction to Energy Use in Design

Companion to the video: Script and Illustrations

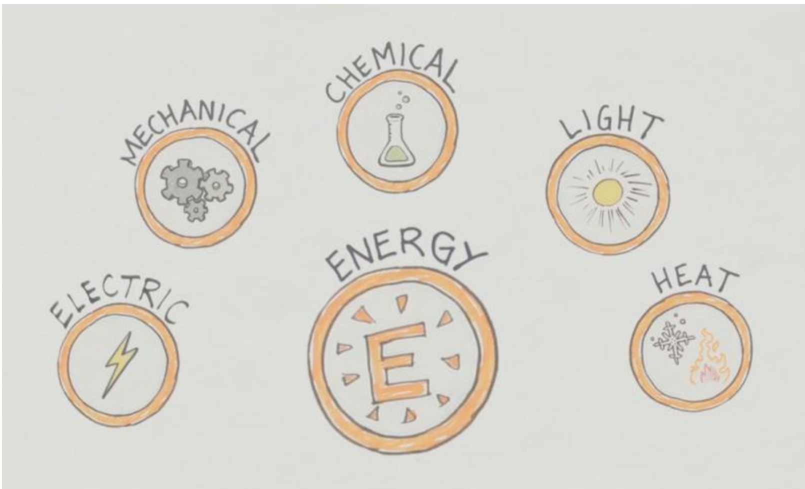
By harnessing energy to do work for us, we humans have gotten really good at making life easier.

Cars, computers, refrigerators and buildings all use energy to get us what we want.

But it's their use of energy that is often the biggest source of their environmental impacts.

So, to make a product like a refrigerator more sustainable, you've got to understand energy.

To cool your food, your refrigerator uses electricity. That electricity is made by converting energy from one form to another, like mechanical, chemical, light, or heat energy. Some energy is lost in each conversion.

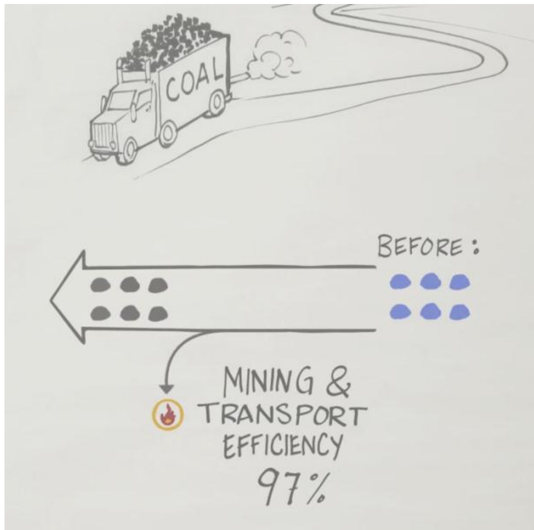


Well, technically, energy cannot be lost or destroyed. The first law of Thermodynamics tells us that's impossible.

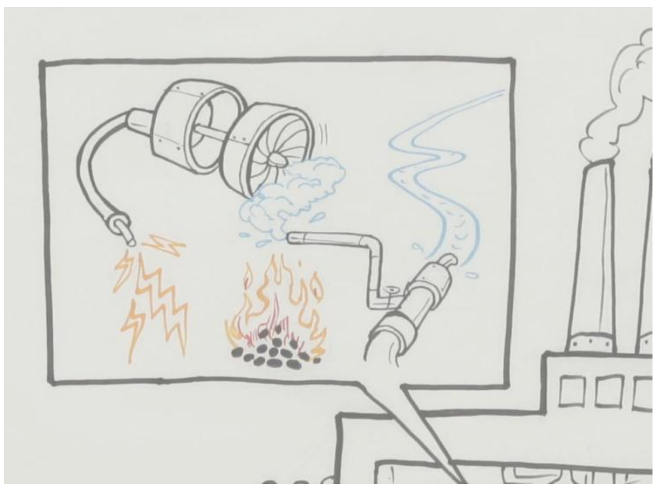
But as it's converted between its different forms, it's also converted to forms we don't want – like noise, heat, and vibration. This makes your designs less efficient.

So, if your power is from a coal plant, the first stage in your energy system is the mining and transport of the coal.

Although it takes energy to mine the coal and truck it to a power plant, the energy made available is much greater, so that step is about 97% efficient.



Within the power plant the coal is burned to heat water into steam, which pushes a turbine connected to an electric motor, which generates electricity.



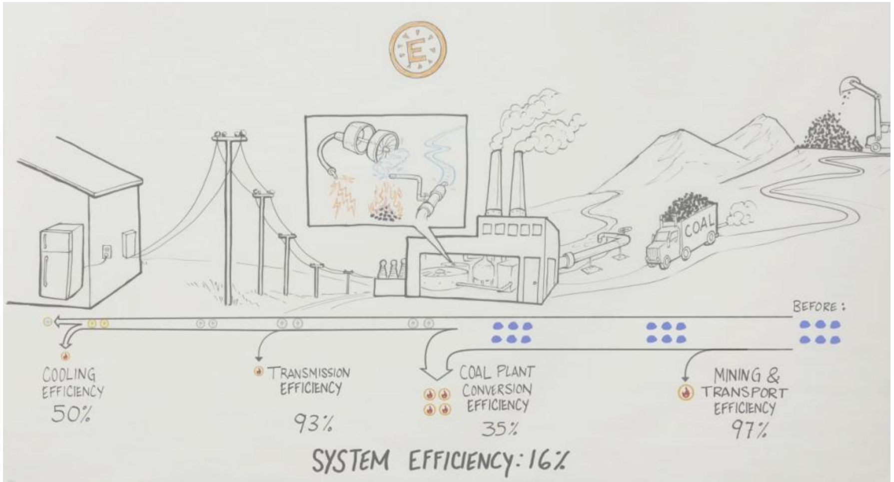
This converts coal's chemical energy to heat energy, then to mechanical energy, then to electrical energy. That's a lot of conversions, and the total efficiency is about 35%.

Then the electricity for your fridge gets to your home over high-voltage powerlines, which are 93% efficient.

Finally, let's say that 50% of the electricity your fridge uses actually goes into cooling the food inside. The other half escapes through the insulation, the occasional open door, or other losses.

To find how efficient the whole system is, you can multiply the efficiencies of each stage.

It turns out this system is only 16% efficient.

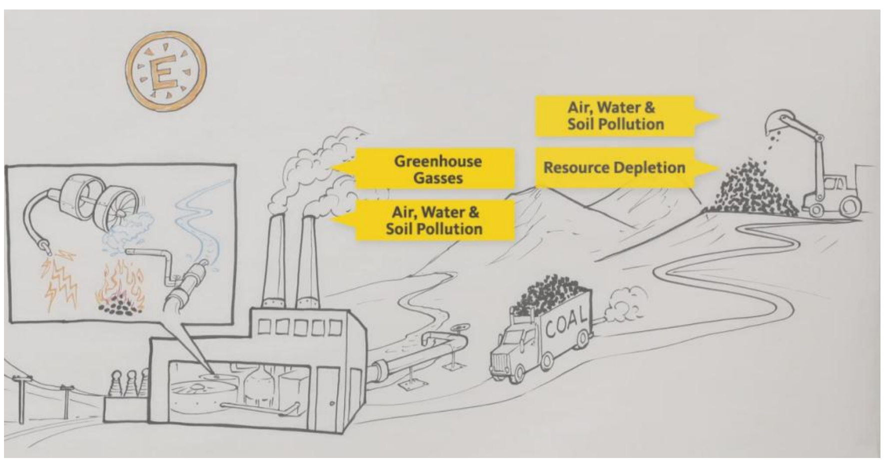


So if your food needs 100 units of electrical energy a day to keep cold, you're actually using over 600 units of energy to cool it.

But if you can help your fridge use less energy with better insulation, or even a chime to remind your user that the door is open, every unit of cooling energy saved can save 6 units of energy from the coal upstream!

But of course, not at all energy is created equal. The environmental impacts shift based on your power source.

For instance, mining coal can remove mountaintops. Then burning it releases carcinogens and a lot of greenhouse gases.



On the other hand, you can have a much lower environmental impact by using solar panels to generate electricity.

Even though most solar panels are less than 20% efficient at turning sunlight into electricity, the environmental impacts per watt are just a fraction of using coal.

So you don't always need to be efficient to be energy-effective.

We've talked about how energy is used and where it comes from, but what IS energy?

Simply, it's the ability to do work. It's measured in joules.

If I lift this apple from the floor to the desk, that takes about 1 Joule of mechanical energy.

Lifting a person that high could take a kilojoule of energy.

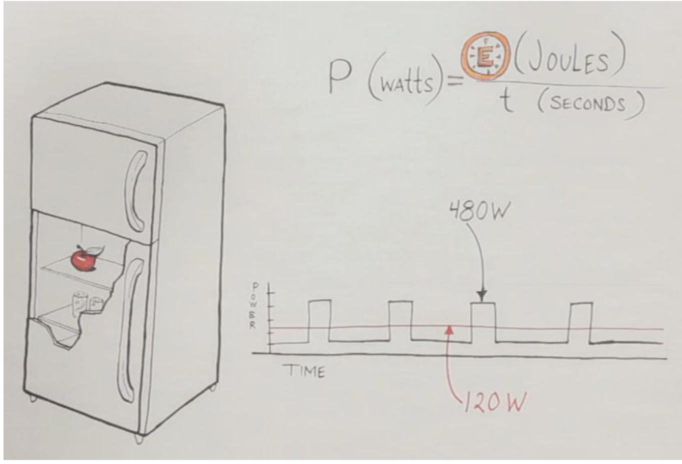
A double-A battery holds about 10 kilojoules of chemical energy.

And you need about 10 kilojoules to move enough heat energy from an apple to cool it to refrigerator temperature.

So is that all the energy this apple needs to stay fresh? Of course not. The fridge has to keep using energy over time so the apple stays cold.

Power is the rate at which we use energy, and it's measured in watts. A Watt is one joule per second.

Your refrigerator may use 480 watts of power when its compressor is on, but if it's only on a quarter of the time, it would average 120 watts.



As an engineer or designer, you can help people use energy more effectively by understanding energy systems and how your designs fit in.

You can often make efficiency improvements by minimizing common forms of energy loss, like mechanical friction, fluid drag, and unwanted heat transfer. And in the lessons that follow, we'll cover strategies to do just that.