Science Forward-Energy

Emily Rice, Astronomer, Host, Science Forward: When you think of energy, what comes to mind?

[background music]

Is it the battery indicator on your phone? The third rail of the subway tracks? A bill from the power company? A hair dryer, a coffee maker, a television? Or the lights coming on when you want them to?

We're used to having energy available to us at the literal flip of a switch but where do we actually get the energy from? A light bulb without a socket is just glass and metal, and a socket without a power grid can't transform that glass and metal into a source of light.

In this video, we will find out more about energy. How we produce it, how we distribute it, and why energy use is one of the biggest scientific challenges of our time. Let's take a closer look at what it really takes to turn on the lights.

[Science Forward theme music]

Shannon Swilley Greco, Princeton Plasma Physics Laboratory:A long time ago, what did we heat our homes with and cook our food with? We burned wood. We burned plant matter. We burned dung. But something changed around the industrial revolution. We started using coal first.

Picture Oliver Twist in the dirty streets of London. We started using fossil fuels to fund our economic expansion. We started increasing our standard of living, even though it sounds really gross to live in dirty old London.

We actually were making huge advances and we were doing amazing things with this fossil fuel. It is incredibly energy dense. It gives off a lot of heat when you burn it. It was readily available. We kept finding more of it.

Sanjoy Bannerjee, CUNY Energy Institute: Currently, energy use is very related to the quality of our life. It's largely used to make things easier for us.

Shannon Swilley Greco: The world energy consumption, it's growing but that's not necessarily a bad thing. That corresponds with an increased standard of living. Who are we to say, "No, I'm sorry. You can't have a car. You can't have air conditioning or refrigeration."

We have so much food and so much energy because of fossil fuels. It's just so addicting. It's so easy. It's so energy dense. It's so easy to use. It's a great source of energy but it's got these major consequences.

Emily Rice: Fossil fuels include coal, oil, and natural gas. If fossils are ancient, then why are fossil fuels a modern problem?

Shannon Swilley Greco: The thing is, it was stored safely for millions of years. It was no problem whatsoever when it was under the ground. They call it fossil fuels for a reason. It was from the time of the dinosaurs. It's not necessarily actual dinosaurs. It's plants from when the dinosaurs were around.

But when all of that carbon that is the main component of fossil fuels was in the air as carbon dioxide, before these things were actually fossils, global temperature was huge. Now we're putting all of it back into the air.

That combustion reaction puts more carbon dioxide in the air. We are bringing ourselves back to the climate of the dinosaurs. We would prefer to use something else so that we can sustain our population.

Emily Rice: Our ability to harness energy, from fire, to coal, to oil, has created big leaps in progress but the story of human energy use is also about scientific progress. We know about the hazards of fossil fuels and scientists are working on solutions and alternatives. The answers aren't easy.

It's often not just a question of science. Our behaviors as a society influence the progress we can make.

Sanjoy Bannerjee: Typically, a New York household uses between 10 and 20 kilowatt-hours a day of electricity. We use about 60 percent of the average of other Americans, partly because we live in apartment buildings, which saves costs to heat and cool compared to living in your own house.

Second, we use public transportation simply because we can't drive in the city. Also, we live in much smaller places than most parts of the country. We just have less area.

Emily Rice: Even if we all lived in cities, and even if scientists and engineers come up with more efficient and cleaner ways to use fossil fuels, we are still at risk of running out. The hunt for new reserves or new ways to harvest fossil fuels shows how serious the problem is.

Shannon Swilley Greco: Fracking, I think, is an indication that we're getting desperate. I think that we're scraping the bottom of the barrel. It's an indication of where we are in terms of peak oil. Everything has this bell curve shape to it, for all resources. First, you're extracting a little bit. That's because your extraction methods are not that great.

As you get better at extracting oil or whatever the resource is, it gets bigger, and bigger, and bigger. Then you start on this decline on the other side of your bell curve.

There was a time in the 1950s where practically if you stuck a straw in the ground oil would spring out, a literal gusher. We're past that. That doesn't happen anymore. We are getting more and more desperate in ways of extracting the remaining fossil fuel that's in the ground. We pretty much know most of the places on Earth that have oil. We're not very likely to find any more big, gigantic vats of oil underground.

So we've got to find out other options before we get too far on that decline.

Emily Rice: Why are we burning all these fossil fuels in the first place? Average New Yorkers don't see coal or oil as we go about our daily business. It can be hard to understand how plugging in your laptop contributes to the use of fossil fuels.

When you turn on your lights or hear the whir of your refrigerator, the energy is being drawn from what we call the grid. The grid is a real technological and engineering wonder. It carries electricity from power plants, through transmission lines, and to the people who need it.

The power plants have to get their energy from somewhere. That could be from solar, wind, nuclear, or hydroelectric sources. In most cases, it still comes from burning natural gas, coal, or oil.

Many scientists are working on durable, sustainable, and affordable ways to generate and store the energy we need. That includes figuring out better ways to use renewable sources like wind and solar and exciting new ways to produce energy like fusion.

Just like the discovery of oil's potential once was, developing new and clean sources of power will be a big step forward for science.

Sanjoy Bannerjee: The grid is one of the marvels of the 20th century. It's brought enormous progress to the whole world and to the quality of life. To evolve out of that is going to be a long period. The time constant for things to happen in the energy sector are roughly 50 to 100 years. It takes a long time.

Emily Rice: Here at Freshkills Park on Staten Island, we are standing on what was once the world's largest landfill. Behind me we can see our energy past in the form of oil refineries. We can also see some alternative energy options.

There's a windmill in the distance. Here at Freshkills, we are harvesting some sources of energy that our waste has produced.

Everyone knows that there's a landfill and there's garbage here but what don't they know? How do we benefit from this?

Ted Nabavi, NYC Dept. of Sanitation: What they don't know is through this natural decomposition we are able to collect this landfill gas and use it as a source of energy. As the garbage decays, it generates landfill gas or decompost material as a result to anaerobic decomposition.

Anaerobic decomposition is primarily when there's an absence of oxygen. The garbage, being covered, is going through anaerobic, generating landfill gas.

As you can see behind you, there are gas wells. We have over 600 types of landfill gas well collections. The landfill gas that's generated here in particular is being purified and cleaned, then is distributed to about 20-25,000 customers in Staten Island for both residential and domestic use.

As a result of this arrangement and agreement, the Department also gets environmental benefits for selling the natural gas. It also helps National Grid to have a supplier.

Emily Rice: Our energy future is going to require advances in storage capacity and maybe even new sources of energy.

Sanjoy Bannerjee: We have several areas of work. One is to use energy storage as a way to enable renewable energy, such as solar and wind. You have a problem when the wind doesn't blow or the sun doesn't shine and you need energy. In order to enable wider use of renewables you need to be able to store the energy.

You may think of what we do as developing innovative, new, large-scale electrochemical storage systems such as batteries or capacitors.

Andrew Zwicker, Princeton Plasma Physics Laboratory: This is the Princeton Plasma Physics Laboratory. We study the fourth state of matter. Solid, liquid, gas, plasma. The four states of matter.

Add energy to a solid, it becomes a liquid. Add energy to a liquid, it becomes a gas. Add energy to any gas, it becomes a plasma. The sun, the stars, all plasma.

This laboratory is dedicated to not just understanding plasma, which is beautiful, and complicated, and just really an interesting thing to study, but also looking at can we control plasma and recreate the fundamental process in the core of the sun to create electricity here on Earth. It's called fusion. Fusion energy.

We have about 500 people here who love what they do and are working hard on that project.

Emily Rice: Some people get confused between fission and fusion. What's the difference?

Andrew Zwicker: Fission is you take a large atom, like uranium, and you split it in half. Fusion is the opposite of fission. Fusion is you take two small atoms and, just like the word sounds like, you combine them. Hydrogen, or these small atoms, don't want to get combined normally because they're each charged positively. We need to figure out how to get them together.

If you get them close enough together, they'll fuse. The sun does it by squeezing. It uses gravity. Squeezes them down so much that boom. It combines. It gives off energy. That energy gets turned into light and heat. That's the star.

We are going to try to do the same thing but we're going to heat it up using other methods and hold onto it using magnets. There are a lot of different ways we try to heat it up. It turns out that we have to make a plasma about seven times hotter than the center of the sun to make this work. We can do that in just a second or two.

We start from room temperature. We turn on our magnets. We turn on these ways that we have to heat this hydrogen gas. If we get everything just right then the hydrogen will fuse, make helium, make energy. And when we get a little bit further down the road, we're going to turn that energy that's made into electricity that powers our homes, our schools, our factories, our lives.

The idea is we're going to make these in a fusion plant to produce the amount of energy that we see in the power plants that we have right now, let's say the fossil fuel plants.

The hydrogen we need, we put it in some containers that go in the back of a pickup truck. It's actually not very much.

To give you an idea of comparison, if you have a coal plant, so it's burning coal. In a year, a typical coal plant needs about 100 railroad cars full of coal. If you have an oil plant, it would need about 11 supertankers of oil. 11 supertankers, 100 railroad cars, or a couple of containers on the back of a pickup truck.

It gives you a sense of just how powerful fusion can be when we get it producing electricity. That's a grand scientific and engineering challenge.

We also have to make sure that we do it in such a way that the electricity that we produce is economically competitive with the fossil fuels, or with fission, or with solar, or with wind.

The challenge is one part scientific, one part economic, one part engineering, as well. The downside is that it's a complicated process. The upside is it has such a huge potential. That's why we're working so hard on this.

[Science Forward theme music]