Can We Make Electricity Without Fossil Fuels?

Nearly a third of all our greenhouse gas emissions come from generating electricity. Scientists agree that we have to find ways to make electricity without releasing so much carbon dioxide into the air. In this episode of Crash Course Climate and Energy, we're going to tell you about some of the ways scientists and engineers are decarbonizing the electricity supply with energy sources such as solar, wind, nuclear, and hydroelectric and the benefits and drawbacks of each.

0:00

Narrator M Jackson appears on screen; clips of a neighborhood, students in class, open-concept office; accelerated aerial video of a city at night, accelerated video of Times Square; Crash Course Climate + Energy intro clip plays

Hello from the internet! I'm coming to you on-demand through a vast, interconnected network of wires and electromagnetic waves that spans the globe. And chances are, you're watching this in the comfort of your home, school, or workplace that's lit and heated on-demand, too.

You can cook up mac and cheese, charge your cell phone, and put on the TV to keep the dog company, as easy as flipping a switch or pushing a button. But none of this would be possible without electricity.

Our lifestyles are centered around electricity, and worldwide, we consume more than 22,000 terawatt hours every year. That's enough to microwave about two trillion mac and cheeses. But the way we make electricity is changing.

Hi hi! I'm M Jackson, and this is Crash Course Climate and Energy. [INTRO]

Swimming pools full of mac and cheese aside, making all that electricity is taking a toll on Earth's climate.

1:02

Animation depicting the planet's Greenhouse effect in space; pie chart of emitters of greenhouse gases: buildings 7%, transportation 16%, agriculture 21%, electricity 26%, industry 30%; clips of manufacturing plants and equipment

Power plants running on fossil fuels are pumping carbon dioxide into the atmosphere, enhancing –in a bad way–the planet's greenhouse effect, which warms the Earth.

Scientists agree that we have to find ways to make electricity without releasing so much carbon dioxide, also known as decarbonizing the electricity supply. This would make a huge impact because a little over a quarter of all of our greenhouse gas emissions come from generating electricity.

And that's not even including the electricity it takes to manufacture things or power large-scale agriculture, which are often counted as their own categories when measuring fossil fuel emissions by sector. A growing number of countries are committing to becoming carbon neutral by 2050.

That means reaching no net carbon emissions, by both massively reducing emissions and offsetting the ones we can't avoid by scrubbing extra carbon out of the air.

But in an increasingly populous world with an ever-growing appetite for energy, this is a challenge. We'll need to find a way to decarbonize … while also meeting people's needs. The good news is: we have options!

2:05

Diagram of photovoltaic panels; clip of a solar power plant; diagram showing how concentrated solar panels operate; clips of wind turbines

Some biggies are solar and wind power. Solar power involves capturing radiation from the sun and converting it to electricity. Most often, this happens in photovoltaic panels.

These panels contain metals like silicon that absorb particles of light, called photons, and emit electrons. Those electrons are captured to form an electric current.

The sun's energy can also be captured on a large scale in what are called Concentrating Solar Power Plants. Here, instead of using a bunch of separate panels, a big field of mirrors focuses sunlight onto a single receiver, where temperatures can reach hundreds of degrees Celsius.

It's like the coolest laser on the planet. That heat can then be used to boil water and create steam, which can turn a turbine and generate electricity like in a fossil fuel power plant. But crucially, it does this without releasing a bunch of carbon dioxide!

Another option is wind power, which uses the force of moving air to turn turbines and directly generate electricity.

There are different turbine designs for different locations, but especially if you've ever driven through a rural area, you've probably seen some of them in the wild, lurking in the fields like strange, high-tech crops.

In the last decade, the costs of both wind and solar energy have dropped massively, helping to make them more affordable worldwide. Because of this, wind and solar now account for about 7% of the global electricity supply!

And if we built and installed more panels and more turbines, that number would go up, which would definitely help in reducing carbon dioxide emissions.

But don't bring out the balloons yet. Scientists don't think that wind and solar could ever completely replace fossil fuel power plants.

3:44

Graphic showing the amount of space needed by wind turbines to equal that of natural gas power plants; animation of a bucket of water explaining how electricity would work if powered by a renewable source

That's partly because wind and solar need a lot more space. For instance, to generate the same amount of energy as a one-square-kilometer power plant, you might need 5,000 square kilometers of wind turbines, depending on how efficient they are.

But there's also another major barrier: supply and demand. Let's head to the Thought Bubble.

Think of the electricity grid as a huge bucket of water. The water itself is the electricity, if you haven't guessed. And when homes and businesses need to use some of that electricity, the water flows out of the holes of the bottom of the bucket, then through the hoses to the destination.

So, when you flip on the TV for a movie marathon, some water flows out, and needs to be replaced at the top. That's where electricity generation comes in. Power that comes from fossil fuel power plants is like water pumped from underground into our bucket.

Utility companies can provide a constant flow of water, which they can switch on or off to control the amount flowing out the bottom of the bucket. But groundwater going into the bucket, just like fossil fuels, is finite. Once it's gone, it's gone.

So, instead, you could opt to refill your bucket with rainwater. And like solar and wind power, the rain is renewable — you'll always be able to get more of it. But you have no control over when that rain falls, just like you have little control over how much the sun shines or the wind blows, as convenient as that would be.

So, if you relied on rainfall alone to refill your bucket, the levels could get dangerously low. Or in a big downpour, the bucket might overflow, damaging the whole system. And then, there goes your plans for movie night… and potentially, your TV.

Thanks, Thought Bubble!

5:21

Images of solar farms; diagram showing the fluctuation of energy load over time; animation of electricity usage in the kitchen at dinner time

The key here is that there's a crucial difference between electricity capacity and electricity generation in a given area. In a hypothetical world with unlimited space, you might be able to install enough solar panels or wind turbines to supply the entire planet with electricity when the sun is shining the brightest or the wind is blowing the hardest.

But what happens when the sun goes down and the wind drops? Even though you might have the capacity to supply everyone's needs, the conditions outside can't generate the right amount of energy at the right time. The supply is intermittent: it comes and goes.

Add that to the fact that our electricity usage isn't always the same, either. There's always some demand for power, which is known as a baseload, but at certain times of the day and year, this can increase to a peak load.

For example, say every refrigerator in your neighborhood is always running. That's the kitchens' baseload. But in the evenings, when everyone on the block is cooking dinner and running the dishwasher and has all the lights on, the electricity grid will have to supply a lot more power than in the middle of the night when it's just powering the fridge.

Or you know, the fridge plus a few people who are reheating pizza for a midnight snack. So, whatever we use to supply electricity, it needs to be able to adapt to these changes.

6:36

Graphic diagram explaining how Hydroelectric Dams are powered and function; images of Three Gorges Dam in China

And right now, our demand for…well, power on demand just isn't compatible with the intermittency of wind and solar power. That's where some other low-carbon options come in. For instance, hydroelectric power makes use of that old adage, "what goes up, must come down."

Essentially, you trap huge amounts of water in a reservoir at the top of a hill. Then, you control that flow of water downhill, past turbines that spin and make electricity.

Hydroelectricity is renewable, since it relies on rain and groundwater that are replaced through the natural water cycle. And, after you've built your reservoir, any electricity you generate is carbon neutral as well.

As long as there's enough water in the reservoir, operators can also change the amount of water flowing through the facility to meet varying demand, from baseload to peak load.

Right now, the biggest hydroelectric facility in the world is at the Three Gorges Dam in China. In 2021, it generated enough energy to hypothetically power a small country like the Netherlands. Worldwide, hydroelectric power accounts for about 16% of all electricity generation.

7:42

Images of the different phases of building Three Gorges Dam and the negative impact on various towns; aerial image of flatlands in the Netherlands; photo of a nuclear power plant; diagram demonstrating Nuclear Fission

But maybe hold the confetti cannons, because it's not all good news. Building a reservoir capable of powering cities comes with serious environmental and economic consequences.

Three Gorges took nearly 20 years to build, and cost at least 28 billion dollars. More than 1.3 million people also had to be moved from their homes, and the Yangtze River valleys were submerged more than 600 kilometers upstream, destroying huge swaths of the natural environment.

Also, hydroelectric plants only really work when you have plenty of water and plenty of drop. Realistically, a flat country like the Netherlands could never hope to power itself hydroelectrically.

So another alternative, and one that can be a bit more flexible, is nuclear power.

When you hit a large atom of uranium with another particle, the uranium undergoes nuclear fission. It breaks down into other elements while releasing heat.

By harnessing that fission in a controlled chain reaction, the generated heat can be used to create steam and turn a turbine, just like in a fossil fuel power plant.

8:46

Images of nuclear fuel reprocessing plants including plants in Chernobyl, Fukushima and Three Mile Island; side by side images of damage caused by radioactive leaking of nuclear plants; chart of death rates by type of energy production source- showing coal causes the most deaths

The benefit here is that nuclear fission doesn't release any carbon, and by carefully tweaking the amount of fission happening at any time, the plant can easily ramp up production to meet peak demand.

Now, uranium fuel itself isn't renewable, so there's only a limited supply. But the next generation of nuclear plants is finding ways to make it last longer, by using one of the leftovers from uranium fission to make even more heat after round one.

Right now, nuclear fission supplies around 10% of the world's electricity, and since it's so flexible and scales up so well, it could supply more.

But there are significant challenges: Building nuclear power plants is costly and slow, and there have also been a few high-profile, and devastating, accidents.

Throughout the years, power plants at Three Mile Island, Chernobyl, and Fukushima all made headlines when their dangerously radioactive insides leaked outside.

In reality, far more people have been killed by air pollution from fossil fuel power plants than nuclear accidents. But there's still a level of risk not everyone is comfortable with.

Solar, wind, hydroelectric, nuclear. The point here is that there's not going to be a single solution to completely decarbonizing our electricity supply. It's going to take a variety of technologies. And none of these transitions will be cheap.

10:08

Clips of fracking rig, oil wells, solar panels

Compared with fossil fuel sources, all low-carbon options come with what's known as a Green Premium. Over the years, many countries have done what they can to keep the price of fossil fuels low, in order to boost their economies and technological development.

They've tapped into whatever fuel reserves they have nearby, and provided tax cuts and subsidies to allow companies to produce and use that fuel cheaply.

That means any new technology that doesn't use fossil fuels seems artificially expensive, even while the resources themselves, like sunlight and wind, might be free.

Installing new facilities also requires research and development, as well as new infrastructure, and right now, there aren't many policies out there to reduce that cost.

These are not insurmountable challenges, though. The incredible thing is that if we can decarbonize electricity, it'll have an impact on the other major industries that currently release greenhouse gases.

11:01

Images of electric car charging, home with solar panels; clips of agricultural equipment in operation; video credits displayed

New generations of vehicles can be fueled by carbon-free electricity, instead of guzzling tankfuls of gas. And homes can be heated efficiently without emitting carbon dioxide.

Decarbonizing electricity would even help the agricultural industry — not by electrifying the crops somehow, but by powering everything that goes into growing them.

We're talking electrifying tractors, pumps in watering systems, the machines that pick your green beans: heavy equipment that currently runs on fossil fuels.

And for the emissions that are left, researchers are looking into ways to capture the excess carbon and lock it away where it can't cause further warming. So, decarbonizing our electricity supplies won't solve the climate crisis by itself, but it can take us a good way in that direction.

Someday soon, the electricity that powers your internet or your midnight pizza might come from something like solar or hydroelectric power — in fact, it might already!

That being said, the biggest hurdle to large-scale carbon-free electricity won't actually be generating it, but rather storing and transmitting it so we can use it exactly when and where we need it.

In other words, we need to seriously improve our water buckets. We'll explore how we do that, and why it's harder than you might imagine, next time.

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