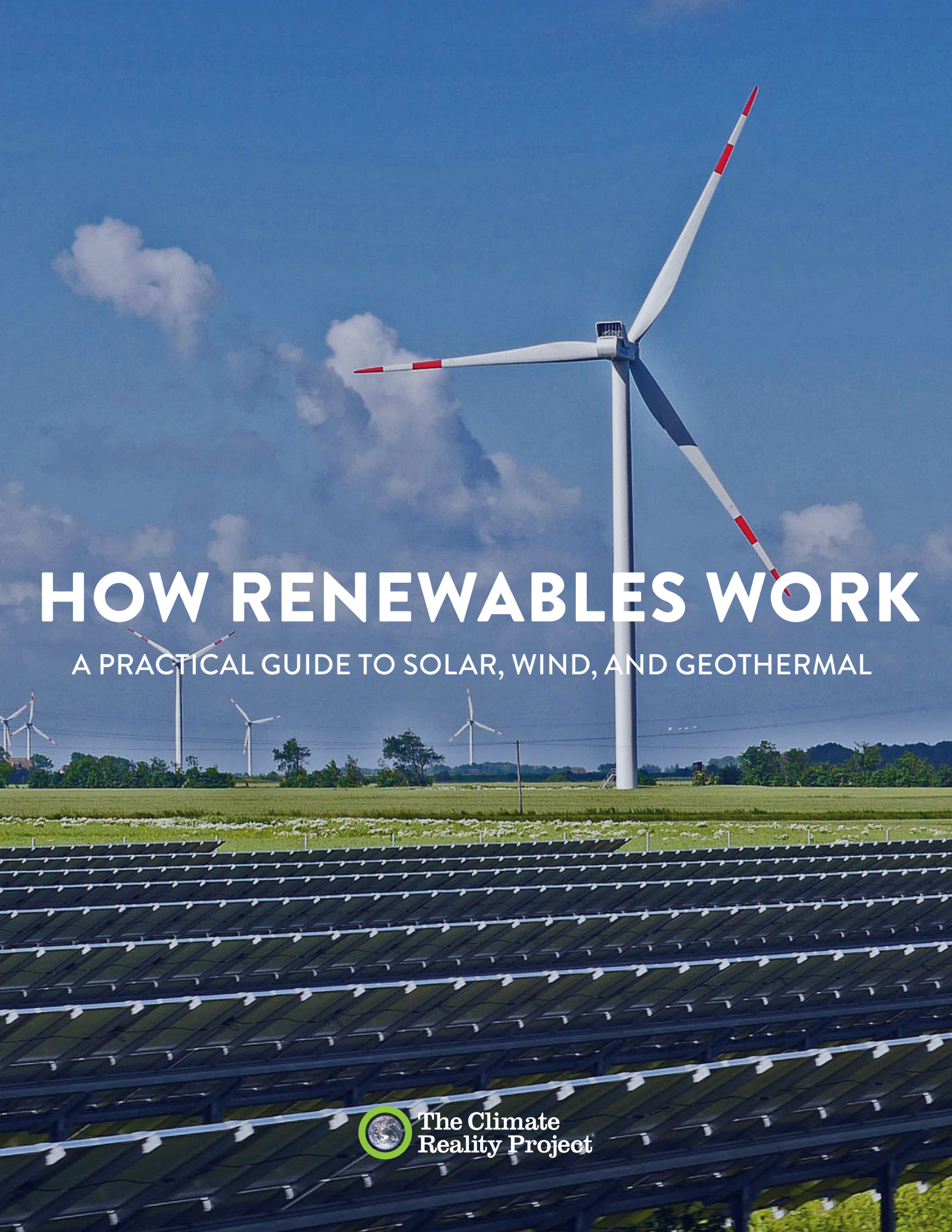

HOW RENEWABLES WORK

A PRACTICAL GUIDE TO SOLAR, WIND, AND GEOTHERMAL

The Climate Reality Project®

INTRODUCTION

Around the world, cities, states, countries, and companies (and people just like you!) are making the switch to clean, renewable energy to help confront climate change – and because it just makes good economic sense.

Renewable energy is both a clean alternative to the fossil fuels driving the climate crisis and an engine for job creation. What's not to love? But like any new technology, as it starts to take hold, there are bound to be questions.

How effective is solar energy? Is wind energy more expensive than energy produced by traditional fossil fuel sources? Where and how does geothermal even fit in the larger power mix?

We hear you and we get it: An awful lot is changing fast, and maybe you're not so sure which end is up.

That's why we're setting the record straight about renewable energy – and there's no time like the present to get everyone up to speed. So what's the rub on solar, wind, and geothermal? How do they work? What are the upfront costs and maintenance expenses involved? What are the many years-long benefits to your household or business bottom line?

Well, read on and find out!

SOLAR

Today, solar power is everywhere – from home roofs to Ikea superstores to the Nevada desert. And thank goodness. It's a win-win solution to the climate crisis that creates jobs, saves money, and helps cut the carbon pollution changing our planet.

Plus, when it comes to energy, solar might be the closest thing to free money out there – and we haven't even begun to touch its full potential.

Why? Well consider this fact from the US National Renewable Energy Laboratory (NREL): More energy from the sun strikes the Earth in an hour than all of humanity uses in a year.

You've seen the panels. And now you know about solar's incredible possibilities. So let's get to it.

How do solar panels work?

A solar panel "works by allowing photons, or particles of light, to knock electrons free from atoms, generating a flow of electricity," according to Live Science. That's a technical way of saying that the panel's photovoltaic cells convert the energy in sunlight to electricity (specifically, direct current (DC)). This DC electricity is then converted to alternating current (AC) by an inverter.

AC is the type of electrical current you typically use when you plug anything into a residential wall socket. If you have solar on your roof, the system's electrical panel sends power to your lights and appliances.

How long will solar panels last?

A long time. Like, a really long time.

Many home array solar panels are guaranteed for decades, thanks to warranties that typically cover 25-30 years. But because their parts do not wear out easily, solar arrays are well-known to continue producing clean electricity even beyond these lengthy timeframes.

"Unlike many other consumer goods, [solar panels] don't 'give up the ghost' at the end of their warranty period and need to be replaced, but continue to still produce clean electricity, although at a slightly less efficiency each year," Clean Technica reports.

"In fact, some decidedly old-school solar cells have been producing electricity daily for about 40 years or so, and are expected to continue to power homes and businesses for decades more."

A June 2012 NREL study investigating the "photovoltaic degradation" rates of about 2,000 solar installations over a period of 40 years found the median solar system lost just 0.5 percent of its efficiency per year. So, by the end of your 25-year warranty, the solar panels on your roof could still be operating at about 88 percent of their original capacity.

Is your ’93 Camry still running near-perfect with very, very little maintenance (more on that below)?

(Psst… a quick note on the word “photovoltaic”: It means “capable of producing a voltage, usually through photoemission, when exposed to radiant energy, especially light.” Which is a very long, science-y way of saying “converts sunlight into electricity.”)

What sort of maintenance is required?

Not too much, really. Your solar panels themselves can last for decades on end without much upkeep (maybe just remember to keep them free of debris, snow, etc.). But you will likely need to replace the inverter a few times throughout the life of your system.

Like the solar panels themselves, inverters typically come with a warranty – these can range from 5-15 years (and sometimes even longer). Unlike your panels, your inverter will not see its efficiency dwindle very slowly; instead, it may simply stop working and need to be replaced.

However, technological developments on this front are afoot! New “micro-inverters,” which are installed or included with each solar panel, are quickly replacing the more-common central inverters that handle the output of all your panels at once. These micro-inverters can have a much longer lifespan (all the way up to 25 years) than a central inverter, and if one does fail, it won’t shut your entire system down cold.

Do solar panels work on cloudy, rainy, or cold days?

We'll cut straight to the chase – solar panels work just fine when it's cloudy, rainy, and/or cold.

Are clouds and rain ideal for solar panels? Of course not. They are most effective in direct sunlight. But solar panels can still generate power when the sun is blocked by clouds – more than enough, in fact, to remain a viable source of electricity. Take Germany, for example. It's not particularly warm or sunny, but is nevertheless a world leader in solar energy.

As for winter, there's some even better news: Solar panels are powered by light, not heat, and because of the way the technology works, they're just as effective — if not *more* effective — in cooler temperatures as in hot ones.

How much does a solar energy system cost?

That depends.

"Because price paid per watt ranges from $2.71 to $3.57 and the average US household system size is 6 kW (6,000 watts), the average gross solar panel [system] cost is $18,840," EnergySage estimates.

That may seem quite expensive because, for most of us, it is. But gross expense doesn't factor in the many incentives available to solar customers and the multiple new forms of solar financing that have emerged in recent years that can allow customers to put solar on their rooftops at little or no cost up front.

In addition, in the US, a 30 percent federal investment tax credit is available until 2019 (stepping down in the years beyond) that can offset the cost of your investment substantially, and many states also offer their own tax breaks and incentives to encourage home solar panel installation.

And, of course, looking at the straight upfront cost of the system and its installation is far from the whole story, at least as far as your bank account is concerned. Which leads us to our next question…

Can people ***really*** save money with solar panels?

Yes. Not only does a solar energy system add substantial value to your home the minute it's up and running, it often pays for itself – and then some!

"Twenty-year electricity savings from solar can be significant, ranging from the low end of $10k to almost $30k," according to EnergySage.

If you follow that math – and please keep in mind your savings will vary based on factors like your typical electricity cost, average sunlight in your region, and the scale of your system you install – depending on the final cost of your system after federal, state, and local incentives, in as little as six or so years, **your system will have paid for itself.**

Few major purchases can claim such an impressive return on investment.

Looking at these numbers, the conclusion is clear: Solar isn't just the right choice for the planet – it can also be the smart choice for your wallet. Whatever fossil fuel companies may claim.

WHAT DO UNICORNS, THE TOOTH FAIRY,
AND "CLEAN COAL" ALL HAVE IN COMMON?
THEY AREN'T REAL.

WIND

As wind systems keep growing everywhere from Copenhagen to California to China, so do the misconceptions that critics keep spreading in the media and beyond.

But the truth is, this clean form of energy is a wind-wind (ha!) for consumers, job seekers, and even utility companies keen on, you know, making bank. The US Department of Energy has found that increased wind power development in the US alone could result in a net savings of $149 billion by 2050 as average fossil fuel prices go up and aging plants and other infrastructure have to be replaced.

That's just one fact among many that's sure to turn you into a huge fan (we'll be here all night…) of wind energy.

You've asked. We'll answer. Exactly how the heck does wind energy work, anyway?

How do we get energy from wind?

It all starts with a simple technology known as a turbine.

There are two basic types of turbines: horizontal-axis and vertical-axis turbines. A vertical-axis turbine kind of looks like an eggbeater, but you're probably much more familiar with horizontal-axis wind turbines. These are the turbines that typically have two or three large propeller-like blades that face into the wind. Wind turbines can be

built on both land and – increasingly and to great effect – offshore in large bodies of water like oceans and lakes.

The turbine converts the kinetic energy of the wind into mechanical power.

It's actually pretty simple: The energy in wind turns the turbine's blades around a rotor connected to the main shaft, which then spins a generator to create electricity.

How much electricity can a wind turbine generate?

That depends.

"The output of a wind turbine depends on the turbine's size and the wind's speed through the rotor," according to the European Wind Energy Association (EWEA). "An average onshore wind turbine with a capacity of 2.5–3 MW can produce more than 6 million kWh in a year – enough to supply 1,500 average EU households with electricity."

Meanwhile, the American Wind Energy Association (AWEA) estimates that about 25 million households can be powered each year with current installed wind capacity in the US.

And it's creating jobs?

Good jobs. A lot of them, too – and more every day.

The most recent employment data available shows US wind generation put 106,000 Americans to work in 2017. And the US Bureau of Labor Statistics reports that the number of wind turbine service technician jobs is expected to increase by 96 percent by 2026, making it the second fastest-growing job in America.

With a median annual pay of $53,880 in 2017, that's an awful lot of well-paying jobs on the horizon.

And while it's not a contest, it's also definitely worth noting that many of America's fastest-growing jobs are in clean energy.

Should we use wind energy over energy produced by fossil fuels?

Absolutely!

This one is pretty straightforward, too: Energy produced by wind doesn't pollute the air with toxins or emit the dangerous greenhouse gases driving climate change. Power plants that rely on the combustion of fossil fuels like coal, oil, or natural gas to create electricity do both of those things in spades.

Moreover, particularly given the White House's bluster about American energy independence, it's important to note that wind is a domestic source of energy. Those turbines you see spinning on the horizon aren't importing or exporting the breeze.

How much does a "small wind turbine" generate electricity?

When we talk about small wind turbines we're talking about microgeneration – the small-scale generation of electric power by individuals – as opposed to the larger, grid-tied power production of commercial wind turbines, such as those found on wind farms.

That's right, you can have your very own wind turbine, just like you can have rooftop solar panels!

According to the Wind Energy Foundation, a 5 kilowatt turbine with an 18-foot rotor diameter is the average residential size. A turbine of this size will produce around 8,000 kWh of electricity per year in 12-mph average winds. That's about 100 percent of what the average home in the US requires.

LEARN MORE:
3 BIG MYTHS ABOUT NATURAL GAS AND OUR CLIMATE

This much is clear: One of the best ways to create a sustainable future for our planet and avoid some of the worst possibilities of climate change is to invest in sources of clean, renewable energy like wind, solar, and geothermal energy.

GEOTHERMAL

While it's hard to miss a massive solar array or a field full of wind turbines, so much of the action with geothermal energy happens out-of-sight that it tends to not generate as much love as its buzzier brothers in the renewable energy landscape.

And that's too bad, because geothermal energy is pretty awesome. It takes the natural functions of the Earth and puts them to great use heating homes, creating electricity, and helping to propel the global shift from the dirty fossil fuels driving climate change to renewables.

But how? It's time to dig (get it?) into a less talked about-but-powerful source of renewable energy, and tackle some of the most common questions about geothermal.

What is geothermal energy?

"If you were to dig a big hole straight down into the Earth, you would notice the temperature getting warmer the deeper you go. That's because the inside of the Earth is full of heat. This heat is called geothermal energy," the US Environmental Protection Agency (EPA) explains in its Student's Guide to Global Climate Change.

And that's pretty much the gist: When we talk about "geothermal," we're talking about tapping into the heat energy contained in the rock and waters of the Earth's crust.

What is geothermal energy used for?

Geothermal energy is largely used in two distinct ways – to heat homes and other buildings or to create electricity.

Home heating (and cooling)

The first is the best-known and easiest to understand. Geothermal heat pumps transfer the moderate heat found not far below the Earth's surface into homes and buildings through a looping pipe system.

When it's cold outside, the fluid in the pipes warms as it travels through the stretch of pipe buried underground, where temperatures in the upper 10 feet of the Earth remain at a constant 50 to 60 degrees Fahrenheit. The system then carries the now-warmed fluid into a home or building, where the geothermal unit uses it to heat air circulated through your home via a standard duct system.

Some geothermal systems also circulate the fluid directly as sub-floor radiant heat, aka a series of pipes that have been laid beneath your flooring.

An inversion of this process can be used to cool your home in the summertime, too.

Utility-scale electricity

There are a few more moving parts to a geothermal power plant. These plants tap into the much higher temperatures deeper inside the planet to generate electricity.

This is typically done by pumping very hot water under high pressure from as deep as one or two miles underground. Once the water reaches the surface, the pressure drops, causing the water to turn to steam. That steam then turns a turbine that is connected to a generator, producing electricity.

If this sounds confusing, just imagine a geyser like Old Faithful spouting steam and hot water out of the earth, only here all that steam generates electricity. It's more than just an analogy – according to the US EPA: "Deep geothermal technologies harness the same kind of energy that produces geysers."

One key difference between natural geysers and geothermal power plants, though, is that these plants usually recycle the fluid pumped to the surface to use again.

It works like this. Plants often gather the steam that passes through turbines in a cooling tower or some other capturing unit, where it cools off and condenses back into liquid water. Then, they pump this water back into the Earth, so it can warm back up and begin the whole process again.

Is geothermal energy available everywhere?

Geothermal energy can be found almost anywhere, but it's certainly more readily accessible in some places than others. Regions rich in hot springs and other natural hot water reservoirs (i.e., places where the Earth's heat is closer to the surface) are going to have an easier time finding and using geothermal, particularly on a larger scale.

In the US, most geothermal power plants are located in the geologically active West.

"The areas with the highest underground temperatures are in regions with active or geologically young volcanoes. These 'hot spots' occur at tectonic plate boundaries or at places where the crust is thin enough to let the heat through," the Union of Concerned Scientists explains.

"The Pacific Rim, often called the Ring of Fire for its many volcanoes, has many hot spots, including some in Alaska, California, and Oregon. Nevada has hundreds of hot spots, covering much of the northern part of the state."

It's unsurprising then that California, already a national leader in renewable energy, has far-and-away the most installed geothermal capacity in the US. The state's 40-plus geothermal plants provided nearly 6 percent of its electricity in 2017.

But the US is far from the only country using geothermal. Half a world away in chilly Iceland, "virtually every building in the country is heated with hot spring water. In fact, Iceland gets more than 50 percent of its primary energy from geothermal sources."

How much do home geothermal systems cost?

Just like with home solar energy systems, that depends. The price of a home geothermal heating/cooling system varies, largely depending on the size and type of loop system needed.

By and large, a home or small-scale commercial geothermal system can run anywhere from $10,000 to $25,000. The reason for that broad cost spectrum: "soil conditions, plot size, system configuration, site accessibility, and the amount of digging and drilling required" all play a role in determining how much your system will set you back. Many of those conditions can vary wildly from one place to another.

While these price tags might look scary, many folks don't have to pay the sticker price for geothermal heat pumps. A number of federal, state, and local incentives can help to offset the initial up-front costs of going geothermal, bringing you all the benefits of clean energy with a much shorter payback period.

Additionally, in the US and in much of the wider world, it's worth noting that at the larger power plant level, electricity generated from geothermal sources is already cost-competitive with electricity generated by fossil fuels.

Will I ***really*** save money with a geothermal system?

You will.

"Homeowners save 30-70 percent on heating and 20-50 percent on cooling costs by using geothermal heat pumps compared to other conventional systems," according to Energy Informative. "This translates to roughly $400 to $1,500 annual savings."

If you follow those numbers, you could recoup the cost of your geothermal system installation through energy savings in as little as five years (or as many as 15 or 16), depending on a number of factors, from the cost of your installation and local utility rates to your climate and home heating and cooling needs.

Most folks likely fall somewhere in between: "Although installation costs can be up to several times more expensive, [geothermal heat pumps] are up to 65 percent more efficient than traditional HVAC units and pay themselves back over time in energy savings — typically within 10 years," according to the US Department of Energy (DOE).

How long do geothermal systems last?

This is where you'll really start to see the value of a home geothermal system pay off. Geothermal systems are built to last a very long time.

"The indoor components typically last about 25 years (compared with 15 years or less for a furnace or conventional AC unit) and more than 50 years for the ground loop," *The Family Handyman* magazine reports. "The system has fewer moving parts and is protected from outdoor elements, so it requires minimal maintenance."

DOE backs up those numbers, adding that geothermal systems also benefit the overall electrical grid by lightening demand for power during peak seasons like summer.

The point is, not only will your system eventually pay for itself, it will last long enough for you to enjoy years and years (perhaps decades!) of straight energy savings after it has.

GET THE DETAILS:
MARKET FORCES ARE DRIVING A CLEAN ENERGY REVOLUTION

WHAT'S NEXT?

With seas rising, global heat records falling, and storms becoming more and more devastating, the reality of climate change has never been clearer. But with renewable energy solutions like wind and solar energy getting more affordable, batteries getting better, and buildings and other technologies becoming more efficient every year, neither has the way forward.

If you are in a position to install home solar, a geothermal heating system, or a small wind turbine, we've just ran down some (though far from all) of the reasons you should dig even further into what renewables can do for you – and how they can save you money. **What are you waiting for?**

But we also know that even with incentive programs, tax benefits, and new financing models, home solar or geothermal simply may not be in the cards for everyone.

Perhaps you are a renter? Maybe your home needs some structural improvements before it can support solar panels? Perhaps you simply just don't have the resources to take the leap?

In cases like these, there are still plenty of options: Community or shared solar has grown in popularity, and many power providers offer you a chance to elect to receive your electricity from additional renewable energy procurement methods (e.g., through Renewable Energy Certificates), thereby increasing demand for utility-scale renewable energy.

And it's important to remember that the benefits of renewable energy don't end with the economic advantages. Cutting carbon pollution? Check. Empowering communities? Check. Creating good jobs? Check and check.

Stopping the climate crisis is the challenge of our time. But the sustainable future we want is finally within our grasp. And at Climate Reality, we won't let it slip away.

SPREAD THE WORD

Do your part and share the graphics below on your social media networks to spread the truth about dirty coal and the good word about the many benefits of going renewable. Simply click the graphic(s) you want to share.

The Climate Reality Project®

Founded and chaired by former US Vice President and Nobel Laureate Al Gore, The Climate Reality Project is dedicated to catalyzing a global solution to the climate crisis by making urgent action a necessity across every level of society.

Today, climate change is standing in the way of a healthy tomorrow for all of us. But we know that practical solutions are right in front of us. We can create a healthy, sustainable, and prosperous future by making a planet-wide shift from dirty fossil fuels to clean, reliable, and affordable renewable energy. At Climate Reality, we combine digital media initiatives, global organizing events, and peer-to-peer outreach programs to share this good news with citizens everywhere and build overwhelming popular support for policies that accelerate the global transition to a clean energy economy.

To learn more, visit www.climaterealityproject.org