Goodside

THE GOOD GUIDE TO:

LEARNING ABOUT CLIMATE CHANGE

By Lisa Jackson and Lauren Jerome

Introduction

Whether it's articles popping up on your newsfeed or a heated dinner table discussion, there's seemingly endless information to digest about climate change. With so many stories swirling in the news and on Twitter, it can be hard to get a handle on climate change definitions, what's real or "fake" news and how it's all connected. As an environmentally conscious citizen, you've undoubtedly got questions, like what can we do to slow global warming? Is it even possible to reverse climate change at this point?

Our understanding of how the climate works is constantly being refined based on what scientists are learning, but the key points—and what we need to do to change things—are well understood. Here are the current facts as we know them today.

In this book:

CHAPTER 1

Give It to Me Straight: What Is Climate Change?

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1
Give it to me straight: What is climate change?

Buckle up, because we've got a lot to cover. But before we dive into climate change science, let's first get a handle on the meaning of climate change, the definition of global warming and other must-know terminology.

Consider this your cheat sheet to the main facts:

- → "Climate change" refers to long-term shifts in weather patterns.
- → Yes, the climate has changed naturally over the past 650,000 years, fluctuating between ice ages and warmer periods.
- → But modern-day climate change is *not* a naturally occurring phenomenon. It refers to alterations in weather patterns caused by human activities.
- → "Global warming" is one measure of climate change and refers to a rise in the average global temperature. Human activities such as industrialization, deforestation and intensive agriculture have increased emissions of greenhouse gases (we'll call them GHGs, starting now), causing temperatures to rise.
- → Extreme weather events, rising sea levels and melting polar ice caps are some of the effects of climate change.
- → Although the climate has shifted throughout the Earth's history, this is the first time that climate change has been human-caused and happened so rapidly.
- → Looking at the climate change timeline, scientists report that temperatures are rising faster now than at any other time in history. The average global temperature on Earth has risen a little more than 1.8°F since 1880, and today's atmosphere contains 42 percent more carbon dioxide than it did before the industrial era.
- → The resulting negative effects of climate change, like rising temperatures and sea levels and extreme weather events, have far-reaching social, economic and political implications across every sector of society.
- → Some of the most disturbing data on climate change is that it will not happen gradually—like a line rising steadily on a graph—but rather as a series of "tipping points" that can form a cascade, unleashing a "domino effect" of irreversible consequences.

> **"Today's atmosphere contains 42 percent more carbon dioxide than it did before the industrial era.**

The consensus among experts—people who study climate science for a living—is that climate change is happening, and human activity is causing it.

While a small number of climate change deniers do exist—and they can be noisy—their anti-climate change arguments have been debunked by the scientific community. (More on this below.)

But why is it happening? What is the science behind climate change?

The basic scientific facts about climate change are actually simple, and interesting too. Here are the top three things you need to know:

→ The average global temperature is directly linked to the concentration of greenhouse gases in the atmosphere. (See below for more on GHGs.)

→ The concentration of greenhouse gases has been rising steadily since the Industrial Revolution, and global temperatures are increasing as a result.

→ Carbon dioxide (CO_2) is the most abundant, accounting for about three-quarters of GHGs. Its increased concentration is largely due to burning fossil fuels.

Climate change vs. climate crisis: What's in a word?

If you've ever tried to rope a buttoned-up friend into doing something exciting but risky, you know that you have to use the right words to convince them. The same goes for getting people to care about climate change.

Some media outlets, like the British newspaper *The Guardian*, are revamping style guides "to introduce terms that more accurately describe the environmental crises facing the world." Phrases like "climate emergency" and "climate crisis" may be used instead of "climate change," or "global heating" instead of "global warming."

This new terminology reflects shifting attitudes and attempts to better capture climate change science. You'll note the level of urgency injected into some of the lingo, which also acts as a rallying cry for us all to fight the climate crisis.

Language really does matter, and how words are used can influence the public's reaction.

For starters, scientific language can be very dense and jargony, making it difficult for laypeople to understand. This has prompted the scientific community to "rebrand" climate change concepts.

For example, scientists once used the entirely unrelatable term "inadvertent climate modification" to describe human-caused climate change. This went on until the scientific community came up with two new terms in the 1970s: "global warming" and "climate change." These are simpler, more relatable concepts that resonate with those of us who don't know our way around a lab.

Also, many scientists and activists have criticized what they call "neutral language" for masking the truth about the climate crisis. Take the term "climate change." It's scientifically accurate, yes, but it doesn't exactly get the blood boiling. It also doesn't reveal that this is a full-blown, human-created crisis and not just a shift in weather.

Author and speaker Simon Sinek goes so far as to suggest the term "climate cancer" instead of climate change, and the phrase "save your family" instead of "save the planet." Convincing, right?

What's the difference between climate and weather? And if scientists are saying the planet's getting warmer, why is it still so cold in the winter?

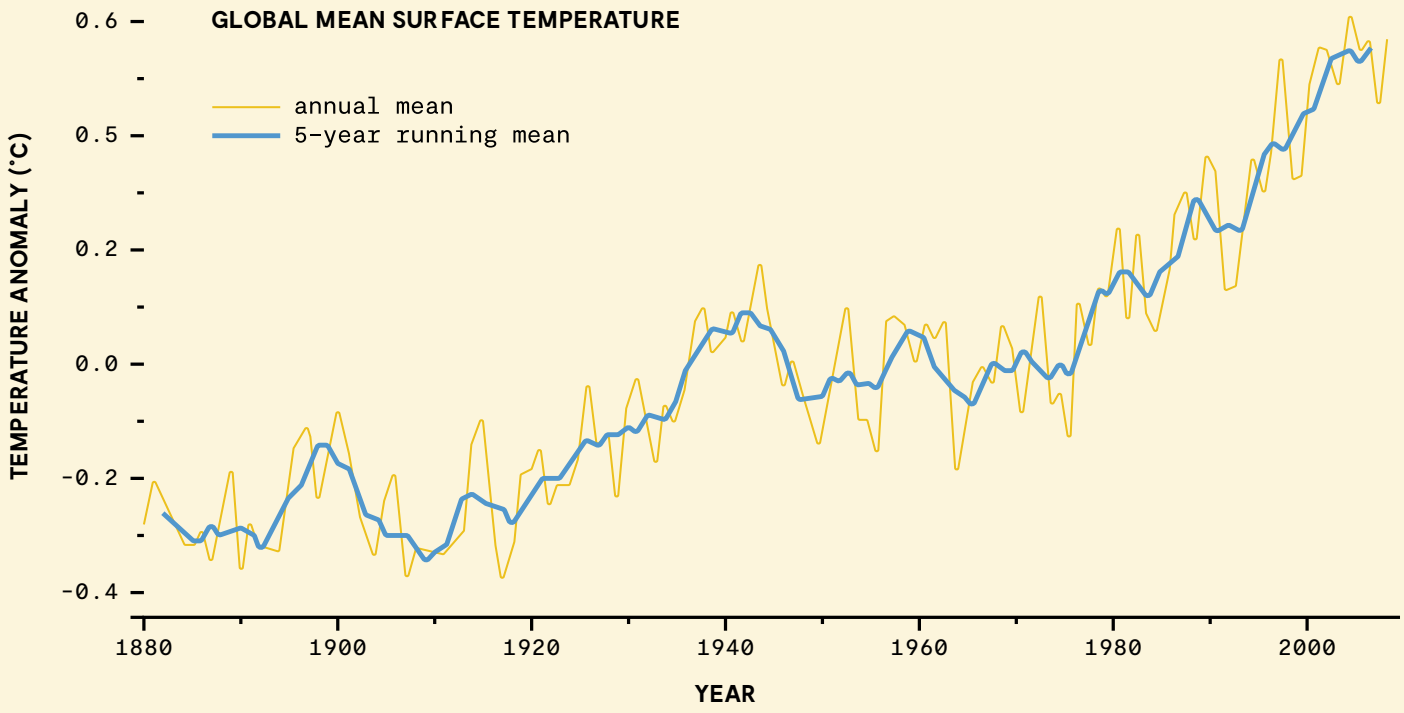
Great question, and a good example of why some people are saying "global heating" instead of "global warming"—if you live in a cold climate, global warming sounds kind of nice, right? Like growing oranges and lemons in your Minnesota backyard? Unfortunately, that's not exactly how it works.

Weather describes short-term occurrences, like a rainy morning or a hot, sunny day.

Climate refers to what the weather looks like in a particular place over a long period of time. For example, a desert region is typically very dry and hot, with temperatures exceeding 104°F in the daytime and receiving less than 9.75 inches of rain per year.

When talking about climate, scientists often look at averages of precipitation, temperature, humidity, sunshine, wind and other weather measures that happen over an extended period (e.g., 30 years) in a specific region.

The bottom line: Climate is what you expect to happen overall, and weather is what you get in the moment.



Despite ups and downs from year to year, global average surface temperature is rising. By the beginning of the 21st century, Earth's temperature was roughly 0.5 degrees Celsius above the long-term (1951–1980) average. (NASA figure adapted from Goddard Institute for Space Studies Surface Temperature Analysis.)

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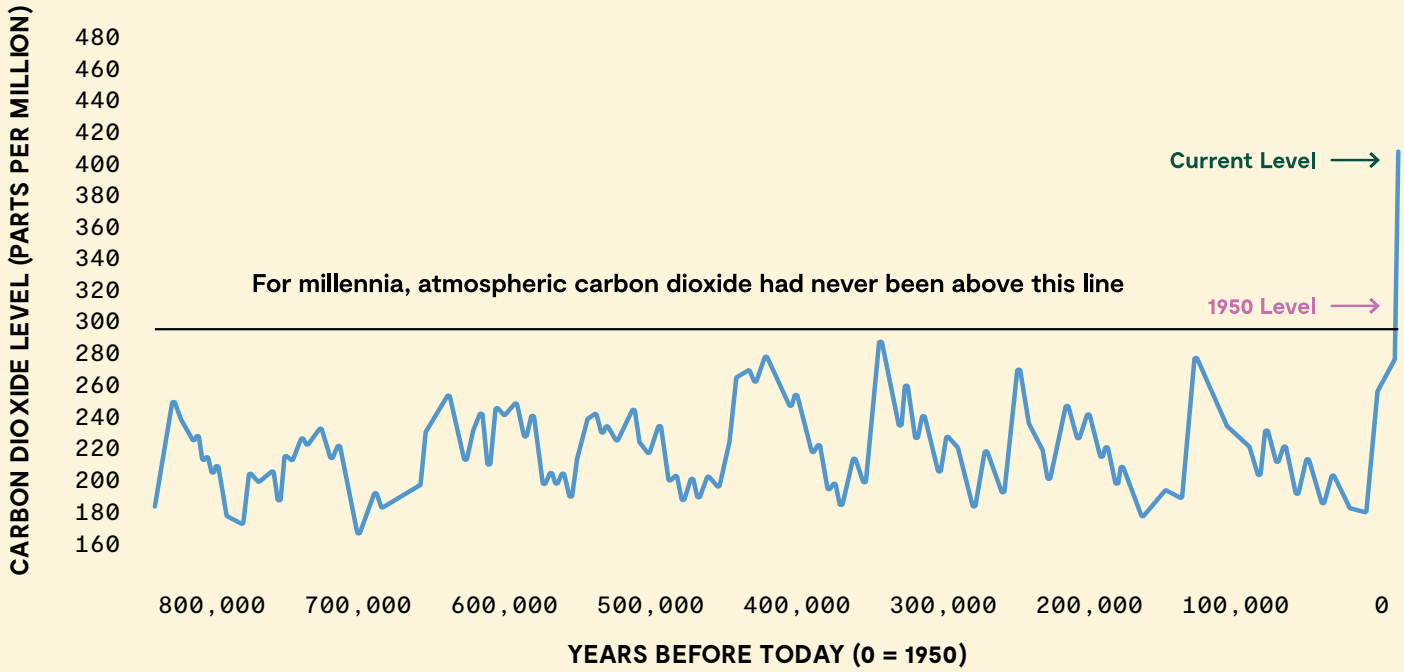

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A region's climate can give us a sense of what to expect in general, but it can't predict the weather on a given day.

The other thing to know is that climate scientists deal in averages. They might predict a specific average global temperature rise of 1°F, but that doesn't mean that every day of the whole year will be one degree warmer. So here's what to tell that antagonistic family member when they argue against climate change because it's cold out: You might still get frigid winters, but the number of warm and hot days will push the average temperature higher.

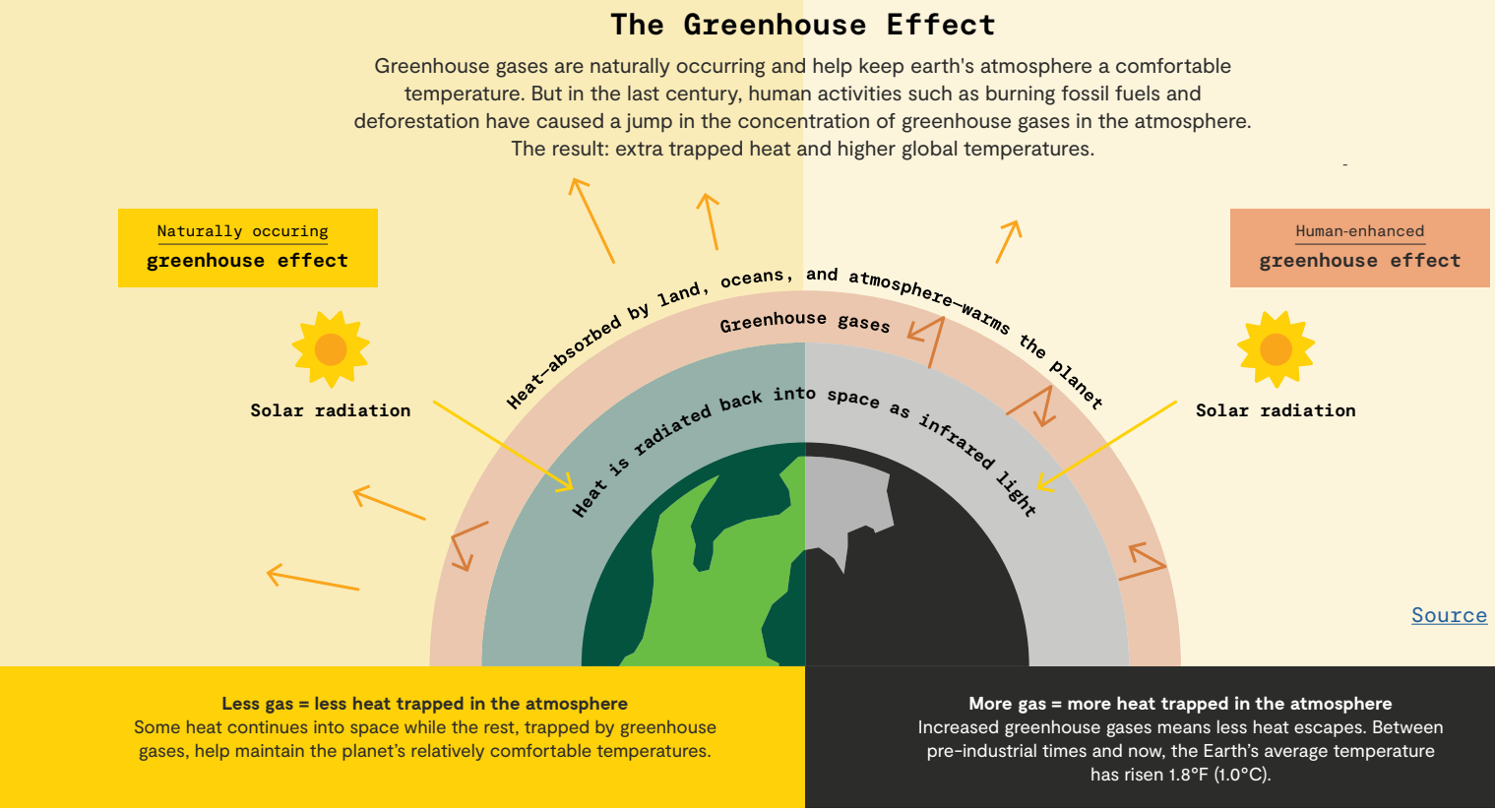
> **"The bottom line: Climate is what you expect to happen overall, and weather is what you get in the moment. A region's climate can give us a sense of what to expect in general, but it can't predict the weather on a given day.**

Global warming vs. climate change: Are they the same thing or not?

Global warming and climate change overlap, but they're not the same thing. To spend a little longer in terminology land, let's look at the difference between the two.

Global warming is the long-term heating of the Earth's climate system due to human activity. It refers specifically to a rise in the average global temperature. Climate change is bigger than that—it includes global warming as well as other shifts in weather patterns, like an increase or decrease in average rainfall.

Since 1880, human activities are estimated to have increased Earth's global average temperature by approximately 1.8°F. This number is currently increasing by 0.36°F per decade. Looking at the global warming timeline, we're expected to reach the 2.7°F mark between 2030 and 2052 if the planet's temperature continues to increase at the current rate. And if we hit that mark? We've got bigger problems than a few summer heatwaves.



The greenhouse effect: a definition for those of you who slept through grade 10 science class

Next on our list of terms that sound less bad than they really are is the greenhouse effect. Again, sounds positive, right? Getting the place a little warmer for all your plant babies?

The truth is, you wouldn't be entirely wrong. The sun's heat is a good thing—it makes life on Earth possible. A small amount of incoming solar radiation gets "trapped" by the gases in our atmosphere. This, right here, is the greenhouse effect.

Like the glass of a greenhouse, these "greenhouse gases" act as a layer of insulation that prevents heat from escaping. Without these heat-trapping gases, our planet would be an icebox.

Unfortunately, like eating an entire cheesecake in one sitting, you really can have too much of a good thing. Human activities have been piling on to the Earth's natural greenhouse effect for a while now. In particular, through burning fossil fuels, we've increased the amount of carbon dioxide and other greenhouse gases in the atmosphere. As a result, the atmosphere is trapping more heat and causing the planet to heat up—fast.

More than CO_2: The gases contributing to the greenhouse effect

Knowing which gases the scientists are talking about is fundamental to understanding the causes of the greenhouse effect. A few specific GHGs are of particular concern because they are tied to human activity. Let's break it down:

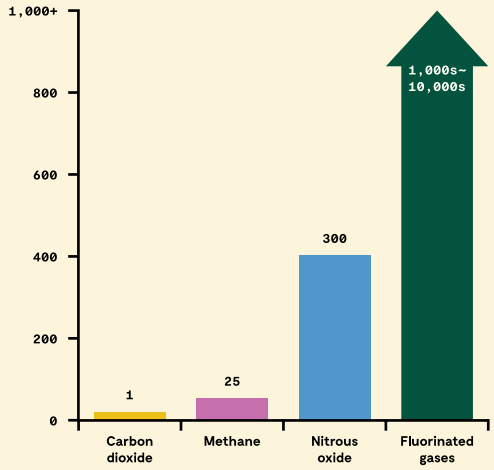
1. Carbon dioxide (CO_2)

If you were wondering which greenhouse gas is most responsible for global warming, you can stop holding your breath—it's carbon dioxide.

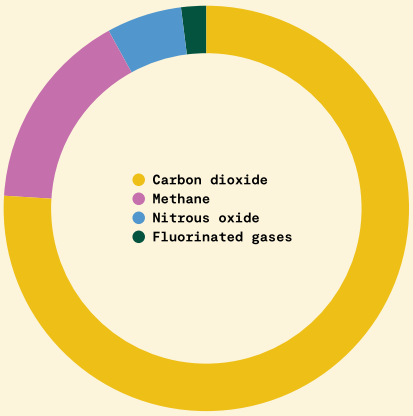
While this greenhouse gas is a natural component of our atmosphere, the issue is one of quantity.

Levels of CO_2 increase through things like burning fuel—like wood, solid waste and fossil fuels—and as a result of certain chemical reactions. The process of making cement, for example, is a massive CO_2 emitter. Carbon dioxide is removed from the atmosphere ("sequestered") during the biological carbon cycle, carbon is absorbed by plants.

How greenhouse gases warm our planet



The global warming potential (GWP) of human-generated greenhouse gases is a measure of how much heat each gas traps in the atmosphere, relative to carbon dioxide.



How much each human-caused greenhouse gas contributes to total emissions around the globe.

Source

Excess CO_2 is one of the biggest contributors to climate change, particularly through the burning of fossil fuels.

2. Methane (CH_4)

Methane is produced naturally whenever vegetation is burned, digested or rotted without the presence of oxygen. Cattle digestion (read: cow burps) is a big contributor, as are out-of-control wildfires.

3. Nitrous oxide (N_2O)

Nitrous oxide is released during agricultural and industrial activities, the burning of fossil fuels and solid waste, and the treatment of wastewater. As a greenhouse gas, it has massive global warming potential—it's up to 298 times more potent than carbon dioxide.

4. Fluorinated gases

Some industrial processes release fluorinated gases (hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride and nitrogen trifluoride), which are synthetic greenhouse gases. Though typically emitted in relatively small quantities, they're extremely potent.

Sulfur hexafluoride (SF_6), for example, has a global warming potential 22,800 times that of CO_2.

But how exactly do greenhouse gases contribute to climate change?

Like a really bad smell, greenhouse gases like to linger—and the stronger they are, the more they affect how much heat is trapped in the atmosphere. The effect of each GHG depends on the following:

→ **Concentration (or abundance)**: The amount of a GHG in the air. Larger emissions of GHGs lead to higher concentrations in the atmosphere.

→ **Duration**: How long the gas stays in the atmosphere. The time frame can range from several years to several millennia.

→ **Potency**: How strongly the gas contributes to heating the earth. Some GHGs have a higher global warming potential.

> **Like a really bad smell, greenhouse gases like to linger—and the stronger they are, the more they affect how much heat is trapped in the atmosphere.**

Break it down for me: What are the main causes of global warming?

TL;DR: Humans are burning too much stuff too quickly.

While the greenhouse effect is a naturally occurring phenomenon, the real problem is the huge amounts of gases that human activities have released into the atmosphere.

For a long, long time, various natural processes have been sequestering and fossilizing carbon underground, keeping it out of the atmosphere. (This is where the name fossil fuels comes from.) Coal, for instance, took millions of years to form, as dead plant matter was buried under rock and dirt and then gradually changed through heat and pressure.

Over time, human communities learned that these carbon deposits in their various forms were potent fuel sources, and started uncovering and burning these forms of carbon to heat their homes and power things like transportation and factories.

Over the past few centuries, and mainly since the early 1900s, human activities have rapidly released massive amounts of CO_2 and other greenhouse gases into the atmosphere.

In fact, the levels of greenhouse gases in the atmosphere have risen to levels not seen in 3 million years. Yes, you heard that correctly. 3. Million. Years. Let that sink in.

Rising temperatures and changes in climate are creating extreme weather events (e.g., hurricanes, flooding and droughts), leading to devastating environmental, social and economic consequences.

Photo by Nik Shuliahin on Unsplash

So, yeah. Burning too much stuff too quickly has a big cost.

> **In fact, the levels of greenhouse gases in the atmosphere have risen to levels not seen in 3 million years.**

CHAPTER 2

The Causes of Climate Change: Yes, It's Us

2
The causes of climate change: Yep, it's us

In short: we humans are the problem. Looking at the climate change science, there's no doubt that human activity is causing modern-day climate change.

Granted, naturally occurring phenomena—like the sun's intensity, volcanic eruptions and shifts in greenhouse gas concentrations—do play a role in climate change. But as NASA says, their "influence is too small or they occur too slowly to explain the rapid warming seen in recent decades."

The Intergovernmental Panel on Climate Change (IPCC)—a group of 1,300 independent scientific experts under the guidance of the United Nations—concluded that there's a greater than 95 percent probability that human activities over the past 50 years have heated the planet.

Evidence overwhelmingly indicates that we've got to own our significant role in climate change, and we've got to do it today.

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Where do GHGs come from?

As we mentioned above, the presence of GHGs in our atmosphere is a natural part of the Earth's climate systems. The issue is one of quantity, and in our quest to develop new ways to heat our homes, feed our families and fuel our lives, we've let things get a little out of hand. (The good news is, humans are pretty clever, and we're already developing even newer ways to build the lives we want, without overheating the planet.)

When it comes to excess GHG emissions created by humans, there are five main sources. Here's an overview.

1. Burning fossil fuels

The majority of greenhouse gas emissions are released from the burning of fossil fuels like oil, gas and coal for things like powering our cars and heating our homes.

SAILING WITH GRETA

To practice what she preaches en route to the 2019 UN Climate Action Summit, activist Greta Thunberg journeyed by solar panel–equipped yacht. Her 15-day trek across the Atlantic, which would create about a ton of CO_2e by plane, was a completely zero-carbon mission.

The 60-foot boat was cozy, to say the least. Accommodations could be likened to camping on the sea, with only thin mattresses, sleeping bags and freeze-dried vegan eats. And in true roughing-it style, there was no toilet—a blue bucket that was emptied overboard after each use did the trick.

When you add it up, according to data from Climate Watch, more than three-quarters of human-made greenhouse gases currently come from our need for energy.

2. Clearing forests and grasslands

Trees and other plants use CO_2 in the air as part of photosynthesis, and store the carbon in their roots, leaves, stems and trunks. When forests are cut down and ancient grasslands are dug up, it means more carbon is released and less is absorbed.

Evidence also indicates that the ongoing destruction of tropical forests is disrupting the movement of water in the atmosphere. This is triggering major changes in precipitation that could lead to drought in agricultural areas of China, India and the U.S. Midwest.

Here, the goal is to leave as much land to nature as possible. Solutions include more climate-friendly farming techniques (and reducing food waste), limiting urban sprawl, and taking the planet's urgent need for carbon sequestration into account in all land use decisions.

3. Animal farms

Agriculture generates an estimated 25 percent of annual GHG emissions when you combine food production and the land-use changes associated with farming, such as clearing vegetation and plowing. Cattle and other livestock also produce significant quantities of methane.

4. Industry

In addition to industry's energy needs, some processes create emissions, such as those needed to create metals like steel or to convert raw materials into resources, like when producing paper. The production of concrete also contributes to CO_2 emissions.

5. Waste disposal

Waste disposal in both homes and businesses contributes to GHG emissions, whether the garbage is being compacted into a landfill, incinerated in a plant or burned in someone's backyard.

Photo by Jakob Cotton on Unsplash

A history of climate change: How did we get here?

Well, it happened slowly, and then very, very quickly. Nailing down when human-caused climate change first began, and how rapidly the Earth has warmed since that date, is key to understanding how much humans have altered the climate.

Recent studies reveal that warming began as early as the 1830s, starting with the tropical oceans and the Arctic. Europe, North America and Asia followed roughly 20 years later, and the Southern hemisphere started showing signs of warming in the early 20th century.

But how did we get here, and when was climate change discovered? The answer involves a quick trip back in time.

While people have been cutting down forests and burning fuel like wood, coal and peat for an incredibly long time, the effects were minor until the onset of the Industrial Revolution in the 1750s. (Picture horse-drawn carriages, stylish gray wigs and towering smoke stacks.) This is when humans began using coal in mass quantities, producing goods in factories and clearing large tracts of land.

First, urban industrial centers emerged in Europe and North America. With the introduction of new technology and machinery, products such as textiles began to be mass produced in factories using steam power. As a result, coal became an essential fuel, needed to both produce and transport these goods.

The early 20th century saw the introduction of fertilizers, chemicals, electricity production and construction materials such as steel and iron. After the First World War, oil became a hot commodity with the growth of cars, airplanes and industrialized warfare.

Aside from the "smoke problem" generated by coal-burning industrial cities, the growing popularity of automobiles also triggered a spike in air pollution. In December 1952, for instance, a fog descended upon London for five days, killing up to 12,000 people. Parliament eventually passed the U.K. Clean Air Act in 1956, effectively reducing the burning of coal and providing an excellent example of how the right government legislation can have significant results.

In the 1930s, British engineer Guy Stewart Callendar suggested that carbon emissions might have a warming effect. His calculations predicting an overall warming of the planet by 3.6°F were met with skepticism. Sound familiar?

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From 1930 onwards, studies popped up introducing and debating many climate change–related topics, among them global warming and GHGs, ozone layer damage and the inability of oceans to absorb growing carbon emissions. Studies also appeared that warned of potentially catastrophic effects of climate change, such as rising sea levels and the possible collapse of Antarctica's ice sheets.

One famous research project that emerged in 1958 was the "Keeling Curve," a graph that charted the buildup of CO_2 in the atmosphere. Named after Dr. Charles Keeling, a climate change scientist at the Mauna Loa Observatory in Hawaii, the Keeling Curve is now the longest uninterrupted instrumental record of atmospheric CO_2 in the world.

Global temperatures began spiking in the 1980s, with experts pinpointing 1988 as the year that put global warming on the public's radar. It was the hot-test summer on record, and drought and wildfires ripped through the United States. People began to pay more attention to media reports and scientists' warnings about human-induced climate change. By year's end, "The Endangered Earth" had made the cover of Time magazine as "Planet of the Year."

Also that year, the United Nations and the World Meteorological Organization founded the Intergovernmental Panel on Climate Change (IPCC), a committee of experts tasked with giving policymakers regular scientific information about climate change.

CHAPTER 3

How Scientists Have Proved That Climate Change Is Real

3
Proof of climate change (or, a guide to the sophisticated ways scientists measure things)

This all feels very abstract when you're reading about it on a screen. But the reason we have so much information about climate change is because climate scientists have been putting in the leg work, digging up ice cores and launching satellites.

What have they learned? Well, in the past 650,000 years, the Earth has gone through seven cycles of glacial advance and retreat. But thanks to a lot of in-depth research, we know that this current warming isn't just another natural cycle. Climate change as we're experiencing it now isn't natural—it's real, and it's definitely human-made.

> **“ In the past 650,000 years, the Earth has gone through seven cycles of glacial advance and retreat. But thanks to a lot of in-depth research, we know that this current warming isn't just another natural cycle.**

Let's dig into some more climate change facts.

The rate of global warming (it's faster than it should be)

Sure, Earth's temperature over time does naturally fluctuate due to slight changes in the planet's orbit, impacting how much solar energy gets here.

But—and this is a big but—we're currently experiencing changes within only a few decades that would normally happen over hundreds of thousands of years. It's the intensity of the shift over such a short period of time that is the strongest evidence of global warming.

> **“ Since 2014, we've experienced six of the warmest years on record, and 2016 and 2020 have tied as the hottest years yet, according to a NASA analysis.**

The Earth's temperature is rising over time—for real

Human memory can be untrustworthy, so scientists have been measuring and writing down temperatures around the world for a long time so we have evidence of what's happening. The global temperature change so far is an average increase of 1.8°F since the late 19th century. That may not seem like a lot, but consider this: the highest level of temperature increase since 1880 (when modern recordkeeping started) occurred in the past 35 years.

Since 2014, we've experienced six of the warmest years on record, and 2016 and 2020 have tied as the hottest years yet, according to a NASA analysis. The ocean has also warmed significantly, showing an increase of more than 0.6°F since 1969.

Carbon dioxide levels: We broke an 800,000-year-old world record

Everyone wants to be the world's best at something, but this is a top number no one will be proud to see in the Guinness World Records.

Photo by photo sung on Unsplash

We already know that CO_2 (along with other GHGs) is a global heat trapper and plays an integral role in climate change. Historical climate data has been found in mountain glacier and ice core air bubbles in Antarctica and Greenland, showing that carbon dioxide levels today far exceed any from the past 800,000 years. Atmospheric carbon dioxide levels now are about 40 percent higher than they were in the pre-industrial era.

Models of the past half million years or so suggest that CO_2 levels have fluctuated between about 180 and 300 parts per million (ppm). Today, atmospheric CO_2 hovers around 415 ppm. Scientists agree that current levels of greenhouse gases correlate with the record levels of global temperature.

Shrinking ice sheets and disappearing glaciers

Melting glaciers tell the undeniable story of climate change because they're very sensitive to global temperature changes.

Based on historical climate data from aerial and ground photography as well as satellite imagery, it's clear that the Earth's glaciers have retreated at an alarming pace over the past century. Some have completely disappeared. Sad times indeed.

In August 2019, Iceland held a funeral ceremony for its Okjökull glacier, which in 2014 was the country's first to lose its status as a glacier. The plaque they unveiled holds the grim honor of being "the first monument to a glacier lost to climate change anywhere in the world." (That's another world record no one really wants their name next to.)

Satellite data from NASA's Gravity Recovery and Climate Experiment data show that in the past decade, the rate of Antarctica's ice mass loss has tripled. In Greenland from 1993 to 2016, 286 billion tons of ice per year were lost. During the same time frame, Antarctica lost about 127 billion tons each year.

The case of the disappearing Arctic snow

It gets worse. Satellite data is also showing a significant reduction in snow cover in the Arctic, specifically in the spring and summer, a result of global temperatures rising.

This matters because snow may reflect about 80 to 90 percent of incoming solar energy, while snow-free surfaces may reflect only 10 to 20 percent. The effect is compounded when permafrost melts, causing methane and carbon dioxide to be released into the atmosphere.

> **"In August 2019, Iceland held a funeral ceremony for its Okjökull glacier, which in 2014 was the country's first to lose its status as a glacier.**

Rising oceans and acidity levels (or why not to buy waterfront property)

All that water has to go somewhere. So when the earth's ice sheets and glaciers melt, the oceans rise.

Through the 20th century, sea levels rose about six inches in total, an average of about 1/16 inch per year. In the past couple of decades, though, the rate has doubled to more than 1/8 inch per year, and it continues to speed up.

On top of rising sea levels, about 20 to 30 percent of human-induced CO_2 emissions in the atmosphere end up in the ocean, which increases its acidity. This is a major problem because even slight changes in the ocean's acidity levels can seriously harm marine sea life.

Extreme weather events are everywhere

Across the globe, including in the United States, countries keep clocking record levels of heat. Coastal weather events such as hurricanes are becoming more severe. Droughts and wildfires are intensifying in both frequency and size.

The intensity of the recent devastating forest fires in California and Australia, for example, has been attributed to global warming.

Climate science: Why the research is legit

If you're not a climate scientist, it's easy to underestimate how much effort has gone into proving the existence of global warming. The thing is, we're not just talking about a couple of researchers crunching numbers in their ivory towers. The proof of climate change lies in data collected and analyzed over decades, and extensive, comprehensive reporting coming from all around the world.

According to IPCC (the panel made up of more than 1,300 climate scientists from the U.S. and around the world), "Warming of the climate system is unequivocal." They pin the cause of the warming on human activity with a greater than 95 percent probability and predict "profound consequences for the ecosystem and people."

Similarly, the National Climate Assessment (NCA) concluded in their most recent report that our climate has undoubtedly changed faster than ever in the past 50 years. They confidently attribute this change to human activity.

The proportion of climate scientists who agree that global warming trends are the result of human activity is perhaps the most convincing stat of all: a staggering 97 percent. After all, how often do 97 percent of people ever agree on anything?

> **"The proportion of climate scientists who agree global warming trends are the result of human activity is perhaps the most convincing stat of all: a staggering 97 percent.**

Photo by Paweł Czerwiński on Unsplash

4
The effects of climate change—and why we need to act now

No matter how you look at it, we're facing some grim realities in the not-so-distant future: climate change droughts, heatwaves, significant changes in weather systems and more intense and frequent natural disasters such as floods, mudslides, forest fires and hurricanes.

With all of that come the forced relocations of climate refugees and a mass destruction of assets, plus insect infestations, destruction of coral reefs, increased air pollution, mass habitat loss and extinctions, and much more.

The bad news: We're blowing past our global warming targets

You know that old tale about the frog in the pot of water that's slowly heating up? Well, we're the frog.

CHAPTER 4

The Effects of Climate Change—and Why We Need to Act Now

Unsurprisingly, the higher the warming, the more damage to our natural and human systems. But because global warming has been creeping up on us, to many people, it has never felt quite urgent enough to be our top priority—and we gradually adjust to the changes and feel they are more normal than they really are. And the longer we put off doing anything substantial to stop climate change, the worse it's going to get.

Human activities account for approximately 1.8°F of the global temperature increase since the pre-industrial era, and we're still continuing at a breakneck pace

At the 2015 United Nations Climate Change Conference in Paris, the world agreed to keep the rise in global temperature this century "well below" 2°C (3.6°F) compared to pre-industrial levels.

But we're on track to blow past this critical threshold; in 2018, the UN World Meteorological Organization predicted a rise of 5.4°F to 9°F by 2100, should we continue at the rate we're going.

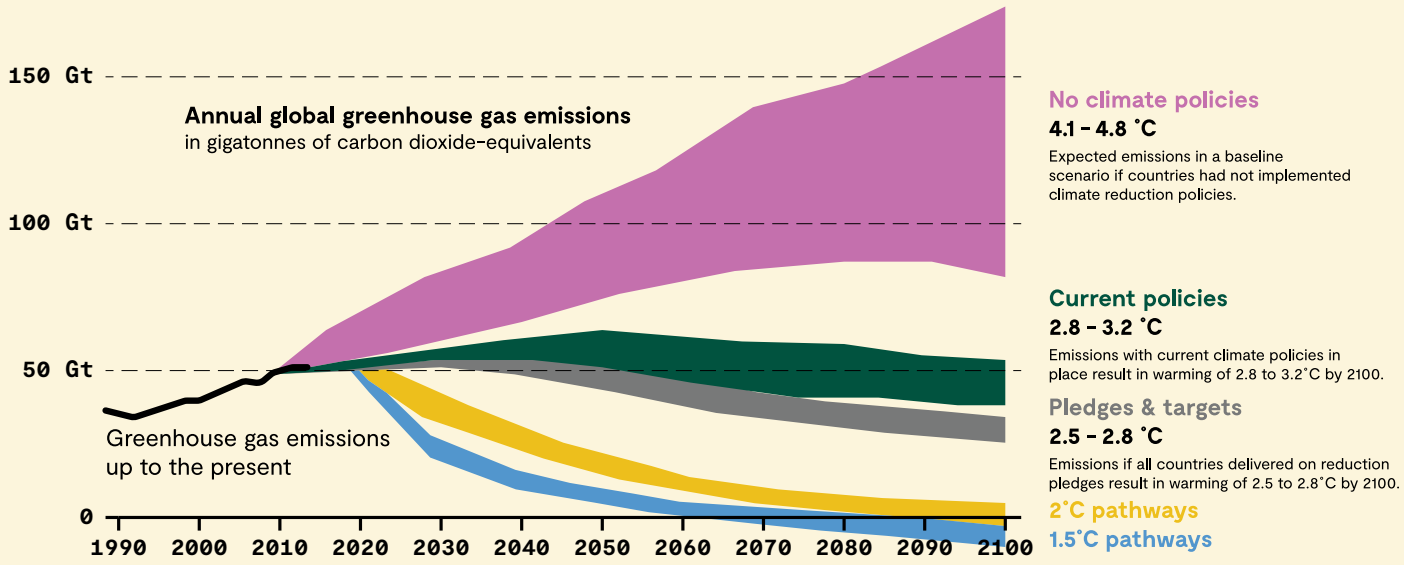
Climate change impacts: How much difference does half a degree make?

Even if we went completely cold turkey on our dependence on fossil fuels, we wouldn't be able to stop global warming entirely. Climate change is already happening. But the good news is, this isn't an all-or-nothing scenario. The lower the temperature rise, the better. But there is debate among scientists and policymakers over where we should set limits.

For instance, the 2018 IPCC report outlined the difference between an increase of 1.5°C and 2°C by 2100. Basically, the more average temperatures increase, the worse all of the projected consequences of global warming will get.

With a two-degree Celsius increase by 2100, for instance, the IPCC predicts that more than 35 percent of the global population will experience severe heat waves at least once every five years, roughly triple the number as under 1.5°C of warming. Fishing yields could decrease by about 3.3 billion pounds and agriculture in some areas could completely collapse. Hundreds of millions more of the world's population could face poverty and other climate-related risks (to their health, food security, water supply, livelihood, human security and economic growth).

GLOBAL GREENHOUSE GAS EMISSIONS AND WARMING SCENARIOS



— Each pathway comes with uncertainty, marked by the shadings from low to high under each scenario.

— Warming refers to the expected global temperature rise by 2100, relative to pre-industrial temperatures.

Source

To be clear, the climate crisis doesn't start at 1.5°C above pre-industrial levels. We're already in it. But when the average global temperature increase surpasses that 1.5-degree mark, climate change projections become significantly worse.

Regardless of warming levels, here are some examples of climate change effects that we can expect.

1. Rising sea levels and ocean acidification

As ice melts, sea levels rise and the proportion of the Earth's surface that is dark (water) versus light (ice) increases. Water absorbs more of the sun's energy than ice, which mostly reflects it, thereby heating up the oceans and accelerating the melting process in a cascade effect.

As oceans get warmer, they also expand in volume, causing sea levels to increase even more.

As sea ice melts and temperatures rise, the Arctic Ocean is becoming more like the Atlantic and Pacific, say scientists—which, among other things, means bigger storms and bigger waves. The community of Tuktoyaktuk in northern Canada, for instance, is on the shore of the Beaufort Sea, where coastal erosion is reaching some two meters per year, and wave heights are expected to increase by some two to three times, reaching one to four meters high by the end of this century, further increasing erosion. The result could be completely losing the town's harbor, which is essential for fishing and other economic activity.

CO_2 in the atmosphere also enters the ocean and makes it more acidic. This acidification will likely cause devastation to many aquatic ecosystems.

Coral and shellfish, for example, are very sensitive to even slight changes in temperature and acidity levels. Warming waters cause the bleaching of coral reefs, and the acidity dissolves the shells of sea creatures and weakens coral structures.

2. Extreme weather conditions

Extreme weather events caused by climate change are already happening: not just rising temperatures and heat waves, but also storms of higher intensity,

including wetter and more frequent hurricanes. Rising sea levels also mean higher coastal inundation and more potential for damage.

Global warming is partly to blame for the devastation caused to Puerto Rico by Hurricane Maria in 2017, for example. Record levels of extreme rainfall hit the country, causing unprecedented flooding and landslides.

3. Mass displacement of climate refugees

As sea levels rise and natural disasters become more frequent, the number of people seeking refuge will inevitably continue to increase.

Kiribati, for example, an island nation in the South Pacific, could be completely submerged in the coming decades due to rising ocean levels—they've already purchased land in Fiji should the population need to evacuate.

Drought, heat waves, agricultural disruption and lack of access to water will force large populations of climate refugees around the world to seek out cooler, more hospitable conditions. **By 2050, hundreds of millions of people may be displaced due to the effects of global warming, according to the International Organization for Migration.**

This isn't a story about some far-off distant future—it's happening now. A 2016 article in the New York Times, for instance, called residents of Isle de Jean Charles, La.—forced to relocate due to the effects of flooding and hurricanes—America's first climate refugees.

Climate change and inequality: The poor are getting hit the hardest

Climate change affects the whole planet, so you might think we're all in this together. And to a certain point, we are. But how much wealth you have—both personally, and as a society—matters, as does your geography.

Countries where a significant proportion of the population depend on natural resources for their livelihood, and those with poor infrastructure and dense, quickly growing populations—plus those who live on coasts and islands—are especially vulnerable to the consequences of climate change.

Lagos, Nigeria, for example, is one of the fastest-growing cities in the world. Located on the western coast of Africa, on the Gulf of Guinea, the city of close to 15 million people is projected to double in population by 2050—an obvious strain on their infrastructure.

> **"Sadly, those who will ultimately suffer the most from the consequences of global warming are those who are the least responsible for its cause.**

Lagos can expect even more hot days and droughts due to global warming, and as rising sea levels continue, seawater may contaminate fresh water and permeate farmlands. Nigeria can expect coastal erosion and a blow to their fishing industry as well.

And consider what the effects of climate change might be in Yemen, which has been in a state of civil war since 2015. The Middle Eastern country is already struggling with mass famine, child malnutrition and casualties, sanitation issues and a lack of potable water. These conditions are likely to be exacerbated by global warming.

Sadly, those who will ultimately suffer the most from the consequences of global warming are those who are the least responsible for its cause.

In light of this painful fact, the concept of climate justice shifts the global warming focus from an environmental phenomenon into the realm of ethics human rights issues and inequalities

Domino effects of global warming: The critical tipping points

Now we get to the part of the disaster movie where all the bad things happen at once.

The effects of global warming don't happen in a vacuum. Each change impacts something else, which impacts something else, and on and on. Within the very long list of climate change projections, climate scientists have identified three potential critical "tipping points."

These tipping points could set off a disastrous domino effect, leading to an irreversible shift in the Earth's temperature and climate systems.

First is the loss of ice sheets, which continues to increase sea levels at alarming rates, triggering a cascade of effects. Second, forest fires and melting permafrost caused by global warming release even more CO_2 into the atmosphere, accelerating global heating.

The third tipping point, and what sounds like a scene straight out of "The Day After Tomorrow," is the shift in the ocean's circulation system, responsible for heat distribution around the globe. Already, the system is experiencing a thousand-year low, believed to be caused by melting ice in Greenland. If this trend continues, the change could set off a collapse to the Amazon rainforest, nearly permanent droughts in Africa's Sahel region, disruption to Asian monsoons and much more.

Effects of global warming in the United States, now and in the future

Sounds rough, right? Well, it is. And while these examples may feel worlds away, the U.S. is going to experience its own climate change problems. In fact, it's already happening.

For example, the Fourth National Climate Assessment (NCA4) predicts an increase in high-temperature extremes, heavy precipitation events, forest fires, high-tide flooding events along the coastline and ocean acidification and warming. On the flipside, they also expect a decline in land and sea ice cover, snowpack and surface soil moisture.

With these climate change issues we can foresee problems for people and industries all around the United States. Here are a few examples.

1. Much higher temperatures

The Northeast will see the highest temperature increase in the contiguous country. The region is also projected to see the highest rise in fatalities due to heat, the highest rate of ocean warming and the highest rising sea levels in the country. (In other words: expect floods.)

The already hot and humid Southeast can bank on up to 100 more "warm nights" by 2100.

2. Intense and dangerous heat in cities

Cities are already experiencing the "urban heat island" effect, whereby heat waves are amped up in urban centers. Dark pavement absorbs heat and releases it slowly, and buildings can cause stagnant air to warm up rather than mixing. Add exhaust from vehicles and buildings plus a lack of tree cover and you get dangerously hot conditions during heat waves, causing power outages and critical or fatal health risks.

These risks are even higher in lower-income urban areas, where there tends to be even less green space and less likelihood of air conditioning.

3. Loss of wages

Among the many costs of climate change, we can expect a decline in wages earned. As anyone experiencing the dog days of summer can tell you, when heat increases, productivity decreases. The NCA estimates that by 2090, we'll see $160 billion in lost wages because of lower productivity caused by increased heat.

4. Climate change effects on agriculture

The Midwest can expect a significant reduction in yields of corn (5 to 25 percent) and soybeans (more than 25 percent) thanks in large part to hotter temperatures. Products made from these crops could, in turn, become harder to find and/or more expensive. (Don't worry, tofu lovers, the bulk of these soybeans are used to feed livestock.)

The Northern Great Plains—responsible for a significant portion of the country's agriculture—will see their winters end earlier and snow levels in the mountains decrease by 25 to 40 percent.

5. Irregular and extreme weather

Hawaii will experience rising sea levels, irregular rainfall, extreme temperatures and weather patterns, drought, flooding and a serious negative impact on wildlife, including seabirds, turtles and seals.

Wildfires and thawing permafrost in Alaska will continue and increase.

The Caribbean will see longer dry seasons and shorter, but more intense, rainy seasons. Puerto Rico may lose more than 3 percent of its total coastal land area and the U.S. Virgin Islands, more than 4 percent.

> **"The NCA estimates that by 2090, we'll see $160 billion in lost wages because of lower productivity caused by increased heat.**

5
Wow, okay. So how do we stop climate change? What are some solutions to global warming?

Let's start with the bad news: there's no "magic bullet" for reversing climate change.

In a 2018 report by the IPCC, leading climate change scientists warned we had only 12 years for global warming to be kept to a maximum of 1.5°C.

Some scientists believe we can't stop climate change, pointing to tipping points and climate change deadlines that may have already been reached or passed. In their opinion, we've already seen irreversible changes in major ecosystems and the Earth's climate system, and we may have hit a climate change "point of no return."

Others, like the IPCC, advocate for healthy climate solutions to put the world on track to fulfill the Paris Agreement goals of limiting global warming to 1.5°C to 2°C.

But what are these solutions for climate change? Read on.

How to stop global warming: What are some of the policy solutions?

Governments have a lot of power to make changes, Here are some examples of solutions that countries around the world are introducing.

1. Price carbon pollution

Putting a price on carbon incentivizes polluters to either reduce their emissions or pay for polluting practices. There are two main types of carbon pricing:

CHAPTER 5

How Do We Stop Climate Change?

Photo by Matias Malka on Unsplash

- **Emissions trading systems (ETS):** Otherwise known as a "cap-and-trade system," this approach sets a limit on total GHG emissions and allows industries with low emissions to sell their allowance to other polluters.
- **Carbon tax:** This approach sets a tax rate on GHG emissions or on the carbon content of fossil fuels. The bar for emissions isn't defined, but the tax rate is. In some countries such as Canada, the carbon tax that's collected by the government is then redistributed to citizens in the form of a rebate.

With carbon pricing, governments can funnel these funds into climate change mitigation strategies and finding ways to stop global warming.

> **"Great Britain introduced a carbon tax in 2013, which has encouraged electric utilities to phase out coal. This influenced a drop in the country's GHG emissions, which have plummeted to their lowest level since 1890.**

Case in point: Great Britain introduced a carbon tax in 2013, which has encouraged electric utilities to phase out coal. This influenced a drop in the country's GHG emissions, which have plummeted to their lowest level since 1890.

2. Shift to electric

That magic plug in the wall has changed our world, and it's time to depend on it even more. Unlike energy sources like natural gas and oil, electricity can be generated from renewable sources. The more we electrify, the more impact there is when we shift our sources of electricity to clean energy. Plus, will any of us really miss gas-powered leaf blowers?

One huge example is electrifying transportation. **According to a 2019 survey, more than one-third of all prospective car buyers in the U.S. would consider buying a plug-in electric vehicle within the next two years.** IEVs are certainly growing in popularity, and in the case of Tesla, have even achieved a "cool factor."

More than one-quarter of American carbon emissions stem from the transportation sector according to the EPA, so switching vehicles' fuel source from oil (and its derivatives) to electricity could help combat climate change as well.

Today, EVs represent a sliver in the percentage of total vehicle sales, and cost can be a hurdle to getting more of them on the road. The federal tax credit of up to $7,500 helps—especially when combined with any state incentives—but boosting EV sales means expanding incentive programs and making rebates available at the car dealership rather than on annual tax returns.

Global warming prevention relies on government support for active transport (like cycling and walking) and electrifying public transit systems. And consider this: the United States has more than 8 million fleet

vehicles—which includes everything from military and police vehicles to school buses to federal cars. The impact of electrifying the bulk of those vehicles could be massive.

3. Be smart about nuclear power

This might be a shocker to those of us who watched "Chernobyl," but nuclear power is a vital part of climate change prevention. In looking at how we can help climate change, leading environmental organizations such as the Union of Concerned Scientists have recommended safely operating nuclear power plants until other low-carbon energy technologies can be rolled out.

But there's a snag: out of the 60 nuclear power plants operating in the U.S at the end of 2017, more than one-third were either unprofitable or slated to close within the next 10 years.

Something needs to change to keep these plants running, or they risk being replaced by natural gas—a move that could increase the U.S. electric power sector's carbon emissions by an estimated 6 percent by 2035. Experts say a few key things could help keep nuclear energy on the grid, including carbon pricing and subsidies.

4. What about corporations? What's their role in fighting climate change?

Companies have a lot of power to do good, not just in the money they have to spend on solutions, but in the influence they have on others. Some examples:

Transparency and accountability

One of the most important global warming solutions is for corporations to set strict emission reduction targets that support the Paris Agreement or, better yet, the IPCC's most recent 1.5°C goal. Achieving this means tracking their carbon emissions and regularly reporting these numbers to the public with full transparency.

Fortunately, we're going in the right direction. According to CDP (formerly the Carbon Disclosure Project), the number of companies with active emissions targets and those disclosing emissions data is increasing year over year. Check out our other eBook, *The Good Guide to Measuring Your Carbon Footprint*, for more on what companies are doing about their carbon footprint.

Commitment to carbon reduction

Efforts from corporations to become carbon neutral or even, carbon negative goes a long way, and is becoming increasingly more common. Some of this is coming from improvements in how companies do business in the first place—think of Apple's innovations in using recycled content in its products—and some from carbon offsetting.

Thankfully, we're seeing these kinds of promises from major corporations already. Some of the businesses playing ball are airlines such as Delta, which has pledged to go carbon neutral, and both Microsoft and Ikea, which have declared that they will actively reduce carbon dioxide emissions.

Photo by S. Nou on Unsplash

What about me? What can individuals do to help stop climate change?

What can we do at the individual level to stop global warming? Fortunately, there are a lot of ways we can help fight climate change and reduce our own environmental impact. Check out our other eBook, *The Good Guide to Measuring Your Carbon Footprint*, for more on what companies are doing about their carbon footprint.

Individual actions that can have the greatest effect are things like eating less meat and travelling less, especially by air. Take transit, bike, walk or work from home. Make your home sustainable by using energy saving-appliances and low-flow showers and sinks. Buy less stuff! Invest in and support businesses that practice climate consciousness. Educate your friends and family in a shame-free way that gets them onside.

Every little bit helps.

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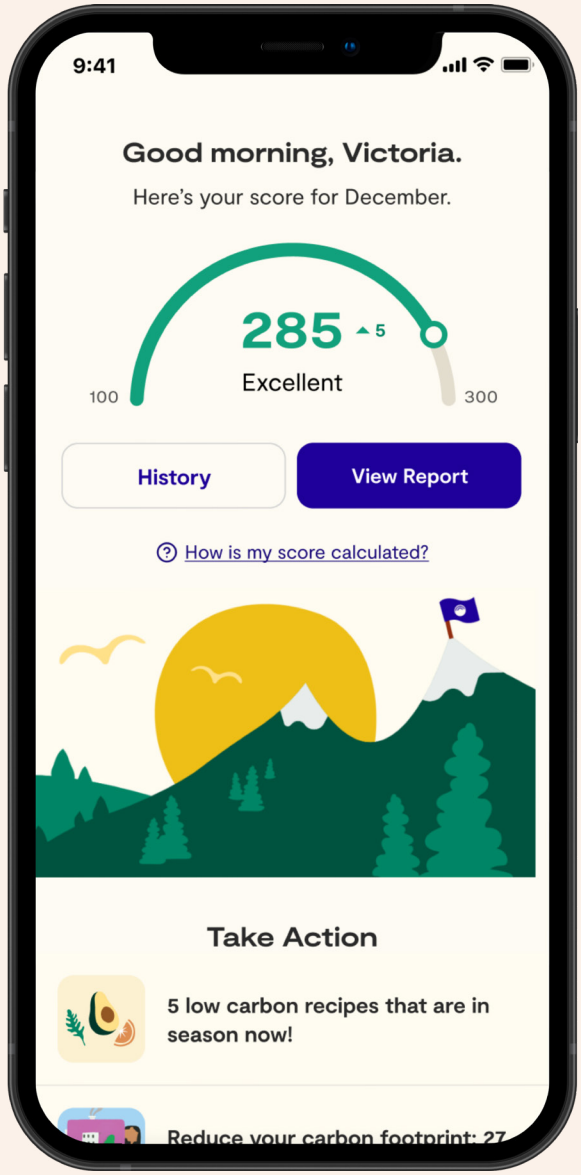
About Goodside

Goodside is on a mission to facilitate real and lasting action against the climate crisis by building tools to help individuals measure, reduce and offset their impact on the planet.

Goodside is a company from RBC Ventures Inc., a subsidiary of the Royal Bank of Canada (RBC). RBC Ventures goes beyond banking by building new ventures, acquiring growing firms, making investments and partnering with organizations that share our vision to solve problems and make lives better.



Together for the Planet

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