CLIMATE SOLUTIONS for kids

*An adaptation of **Project Drawdown** for young readers*

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GLOSSARY

Climate Change

The process in which human-produced greenhouse gases trap excess heat in the atmosphere. This trapped heat causes the Earth's climate to warm. For this reason, the process is sometimes referred to as global warming.

Greenhouse gas/gasses

Greenhouse gases are gases that trap heat in earth's atmosphere by absorbing infrared radiation. The four main greenhouse gases are carbon dioxide, methane, nitrous oxide, and fluorinated gases. The accumulation of these gases in the atmosphere are the main cause of climate change.

Drawdown

Drawdown is the point in the future when levels of greenhouse gases in the atmosphere stop climbing and start to steadily decline. If we are able to drawdown greenhouse gases to the level they were at before the Industrial Revolution, we have a chance to stop the negative impacts of climate change.

Carbon

Carbon is a chemical element that is one of the building blocks of life. It is present in all living things on Earth. It's simple atomic structure allows it to bond in many different ways and with many different elements. In terms of climate change, carbon can combine with other elements to form greenhouse gases, such as carbon dioxide or methane.

Carbon dioxide

Carbon dioxide, or CO2, is a heavy, odorless gas. It is the most abundant greenhouse gas after water vapor. Carbon dioxide is produced when we burn fossil fuels, when animals and plants decompose, and when humans breathe. It is absorbed from the air by plants as part of the process of photosynthesis.

Carbon sink

Carbon sinks are natural features, such as forests, wetlands and oceans. They take carbon dioxide out of the atmosphere and sequester (store) it in their biomass as part of the carbon cycle. Carbon sinks are important for climate change because they sequester carbon dioxide so that it does not accumulate in the atmosphere. Rainforests are an important example of carbon sinks because as plants grow, they absorb carbon in their roots, trunks, and branches. When we burn and cut down rainforests, the carbon dioxide that plants have sequestered is released again into the atmosphere.

Rainforests are great examples of carbon sinks because they absorb carbon as plants grow.

Photo: Bernard Hermant / Unsplash

Methane

Methane is a colorless, odorless, flammable gas that is generally released by the decomposition of organic matter and the process of extracting fossil fuels. For example, cows release methane as part of their digestion process and trapped pockets of methane can be released when we drill for oil. Methane is the main component of natural gas. It is a greenhouse gas that can trap 34 times more heat than carbon dioxide in earth's atmosphere. That means that it warms the earth 34 times faster than carbon dioxide.

Emissions

Emission means sending or throwing out. When we use this term in the context of climate change, we refer to the greenhouse gases that are released when things, such as fossil fuels and biomass are burned. One of the most common examples is a car burning gas and creating emissions through exhaust.

Energy

Energy is the ability to do work or create heat. Everything around us has energy, and energy can take many forms: electrical, thermal, chemical, potential and kinetic. We use energy to cook food, to light and heat our homes, and our bodies even transfer energy when we kick a soccer ball.

Electricity

Electricity is a form of energy that involves the movement of charged particles. We use electricity to power things like lights, appliances, and even cars.

Fossil fuels

Fossil fuels are created when plants and animals die, are buried in the earth, and after thousands of years turn into substances like oil, coal, and methane. When fossil fuels are burned, the chemical energy inside of them turns into heat. We use this heat to create electricity or create motion, such as in the engine of a car. Burning fossil fuels also releases carbon dioxide and other air pollutants into the atmosphere. Fossil fuels are considered a nonrenewable energy source because there is a limited amount of them.

Renewable energy

Energy that comes from relatively unlimited sources such as wind, geothermal, sun, or tides. Sometimes referred to as "clean" energy. This type of energy is in contrast to non-renewable energy sources, such as fossil fuels.

Wind turbines are a good way of harnessing renewable energy. They turn wind energy into electricity for people to use.

Photo: Dan Meyers / Unsplash

Photo courtesy of Boulder Food Rescue
www.boulderfoodrescue.org

Solution #1

REDUCED FOOD WASTE

Boulder Food Rescue delivers unused food to families who need it so it is not wasted. This helps people and the planet.

87.5–94.6
GIGATONS
CO2 EQUIVALENT
REDUCED / SEQUESTERED
(2020–2050)

Globally, one third of all food does not make it from the farms and factories, where it is either grown or produced, to our plates. The process of making food that ever gets eaten wastes a LOT of valuable resources. For example, seeds, water, energy, land, fertilizer, people's time working, and money is wasted. Wasted food makes up 8 percent of global **greenhouse gas emissions** every year!

Wasting food is an issue all around the world.

The process of moving food from where it is grown or made to where people buy it from grocery stores, is called a supply chain. In some places, food is usually wasted early in the supply chain process. For example, food rots on farms, or goes bad when it is stored or shipped to markets. In other places, food is wasted towards the end of the supply chain. For example, restaurants and customers shopping at grocery stores usually do not buy fruits and vegetables with bumps, bruises or strang coloring. Also, sometimes people buy too much food. The extra food goes bad and gets wasted.

Food supply chain: *This is a simple version of how food gets from the farm to our stores. There are lots of different spots where food can get lost or wasted before it even makes it to the store!*

What can we do to waste less food?

The good thing is there are many ways to fix the problem of food waste!

There are two ways to reduce food waste in the supply chain. Early in the supply chain, countries need tools and technology to:

- Store food so it does not go bad
- Move the food more quickly from farms and factories to stores
- Process food to keep it fresh

Trashed produce: *These fruits and vegetables were found in the trash behind a supermarket. This food would still be good for someone to eat.*

Later in the supply chain, countries can work to change consumer habits:

- Set community and state goals for reducing waste.
- Encourage shoppers to only buy food that they need or items that will last a long time.
- Change negative attitudes about bruised fruits or vegetables with bumps on them.

Aside from reducing emissions, reducing food waste is important for another reason too. The world's population is growing every year. If we create global systems to prevent food waste, there can be enough food to feed everyone.

Acting it out: *To help change negative attitudes about ugly produce, these kids wrote a comedy sketch to laugh about it. Making a subject funny is a good way to raise awareness.*

Photo Credits -
Trashed produce: Foerster / Wikimedia Commons
Acting it out: Isabel Cousins

Photo by MAIA Impact School

Solution #2

HEALTH AND EDUCATION

This young woman is learning at the MAIA Impact School in Sololá, Guatemala. The school supports young Indigenous women's education.

85.42

GIGATONS

CO2 EQUIVALENT
REDUCED / SEQUESTERED
(2020–2050)

KEY WORDS

reproductive healthcare
This means that people can have a healthy reproductive system and they have the ability to reproduce and have a family when they choose to.

equal educational opportunities
An education that is equitable and accessible to all genders and that prepares all students to be decision-makers and knowledge-producers.

Climate change solutions are often located at the connection between people and the environment. Two examples of the important connections between people and the environment are high-quality reproductive healthcare and equal educational opportunities. Both of these issues are human rights and they are both very important to ensure that women and men are treated equally. When everyone has access to reproductive healthcare and equal educational opportunities, we are better prepared to address **climate change**.

Acting it out: *These students in Malope, South Africa enact a skit about reproductive health.*

Today there are over 7.7 billion people living on Earth. That includes you! When we think about the future of people on our planet, the number of people who eat, go to school, drive cars, go to work, plug things in, buy things, and throw things away everyday matters. When more people live on our planet, we collectively use more resources. This is because when the population grows, factories need to produce more of the things we need and want. Things we need include beds, silverware, and clothing. Things we want maybe include toys, bikes, and videogames. When the population goes up, so does our global fossil fuel use.

How many people do you think will live on this planet in 2050, or even in 2100? According to the United Nations there will be 9.4 to 10.1 billion people living on earth in 2050. When young women and girls have access to equal educational opportunities and reproductive healthcare, they generally are more respected by others, have more status in their communities, and have more money. These factors often lead women to have fewer children. Across the world and over time, when women have less children, the size of the global population goes down.

Studying reproductive health: *Young women in Malope, South Africa study reproductive health.*

Why is considering the wealth of a country important?

People in wealthy countries only make up 10% of the world's population but they create more than 50% of **greenhouse gas emissions** that cause climate change. As a result, population growth in wealthy countries impacts climate change more than population growth in less wealthy countries. People might feel a variety of emotions related to the topic of population growth. Some people might feel or say mean things. Ultimately, people's choice about how many children to have should be their personal choice. And all children should inherit a livable planet.

It is important that we always focus on the goals of human rights and equal treatment of women and all genders. Working toward this goal benefits both humans and the planet.

In its most recent report on "world population prospects," the United Nations says that the international community has committed to making sure that all people can decide when they want to have children and how many children they will have. This commitment can change the world because it helps humans address climate change by using fewer resources.

Speaking up to protect the planet: *These young women are members of SPEAK.WORLD, an organization that empowers young women to use their voices for change.*

Photo Credits
Acting it out: Melisande Osnes
Studying reproductive health: Melisande Osnes
Speaking up to protect the planet: Beth Osnes

Photo by Ella Olsson from Pexels

Solution #3

PLANT-RICH DIET

65–91.72

GIGATONS

CO2 EQUIVALENT
REDUCED / SEQUESTERED
(2020–2050)

Meat-heavy diets are becoming more common. By switching your diet to include more plants, you can help stop global warming.

Focusing on eating fruits and vegetables as our main source of food can help keep us healthy and help prevent climate change. In many countries, including the United States, most people eat meat as their main course every meal and include fruits and vegetables as side courses. Eating meat as the main food source is becoming more common around the world.

However, eating so much meat contributes a lot to global warming. Meat production accounts for 20 percent of global greenhouse gas emissions. If all the cattle in the world lived together in their own country without humans, that country would place third for the largest producer of greenhouse gas in the world.

What can we do?

If people eat more fruits, vegetables, and beans, they can reduce greenhouse gas emissions. Many people think of vegetarian and vegan diets when they think of eating less meat, but those are not the only options. A plant-rich diet can look similar to a vegetarian diet, but also include meat that produces less greenhouse gas emissions, like chicken or fish. The main goal for any plant-rich diet is to center meals around plants instead of meat. Anyone can start eating more plants to lower their emissions.

Plant-based party: *Making a feast focused on plants with friends or family is a great way to encourage people to make good choices for the planet.*

What makes it hard to switch to a plant-rich diet?

What people eat is connected to where they grew up, what they value, and what they were taught to eat as kids. This can make choosing a plant-rich diet difficult. But more tasty plant-rich foods, such as Beyond Burgers, are becoming available. So, it's getting easier to eat less meat or not eat meat at all.

Plant-rich burgers: *New plant-rich burgers are made to taste just like hamburgers. People may eat more plant-rich foods when they look and taste more like the meat-based foods that they enjoy.*

Another problem is that many governments help ranchers pay for raising cows. As a result, meat is very inexpensive. If this policy changed and the price of meat went up to its true cost, more people might choose a plant-rich diet.

As Zen master Thich Nhat Hanh has said, making the transition to a plant-rich diet may be the most effective way an individual can stop climate change.

What does each type of plant-rich diet look like?

- In a plant-rich diet, people may still eat meat, but it is not the focus of their diet. Instead, they try to eat mostly plants and occasionally include meats with low greenhouse gas emissions.
- In a vegetarian diet, people don't eat meat but they do eat things like cheese, milk, and eggs. If we all ate this way, we could reduce greenhouse gas emissions by 63 percent.
- In a vegan diet, people don't eat any foods that come from animals at all. This means they do not eat meat, cheese, milk, or eggs. If everyone ate this way, we could reduce greenhouse gas emissions by up to 70 percent.

Any of these diets could help us save up to $1 trillion dollars in health care costs.

Here is an example of what meals might look like for each type of a plant-rich diet.

Plant-Rich	VEGETARIAN	VEGAN
Breakfast Eggs with toast and fruit	**Breakfast** Eggs with toast and fruit	**Breakfast** Oatmeal with chia or flax seeds, topped with fruit and/or nuts
Lunch Plant-based burger with cheese and vegetable toppings, served with potato fries	**Lunch** Plant-based burger with cheese and vegetable toppings, served with potato fries	**Lunch** Bean and lentil chili served with roasted potatoes
Dinner Garlic ginger **chicken** stir-fryed with vegetables of choice, served with rice or quinoa	**Dinner** Garlic ginger **tofu** stir-fryed with vegetables of choice, served with rice or quinoa	**Dinner** Garlic ginger tofu stir-fryed with vegetables of choice, served with rice or quinoa

Note: These are just examples! The foods you might choose in your plant-rich diet depend on your personal choices.

Photo Credits
Plant-based party: Beth Osnes
Plant-based burger: Dllu / Wikimedia Commons

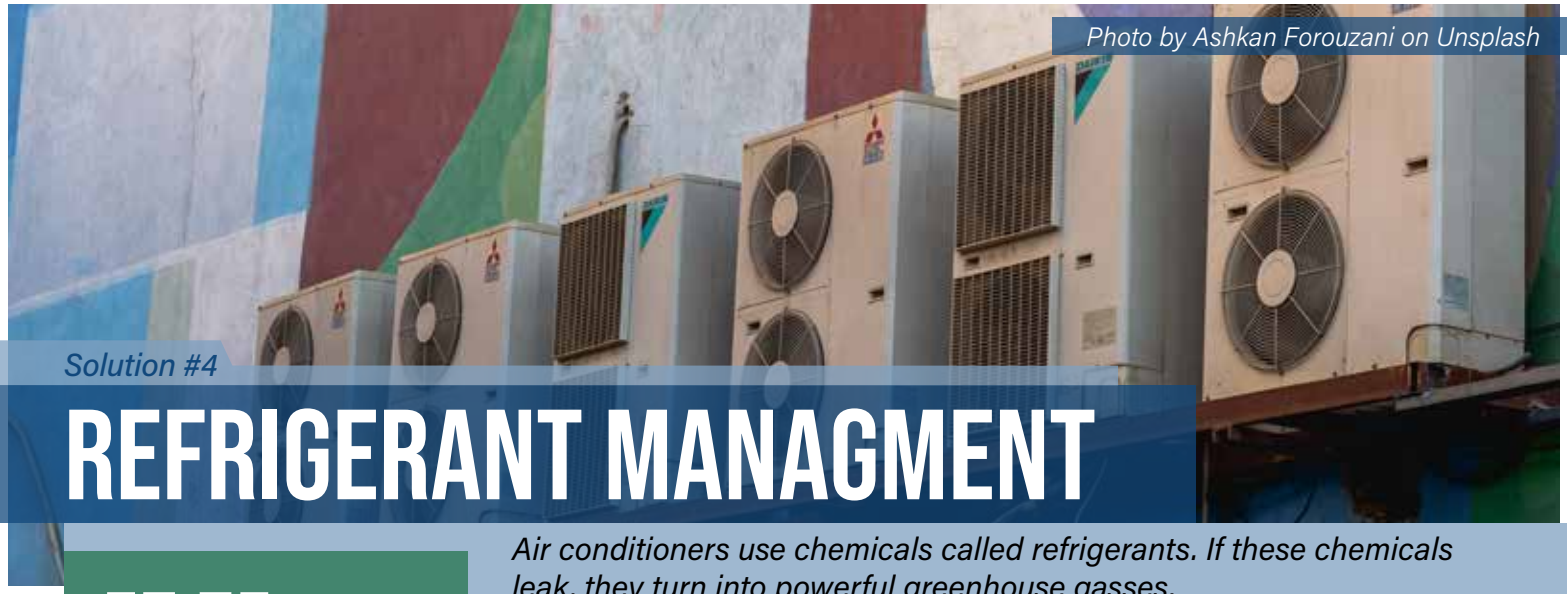


Photo by Ashkan Forouzani on Unsplash

Solution #4

REFRIGERANT MANAGMENT

57.75

GIGATONS

CO2 EQUIVALENT
REDUCED / SEQUESTERED
(2020–2050)

Air conditioners use chemicals called refrigerants. If these chemicals leak, they turn into powerful greenhouse gasses.

Refrigerators keep our food cold to make sure it stays fresh. Air conditioners keep buildings and homes cool during hot summers. Both refrigerators and air conditioners use chemicals that can absorb and give off heat to create cool air. These chemicals are called refrigerants. Up until 1987, two of the most common types of refrigerants were chlorofluorocarbons (CFCs) and hydro-chlorofluorocarbons (HCFCs). Even though they are effective refrigerants, these chemicals cause a problem.

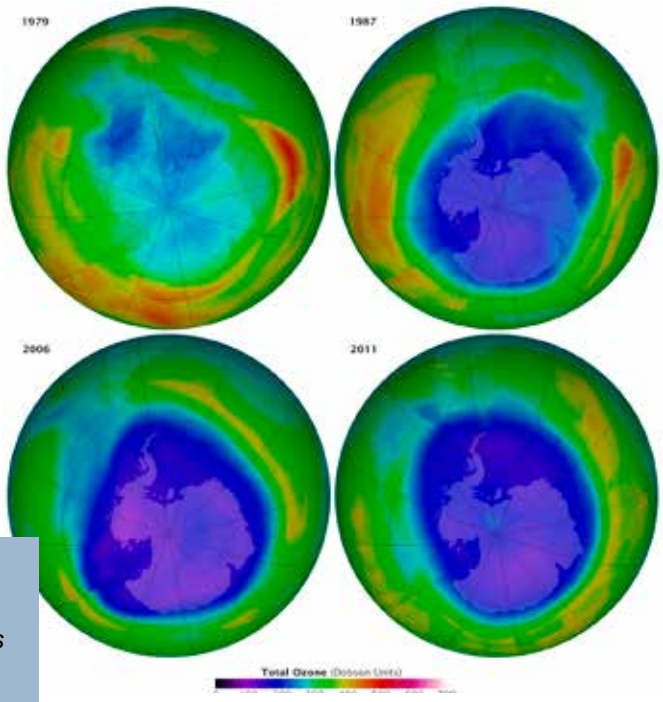
The problems with refrigerants

If CFCs and HCFCs escape into the air, they can harm part of our atmosphere called the ozone layer. In 1987 many people came together to create a new international law called the Montreal Protocol. This law said that CFCs and HCFCs can no longer be used as refrigerants.

When these chemicals were banned, scientists developed a new refrigerant called hydrofluorocarbons (HFCs). HFCs are better for the ozone, but they are a very big issue for **climate change**. HFCs trap 1,000-9,000 times more heat than **carbon dioxide**! This means that even a small amount in the atmosphere can contribute a lot to climate change!

KEY WORD

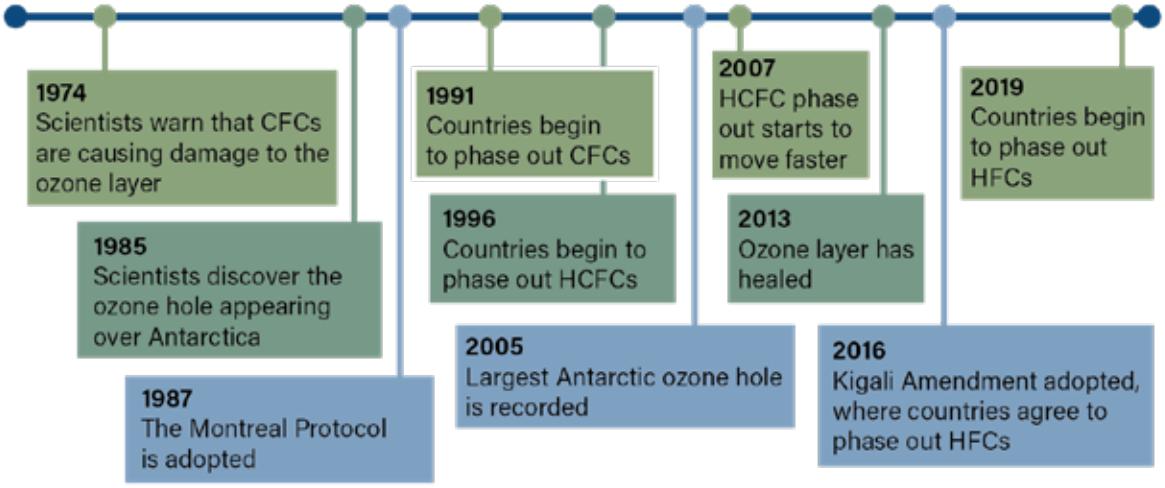
ozone layer
The ozone layer is a layer of Earth's atmosphere that absorbs most of the ultraviolet (UV) energy reaching Earth from the sun.



Ozone layer over time: *These images show how the ozone "hole" in the South pole has changed over time. The blue and purple areas are where there is less ozone, so the ozone layer is thinner. The Montreal Protocol was created after scientists saw this "hole" growing larger.*

Revising the Montreal Protocol

In October of 2016, leaders from more than 170 countries came together in Kigali, Rwanda, a country in Africa. They discussed the problems with HFCs and decided to revise the Montreal Protocol. In this revision, countries agreed to slowly stop using HFCs. Scientists calculate that getting rid of HFCs will reduce global warming by one degree Fahrenheit. This might not seem like much, but it is a big deal!

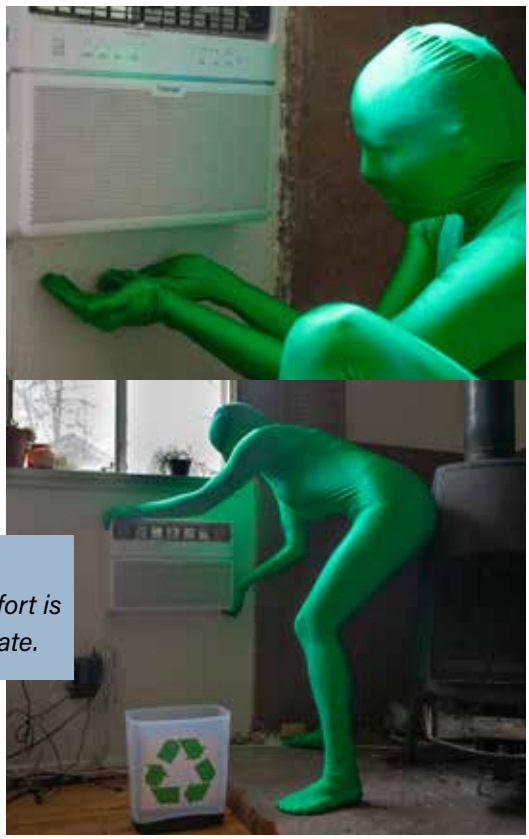


Montreal Protocol timeline: *This timeline shows when major events for the Montreal Protocol happened.*

In the revised Montreal Protocol, different countries stop using them based on how much money the country has to pay for new refrigerants. Rich countries had to stop using HFCs by 2019. Countries that do not make as much money have until 2024 or 2028 to switch to new refrigerants. Countries agreed to explore a few different refrigerant options that are much better for the environment. These options include propane and ammonium.

What can I do?

Ninety percent of the refrigerants that enter the air escape after refrigerators and air conditioners get old and people throw them away. If people are more careful about how they throw away their old refrigerators and air conditioners, we can keep this from happening. When people take their old appliances to special recycling centers, recycling companies can purify the old refrigerant chemicals and reuse them or even turn them into other things! Recycling and reusing refrigerant is important because it keeps those chemicals from going into the atmosphere and warming Earth.



Green suits: *These green suited students are visually demonstrating checking for refrigerant leaks and recycling old air conditioners. This effort is part of Green Suits, a fun way to use photography to communicate climate.*

Photo Credits
Ozone Layer: NASA Earth Observatory
Green suits: Ava Lypps & Erica Nesheim

Photo by CHUTTERSNAP on Unsplash

Solution #5

TROPICAL FOREST RESTORATION

54.5–85

GIGATONS

CO2 EQUIVALENT
REDUCED / SEQUESTERED
(2020–2050)

Tropical forests trap a lot of carbon. In order to slow climate change, we need to preserve these forests.

Tropical forests, like the Amazon rainforest and the Congo rainforest, used to cover 12 percent of land in the world. In the last few decades, they have been cut down for lumber for buildings, burnt down to make space for farming and ranching, and cleared so that cities can expand. This destruction not only hurts the trees. It also hurts the animals and other plants that live under and in the trees. Now tropical forests only cover 5 percent of land on Earth.

While tropical forest destruction continues in many places, there are also places where new tropical forests are growing. This happens naturally and when people plant trees. This is called restoration. New tropical forests capture a lot of **carbon dioxide**, up to six gigatons per year!

Promoting recycled paper: *Young people can help reduce the need for tropical forest restoration by promoting the use of recycled paper products that come from trees as in this skit, Recycled Toilet Paper included in www.enactingclimate.org.*

How does reforestation absorb carbon from the air?

When forests begin to grow again, or restore themselves, the trees, roots, and leaves of plants absorb and hold carbon! When forests hold carbon, they become a **carbon sink**. As forests becomes healthy again, they are able to:

- Support the water cycle
- Protect pollinators & soil from erosion
- Provide food and medicine for many people
- Provide people with places to live, adventure, and worship

Forest residents: *Animals, like these elephants, rely on tropical forests for their home and food.*

KEY WORDS

pollinator
An animal or insect that moves pollen from plant to plant in order to fertilize the flowers

erosion
Erosion is when soil and rocks are slowly moved from one area to another by wind and rain.

invasive species
An invasive species is a plant or animal that does not naturally live in that area. Sometimes invasive species multiply and spread out in new environments where they have not natural predators. The spread of invasive species can cause harm to local plants and animals.

How can people help restore tropical forests?

Some people now farm on land that was once tropical forest. Some communities have turned valleys that were once tropical forest into reservoirs to store water. Here are a few ways people can support the restoration of tropical forests:

- People can restore tropical forests by letting forests grow back on land that is being used for farming and reservoirs.
- As forests begin to grow back, people can protect them from fires, erosion, and animals.
- People can plant baby trees where adult trees used to grow.
- People can remove invasive plants that don't belong in tropical forests.

Often, communities of people live near tropical forests. It is important to include local communities in efforts to restore these forests.

New Guinea forests: *New Guinea has more plant species than any other island. These researchers are learning about the forest and its plants so they can better protect it.*

Photo Credits
Promoting recycled paper: Max Boykoff
Forest Residents: Photo by paweldotio on Unsplash
New Guinea Forest: William J. Baker, Royal Botanic Gardens, Kew

Photo by JOHANNA MONTOYA on Unsplash

Solution #6

ONSHORE WIND TURBINES

Pictured above is an onshore wind turbine farm. These large wind power machines are able to go on land that is also used for farming.

47.2–147

GIGATONS

CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

Wind energy is one of the most exciting solutions to climate change. Companies are building more wind turbines every year. Wind turbines are large wheels that rotate when the wind blows through them. As they rotate, wind turbines convert wind energy into electrical energy that people use in their homes and businesses. Today, there are 314,000 wind turbines around the world! They produce four percent of all electricity used.

More wind energy for our electricity needs

We will soon have access to more wind energy for our electricity needs because:

- Every year people build more turbines
- The cost for wind energy is going down
- In many places, wind energy is cheaper than energy made from burning coal and other **fossil fuels**
- Once wind farms are built, they don't need any fuel to run
- Wind turbines continue to perform better as technology improves
- Within 10 years, wind energy may be the cheapest energy available

Wind turbine setup: *Engineers set up wind turbines on existing farmland, and they only need to come for repairs.*

Wind farm land

Wind turbines do not need a lot of land in order to make electricity. Because they do not need a lot of land, the land is available for other uses. Farmers can still plant their crops or let their animals graze. People can use the land on wind farms to do their favorite activities, like hiking and biking. Sometimes communities protect the land on wind farms to help conserve the environment!

KEY WORDS

graze
Graze means eat grass in a field. Many cows graze in open fields.

conserve
Conserve means to protect from harm or destruction. When we conserve the environment, we protect it from being destroyed by human activity, like farming or building homes.

Wind farms are fast to build

It takes about one year for engineers to build an entire wind farm! That means that people can start producing and using wind energy quickly. It also means that communities and companies that spend money to build wind farms can make their money back quickly.

What happens when the wind is not blowing?

Even though wind turbines can make a lot of energy, the wind isn't always blowing. So, wind energy must be part of a system.
Other actions we can take to build a green energy system include:

- Convert solar and geothermal energy into electricity
- Build batteries that can store a lot of energy
- Create new systems to help move energy around communities.

Learn more about Green Energy Systems

Utility-Scale Solar Power: page 20
Distributed Solar Power: page 24

Using all of these elements together, we can produce the energy we need without burning fossil fuels.

Acting it out: *Performing skits is one way to let people know about the benefits of wind power! Here, youth perform a skit, Wind Turbines are Beautiful from the Enacting Climate activities found at www.enactingclimate.org.*

Photo Credits
Acting it out: Isabel Cousins
Wind turbine setup: REVE (Wind Energy and Electric Vehicle Magazine)

Photo by Dewi Karuniasih on Unsplash

Solution #7

ALTERNATIVE REFRIGERANTS

43.5–50.5
GIGATONS
CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

Air conditioners keep us cool with chemicals called refrigerants. We need to start using refrigerants that are better for our environment.

Refrigerators keep our food cold to make sure it stays fresh. Air conditioners keep buildings and homes cool during hot summers. Both refrigerators and air conditioners use chemicals that can absorb and give off heat to create cool air. These chemicals are called refrigerants. Up until 1987, two of the most common types of refrigerants were CFCs and HCFCs. Even though they are effective refrigerants, these chemicals cause a problem.

KEY WORDS

ozone layer
The ozone layer is a layer of Earth's atmosphere that absorbs most of the ultraviolet (UV) energy reaching Earth from the sun.

Montreal Protocol
Learn more on page 19.

The problems with refrigerants

If CFCs and HCFCs escape into the air, they can harm part of our atmosphere called the ozone layer. In 1987 many people came together to create a new international law called the Montreal Protocol. This law said that CFCs and HCFCs can no longer be used as refrigerants.

Meeting of the Parties to the Montreal Protocol: *Each year, every country who signed the Montreal Protocol will send a representative to this meeting to make sure they are meeting the reccommendations made by scientists.*

When these chemicals were banned, scientists developed a new refrigerant called HFCs. HFCs are better for the ozone, but they are a very big issue for **climate change**. HFCs trap 1,000-9,000 times more heat than **carbon dioxide**! This means that even a small amount in the atmosphere can contribute a lot to **global warming**!

Alternative refrigerants

We need to start using new refrigerants in order to preserve the ozone layer and avoid using chemicals that heat up our earth. As part of the Montreal Protocol, countries agreed to explore a few different refrigerant options that are better for the environment. Ammonia, **carbon dioxide** and even propane, are much better for the environment than the refrigerants we have been using.

1. First, they are chemicals that are found in nature and do not need to be created by people.
2. Second, compared to the refrigerants we use now, these alternatives have a low global warming potential. This means that they do not trap or release as much heat into the atmosphere over time.

Scientists have found that if countries use alternative refrigerants, it will prevent 50.5 gigatons of refrigerants from entering the atmosphere. This is a huge number that can help us fight against climate change!

Acting it out: *Comedic skits can actively communicate local actions for refrigerant management in a fun and engaging way. In this skit entitled "Grandma Fridge Cools Off" a family is taking their aging grandmother, who is a refrigerator, to Rocky Mountain National Park for one last vacation before she gets properly recycled through an Environmental Protection Agency-approved local program. This was performed at Rocky Mountain National Park on Discovery Day to educate park visitors about the importance of properly disposing of aging refrigerators. The skit is available at www.enactingclimate.org.*

Photo Credits
Meeting of the Parties to the Montreal Protocol: Paul Kagame / Flickr
Ozone loss in just one year: NASA Earth Observatory / Rob Simmon
Acting it out: Isabel Cousins

Photo by Zbynek Burival on Unsplash

Solution #8

UTILITY-SCALE SOLAR POWER*

This solution is called **Utility Scale Solar Photovoltaics in Drawdown Review. Photovoltaics are the technology that makes solar power.*

42.3–119
GIGATONS
CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

The sun provides an unlimited source of **energy**, called solar energy. The awesome thing about solar energy is that it has a low impact on our environment! We use solar panels in order to collect the energy from the sun and convert it into electrical energy so we can power the lights, heat, and appliances in our homes and buildings. Have you seen solar panels on top of houses or buildings in your community? Maybe you've even seen a huge solar farm like the one in the picture below. These large farms are an example of utility-scale photovoltaics.

Solar farms

A solar farm is a good way to harness a lot of the sun's energy. Solar farms are located on large pieces of land where many, sometimes millions, of photovoltaic (PV) panels, all work together. Another more common name for photovoltaic panels is solar panels. Solar farms act as power plants because they produce just as much electricity as power plants that use **fossil fuels**. Solar farms send energy out to homes, schools, offices, and stores like other power plants.

Desert solar farm: *Solar farms work well in flat, hot places that get lots of sunlight.*

What's the difference between power plants that use fossil fuels and solar farms? The difference is that solar farms don't release **greenhouse gas emissions** like fossil fuel powered power plants! This means that they don't produce greenhouse gases when they make energy.

Where can I find solar farms?

Solar farms can be found in deserts, on military bases, and on top of closed landfills that are full of trash. Sometimes they are even built on lakes and reservoirs where the solar panels float on the water!

How much does solar energy cost?

Back in 1954, Bell Labs created silicon PV technology, which is what we use today in solar panels. At that time, almost 70 years ago, that technology was very very expensive. It would sell for $1,900 per watt. That cost has dropped so much that solar energy is sometimes even cheaper than fossil fuel created electricity. Today solar costs $0.65 per watt!

Solar energy is cheaper today because:

- People invested, or gave their money, to solar scientists and engineering companies
- Governments gave benefits to make solar cheaper
- Scientists created better technology
- Engineers created better processes to build the panels

Solar farms are an important part of our transition to greener energy. We are working towards a clean energy revolution with cheaper costs for solar panels, better technology to capture and store solar energy, and the power of other renewable energy!

KEY WORD

watt

A watt is a way to measure power, or the speed of energy transfer of appliances. For example, many lightbulbs in homes are 60 watts. That means they will change 60 joules of electrical energy into light energy every second.

Large solar farm: *A solar farm can be created on almost any large land area that gets lots of sun.*

Learn more about a related solution

Distributed Solar Power: page 24

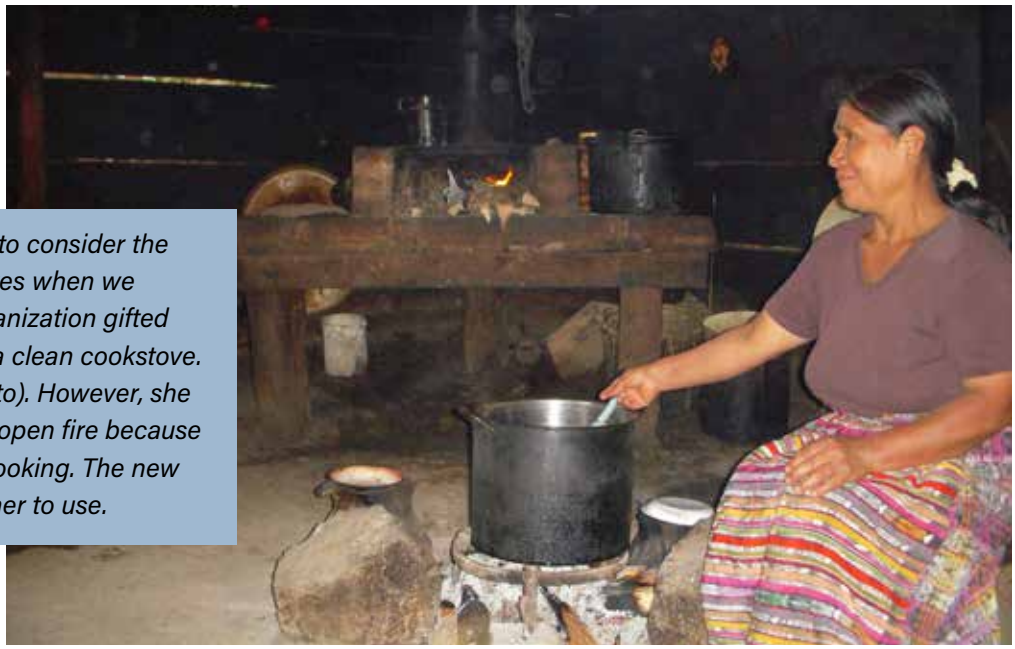
Acting it out: *Students at Tuba City High School within the Navajo Nation enact power generation from solar photovoltaics.*

Photo Credits
Desert solar farm: U.S. Department of the Interior / Wikimedia Commons
Large solar farm: Photo by Ryan Searle on Unsplash
Acting it out: Photo by Beth Osnes

IMPROVED CLEAN COOKSTOVES

31.3–72.6
GIGATONS
CO2 EQUIVALENT
REDUCED / SEQUESTERED
(2020–2050)

Around the world people cook in many different ways. In the United States, you may be used to seeing your family cook dinners on a gas or electric stove or in the microwave. However, about 3 billion people in the world cook their meals on open fires or on very basic stoves.



Open fire cooking: *It is important to consider the people who will use clean cookstoves when we design them. A local non-profit organization gifted this woman, in Chajul, Guatemala, a clean cookstove. (You can see it behind her this photo). However, she continues to cook on a three stone open fire because she prefers her traditional way of cooking. The new clean stove is too tall, not easy for her to use.*

Open flames or simple stoves often use sources of fuel that pollute the air. While most people in the United States cook with gas or electricity, many people cook with these materials:

- Wood
- Charcoal
- Dried animal poop (usually from grazing animals like cows)
- Parts of plants leftover from harvesting crops
- Coal

When things like wood and dried animal poop are burned, a lot of smoke and soot is released. When people use open fires and simple stoves inside, this smoke and soot stays inside of people's homes and it is very unhealthy to breathe. Sadly, cooking in this way leads to an early death for more than 4 million people every year.

Gathering fuel for cooking: *In many communities that continue to cook over open flames, women and girls collect the fuel. This arrangement negatively impacts the lives of women and girls more than men and boys.*

How does cooking over fires and with simple stoves impact the planet?

Cooking on open fires and simple stoves indoors can impact the Earth in the following ways:

Deforestation and forest degradation: Wood is one of the most popular sources of fuel for cooking. Because of this, people around the world cut down many trees and forests. This means that the Earth loses parts of our very important **carbon sink**.

Emissions: These cooking practices emite two to five percent of annual **greenhouse gas emissions**.

Early death: Burning the materials listed above releases methane, **carbon dioxide**, carbon monoxide, and black carbon into the air. These things, especially carbon monoxide and black carbon, are what cause so much harm to human health.

Improved cookstoves

Luckily, engineers, scientists and community memebers have created 'improved cookstove' technology to address the problems you have just learned about. This technology forces the gases and smoke back into the cooking flames where it goes through a second cycle of burning. In some improved cookstoves, this process decreases the amount of smoke and emissions released into the air by 95 percent!

The Global Alliance for Clean Cookstoves was created in 2010 by the United Nations. It is an organization that helps people around the world buy clean cookstoves. They make sure clean cookstoves are not too expensive, that they are durable, and that the technology works well. Their mission is to help people cook meals without hurting themselves, their families, or the planet.

KEY WORDS

carbon monoxide
In many buildings and homes in the U.S., carbon monoxide alarms are placed on the walls. There are probably a few in your school, or your home. Carbon monoxide is toxic to breathe, which is why so many of these alarms are installed.

black carbon
This is created when certain things are burned. It forms a powdery black dust called soot. It also is very bad for human health.

Carbon from a stove: *The smoke coming from the house is from a basic three-stone stove. This type of cooking creates toxic carbon monoxide and black carbon that sticks to the roof.*

Potter with clean cookstove: *This pot maker from Tanzania has started to make clean cookstoves for himself and other members of his community.*

Photo Credits
Gathering fuel for cooking: Pikrepo
Open fire cooking and Carbon from a stove: Jason Bisping
Potter with clean cookstove: Russell Watkins/Department for International Development

Photo by Stephen Yang / The Solutions Project

Solution #10

DISTRIBUTED SOLAR POWER*

27.9–68.6

GIGATONS

CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

This solution is called **Distibuted Solar Photovoltaics in Drawdown Review. Photovoltaics are the technology that makes solar power.*

In the 1800s, solar panels used to be made of selenium. This is a chemical that can spread heat when the sun shines on it. Today, we use something called PV (photovoltaic) panels. The PV (photovoltaic) panels are made of tiny silicon crystals. When the sun shines on the crystals, the heat absorbed creates an electric charge. This process doesn't require any fuel, just sunlight and PV panels. Making energy with solar PV panels doesn't release any **greenhouse gases**.

How do people use solar PV panels to make electricity?

There are two ways we use solar PV panels to make electricity.

1. Utility-scale solar energy collection: This is when utility companies fill a large field with solar panels. These panels provide energy for many homes and businesses.
2. Distributed solar energy collection: This is when individual people install a few PV panels on rooftops or near homes and businesses. This type of PV panel provides energy for the building they are attached to.

Learn more about a related solution

Utility-Scale Solar Power: page 20

In 2015, distributed solar made up 30 percent of all solar energy produced from PV panels. Germany is the leader in solar energy and has over 1.5 million distributed solar panels. In Bangladesh, a country next to India that has a population of over 157 million people, there are more than 3.6 million solar panels installed on or near homes.

Is it expensive to install solar panels on rooftop?

Each year, more people use solar panels. This is because they are getting less expensive. The price is going down because we are getting better at making them and some governments help pay to build them. There are also programs that help people get solar energy by buying panels and renting them to their customers. Unfortunately, the cost to install PV panels is still high, but they are getting cheaper.

Solar panels on a roof: *More and more homes install solar panels as they become less expensive.*

Solar PV panels can bring unlimited electricity to places where it is needed!

In places where most homes and businesses are connected to power lines, solar panels help people disconnect from the power line system and control their own electricity. In places where there are no electric utilities or power lines, solar panels can help people access electricity. Solar PV panels do not require big companies or **fossil fuels**. By providing a way for people to access electricity on their own, solar PV panels can help eliminate poverty.

Solar LED Lighting: *LED lights are very energy efficient, so they can be used with solar panels to bring light to places that do not have a power grid. This woman is fixing the solar powered light for her village in India.*

Photo Credits
Solar panels on a roof: Pujanak / Wikimedia Commons
Solar LED Lighting: Abbie Trayler-Smith / Panos Pictures / Department for International Development

Photo by Christian Widell on Unsplash

Solution #11

SILVOPASTURE

26–42.3

GIGATONS

CO2 EQUIVALENT
REDUCED / SEQUESTERED
(2020–2050)

These dairy cows live on a small farm with a mix of pastures and woods. The farmers uses practices that help reduce the farm's environmental impact.

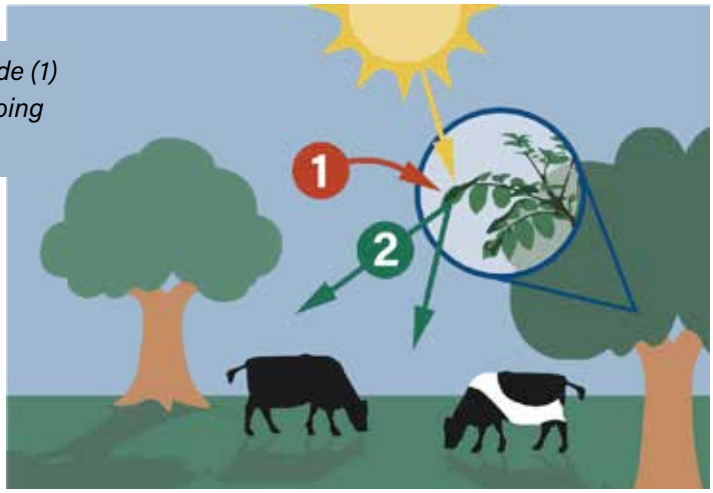
In most modern farms, animals are kept on pastures, fields of grass, without trees. Silvopasture is an old and environmentally friendly way to raise cows and other farm animals that includes trees planted in pastures!

Why would we plant trees in pastures?

Trees act as sponges that absorb **carbon dioxide**. This process helps reduce the amount of greenhouse gasses in the atmosphere.

Silvopasture allows the soil to absorb (take in) 5 to 10 times more carbon than pastures that have no trees. The carbon is sequestered, stored, in the trees and dirt. Ultimately, silvopasture also helps to keep the Earth cooler!

Trees sequestering carbon: *Trees take carbon dioxide (1) and convert it to oxygen (2) for us to breathe. While doing that, the tree also returns carbon back to the soil.*



Learn more about greenhouse gasses like carbon dioxide and methane in the glossary on page 4.

Why is silvopasture a good idea?

- Farmers can plant fruit or nut trees in pastures and allow mushrooms to grow. Farmers can then sell the fruit, nuts or mushrooms to make extra money.
- Cows and other farm animals wear down the grass in pastures. They do this when they eat and walk on the grass all day, everyday. By having more living things on pastures, like trees, the farm ecosystem will be healthier and the land will be stronger.
- Silvopasture can help farmers and their animals adjust to different weather patterns and the more frequent droughts that will be a result of **climate change.**

Silvopastoral Farm: *Cows that graze in fields using silvopasture can rest in the shade of the trees. This can help both the cows and the pasture.*

KEY WORD

ecosystem
An ecosystem is a community of living organisms (such as plants, animals, and bacteria) along with the nonliving parts of their environments (such as air, water, sunlight, and soil).

Why don't all farmers use silvopasture?

Silvopasture is not the most popular way to raise cows and other farm animals. As a result, some farmers are hesitant to try it. Also, at first silvopasture costs more money than having fields of only grass.. It takes time for farmers to start to make money from silvopasture, so it can be hard for farmers to make the switch. To raise awareness about the positive impact of silvopasture, farmers can talk to each other about it. When farmers share their experiences, they can learn from and support one another as they make more environmentally friendly changes to their farms and farming practices.

Farmers share their experience: *Farmers who use silvopasture methods can share their experiences with other farmers. Sharing ideas can help more farmers start to use silvopasture.*

Photo Credits
Silvopastoral Field: CSTAF
Farmers share their experience: University of Wiconsin Extension

Photo by Ken Shono on Unsplash

Solution #12

PEATLAND PROTECTION & REWETTING

Peatlands are swampy places with carbon-rich soil. They can be full of water-loving plants, like this peat forest in Brunei.

26–41.93

GIGATONS

CO2 EQUIVALENT
REDUCED / SEQUESTERED
(2020–2050)

Peatlands are one of the most important types of wetlands in the world. They are also sometimes called bogs or mires. Peat is made out of dead or decomposing plants from hundreds and thousands of years ago. It is formed when dead plants that grew in the peatland areas begin to decompose under a layer of living vegetation and water. The decomposition process never finishes because the water stops the decomposition. Over the years, peat becomes thick and forms a very wet and dense soil. Water-loving plants grow on top of it.

KEY WORD

decompose

Decomposition is when formerly living things (plants and animals) are broken down into their component parts, such as carbon dioxide, water, salts and simple sugars.

A piece of peat: *This may look like just dirt, but it is actually peat! This chunk is full of decayed organic matter. It is very rich with carbon and could be burned, almost like wood.*

Where in the world are peatlands and what do they look like?

Peat is extremely important to our Earth and the many systems that regulate our planet. While only three percent of the Earth is covered in peat, only the earth's oceans hold more **carbon dioxide**. Peatlands store twice as much carbon dioxide as all of the forests in the world combined! Protecting peatlands from fire and development is a very important way to trap **greenhouse gases.**

Peatland Map: *The green areas on this map are where peatlands are located. The countries in gray are countries that have known peatlands. The countries in gray have known peatlands. Interestingly, almost all countries in the world have peatlands.*

Carbon is found in all living things. Usually, 50 percent of peatlands are composed of carbon. If they are disrupted by fire or burned to clear space, peat bogs release the carbon they have stored. This means they will let out A LOT of carbon dioxide. It only takes a few years to release the carbon from peat, but it takes thousands of years for carbon to turn into peat. This is why it is so important to protect peatlands.

Luckily, 85 percent of the world's peatlands are healthy! Restoring the 15 percent of peatlands that have been damaged or drained is one way to combat **climate change**.

Cross section of peatland: *This drainage area shows how thick a peat bog can get. This is what the layers of peat underneath the plants look like.*

Photo Credits
A piece of peat: David Stanley / Flickr
Peatland map: Levi Westerveld (www.grida.no/publications/355)
Cross section of peatland: Copyright John Lucas

Photo by Johannes Plenio on Unsplash

Solution #13

TREE PLANTATIONS

22–35.94
GIGATONS
CO2 EQUIVALENT
REDUCED / SEQUESTERED
(2020–2050)

Trees take a lot of the carbon dioxide from the atmosphere and store it in the soil. We can plant trees on land that would otherwise not be used.

Afforestation is the process of planting trees to create forests in places where there were not forests before. Land that has been used in the past for farming, animal grazing, and even mining can be great places for new trees and perennial plants to grow.

KEY WORD

perennial plants
Perennials are plants that live more than two years. Technically trees and shrubs are perennials, but trees and shrubs have woody branches whereas perennial plants do not. Examples of perennials are lilies, lavender, and daisies.

Monterey pine trees

How does afforestation happen?

Afforestation can happen in a few different ways. One way is to plant many different types of trees and perennials that are indigenous to the area, meaning they grow naturally in that specific area. Another way is to plant just one kind of tree that grows very fast. In this method trees are planted as if they are a crop, like the way corn is planted and grown. This method makes up the majority of afforestation efforts and the most commonly tree planted is the Monterey pine. The Monterey pine is actually the most planted tree in the entire world!

However people plant trees, afforestation creates a **carbon sink**. A carbon sink is when plants, like trees, absorb carbon dioxide from the atmosphere and hold it in their roots and soil.

Afforestation in Nepal: *These people are helping to plant trees as part of an afforestation project.*

When many trees of the same kind are planted close together, we call the land where they grow a tree plantation. One reason for planting a tree plantation is to make money from harvesting timber and fibers. Recently it is more popular to plant tree plantations for the purpose of absorbing the carbon dioxide out of our air.

Afforestation in India: *These people are helping to plant trees as part of an afforestation project in Kanakakunnu, India.*

The idea of tree plantations is an issue for some people. Why? Because some tree plantation owners do not take care of the land - they only care about making money from the land. This can create long-term issues for the land and the people and environment near the plantations.

A Japanese plant expert, named Akira Miyawaki, created another method of afforestation. He plants trees that grow very quickly and are indigenous to the land! So, he has found that this combination helps with quite a few things:

- Brings down the amount of carbon dioxide in our air
- Creates a source for firewood, food, and medicine
- Protects areas from floods and droughts
- Increases the biodiversity of the area

KEY WORD

biodiversity
Biodiversity means that lots of different kinds of plants and animals live together in an area.

Earth Guardian Leaders: *Youth leaders of the activist group Earth Guardians created a "pledge to plant" Earth Day challenge to their international youth groups to encourage the planting of trees on degraded land.*

Photo Credits
Monterey pine tree: Copyright Rod Allday
Afforestation in Nepal: Maandhozzgrg / Wikimedia commons
Afforestation in India: Beman Herish / Wikimedia commons
Earth Guardian Leaders: Inside the Greenhouse

Photo by Phil DuFrene on Unsplash

Solution #14

TEMPERATE FOREST RESTORATION

19–27.9

GIGATONS

CO2 EQUIVALENT
REDUCED / SEQUESTERED
(2020–2050)

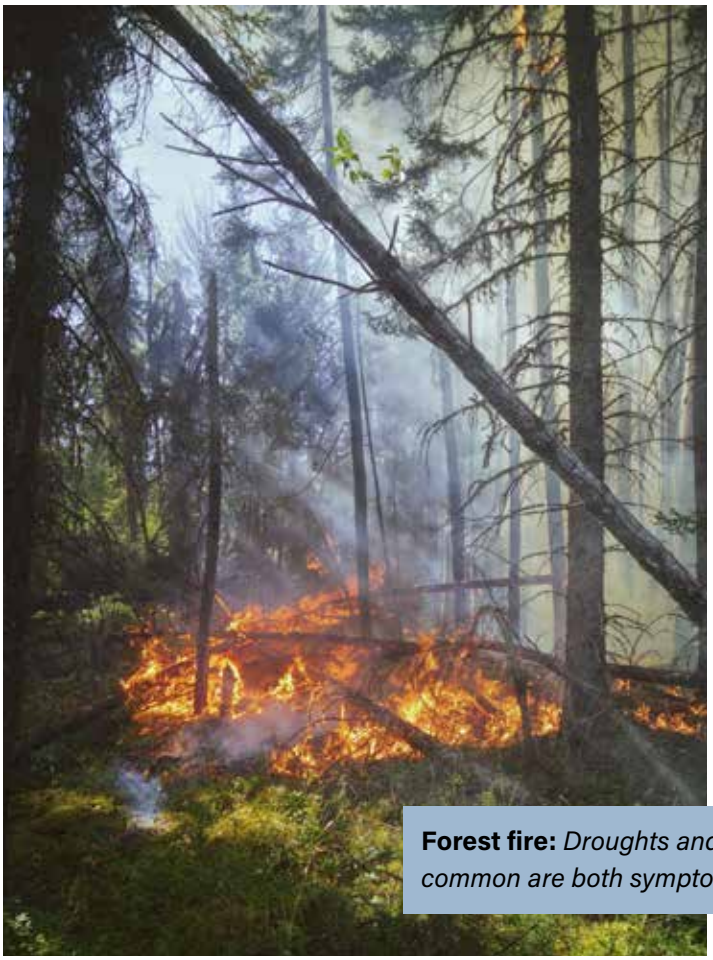
We need to protect temperate forests so they can hold lots of carbon and support wildlife.

Temperate zones are places on Earth that are located about midway between the equator and the North and South Poles. About 25% of all trees on Earth are found in temperate zones, mostly in the Northern Hemisphere. Some of those trees are deciduous, which grow and lose their leaves every year. Other trees are evergreen, with needles that stay green all year round. Throughout human history, 99 percent of temperate forests have been used or changed by humans in some way. Many forests have been used to create wood for construction, while others have been cut down to create space for farming and cities. Even though temperate forests have faced many challenges and pressures, they are very strong. They are able to recover from impacts over time, and can eventually regenerate ecosystems that used to exist many years ago.

Enjoying temperate forests: *If you like to hike, camp, or visit the outdoors, there's a good chance that you have visited a temperate forest! It is important to preserve these places for the planet.*

Why is it important to restore temperate forests?

Across the world, there are 1.9 billion acres of temperate forests! These forests act as **carbon sinks**. The World Resources Institute calculated that another 1.4 billion acres of temperate forests could be grown through restoration projects. More trees means more carbon could be captured from the atmosphere and this would help reduce the impact **climate change**.



Forest fire: *Droughts and wild fires becoming more common are both symptoms and signs of climate change.*

While temperate forests are not as threatened as tropical forests, they are still being cut down to create more room for cities and farming. In addition, climate change means that forests will experience hotter and more frequent droughts, longer heat waves, more severe wildfires, and increased insect activity and disease damage. The combination of these impacts can push temperate forests beyond the point they can recover. In order to keep our forests healthy and reduce the impact of climate change, we need to protect the forests we still have and work to restore those that have been damaged.

Learn more about related solutions

Tropical Forest Restoration: page 14

Save old growth forests: *Activists in Vancouver, Canada are speaking up about protecting old growth forests to help save our climate.*

Photo Credits
Enjoying temperate forests: Juliane Liebermann on Unsplash
Forest Fire: Landon Parenteau on Unsplash
Save Old Growth Forests: Peter Osnes

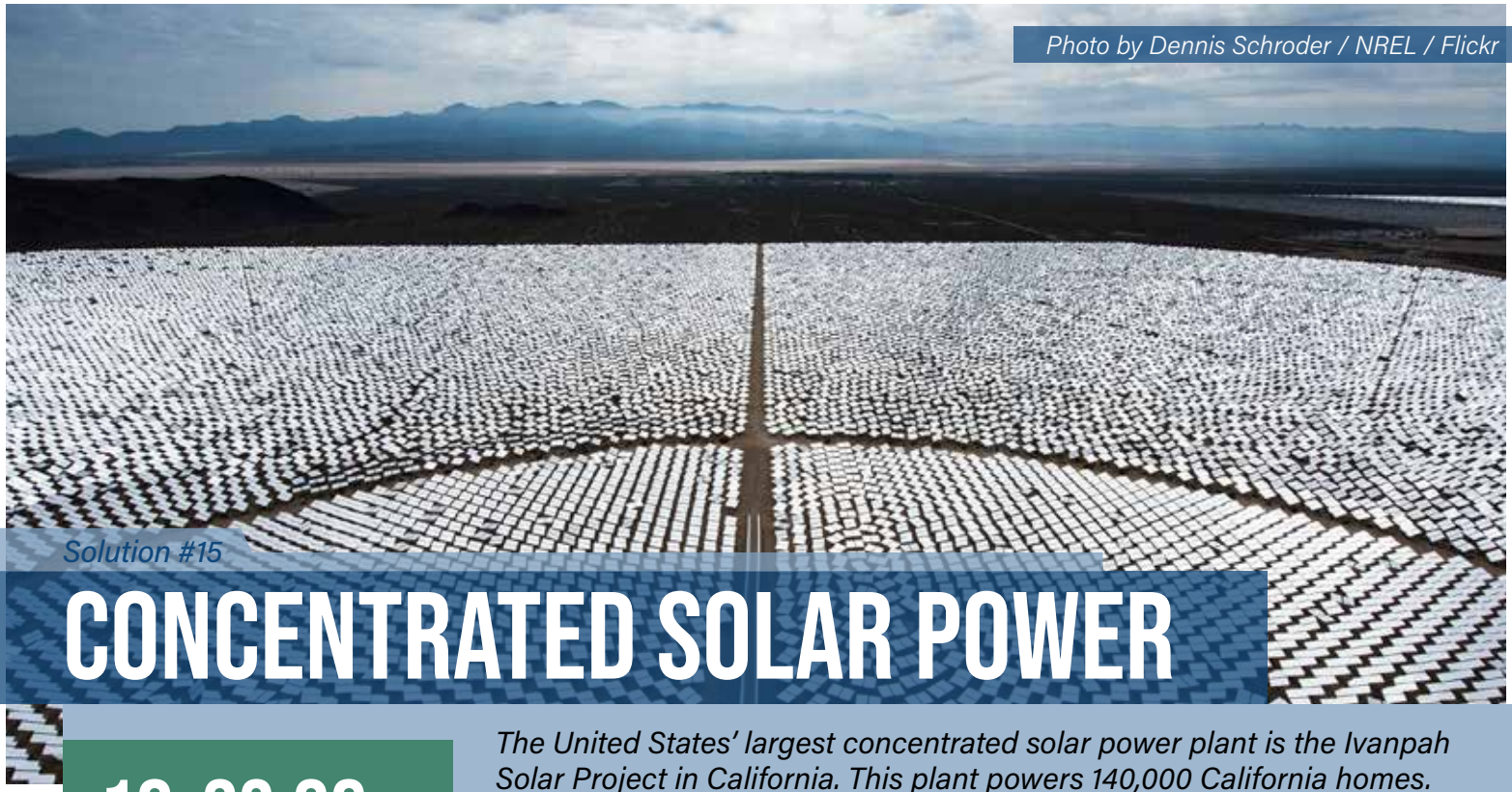


Photo by Dennis Schroder / NREL / Flickr

Solution #15

CONCENTRATED SOLAR POWER

18–23.96
GIGATONS
CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

The United States' largest concentrated solar power plant is the Ivanpah Solar Project in California. This plant powers 140,000 California homes.

Concentrated solar power (CSP) has been around since the 1980s. It is becoming more and more popular.

How do concentrated solar power plants make electricity?

CSP power plants use mirrors to concentrate, or focus, solar rays. These concentrated solar rays heat a fluid, produce steam, and turn turbines to create **electricity**. Concentrated solar power plants need a huge amount of sunlight to create energy so they work best in really sunny and dry places, like deserts.

KEY WORD

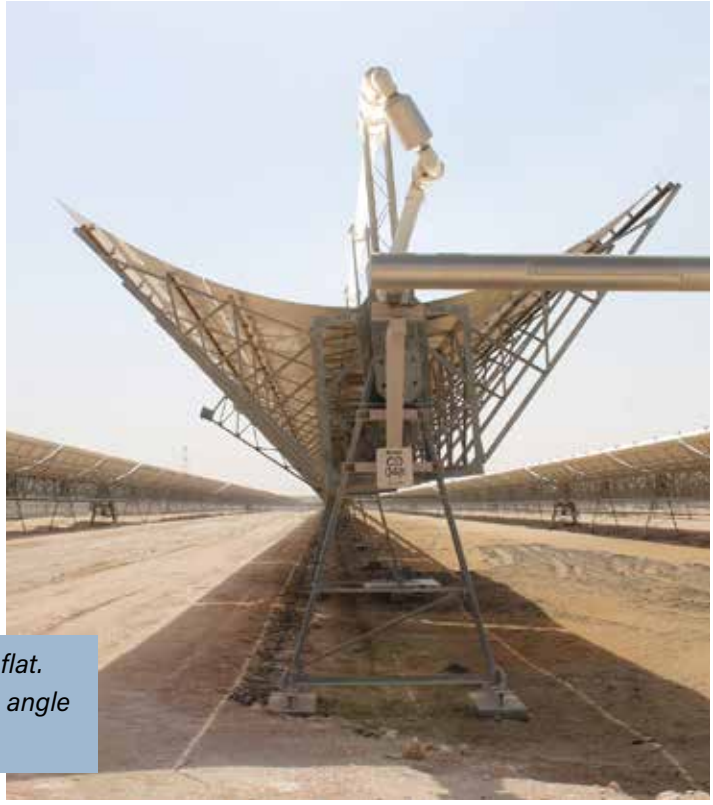
turbine
A turbine is a machine with a wheel or rotor with vanes. When the turbine spins, it creates electricity.

CSP plant from above: *Concentrated solar plants put the mirrors in a circular pattern to focus the sunlight into one area in the middle.*

Unlike solar panels and wind turbines, CSP creates heat before it makes electricity. The great thing about heat is that it is easier to store than electricity. CSP plants can use the heat created when the sun is shining to warm up tanks full of liquid salt until they are almost boiling! These tanks stay hot for a long time, so CSP plants can continue to make electricity long after the sun goes down each day.

Learn more about related solutions

Utility scale solar power: page 20
Distributed solar power: page 24
Onshore wind turbines: page 16



Curved mirrors: *Normal solar panels are flat. Concentrated solar uses curved mirrors to angle the energy from the sun at the solar tower.*

In 2014, concentrated solar power plants only made 4 gigawatts of electricity, which is not much compared to other solar sources. But as this amazing technology becomes more effective and less expensive, it will likely be used much more because it is very reliable!

KEY WORD

reliable
Reliable means that the quality is consistent over time. CSP plants can be trusted to make the same amount of electricity each day.

Solar power tower: *This concentrated solar power plant tower in California glows at night becuase the inside is full of liquid salt that stays warm after the sun goes down.*

Photo Credits
CSP plant from above: Masdar Official / Flickr
Curved mirrors: IRENA / Flickr
Solar power tower: Kend Lund / Flickr

Photo by Ian Haycox on Flickr

Solution #16

INSULATION

Insulation can keep the temperature in our homes stable even when the air temperature outside goes up and down.

16.97–19

GIGATONS

CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

KEY WORD

insulation

Insulation in homes and buildings is a material that builders use to stop heat from escaping or entering the building.

It can be really uncomfortable when you feel too warm, or too cold. This is why it's nice to have heating and cooling systems in offices, restaurants, schools, and homes. But, about 25 to 60 percent of energy that is used for heating and cooling buildings is lost.

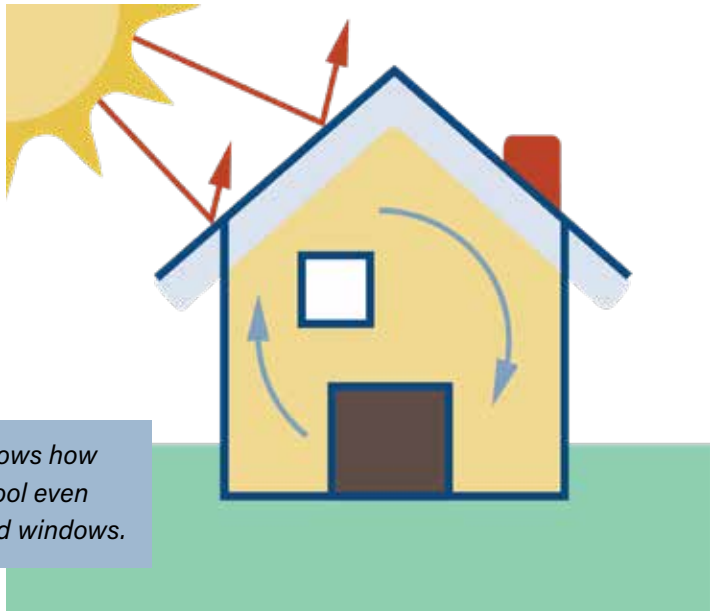
So, where does all that energy go?

Energy that we use to heat and cool rooms and buildings gets wasted because many buildings are not well insulated. The heated air, or cooled air, can find its way out of a building through many different ways, such as through cracks around windows and doors. Some materials are better than others for keeping a building well insulated. Buildings that are made out of materials that poorly insulate, such as metal or plastic, basically allow the warm or cold air to leak out. This is how energy is lost due to poor insulation. When builders better insulate a building, the temperature inside stays more constant. We also save energy, and **greenhouse gas emissions** will not be as high!

Recycled insulation: *This insulation was made from old blue jeans. While all types of insulation help make homes more energy efficient, insulation made from recycled materials uses less energy to make. A win-win!*

The thermal layer

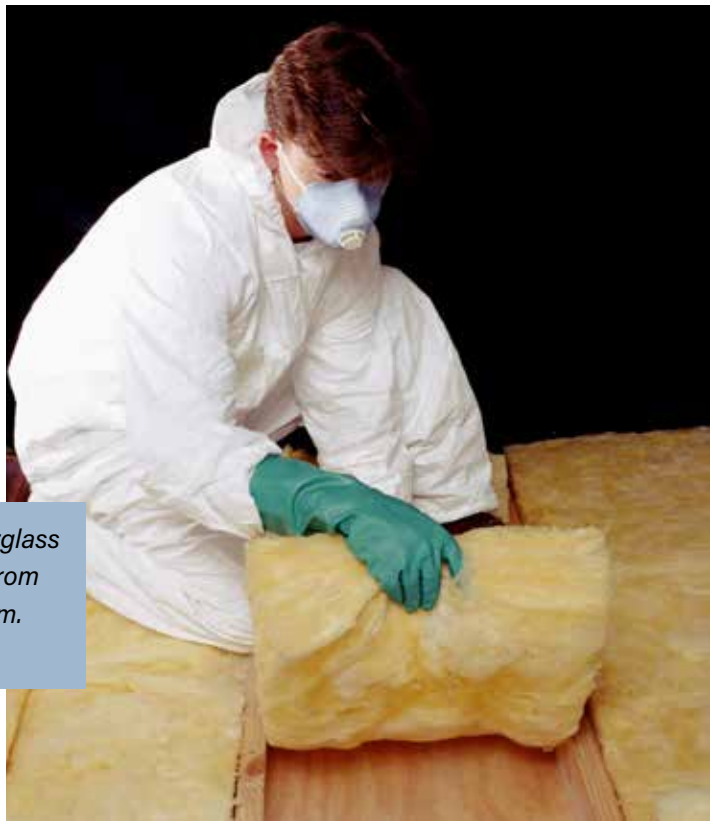
Another name for insulation is a building's thermal layer. It is measured as R-value - the higher the better. For example, the R-value of brick is 0.20 while the R-value of typical asphalt roof shingles is 0.44. Shingles insulate better than bricks. The thermal layer of a building needs to cover ALL the different sides and it must not have any cracks or gaps in the floor, outside walls or the roof.



The thermal layer: *This is a simple diagram that shows how insulation keeps the temperature inside the house cool even though the sun's warm rays touch the roof, walls, and windows.*

Insulation is one of the best ways to make a building **energy efficient**! It is cost effective, meaning it is a bit expensive but overall you save money after several years because you spend less money on energy for heating and cooling. Builders add insulation to new buildings. In older buildings, builders can replace the old thermal layers with new ones. Insulation can also protect buildings from water damage. This is important in places like Florida that have a lot of rain and storms. Lastly, insulation can make the quality of the air inside of a building healthier!

All around, insulation is necessary. It makes buildings more comfortable to live and work in and it lowers energy bills. Perhaps most importantly, it is a simple way to reduce greenhouse gas emissions!



Fiberglass insulation: *This builder is installing fiberglass insulation in a house. Fiberglass insulation is made from very small threads of glass that trap air between them. Some people call it 'glass wool.'*

Photo Credits
Recycled insulation: Zane Selvans / Flickr
Installing insulation: Tracey Nicholls, CSIRO / Wikimedia Commons

Photo by C. Z. Shi on Unsplash

Solution #17

MANAGED GRAZING

Bison graze in Yellowstone National Park in Wyoming.

16.42–26
GIGATONS
CO2 EQUIVALENT
REDUCED / SEQUESTERED
(2020–2050)

KEY WORD

ecosystem
An ecosystem is the community of living organisms (animals, plants, bacteria) in a specific place along with the nonliving elements of that place (air, water, soil, sun). These elements work together as a system.

Some animals, like bison and antelope, live in grassy places and eat small plants. These grazing animals are extremely important to the environment. The way they eat and live helps create amazing places like the Serengeti plains in Africa and the tall grass prairies of the United States.

Why are grazing animals important?

Grassy ecosystems around the world sequester (trap and hide) a lot of **carbon dioxide** in their soil in the form of biomass. Wild grazing animals improve the health of the environment in grassy ecosystems. They are herd animals, meaning they stand very close to one another to make sure no one gets hurt or lost. As they walk, they eat the tops of the grass. This way of eating actually helps the grass grow. As they move around the grassy ecosystem, wild grazing animals' hooves also dig up the dirt a little bit and mix in their poop. This mixing helps fertilize the soil! As a result, more grass grows and the extra grass traps carbon dioxide in the soil - combatting one of the key components of **climate change**.

Herd of grazing animals: *Grazing animals travel in herds for safety, like this herd of buffalo in the Serengeti.*

What is managed grazing?

Sheep and cows are also grazing animals. But they usually live on farms inside of fenced areas. Sometimes they eat more grass than the land can grow. This isn't good for the land and means that the soil does not sequester as much carbon. To keep the grass healthy and to keep carbon in the soil, farmers can use managed grazing. Managed grazing imitates the way wild grazing animals move around the land. With managed grazing, domestic animals move from field to field so they never eat all the grass in one area.

What do farmers have to think about?

When farmers decide to use managed grazing, they have to understand two things.

1. How long can their animals stay in one spot before they eat too much grass and hurt the land?
2. How long should they wait for the land to recover before they can graze the same grass again?

There are three ways farmers and ranchers can manage grazing:

- Make sure there are not too many animals in each field so that every animal has enough food.
- Rotate where the animals are eating. This helps spread the animals' impact to other parts of land and allows the grass to regrow before animals return.
- Move animals quickly between smaller fields. This gives the land time to recover before animals return.

Benefits of managed grazing

Managed grazing is good for every part of the farm animal ecosystem. It allows the soil to hold more water so plants are healthy. It helps animals find grass so they stay healthy and grow quickly. And it helps sequester more carbon in the soil - 0.5 to 3 tons of carbon for every acre of land (about one football field)!

Cattle grazing: *Cows can help keep the grass trimmed, but if they graze for too long, they will eat too much grass. By moving cows between fields, the grasses stay healthy because they have time to regrow.*

Photo Credits
Herd of grazing animals: Hu Chen / Unsplash
Cattle grazing: Dhruv Mehra / Unsplash

Photo by Justin Lane on Unsplash

Solution #18

LED LIGHTING

6.99–7.4
GIGATONS
CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

LED lights, like these, use less energy than conventional light bulbs. They can also can make lots of different colors of light.

What are LED lights?

LED lights are light bulbs that are more environmentally friendly than conventional light bulbs (like incandescent or fluorescent light bulbs). Their name stands for 'light emitting diodes' (LED). Diodes are small electronic devices that conduct current in one direction. Sometimes they light up. Diodes were invented way back in 1874, but we couldn't see the light that they were making very well. In 1994, more than 100 years later, Japanese scientists invented LED lights that were just as bright as conventional light bulbs. These scientists won the Nobel Prize in Physics in 2004 for their work with LEDs.

What are the differences between LEDs and conventional light bulbs?

- LEDs use 90% less **energy** than conventional light bulbs, but make the same amount of light.
- Conventional light bulbs create light by heating special types of metal that glow when they get hot. This process of heating metal to make light wastes a lot of energy. In contrast, LEDs have a different process to make light and they do not give off much heat.
- LEDs are not created with toxic chemicals. Some other light bulbs do contain toxic chemicals. For example, compact fluorescent lights (CFLs) have a small amount of mercury in them.
- LED light bulbs last longer than other light bulbs.

Inside an LED light bulb: *These light bulbs each have multiple LEDs inside of them (little orange squares) that create bright light when electricity runs through them.*

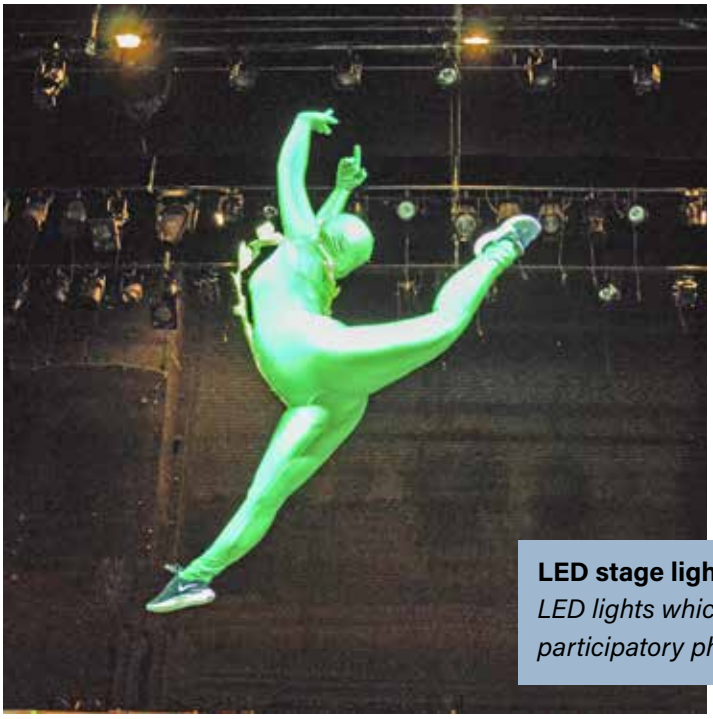
Why doesn't every household use LEDs?

LED light bulbs cost two or three times more money than conventional light bulbs. The higher price makes it hard for some people to switch to LEDs in their homes. The good news is that LEDs are becoming less expensive! Also, since LEDs last a lot longer than conventional light bulbs, people will save money in the long term because they do not have to buy light bulbs as often.

The sun can power LED lights!

More than a billion people in the world live without electricity. For them, solar LED lights are a great option. These lights don't need to be plugged into the wall. They only need the sun to power them! Solar powered LED lights can replace expensive oil lamps. They are also a better option than oil lamps because LED lights don't release unhealthy, toxic fumes.

Should we use LEDs in stores and offices? In streetlights?



Absolutely. Lights use 15 percent of the world's electricity. Since LEDs do not get hot like traditional light bulbs, they use less electricity. LEDs also won't make indoor spaces warmer and require air conditioning to cool them down.

Some towns have switched to LED lights in their streetlights. This change can save up to 70 percent of the energy streetlights normally use with conventional lights. Streetlights with LEDs are also less expensive because the LEDs last a long time and money is not wasted in changing light bulbs.

LED stage lighting: *This green suited students is lit by theatrical LED lights which are energy efficient. Green Suits is a fun participatory photography project to communicate climate.*

What does all of this mean?

Almost any light bulb can be replaced by an LED. Eventually, LEDs will replace all conventional light bulbs. People will be able to light their homes and businesses while using less electricity.

Explore LED Lighting

- Investigate the types of light bulbs used at your school and in your home. Did you find any LEDs?
- Carefully compare the heat emitted by conventional light bulbs and LED lights. (Don't actually touch the light bulbs. Just put your hands near the lights.)

Photo Credits
Inside of an LED Lightbulb: Green Energy Futures / Flickr
Lightbulb pictured is a Cree 9.5 Watt LED Lightbulb
LED stage lighting: Sarah Manning and Samantha Dunlap

Photo by Max Ducourneau on Unsplash

Solution #19

PERENNIAL STAPLE CROPS

15.5–31.3
GIGATONS
CO2 EQUIVALENT
REDUCED / SEQUESTERED
(2020–2050)

These banana trees produce a lot of food year after year. They also hold a lot of carbon in the soil.

The majority of crops we use for food, like corn, are annual plants. That means that every year we have to plant new seeds for the crops to grow. Other plants, like trees, are known as perennials. People do not need to replant them each year. Every year they continue to grow and get bigger. Perennial crops we grow for food include coconuts, bananas, avocados, and many kinds of nuts. The trees that produce these foods also pull much more **carbon** out of the air and store more in the soil compared to annual plants.

Why are perennial staple crops important?

Many perennial crops have been grown and harvested for centuries, and some are very important to the world's food supply. This is especially true in tropical areas where many perennial food crops grow. Crops that provide the majority of the food people eat are called staple crops. Africa has a lot of staple tree crops including baobab, mafura, argan, and more! These trees can grow in forest-farms and also grow on farms that include many different crops that grow to different heights (multistrata agroforestry).

Baobab trees

Baobab fruit

Why are perennial staple crops good for the land?

Staple crop trees that grow in the tropics, land near the equator, help with issues such as erosion and excessive water runoff. Their complex root systems allow for water to get into the soil when it rains. The roots add more water into underground water systems and save water in the soil for dryer times. The tropics are made up of a lot of different landscapes, which sometimes limits where plants can grow. But not tropical staple crops! They can grow on steep slopes of hills and in many different types of soils. Because perennial plants and crops are very strong, humans use less fuel, pesticides and fertilizers to help them grow and produce food.

Staple crop trees: *This farmer in Kenya has created a climate-smart farm that includes perennial fruit trees.*

KEY WORDS

erosion
Erosion is when soil and rocks are slowly moved from one area to another by wind and rain.

The land needs more perennial staple crops

Today, about 89 percent of agricultural land is used to grow annual plants. That is almost 3 billion acres just for crops like corn! One acre is only a little bit bigger than an American football field. 3 billion football fields is a lot of land and a lot of energy used to grow these annual crops. When land used to grow annual crops is converted to perennial crops, the amount of carbon the land and plants can absorb increases by about two tons per acre! Climate change is a global problem and will change plant-growing conditions around the world. This makes perennial crops even more important. Perennial plants can live in a lot of different places and are much more resilient to the weather changes that we will see in the future.

Acting it out: *These youth are enacting a skit about how both tomatoes and eggplants are foods that can grow as perennials in some areas.*

Photo Credits
Baobab Tree: Theme Inn on Unsplash
Baobab fruit: Ton Rulkens from Mozambique
Staple crop trees: C. Schubert (CCAFS) / Flickr
Acting it out: Patrick Campbell

Photo by Ezhuttukari / Wikimedia Commons

Solution #20

TREE INTERCROPPING

This farm in Kerala, India grows coconut and marigold flowers together. Certain plants and trees grow better together.

15–24.4

GIGATONS

CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

KEY WORDS

crops
Crops are plants that farmers grow for food. Examples are vegetables, grains (like wheat), and fruits.

erosion
Erosion is when soil and rocks are slowly moved from one area to another by wind and rain.

Tree intercropping means planting trees in fields with crops. This helps the soil hold more **carbon** and keep **carbon dioxide** out of the air where it can warm the Earth and cause **climate change**. It also helps crops grow by keeping the soil healthy. Farmers change the type of crops they plant with trees based on the type of land, the climate, how much money farmers make on the crop, and the people planting the crop.

Why is tree intercropping a good idea?

The benefits of tree intercropping include:

- Trees protect crops from extreme wind, rain, and sun damage.
- Trees help reduce erosion that can harm the land
- Trees have very long roots. The roots bring minerals and nutrients (like vitamins) from deep in the soil up to where plants with shorter roots can find them
- Trees create homes for different birds and insect pollinators that help crops grow

What can tree intercropping look like?

Trees and crops can be combined in many different ways. There are two main ways:

- Alley cropping is when trees are planted in rows with crops in between them. This method helps trees fertilize crops.
- Parkland systems are when trees are scattered throughout fields with crops. There are many other ways to combine trees and crops and most of them make fields beautiful.

Intercropped farm: *This woman shows her rubber plants and vegetables that she is growing together.*

Some combinations of crops and trees include:

- chili pepper plants and coffee trees
- marigolds and coconut trees
- walnut trees and corn
- citrus trees and eggplant
- olive trees and barley
- teak trees and taro
- oak trees and lavender

There are endless possible combinations of trees and crops!

As machines replaced people working in crop fields over the past 100 years, the mixing of crops and trees became much less common. Farmers are now realizing the importance of tree intercropping. It can help us grow healthy food, take care of the land, and address **global warming** at the same time.

Tropical intercropping: *This farm is Rwanda grows coffee plants and banana trees together.*

Photo Credits
Intercropped farm: Photo by Julius Atia / World Agroforestry / Flickr
Tropical intercropping: Neil Palmer (CIAT) / Wikimedia Commons

TEACHER GUIDE

Enacting Climate — The Story of Drawdown Depends on Our Actions

Learning about climate is a necessary step in preserving life on this planet, but enacting climate is what allow us to arrive at that point. We invite you to put these top climate solutions into action within your classroom through our growing collection of Enacting Climate resources, activities, and curricula that are:

- Embodied and creative
- Classroom tested
- Ready to use in a 'grab and go' format

Gaining access to expression around issues that matter to us all in creative and embodied ways can help our youth feel good about their collective future. The communications these youth generate can be disseminated to impact policy change and feed hope. We can replace a doom and gloom narrative with effective enactment of climate solutions and policies to support a thriving future. This collection of activities is designed to support students in generating expressions to inspire their circles of influence to adopt pro-environmental policies at the governmental, business, school, family or individual level. The development of each module in this collection is:

- Grounded in physical and life science
- Informed by social science
- Enacted through performance and policy
- Disseminated openly

At the root of this entire effort is action. The time to act is now. The ones to inspire us all to act are our youth. We can support and encourage their public actions in the classroom and other informal learning spaces. We can sustain their engagement in climate action by making it purposeful, fun, satisfying, and emotionally and aesthetically stirring. Action gives real-world meaning to learning. Action helps students connect, make change, and ensure a future for themselves and other forms of life on Earth. Educational spaces need not be 'dressed rehearsals' for the real world. Our places of education are part of the real world and students are citizens (whether documented or not) of a global community of life on this planet. One of your actions may be sharing out this resource with other educators you know who may want to begin enacting climate in their classrooms and schools.

Drawdown Adapted: A Solutions-Oriented Climate Change Resource for Youth

This resource offers top climate solutions identified by leading climate experts in a lively format accessible to K-12 students and non-specialists. The top 10 solutions are also available in Spanish. Young people all over the world are ready to act to ensure a survivable future. This resource provides reliable and up-to-date information in one source to guide that action towards a bright future. This Open Educational Resource (OER) is an adaptation of top climate solutions from Project Drawdown that lists and describes the top 82 most impactful solutions for reversing global warming. This adaptation is adjusted to target a 5th grade reading level, but students younger and older will enjoy the engaging writing, descriptive illustrations, and vibrant photos. Solutions include a written description and story of the solution, illustrations to help students visualize this solution in context, and data relevant to each solution, along with further research sources.

This resource is created by a team at the University of Colorado led by Patrick Chandler, an experienced environmental educator and PhD candidate in Environmental Studies, and Beth Osnes, an associate professor of Theatre and Environmental Studies. With three undergraduate interns and two experienced bilingual PhD graduate students in Education, the team has taken on the challenge of adapting each solution for youth (see bios below). During the process, we have had our adaptations peer reviewed by 5th grade students and teachers. These solutions are classroom-ready to support climate education and to inspire meaningful climate action.

Photo by Isabel Cousins

Project Drawdown: The book versus the website—how to navigate Project Drawdown

Our world is quickly changing; so too, top climate solutions adjust over time with these changes. In 2017 the book Drawdown: The Most Comprehensive Plan Ever to Reverse Global Warming made a splash at the top of The New York Times best seller list. It was the first publication to take a wholistic approach to studying the projected impacts of various climate solutions to determine which ones either pulled down or sequestered the most greenhouse gas. The book may have made it into your school library by now and is a great resource, especially for some of the introductory essays. However, the most up to date rating of top climate solutions are published in the 2020 open source, free downloadable publication: The Drawdown Review, available from the Project Drawdown website. We have based our adaptation of these solutions on this 2020 publication.

Ranking the Solutions

You can visit the Project Drawdown website and download your own free copy of ***The Drawdown Review***. The summary and ranking on all of the solutions are listed beginning on page 86. For our adaptation of these solutions, we used the list of solutions based on Scenario 1 which puts us on track to reach drawdown in the mid-2060s. **Drawdown** is the point in the future when levels of greenhouse gases in the atmosphere stop climbing and start to steadily decline, thereby stopping catastrophic climate change. Learning about climate is a necessary step in preserving life on this planet, but enacting climate is what allow us to arrive at that point. "Of course, scenarios are stories of what could be, not what will be. What will be? That will be decided by our collective ambition and determined action this decade and beyond (*page 74 The Drawdown Review*)." Important to remember is that all the solutions are necessary for getting to drawdown.

Why Students Need Access to Top Solutions

Youth voices and actions matter. They can be effective communicators of climate change and can act to reduce global warming in their communities, states, nations, and the world. Researchers have found youth to be among the top trusted messengers of groups capable of influencing those within their circles of community, in part because of their lack of political agenda, direct truthfulness, and investment in the outcome of stabilizing the climate (*BU Institute for Sustainable Energy*). To make a difference they need access to impactful solutions.

The genesis for this project

In 2019 Patrick and Beth were collaborating with a team of 5th grade teachers to use arts-based methods to support students in authoring solutions to climate change within their local context. Every student group created ingenious skits about ways to pick up trash, which is actually an issue of aesthetics and does not impact climate change! After that experience we set out to make top climate solutions accessible to students to put their creative ingenuity in service of true impact.

Our Partnership with Project Drawdown

After the successful launching of Project Drawdown with the publication of *Drawdown: The Most Comprehensive Plan Ever to Reverse Global Warming*, in 2018 the Drawdown Learn Conference brought together climate educators from around the US. Beth was invited to present on performance-based methods for engaging students in authoring local climate solutions. This work was featured by Drawdown founder and noted environmentalist, Paul Hawken, in the opening plenary session at the conference (see photo). Patrick and Beth both presented at the 2019 Drawdown Learn conference. Their workshop facilitated youth participants in authoring a plenary performance for the final evening conference celebration. In 2020 Dr. Elizabeth Bagley became the first director of Drawdown Learn at Project Drawdown. Our team has been working with her on this adaptation of the Drawdown solutions. Both Beth and Patrick are a part of Inside the Greenhouse, a project at the University of Colorado that supports creative climate communication. It is through Inside the Greenhouse that we partner with Project Drawdown in making this open-source resource available free of charge for all. We thank the Office of Outreach and Engagement at the University of Colorado for support of this project. This work will be submitted to the Climate Literacy Energy Awareness Network (CLEAN) to be peer-reviewed and promoted to climate educators nationally. It is available on the Inside the Greenhouse website and on enactingclimate.org.

Noted environmentalist Paul Hawken highlighting the work of Enacting Climate at Drawdown Learn Conference

Holding A Place for Student Emotions Around Climate Change

As student knowledge and awareness about the consequences of climate change increase, so too can anxiety and despair about environmental loss and fear for the future. It is important to acknowledge and guide students in managing these feelings and emotions. Likewise, as a teacher you don't need to have the answers, but you can acknowledge and share their questions. The future is unknown and depends in large part upon what we do in the present. Actively involving youth and adolescents while they are still young is important regarding climate related issues because research reveals that pessimism about addressing climate change increases with age, particularly from early to late adolescence (*Ojala, 2012*). With increased knowledge of climate challenges and biodiversity loss, youth mental health and well-being can be impacted. Researchers, such as CU Professor Emerita of Environmental Design, Louise Chawla, offers some key ways adults can help youth work through these feelings and maintain hope to actively address environmental problems constructively, such as sharing and listening to each other, spending time outdoors connecting with nature, building a community of shared concerns, and valuing young people as partners in addressing environmental challenges and actively authoring and enacting solutions (*Chawla 2020*).

CONSIDER BRINGING DRAWDOWN ADAPTED TO LIFE THROUGH THE SHINE CURRICLUM!

Shine: Youth Authored Climate Solutions Curriculum

The multi-session Shine curriculum was created by Patrick Chandler and Beth Osnes to support 4-7 grade students in being authors of local climate action (available on enactingclimate.org). **This open-source curriculum is designed to support students in putting these Drawdown Adapted climate solutions into action.** Spanning 300 million years of geological time, Shine leads students through a funny and powerful story of how humanity, climate, and energy are interrelated. It grounds the issue of climate and energy in the creation of fossil fuels and their overuse by humans which has led us to this climate crisis. Accompanying kits for this curriculum available through the University of Colorado provide tactile experience with fossils and the tools scientists use to study them. Kits also include fun costumes for characters in this story and some of the art supplies needed to explore various aspects of our collective development. In fact, Chandler and Osnes (as authors of the Shine curriculum) adapted the Drawdown solutions specifically for use with the Shine curriculum!

Features of the Shine curriculum

- classroom-tested, grab and go curriculum, open-source and supported (classroom kits, professional developments, and other support and encouragement available)
- addresses the current shortage of embodied and tactile participatory learning in school classrooms
- co-created *with* educators rather than *for* educators
- supports and guides students in being authors of knowledge and initiators of action in their schools, communities, and the world

Contact Us

Please feel free to reach out to Beth Osnes (beth.osnes@colorado.edu) or Patrick Chandler (patrick.chandler@colorado.edu) with any questions, requests for supporting professional development, or other ideas.

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Ojala, M. (2012). "Regulating worry, promoting hope: How do children, adolescents, and young adults cope with climate change?" *Int. J. Environ. Sci. Educ.* 7, 537–561.

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Spanish Translation of the Adult Version of *The Drawdown Review*

French Translation of the Adult Version of *The Drawdown Review*

Key word color coding system

Climate Science Words: Terms relevant to many solutions that may be new to students when learning about climate science. These are all defined in the glossary.

Key Solution Words: Terms relevant to the current solution that may be new to students reading the solution. These are either defined in the text or with an accompanying pop-out box. They may also be the focus of the solution.

CREDITS

A dedicated team through Inside the Greenhouse at the University of Colorado adapted the Project Drawdown solutions to a 5th-grade reading level and translated the top solutions into Spanish. We acknowledge the contributions of the 2019 CU Creative Climate Communication students who helped begin this adaptation work. We also thank the students and teachers of the 5th grade classes of University Hill Elementary School (a dual-immersion Spanish-English school in Boulder, Colorado) who shared their feedback early on in this process with our CU students. We also thank the 4th/5th grade teachers at Stober Elementary School in Lakewood, Colorado who contributed to this work early on.

Co-Leads for the Project

Patrick Chandler is a PhD candidate in Environmental Studies at the University of Colorado, Boulder who has fifteen years' experience working in and developing environmental education, stewardship, and science programs. His current focus is the co-creation of guidelines to help bring together partners from multiple fields to work together on projects for a sustainable future, including working with artists and arts organizations to catalyze collective action on social and environmental issues.

Beth Osnes PhD, is an Associate Professor of Theatre at the University of Colorado Boulder, and is an associate of the Environmental Studies faculty. She is passionate about using performance as a tool for women and youth to author an equitable, survivable and thrive-able future for all life and the ecosystems upon which all life depends. She is co-founder and co-director of Inside the Greenhouse, an endowed initiative on the CU campus to inspire creative communication on climate (www.insidethegreenhouse.net). She toured her original musical Shine to select cities that were part of the Rockefeller Foundation 100 Resilient Cities Initiative to engage youth voices in resilience planning. Her most recent book Performance for Resilience: Engaging Youth on Energy and Climate through Music, Movement, and Theatre (Palgrave 2017) shares an account of each location reached and the lessons learned. She is co-founder of SPEAK.WORLD, an approach towards vocal empowerment for young omen for increased self-advocacy and civic participation that has been implemented in Guatemala, Tanzania, Egypt, and the USA.

Adaptation and Editing by Graduate Interns

Daniel Garzón is a fourth-year doctoral candidate in the Equity, Bilingualism, and Biliteracy program in the School of Education at the University of Colorado Boulder. He was previously a Spanish teacher for the elementary level grades in the Washington, D.C. area. His research interests include racial/linguistic identity development, sociolinguistics, and educational linguistics. He is interested in expanding multilingual education and the use of culturally sustaining pedagogies for diverse communities.

Caitlin G McC Fine is a PhD candidate in the Equity, Bilingualism and Biliteracy program at the School of Education. A former elementary bilingual science teacher, she is dedicated to working with practitioners and students at the intersection of bi/multilingual education, science education, formative assessment, and teacher education. She uses participatory design-based research to put theory to work by collaboratively imagining, building, testing, reflecting upon and refining tools and routines to support translanguaging pedagogies in science classrooms. Additionally, she is interested in the ways in which co-design work focused on equitable language pedagogies supports shifts in teachers' language ideologies and the ways in which they interpret students' ideas.

Graphic Design & Web Development

Sarah Manning is a designer and multimedia artist born in California who is currently based in Colorado. She recently graduated from the University of Colorado Boulder with a B.S. in Creative Technology and Design, Cum Laude. Her work combines art, design, and technology in both the analog and digital worlds. She is passionate about subjects that combines design with sustainability, especially in areas of modern consumerism and electronic waste.

Spanish Translation

(along with Daniel Garzón, described above)

Saúl Blanco is a freelance architect from Cali, Colombia. He received his bachelors from the Universidad del Valle, and has worked with architecture firms internationally. His interests include sustainability, eco-friendly development, locally sourced materials, and climate/environmental education.

Adaptation and Editing by Undergraduate Interns

Izzy Sofio graduated from the University of Colorado at Boulder in May 2020 with a B.A. in Environmental Studies, Magna Cum Laude, a minor in Creative Writing, and with a certificate from the Eco-social Justice Leadership Program. She was so happy to be a part of the awesome team that worked so hard in creating the Project Drawdown Adaptations. She looks forward to students and educators using these solutions and hopes it inspires change in all who get to learn and work from it!

Erzebet Kalwaitis is a recent graduate from the University of Colorado Boulder majoring in Environmental Studies and Geography.

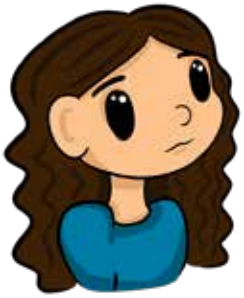
Youth Peer-Review

5th Grade Peer reviewers of these adapted climate solutions include **Jaden Chang**, **Luna Fierer**, **Niko Striphas**, **Simone Tewksbury**, **Darya Yazdı**, and **Osel Yeh**, who are all living, learning, and acting up on climate in Boulder, Colorado. Many thanks to each of them and to **Phaedra Pezzullo**--Niko's ma, CU professor, and Inside the Greenhouse co-director—who facilitated this weekly group.

Jaden

Luna

Simone



Darya

Osel

Niko

Phaedra

Cartoon portraits by Melisande Osnes