CLIMATE SOLUTIONS for ALL

Solutions 51-82

*An adaptation of **Project Drawdown** for all 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 CO_2, 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.

Photo by Bernard Hermany on Unsplash

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

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.

Photo by Dan Meyers on Unsplash

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

BICYCLE INFRASTRUCTURE

2.73-4.63
GIGATONS
CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

All over the world, bicycles are a popular way to get around. People who live in cities want less car traffic on the roads and they want an inexpensive way to travel around. Bikes are a great solution. They decrease car traffic, they are less expensive than cars, and they do not pollute the air with **greenhouse gases**. When people do not drive cars as much, car **emissions** will also decrease.

Bike Infrastructure

In order for more people to ride bikes (and drive less) bicycle infrastructure is needed. Bicycle infrastructure is all of the physical paths, road signs and lights that keep cyclists safe. **Bicycle infrastructure** is important for protecting bikers from cars and trucks on busy roads. It also makes biking more fun when bike paths are pretty and easy to ride on!

What are the main elements for bicycle infrastructure?

1. **Bike paths**: Bike paths are just like roads for cars, but instead they are roads for bikes. No cars allowed! These paths should be flat, so bikers can ride quickly and safely. And, they should cross cities and towns so bikers can get everywhere they need to go.
2. **Lights**: Paths must have lights so bikers can see at night or early in the morning when it is dark outside. If there are no lights, then biking could be dangerous.
3. **Safe intersections**: Intersections where cars and bikes share the same roads can be dangerous for cyclists. This means that the paths have to be planned very carefully!
4. **Accessibility**: Cities should provide access to public transportation, safe places for people to park their bicycles, and city bike-share programs.
5. **Showers**: Office buildings should build showers so people can shower after they ride their bike to work and won't be smelly!
6. **Education**: City governments should teach their citizens about the benefits of biking.
7. **Laws**: Sometimes people do not want to bike because they are afraid they may get hurt by a car. Many cities make sure that bikers are protected by laws in case there are bike accidents involving cars.

Bicycle paths: *In some places, bikers have to ride on the road with cars. Paths made for bikers only can help keep people safer when riding. When people feel more safe biking, they are more likely to bike instead of drive their car.*

Bicycle paths: Mat Reding on Unsplash
City bike share: Greg Jeanneau on Unsplash

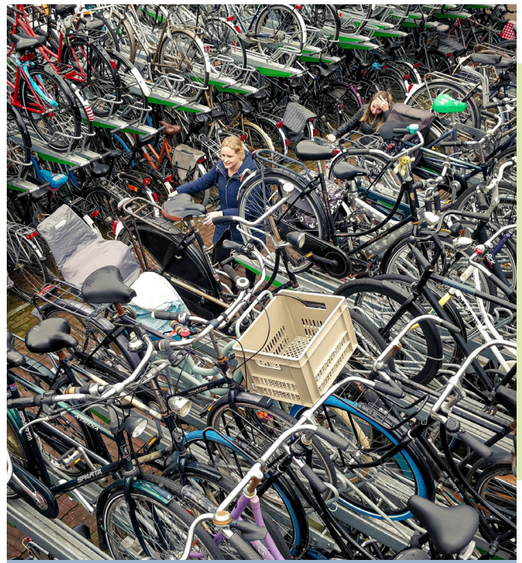
Where in the world are there a lot of bikers?

In Denmark, 18 percent of local trips, like going from your home to school, or to the grocery store, are done by bicycle. In the Netherlands, more than one fourth (27%) of local trips are done on bikes! This means that both Denmark and the Netherlands have fewer emissions from cars.

A Positive Cycle

Bicycle infrastructure can support an important cycle for our health and the quality of our air. More bicycle infrastructure creates more bicycle riders! With more cyclists, cities create more support for bicycle safety.

Another great thing about having more people on bikes, is that people will move their bodies more. Being active is important for our health. Finally, when bicycles replace cars on the roads, we release fewer emissions into the air. Overall, more bicycle infrastructure has a positive impact on citizens and our environment!



City bike shares: *This is an example of a city bike share.*

REAL-WORLD SOLUTIONS
City Bike-Share Programs

In Forteleza, Brazil a city created a unique bike share program... one just for kids! If young people begin biking when they are kids then they will continue to bike (instead of driving cars) as they grow up and become adults! Everyday the program supplies an average of 36 rides to kids without bikes!

Basketball star Lebron James started a program in 2020 through the YMCA to create bike-share programs for teens in Chicago, New York City, and the San Francisco Bay Area. This program makes it free for teens in these places to use bikes as a mode to transportation.

Community Connections

1. How often do you see people biking where you live?
2. Do you ride on a bike, or in a car, or bus more often?
3. Does your town (or school) have programs where many people can share bikes with each other?
4. Do you think that your class could start a bike-sharing program at your school?
5. Do you see how riding bikes to the store, school, or to work can reduce the amount of greenhouse gas emissions that are released into our air?

Photo by Wolfgang Stemme on Pixabay

Solution #52

NUCLEAR POWER

2.65–3.23

GIGATONS

CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

Nuclear power plants can create lots of power with less greenhouse gasses than fossil fuel plants.

Nuclear power plants create energy through very complex processes. In this process, the center of tiny uranium atoms are split in half. When uranium atoms split, they release a lot of energy. This energy is used to boil water, which creates steam. The steam powers huge turbines. When the turbines spin, they create electricity. Using nuclear power is the most complicated way to boil water ever invented.

Benefits of Nuclear Power

When nuclear power plants make electricity, they create 10 to 100 times less greenhouse gas than coal-fired power plants. Twenty-nine of the 195 countries on Earth have nuclear power plants. Nuclear power is so powerful that those 29 countries make 11 percent of the entire world's electricity!

KEY WORDS

power plant
The place where electric energy is made and sent through electrical grids to homes and businesses.

uranium
A silvery-grey metal and a chemical element with the symbol U.

atoms
The building blocks of matter. All things are made up of atoms that are too small to see with our eyes.

Close up of a cooling tower: *Cooling towers are used in nuclear power plants to cool water and release steam.*

Close up of a cooling tower: *Markus Distelrath on Pixabay*
Chernobyl: *Oleksandra Bardash on Unsplash*

Negatives of Nuclear Power

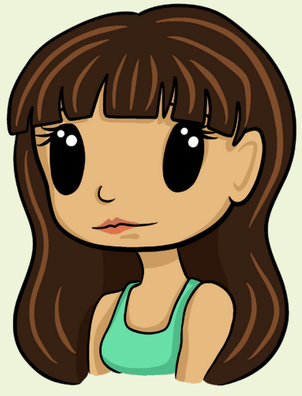
Nuclear power plants cost a lot of money to build and take care of. That is the reason they are not in every country. In fact, while almost every other energy source has become cheaper over the years, nuclear energy is 4 to 8 times more expensive than it was 40 years ago.

The other negative aspect of nuclear power is that the power plants can be dangerous. The process that creates electrical energy uses toxic materials. Nuclear power plants create waste that can be deadily to people and other living things if they come into contact with it. So, if something goes wrong at a nuclear power plant, people, animals, and natural life around can be in danger. This happens very very rarely, but when it does it can cause major problems, for example in Chernobyl, Ukraine and in Fukushima, Japan.

Chernobyl: *In 1986, a nuclear accident happened in Chernobyl, Ukraine that is still considered the worst nuclear disaster in history. This event still makes many people feel nervous about nuclear.*

The dilemma with nuclear power is that even though it has some risk, it can create so much energy with very little **greenhouse gas emissions**. The benefits make it an obvious choice, but the negatives make many people worried. Because of the dangerous negative aspects of nuclear power, Drawdown considers using nuclear power a "regrets solution" to climate change. This means that in the long term the impact of nuclear power on humans and other living things is not worth the risk. What do you think?

Story from a Izzy Sofia, Project Editor



When I was young I lived on a lake. For a long time, I didn't know that the lake was manmade. The lake was made by people when they dammed the Catawba River and flooded the area to create the lake. Why did they do this? So they could build a nuclear power plant in the area. Water is needed to cool the nuclear plant to ensure that it is run safely. Nuclear energy can cause serious damage. When I lived near the lake and the nuclear power plant, my parents had pills that the town gave us in case the nuclear power plant would have any leaks or explosions. These pills were meant to reduce the toxicity of the uranium that could leak out during this time. This is one way that communities surrounding nuclear power plants keep their people safe.

Photo by Jed Owen on Unsplash

Solution #53

BIOMASS POWER

2.52–3.57

GIGATONS

CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

Biomass waste can be used to make power. This is a solution that we shouldn't use forever, but can help us move away from fossil fuels now.

Did you know that **energy** can be made from plants? Energy that is made from plants is called **biomass energy**. This kind of energy is known as a 'bridge' fuel. It can be used instead of **fossil fuels** while the world works to be powered by 100 percent clean and **renewable energy**. We have a lot of work to do before most clean and renewable energy sources, like solar or wind energy, can supply energy 100% of the time. In the meantime, biomass energy is a great solution.

Renewable energy is energy that does not come from burning things. This type of energy does not release carbon into the atmosphere, which means it is not harmful to the planet.

Three Ways Biomass can be used to Make Energy

1. Wood and other biomass sources can be burned to make heat.
2. Biomass can be burned to make for **electricity**.
3. Some plants, like corn, can be made into gas or oil to power cars and lights.

Biomass power plant: *Biomass is burned instead of fossil fuels at these power plants to create steam. The hot steam is used to create electricity.*

Where does biomass come from?

As plants grow, they sequester (trap) carbon from the air in their plant parts (leaves, stems, roots, etc.). After farmers harvest plants, the food-parts are processed and shipped to stores. The non-food parts can be burned to make biomass energy. When plant parts are burned, they release the carbon that they were sequestering into the air. This might seem like a bad thing. However, if farmers plant new crops in their now empty fields, then the cycle of carbon sequestration and release continues. This cycle is carbon net-zero. Carbon net-zero means that greenhouse gas emissions released when biomass is burned can be sequestered again in new plant growth on farms around the country.

What plant parts can be used to create biomass energy?

There are quite a few options. First, biomass energy can be made from the parts of crops that are harvested but cannot be eaten. For example, many seasonal crops we grow for food have stems, leaves and stalks that no one eats. Second, waste from mills, such as paper pulp from paper mills, can be burned to create biomass energy. Third, seasonal crops that don't require a lot of water or energy to grow can be burned for biomass energy.

KEY WORDS

harvest
When plants are picked and gathered from the ground

crops
Plants that are grown as food, such as vegetables, grains, and fruit.

seasonal crops
Crops that grow quickly during only one season (i.e. spring /summer).

Are certain plants bad to use for biomass energy?

Yes. Crops, like corn and wheat, need a lot of water and energy to grow. They are not good options for biomass energy. Also, we don't want to cut down trees just to burn them for biomass energy or cut down trees to create large fields to plant crops for biomass energy. We already have enough fields and enough inedible crop parts to create biomass energy.

Remember, biomass energy is not our goal. Even though it makes energy in a cleaner way than fossil fuels, other renewable energy sources (like solar energy and wind energy) will be better in the long run. We can think of biomass energy as the bridge that will take us to the future of clean, renewable energy!

Corn stover: *The inedible part of corn is often burned for biomass energy.*

Biomass power plant: *Tiia Monto on Wikimedia Commons*
Corn stover: *Rudolph Ratti on pixy.org*

Solution #54

NUTRIENT MANAGEMENT

2.34–12.06
GIGATONS
CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

In the past 100 years, humans have used nitrogen-based fertilizers to grow crops. These fertilizers are important because they give the plants the nutrients they need to grow. They also help farmers produce more and larger crops to feed a growing worldwide population. Currently, many farmers apply more fertilizer to their soil than necessary.

Negative Impacts of Fertilizer

The nitrogen that plants do not use either stays in the soil or washes away. This can cause a lot of issues for the surrounding environments. Some of the problems caused by too much nitrogen are:

- Too many chemicals in the soil can destroy plants and can make the soil unhealthy.
- Nitrogen can wash into rivers, lakes or ponds. The extra nitrogen causes algal blooms.
- Bacteria living in the soil can eat the extra nitrogen and release **nitrous oxide** into the air. Nitrous oxide is a much more powerful **greenhouse gases** than **carbon dioxide**!

Algal blooms: *This algal bloom is in a river, animals cannot live in this water.*

What can farmers do?

People can be careful with their use of nitrogen-based fertilizers to reduce the negative effects. Farmers need to remember the Four R's:

- **Right Source**: Make sure that you buy the correct fertilizers based on the needs of the particular plant.
- **Right Time** and **Right Place**: Keep track of when and where plants need fertilizer to grow. This helps you not use too much fertilizer.
- **Right Rate**: Learn how often you need to give your plants fertilizers. Plants might not need as much as farmers think.

Mainly, farmers should reduce how much fertilizer they give their plants. It is not always easy to help people to change their farming habits. Teaching the Four R's can help.

Reducing the use of nitrogen-based fertilizers can help stop **climate change**, but there are also many farming practices described across the Drawdown solutions that can help even more. When we keep the land healthy, we eliminate the need for nitrogen-based fertilizers completely!

KEY WORDS

algal blooms
Algal blooms appear when algae grows out of control and creates dead zones in water. Dead zones do not have enough oxygen in the water so fish and other animals often die.

fertilizer
Fertilizers are chemicals used on farms to help grow more crops or bigger crops.

Algal blooms: Felix Andrews on Wikimedia Commons

Photo by Oregon Department of Forestry on Flickr

Solution #55

BIOCHAR PRODUCTION

2.22–4.39
GIGATONS
CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

Biochar is charchol produced from burning trees and other organic matter and is used as a natural fertilizer.

In ancient Amazonia, people got rid of waste by burying it and then burning it. Fire baked the waste under the soil. After it burned, the waste created a new layer of charcoal soil that contained a lot of carbon. This soil layer was called terra preta, which means "black earth" in Portuguese. Today, terra preta soils cover around 10 percent of the Amazon basin.

How is Biochar made?

The ancient practice of terra preta can help us fight climate change. Today, we call this process biochar. Biochar can be made from waste such as peanut shells and wood scraps. Farmers burn the waste in a large oven that is very hot. The oven does not have any oxygen inside of it. While it burns, gas and oil separate from carbon-rich solids. This leaves carbon-rich soil, known as biochar. People burn the gases and oils for energy and they use the biochar as fertilizer to help plants grow. Because it is rich in carbon, biochar is a good natural fertilizer.

Biochar kilns: *Biochar is made in kilns, which are ovens that get super hot.*

Why is Biochar used?

When biomass(dead plant material) **decomposes** on top of the soil, it releases **carbon** and **methane** into the atmosphere. Biochar helps prevent carbon from going into the air by trapping it under the soil. Biochar allows for carbon sequestering - when carbon stays in the ground. This means that over time, there is less carbon going into the atmosphere. Creating biochar could prevent billions of tons of **carbon dioxide** from entering the atmosphere every year!

Biochar kilns: NRCS Oregon on Flickr

Solution #56

LANDFILL METHANE CAPTURE

~2.18
GIGATONS
CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

This number is based on Drawdown Scenario 1. In Drawdown Scenario 2, this solution might not reduce greenhouse gas emissions. For more information visit drawdown.org

Most of the time, **carbon dioxide** is the **greenhouse gas** that everyone talks about. Let me tell you a secret... **methane** actually warms our Earth more than carbon dioxide. Landfills (areas of land where dump trucks take our trash) make up 12 percent of the world's methane emissions.

How do landfills create methane?

The majority of what is put into landfills is material that was once living: old food, dead leaves, old wood, and paper. When these things rot, something called biogas is made. Biogas is a mix of carbon dioxide and methane. (Think of it as the landfills farting.) Items that were once living can usually be recycled or composted instead of put into landfills. In many cases, we could avoid food waste if we were more careful about how we store, move, and serve our meals. Until we stop putting these materials in landfills, we have to manage the methane that they produce.

Figure 1 shows how methane from landfills is turned into energy. Step 1 is collecting the methane from the trash with gas collectors. Step 2 is burning the gas to make heat. Step 3 is using the heat to make energy that people can use.

KEY WORD

fuel
Fuel is anything that can be burned to create heat or energy. This can be fossil fuels, or natural fuels, such as biogas.

How can we make energy from landfill methane?

Technology can help us make energy from biogas. It is a pretty simple process. Engineers place long tubes with little holes deep into landfills, shown in Figure 1. The tubes collect the methane and remove it from landfills so it is not trapped. Once the gas is collected, it can be released into the air or burned. Better yet - it can be made into fuel. The fuel can then be used for lots of things. For example, garbage trucks can use it to take trash to landfills!
By using methane from landfills as fuel we can:

- Keep methane from entering the air, which reduces **global warming**
- Use an energy source that does not require us to use **fossil fuels**, which further reduces global warming

Solution #57

COMPOSTING

2.14–3.13
GIGATONS
CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

Almost half of the waste around the world is organic waste. Organic waste is material that was once living. Examples include old food, dead leaves, old wood, and paper. Most of the time this kind of waste goes into a landfill. Organic waste in landfills does not decompose (rot) because it cannot get enough oxygen. Oxygen helps things that were once living decompose and turn back into soil. Because organic waste in landfills is buried and can't decompose as it normally would, bacteria eat the organic waste and create methane. Landfills produce a lot of methane. Many landfills try to manage the amount of methane they put into the air by capturing it as it is released. But a more effective way is to make sure organic waste goes to the compost instead of to the landfill.

So, what is 'composting'?

Composting is a process where organic waste breaks down so the nutrients and materials found in old food, paper products, and yard cuttings can turn back into a rich soil! In order for organic matter to decompose (turn from waste into soil), it needs water, air, and heat to keep bacteria and fungus healthy. Usually, compost ends up as fertilizer and farmers spread it around gardens and fields to help plants grow.

KEY WORDS

landfill
A place for waste to go within the ground that is eventually buried.

methane
Methane is a **greenhouse gas** like carbon dioxide. Methane can trap 34 times more heat than carbon dioxide in Earth's atmosphere.

Where do people compost?

People can compost in a small bin or container in their backyards. Schools can compost students' lunch scraps as a way to create fertilizer for gardens. Many cities also have large composting facilities that take organic waste from homes and businesses around the city to make fertilizer. Composting helps keep organic matter and carbon trapped in the soil and keeps carbon from escaping into the air as carbon dioxide where it can warm the Earth.

Backyard compost: *This compost bin is perfect for throwing away organic waste. Then, it can be used in a backyard garden to improve the soil.*

Is composting a new idea?

Humans have composted for many years. Today, composting is very useful for taking care of the waste that comes from big cities. San Francisco, California, made it a law that the city's food waste has to be composted. In Copenhagen, Denmark, organic waste has not gone to the landfill in over 25 years! By composting organic waste, people reduce greenhouse gas emissions and create a great soil fertilizer!

Backyard compost: *Manfred Antranias on Pixabay*

Photo by Fletcher6 on Wikimedia Commons

Solution #58

WASTE-TO-ENERGY

This Waste-to-Energy power plant burns trash to create energy.

2.04–3.00

GIGATONS

CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

In a sustainable world, we would reduce, reuse, recycle, and compost all of our waste. Unfortunately, cities and countries around the world create a lot of waste, and it goes mostly to the landfill. Many cities and countries that do not have a lot of land have a big problem. They are running out of space for all the trash that humans create! **Waste-to-energy** is a method to use the trash we don't have space for by burning it to create energy.

What is the benefit of Waste-to-Energy?

Besides saving space, the main benefit of burning trash for energy is that it replaces energy made by coal or gas-fired power plants. Coal and gas-fired power plants create a LOT of **greenhouse gas emissions**. Waste-to-energy is a good alternative because it does not emit as many greenhouse gases.

What are the problems with Waster-to-Energy?

Using waste-to-energy as a long-term solution to climate change is not recommended. One problem with waste-to-energy is that burning waste releases toxic chemicals from the trash. Creating energy in this way does have harmful effects on people and the environment. Even when waste-to-energy treatment facilities are the best of the best, they still are not toxin-free. Making energy in this way in the short-term can help us transition away from the use of fossil fuels.

While this solution is not a long-term solution because it has a lot of negative side effects, it does bring up an interesting point. Waste-to-energy is a better option than many of the ways we currently make our energy with **fossil fuels**. This shows how serious the problem of climate change is. With waste-to-energy we are choosing the lesser of two evils.

Solution #59

SMALL HYDROPOWER

1.69–3.28

GIGATONS

CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

One way we create electricity from **renewable** and **natural resources** is by harvesting the immense power of moving water. This is called hydropower.

Large Hydropower Systems

Hydropower usually involves large dams that block the flow of rivers and direct water through systems that create electricity. One of the largest dams in the world is the Three Gorges on China's Yangtze River. Even though these dams produce a lot of electric power, they are so big that they take up a lot of land that could be used by both humans and animals. They also can cause problems that affect the water and the **ecosystems** around them. Dams can slow rivers down and change the quality of the water. They can also keep fish from swimming to places they need to reach to survive and reproduce.

Three Gorges: *The Three Gorges Dam is one of the largest dams in the work on China's Yangtze River.*

Small hydropower plant: *Small Hydropower plants sit on small bodies of water like rivers or streams.*

Small Hydropower Systems

Small hydropower systems, however, help keep rivers and the land around them healthy. Small hydropower technology can sit in rivers and streams and uses small propellers that spin from the movement of the water. Many propellers spinning together can make a lot of electricity! Because they are small and easy to set up, small hydropower systems don't require dams or walls to be built.

A Great Solution for Small Communities and Large Cities

In rural communities far from cities, small hydropower systems can replace diesel generators. Diesel generators create a lot of pollution. Small hydropower systems are increasing in rural communities in Alaska and Nepal. Small hydropower can also be used in cities. They can be set up in the water mains that move water from building to building.

As small hydropower becomes more popular, it is important to note that not all projects actually let the river run freely. Some projects have diverted water, caused floods, and harmed fish migration. Careful design and installation of small hydropower systems can help make sure that this type of clean energy is also safe for our local habitats.

Three Gorges: *Le Grand Portage on Wikimedia Commons*
Small hydropower plant: *Marcus Ganahal on Unsplash*

Photo by Arturo Castaneyra on Unsplash

Solution #60

WALKABLE CITIES

1.44–5.45
GIGATONS

CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

Walking is the most sustainable way to get around. When it is easy to walk to places, people are more likely to walk.

Walkable cities are cities that are designed to make walking from place to place as easy (or easier) than driving. When people walk instead of drive their car, they help reduce **greenhouse gas emissions**. According to the Urban Land Institute, in places where walking is easy and fun, people drive 20 to 40 percent less.

Public art: *Murals, sculptures and other art along walking paths make walking more exciting.*

Walk Appeal

In walkable cities, people should be able to walk to their destinations (stores, homes, offices) in about 10-15 minutes. But that is not all. Walkable cities should help people enjoy their walks. This is called walk appeal. Walk appeal happens when people see their friends and neighbors walking too. People also enjoy their walks when different buildings (like homes, stores, and offices) are mixed together and when the city has fun things to look at. Some fun things to look at could be murals painted on buildings, large sculptures, and interactive community art projects.

What structural elements make cities walkable?

Towns can help make cities walkable. They can:

- Increase how close buildings are to each other (so homes are close to businesses and stores)
- Build wide sidewalks with lots of trees and street lights
- Create safe and easy places to cross streets
- Engineer easy ways for walkers to get to buses and trains for when they have longer journeys

People like to live in walkable places, but a lot of cities today are not very walkable. Walkable cities are easier to live in and they help people stay healthier and happier. Walkable cities also help our planet reduce global warming. Is your city or town walkable?

Public art: *Oliver Cole on Unsplash*

Photo by Ivan Bandura on Unsplash

Solution #61

OCEAN POWER

1.38
GIGATONS

CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

Energy is created by the oceans waves and tides. This energy can be used for electricity!

The ocean is in constant motion. Ocean currents constantly swirl and move and waves crash on the shore. All of this motion has a lot of energy behind it and the ocean's movement never stops. People who work for companies, governments, and universities have created machines that let the ocean flow through them. As the ocean water moves through the machines, they produce electricity! Unfortunately, ocean energy technologies are not very common. They make only a small amount of the energy people use around the world. Many people are working to make the technology better so that we can create more reliable energy from the sea.

Ocean Power Technology

The ocean is very powerful so it can be challenging to build and maintain ocean energy technologies in the water. Right now, it's much easier to create renewable energy on land with solar and wind power. It also cost less money.

With today's technology, capturing the energy of ocean tides is easier and more common than capturing the energy of ocean waves. There are several tidal energy systems in operation today. But lots of people are researching how to capture energy from waves and they are very hopeful they will find new methods and create new machines soon.

Ocean power technology: *This buoy records information about the ocean's waves to determine if their energy can be converted into electricity.*

Difficulties of Capturing Ocean Power

Making energy from the ocean's waves and tides is difficult and expensive. It is currently considered the most expensive renewable energy! Since the majority of our planet is covered in water, scientists believe that electricity made from ocean waves and tides has a lot of potential. They estimate that 25 percent of the electricity used in the United States could be created by the ocean! Making this dream a reality will take more research and money, but it's an exciting possibility.

Ocean power technology: *Province of British Columbia on Flickr*

Solution #62

SUSTAINABLE INTENSIFICATION FOR SMALLHOLDERS

0.68–1.36
GIGATONS
CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

KEY WORDS

agriculture
The practice of farming animals and vegetables for food and other products.

harvest
When crops are picked and gathered from the ground to be eaten or sold.

In farming communities in low-income countries there is a gender gap. A gender gap is when women and men do the same work, but women do not have the same rights and are paid less money.

In poorer parts of the world, women make up almost half (43%) of all the people who work in agriculture and they produce 60% - 80% of food crops. They work in fields as farmers. They take care of livestock, like cows and pigs. And they grow home gardens. Although women work as hard as men, many of these women are paid very little money or NO money at all. Does this sound fair?

Why are women paid less?

Most of the women who experience the gender gap are smallholder farmers. Smallholder farmers are people who farm on small plots of land. Most smallholder farmers work fields that are less than 5 acres, which is about the size of 4 football fields.

A family farm: *a mother with her garden in Sololá, Guatemala*

Women have less access to education, technology, money, legal rights, and resources than men do. Women are great farmers. Unfortunately, because of inequalities in access, women produce less animals and crops than men do on the same amount of land. If we all work to fix the gender gap, these women's lives will improve. They will be able to provide more for themselves, their families, and their communities.

Fighting the Gender Gap in Farming also Helps Fight Climate Change

If all women smallholder farmers receive equal access to the resources they need, they will be able to harvest 20% to 30% more food! If harvests increase, then 100 to 150 million people will no longer go hungry. That's about the size of Russia's population... think of that many people finally having full stomachs! If people harvest more food on the same amount of land, we won't have to cut down forests to make new farms. This is how fixing the gender gap in smallholder farming communities helps the Earth, too!

A family farm: MAIA Impact School

Photo by US National Park Service

Solution #63

ELECTRIC BICYCLES

1.31–4.07
GIGATONS
CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

Electric bikes can help anyone ride a bike! They help make biking accesible with a small amount of electricity.

Electric bikes, also known as e-bikes, are the most environmentally friendly form of transportation that involves a motor! E-bikes look like a typical bike, and come in many shapes and sizes. What makes them different is that they have a small motor attached. The motor makes it easier to go up big hills, to arrive at places faster, and to ride for longer distances. Electric bikes are becoming cheaper so people are starting to use them instead of driving their car. Less trips in cars means less pollution.

E-bikes as transport: *Electric bikes can make riding a bike a cost and time effecient way to get around for anyone.*

China Loves E-bikes

In China, e-bikes, are super popular. Millions of people use e-bikes instead of cars to get to work and school. In fact, the amount of people that own e-bikes in China is double that of people who own cars! E-bikes are popular in China because in the 1990's, cities throughout China made strict laws against pollution. E-bikes produce much less pollution than cars.

Why else are e-bikes more popular than cars?

- **Speediness:** E-bike riders do not have to wait in car traffic, or in line for a subway or train.
- **Health:** Using an e-bike is a good way to stay healthy. Even though they have a motor, the biker still needs to pedal to move around town.
- **Money:** Cars are expensive, but e-bikes are an affordable option.

People charge e-bike motors from regular electrical outlets. E-bikes have higher **greenhouse gas emissions** than regular bikes or simply walking because their battery needs to be charged with electricity. Sometimes the electricity used to charge an e-bike comes from **fossil fuel** powered energy. But, if the electricity to charge the motor comes from solar or wind energy then the e-bike does not create greenhouse gas emissions. Either way, e-bikes are more environmentally friendly than cars.

E-bikes as transport: Øyvind Holmstad on Wikimedia Commons

Photo by Shilpy Arora on Wikimedia Commons

Solution #64

HIGH-SPEED RAIL

Bullet trains have a unique design that helps them to travel faster than traditional trains.

1.30–3.77
GIGATONS
CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

In 1964, Japan opened the world's first high-speed "bullet" train. This train traveled 247 miles from Osaka to Tokyo! According to the International Union of Railways, as of 2020 there were more than 18,500 miles of high-speed train lines around the world. This number will increase by about 9,000 miles very soon because engineers are building many high-speed railroads right now.

Benefits of High-Speed Trains

High-speed trains are special because they only use electric power. Older trains burn **fossil fuels** to move. Compared to driving, flying, or older trains, high-speed trains release about 90 percent less carbon into the air. These trains also travel faster than older trains!

Why isn't high-speed rail used everywhere?

Even though high speed trains are better for the environment, they are very expensive to make. As a result, high speed trains are mainly built in places where a lot of people live and ride trains. China has 50 percent of the world's high speed trains. Japan and Western Europe also have a lot of high speed trains because they have big cities where there are a lot of people who travel by train. Where there are enough people, high speed trains are a sustainable way to travel to work, to stores and to activities.

Traditional train station: *Traditional train stations would need to be redesigned for high-speed rail*

Traditional train station: *Roman Fox on Unsplash*

Photo by Sheila Sund on Pxhere

Solution #65

FARM IRRIGATION EFFICIENCY

We need water for lots of things, such as growing our food. We also need to make sure we only use as much as we need.

1.13–2.07
GIGATONS
CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

Farmers have used rivers to water their fields since 6000 BC, through a process called irrigation. Irrigation is a system that takes water from the rivers to farms. The Nile and Tigris-Euphrates rivers were the first two rivers where irrigation was used. Today, farmers use 70% of the world's freshwater to grow crops and animals for food. Irrigation helps us grow 40% of the world's food. Modern irrigation systems use a lot more energy than they did back in 6000 BC. Because these systems use energy to pump water from rivers and deliver it to fields, irrigation creates **carbon emissions**.

Two Important Irrigation Tools

Irrigation tools help farmers bring water exactly where they need it so they do not waste water. Two important irrigation tools that help farmers save water and energy are drip hoses and sprinklers. These tools deliver 70% to 90% of the water taken from rivers straight to farms.

KEY WORDS

drip hoses
Drip hoses are thin hoses with small holes at each plant. The water slowly drips out of a drip hose at the base of each plant instead of watering the entire field.

sprinklers
Sprinklers are devices that spray water over large areas of land. The water from sprinklers falls on plants similar to rainfall. Sprinklers can be controlled, so they only turn on a certain times of the day. Have you ever played in a sprinkler in your yard or neighborhood?

Drip hose

Drip hose system

Sprinkler

How do these tools help farmers?

Drip hoses and sprinklers that use less water help farmers in many ways:

- More vegetables grow
- Farmers save money
- Soil stays in place and there is less erosion
- Less bugs eat the vegetables
- Water is not wasted
- In parts of the world that do not have a lot of water, people will not fight over the water

These tools can help farmers, but they also cost money. Additionally, farmers have to spend time making sure they work properly and farmers have to fix the tools when they break.

Large sprinklers: *For big farms, you need big sprinklers. This is part of a rotating sprinkler than can move around to water the entire field.*

Are there other ways farmers can save water?

Yes! One thing farmers can do is observe and plan the best time to water their fields. Also, farmers can use special technology that checks how much water is in the dirt and decides if the fields need to be watered. Lastly, farmers can capture rainwater and water that runs off the ground during storms. They can use this rainwater on their fields. Can you think of any other ways to help farmers save water?

Water efficient sprinklers: *These two farmers in Oregon show off their field of crops and the sprinkler that helps them save water.*

Drip hose: *Fir0002 / Flagstaffotos on Wikimedia Commons*
Drip hose system: *Borisshin on Wikimedia Commons*
Sprinkler: *Aqua Mechanical on Flickr*
Large sprinklers: *Vidar Nordli-Mathisen on Unsplash*
Water efficient sprinklers: *Tracy Robillard / NRCS Oregon on Flickr*

Solution #66

RECYCLED PAPER

1.10–1.95
GIGATONS
CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

People use paper for lots of things. Maybe you use paper to take notes in school or for art projects. One of the main things people use paper for is to make packaging materials to ship things in the mail. About half of all paper is thrown away after just one use and the other half is recycled. In some places in the world, 75 percent of paper is recycled. If everyone recycled at least 75% of their paper products, we could reduce **greenhouse gas emissions** a lot!

How is recycled paper used?

Recycling paper makes it possible to make new products without cutting down trees! Every tree cut down adds carbon to the atmosphere. Every time paper is recycled, it helps to save trees and prevent more carbon from being released. Paper can be recycled after people use it and also at the factories that make paper. Factories can recycle paper waste materials that are produced when making paper instead of throwing them out. If both consumers and factories recycle paper, we can save a lot of trees and keep a lot of carbon dioxide out of the atmosphere. Another benefit of recycling paper is that is reduces the amount of paper decomposing in landfills. This keeps methane from being released and further reduces global warming.

KEY WORD

contaminate
to make unfit for use by adding something harmful or unpleasant
definition from Merriam-Webster

How is paper recycled?

The process of recycling paper makes it look as good as new! First paper is shredded. Then it is turned into pulp. The pulp is cleaned to make sure that there are no chemicals or particles that could contaminate the newly made paper. Then companies make all kinds of paper products out of the newly cleaned paper pulp. For example, companies make printer paper and even toilet paper from recycled paper pulp. Recycling paper also helps save water that is used when new paper is made. Did you know that one piece of paper can be recycled 5 to 7 times?! When we recycle paper, we help our environment!

Bales of recycled paper: *Recycled paper is stored in bales like this before it goes through the recycling process.*

Bales of recycled paper: *Ben Kerckx on Pixabay*

Photo by Mikey Harris on Unsplash

Solution #67

TELEPRESENCE

1.05–3.80
GIGATONS

CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

Online school and work is much more common today then it was just a few years ago.

Talking to people in person is great! But when that isn't possible, for example during the Covid-19 pandemic, telepresence helps us communicate with friends, family and classmates through audio and video technology. Telepresence also requires a person to have a strong internet connection so the sound and video are clear. With the combination of strong audio, video, and internet technology, telepresence helps us to experience many of the best parts of talking face-to-face through a virtual format.

Who uses telepresence?

Many companies and organizations can use telepresence. As we have seen through the Covid-19 pandemic, schools, families, religious institutions, museums, artists and large companies can use telepresence. Sometimes doctors do not even need to travel from one part of the world to another because they can use telepresence robots to help another doctor during surgery! Business executives can make important decisions during virtual meetings without traveling. Students even take classes online. All of these options are super easy and helpful to many people!

Why is telepresence important?

When we attend meetings virtually from anywhere in the world, we do not need to travel as much. When we travel less by airplane, train or car, we release fewer **greenhouse gases** into the atmosphere. In this way, we can slow climate change. There are also other important benefits of telepresence. People can save time and money by not traveling for in-person meetings. Business people can also make faster decisions and have more productive meetings. Telepresence helps connections between people become stronger across the world!

Photo by Alexandra Newton @artbyalexandranicole

Solution #68 & #69

COASTAL WETLANDS

PROTECTION(68) & RESTORATION(69)

1.76–2.46
GIGATONS*

CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

Protection (keeping existing coastal wetlands healthy) and restoration (helping to heal damaged coastal wetlands) are both important to create strong coastal ecosystems that can help reduce global warming and protect coasts!

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.

In between the ocean and land there is an ecosystem known as the coastal wetland. Salt marshes, mangroves, and sea grasses are all coastal wetland ecosystems. They are found on every continent except Antarctica because it is so cold there.

Mangrove trees

Salt marsh

Sea grass

Why are coastal wetlands important?

Coastal wetlands are safe places for young fish, and have a lot of food for birds that migrate. They protect the mainland by being a place for big storm waves and flooding to occur without damaging large trees or buildings. Lastly, the plants and soil in coastal wetlands help filter water to keep it clean near the coasts. This water filtering happens both aboveground and underground.

Coastal Wetlands Help Avoid Global Warming

Coastal wetlands are especially important to help us avoid **global warming** because so many plants with very deep roots grow in these ecosystems. These plants sequester (trap) **carbon** both above ground in their branches and leaves and below ground in their roots and the soil. When plants die and are buried under the soil, the carbon they have sequestered is buried too. Burying carbon helps remove it from the atmosphere. This is important because atmospheric carbon can warm the earth.

Roots of a mangrove tree: *On top of sequestering carbon, the roots of the mangrove tree can also make for good fish nurseries.*

The Magic of Mangrove Forests

Coastal wetlands are very important because they can absorb 5 times more carbon than tropical forests! One type of important coastal wetland ecosystem is a mangrove forest. In mangroves, trees grow closely together and they grow directly in the water. By themselves, Earth's mangrove forests hold the amount of carbon currently released in 2 years by all human activity on earth - 22 billion tons of carbon. If humans destroy mangrove forests, there will be a lot more carbon in the atmosphere and the Earth might become a lot warmer.

We Need to Protect Wetland Ecosystems

Wetland ecosystems face many threats. But researchers and those who stand up and speak for coastal wetlands have taught people their importance when it comes to **climate change**. More people are learning about the importance of wetlands every year. If we keep these ecosystems healthy, we can help our Earth stay healthy too. Let's take care of wetlands all around the world and make sure the ones that have been damaged are repaired.

Mangrove trees: *Timothy K on Unsplash*
Salt marsh: *Jennifer Crowder on Pixabay*
Sea grass: *Peter Southwood on Wikimedia Commons*
Roots of a mangrove tree: *Phil's 1stPix on Flickr*

Solution #70

BIOPLASTICS

0.96–3.80
GIGATONS
CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

Around the world, people produce about 310 million tons of plastic every year. Most plastic today is made from fossil fuels. Scientists say that 90% of plastics that we use could be made from plants. Plastics made from plants are called bio-based plastics or bioplastics. Because they are made from plants, some bioplastics are biodegradeable. Some bioplastics made can be turned back into soil for us to use in farming, gardens, or even parks.

KEY WORDS

biodegradable
Biodegradable means that materials are broken down by nature overtime.

polymers
Polymers are chains made up of building blocks called monomers. The type of monomers used and how they are connected creates different types of polymers.

What is plastic made of?

Plastics are polymers. Some polymers are natural, like spider silk and human hair. Some polymers are artificial, like plastics and fleece. Because they are made up of lots of molecule chains, polymers are very strong. Polymers are often more flexible and can hold more weight for their size than other materials. Because they are strong and flexible, plastics are used to make things that last a long time.

What is bioplastic made of?

There are two common natural polymers that we can use to create bioplastics. Cellulose is a natural polymer that makes up the cell walls in plants. It is one of the most common natural materials on earth! It is what helps plants stand up. Chitin can be found in the shells of bugs and ocean animals with shells, like crabs and shrimp. It helps keep their shells hard so they are protected. Chitin is a polymer. Both cellulose and chitin can be used to make plastic! Other plants like potatoes, sugarcane, tree bark and algae can also be used to help create bio-based plastics.

Where is bioplastic used?

Plastic bottles: *Plastic bottles are some of the most used plastic products. Making them out of bioplastic would be good for the environment.*

Most bioplastics are used in packaging, but they are finding their way into lots of other products, too! They can be found in clothes, medical devices, and electronics. New research is helping us to find new ways to include bioplastics in even more products. Making plastic from natural materials can help reduce **greenhouse gas emissions**. This is especially true when plastic is made from plant waste.

One challenge with bioplastics is that not everyone knows how to throw them away. Many people throw them in the trash and they travel to landfills where they will not break down. In fact, some bioplastics are biodegradable and can be composted! Compostable bioplastics have to go to an industrial composting facility (not your backyard), where workers have the proper tools and machines to makes sure they decompose. Hopefully, more people will learn about bioplastics and help keep more plastic out of landfills.

Plastic bottles: *Timothy K on Flickr*

Photo by David Becker on Unsplash

Solution #71

LOW-FLOW FIXTURES

0.91–1.56
GIGATONS
CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

Low-flow fixtures limit the water flow through them in order to avoid unnecessary water waste.

Water Uses Energy

When you use water in your house to shower, wash your clothes and water your plants, did you know that you are also using **energy**? It's true. The process of moving and heating water uses a lot of energy. Trucks, pumps, and pipes move water from its sources (lakes, rivers and underground aquifers) to your local community. It also takes energy to move water through our communities to our homes. When we take a hot shower, do the dishes, or wash our hands, we use energy to heat the water. Around the world, the process of heating water uses 25% of all energy.

Energy is also used to clean dirty water. Dirty water, called wastewater, comes out of our house after we are done using water inside our homes. If we want to use less energy, one thing we can do is use less water. Almost everyone in the world can save water in their home through a few simple changes.

There are three ways that households use water:

- The water we use inside our houses when we shower, do laundry, wash dishes
- The water we use outside of our houses to water lawns, gardens, plants
- All the water that no one uses because of leaks from pipes, sinks, and showers.

Water Treatment plant: *At a water treatment plant, energy is used to clean water before it is sent to our homes so that it is safe to drink.*

Water Treatment plant: USEPA Environmental-Protection-Agency on Flickr
Low-flush foilet: SuSanA Secretariat on Flickr
Efficient washing machine: David Ludlow on Trusted Reviews
Low-flow faucet: Rawpixel
Low-flow showerhead: Green Energy Futures on Flickr
A water efficient garden: Jeremy Levine on Flickr

What can I do to reduce the water I use?

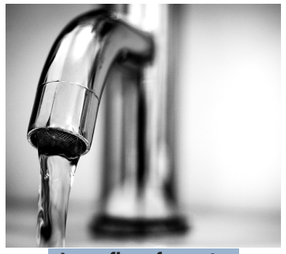
Inside your home, try out these tools to use less water and less energy:

- Low-flush toilets save water by allowing less water to flush away
- Efficient washing machines and dishwashers are designed to use less water
- Low-flow faucets and low-flow showerheads reduce water flow

If all of these tools were used in every home, almost half (45%) of the water used in houses now would be saved!

Low-flush toilet

Efficient washing machine



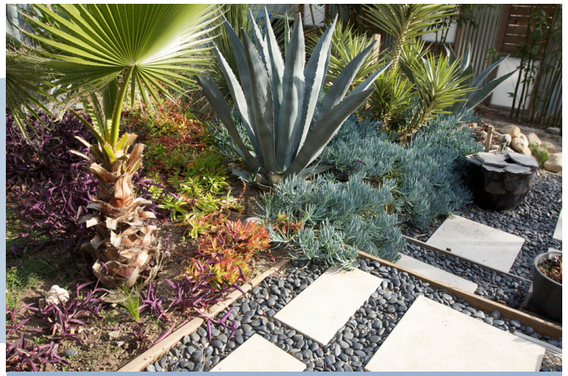
Low-flow faucet

Low-flow showerhead

Outside your home, try these ways to reduce water use:

- Collect rainwater to water lawns and plants
- Plant gardens of native (local) plants that need less water instead of lawns
- Water plants with drip irrigation that only places water exactly where it is needed
- Turn off the outdoor faucet altogether. Then no water is used at all!

It is also important to fix leaks in pipes, pumps and other home water systems when you find them.



A water efficient garden: *Grass lawns need a lot of water. Gardens with native (local) plants use less water in dry areas and create beautiful yards.*

How can communities help people use less water?

There are many ways for communities to help people use less water. Here are a few ideas:

- Give people rewards when they buy water saving tools (like low-flush toilets)
- Put labels on water saving tools that teach people how to use less water
- Create laws that require builders to build homes with energy-saving plumbing

Limit the amount of water houses receive, when people can use water, or how people can use water. For example, houses can only water their garden three times a week and only after dark.

Solution #72

WATER DISTRIBUTION EFFICIENCY

0.66–0.94
GIGATONS
CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

In cities and towns around the world, large pipes move water from sources like lakes and rivers to homes. Before water is moved from its source to the sink, it goes through a water treatment plant. Water treatment plants clean the water so it is safe and drinkable. The full process of moving and cleaning water for our use is called **water distribution**. Companies called utilities do the work to deliver water to homes. Water utilities spend a lot of **energy** and money to make water drinkable and available in homes and businesses. The World Bank says that almost 9 trillion gallons of water are lost from leaks all over the world every year. That means that a lot of energy and money used to clean and move that 9 trillion gallons of water also gets wasted!

Two Types of Pipe Problems

There are two types of water distribution problems: large breaks in pipes and small leaks in pipes.

Large breaks or bursts in water pipes are so large that they can flood streets. Large breaks seem like they would be very wasteful, but surprisingly they are not. Larger breaks in water pipes are visible because people can see the water rushing around above the ground. As a result, they are quickly fixed. Small leaks that nobody notices are actually the bigger problem. This is because most of the time, small leaks are never seen and can leak for years and years. Ultimately, small leaks are the bigger waste of water and energy.

It is very expensive and wasteful to use electricity to clean the 9 trillion gallons of water that never make it into homes and businesses because of leaks. The lost water and electricity means that a lot of extra **carbon emissions** are released into the air because most electricity is made from burning **fossil fuels**. We can improve water distribution if leaks are fixed. This will save water and money AND reduce carbon emissions!

It costs a lot of money to fix both big and small leaks. Yet, if we fix leaks now we will save money in the future as our population grows. When we fix leaks, we also make sure water systems can store water for us when there are droughts.

Water pipeline: *Large pipelines carry water from the sources to cities and towns for people to use.*

Water pipeline: Linnaea Mallette on Public Domain Pictures

Photo by Recover Green Roofs

Solution #73

GREEN AND COOL ROOFS

0.6–1.1
GIGATONS
CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

Green roofs can simply have a layer of grass or moss over them. Or, they can hold entire parks, farms, and gardens.

Buildings have roofs to protect us when we are inside. Roofs block weather, like snow, rain, and wind, from coming inside. They also help block out the sun and heat. While roofs protect us, they also can make buildings much warmer by absorbing heat. To make sure the roofs of our building don't make our buildings too hot, we can replace traditional roofs with **green roofs** or **cool roofs**.

What are green roofs?

Green roofs have soil and plants on them. These plants:

- Help the earth by absorbing **carbon dioxide**
- Keep the house cool during summer and warm during winter.
- Lower heating and cooling costs

The soil and plants on top of green roof buildings keep the temperature comfortable inside by helping the inside temperature be different from the outside temperature. This is called insulation. Houses and buildings have insulation in their walls and below the roofs to keep extreme heat and cold outside. Insulation from green roofs saves **energy** by keeping down the costs of heating and cooling homes and businesses.

Green roof installation: *In order to turn a traditional roof into a green roof, grass and plants must be installed on the roof.*

White roofs: *Roofs that are painted white reflect more heat back into space than roofs that are darker colors. This keeps the house inside much cooler.*

How are cool roofs different from green roofs?

Cool roofs are able to reflect (throw back without absorbing it) almost all of the heat that a roof is exposed to from sunshine. They can reflect a lot more heat than both traditional roofs and green roofs. Usually, traditional roofs absorb (take in) a lot of the sun's heat because they are made of asphalt shingles, stone or metal. A traditional roof can absorb up to 95 percent of the heat from sunshine, and only send 5 percent back to space.

A cool roof can reflect about 80 percent of the sun's heat back into space! Cool roofs make buildings, and even cities, cooler because heat doesn't get trapped; it gets reflected away! Figure 1 shows how cities trap more heat than other places. If you have ever been in a city during the summer, you know how hot it can be! Cool roofs not only keep people cool during summers, but they also save energy.

Figure 1 shows how the heat from the sun can affect rural and city areas differently. Dirt ground is more likely to reflect the heat from the sun, while paved city roads trap heat, making cities hotter overall. Green or cool roofs can help reflect the heat from the sun as well.

How can we get more of our roofs green and cool?

Right now, architects (people who design buildings) and builders (people who construct buildings) may not want to use green or cool roofs because they cost a lot of money to build. Here are two ways to make these designs more popular:

1. Create policies and laws that give people money to build green and cool roofs
2. Create policies that require buildings to have green or cool roofs

White roofs: *The Christian Science Monitor*
Green roof installation: *Corey Seeman on Flickr*

Solution #74

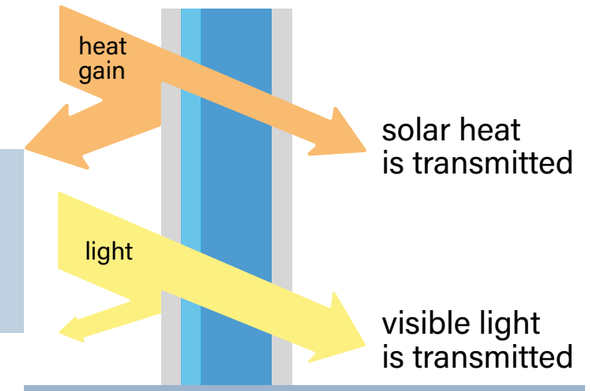
DYNAMIC GLASS

0.29-0.47
GIGATONS
CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

Glass windows were once something that only people with a lot of money could have. Now, most homes and buildings around the world have glass windows. Windows help bring in light and give people a view of the outside world. Though windows do their best to keep the weather out of a building, many windows still let in some heat or cold. Windows are much thinner than walls and they have less insulation. Insulation helps keep the temperature of a room constant.

Even though windows are not as **energy efficient** as walls, there are many ways to make them more efficient. For example, high-performance windows use:

- Multiple layers of glass
- Reflective coatings to reflect the sun's rays
- Gases that provide insulation between the layers of glass and heavily sealed window frames.



Smart glass diagram: *Smart glass helps keep buildings cool on hot and sunny days by keeping light and heat from entering through the windows.*

Smart Glass

A new type of window is made of "smart glass." The special glass lets windows respond to different amounts of sunlight and weather outside of a building! This means that they can help buildings save energy. Smart glass uses chromism. Chromism is a process that allows glass to change color. Smart glass can change its colors with just a little bit of electricity. When the glass needs to change color, a small bit of electricity shocks the glass. Ions, which are small particles, are electrically charged and carry energy. When the glass gets shocked, the ions jump to a new layer of the glass, which causes the glass to change color.

Smart Glass Options

There are different types of smart glass. Thermochromic glass changes color based on how hot it is outside of a building. The hotter it is outside, the darker the glass will turn in order to block out the heat. When less heat energy enters a building through the windows, you do not need to use as much electricity to keep the inside of the building cool. There are also photochromic windows. These are similar to thermochromic glass but they change color based on how sunny it is outside and not how hot it is outside. We do not see more smart glass windows in buildings because they are very expensive to make. Hopefully they will become less expensive in the future and we will see them used in more buildings.

Photo by Markus Winkler on Unsplash

Solution #75

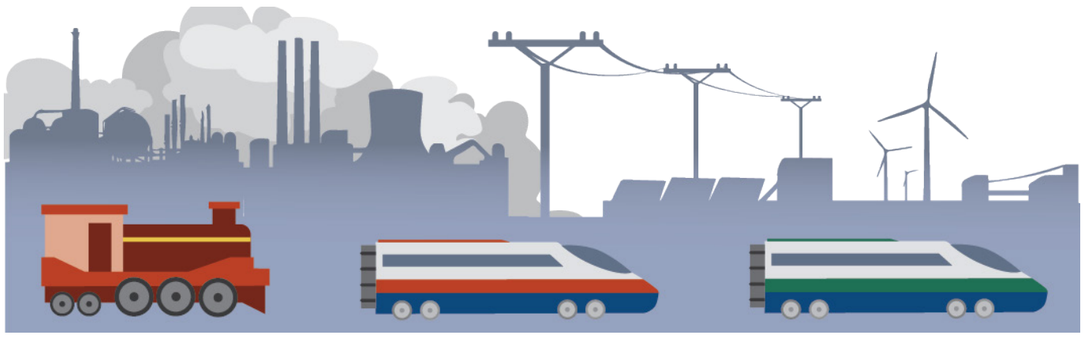
ELECTRIC TRAINS

High speed electric trains are one of the fastest ways to move people long distances.

0.1-0.65
GIGATONS
CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

People use trains to move from place to place. Each year, people around the world take about 28 billion train trips. Trains do not only move people; they also move a lot of different products, like food, toys, cars, and building supplies. Trains move 12 billion tons of products each year.

A lot of trains get the energy to power them by burning **fossil fuels**, such as coal and diesel. When trains burn fossil fuels, they create **carbon emissions**. In 2013, trains that burn fossil fuels created 3.5% of carbon emissions within the entire transportation sector (all trucks, cars, buses, trains, airplanes). Some newer trains are powered by electricity - an energy source that can produce less polution.



How can we make trains better?

Many people work to find ways for trains to use less energy. When trains use less energy, they cost less to operate and they use less fossil fuel. Newer trains move faster than traditional ones because they are more aerodynamic.

KEY WORD

aerodynamic
Aerodynamic describes the shape of the trains and means they can move through the air and wind without using a lot of energy.

Aerodynamic train: *High speed trains have been made so that they will move through the air faster than regular trains.*

Sometimes newer trains use both electricity and fossil fuels; these are known as hybrid trains. Hybrid trains use 10 to 20 percent less fuel than traditional trains.

We can make trains lighter so they use less fuel to travel from place to place. Engineers can make better rails, or tracks, for trains. Better rails help trains move smoothly, quickly, and with less energy. Computer software can also help trains use even less energy.

Each year, train companies make more electric trains. At the same time, people are increasing the amount of **renewable energy** that is available, such as solar energy and wind energy. This is important, because when trains run on renewable energy, they do not release carbon emissions.

Renewable energy is energy that does not come from fossil fuels. This type of energy does not release carbon into the atmosphere, which means it is not harmful to the planet.

High speed rail: *High speed rail systems can connect cities across the country together. These aerodynamic electric trains provide fast and fuel efficient transportation.*

Aerodynamic train: *Pikrepo*
High speed rail: *Enzo JIANG on Flickr*

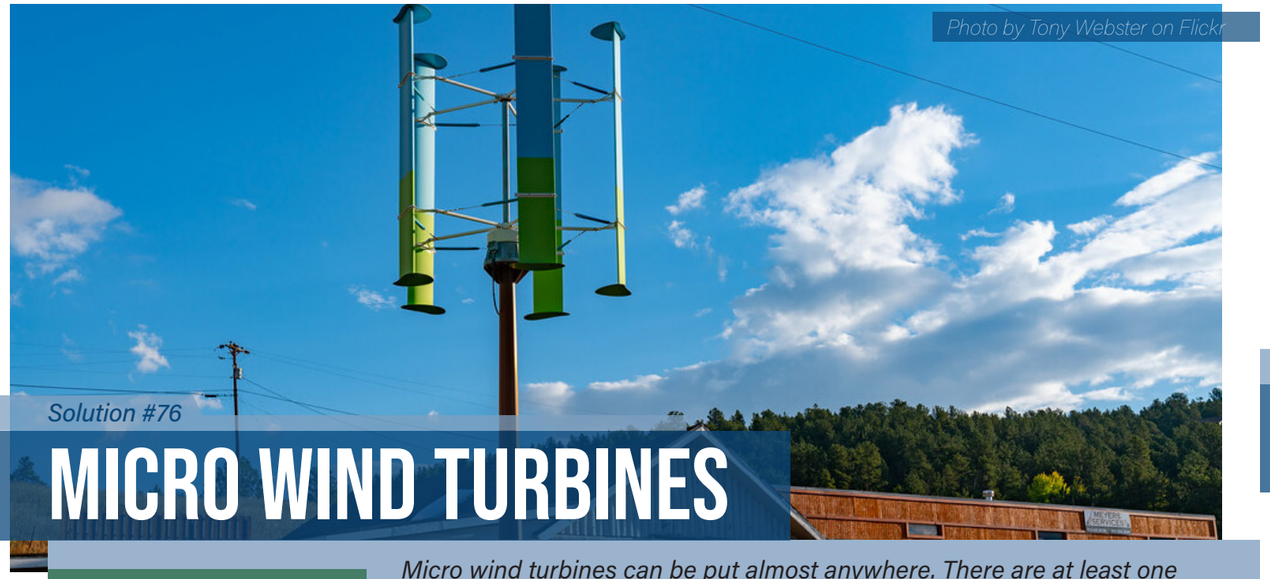


Photo by Tony Webster on Flickr

Solution #76

MICRO WIND TURBINES

0.09–0.13
GIGATONS

CO2 EQUIVALENT REDUCED / SEQUESTERED (2020–2050)

Micro wind turbines can be put almost anywhere. There are at least one million micro wind turbines in use around the world.

Wind turbines, look like giant fans. Their blades move in the wind to create **electric energy**. Many people may recognize the giant wind turbines that sit in big fields. But there are smaller wind turbines too, called **micro wind turbines**. Because they are smaller, micro wind turbines make less energy. But, they can make enough energy to help a family charge batteries, pump water or power lights and stoves. They can be easily built in small towns and on small farms. There are at least one million micro wind turbines in use around the world today.

Why aren't there more micro wind turbines?

One of the big reasons why people do not use more micro wind turbines is money. Micro wind turbines can be expensive to build and install. Also, people have to pay more for each kilowatt (unit) of energy made by the micro wind turbine as compared to larger wind turbines. People only start to save money after having a micro wind turbine for a while.

Why are micro wind turbines a good thing?

In some areas of the world, people do not have access to electricity from a large electrical network. They often make electricity for their homes by using gasoline generators or they light their homes with lamps that run on **fossil fuels** and cause pollution. Micro wind turbines can provide people who live in these areas with **renewable energy**. This renewable energy gives people electricity to light their homes and to cook more safely at home. Using micro wind turbines can help lower the amount of pollution people make.

Micro wind turbines are not just found by small family homes. They can also be found on top of skyscrapers, such as the Eiffel Tower! This means that tall buildings can also use clean energy from micro wind turbines.

Photo by Lucian Alexe on Unsplash

Solution #77

BUILDING RETROFITTING

CO2 EQUIVALENT REDUCED / SEQUESTERED NOT CALCULATED (SEE DRAWDOWN.ORG FOR MORE INFORMATION)

Most buildings were not made to be conserve energy. We can make buildings better for the planet with impovments on the inside.

There are many types of buildings around the world, such as homes, schools, grocery stores and skyscrapers. Buildings use 32 percent of the total energy used around the world. Because they use so much energy, buildings also produce 19 percent of **greenhouse gas emissions**. People use energy in buildings in different ways. For example, people use electricity or natural gas to heat and cool the air and to power lights. They also use energy to power technologies, like computers and microwaves.

Unfortunately, up to 80 percent of the energy a building uses can be wasted. This can happen when people leave the lights on. This can also happen when buildings have gaps in the walls, windows and doors that don't close all the way, or other problems that let the warmed or cooled air out by accident.

What can we do?

Often, people do not think about fixing old buildings so that they use less energy. Instead, they focus on building better buildings for the future. But that does not always help save energy right now. Retrofitting buildings is a great way to fix that problem! Retrofitting is when you update already built, older buildings to help them save energy. For example, you can replace the windows so air does not escape, replace the old heater or air conditioner, and replace lightbulbs with energy-saving LED bulbs. When you retrofit a building, you do not have to tear it down and build a new building.

Buildings around the world take up 1.6 trillion square feet of space. About 99 percent of the energy buildings use is not **green energy**. This means that the energy comes from sources other than wind and solar energy and can be very polluting. With retrofitting, you can help buildings pollute less. Retrofitting also makes buildings more comfortable for people to be in.

We already know how to retrofit buildings and new technology that helps us understand how buildings use energy is making it even easier. Because it saves energy, retrofitting also saves money. The cost of retrofitting buildings is usually made back in energy savings five to seven years after the work is completed. A recent retrofit of New York's Empire State Building will cut energy use by 40 percent and keep 105,000 tons of greenhouse gas from entering the air!

Solution #78

NET ZERO BUILDINGS

CO2 EQUIVALENT REDUCED / SEQUESTERED NOT CALCULATED (SEE DRAWDOWN.ORG FOR MORE INFORMATION)

A net zero building makes the same amount of energy that it uses. Sometimes during the year, the building will make more energy than it needs. When this happens, the extra energy goes into the energy grid for other builds to use. Other times, the net zero building cannot make enough energy. Then it must get energy from the energy grid. But, at the end of the year, the amount of energy a net zero building takes from the grid is equal to the amount it makes. Aside from a net zero building's ability to power itself, it has other benefits too!

Benefits of Net Zero Buildings

- During natural disasters, like hurricanes or snow storms, sometimes buildings experience blackouts and they have no power for lights, air conditioning or heating. During blackouts, net zero buildings often still have power!
- Buildings are often designed to use renewable resources and this helps save energy.
- They are cheaper to take care of!

KEY WORDS

energy grid
The path for energy to go from where it is made to your home, your school, restaurants, and offices. It is a path connected to places and buildings all over a city, town, or county.

blackout
A total crash of all power when nothing on the 'energy grid' works.

Characteristics of Net Zero Buildings

Here are some characteristics of net zero buildings.

- **Daylighting:** Buildings have a lot of big windows so sunlight brightens a room rather than people using light bulbs.
- **Maximum insulation:** Insulation helps buildings use less energy by keeping them warmer in the winter and cooler in the summer.
- **Electrochromic glass:** This type of glass can be electronically controlled to let in more or less light depending on whether the building needs to be warmer or cooler. It can be controlled automatically, or by people in the building.
- **Passive solar design:** As the seasons change, the sun moves higher or lower in the sky. Passive solar buildings are positioned and built so that they let in winter sun and keep out the summer sun. Letting in sun during the winter helps to warm the inside of a building when it is cold outside. Keeping the sun out during the summer helps to keep the inside cool.
- **Advanced heating and cooling:** There are many different ways to heat up and cool down buildings. Advanced heating and cooling technology works to use as little energy as possible to make the building temperature comfortable for us.

Recently net zero buildings have become more common. Only a few years ago they were very rare. Architects have designed and built amazing net zero buildings all over the world. There is even a Walgreens pharmacy in Chicago that is net zero! Entire net zero neighborhoods and communities are being built too. New net zero buildings even try to be net zero in water and waste. They can collect water from rain and turn sewage into compost inside the building!

Photo by Fré Sonneveld on Unsplash

Solution #79

GRID FLEXIBILITY

Power lines make up a grid across that country that stores and sends electricity for everyone to use

CO2 EQUIVALENT REDUCED / SEQUESTERED NOT CALCULATED (SEE DRAWDOWN.ORG FOR MORE INFORMATION)

Electricity is an energy source that most people on earth use everyday. Eighty-five percent of people get their electricity from the grid. The grid is where electricity is made, stored and moved until it is used. The grid was made before **renewable energy** was common. Because of this, the grid only really works for the movement of electricity made from sources like coal, gas, and nuclear power. Because energy from the sun and wind do not happen all of the time, they do not work well with how the grid is organized. If people want to use more **renewable energy**, there needs to be changes to the grid. It needs to be much more flexible.

How can the grid be more flexible?

Some technologies that can help the grid be more flexible are:

- **Constant Renewables** use **renewable energy** like geothermal that is always available.
- **Utility-Scale Storage** use large-scale storage like special materials that store heat (like molten salt) or that store energy by moving water (like pumped hydro)
- **Small-Scale Storage** use small-scale storage like batteries.
- **Demand-Response Tools** use new technologies like smart thermostats or appliances because they can change how much electricity someone uses in their home.

For the grid to be more flexible than it is today, we need ways to move energy quickly and evenly across the grid. Larger and more connected grids allow more types of energy sources, including renewable energy. Good weather forecasting and prediction can help us to predict when and where the most renewable energy will be created.

Solar panels and wind turbines get a lot of attention because they are the most well-known technologies for creating renewable energy. We also need flexible grids to help make solar and wind energy available for everyone.

Photo by Cem Ersozlu on Unsplash

Solution #80

MICROGRIDS

CO2 EQUIVALENT REDUCED / SEQUESTERED NOT CALCULATED (SEE DRAWDOWN.ORG FOR MORE INFORMATION)

Microgrids are effective in cities because this is where a bunch of people live in a small area.

Today, 85% percent of the world's users of electricity get their energy from macrogrids. Macrogrids are huge systems that sometimes stretch across entire countries. Through macrogrids, electricity is made, stored and moved to be used. However, most macrogrids were made before **renewable energy** sources were common. Because of this, they only work well with constant movement of electricity made from sources like coal, gas, and nuclear power. This makes it hard to include power from renewable sources in macrogrids.

What are microgrids?

To help solve this problem, microgrids were created. These are much smaller systems that can provide and move energy around in a small area where people live. Microgrids work well with renewable energy sources like **solar and wind energy**. They are designed to store and keep energy available in a small area even when the sun isn't shining and the wind isn't blowing. Places that use microgrids can often also plug into macrogrids in case they need more electricity.

Where can microgrids be used?

Because microgrids are built for small communities, they don't have to store or move huge amounts of energy. Microgrids can connect with many different power sources. They are easier to maintain and repair than macrogrids.

Microgrids can help people who live in places that don't have access to macrogrids. Currently, 1.1 billion people don't have access to power. Many of them live in sub-Saharan Africa and Asia. In places without big cities or a lot of money, microgrids are a great solution to provide electricity. They are cheaper to build and easier to set up than bigger power systems.

Solution #81

DISTRIBUTED ENERGY STORAGE

CO2 EQUIVALENT REDUCED / SEQUESTERED NOT CALCULATED (SEE DRAWDOWN.ORG FOR MORE INFORMATION)

There is an energy transition happening. The world is moving from **carbon-based fuels** to **renewable energy** sources. There are many ways for people to get renewable energy. They can have rooftop solar panels on their houses or small wind turbines on their land. Sometimes, people can gather so much energy that they sell it back to the power company!

Batteries for Energy Storage

The sun doesn't always shine and the wind doesn't always blow. It can be useful to store energy for later by putting it into large batteries. With batteries, people will have energy when they need it.

There are two main systems for charging batteries:

1. Large batteries can be charged and kept inside a home.
2. Renewable energy can be used to charge batteries in electric cars. The car batteries can be plugged in and used to provide power to the house.

Solar panel batteries: *These batteries store the energy from solar panels so it can be used later if needed.*

Both types of batteries help people use renewable energy without connecting to the power grid. Most power grids use **fossil-fuel energy sources** - not renewable energy. Energy storage batteries can help reduce the use of fossil fuels. This will help reduce climate change!

Batteries for Everyone

Batteries used to be very expensive, but they are quickly getting cheaper. Between 2009 and 2016, the cost of one kilowatt-hour (a unit used to measure electricity) went from $1,200 to $200. This is a huge drop! Companies are predicting $50 per kilowatt-hour in a few years. This means that more people will be able to afford battery storage systems very soon. Electric cars are getting cheaper too. This makes it possible for homes to have power from electric cars while they are parked at night.

Car plugged into house: *Right now we mainly charge cars from our houses but technology is developing to charge houses from cars!*

Car plugged into house: *Ed Harvey on Unsplash*
Solar panel batteries: *Stephan Ridgway on Flickr*

UTILITY SCALE ENERGY STORAGE

CO2 EQUIVALENT REDUCED / SEQUESTERED NOT CALCULATED (SEE DRAWDOWN.ORG FOR MORE INFORMATION)

Utilities are companies that produce and sell things like water, electricity, gas and cable. When electricity utilities were built, engineers wanted to make sure people had electricity whenever they wanted it. Sometimes there was not enough electricity. Peaker plants were made to help. These buildings had big machines that made extra electricity when people needed it. Unfortunately, peaker plants create a lot of pollution because they burn **fossil fuels** like coal and gas.

Instead of peaker plants, utility companies can use energy storage units. These units save the extra electricity created when people do not need it so people can use the electricity when they do need it. Energy storage units create less pollution than peaker plants. They can also store **renewable energy**, such as solar and wind energy. Energy storage units can even store energy for many months so can use it at different times of the year.

KEY WORDS

electricity utilities
Electricity utilities are big companies that sell electricity to homes and businesses

peaker plants
Peaker plants are special fossil fuel-burning power plants that make extra electricity for homes and businesses when normal power plants can not make enough

generator
A generator is a machine that converts mechanical energy (like the spinning motion of a fan) into electricity

Power plant burning fossil fuels: *Many power plants create pollution when they burn fossil fuels and release greenhouse gases.*

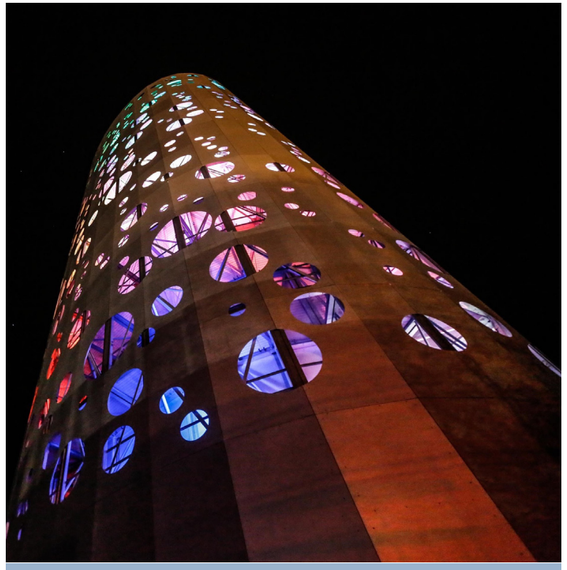
Power plant burning fossil fuels: Max Pixel
Pumped-storage system: Global Water Partnership on Flickr
Thermal energy storage: Bartleby08 on Wikimedia Commons

HOW DO ENERGY STORAGE UNITS WORK?

Pumped-storage Systems

One way to store energy is through the movement of water. These are called pumped-storage systems. These systems use pumps to move water from a lower reservoir to another reservoir that is at least 1,500 ft higher. That is taller than the Empire State building in New York City! When electricity is needed, the water runs down from the upper reservoir to the lower one. Along the way the water hits generators. These generators use the movement of the water to make electricity. Pumped-storage systems are the most popular way to store energy. There are currently 200 pumped-storage systems in the world. These systems make up 97% of the energy storage systems used today.

Pumped-storage system: *Pumped-storage systems use pumps to move water across generators and produce electricity when it is needed.*



Thermal energy storage: *This thermal energy tower was created in 2016 in Italy. It stores enough energy to supply 5,000 households.*

Thermal Energy Storage

A second way to store energy is through thermal energy storage. This means that energy is stored as heat until it is needed as electricity. Some large solar power plants store energy as molten (liquid) salt. In this system, solar energy is used to heat salt until it becomes a liquid. Molten salt can hold a lot of energy. When electricity is needed, engineers make electricity out of the heat energy stored in the liquid salt.

Giant Batteries

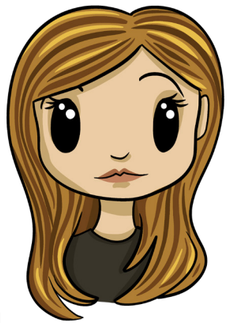
A third way to store energy is in giant batteries! A lot of utility companies like this idea. Some companies are already using large lithium-ion batteries, like the ones in cell phones. One problem is that large batteries are really expensive and they use minerals that are not always safe. Other companies are doing more research to see how they can make large batteries cheaper and more safe. If we can make them safe, more companies can use large batteries to store energy. This will help electricity utility companies around the world pollute less!

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. The creation of this work "Enacting Climate" was supported by Open CU Boulder 2021-2022, a grant funded by the Colorado Department of Higher Education with additional support from the CU Office of the President, CU Office of Academic Affairs, CU Boulder Office of the Provost, and CU Boulder University Libraries. Development of Enacting Climate was also supported by the CU Office of Outreach and Engagement and Inside the Greenhouse.

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

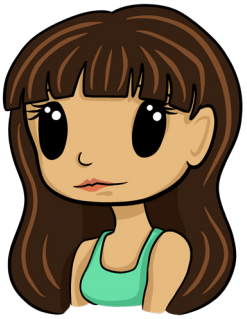
Sarah Manning is a designer and multimedia artist born in California who is currently based in Colorado. She recently graduated from the University of Colorado Boulder with a B.S. in Creative Technology and Design, Cum Laude. Her work combines art, design, and technology in both the analog and digital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

Spanish Translation

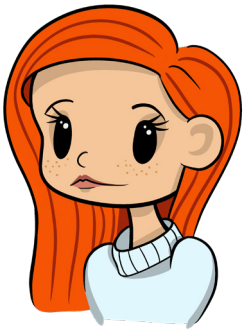
(along with Daniel Garzón, described above)

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



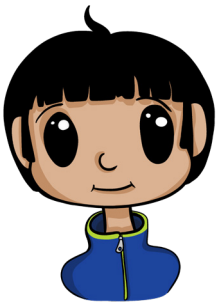
Izzy Sofio graduated from the University of Colorado at Boulder in May 2020 with a B.A. in Environmental Studies, Magna Cum Laude, a minor in Creative Writing, and with a certificate from the Eco-social Justice Leadership Program. She was so happy to be a part of the awesome team that worked so hard 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!



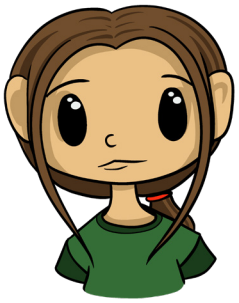
Erzebet Kalwaitis is a recent graduate from the University of Colorado Boulder majoring in Environmental Studies and Geography.

Youth Peer-Review

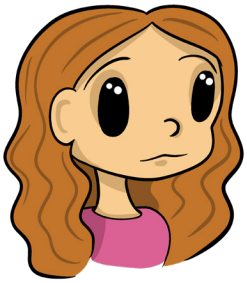
5th Grade Peer reviewers of these adapted climate solutions include **Jaden Chang**, **Luna Fierer**, **Niko Striphas**, **Simone Tewksbury**, **Darya Yazdı**, and **Osel Yeh**, who are all living, learning, and acting up on climate in Boulder, Colorado. Many thanks to each of them and to **Phaedra Pezzullo**--Niko's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



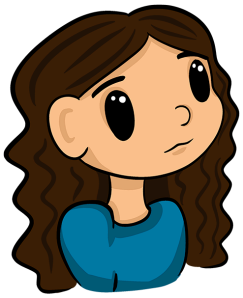
Jaden



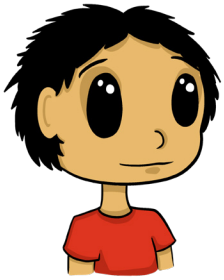
Luna



Simone

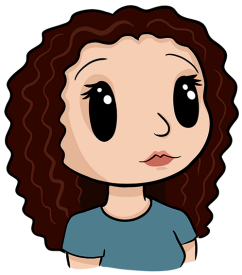


Darya



Osel

Niko



Phaedra

Cartoon portraits by Melisande Osnes