



Energy Guide



from  **Sustainable
Earth**



Welcome to our introduction to energy guide for middle- and high-school students! In this guide, we'll be exploring different types of energy, where energy comes from, how to conserve energy, and energy-efficient alternatives. You'll also learn about the impact of energy use on climate change and how you can help reduce your carbon footprint. So, buckle up and get ready to learn about the amazing world of energy!



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Energy Guide Takeaways

I. Introduction

- Identify what energy is and why it is important
- Find examples of energy used in your daily life
- Develop an understanding of how energy is used and how it impacts our everyday experiences

II. Sources of Energy

- Identify the benefits and drawbacks of renewable and non-renewable energy sources
- Brainstorm examples of renewable and non-renewable energy sources
- Conceptualize how we can transition to renewable energy sources and reduce our dependence on non-renewable sources

III. Conservation of Energy

- Identify what is conservation and why is it important
- Find ways to conserve energy at home or at school
- Develop an understanding of how conservation efforts benefit both the environment and the economy



I. Introduction

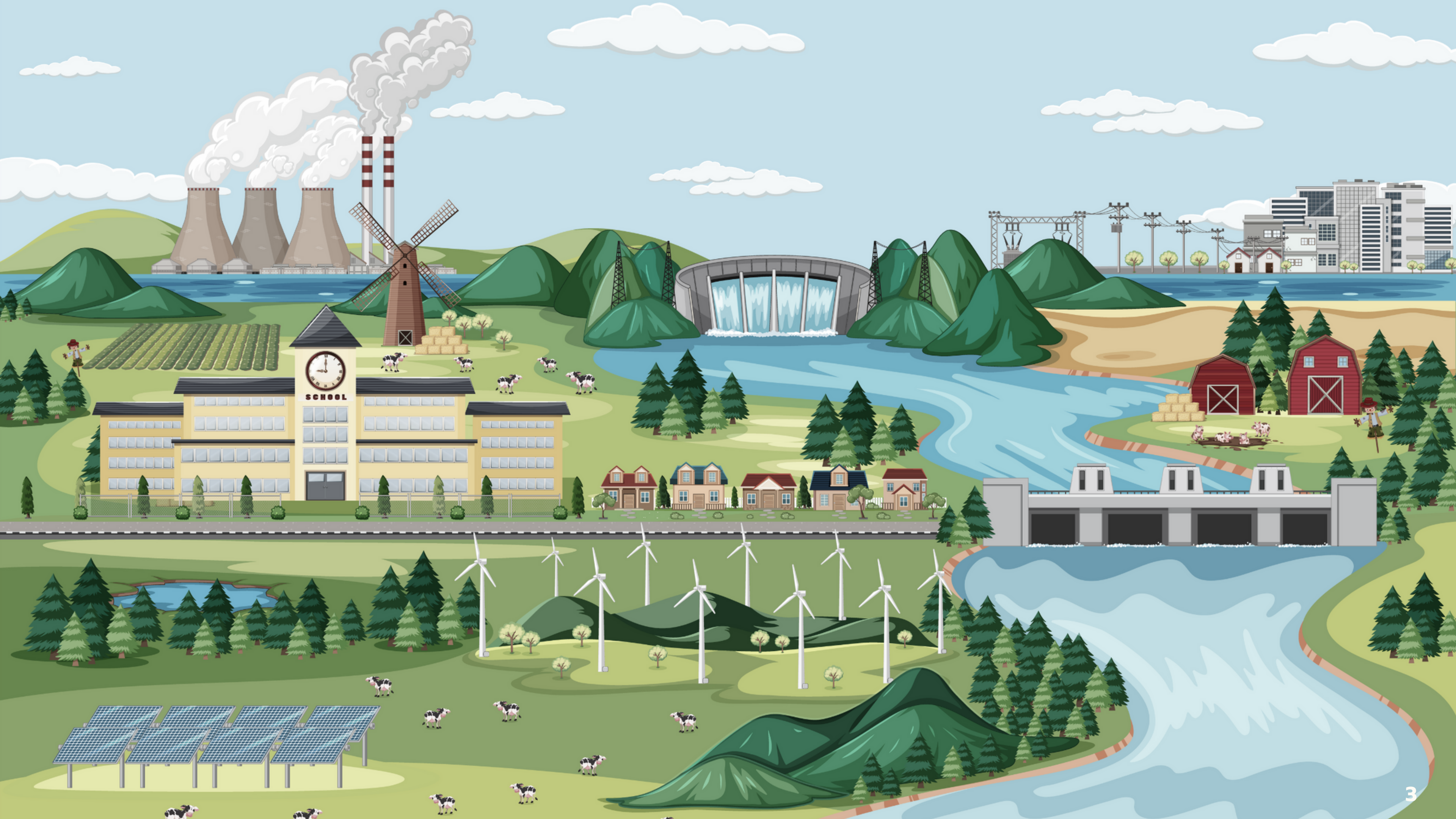
Did you know that the sun provides enough energy to power the entire world for a whole year in just one hour?



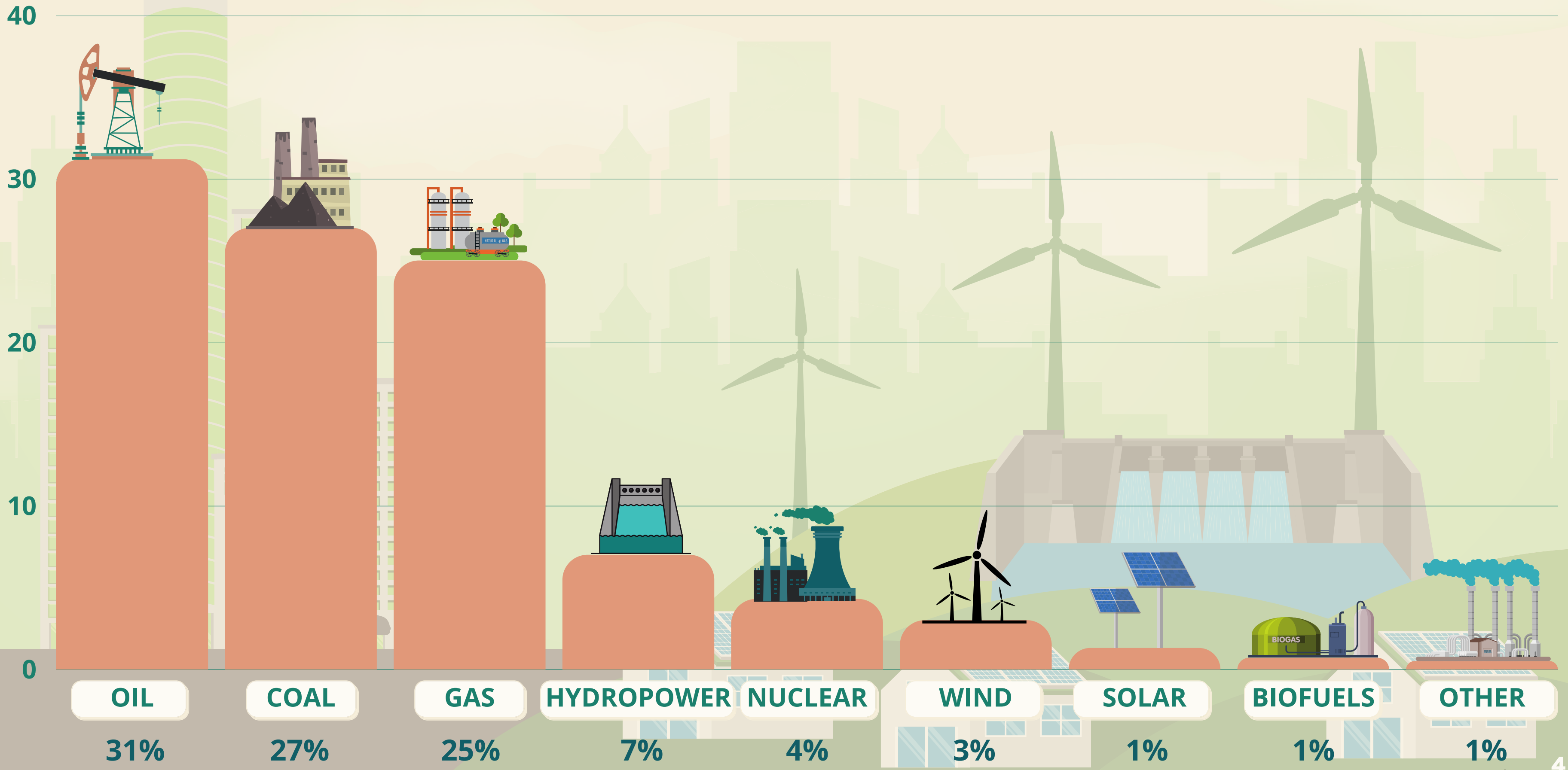
Energy is all around us! It's what makes almost everything work, from our phones to our cars to our homes. But do you know how energy works, or where it comes from? If you're interested in learning about energy and how you can help conserve it, then you're in the right place! Let's explore the exciting world of energy together!

Energy is a fundamental requirement for maintaining life on Earth. It is the basic input in the production of goods and services, and it provides a foundational element for economic development. As such, energy has been a central concern for governments, businesses, and individuals around the world for centuries. Since the 19th century, the use of energy has become a strategic component of human progress.



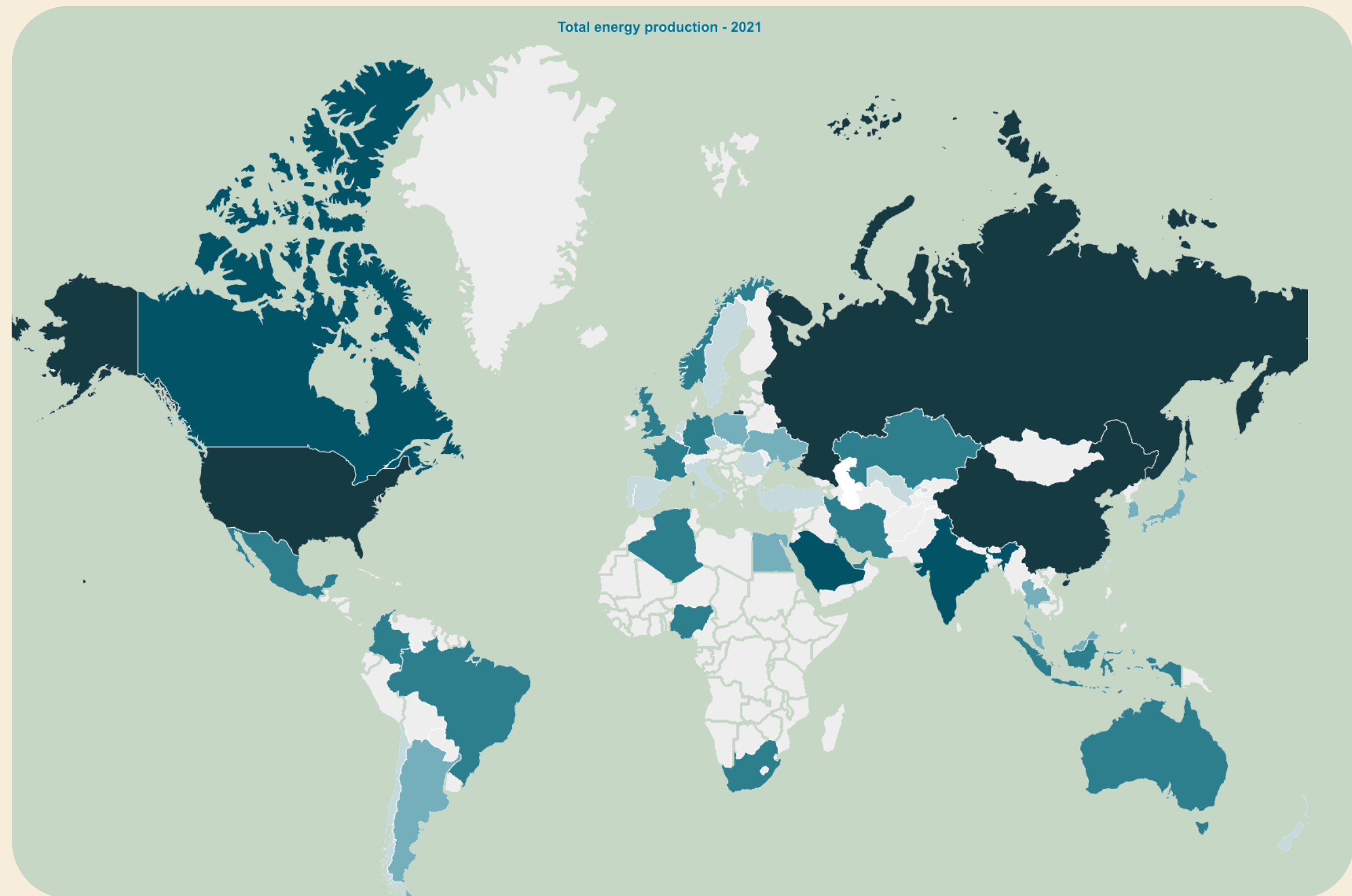


Global energy consumption by source (2020)



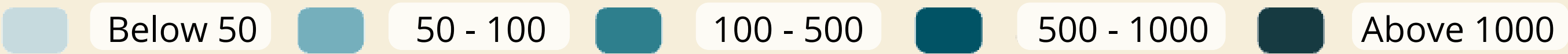
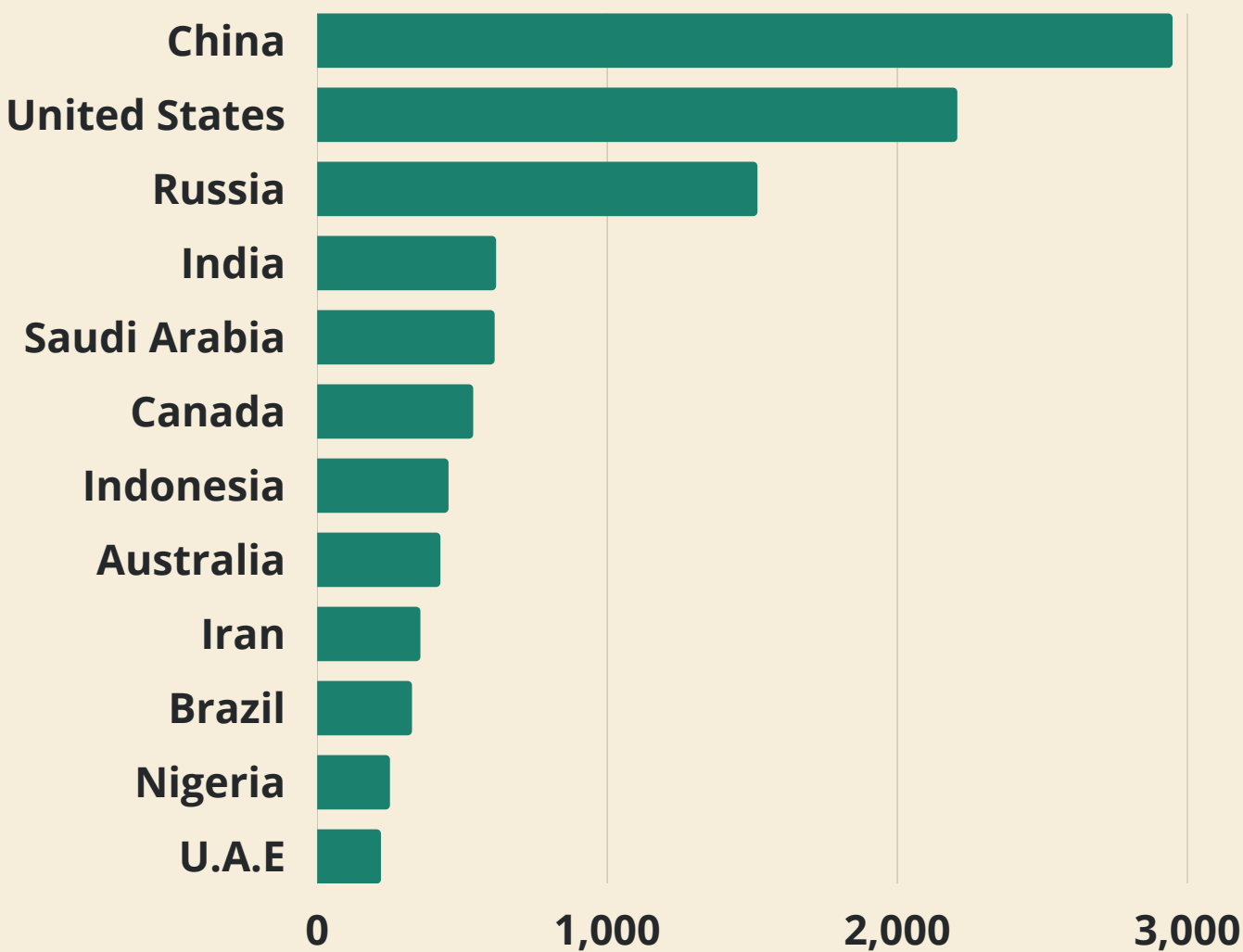
Total energy production 2021

Total energy production - 2021

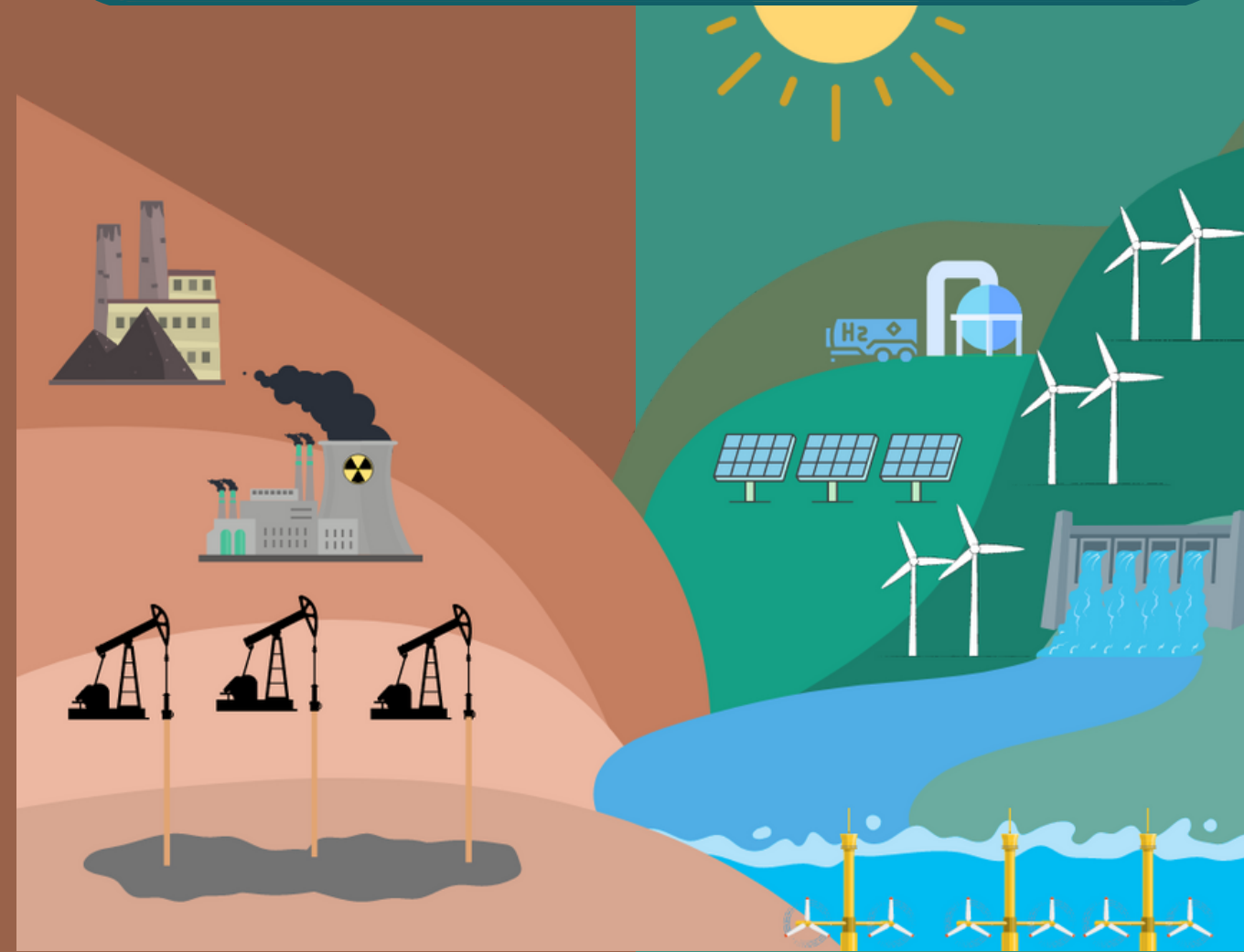


Top countries

Unit : Mtoe (mega tonnes of oil equivalent)



II. Sources of energy

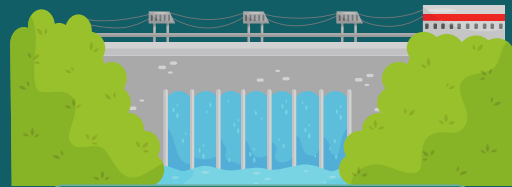


Non-renewable energy

Renewable energy

Understanding the distinction between the various types of energy sources is crucial. Energy sources can be broadly classified into two categories: renewable and non-renewable. While renewable sources of energy can be regenerated, some of them emit significant amounts of carbon. Conversely, certain non-renewable sources of energy can be environmentally friendly with minimal or zero emissions, but they are finite and extraction contributes to environmental issues.

Renewable Energy



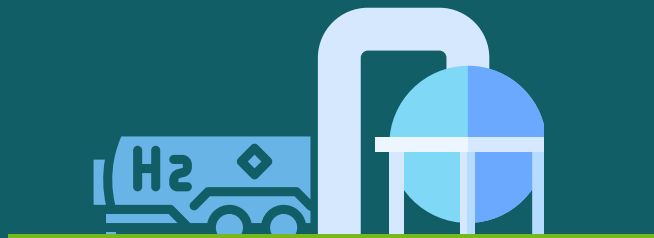
Hydropower energy



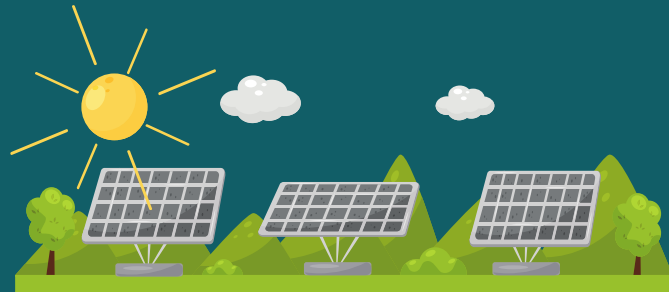
Wind energy



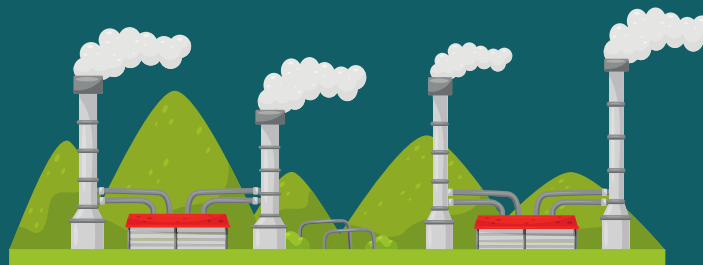
Geothermal energy



Hydrogen energy



Solar energy



Biomass energy



Renewable energy sources are replenished naturally and will never run out. They include solar energy, wind energy, hydropower, geothermal energy, hydrogen energy, and biomass. Renewable energy sources produce little to no carbon emissions and are key to reducing our impact on the environment.

Compare renewable energy sources



Solar Energy
\$70/MWh

Pros:

- Cheap When Produced in Scale
- Environmentally Clean
- Easy to Build New Capacity

Cons:

- Unreliable Production
- Fixed Ability in Generation



Wind Energy
\$55/MWh

Pros:

- Cheap When Produced in Scale
- Environmentally Clean
- Easy to Build New Capacity

Cons:

- Unreliable Production
- Fixed Ability in Generation



Biomass Energy
\$90/MWh

Pros:

- Uses Organic Material
- Environmentally Clean
- Reduces Material in Landfill

Cons:

- Uses Lots of Land
- Difficult Storage



Hydro Energy
\$60/MWh

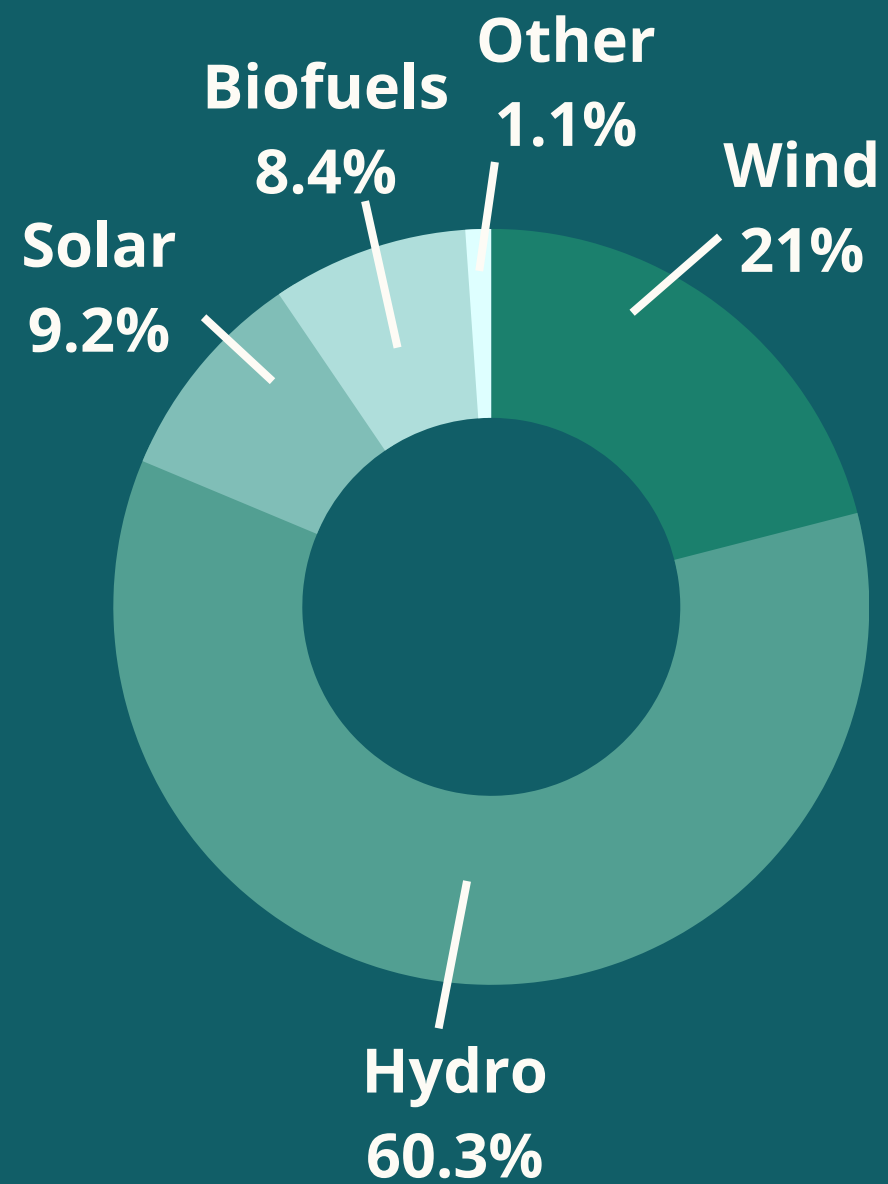
Pros:

- Very Cheap Energy
- Environmentally Clean
- Quite Reliable Production

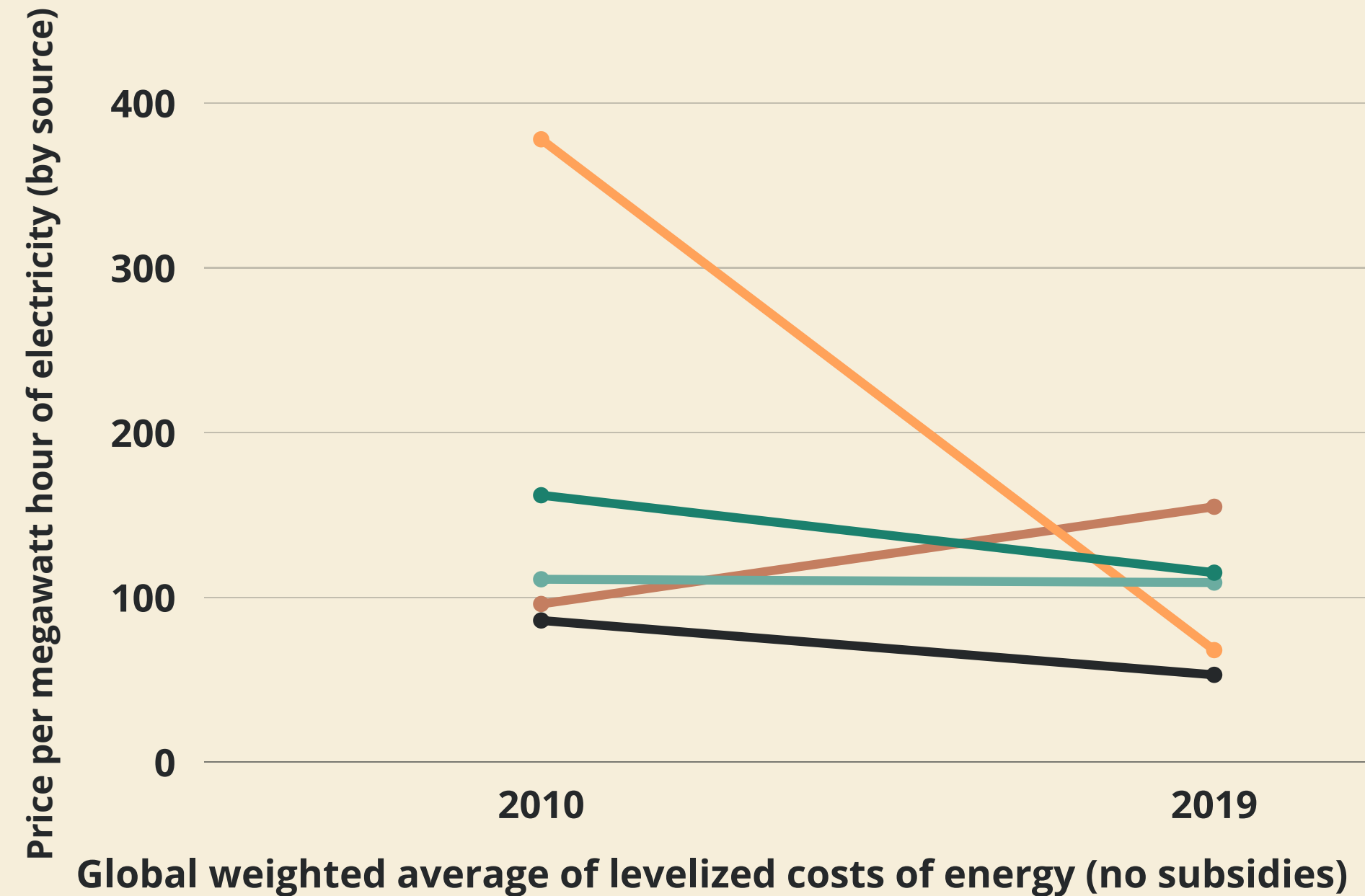
Cons:

- Expensive to Build
- Large Local Impact
- Disrupts Ecosystems

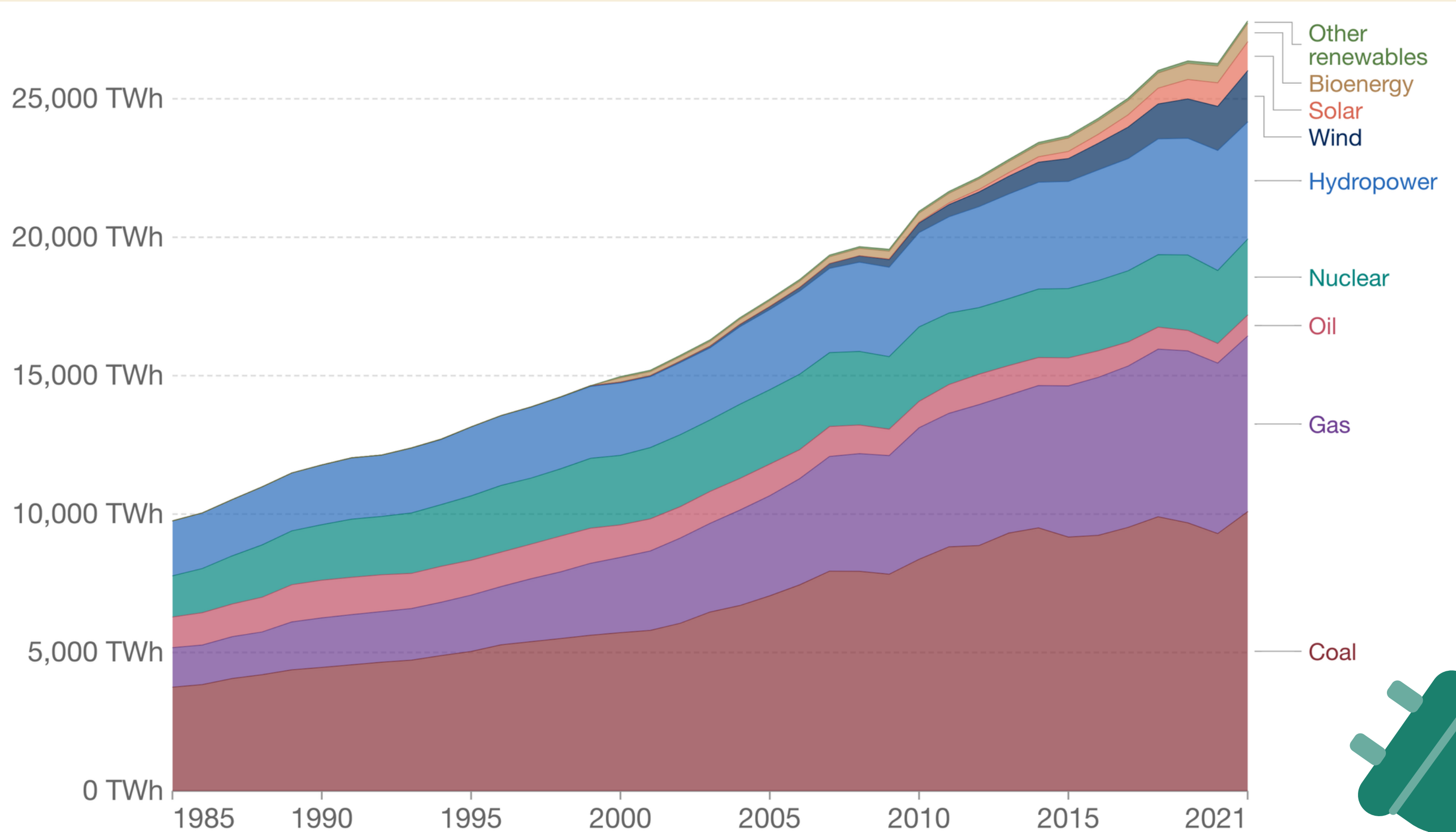
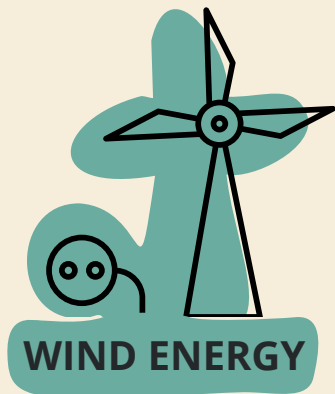
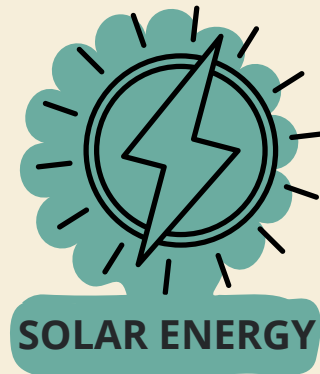
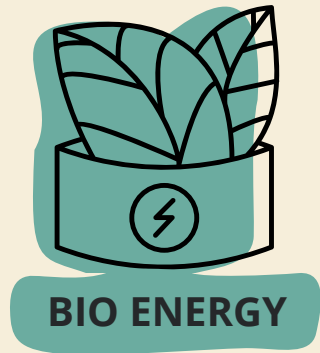
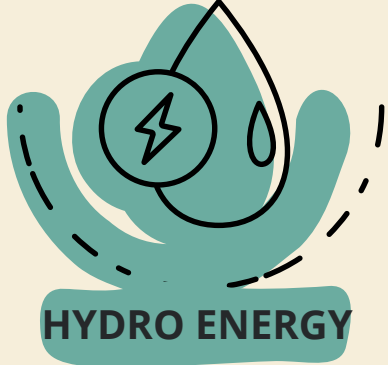
Renewable sources generating electricity globally, 2018



The falling cost of renewable energy

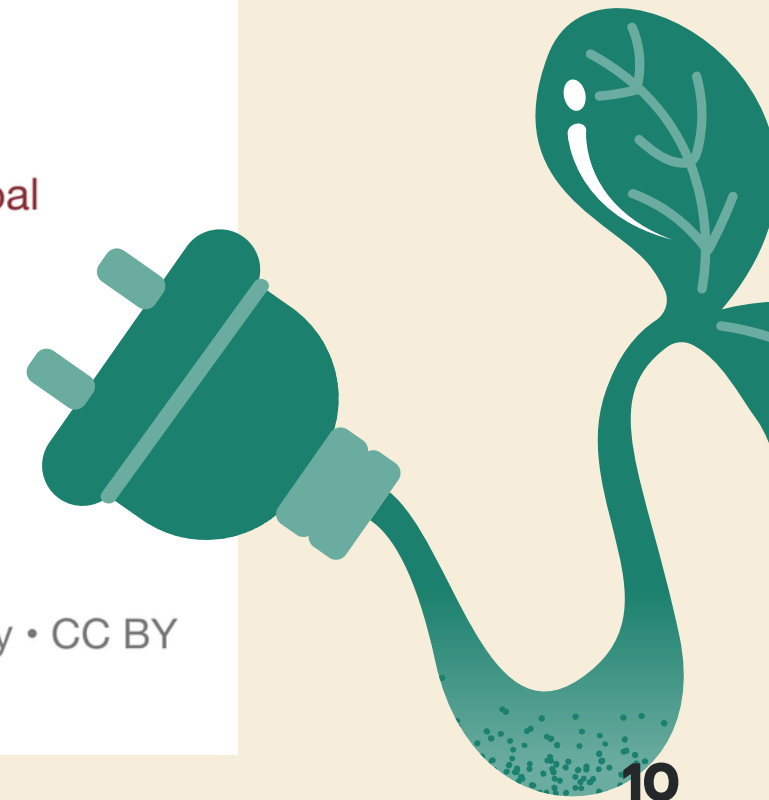


Production of Renewable Energy



Source: Our World in Data based on BP Statistical Review of World Energy (2022); Ember (2023)
Note: 'Other renewables' includes waste, geothermal, wave and tidal.

OurWorldInData.org/energy • CC BY

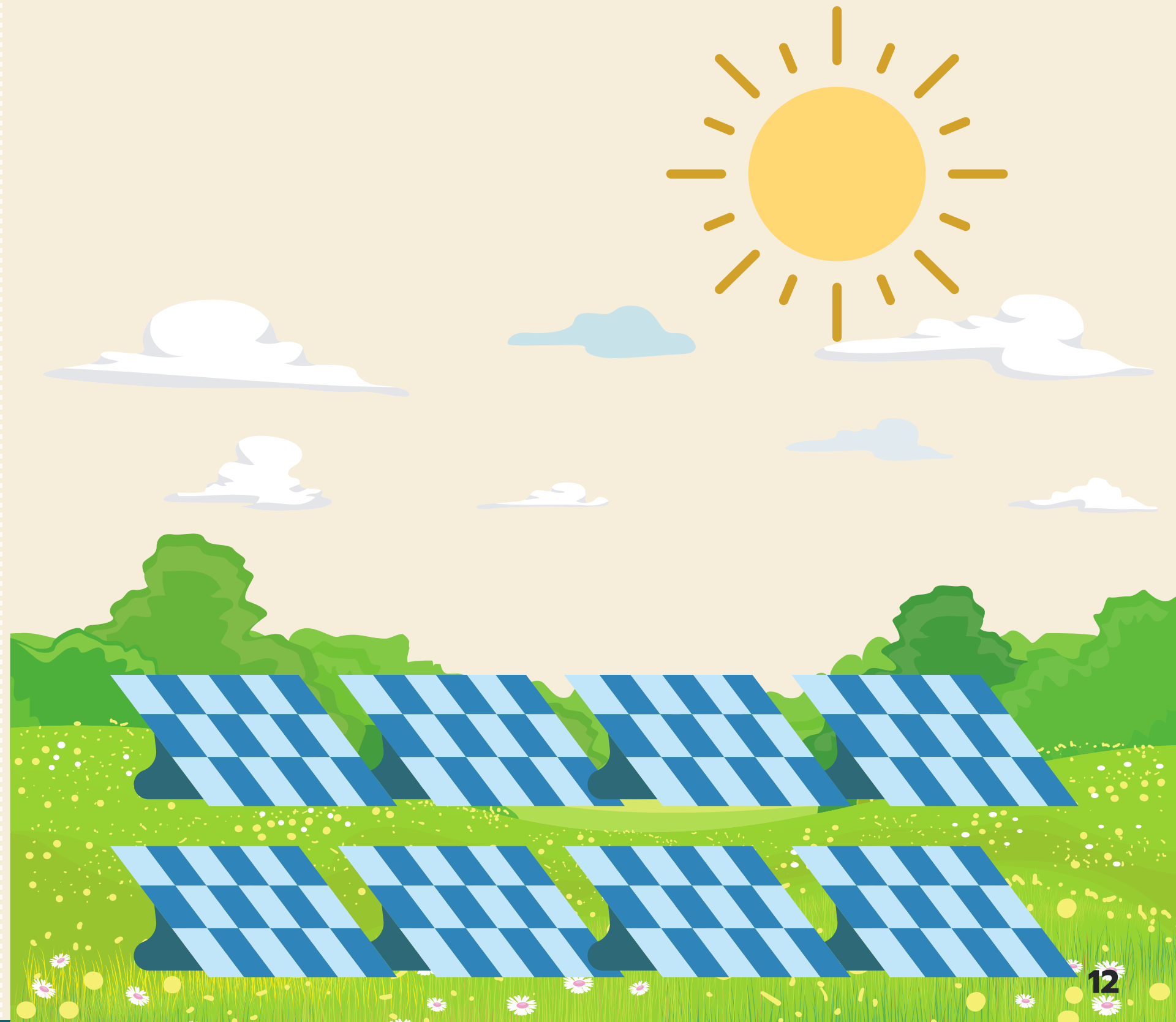




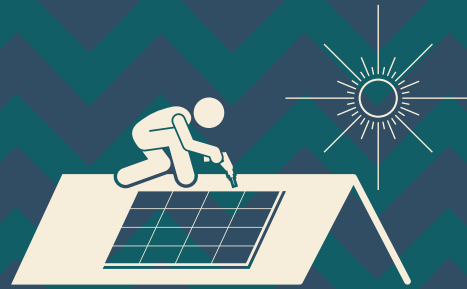
Solar energy



The **sun's** energy is turned into **electricity** and **heat** energy by solar panels.



Technology has increased the efficiency of solar cells by more than 5% over the last decade

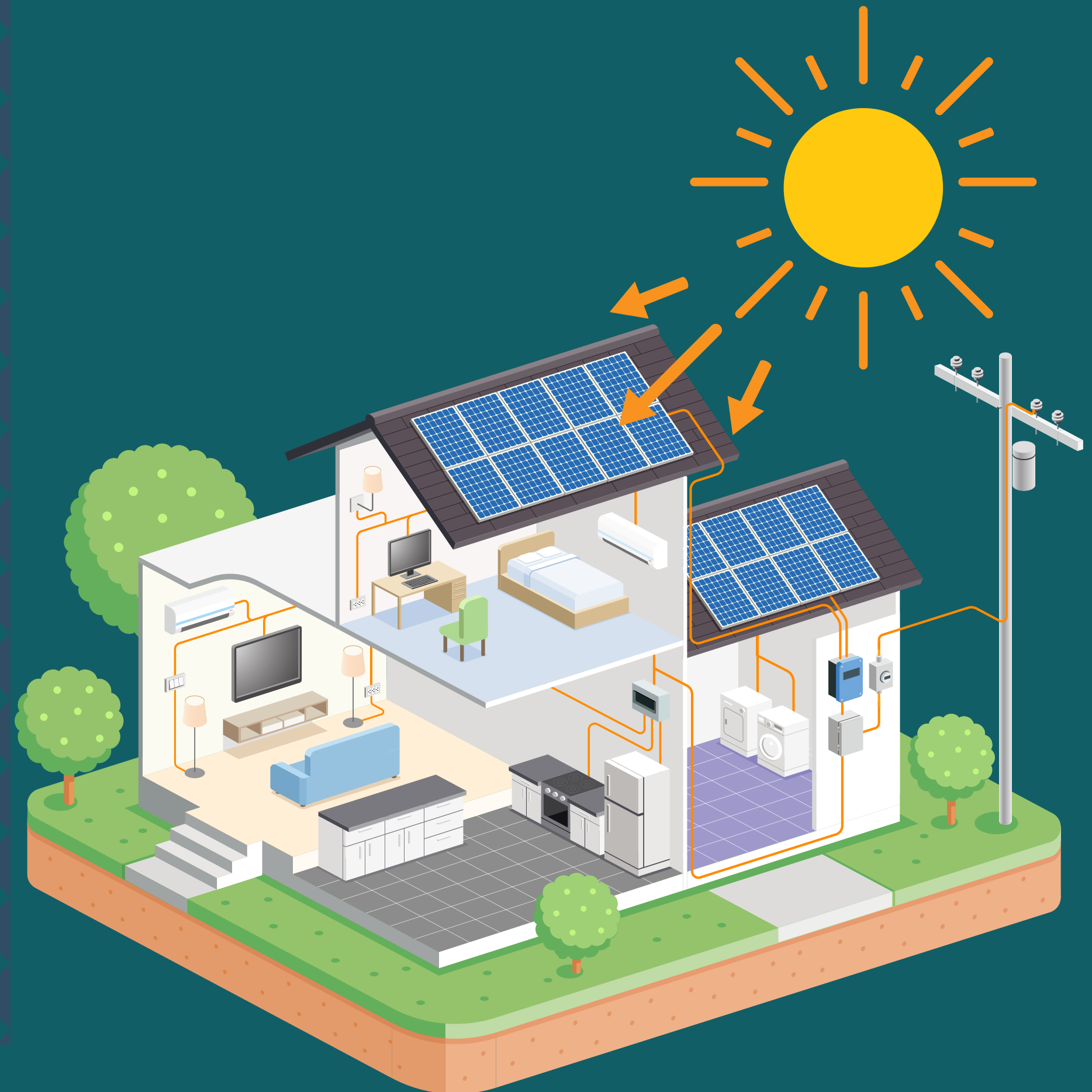


The cost of installing solar energy has fallen by 70% in the past 10 years

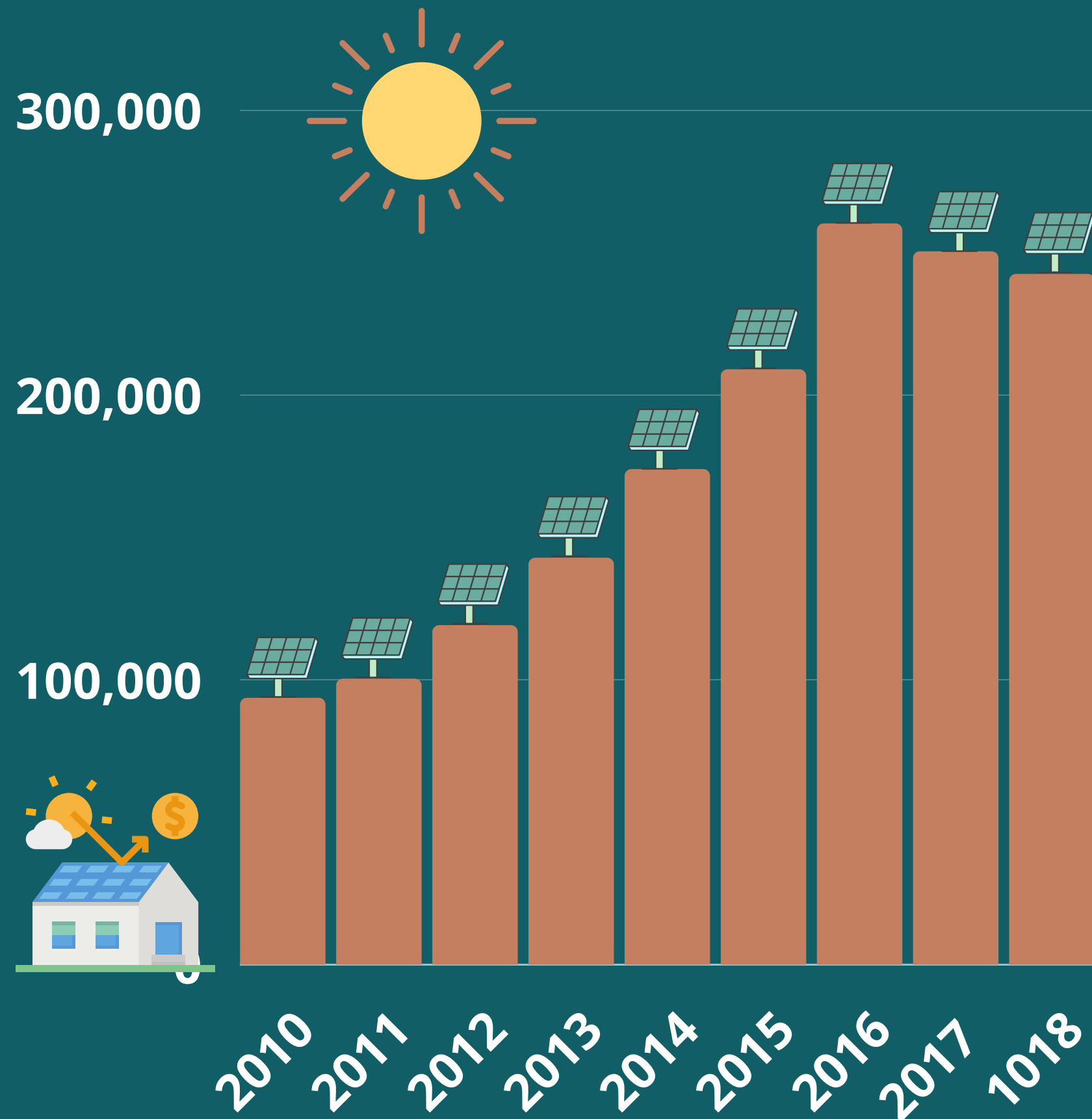
The United States creates enough solar energy annually to power over 21.8 million American homes



Less than 1% of commercial businesses in the US use solar power



Solar Jobs in the United States



Solar energy is a renewable and clean source of energy. It is a form of alternative energy that does not pollute the environment. Solar power is generated by using photovoltaic cells to convert sunlight into electricity.

The solar panels are installed on the roof or on the ground and are connected to an inverter, which converts direct current (DC) electricity from the solar panels into alternating current (AC) electricity for use in your home or business.

The benefits of solar energy are that it is **clean and renewable**. The disadvantages of solar power include high installation costs and reliance on sunlight to generate electricity. Solar battery storage is needed to use electricity at night.



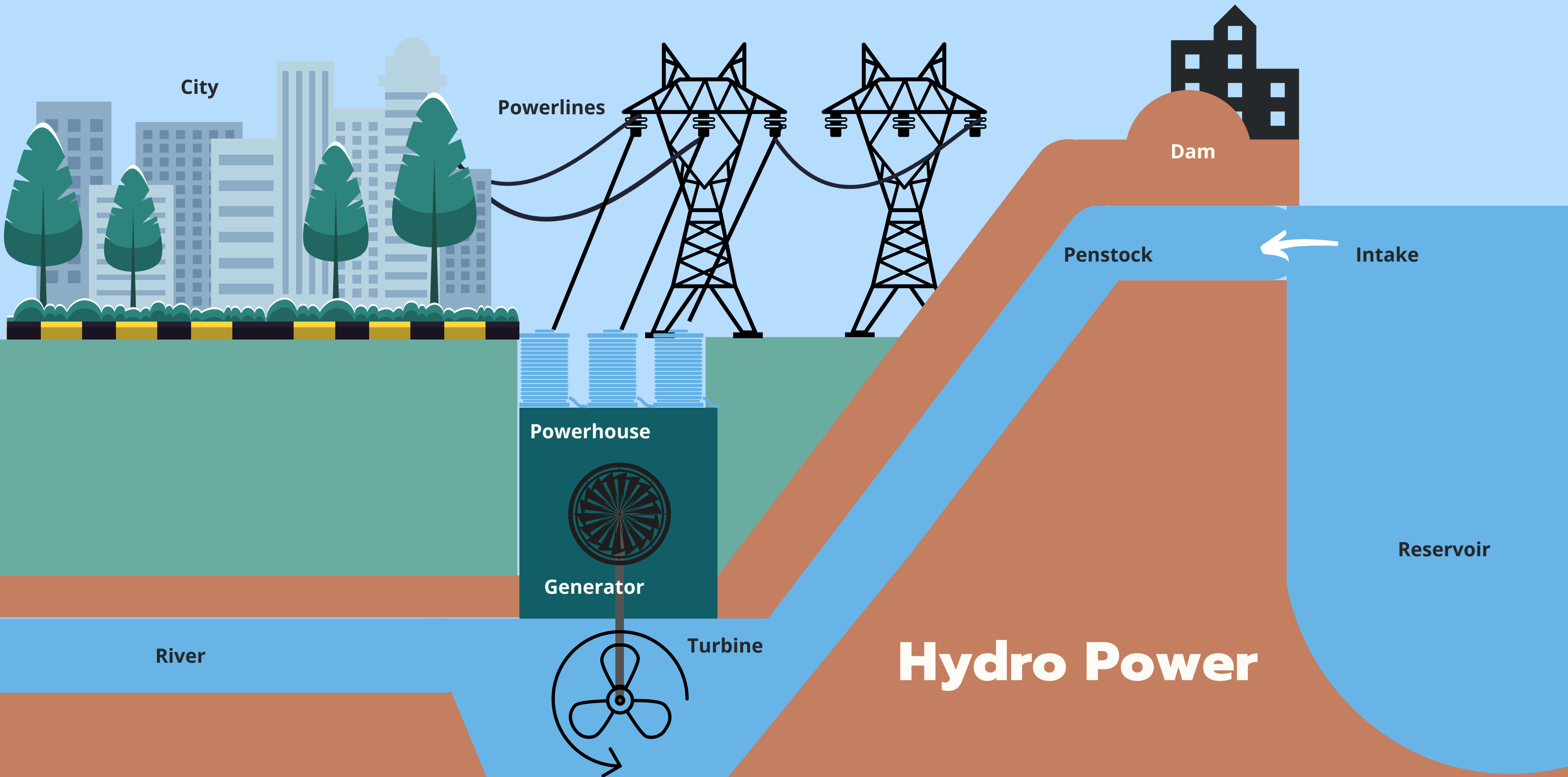


Hydro- energy



Gravitational potential energy of **water** converted into electrical energy through a hydraulic turbine

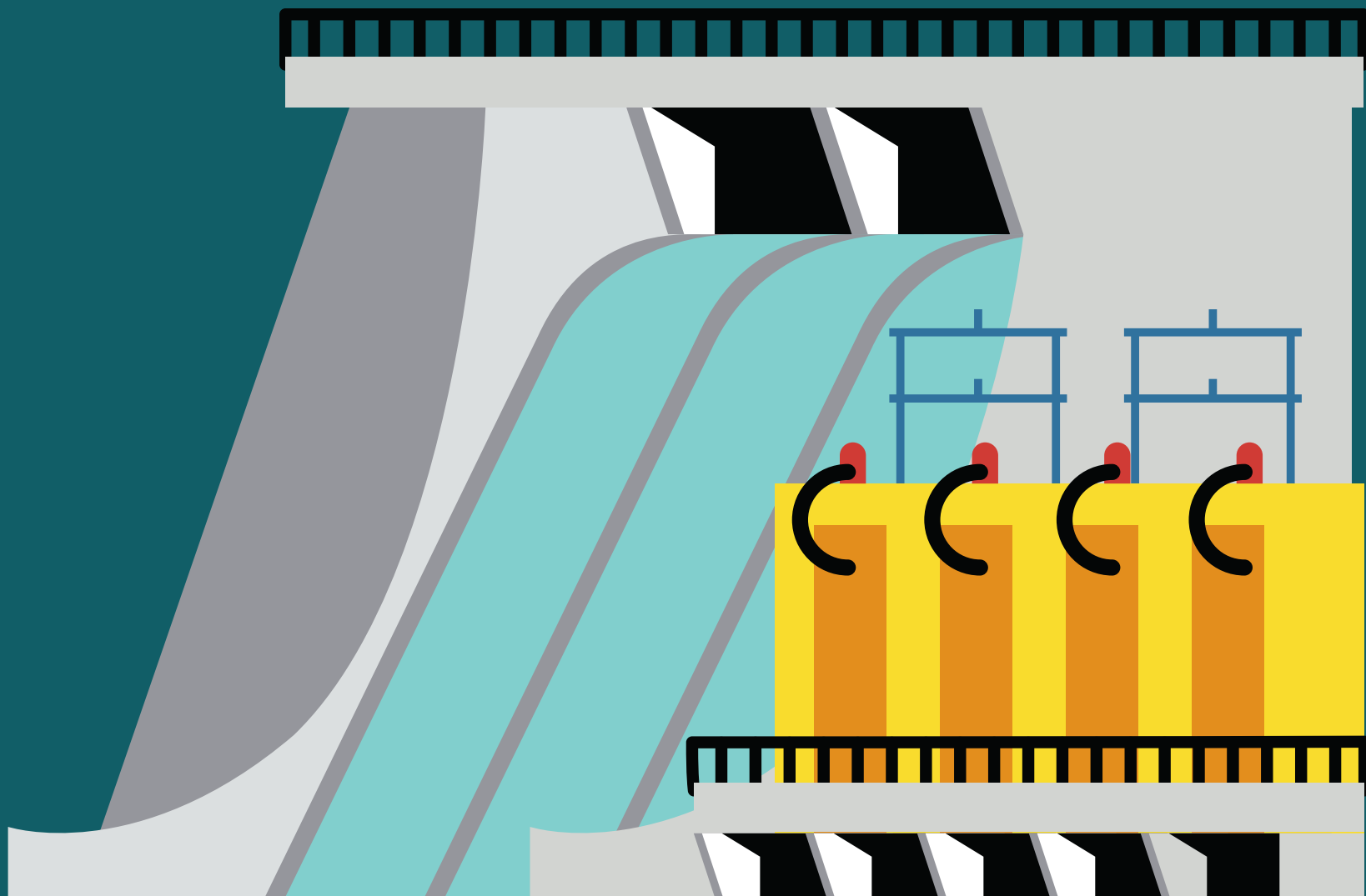




Hydro energy is a renewable source of energy because it is generated from flowing water.

The hydroelectricity industry has been around for more than 100 years. The first modern use of hydroelectricity was in 1882 when water was diverted from a river and used to turn a turbine that generated electricity. The process used to generate hydroelectricity has not changed much since then, but the turbines have become much more efficient and powerful.

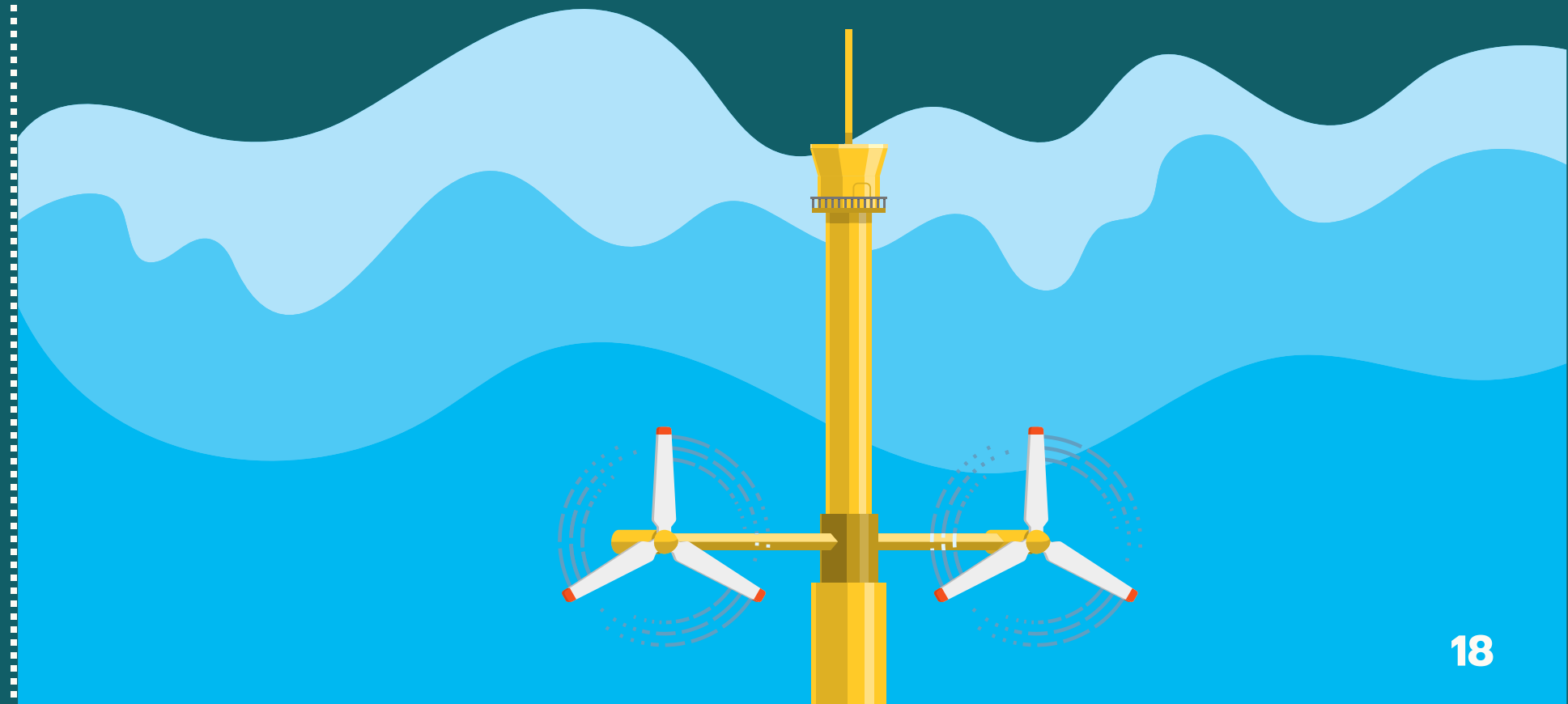
The cost of hydroelectricity has decreased significantly over the last few decades, making it an attractive option for many companies looking to switch away from traditional sources of power.



Hydroelectricity currently provides about **16% of all electricity generated globally**. Countries with high levels of hydroelectricity production include Canada, Norway, and Brazil. Hydroelectricity is the most widely used form of renewable energy.

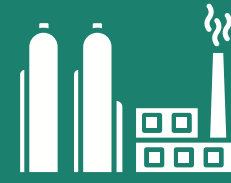
Hydropower is generated in hydroelectric power plants and tidal energy options. Tidal energy uses the natural rise and fall of tides to generate kinetic electricity.

Pros of hydro energy include its renewable nature, relying on a consistent water supply, and its potential for long lifespans, with hydroelectric power plants often operating for 50 to 100 years or more. However, cons of hydro energy include potential ecosystem disruption, significant upfront costs for construction, and vulnerability to droughts and changing environmental conditions.

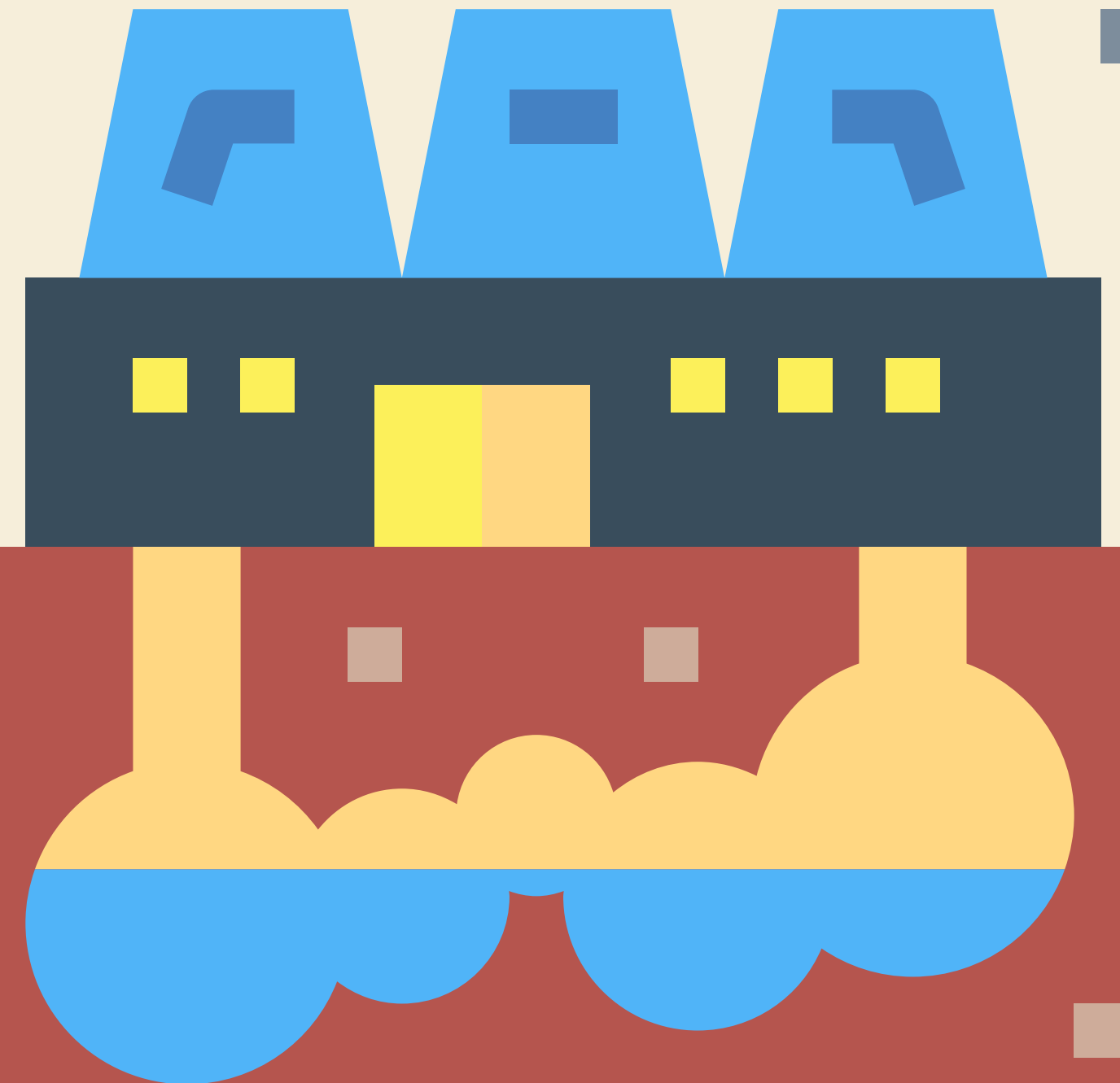




Geothermal energy

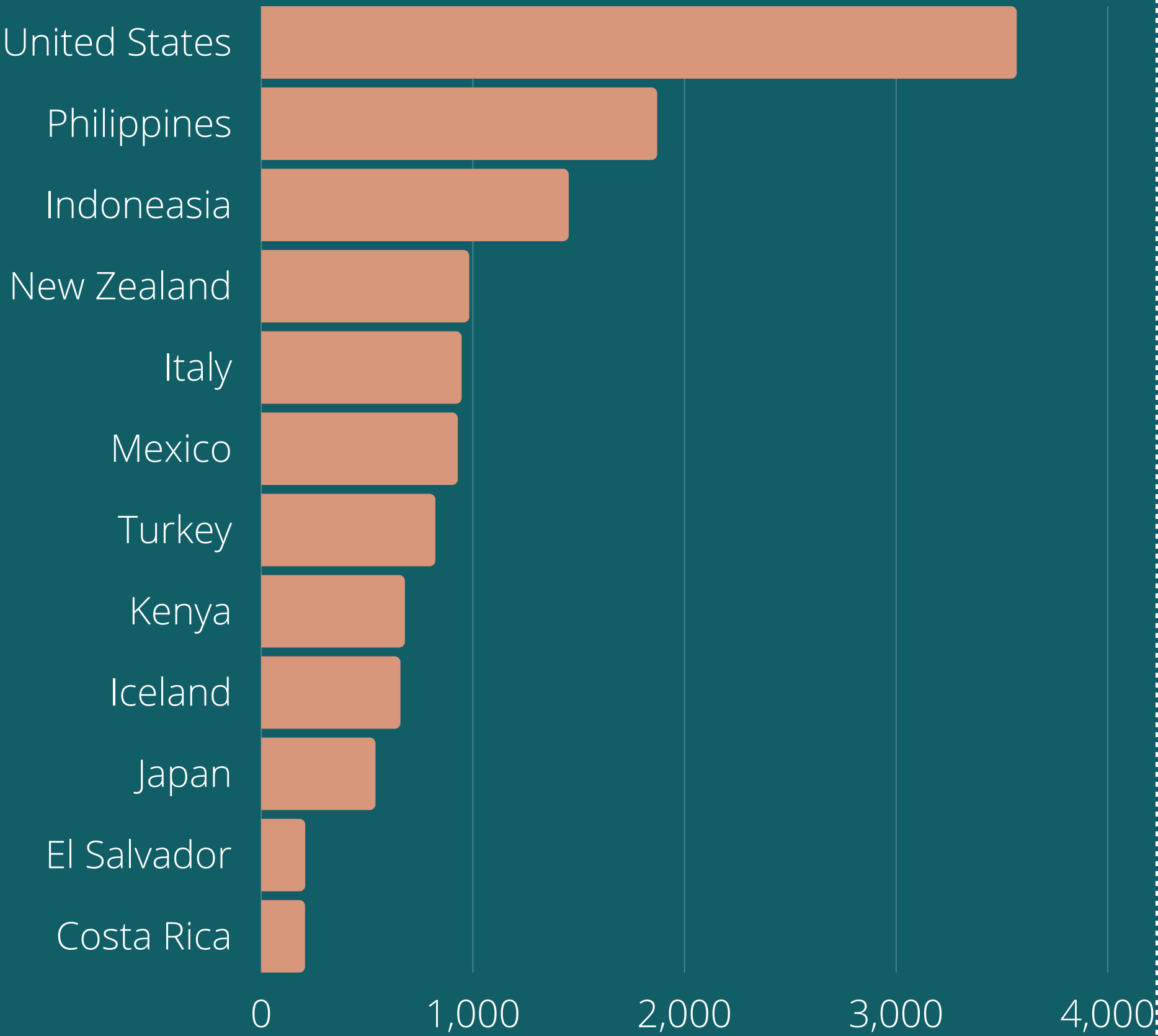


Heat energy trapped underneath the earth's crust converted into electricity by steam turbines



Geothermal Countries

Installed power generation capacity (Jan 2017)



source: ThinkGeoEnergy

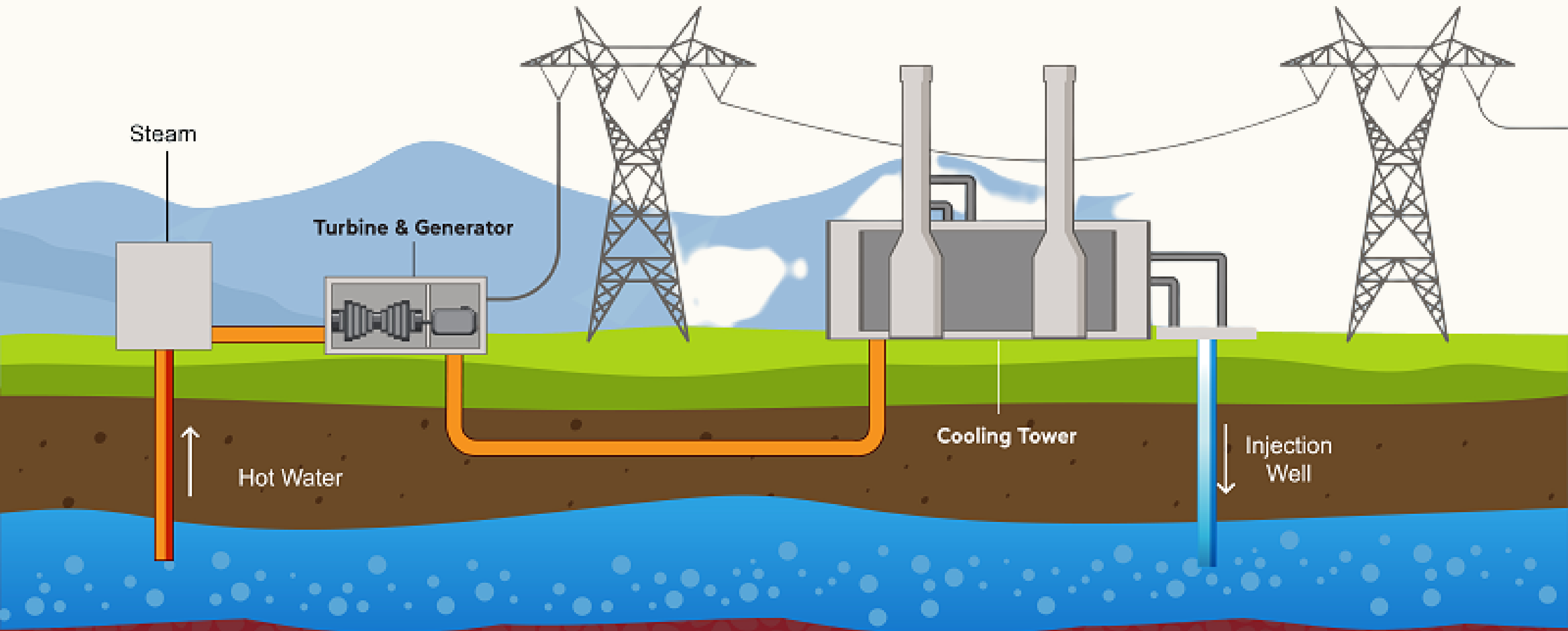
Geothermal energy is the heat that comes from within the Earth. The **heat is created by the decay of radioactive elements in the Earth's crust and mantle**. It provides a renewable energy source that can be used for heating buildings, producing electricity and more.

In order to use geothermal energy, we need to drill deep into the earth and find hot water or steam. The hot water or steam turns into steam when it reaches the surface of the earth. The steam can turn a turbine into a power plant which then generates electricity.

The first geothermal power plants were built in 1891 in Larderello, Italy, and at Wairakei in New Zealand. **In 2013, geothermal power provided about 3% of total world electricity production and 13% of global renewable electricity generation.**



Geothermal Energy System

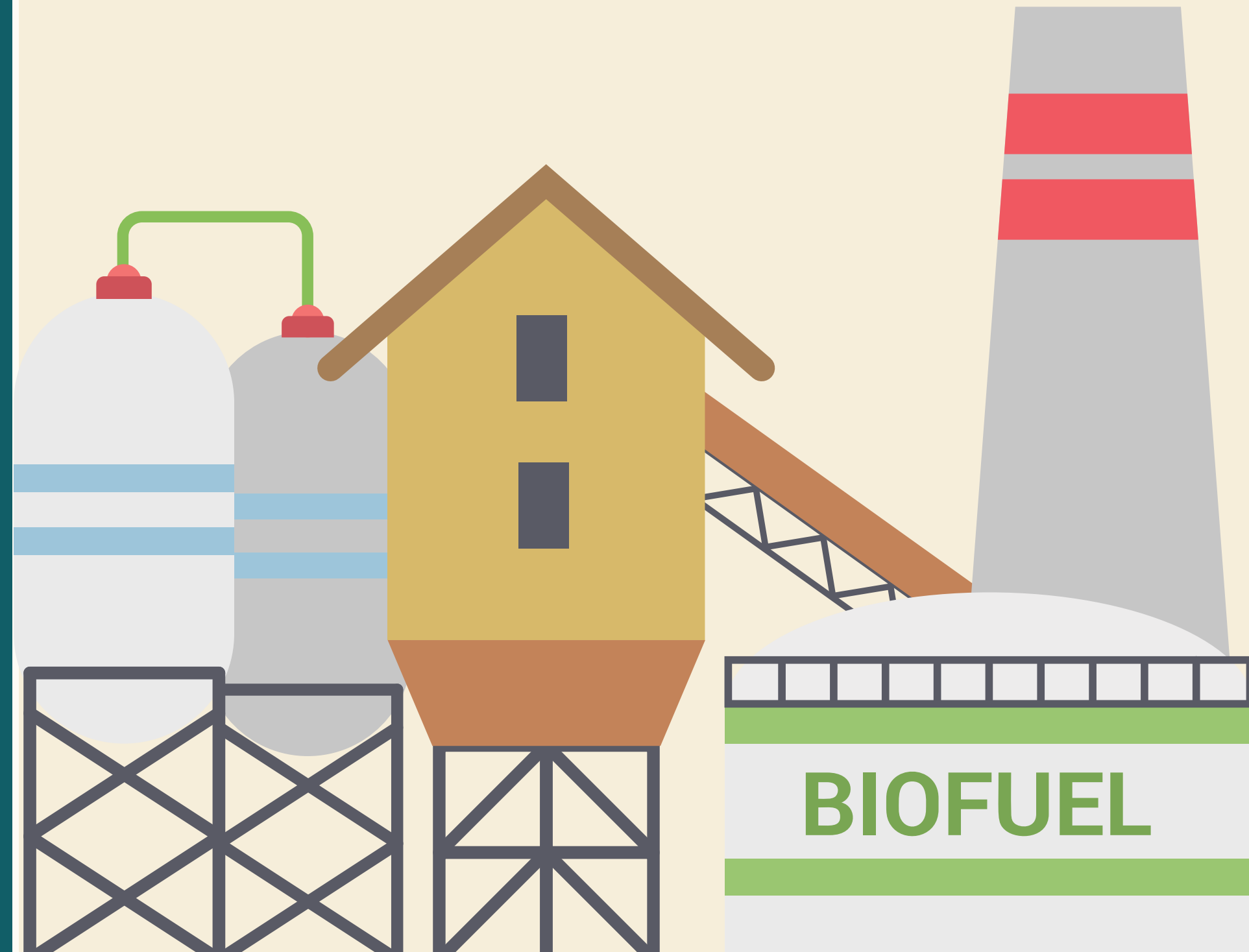




Biomass energy



Energy obtained from plant and animal remains. Eg. burning wood produces heat energy





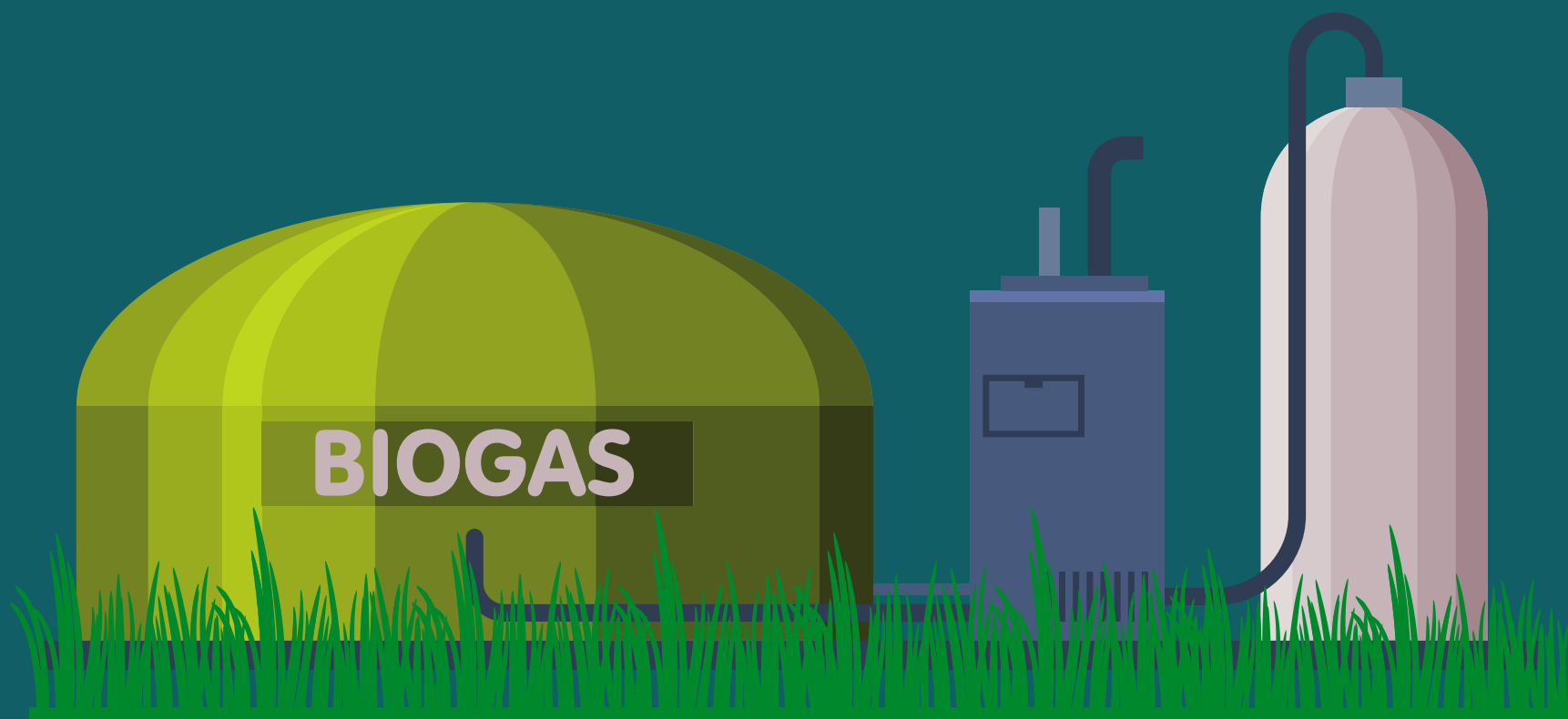
Biomass is the organic material derived from living, or recently living organisms such as plants and animals.

It can be used to produce a number of different products including heat, electricity, and fuels such as biodiesel and biogas.

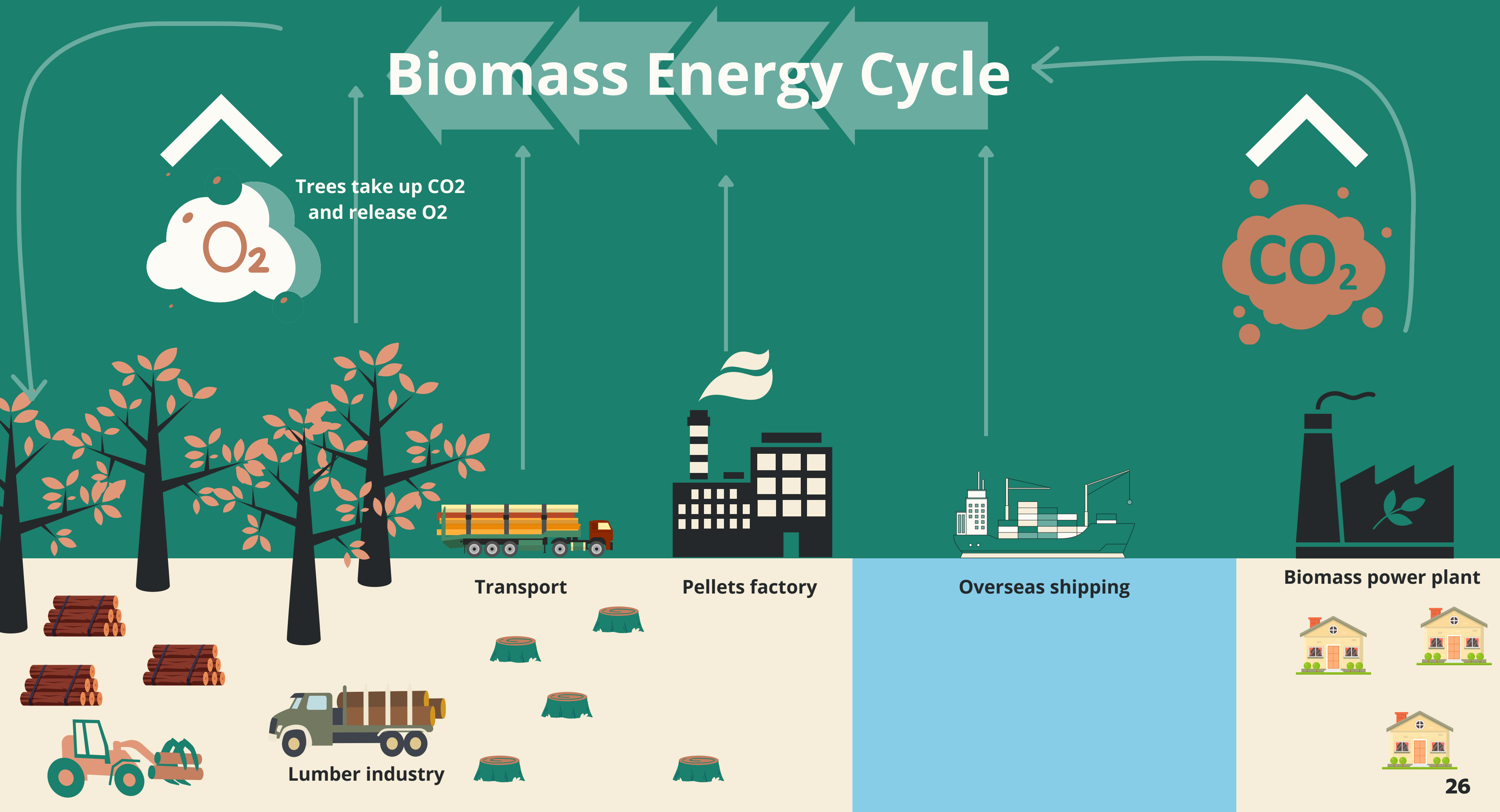
Biomass power plants are a type of thermal power plant that uses a renewable fuel source such as wood chips, straw, or maize cobs to produce electricity.

The biomass energy industry is growing quickly. As of 2017, biomass accounted for about 8% of total global final energy consumption.

Biomass power plants produce less pollution than fossil fuel-powered electricity production plants and are considered an efficient way to produce energy because they can be grown and harvested quickly.



Biomass Energy Cycle





Biomass energy has the potential to reduce greenhouse gas emissions, particularly if it is produced using sustainable practices that do not result in deforestation or other forms of environmental degradation.



Biomass can be used to produce different types of energy including electricity, heat, and transportation fuels like ethanol and biodiesel.



Some types of biomass, such as algae, have the potential to be produced in large quantities using advanced biotechnology techniques. This could make them an even more sustainable and scalable source of renewable energy in the future.

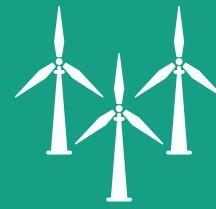


Half of the renewable energy produced in U.S. comes from biomass sources.





Wind Energy



Kinetic energy of wind converted into electricity by wind turbines



Electricity to U.S. homes



Wind power helps create

JOBS



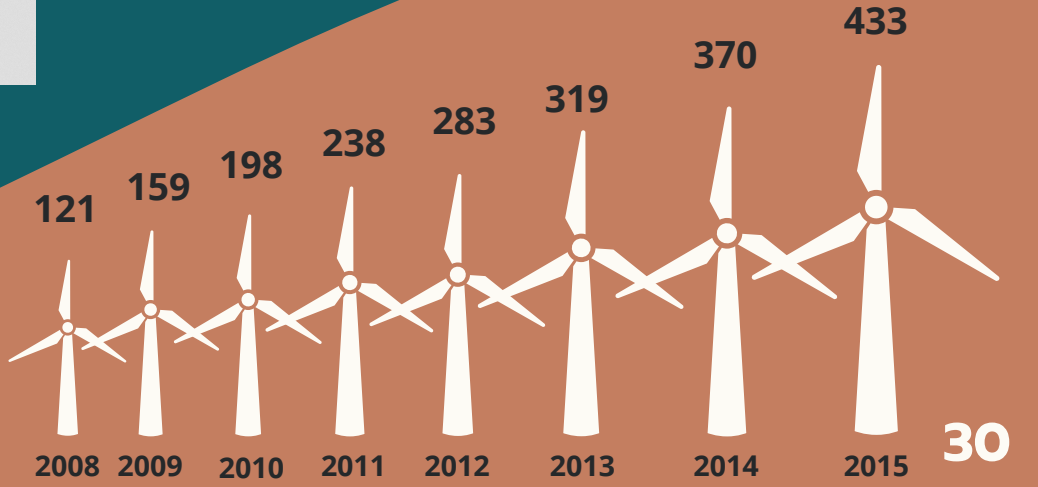
The U.S. wind industry
employs more than **85,000**
people in over 550 facilities

Pitch gear

Gear box

Main shaft bearings

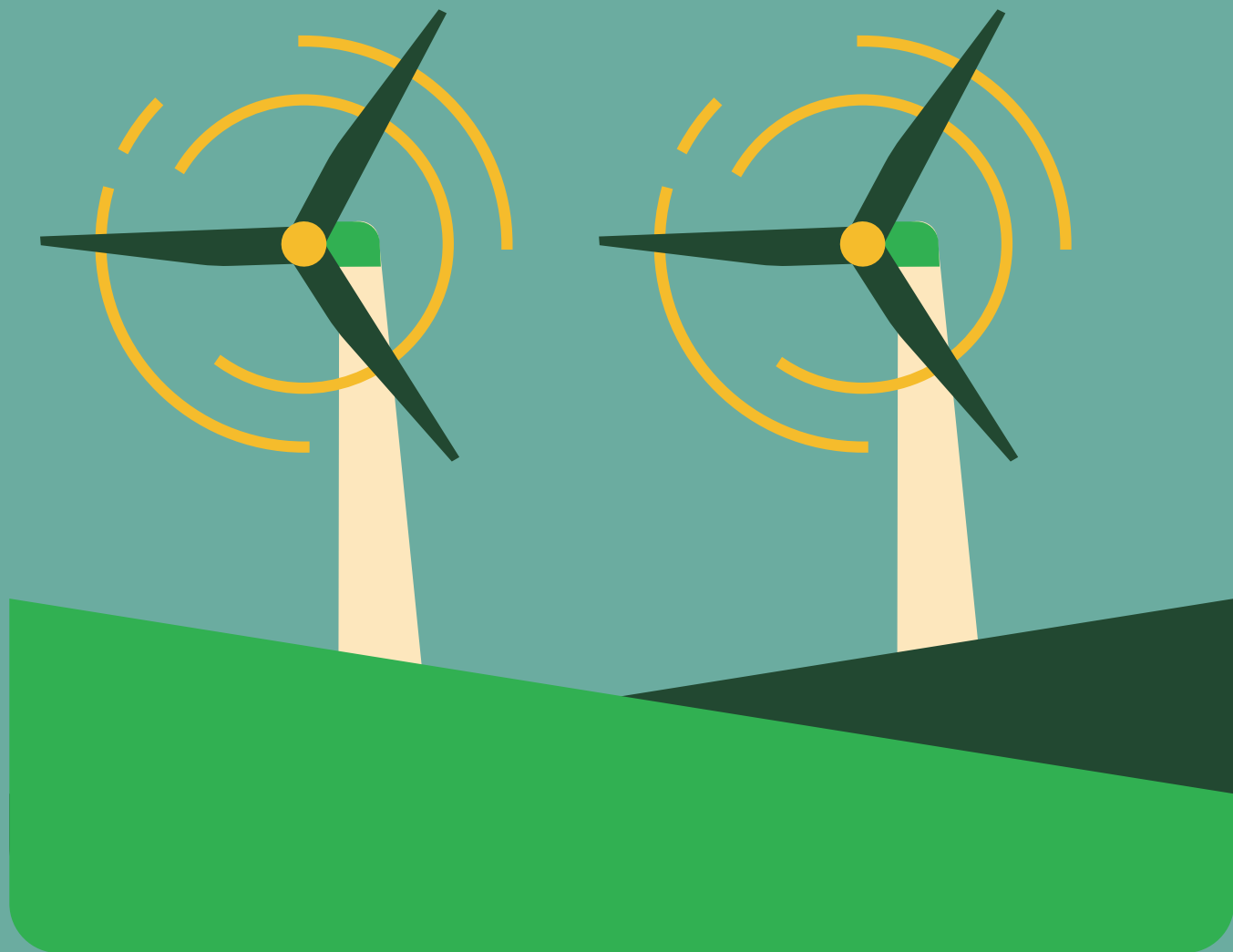
Generator





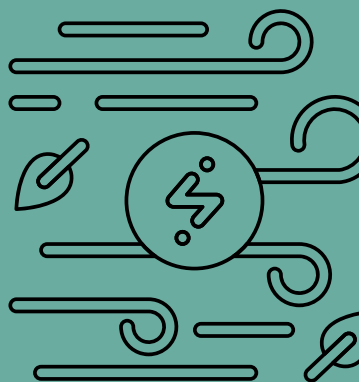
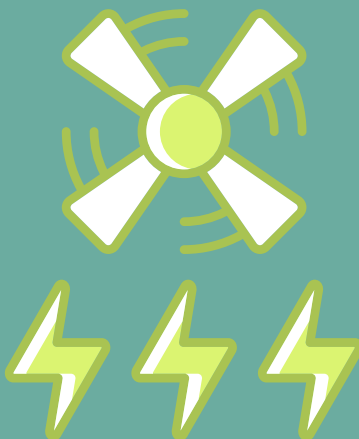
Wind energy is a type of renewable energy that has become more popular in recent years. It is generated by wind turbines, which are used to convert kinetic energy from the wind into mechanical energy. Wind power is considered to be one of the most promising sources for renewable energy because it has been found to be an inexhaustible and clean source of power.

In order to generate electricity, a turbine must be connected with an electric generator and then turned by wind. The generators are usually powered by AC current, which can then be converted into DC current for use in homes and businesses.



Wind turbines are used in many places around the world, but they are most common in Europe and China. As of 2021, the United States has over 135 GW of installed wind power capacity.

The use of wind turbines has increased since their introduction in the 1970s and 1980s, partly because they can generate electricity without producing greenhouse gases or other air pollutants.



01

China 220 GW

Installed Wind Farm Capacity

02

U.S.A 96 GW+

Installed Wind Farm Capacity

03

Germany 60 GW

Installed Wind Farm Capacity

04

India 35 GW

Installed Wind Farm Capacity

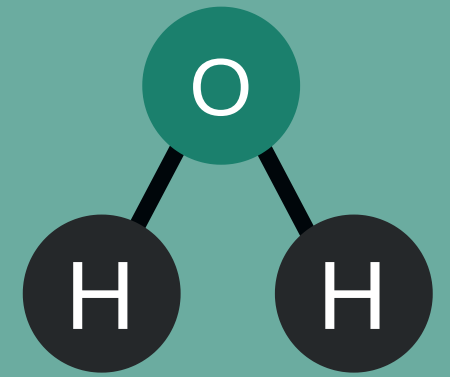




Hydrogen Energy



Hydrogen's potential chemical energy converted into electricity by hydrogen fuel cells





Hydrogen is a chemical element with atomic number 1. **Hydrogen is the most abundant element in the universe**, constituting roughly 75% of all baryonic mass.

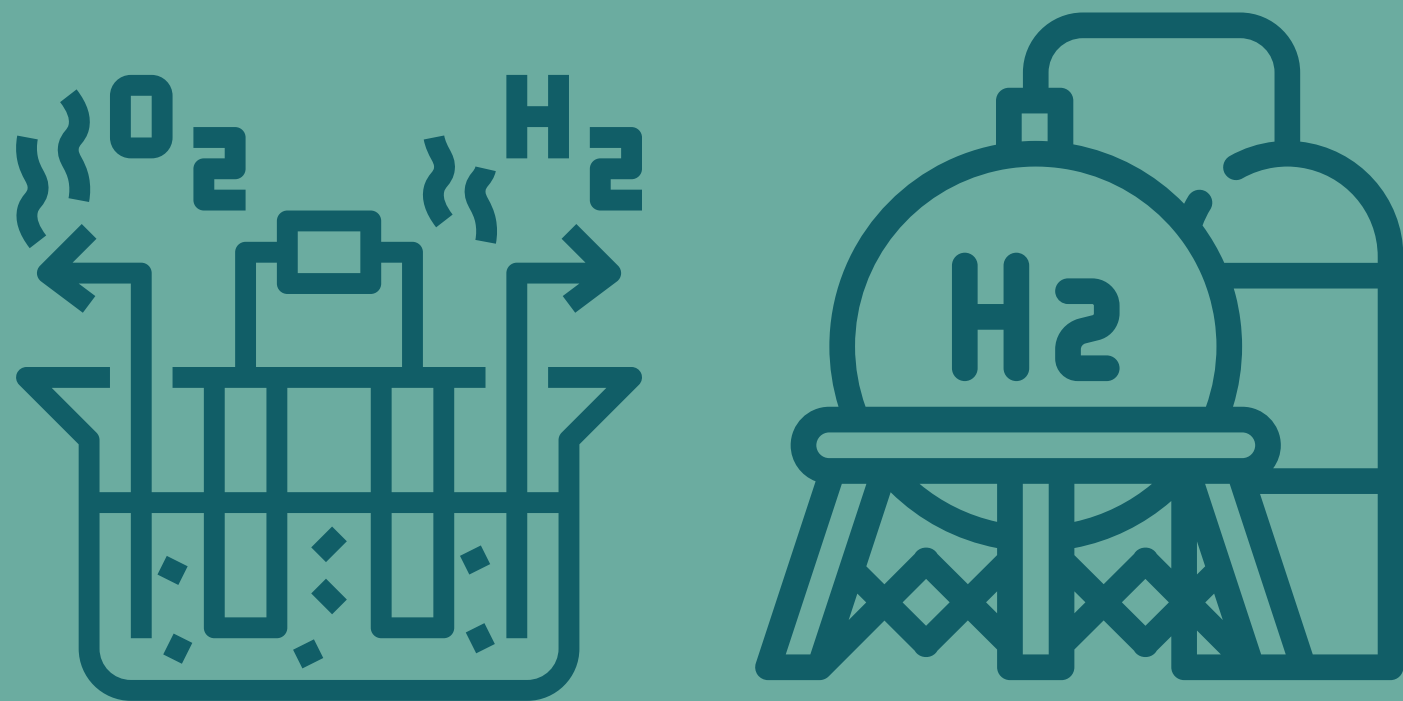
Hydrogen is used as an energy source and fuel for vehicles such as rockets, cars, and trains.

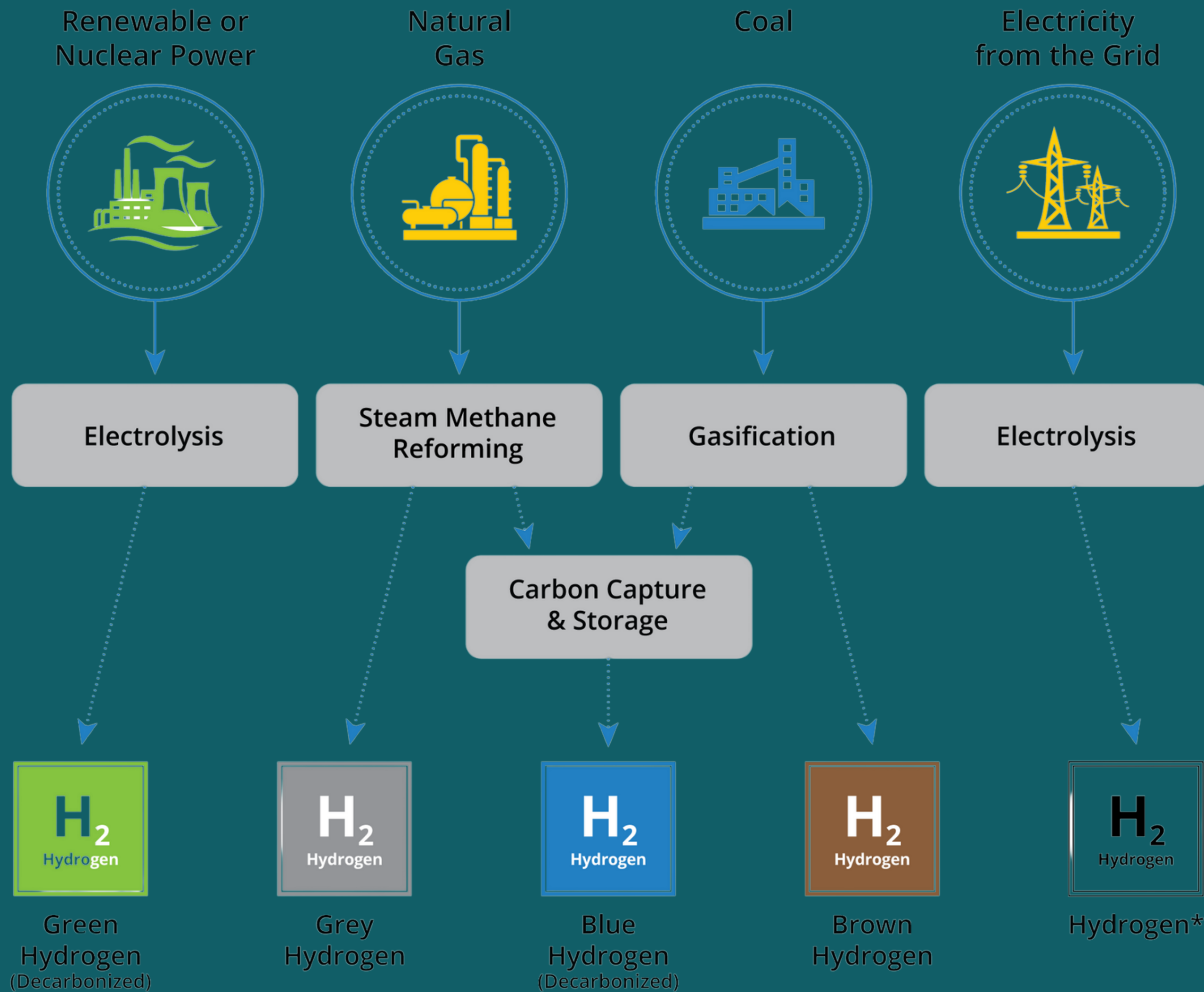
Hydrogen can also be used to generate electricity through a process called electrolysis. In this process, **hydrogen gas is decomposed into its constituent parts of hydrogen and oxygen by an electric current that splits water into its two components: hydrogen ions (H⁺) and hydroxide ions (OH⁻).** The reaction releases energy that can be harnessed to power an electric generator.

Hydrogen energy could be a solution to our growing energy needs and could help us transition to a sustainable future.

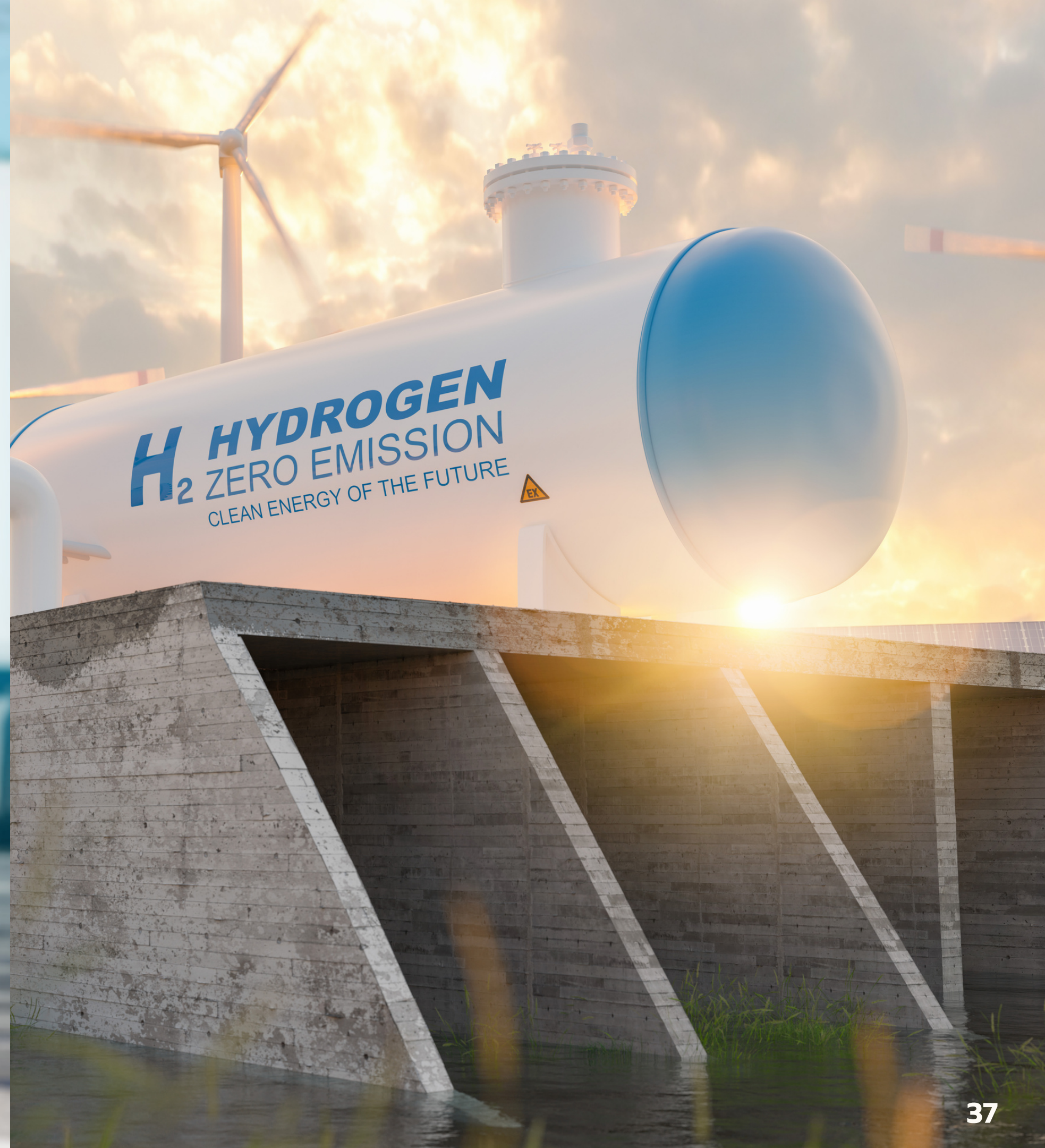
It has many potential benefits for humanity, but it is not without its challenges.

The major challenge is to store hydrogen safely. Hydrogen gas is highly flammable and can be explosive in high concentrations. It also needs to be stored at very low temperatures to avoid it from becoming a gas again.





Hydrogen

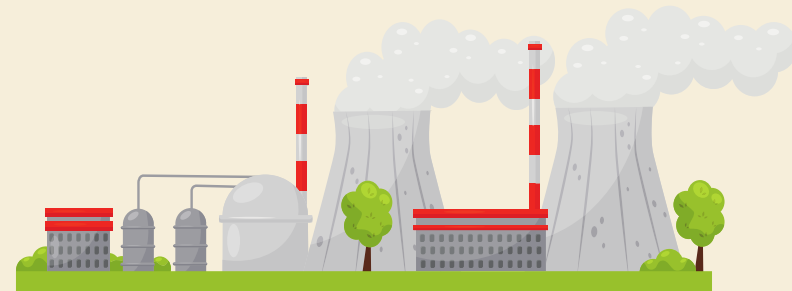


Non-renewable energy

Non-renewable sources are fossil fuels, such as coal, oil and gas. These fuels continue to be burned and release large amounts of heat and carbon dioxide, which is the major greenhouse gas expressed worldwide. The majority of non-renewable energy comes from fossil fuel extraction and consumption. The sources of fossil fuel extraction, such as mining and drilling, are also major sources of pollution. These energy sources have major consequences on the environment.



Non-renewable energy



Nuclear energy



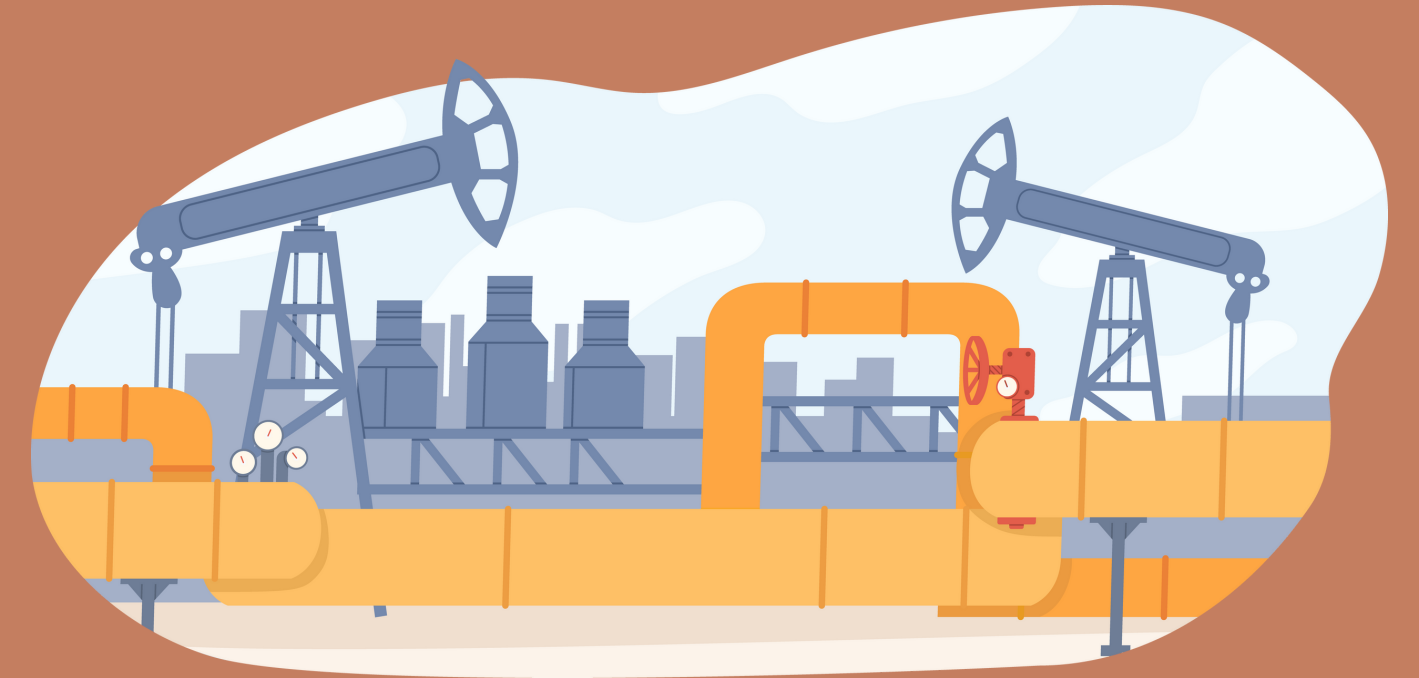
Oil energy



Coal energy



Natural gas



Non-renewable energy sources are finite and will eventually run out. They include fossil fuels such as coal, oil, and natural gas. These fuels are formed from the remains of dead plants and animals that were buried millions of years ago. When we burn fossil fuels, we release carbon dioxide into the atmosphere, which traps in heat and warms up our planet.

Compare non renewable energy sources



Coal Energy
\$100/MWh

Pros:

- Relatively Cheap Energy
- Widely Available, Reliable Production
- High CO2 Emissions
- Environmental Pollution

Cons:

- Health Risks to Workers and Local Communities
- Extraction and Transportation Can Be Dangerous



Natural Gas
\$50/MWh

Pros:

- Relatively Cheap Energy
- Widely Available, Reliable Production
- Low CO2 Emissions Compared to Coal
- Less Environmental Pollution Compared to Coal

Cons:

- Risk of Methane Leaks during Extraction and Transportation
- Extraction Can Be Dangerous to Workers and Local Communities



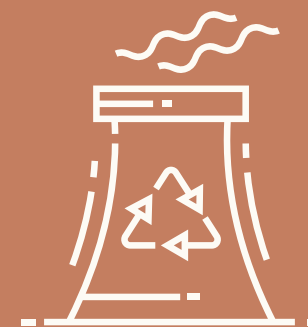
Oil Energy
\$150/MWh

Pros:

- Widely Available
- High Energy Density
- Reliable Production
- High CO2 Emissions

Cons:

- Environmental Pollution
- Risk of Oil Spills
- Extraction Can Be Dangerous to Workers and Local Communities



Nuclear Energy
\$100/MWh

Pros:

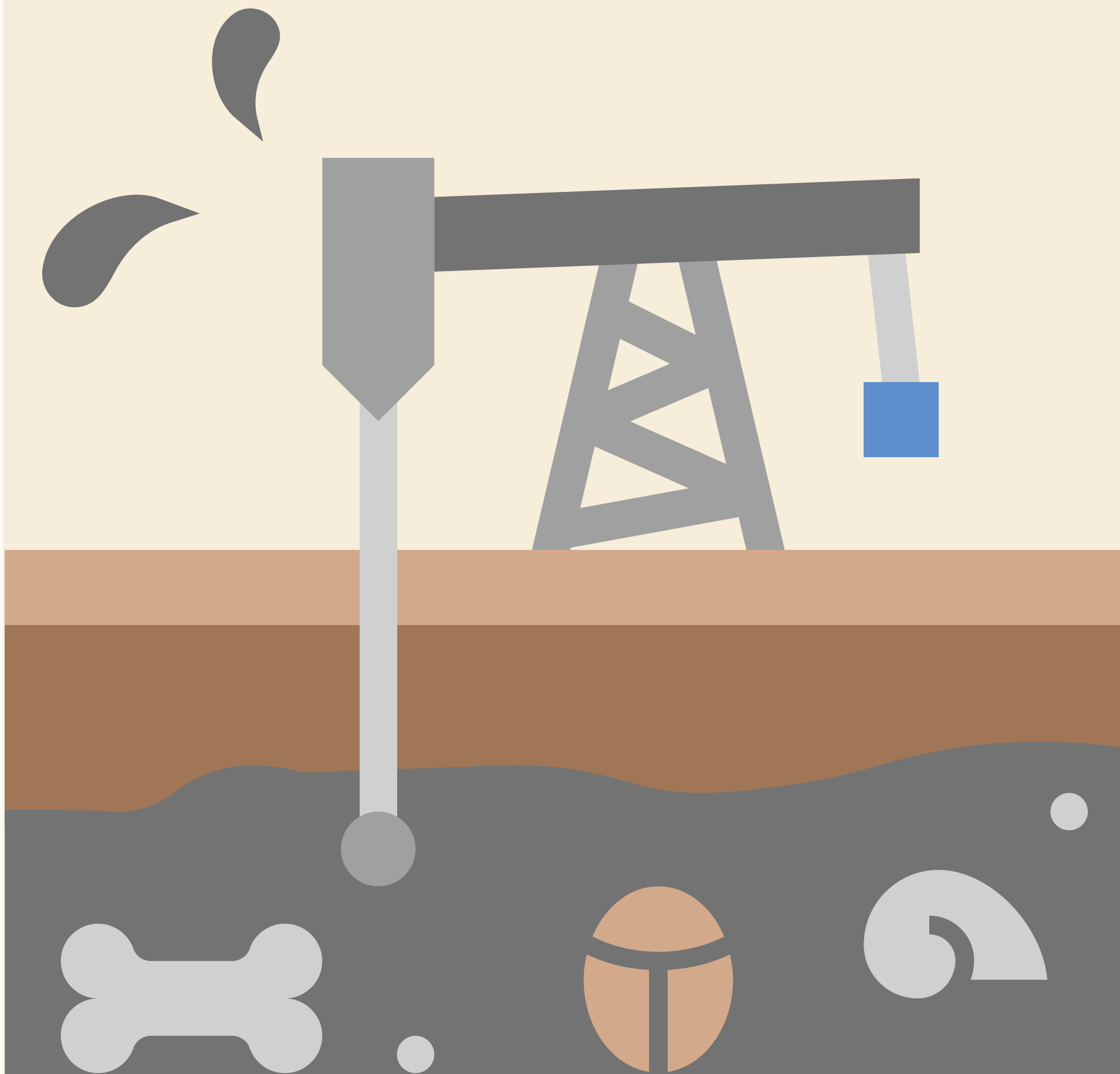
- Extremely Reliable
- Environmentally Clean
- Easy to Build New Capacity

Cons:

- Waste Problem
- Risk of Accidents



Fossil Fuels

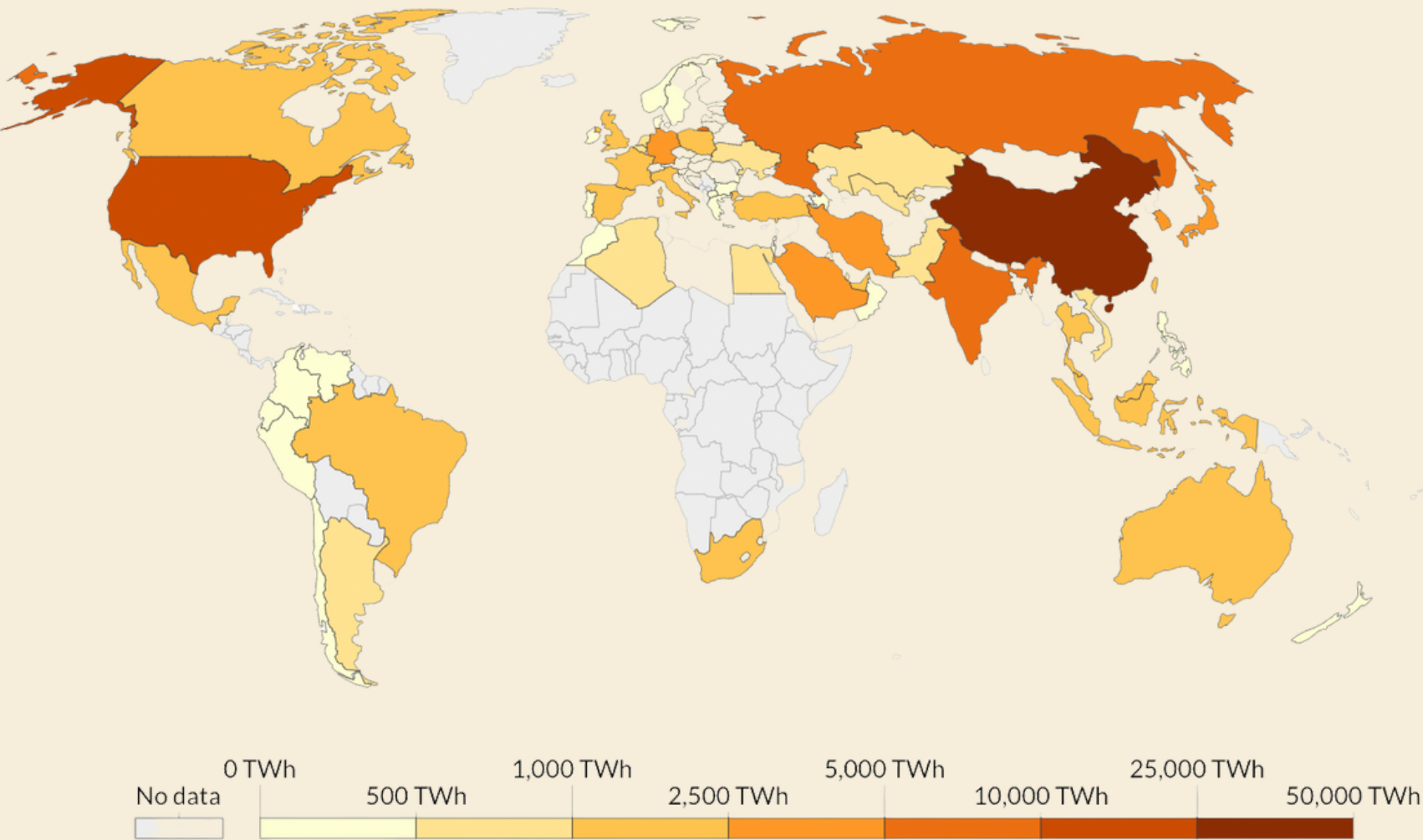


Fossil fuels are a type of energy that is created from the remains of plants and animals that lived millions of years ago. Fossil fuels are the most common type of energy in the world, which is why they are often referred to as fossil fuel energy. There are three main types of fossil fuels: coal, natural gas, and petroleum. Coal is mainly used for electricity production in power plants. Natural gas is mainly used for heating homes and businesses. And petroleum is mainly used as fuel for cars, trucks, trains and airplanes.

Petroleum can be made into gasoline or diesel to power cars or it can be made into jet fuel to power airplanes or it can be turned into plastic which is what most non-food packaging (like soda bottles) are made out of these days.



Which countries use the most energy from fossil fuels?



Source: Our World in Data based on BP Statistical Review of World Energy OurWorldInData.org/energy • CC BY

The top 10 countries that use the most fossil fuel energy are:

- | | |
|------------------|----------------|
| 1. United States | 6. Germany |
| 2. China | 7. South Korea |
| 3. Russia | 8. Canada |
| 4. India | 9. Brazil |
| 5. Japan | 10. France |

The world is running out of fossil fuel energy. Fossil fuels are limited resources and will soon be depleted. Countries need to take action and find new sources of energy or they will face the consequences.

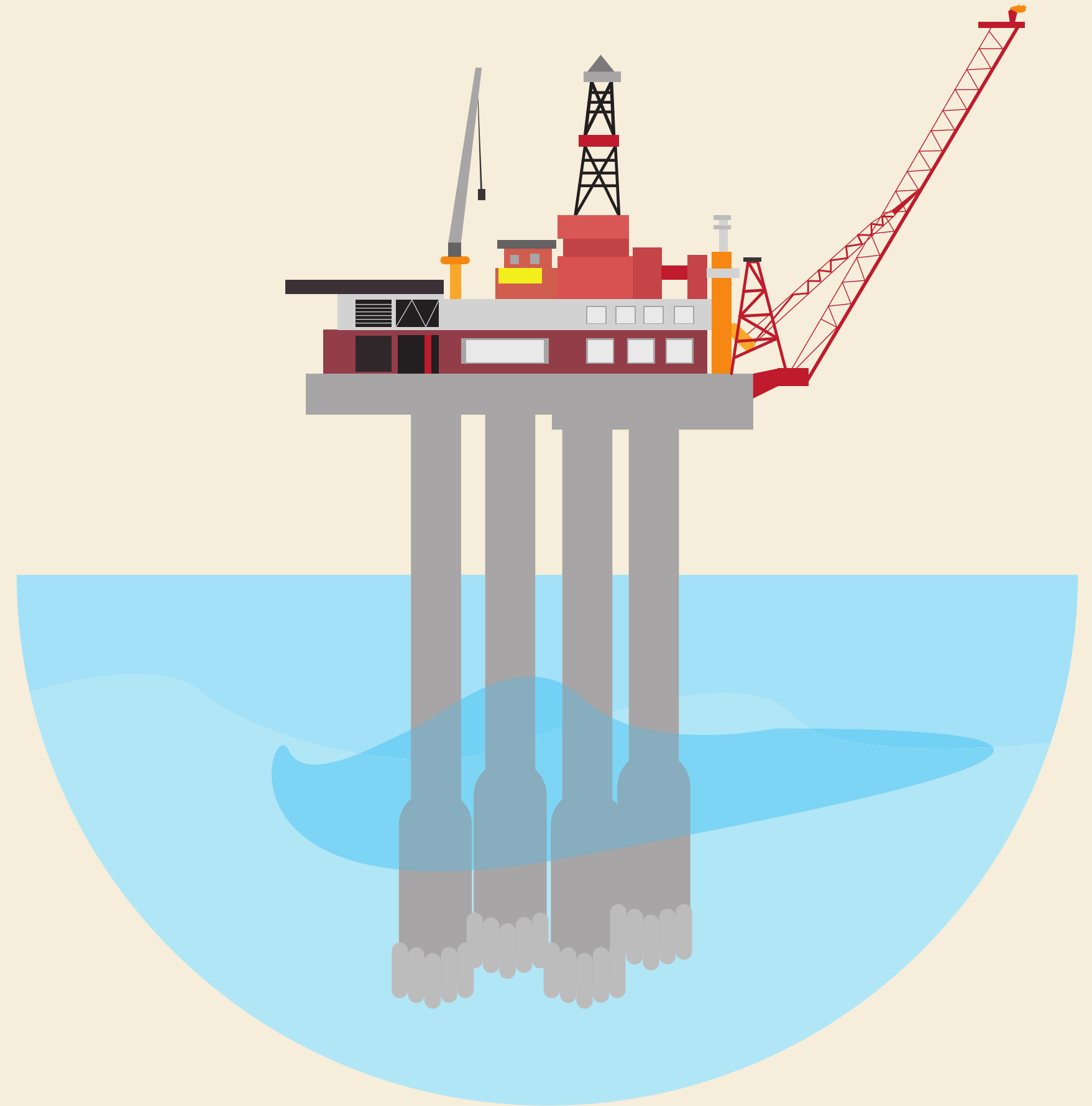
These are combustible forms of hydrocarbons with high carbon content. Fossil fuels take millions of years to form. They were created from ancient organic matter which was transformed over time by geological processes into a combustible form of hydrocarbons with high carbon content. These fossil fuels are still being burnt at an increasing rate. The process of burning fossil fuels results in the release of large amounts of heat and greenhouse gases into the atmosphere, thus causing global warming, which is the main environmental concern in the 21st century.



Fossil fuels are limited resources and will eventually be depleted. The extraction and burning fossil fuels has contributed to climate change and rising global temperatures, increased pollution, and impacted health. Countries need to take action and find new sources of energy or they will face the consequences.

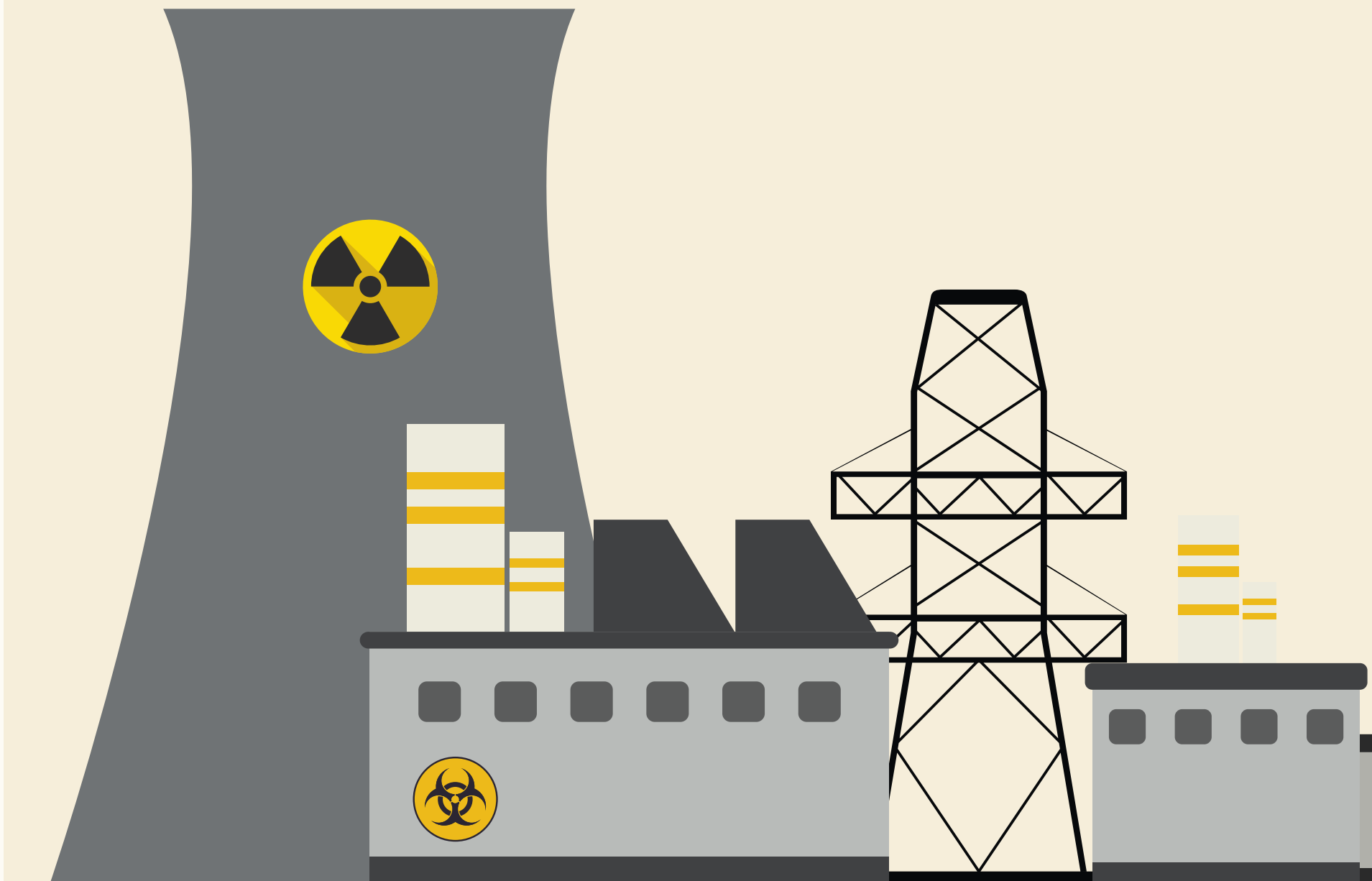
Oil is a fossil fuel that is turned into fuel or diesel to power machines like cars, trains, and airplanes. It is also used in the production of electricity and heat. Oil is a valuable resource because it can be refined into many different products such as plastics, soaps, paints, and synthetic fibers.

The use of oil energy has been criticized for the pollution it creates. There are also concerns about the limited supply of oil in the world. In order to solve these problems, many people are looking for alternative sources of energy that are more sustainable and cleaner than oil energy.

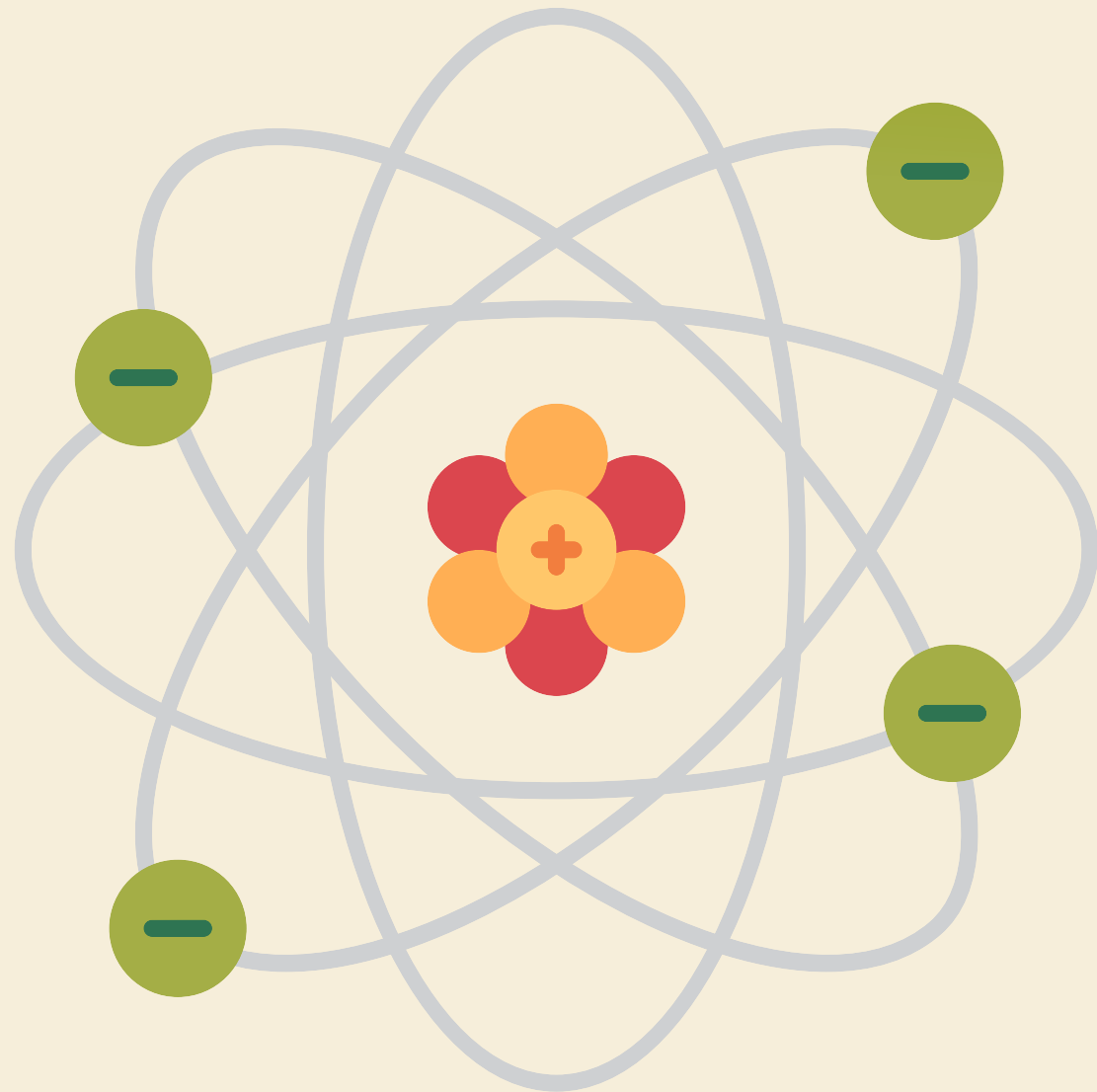




Nuclear Energy



Nuclear Energy



Nuclear energy is released in the fission of atoms. In other words, the splitting of atoms. All of the Earth's elements are made of atoms that contain a nucleus of protons and neutrons. When a nucleus splits, an explosion results and releases energy.

Nuclear energy is one of the most highly researched options for the production of electricity. Nuclear also has significant environmental impact. Once a nuclear reactor is started, nuclear waste will be left behind which is hazardous and difficult to dispose of. The technology of nuclear energy is based on the controlled, sustained release of energy caused by nuclear reactions. Nuclear energy is categorized as either a non-renewable because it is derived from sources that have not been replenished yet.

Although nuclear is not coming from a renewable fuel source, it is still a low carbon emission form of energy that could be helpful in lowering greenhouse gas emissions.

Did you know?

50% of the United State's clean energy is provided through nuclear energy

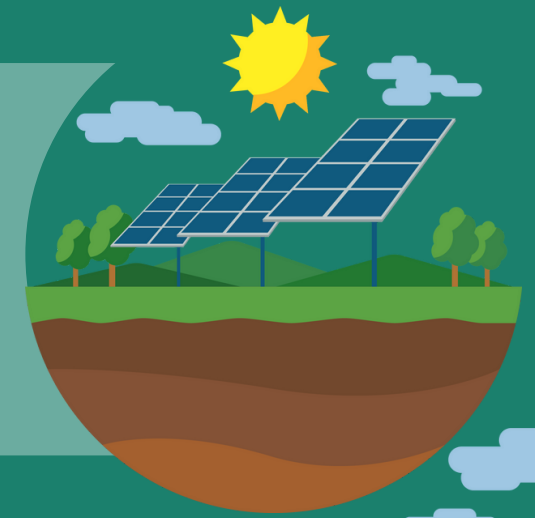




Overview: Renewable Energy

Solar Energy

- Clean and renewable
- Requires a large surface area to generate significant amounts of energy
- Limited availability at night or during overcast weather - Most abundant and widely used fossil fuel



Hydro Energy

- Clean and renewable
- Can have environmental and social impacts, such as flooding and displacement of communities
- Can provide reliable and predictable energy



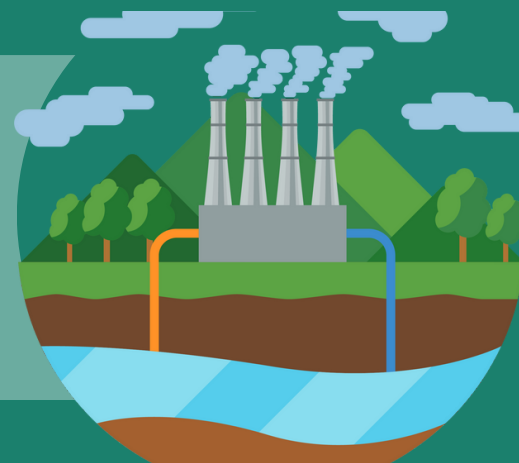
Tidal Energy

- Dependent on tides
- Can have significant environmental impacts on marine ecosystems



Geothermal Energy

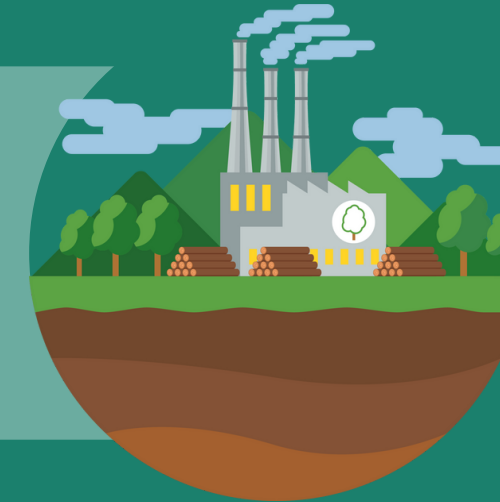
- Clean and renewable
- Dependent on geological conditions
- Can have significant environmental impacts from drilling



Overview: Renewable Energy

Biomass Energy

- Renewable
- Can compete with food production
- Can have significant environmental and social impacts from land use changes



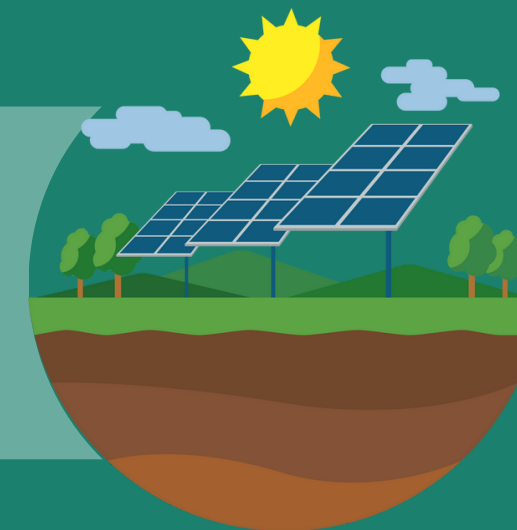
Wind Energy

- Clean and renewable
- Dependent on wind speed and direction



Hydrogen Energy

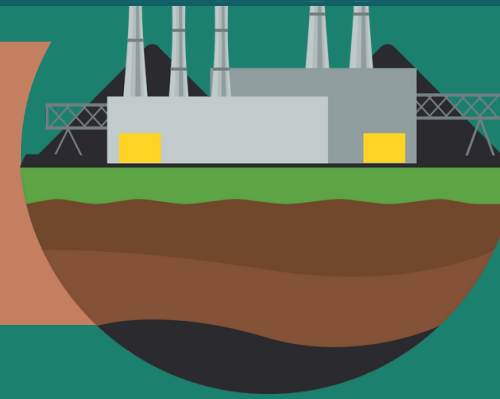
- Renewable, not clean as fossil fuels are needed to produce hydrogen fuel
- Uses the most abundant element



Overview: Nonrenewable Energy

Fossil Fuels

- Nonrenewable, not clean
- Formed naturally, made from decomposing plants and animals



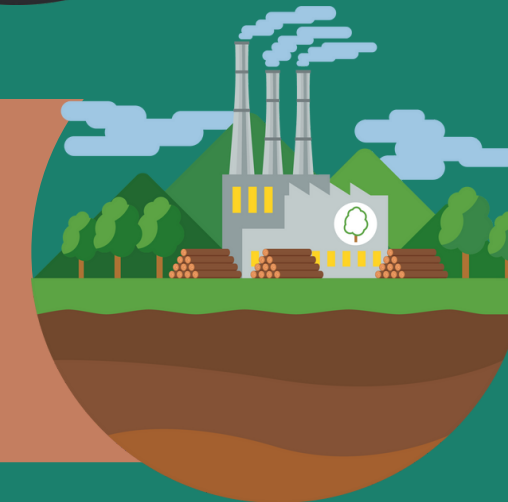
Coal

- Releases carbon dioxide, sulfur dioxide, and nitrogen oxide when burned
- Mining can cause environmental damage



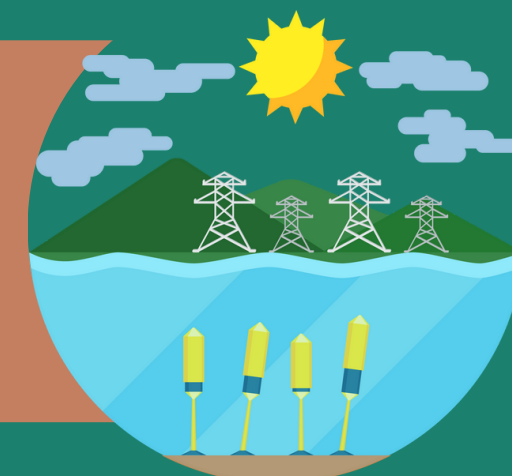
Natural Gas

- Third most widely used fossil fuel
- Releases less carbon dioxide, sulfur dioxide, and nitrogen oxide than coal and oil
- Fracking can contaminate water sources



Oil

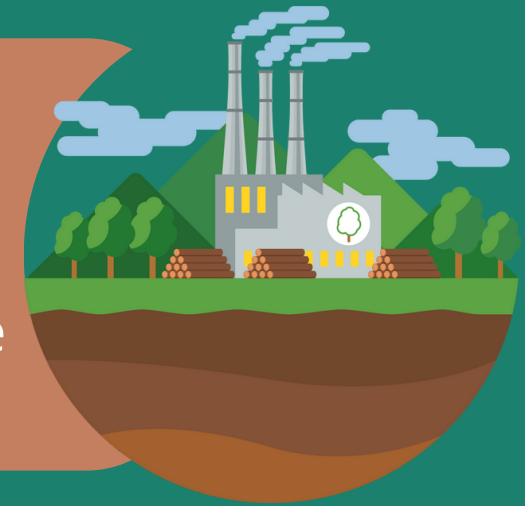
- Can have negative impacts on wildlife and habitats - Second most widely used fossil fuel
- Releases carbon dioxide, sulfur dioxide, and nitrogen oxide when burned
- Oil spills can cause significant environmental damage



Overview: Nonrenewable Energy

Nuclear

- Can provide reliable, clean, and predictable energy
- Uses nuclear fission to generate heat, which then generates electricity
- Does not release carbon dioxide, sulfur dioxide, or nitrogen oxide, but does produce radioactive waste
- Accidents and meltdowns can have catastrophic environmental and health consequences



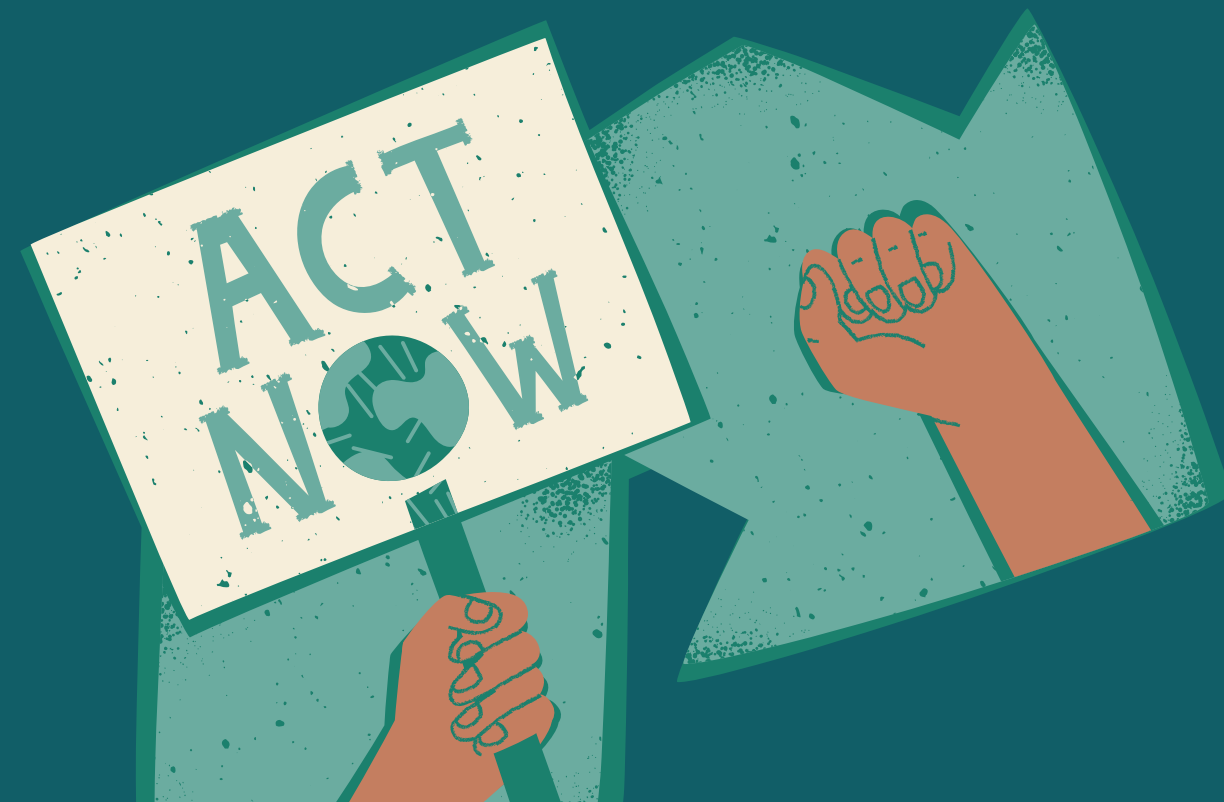
Remember, nonrenewable sources are finite and will eventually run out, while renewable energy sources are sustainable and can be replenished over time. By using more renewable energy sources like solar, wind, and hydropower, we can help reduce our dependence on nonrenewable sources like fossil fuels and protect the air we breathe, the water we drink and the overall environment for generations to come!



Get Involved

Energy conservation is an important issue that affects us all. From reducing greenhouse gas emissions to saving money on energy bills, there are many good reasons to make energy conservation a priority in our daily lives. That's why we're calling on you to get involved and help make a difference! Whether it's through purposeful classroom activities, saving energy around the house, or learning about energy through Sustainable Earth's energy game, there are many ways that you can make a positive impact.

By taking action on energy conservation, you can help create a cleaner, more sustainable future. Plus, you'll be developing important skills and knowledge that can benefit you in your personal lives and future careers! Let's look at ways you can get involved.



Activity Examples

- Complete the energy scavenger hunt by identifying at least five different types of energy in your daily life. Take photos, draw what you see, or make descriptive list to share with the class.
- Take the energy quiz or participate in a trivia game to test your knowledge of energy. Work with a partner or small group to come up with creative and fun questions for the class.
- Build a DIY energy project that demonstrates one of the types of energy you learned about. Share your project with the class and explain how it works.
- Create an energy diagram or visual representation that shows the different types of energy and how they relate to one another. Share your diagram with the class and explain your thought process.
- Play the energy source matching game and work with a partner or small group to match different types of energy sources with their characteristics and benefits. Share your answers with the class.



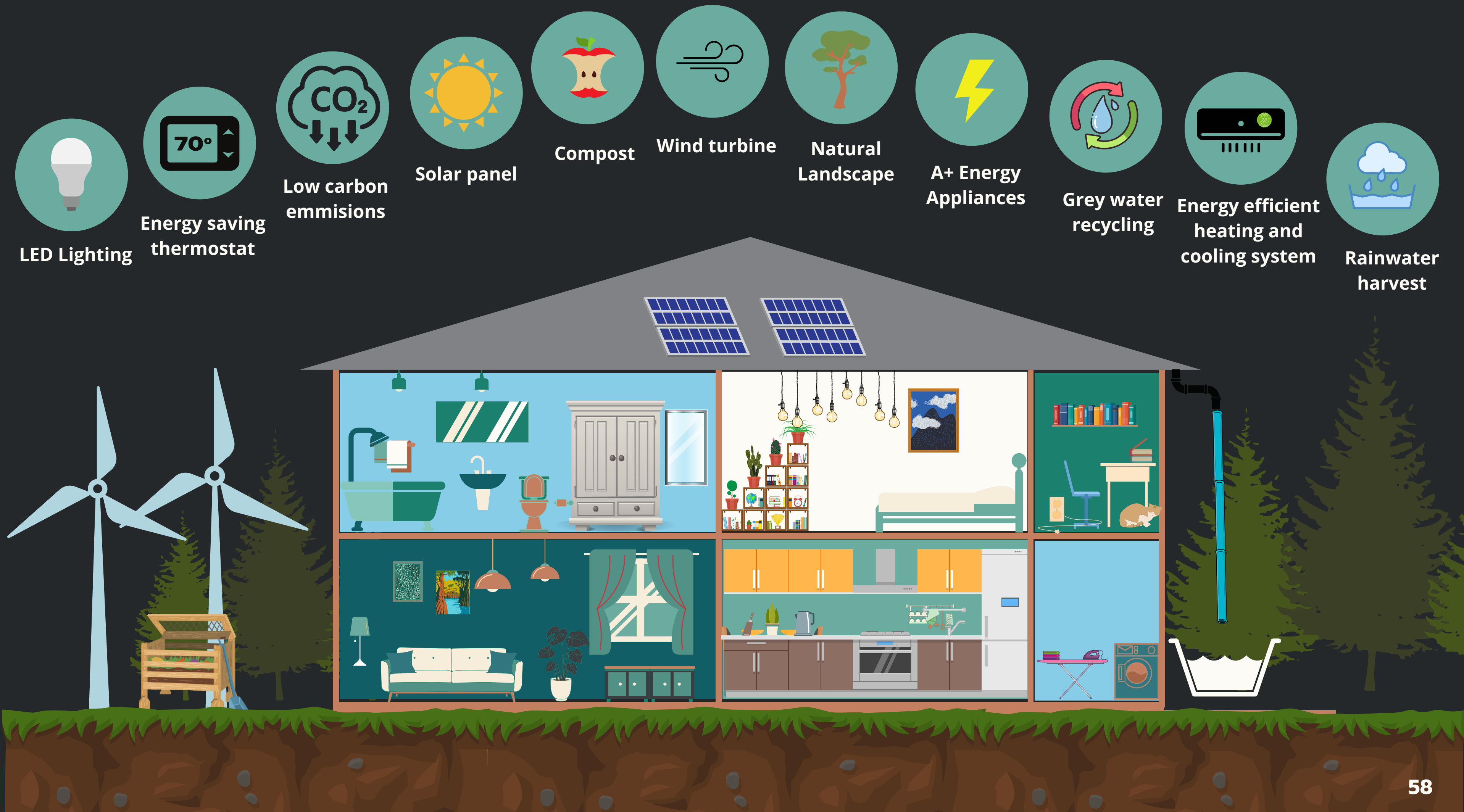
Activity Examples

- Conduct an energy audit of your home or school and identify at least three areas where energy could be saved. Create a plan for how to make these changes and share your findings with the class.
- Research and write reviews of at least two different energy-efficient products, such as LED light bulbs or smart thermostats. Share your reviews with the class and explain how these products can save energy.
- Create a climate action plan that includes at least three actions you can take to reduce your energy footprint, such as taking public transportation or using natural light whenever possible. Share your plan with the class and discuss how these actions can make a difference.
- Participate in the green selfie challenge by taking a photo of yourself engaging in a climate-friendly activity, such as riding a bike instead of taking a gas-powered car. Share your photo on social media with a caption explaining why these actions are important.

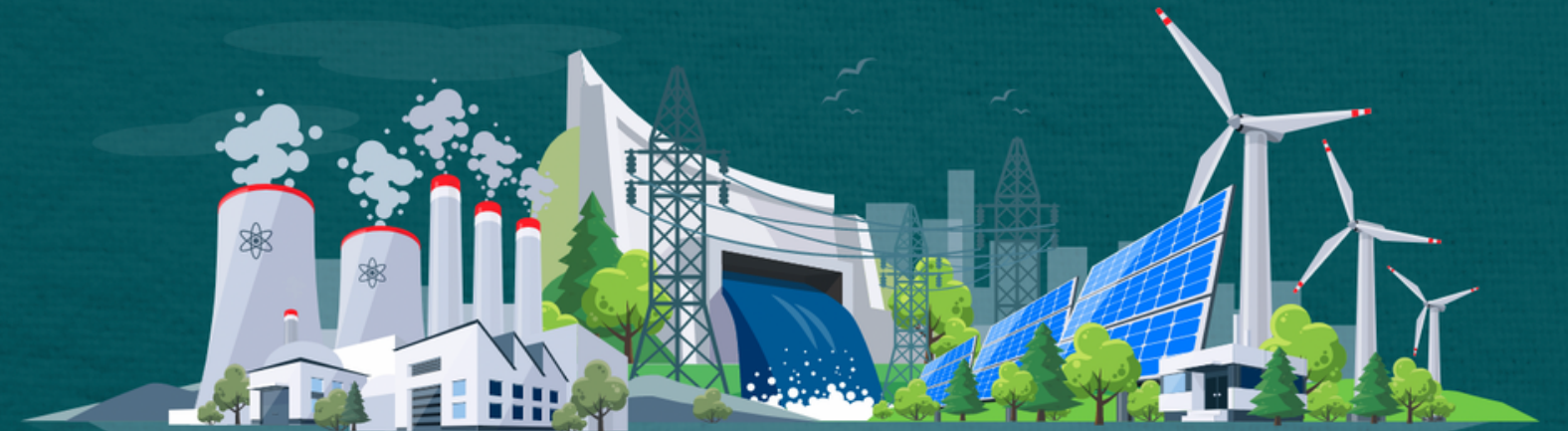


Save energy at
home





Play Power Our Community



Let's Begin

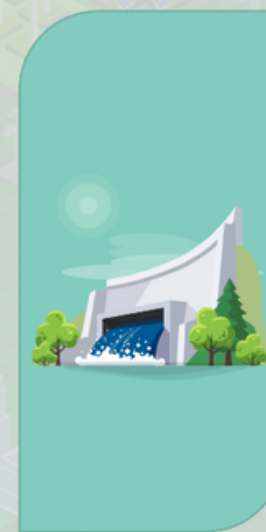
Select each resource to know more.



Wind Turbines



Solar Panels



Hydroelectric



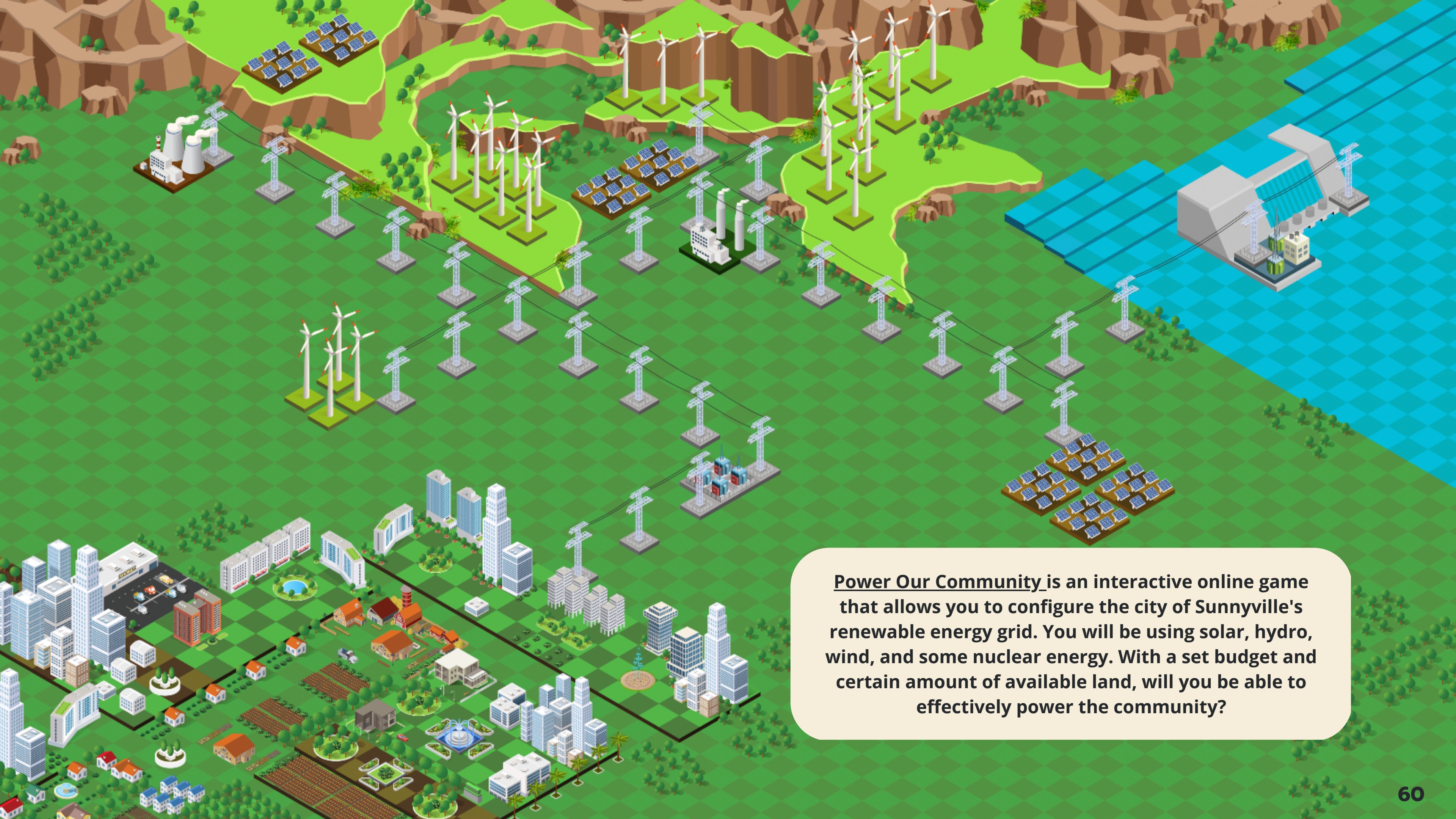
Nuclear



Geothermal



Transmission Lines



Power Our Community is an interactive online game that allows you to configure the city of Sunnyville's renewable energy grid. You will be using solar, hydro, wind, and some nuclear energy. With a set budget and certain amount of available land, will you be able to effectively power the community?



Learn more at
sustainable-earth.org

