SEPTEMBER 2025

The Environment Magazine

Youth Voices and Actions for a Greener Tomorrow

EnvironmentMagazine.earth

Table of Contents

Message from Editor in Chief

My name is Henry Yao. I am Founder and Editor-in-Chief of the Environment Magazine.

The purpose of this magazine is to provide a platform for students of all backgrounds to express their views on current environmental issues to a broad audience. I believe that every student has the ability to make a positive difference in the world, and through this magazine, we aspire to unleash their potential. The project is open to everyone, and there are unlimited spots available for participation. We welcome all students who want to be a part of this effort.

To contribute articles to The Environment Magazine, please contact playfndn.environment@gmail.com. A sample article can be found here. Volunteer hours will be recognized.

Carbon Capture and Storage: Technology and Challenges

Henry Yao
Dougherty Valley High School, San Ramon, CA 94582

Global warming refers to the gradual increase in Earth's average surface temperature due to the rising level of greenhouse gases, such as carbon dioxide (CO_2) . One promising approach is Carbon capture and storage (CCS) that can mitigate greenhouse gas emissions. It captures CO_2 released from industrial and energy production processes, preventing it from entering the atmosphere. Once captured, CO_2 is transported and stored in underground formations for long-term containment. Many modern CCS systems can capture up to 90–100% of CO_2 emissions from major sources.

Figure 1: Heidelberg's Brevik Norway CCUS cement plant. source:www.wri.org

CCS generally involves three main steps: capture, transportation and storage.

- Capture. It is the process of separating CO_2 from other gases produced during fuel combustion or industrial reactions. Three main methods are often used in this step:
  - Post-combustion capture, which extracts CO_2 from the flue gas after fuel is burned;
  - Pre-combustion capture, which removes CO_2 before combustion, usually by gasifying the fuel;

- ○ Oxy-fuel combustion, which burns fuel in pure oxygen to create a concentrated CO_2 stream.
- Transportation. Once captured, CO_2 is compressed into a dense fluid state for transporting via dedicated pipelines. In some cases, ships or railways are used for transportation.
- Storage: Finally, the CO_2 is injected into deep geological formations, such as depleted oil and gas fields, saline aquifers, or unmineable coal seams, where it can be securely contained for centuries or longer.

Among the three steps, carbon capture is most crucial. It separates carbon dioxide from other gases produced during industrial processes. Most of the large-scale carbon capture and storage projects studied in this report use a capture process, shown in Figure 2. This amine-based capture process was invented almost 100 years ago, and has been used to remove CO2 from natural gas and in a variety of other industrial applications.

This process utilizes amines, one type of organic molecule, that can react with and bind carbon dioxide. The mixed gas is introduced into an "absorber" reactor, where an amine solution flows downward and reacts with the carbon dioxide. The amine solution, containing the bound carbon dioxide, is pumped to another reactor, called a stripper or regenerator, where it is heated to release pure carbon dioxide. The purified gas is then compressed using a special compressor so it can be transported and pumped to the underground storage site.

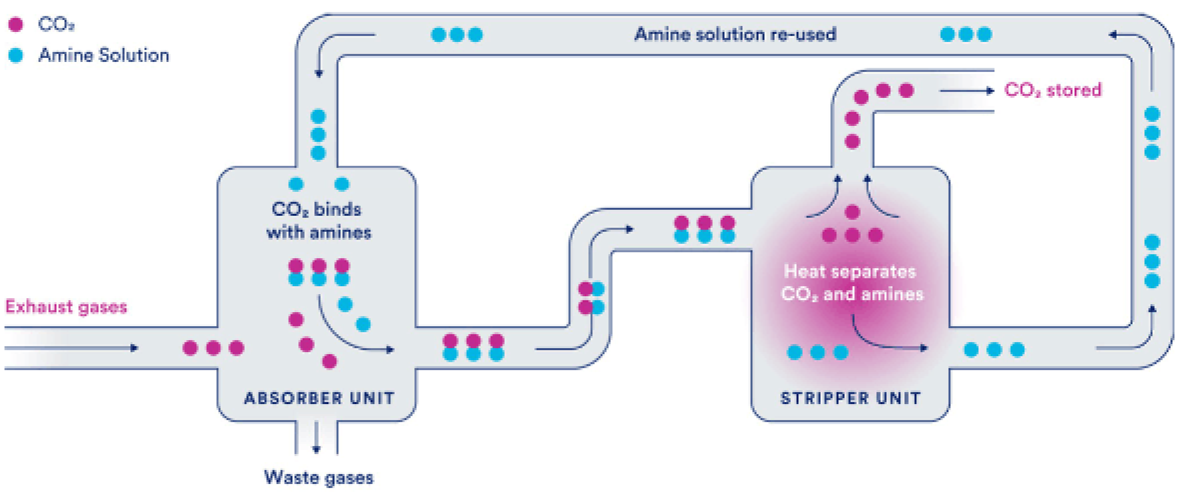

Figure 2: A carbon dioxide capture process using amine absorption technology. Source: www.catf.us

To improve the energy efficiency, this process requires a large number of heat exchangers. They are used to heat the amine solution with steam and to transfer heat from hot amine solution to cold amine solution. In the case of high-pressure CO2-containing gas streams, particularly in the petrochemical industry, an alternative technology is used. This technology dissolves CO2 in an organic solvent (such as cold methanol) instead of chemically binding it.

One way to improve CCS is Carbon Capture, Utilization, and Storage (CCUS). In this process, captured CO_2 is used for other industrial processes. Such utilization can offset some of the economic cost of capture and storage. One example is the so-called enhanced oil recovery (EOR), where CO_2 is injected into oil wells to help push out more crude oil. Although EOR can both generate revenue and sequester CO_2 underground, it may encourage the production of more fossil fuels. Some other CO_2 utilization methods do not reduce carbon emission at all. For example, CO_2 used in beverage carbonation is quickly released back into the atmosphere.

CCS is still at its early stage of large-scale adoption. According to the Global CCS Institute's 2021 Status Report, existing and under-construction facilities had the capacity to capture about 40 million metric tons of CO_2 annually. In that year, 31 commercial-scale CCS projects were either operational or being developed worldwide, including 10 active facilities in the United States. In addition, over 100 additional projects were in planning stages, which could eventually raise global capture capacity to nearly an annual 150 million metric tons. Although these numbers represent significant progress, it is only a tiny portion of total carbon emission. For example, the United States alone emitted over 5 billion metric tons of CO_2 in 2019.

Despite its promise, CCS still faces several challenges before it can make a major contribution to net-zero targets.The most pressing challenge for CCS is its high cost. The capture and compression phases consume large amounts of energy and water, reducing the efficiency of power plants and industrial operations. This “energy penalty” makes CCS less economically attractive without subsidies or carbon pricing. CO_2 must be transported under high pressure and low temperature, so the existing oil and gas pipelines are unsuitable; it is however expensive to build new CO_2 pipeline networks. Even though scientists believe there is enough geological storage capacity globally, potential risks can arise from leakage and induced seismic activity from underground injection.

CCS technologies offer one of the few viable options for reducing emissions in heavy industries and fossil-fuel-based power generation. While it is technically feasible, its success depends on reducing costs, building infrastructure, and earning public trust. CCS is not meant to replace renewable energy or efficiency upgrades, but to work with them to reduce emissions in sectors that are difficult to decarbonize.

References

“Carbon capture and storage: What can we learn from the project track record?” Clean Air Task Force, 31 July, 2024. https://www.catf.us/resource/carbon-capture-storage-what-can-learn-from-project-track-record/

Vincent Gonzales, Alan Krupnick, and Lauren Dunlap. “Carbon Capture and Storage 101.” Resources for the Future, 3 February, 2022. https://www.rff.org/publications/explainers/carbon-capture-and-storage-101/

Katie Lebling, Ankita Gangotra, Karl Hausker and Zachary Byrum. “7 Things to Know About Carbon Capture, Utilization and Sequestration.” World Resources Institute, 16 May, 2025. https://www.wri.org/insights/carbon-capture-technology

Geothermal Energy

Ferrero Zhang
California High School, San Ramon, CA, 94583

As humans continue to harvest raw materials from our environments, the planet we've known as home for the longest time is slowly being torn apart. Many, realizing the seriousness of this situation, have been endlessly searching for a solution through renewable energy. Although not widely known, geothermal energy is actually an extraordinary way to renew energy.

"Geo" means earth, and "therme" means heat. Therefore, geothermal energy is a renewable energy source relating to the use of heat within the Earth's core. With this heat, humans can generate electricity or heat buildings. In other words, geothermal energy is dependent on the consistent heating of the Earth.

The heat formed through Earth's core is made from the decay of radioactive elements, making up about 50% of the total heat produced. Most of the elements are isotopes, which are different forms of the same elements, such as uranium, thorium, and potassium. The decaying process releases energy in the form of heat. This heat is essential in the moving of plate tectonics, volcano activity, mountain formations, as well as geothermal energy.

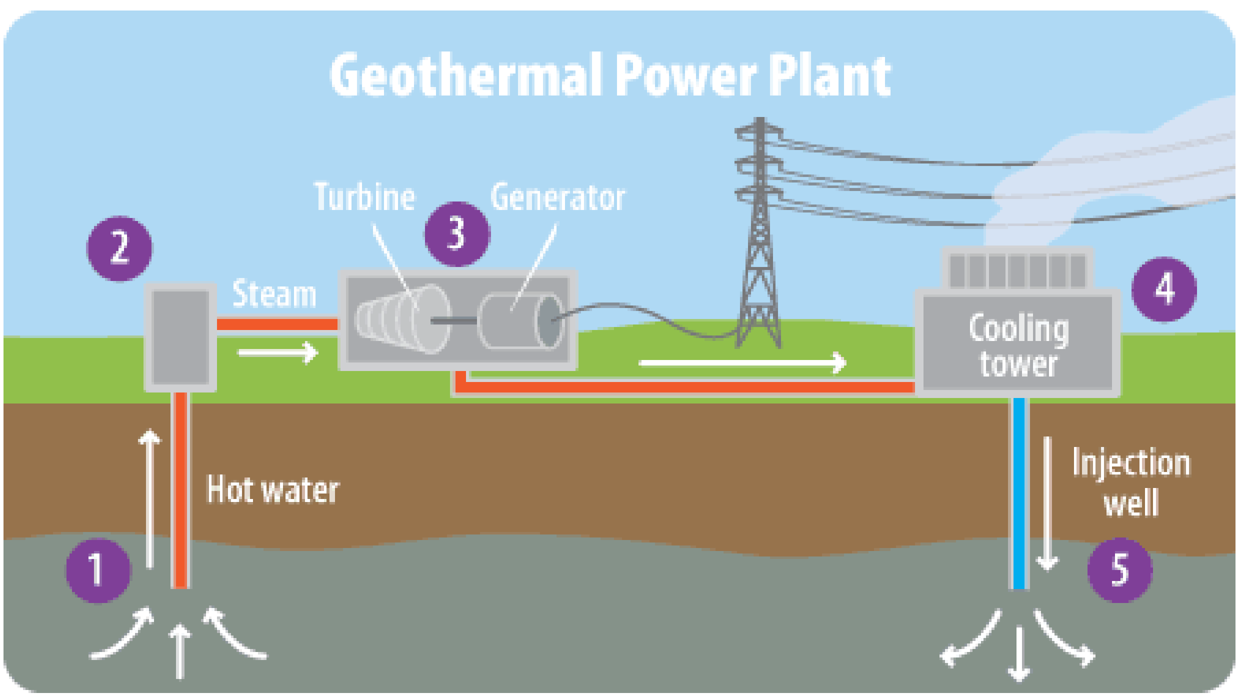

Figure1: Geothermal Power Plants. www.archive.epa.gov

Geothermal energy is transported through geothermal power plants. First, water is heated and rises up since it has a lower density. As the steam rises from the boiling water, it turns turbines in the nearby geothermal power plants. As the turbines spin, they generate energy to power buildings.

Power plants are usually found within regions with constant geothermal activity. Such places include tectonic plate boundaries, volcanic activity, geysers, and underground reservoirs. These places provide enough heat to generate energy.

Geothermal energy is a great energy source for many reasons. First of all, it is renewable and endless, as the Earth's heat will never run out. Secondly, it is very reliable, unlike solar or wind power. Also, geothermal energy requires much less space compared to solar or wind farms.

Although geothermal energy is very reliable and clean, it also has some downsides. First of all, installing geothermal power plants is not an easy task. It requires drilling and setup, which can be quite expensive. Another reason it isn't the best choice is that its locations can be very limited. After all, the power plants can only be installed in places where there is constant geothermal activity. In addition, having power plants in those places can clash with wildlife and tourism in the area.

Despite these complications, geothermal energy is a great renewable energy source for several reasons: its reliability, endlessness, and small land footprint. Although not a common renewable energy source, it has fewer complications than other sources such as solar or wind power.

References

"Geothermal Basics." US Department of Energy, www.energy.gov/eere/geothermal/geothermal-basics.

Press, Paul. "What Keeps the Earth Cooking?" Berkeley Lab News Center, 17 July 2011, newscenter.lbl.gov/2011/07/17/kamland-geoneutrinos/.

"U.S. Energy Information Administration." Geothermal Explained, 27 Dec. 2022, www.eia.gov/energyexplained/geothermal/.

"Understanding Geothermal Energy." Amigo Energy, 7 Dec. 2020, amigoenergy.com/blog/understanding-geothermal-energy/.

Environmentalists in Action

In this issue, we would like to thank the following environmentalists.

July 20, 2025: Joyce Miao, Andrew Sun, and Henry Yao cleaned up Dougherty Valley High School parking lot and the surrounding areas.

September 13, 2025: Lucas Fong, Ian He, Linus Tan, Alex Tong, Sophie Tong, and Andrew Zhang cleaned up Sycamore Valley Park and the surrounding areas.

About

The Environment Magazine is published by the Environment Club. It collects introductory articles on environmental protection written by youth volunteers, with the goal of educating students and parents on how to protect the environment. It aims to provide a platform for all students to express their opinions and inspire change through activism. It also empowers students to become environmentalists and make a positive impact on the world.

The Environment Club is a group of passionate middle and high school students dedicated to environmental protection. We started by organizing youth volunteers to clean up the trails and streets in our local community, and now we're taking the next step by promoting awareness and change through our publication, The Environment Magazine. Our goal is to inspire others to take action and make a positive impact on the environment, both locally and globally. The Environment Club is a subdivision of the PLAY Foundation, a 501(c)(3) non-profit organization.