New NETWORKS Compendium

By John Benson

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1. Introduction

In case you are wondering what the third word in the above title means, it is "a collection of concise but detailed information about a particular subject, especially in a book or other publication."

I started writing the "New NETWORKS" series almost two years ago. Thus, it didn't surprise me recently when, that there were major developments in negative emissions technology (NET). The first was a subject I wrote about a year ago:

XPRIZE officially launched the $100 Million XPRIZE Carbon Removal competition. In honor of the launch, XPRIZE founder Peter H. Diamandis sat down with Elon Musk, who is funding the competition through the Musk Foundation.

https://energycentral.com/c/ec/xprize-carbon-removal

The above contest has now reached a major milestone which is covered in section 2. A summary of a report on Negative Emissions Technologies and Reliable Sequestration from the National Academies of Sciences, Engineering and Medicine is contained in Section 3.

2. XPRIZE Carbon Removal

In April, the first year in this four year competition was completed, and thus the first awards were made: These were 15 Milestone Prizes of $1 million each to competitors that made the most progress.

2.1. Milestone Prizes

The list of these prizes is referenced here.[1] Note that *the competition now completely resets before the remaining $80M prize purse is awarded in 2025. Any team is eligible to win, whether they participated in this Milestone Round or not. Registration is open for any team interested in joining the competition to compete for the Grand Prizes. Registration closes on December 1, 2023. To win the Grand Prize, teams must demonstrate a working solution at a scale of at least 1,000 tonnes removed per year, model their costs at a scale of 1 million tonnes per year, and show a pathway to achieving a scale of gigatonnes per year in future, as validated by a third party. The Grand Prize winner and runners up will be announced on Earth Day 2025.*

8 Rivers, Calcite: *Calcite's advantage is its simplicity. Calcite was intentionally designed to minimize technical complexity and costs. The Calcite process passes ordinary air with approximately ≈415 PPM CO_2 across calcium hydroxide in a large warehouse, absorbing CO_2 from the air into calcium carbonate crystals, similar to how concrete sidewalks dry and absorb carbon in the process. The calcium carbonate that's created is*

[1] XPRIZE, "Xprize and the Musk Foundation Award $15m To Prize Milestone Winners In $100M Carbon Removal Competition," April 22, 2022, https://www.xprize.org/prizes/elonmusk/articles/xprize-and-the-musk-foundation-award-15m-to-prize-milestone-winners-in-100m-carbon-removal-competition

cycled into a kiln to regenerate calcium hydroxide and capture CO_2. The Calcite process accelerates the carbonation of the calcium...[2]

Key Innovation: Calcite's advantage is simplicity and speed. The process uses the natural carbon absorbing properties of Calcium Hydroxide and is able to accelerate its absorption of CO_2 at low cost.

Status: Lab testing has completed. Pilot scale development is currently underway.

Low-Cost: With economics driving the design, the system captures CO_2 for permanent underground storage at exceptionally low-cost.

Commercially Available: Calcite uses readily available and well understood industrial equipment making the technology deployable today.

Scalable: Calcite's unique design and reliance on abundant non-toxic materials enables it to rapidly scale up to meet the global need for carbon removal.

***Carbyon** develops the next generation of equipment to capture CO_2 directly out of ambient air. This technology enables extreme energy efficiency and low manufacturing costs.*[3]

This solution can be scaled up worldwide, on any location with only a small footprint.

A CO_2 adsorbing substance is used to modify fiber membrane material with a huge internal surface, leading to a highly beneficial CO_2 capturing capacity. Modifying the membranes relies on advanced and proven techniques, leveraging production tools that matured and scaled in the semiconductor industry.

The thin membrane operates at low pressure drops, minimizing the energy consumption.

1,000 kWh of energy per ton of CO_2 captured is required by the fast swing process.

$27/ton is the capex contribution due to a very lean machine design, leading to an affordable solution at mass manufacturing scale.

***Heirloom & Carbfix:** These two organizations were grouped together, even though one (Heirloom Carbon Technologies) is in the U.S., and the other is in Iceland. They both use mineralization with a slightly different spin:*

Heirloom: captures and processes atmospheric CO_2. Our partners inject it underground into geological structures. There, it remains permanently trapped in a safe and verifiable way.[4]

Our system implements a looping process that recycles minerals to limit our reliance on mining, and uses 100% renewable energy.

We use creative geometry and aerodynamics to keep the physical footprint of our system small.

Carbfix: Trees and vegetation are not the only form of carbon drawdown from the atmosphere. Vast quantities of carbon are naturally stored in rocks. Carbfix imitates and

[2] 8 Rivers, "Calcite Carbon Removal," https://8rivers.com/calcite/
[3] Carbyon, Direct air capture of CO_2 to clean up our atmosphere, https://carbyon.com/
[4] Heirloom home page, https://www.heirloomcarbon.com/

accelerates these natural processes, where CO_2 is dissolved in water and interacts with reactive rock formations, such as basalts, to form stable minerals that provide a permanent and safe carbon sink…[5]

Carbonated water is acidic. The more carbon you can pack into water, the more acidic the fluid will become. In Carbfix's process, carbonated water reacts with rocks underground and releases available cations such as calcium, magnesium and iron into the water stream. Over time, these elements combine with the dissolved CO_2 and form carbonates filling up the empty space (pores) within the rocks. The carbonates are stable for thousands of years and can thus be considered permanently stored. The timescale of this process initially surprised scientists. In the CarbFix pilot project, it was determined that at least 95% of the injected CO_2 mineralizes within two years, much faster than previously thought.

The injected carbonated water is denser than the surrounding water in the geological formation and therefore has the tendency to sink after it has been injected. This differs from more conventional methods of carbon capture and storage, which depend on cap rock to prevent possible leakage of gaseous CO_2 injected into deep formations. Young basaltic rocks are highly fractured and porous such that water seeps easily through the interconnected cracks and empty spaces underground.

The paper referenced at the end of this paragraph was on the technology used by the above two firms.[6]

Although the next winning technology is technically mineralization, I covered it in more detail about a year after the above referenced post (referenced at the end of this paragraph).[7]

Project Hajar: *Stretching across the northern coasts of Oman and the United Arab Emirates loom the vast jagged peaks of the Al Hajar mountains. The craggy outcrops are made mostly of a rock called peridotite, which absorbs carbon dioxide from the air and turns it into solid minerals. The mountains could store trillions of tonnes of human-made CO_2 emissions, but the natural carbon-mineralization process works at a glacial pace.* [8]

London startup 44.01 has found a way to speed it up. For this endeavor, 44.01 is teaming up with another London startup, Mission Zero Technologies, which has developed an energy-efficient method to capture CO_2 from air. Called Project Hajar, it plans to pull 1,000 tonnes of CO_2/year from air at a demonstration facility in Oman, injecting some 3–4 tonnes/day into the peridotite rocks. Mission Zero's 120 tonne-capacity pilot plant will come online in the first half of 2023.

This project's home page is linked below.

https://www.project-hajar.com/

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[5] Carbfix Home Page, https://www.carbfix.com/

[6] Energy Central, "New NETWORKS Part 2 - Mineralization for GHG Capture," October 2020, https://energycentral.com/c/ec/new-networks-part-2-mineralization-ghg-capture

[7] Energy Central, "New NETWORKS, Part 4 – Peridotite & Soil," October, 2021, section 2, https://energycentral.com/c/ec/new-networks-part-4-%E2%80%93-peridotite-soil

[8] Prachi Patel, IEEE Spectrum, "Carbon-Removal Tech Grabs Elon Musk's Check," May 28, 2022, https://spectrum.ieee.org/carbon-removal-x-prize-finalists

The next prize-winner also uses mineralization (see reference 6). They didn't give a good description of their process, but I found the descriptions below in a couple of news articles linked on their site.

Sustaera's *Direct Air Capture system is powered by carbon-free energy and uses abundantly available natural minerals as carbon dioxide capture sorbents.*[9]

"Sustaera plans to offer commercial DAC systems starting at 10 tons per day that can be multiplied to create facilities capable of capturing thousands of tons of carbon dioxide per day…

The company, based in North Carolina, uses a cheap and easily available alkali-based material to absorb CO_2. Unlike other carbon-capture businesses, its process doesn't require heat from fossil fuel sources and can run entirely on renewable electricity…

The company's machine is built in a modular fashion, with single units that can be put together "like Lego blocks," according to Chief Executive Officer Shantanu Agarwal.[10]

A link to Sustaera's home page is below.

https://www.sustaera.com/

Verdox also partnered with Carbfix (see ***Heirloom & Carbfix*** above).

Traditional carbon capture systems function like sponges for CO_2. When CO_2 comes in contact with the capture material, it is soaked up and trapped inside of the structure. The CO_2 is then squeezed out in the release process by applying large amounts of heat, which breaks the bonds between the CO_2 and the capture material. This process uses vast amounts of energy and is therefore difficult to scale.[11]

Verdox, in contrast, has designed an electric system that makes it easier to both soak up the CO_2 and squeeze it back out. The design of capture devices allows for gases to flow through with less resistance, making the capture process more efficient. Instead of extracting the CO_2 with heat, we also only apply a specific voltage to the capture material to release the CO_2. This different approach allows for a more efficient capture and release of CO_2 using only electricity, and without the need for heat or water.

Our solutions are comprised of stacks of electrodes that are assembled in arrays. To capture more CO_2, more stacks are added. This modular approach makes the technology highly scalable and eliminates the need to redesign systems for larger applications.

Gas enters each stack on one side and is channeled through the electrodes that make up the stack, in which the CO_2 is absorbed. The remaining gas simply passes through the stack and exits on the other side. Once the stack is saturated with CO_2, the incoming gas is stopped, and pure CO_2 exits the stack on the other side. Installing stacks in

[9] Business Wire, "Sustaera Closes $10 million Series A Financing to Develop Low-Cost Direct Air Capture Technology,: Dec 16, 2021, https://www.businesswire.com/news/home/20211216005309/en/
[10] Todd Gillespie, Bloomberg, "Gates-Backed Fund Invests in Carbon Capture Startup Sustaera," Dec 16, 2021, https://www.bloomberg.com/news/articles/2021-12-16/gates-backed-fund-invests-in-carbon-capture-startup-sustaera
[11] Verdox home page, https://verdox.com/

parallel with alternating cycles allows for a continuous flow of incoming mixed gas and outgoing pure CO_2.

Author's comment: I believe the above process uses electrochemical membrane reactors for direct air capture of CO_2. I recently posted a paper (referenced below) that described using this technology to separate hydrogen from hydrogen-containing compounds (a.k.a. carriers). I did a quick web search and found many papers using the above-described process for CO_2 capture. I believe it will requires several stages to achieve a reasonably high concentration of CO_2. Although high-purity CO_2 is not required for geologic sequestration, it needs to be purified considerably (vs. the 415 ppm concentration in our atmosphere) for efficient transport.[12]

Bioeconomy Institute Carbon Removal Team, Iowa State University: *An Iowa State University research team helped develop a demonstration-scale pyrolyzer capable of sequestering thousands of tons of carbon dioxide a year.*[13]

Plants draw carbon dioxide out of the atmosphere to produce biomass as part of photosynthesis. But that carbon storage is often temporary. When plants die and decay, they release that stored carbon back into the atmosphere. The carbon removal team at the Bioeconomy Institute uses biomass from crop residues, wood and perennial grasses as stocks for pyrolysis while the plant matter is still rich in carbon. The biochar that results from the process can be added to agricultural fields, gardens or yards as a soil amendment that improves soil health and further increases carbon storage potential.

Iowa State currently has two pyrolyzers, a lab-scale unit installed on campus in the Biorenewables Research Laboratory and a larger pilot-scale unit at the BioCentury Research Farm outside Ames. The carbon removal team has partnered with Iowa-based Stine Seed Company and Frontline Bioenergy to build a demonstration-scale pyrolyzer near Redfield, Iowa, northwest of Des Moines. The new pyrolyzer is slated to come online this summer and will be capable of capturing and sequestering the equivalent of over 1,000 tons of carbon dioxide a year. That scale made the team eligible for the XPRIZE award.

The ISU scientists have developed a means of making the new pyrolyzer self-heating, improving its cost-effectiveness and environmental performance. This "auto-thermal pyrolyzer" works by pumping a small amount of air into the reactor, which causes some of the products of pyrolysis to partially oxidize and give off heat.

Global Algae *has developed multiple advances spanning the algae production process to enable economical, sustainable production of protein and biofuel commodities.*[14]

The innovations lower energy consumption, increase production efficiency, and lower the cost of conventional algae production technologies. Our technology provides commercial production of algal protein for human consumption and animal feed, algal oil for fuel and polymers, as well as high value products such as Spirulina (filamentous

[12] Energy Central, "An Electrifying Chameleon," June 2022, https://energycentral.com/c/cp/electrifying-chameleon
[13] Iowa State University News Service, "ISU team receives XPRIZE Carbon Removal milestone award for innovative vision to remove carbon from the atmosphere," April 22, 2022, https://www.news.iastate.edu/news/2022/04/22/xprizemilestone
[14] Global Algae, Our Technology, https://www.globalgae.com/our-technology

cyanobacteria which form tangled masses and is used for food supplements), pigments, and omega-3 oils.

Global Algae facilitates large-scale algae production with a systems approach and a detailed model to develop the entire process. We demonstrate these processes in our 8-acre algae farm that includes a large open-pond raceways…

***NetZero®** is a climate venture specializing in long-term carbon removal from the atmosphere.[15]*

We turn agricultural residues into biochar, a very stable form of carbon. The process is as follows: plants capture carbon during photosynthesis; we extract and stabilize this carbon through a pyrolysis process; the resulting biochar is buried in the soil, safely storing the carbon out of the atmosphere for hundreds of years.

This allows generation of high-quality carbon credits. Other benefits include increased crop yields through biochar use in soils, and production of renewable electricity from the excess energy of pyrolysis…

***PlantVillage** has developed a triple-A model (Algorithmic Agricultural Advice) that works to increase the yield and profitability for millions of farmers.[16]*

PlantVillage has created Nuru, an AI assistant for farmers. Nuru has three components to its artificial intelligence:

1. *human expert level crop disease diagnostics using computer vision;*
2. *above human capabilities in anomaly detection and forecasting based on ground and satellite derived data;*
3. *human language comprehension and automated responses to questions posed by farmers. Our AI works with extension services, governments and the UN.*

Author's comment: In looking at the above site extensively. I didn't see anything about "Carbon Removal," which thought was the whole idea of these awards. Also, this comment somewhat applies to Global Algae (see Marine Permaculture® SeaForestation below). Certainly, plants (including algae) sequester carbon, but only temporarily. Perhaps the organizers thought that there was the potential to partner these projects with other projects that can convert the plants biomass to biochar, like ***NetZero®***, above or **Takachar** below? Note the PlantVillage site is part of Penn State.

Takachar is on a mission to fight climate change by transforming waste biomass into marketable products around the world.[17]

Worldwide, $120 billion worth of crop and forest residues are burned in the open each year. If used productively, these residues represent a $10 billion market globally. Takachar's process can be a profitable way to make economic use of this biomass, while reducing air pollution.

Using a novel thermo-chemical process, Takachar has developed and patented the design of small-scale, low-cost, portable equipment to convert waste biomass into solid fuel, fertilizer, and other specialty chemicals. Compared to the process of sending waste

[15] NetZero home page, https://netzero.green/
[16] PlantVillage Home Page, https://plantvillage.psu.edu/
[17] Takachar Home Page, https://www.takachar.com/

biomass to centralized conversion facilities, Takachar's system is more profitable by significantly reducing the logistics cost of hauling loose, wet, and bulky biomass.

Our work impacts the following UN Sustainable Development Goals:

1. Eliminate fossil based sources to produce fuels, fertilizers and specialty chemicals. Eliminate more than 95% of smoke compared to open biomass burning or biomass induced wildfires.
2. Mitigate 700 million tons/year of carbon dioxide equivalent emissions by 2030.
3. Increase the net income of rural communities by 40% by creating a market for crop residues.

Captura *is based on technology recently patented by and licensed from Caltech. It has the potential to scale up to harvesting gigatons of carbon dioxide—that is, billions of tons—from the ocean every year...*[18]

The project began a year ago with a Department of Energy (DOE) Advanced Research Projects Agency–Energy (ARPA-E) funded effort. At the time this project was primarily interested in CO_2 conversion—trying to turn CO_2 into useful products, such as fuels.

…Conversion generates, at best, zero emissions from a CO_2 generation source. A full climate solution for the planet will also require negative emissions by capture of dilute CO_2, both to compensate for previous historical emissions and future emissions from hard-to-decarbonize sectors.

Marine Permaculture® SeaForestation *serves as a regenerative intervention providing deep water irrigated, open-ocean seaweed culture as a strategy for food security, regeneration of ecosystem services and carbon sequestration. At scale, deep water irrigation can regenerate seaweed forests offshore, from tropical to seasonally temperate waters, as demonstrated by the Climate Foundation's Philippines site deployed since 2019.*[19]

The foundational principles underpinning the development of Marine Permacultuare are comprised of:

1. *Food Security: Seaweed grown on our platforms is harvested to create bio-stimulants that confer drought and heat resilience to crops, cutting fertilizer requirements by 20% while preserving yields. Seaweed is also a nutritious and scalable food source, helping to diversify food systems and reducing pressure on land-based agriculture. Offshore seaweed platforms will relieve precious land and coastal ecosystems. They will shift food production to the vast, naturally low-productivity, tropical and subtropical open ocean, with its immense deep water nutrient supply.*
2. *Ocean Ecosystem Regeneration: Marine Permaculture platforms will have a significant impact on marine life by regenerating many of the ecosystem services provided by offshore seaweed forests, including the provision of fish habitat.*

[18] Caltech News Release, "Startup from Caltech Nabs XPRIZE Award," April 22, 2022, https://www.admissions.caltech.edu/news/startup-from-caltech-nabs-xprize-award#

[19] Climate Foundation Press Release, "The Climate Foundation Wins Million-Dollar Milestone XPRIZE for Carbon Removal," April 22, 2022, https://www.climatefoundation.org/xprize.html

3. *Carbon Balance: Every square kilometer of Marine Permaculture could potentially fix thousands of tons of carbon dioxide per year. Much of the seaweed falls from the seaweed platform during growth and sinks to the deep seafloor, where it is sequestered from the atmosphere for centuries in the abyssal ocean.*

***Planetary Technologies** was awarded the XPRIZE Carbon Removal Milestone Award for its accelerated carbon transition platform. Planetary's technology leverages the planet's ability to store carbon as a natural component of ocean chemistry. Planetary will use the $1 million prize to achieve a full-scale demonstration of its technology. Along with removing and storing carbon, Planetary's carbon removal process also creates renewable fuel and restores some of the damage climate change has already caused in ocean ecosystems.*[20]

Planetary's proprietary technology purifies mine waste into a mild, nontoxic antacid which is then released into the ocean through existing, regulated outfalls such as wastewater or stormwater streams that are constantly monitored. When mixed with seawater, the antacid restores the ocean's pH levels and accelerates the ocean's natural process of pulling carbon dioxide from the atmosphere. Restoring the ocean's balance also helps to reverse the damage caused by ocean acidification resulting from climate change.

As the mine waste is purified, clean hydrogen is produced as a by-product, allowing hard-to-decarbonize industries to limit their use of fossil fuel. The purification process also extracts metals that can be used in batteries, another important tool for a future low-carbon economy.

Planetary plans to open pilot plants in Quebec, Nova Scotia, and the UK in late 2022, which will demonstrate a scaled version of its patented process. The pilot plants will come online in phases in coordination with a major oceans research project and local partners to continually monitor local effects and fine-tune Planetary's platform.

***Carbin Minerals:** Certain mine tailings can permanently remove CO_2 directly from the atmosphere through a process known as carbon mineralization.*[21]

We have developed proprietary technologies to optimize and accelerate that process, creating the potential for gigaton-scale capture and permanent storage of atmospheric carbon dioxide…

The rapid deployment of clean energy technologies – essential for the energy transition – will require 4-6 times the supply of critical minerals by 2040. To achieve the Paris Targets, the mining of these metals must be net-zero.

We help producers of critical minerals get to net-zero and beyond.

3. Negative Emissions Technologies & Reliable Sequestration

As understanding of the risks and damages of climate change has improved, almost all nations have committed to limit total global warming to less than 2°C over preindustrial levels, with an aspirational target of 1.5°C. Meeting a 2°C target is becoming

[20] Planetary Technologies Press Release, "Climate Tech Startup Planetary Technologies Wins Million Dollar XPRIZE Carbon Removal Milestone Award," April 22, 2022, https://www.planetarytech.com/2022/04/22/xprize-milestone/

[21] Carbin Minerals Home Page, https://carbinminerals.ca/

exceedingly challenging; the global mean temperature has already risen about 1°C over the 20th century. Most climate and integrated assessment models project that the concentration of atmospheric carbon dioxide (CO_2) would have to stop increasing (and perhaps start decreasing) by the second half of the century for there to be a reasonable chance of limiting warming and the associated dangerous climate impacts.[22]

Fossil fuel consumption, agriculture, land-use change, and cement production are the dominant anthropogenic sources of CO_2 to the atmosphere. The focus of climate mitigation is to reduce energy sector emissions by 80-100 percent, requiring massive deployment of low-carbon technologies between now and 2050. Progress toward these targets could be made by deploying negative emissions technologies (NETs), which remove carbon from the atmosphere and sequester it. Under the present conditions, where fossil CO_2 is continuously added to the atmosphere, removing CO_2 from the atmosphere and storing it has exactly the same impact on the atmosphere and climate as simultaneously preventing emission of an equal amount of CO_2. NETs have been part of the portfolio to achieve net emissions reductions, at least since reforestation, afforestation, and soil sequestration were brought into the United Nations Framework Convention on Climate Change, albeit as mitigation options, more than two decades ago. Recent analyses found that deploying NETs may be less expensive and less disruptive than reducing some emissions, such as a substantial portion of agricultural and land-use emissions and some transportation emissions…

The committee repeatedly encountered the view that NETs will primarily be deployed to reduce atmospheric CO_2 after fossil emissions are reduced to near zero. In contrast, because it will likely be very expensive to decrease anthropogenic emissions once they reach low levels, methods for reduced and negative emissions will probably be competitors for an extended period, even during a sustained period of net negative global emissions. For example, few alternatives to chemical fuels are likely to exist for commercial aviation. One option for zero net aviation emissions would be deployment of $100/t CO_2 NETs to capture and store 2.5 kg of CO_2 for each liter of aviation fuel consumed. This will add ~25 cents per liter of fuel. This is just one example of how NETs might be conceptually bundled with emissions sources that are difficult to eliminate…

As directed by the Statement of Task, the committee focused on six major technical approaches to CO_2 removal and sequestration:

Author's Note: The references below are to other posts by your author. Also note that some of these are earlier footnotes that are cross-referenced below.

- *Coastal blue carbon—Land use and management practices that increase the carbon stored in living plants or sediments in mangroves, tidal marshlands, seagrass beds, and other tidal or salt-water wetlands. These approaches are sometimes called "blue carbon" even though they refer to coastal ecosystems instead of the open ocean.*[23]

[22] See the front matter for the linked document, starting on page v for the authors, National Academies of Sciences, Engineering, and Medicine, "Negative Emissions Technologies and Reliable Sequestration," 2019, https://nap.nationalacademies.org/download/25259

[23] Energy Central, "Wet NET," Jan 2022, Section 3, https://energycentral.com/c/rm/wet-net

- *Terrestrial carbon removal and sequestration—Land use and management practices such as afforestation/reforestation, changes in forest management, or changes in agricultural practices that enhance soil carbon storage ("agricultural soils").*[24] Also see earlier reference 7.

- *Bioenergy with carbon capture and sequestration—Energy production using plant biomass to produce electricity, liquid fuels, and/or heat combined with capture and sequestration of any CO_2 produced when using the bioenergy and any remaining biomass carbon that is not in the liquid fuels.*[25]

- *Direct air capture—Chemical processes that capture CO_2 from ambient air and concentrate it, so that it can be injected into a storage reservoir.* See earlier parts of this post.

- *Carbon mineralization—Accelerated "weathering," in which CO_2 from the atmosphere forms a chemical bond with a reactive mineral (particularly mantle peridotite, basaltic lava, and other reactive rocks), both at the surface (ex situ) where CO_2 in ambient air is mineralized on exposed rock and in the subsurface (in situ) where concentrated CO_2 streams are injected into ultramafic and basaltic rocks where it mineralizes in the pores.* See footnote / reference 6 above.

- *Geologic sequestration—CO_2 captured through BECCS or direct air capture is injected into a geologic formation, such as a saline aquifer, where it remains in the pore space of the rock for a long time. This is not a NET, but rather an option for the sequestration component of BECCS or direct air capture.*[26]

[24] Energy Central, "Trees", Aug 2019, https://www.energycentral.com/c/ec/trees
[25] Energy Central, "New NETWORKS, Part 1: BECCS (bioenergy with carbon capture and sequestration)," Oct 2020, https://energycentral.com/c/ec/new-networks-part-1-beccs
[26] Energy Central, "Verification of Geologic Greenhouse Gas Sequestration," Nov 2019, https://www.energycentral.com/c/cp/verification-geologic-greenhouse-gas-sequestration
Also: Energy Central, "Geologic Greenhouse Gas Sequestration Projects," March 2020, https://energycentral.com/c/ec/geologic-greenhouse-gas-sequestration-projects