CO_2

net 350

CARBON DIOXIDE

WHAT IS THIS GAS?

Origins	CO_2 naturally occurs on Earth due to decomposing vegetation and biomass, natural wildfires, as well as erupting volcanoes both on land and in the oceans (outgassing). CO_2 is also anthropogenically produced, through power generation, transportation (vehicle exhaust), fossil fuel combustion, chemical production, and agricultural practices.
What is the current PPM of this gas? And the atmospheric trend since 1700 and since 1960?	Atmospheric CO_2 in 2020 was recorded as 412.5 PPM. Thirty-four years ago in 1986, 350 PPM of atmospheric CO_2 was measured. Meanwhile, the mid 1700s saw approximately 270 PPM of atmospheric CO_2. In 200 years, from 1750-1986, CO_2 emissions grew just short of 100 PPM. A similar increase occurred between 1986-2022, yet that time frame consists of 34 years, not 200. The almost 100 PPM increase in 34 years displays rapid exponential increase in atmospheric CO_2 measurements.
Why is this gas important to climate change? How long does it remain in the atmosphere?	CO_2 is essential for life on Earth as humans produce it naturally, plants need it to photosynthesize, and it naturally warms the Earth to make it habitable for a swath of species. The exponential PPM increase as seen over the last 300 (approx.) years has contributed to the greenhouse effect. Carbon dioxide plays a part in the greenhouse effect through the capture and trapping of radiation. Both processes have contributed to the overall global temperature increase. CO_2 has a lengthy lifespan (relative to other GHGs) of around 300-1,000 years.
What is an appropriate PPM goal to meet 1.5 degree threshold?	An appropriate goal to mitigate the 1.5-degree (global warming) threshold would be maintaining 350 PPM of CO_2. This allocates a hypothetically reasonable lifestyle while controlling the global temperature increase.

REDUCTION POTENTIAL

Can emissions be reduced?	Emissions can be captured at point-source locations such as flue stacks and power generators. Carbon capture and storage (CCS) collects CO_2 emissions from point-source locations through techniques such as post-combustion, oxyfuel, and pre-combustion. Many CCS strategies involve mixing carbon dioxide with other substances like water and or oxygen. Mixtures are then sequestered and otherwise stored underground in deep, geologic formations.
Can emissions be captured at source?	Emissions can be captured at point-source locations such as flue stacks and power generators. Carbon capture and storage (CCS) collects CO_2 emissions from point-source locations through techniques such as post-combustion, oxyfuel, and pre-combustion. Many CCS strategies involve mixing carbon dioxide with other substances like water and or oxygen. Mixtures are then sequestered and otherwise stored underground in deep, geologic formations.
Can this gas be removed from the atmosphere or ocean?	Carbon dioxide can be removed from both the ocean as well as the atmosphere. Not all CO_2 should be removed, as, once again, it is essential (in appropriate doses) for life on Earth. Modern research and developed technologies have allowed for the removal in both locations, however.

TECHNOLOGY REMAINS IN DEVELOPMENTAL STAGES

What are current and potential removal technologies?	Direct air capture (DAC) and direct ocean capture (DOC) are the most prominent, current technologies. DAC and DOC perform similarly, just in different locations. CO_2 is extracted from ambient air (or water), then attached to sorbents which are heated. CO_2 is released from the sorbents where it is transferred to be utilized (or stored underground). Carbon dioxide can also be captured using vacuums, fans, or passively (using natural winds to pass air over sorbents). CCS does remove CO_2 from the atmosphere as well, but it typically captures at point-source locations and the use of the removed gas is sequestration opposed to utilization. Heimdal, a company in Hawaii, has launched the first ocean-assisted carbon removal plant. At this plant, machines remove acid from the ocean which is then sold as hydrochloric acid. De-acidified ocean water is released back into the ocean which is what captures the CO_2. This plant captures CO_2 at a less expensive rate compared to other operating carbon capture technologies around the world. Specifically, Heimdal can capture carbon at $475 cheaper per ton.
Which of these technologies are potentially scalable?	DAC and CCS are all scalable technologies to reduce / remove CO_2 emissions. 19 DAC plants currently operate globally to capture carbon dioxide emissions. As of 2021, Iceland has an operating plant capable of capturing 4 Mt CO_2 / year (~8,800 LBS) which is then stored. The current goal for DAC is to scale up to 85 Mt CO_2 capture / year (187,391 LBS) by 2030 and around 980 Mt CO_2 / year (2.1 M LBS) by 2050, but this will require more capture plants. DOC is a possible technology; however, it is not as developed as DAC or CCS.

FOR EACH TECHNOLOGY:

What are the uses of the removed gas?	DAC and DOC involve the capture of carbon dioxide emissions from land or water, and "refurbishing" CO_2, in a sense, for utilization. This could be interpreted as a recycling method as captured CO_2 is combined with other materials and transformed into construction matter like bricks and concrete. Additionally, it can be used in enhanced oil recovery and fuel manufacturing. CCS, on the other hand, stores CO_2 in underground geologic formations such as oil and gas reservoirs and coal beds.
If the use is sequestration, what is the sequestration time frame?	When carbon dioxide is captured for storage, it can remain underground for upwards of 10,000 years.
What is the net energy requirement to process removal?	DAC specifically understands the motivation to work towards net-0 carbon emissions. To ensure that carbon dioxide being emitted into the atmosphere is also being taken out, DAC predicts its energy usage to be 0.3%-0.4% of the U.S' generated electricity. Approximately 8.8 GJ / tCO_2, which converts itself to 4,400 LBS, would be necessary for each captured ton of CO_2.

V1.0