TECH BRIEF:
Cowboy Carbon Dioxide Removal (Cowboy CDR)

COWBOY CLEAN FUELS

What is Cowboy CDR?

Cowboy Carbon Dioxide Removal (Cowboy CDR) results from Cowboy Clean Fuels' innovative and patented process defined as Biomass Carbon Removal and Storage plus Renewable Natural Gas (BiCRS+RNG). It works by storing CO_2 removed from the atmosphere permanently in geologic formations, while simultaneously producing Renewable Natural Gas. Cowboy Clean Fuels has pioneered this process in the Powder River Basin (PRB) of Wyoming and is commercializing it there and elsewhere around the globe.

Unlike other emerging and conventional Carbon Capture and Storage (CCS) and CDR methods, Cowboy's BiCRS+RNG process involves the injection of carbon – in the form of solubilized renewable organic materials, such as agricultural processing residues – directly into subsurface, unmineable coal formations, which are home to native microorganisms. These microbes readily digest the carbon-rich materials, producing CO_2 and methane in the process. In this way, the coal seams act as "geo-bioreactors," enabling rapid conversion of the organic feedstock and – due to coal's strong natural affinity to adsorb CO_2 – ensuring the durable and permanent sequestration of carbon deep underground.

What is Conventional Carbon Capture and Storage?

Carbon capture and storage (CCS) refers to the process of separating and capturing CO_2 from industrial processes, power generation facilities, or directly from the air (i.e., direct air capture), concentrating and transporting the CO_2, and finally storing it in underground geologic formations where it can remain safely and permanently sequestered. By preventing or removing carbon dioxide emissions, CCS serves as a vital tool for lowering atmospheric CO_2 levels. The most well-known conventional approach to CCS is direct air capture.

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How is Carbon Dioxide Captured in CCS Today?

The primary separation and capture techniques involved in CCS include chemical absorption and adsorption, membrane separation, cryogenic separation, or oxyfuel combustion combined with post-combustion capture. These methods are expensive, inefficient, and extremely energy-intensive, resulting in poor economics and limited commercial viability.

What are Suitable Geologic Formations for Carbon Storage?

Suitable formations for geologic storage of CO_2 include saline aquifers, oil and natural gas reservoirs, organic-rich shales, basalt formations, and unmineable coal seams. To ensure long-term durable CO_2 storage, the deeper the formation used, the better. However, as depth increases within the Earth's crust, temperature and pressure rise, making it increasingly difficult to inject and store gases like CO_2. These countervailing forces present a challenge for conventional CCS projects.

How is Carbon Stored in Deep Geologic Formations?

Currently, depleted oil and gas reservoirs and saline aquifers are the primary options selected for large-scale commercial CO_2 sequestration projects. There are four main mechanisms that contribute to the trapping of injected CO_2 in depleted oil and gas reservoirs and saline aquifers: structural and stratigraphic trapping, residual trapping, solubility trapping, and mineral trapping. Each of these mechanisms is crucial for ensuring the long-term stability and containment of CO_2 in deep geological formations. However, each mechanism is also potentially reversible, potentially resulting in CO_2 leakage and requiring significant long-term monitoring and maintenance activities to ensure durability and permanence. In addition, due to their depth, oil and gas reservoirs and saline aquifers typically require the injection of supercritical CO_2 into the formation. This process is very energy intensive and costly.

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How is Cowboy's Process Different?

In contrast to other CDR technologies such as Direct Air Capture (DAC), the Cowboy CDR approach leverages the natural process of photosynthesis to remove CO_2 from the atmosphere and store it in plants, such as sugar beets. Soluble sugar beet processing residues like molasses are then injected into relatively shallow, but unmineable, coal formations in a liquid form at low pressures, in contrast to other CDR technologies that inject gaseous CO_2 into geologic formations at high pressures. Once in the formations, the soluble carbohydrates are metabolized by native microbes to produce CO_2 and methane. In this way, the Cowboy process uniquely integrates with the natural carbon cycle and harnesses microbial processes that have been occurring in deep subsurface reservoirs for millennia.

Additionally, while they benefit from the same trapping mechanisms as other geologic formations, coal seams also have a unique advantage: adsorptive sequestration. The large internal surface area of coal makes it particularly effective at adsorbing gases, in particular CO_2. This preferential partitioning of CO_2 onto the coal's surface occurs as a separate phase, ensuring that the CO_2 produced in the Cowboy CDR process by the native microbes remains immobile and securely stored. This characteristic significantly enhances the long-term stability of CO_2 stored in this way. Overall, Cowboy CDR offers a more sustainable, more durable, and less energy-intensive alternative to conventional CDR technologies.

What are Other Advantages of Cowboy CDR?

Another advantage of storing carbon in unmineable coal seams is the extensive research accumulated from the exploration and production of coalbed methane (CBM) reservoirs. For example, tens of thousands of CBM wells have been drilled and produced over nearly three decades in Wyoming's Powder River Basin (PRB), providing a wealth of geological data that confirms the integrity of geologic sequestration over millions of years and provides guidance to regulators and project developers alike. Additionally, the ability to access, modify and utilize existing equipment, wellbores, and other infrastructure enables the rapid and low-cost scaling of carbon storage operations.

Deep coal formations have the capacity to store vast amounts of CO_2. While suitable formations exist all over the globe, Cowboy Clean Fuels estimates that Wyoming's PRB alone could hold over 100 gigatons of CO_2 if fully developed utilizing the Cowboy CDR process.

What is the Impact of Cowboy CDR?

Cowboy CDR represents a transformative climate strategy, repurposing vast coal reservoirs from sources of non-renewable, climate-negative energy into dynamic geo-biological reactors with the ability to durably and permanently store CO_2 removed from the atmosphere while simultaneously producing climate-positive renewable natural gas. By harnessing the potential of these reservoirs for long-term carbon storage through the Cowboy CDR process, Cowboy has reimagined coal's role in the future energy economy, enhancing its value as a crucial resource in the fight against climate change.

CARBON CREDIT