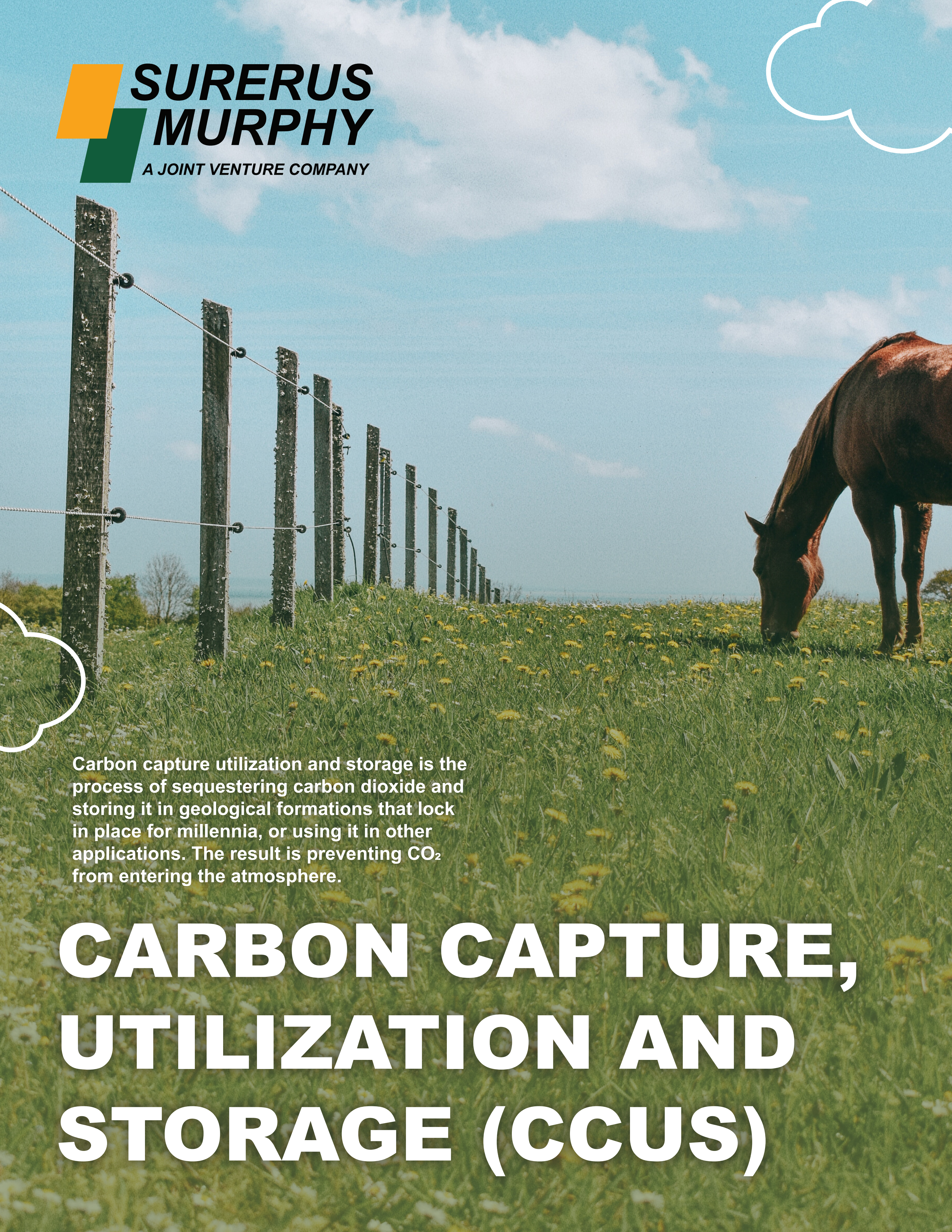


SURERUS MURPHY
A JOINT VENTURE COMPANY

Carbon capture utilization and storage is the process of sequestering carbon dioxide and storing it in geological formations that lock in place for millennia, or using it in other applications. The result is preventing CO_2 from entering the atmosphere.

CARBON CAPTURE, UTILIZATION AND STORAGE (CCUS)

Carbon Capture, Utilization, and Storage is an important emissions reduction strategy that can be applied across the entire energy system. CCUS prevents carbon dioxide from entering the atmosphere.

Carbon Capture, Utilization, and Storage (CCUS) technologies involve the capture of carbon dioxide (CO_2) from fuel combustion or industrial processes, the transport of this CO_2 via ship or pipeline, and either its use as a resource to create valuable products or services or its permanent storage deep underground in geological formations. This technology is applied to decarbonize fossil fuel power generation, as well as the production of steel, cement and blue hydrogen.

Despite the adoption of alternative energy sources and energy efficient systems to reduce the rate of CO_2 emissions, the cumulative amount of CO_2 already in the atmosphere needs to be reduced to limit the detrimental impacts of climate change. CCUS technologies provide the foundation for carbon removal or "negative emissions" when CO_2 comes from bio-based processes, or directly from the atmosphere, such as through a method known as direct air capture.

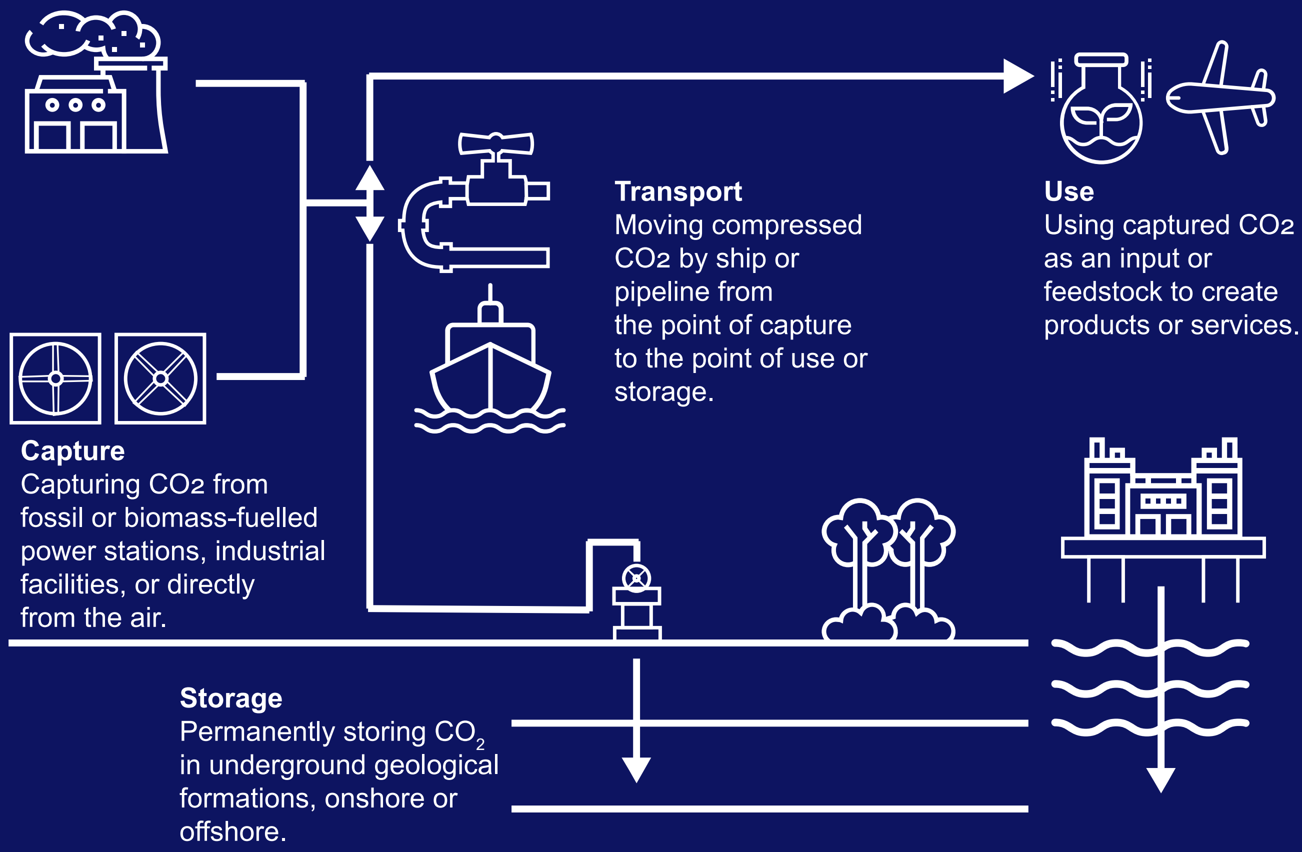
Our Services

Recognizing the ambitions for global decarbonization, Surerus Murphy Joint Venture (SMJV) fully understands the important role CCUS will play in our energy future. In response, we have been working to meet all our clients' needs in constructing the low-carbon economy.

Already leaders in the industry, our teams in the UK have been collaborating with clients on numerous Front End Engineering and Design (FEED) and constructability assessments to help kickstart the decarbonization of two key industrial clusters.

From capture, to transportation, to sequestration, SMJV's professional team of engineers and project management professionals are well versed on supporting all aspects of CCUS, including:

- Carbon Capture Facilities
- CO_2 Pipelines
- Front End Engineering and Design (FEED)
- Constructability & Buildability Studies


Capture
Capturing CO2 from fossil or biomass-fuelled power stations, industrial facilities, or directly from the air.
Transport
Moving compressed CO2 by ship or pipeline from the point of capture to the point of use or storage.
Use
Using captured CO2 as an input or feedstock to create products or services.
Storage
Permanently storing CO_2 in underground geological formations, onshore or offshore.


CO_2 TO MIXER
WATER

Carbon Capture Processes

Flue Gas Capture

Carbon dioxide (CO_2) capture is an integral part of many industrial processes and technologies as it separates and captures the CO_2, removing it from the flue gas stream. The most advanced and widely adopted CO_2 capture technologies are chemical absorption and physical separation. In fact, these technologies are now commercially viable. Other technologies (e.g. membrane separation), are being developed and are not yet commercially viable.

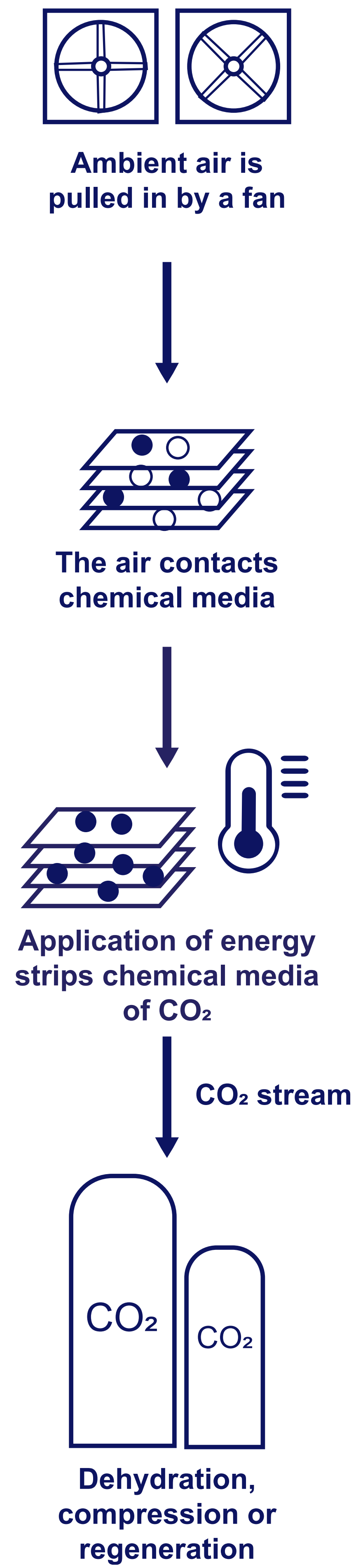
CAPTURE TECHNOLOGY	OVERVIEW	TECHNOLOGY STATUS
CHEMICAL ABSORPTION	A common process operation based on the reaction between CO_2 and a chemical solvent (such as compounds of ethanolamine). Chemical absorption using amine-based solvents are among the most advanced CO_2 separation techniques.	Widely used for decades and currently applied in several small and large-scale projects worldwide in power generation, fuel transformation and industrial production. The Scotford Upgrader near Fort Saskatchewan utilizes amine absorption technology to capture CO_2 as a part of the Shell Quest project. The captured CO_2 is then transported down a 64km pipeline to be sequestered underground in a geological formation. Approximately 1 million tonnes of CO_2 are sequestered annually—equivalent to the emissions from approximately 250,000 cars.
PHYSICAL SEPARATION	This capture technology is based on either adsorption, absorption, or cryogenic separation. Physical adsorption makes use of a solid surface such as activated carbon, alumina, metallic oxides, or zeolites. Physical absorption makes use of a liquid solvent such as Selexol or Rectisol. CO_2 can be separated from other gases by cooling and condensation. Cryogenic separation is widely used commercially for streams that already have high CO_2 concentrations (typically >90%), but it is not used for more dilute CO_2 streams.	Currently used in natural gas processing and ethanol, methanol, and hydrogen production, with nine commercial plants in operation. This capture method is utilized at the Northwest Refinery as a part of the Alberta Carbon Trunk Line. Rectisol is used to condition the syngas and absorb CO_2 which is then sent down a 240km pipeline for use in Enhanced Oil Recovery.
MEMBRANE SEPARATION	Gas separation membranes allow one component in a gas stream to pass through while the other becomes trapped. Membranes cannot usually achieve high degrees of separation, so multiple stages and/or recycling of one of the streams is necessary. This leads to increased complexity, energy consumption and costs.	Technology readiness varies according to the fuel and application. In natural gas processing, it is mainly at the demonstration stage. Membranes for CO_2 removal from syngas and biogas are already commercially available, while membranes for flue gas treatment are currently under development. Much development is required before membranes could be used on a large scale such as for carbon capture in power generating stations.

Direct Air Capture (DAC)

Direct Air Capture (DAC) is a practice of capturing carbon dioxide directly from the ambient air and generating a concentrated stream of CO_2 for sequestration or utilization.

Carbon dioxide (CO_2) removal is achieved when ambient air is pulled through a system by a fan, and contacts chemical media. This is typically an aqueous alkaline solvent or functionalized sorbents. These chemical media are subsequently stripped of CO_2 through the application of energy (usually heat). This results in a CO_2 stream that can undergo dehydration and compression, while simultaneously regenerating the chemical media for reuse. DAC can be deployed almost anywhere in the world depending on the CO_2 storage plan and with an increasing carbon price and cost reductions in technology, DAC has the potential to serve as a viable carbon dioxide removal tool in the near future.

Carbon Engineering is a DAC company founded in 2009 and is backed by Bill Gates and Murray Edwards. They currently operate a pilot project in Squamish B.C. that extracts 1 ton of CO_2/day. Over the course of a year, this is equivalent to removing CO_2 emissions from approximately 80 passenger vehicles. A portion of the captured CO_2 is converted into synthetic fuels, including gasoline, diesel, and jet fuel. Individual DAC facilities can be built to capture 1 million tons of CO_2 per year. This equates to emissions from approximately 250,000 vehicles.



Transportation

The availability of infrastructure to transport CO_2 safely and reliably is essential for deployment of CCUS.

The two main options for the large-scale, long distance transport of CO_2 are via pipeline and ship. Short distance, small volume transportation options include truck and rail, albeit at higher cost than ship or pipeline transport. Pipelines are the most cost effective way of transporting CO_2 in large quantities and have been utilized for many years as a part of the enhanced oil recovery (EOR) process.

There is an extensive onshore CO_2 pipeline network in North America, with a combined length of more than 8,000 km that has been operating safely since the 1970's. There are currently over 300km of CO_2 pipelines operating in Alberta that have the capacity to safely transport up to 17 million tonnes of CO_2 per year for sequestration.

Utilization

CO_2 can be used as an input for a range of products and services.

Today, around 230 million tonnes of CO_2 are used globally each year, primarily to produce fertilizers (around 125 Mt/year) and for enhanced oil recovery (around 70-80 Mt/year). Other commercial uses of CO_2 include food and beverage production, cooling, water treatment, and as a plant feedstock in greenhouses.

New carbon dioxide pathways include using carbon in CO_2 to convert hydrogen into a synthetic hydrocarbon fuel, using carbon in CO_2 as an alternative to fossil fuels in the production of some chemicals, and using CO_2 in the production of building materials to replace water in concrete or as a raw material in its constituents.

Storage

Storing CO_2 involves the injection of captured CO_2 into a deep underground geological reservoir of porous rock overlaid by an impermeable cap rock, which seals the reservoir and prevents the upward migration or "leakage" of CO_2 to the atmosphere. There are several types of reservoirs suitable for CO_2 storage, with deep saline formations and depleted oil and gas reservoirs having the largest capacity.

Deep saline formations are layers of porous and permeable rocks saturated with salty water (brine) – widespread in both onshore and offshore sedimentary basins. Depleted oil and gas reservoirs are porous rock formations that have trapped crude oil or gas for millions of years, before being extracted and can similarly trap injected CO_2.

When CO_2 is injected into a reservoir, condensed gas flows through it filling the porous space. The gas is usually compressed first to increase its density. For this process to work, the reservoir must typically be at depths greater than 800 metres to retain the CO_2 in a dense liquid-like state. The CO_2 is then permanently trapped in the reservoir by the overlaid cap rock and cannot escape.

FURTHER READINGS

HYDROGEN STRATEGY FOR CANADA

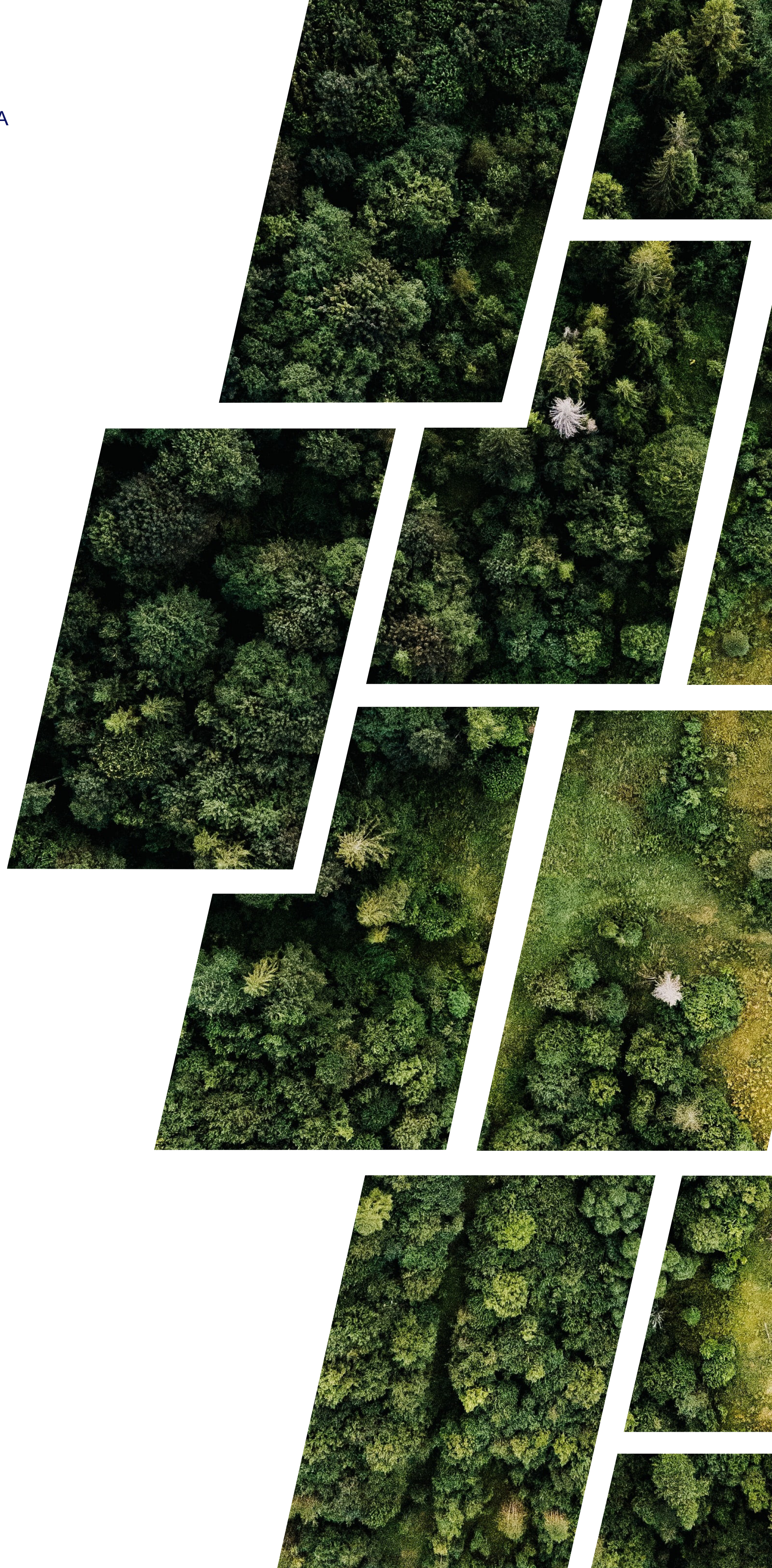
www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/environment/hydrogen/NRCan_Hydrogen-Strategy-Canada-na-en-v3.pdf

CANADA'S NET ZERO FUTURE

climatechoices.ca/wp-content/uploads/2021/02/Canadas-Net-Zero-Future_FINAL-2.pdf

NET ZERO EMISSIONS BY 2050

www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050.html



2200, 605 - 5th Avenue SW
Calgary, AB T2P 3H5

T: 403.930.1358
E: info@surerus-murphy.com

www.surerus-murphy.com