Illustration: Third Way

Engineered Carbon Dioxide Removal in a Net-Zero Canada

Opportunities and challenges for non-biological CDR deployment

What is carbon dioxide removal (CDR)?

For a process to be considered CDR, it needs to:

- remove carbon dioxide from the atmosphere,
- store the carbon dioxide durably so that it does not re-enter the atmosphere,
- remove more carbon dioxide than it emits, and
- be an extra measure in addition to anything that is already happening naturally.

There are **biological CDR solutions** like afforestation. Afforestation is the planting of new forests on land that did not previously have trees. This means that the carbon dioxide removed by this new forest is additional to what would have happened naturally.

Biological CDR options are already well-developed and used widely. The report associated with this fact sheet instead focuses on **engineered, non-biological CDR solutions** that have the potential to play a larger role in the future, but need additional attention to get there.

Why is carbon dioxide removal important?

Canada has committed to reduce emissions 40-45 per cent from 2005 levels by 2030, and then hit net-zero emissions by 2050. Net-zero means the amount of greenhouse gases we take out of the atmosphere must equal the amount we put into it.

It is critical to do all we can to make early, deep and sustained reductions of direct emissions from industry, transportation, agriculture and other sectors. But some industries, such as aviation, could have a very difficult time adequately reducing their emissions. Carbon dioxide removal can address the leftover, difficult-to-avoid emissions indirectly, by removing an equal amount of carbon dioxide from the atmosphere. It will also help us extract some of the legacy carbon that humanity released into the atmosphere over the last few centuries. In this way, CDR can even help achieve negative net emissions once net-zero is reached.

Why do we need to start developing CDR now?

In 2021, Canada made a commitment under an international climate treaty called the Paris Agreement to reduce emissions by 40-45 per cent below 2005 levels by 2030. We also said we would achieve net-zero emissions by 2050.

We can hit the 2030 target by reducing our direct emissions. But reaching the 2050 net-zero target will be more difficult, because we will need to tackle all the remaining emissions. That may not be possible under current and expected technology and economic conditions.

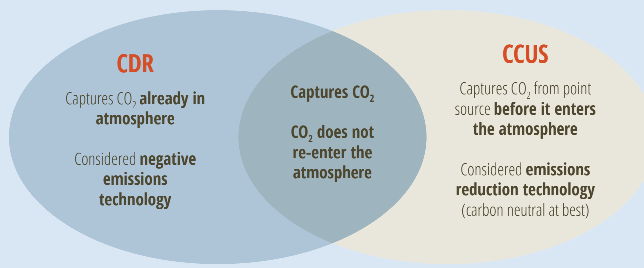
The magnitude of CDR required to achieve net-zero, even with sharp emissions reductions, is enormous. If we want to limit warming to 1.5 C, the world will need to use CDR technology to pull about five to 15 gigatonnes of carbon dioxide out of the air annually globally by 2050, which is expected to be very difficult. (One gigatonne is equal to about 20,000 Titanic ships.)

Early investment in CDR now is important so the technology is ready to rapidly scale into widespread use in the mid-century, when only hard-to-reduce emissions remain. We need to “learn by doing” through pilot and commercial-scale demonstrations, so we can figure out how to reduce the cost of CDR.

How is CDR different from carbon capture, utilization and storage (CCUS)?

Both are methods of capturing carbon dioxide which then either use it as an input to another process or store it in a way where it cannot enter the atmosphere.

The key difference is that CCUS reduces carbon dioxide emissions from industrial processes by capturing it from a point source, like the flue of an industrial facility, before it enters the atmosphere. With CDR, the carbon dioxide is removed directly from the atmosphere and could, in theory, be done anywhere.



What are the engineered CDR options?

There are many ways to remove carbon dioxide from the air. They currently include:

- Direct air capture removes carbon dioxide from the air using liquid or solid materials that bind specifically to carbon dioxide as air passes through them, usually driven with large fans.
- Ocean alkalinity enhancement boosts the amount of carbon the ocean can absorb by adding finely ground rocks to it. This increases its alkalinity and the water’s natural ability to capture and dissolve atmospheric carbon dioxide.
- Carbon mineralization occurs when specific types of rocks are exposed to carbon dioxide. This can happen underground, in industrial facilities, or along the ground in the open environment.
- Geologic storage involves storing carbon dioxide in deep underground saline aquifers. An impermeable layer of rock, called caprock, prevents the carbon dioxide from rising back to the surface.
- Carbon use takes carbon dioxide and turns it into products that generate revenue. An example is concrete, in which carbon dioxide can be securely stored while also reducing the amount of cement required in concrete production.

But isn't this technology expensive?

It's true that the technology doesn't come cheap right now. Costs for non-biological CDR are currently estimated around $300-800 per tonne of carbon dioxide removed. But some models estimate CDR could reduce the cost of tackling the stubborn, difficult-to-avoid remaining emissions by 40 per cent compared to alternatives.

In addition, costs are expected to come down as the technology improves.

And remember, the cost of not doing enough is also enormous. The economic damage done by climate change could cost Canada $391 billion to $865 billion annually by 2100, not to mention the human toll of climate-related disasters.

Where could we do CDR in Canada?

It varies depending on the type of CDR, but the best location for solutions like direct air capture with geologic storage is in areas where a good renewable energy supply exists next to plentiful geologic storage potential. Alberta, Saskatchewan, British Columbia, Manitoba, the Northwest Territories and the Yukon offer that combination. This helps to not only reduce the cost of transporting the carbon dioxide from capture site to storage site, but using renewable energy ensures the whole process removes more carbon dioxide than it emits.

What's stopping us from using CDR now?

We need to address a few issues first, including:

- Involve Indigenous communities to ensure their rights and interests are protected and their consent is obtained.
- Ensure we can credibly measure and verify CDR capture and storage.
- Support research and development that addresses risks, uncertainties and high costs of CDR.
- Create clear regulations to reduce investment uncertainty around CDR development.
- Support a business case for CDR, likely by recognizing CDR in the federal and provincial carbon offset systems, to give projects access to reliable revenue to justify investment.
- Engage and educate communities that might be impacted by CDR development.

The Pembina Institute acknowledges that the work we steward and those we serve is spans across many Nations. We respectfully acknowledge the space our organization is headquartered in as the traditional and ancestral territories of the Blackfoot Confederacy, comprised of the bands Siksika, Piikani, and Kainai, the Îyârhe Nakoda Nations, including the bands of Goodstoney, Chiniki, and Bearspaw, and the Tsuut'ina Dené. These Lands are also home to the Métis Nation of Alberta — Region 3 whose Peoples have deep relationships with the Land.

These acknowledgements are some of the beginning steps on a journey of several generations. We share them in the spirit of truth, justice, reconciliation, and to contribute to a more equitable and inclusive future for all of society.

PEMBINA institute

Carson Fong and Scott MacDougall
April 2023