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ANDREW ISAACS
NATÀLIA COSTA I COROMINA
ADITYA AGGARWAL

Carbon Capture, Utilization, and Storage: Separating Fact From Fiction

"The story of CCUS has largely been one of unmet expectations: its potential to mitigate climate change has been recognised for decades, but deployment has been slow and has had only a limited impact on global CO_2 emissions."

—INTERNATIONAL ENERGY AGENCY (IEA)[1]

In 1992, representatives from 179 countries came together and effectively agreed to end the fossil fuel age. The United Nations Conference on Environment and Development (UNCED), called the Earth Summit, held in Rio de Janeiro, Brazil, promised to deliver a "new blueprint for international action on environmental and development issues that would help guide international cooperation and development policy in the twenty-first century." Stabilizing the climate—as the leaders pledged to do—required stopping the increase of long-lived greenhouse gas concentrations in the earth's atmosphere.[2] And that, in turn, required all but eliminating the production and use of coal, oil and natural gas.

[1] https://www.iea.org/reports/ccus-in-clean-energy-transitions/a-new-era-for-ccus
[2] https://www.un.org/en/conferences/environment/rio1992

Professor Andrew M. Isaacs prepared this case study with Natàlia Costa i Coromina (UC Berkeley, Master of Development Practice 2023) and Aditya Aggarwal (UC Berkeley, BA 2025) with assistance from Case Writer Susan Thomas Springer, as the basis for class discussion rather than to illustrate either effective or ineffective handling of an administrative situation.

Twenty years later, with little progress to show, the "Rio+20" conference called for all countries to phase out fossil fuel subsidies by 2020, reduce annual global energy demand by 5 percent, and decrease annual carbon dioxide (CO_2) emissions by nearly 6 percent.[3] Yet, by late 2022, more than thirty years after the Earth Summit, CO_2 and other greenhouse gases had continued to increase significantly every year; in fact, since 1970, annual CO_2 emissions had increased by about 90%.[4] The United Nations, still searching for a solution to climate change, argued that part of the solution could be that "carbon capture, use and storage (CCUS) can play a significant role in mitigating carbon emissions."[5]

Some climate experts considered that CCUS was necessary for reaching net-zero greenhouse gas (GHG) emissions because cutting emissions to zero was not possible. For example, in 2019, the United Kingdom's Committee on Climate Change (CCC) announced support for CCUS in industries such as steel, cement, glass manufacturing and others that emit CO_2 as part of their production process. The CCC further added that CCUS helped to retain and create jobs in regions that relied on such heavy industries, connecting climate action with job creation.[6]

However, it was widely recognized that CCUS technology and the associated infrastructure were so nascent as to be unlikely to make a difference anytime soon. Problems included the lack of deep geologic sequestration wells with only two wells approved in the US by September, 2022, and very little in the way of pipelines dedicated to transporting CO_2.[7]

"Long term, we need to change many things about our system, rather than using the same old existing fossil fuel sources of energy," said Emiliya Mychasuk, Climate Editor of the Financial Times.[8]

Had decades-old pledges to stop fossil fuel use been replaced by efforts to instead capture fossil emissions? If so—were there really technologies and business models that could reduce carbon emissions via CCUS to meaningfully address climate change?

CCUS 101

The basic idea of CCUS is simple: capture CO_2 either directly from the atmosphere or from concentrated flue gases, compress that CO_2, and inject it deep underground for permanent storage in a geologic reservoir.

The "U" in CCUS means converting the captured CO_2 into a value-added product, although there are few options in this regard.[9] There is also the issue that the physical locations for the main processes—capturing and storing of CO_2 underground—are often not near each other. (**Exhibit 1**)

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[3] https://www.reuters.com/article/us-un-climate-text/factbox-main-points-in-rio20-draft-text-idUKBRE85J18M20120620
[4] https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data#:~:text=Since%201970%2C%20CO2%20emissions,been%20the%20second%2Dlargest%20contributors.
[5] https://unfccc.int/resource/climateaction2020/tep/thematic-areas/carbon-capture/index.html
[6] https://ukccsrc.ac.uk/ccs-explained/
[7] https://news.bloomberglaw.com/environment-and-energy/ira-driven-carbon-capture-needs-better-strategies
[8] https://next-media-api.ft.com/renditions/16492339526870/1280x720.mp4
[9] https://www.iea.org/reports/about-ccus

"One of the really big changes we've seen in the carbon capture space is the emergence of this idea of having hubs, as they're usually called here in the US, or clusters as they like to call them in the UK and in Europe."[10]

One storage issue is that CO_2 pumped underground can potentially escape back to the surface via fractures in bedrock. Research indicates that this kind of leakage is likely to be minor. However, greater leakage can occur in previously-drilled wells. "Both active and abandoned wells can serve as pathways for CO_2 leakage."[11] (**Exhibit 2**)

While CCUS could buy some time while humans get serious about reducing GHG emissions, "we will not store the way out of this problem." Speaking at an energy symposium in 2019, the head of the California Geologic Survey Steven Bohlen noted that the technology exists for California to achieve carbon neutrality in just 24 years but the state must be "much more committed" to CCUS than it had been so far. Whether in California or elsewhere, CCUS required much more investment in technology and infrastructure.[12]

Widespread adoption of CCUS was also essential in meeting the Paris Agreement's goal of limiting the increase in global temperatures to less than 2 degrees C above pre-industrial temperatures. CCUS "technology offers one of the few means of dealing with large, stationary emitters of CO_2." The size of the global problem required massive scaling up: "According to the International Energy Agency, CCUS technology would need to prevent nearly 4.4 gigatons of CO_2 a year from entering the earth's atmosphere by 2040, increasing to 9.4 gigatons annually by 2060."[13]

The success of CCUS also depends on alternative ways to address the climate crisis. "20 years from now the capacity to incorporate solar and wind power into the grid might be limited by an inability to raise capital for new transmission, or by a lack of progress in energy storage technologies." Given that scenario, early CCUS investments could prove more beneficial. "In fact, developing CCUS early, even if it is relatively expensive, can form an effective climate 'hedging' strategy."[14]

The US Inflation Reduction Act (IRA) of 2022 included approximately $369 billion in incentives for climate-related programs, including CCUS projects. The IRA "fundamentally alters the CCUS landscape in the U.S." The IRA increased the availability of federal income tax credits available for CCUS projects making it easier for CCUS projects to qualify for the credits. The law was expected to "encourage new investors to participate in CCUS projects, and should ensure that CCUS projects will be a significant feature of decarbonization efforts in the U.S."[15]

Questions remained about how to navigate CCUS projects as the IRA came into effect. For example, while most developers interested in IRA tax credits were pursuing approvals to store CO_2 in deep geologic sequestration wells regulated by the Environmental Protection Agency (EPA), the well certification program was still in its infancy: "Only two wells have been federally approved for injection, which took upwards of six years to permit fully." A pipeline network essential to large-scale adoption of CCUS did not yet exist at the time that the law was adopted. Without the

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[10] https://www.ft.com/video/25df7aa2-e414-484f-ac2f-63e06644fcb1
[11] https://theicct.org/carbon-capture-and-storage-a-lot-of-eggs-in-a-potentially-leaky-basket/
[12] https://www.bakersfield.com/news/bc-digs-deeper-on-carbon-capture-and-sequestration/article_4d42a344-41c2-11ec-9acf-8ba37ad40316.html
[13] https://www.bcg.com/publications/2019/business-case-carbon-capture
[14] https://dash.harvard.edu/bitstream/handle/1/37372397/CCUS_Final_0.pdf?sequence=1&isAllowed=y
[15] https://www.gibsondunn.com/the-inflation-reduction-act-includes-significant-benefits-for-the-carbon-capture-industry/

federal government leading on developing CO_2 pipelines, "developers will need to continue to incorporate CO_2 pipeline regulatory risk into their planning scenarios."[16]

Also in 2022, the European Commission announced it would "invest €1.8 billion towards seventeen large-scale innovative clean tech projects" including CCUS. Investments ranged from low-carbon cement production, carbon mineral storage site development and sustainable aviation fuel production.[17]

Opposing Views

Some energy experts viewed CCUS with great promise while others voiced skepticism about a technology that had been in the experimental phase for decades.[18]

By 2022, carbon capture and re-use had mostly been used for enhanced oil recovery (EOR) in older oil fields, although "enhancing oil production is not a climate solution."[19] The question remained as to whether CCUS was "a greenwash to extend the life of fossil fuel assets or a panacea to avert catastrophic climate change." Greenpeace called CCUS a "scam" that had driven billions in government spending to "capture and store CO_2" while only removing small amounts."[20]

In some industries, such as agriculture and aviation, zeroing out carbon emissions could simply be impossible, leaving CCUS as the only solution.

"The key problem with carbon capture, as many environmentalists see it, is that fossil fuel producers can continue to operate as they are operating now without having to overhaul the way they do things because any emissions that are produced can just be sucked back up."[21]

Climate Change Solution or Mirage?

In early 2022, ExxonMobil announced that Air Liquide, BASF, Shell Chevron, and Dow had joined ExxonMobil to evaluate CCUS as an emissions reduction technology. The companies planned to "capture and safely store up to 50 million metric tons of CO_2 per year by 2030 and 100 million metric tons per year by 2040." The alliance promised to reduce one of the nation's most concentrated sources of CO_2, and make it the model for an emerging, lower-emissions world that would support jobs, economic growth, and prosperity. Houston's mayor hailed the move as making it possible to reach net-zero emissions goals through companies working together and "applying proven technology to reduce emissions."[22] (**Exhibit 3**)

But it was also in Houston that just a few years earlier the $1 billion Petra Nova project to harness carbon dioxide emissions from a nearby coal facility shut down due to unsolvable technical

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[16] https://news.bloomberglaw.com/environment-and-energy/ira-driven-carbon-capture-needs-better-strategies
[17] https://www.globalccsinstitute.com/news-media/latest-news/eu-innovation-fund-to-invest-in-seven-ccs-and-ccu-projects/
[18] https://wyofile.com/lets-not-exaggerate-ccus-impacts-on-wyoming/?gclid=Cj0KCQjw48OaBhDWARIsAMd966Bd8MXtnP2FChJv8webJmB6jWx2wQgZWiO5LUQ43I_jnwKwzZdeIKUaAmGREALw_wcB
[19] https://ieefa.org/resources/carbon-capture-crux-lessons-learned
[20] https://www.greenpeace.org/international/story/54079/great-carbon-capture-scam/
[21] https://www.ft.com/video/25df7aa2-e414-484f-ac2f-63e06644fcb1
[22] https://www.houston.org/news/momentum-accelerates-houston-carbon-capture-hub

difficulties. The failed plant was seen as a major test of the effort to capture planet-warming gases and store them below ground.[23]

For supporters of CCUS, the years beyond 2022 will be "absolutely crucial" to show that these technologies are viable and can deliver the performance and cost reduction that they promise. "They've got to prove that actually will happen."[24]

Case Discussion Questions

1. Define the business, social, and ethical issues associated with CCUS.

2. What is the liability for corporations that rely on CCUS to meet their climate goals?

[23] https://www.reuters.com/article/us-usa-energy-carbon-capture/problems-plagued-u-s-co2-capture-project-before-shutdown-document-idUSKCN2523K8
[24] https://www.ft.com/video/25df7aa2-e414-484f-ac2f-63e06644fcb1

Exhibit 1 The three required resources for CCUS

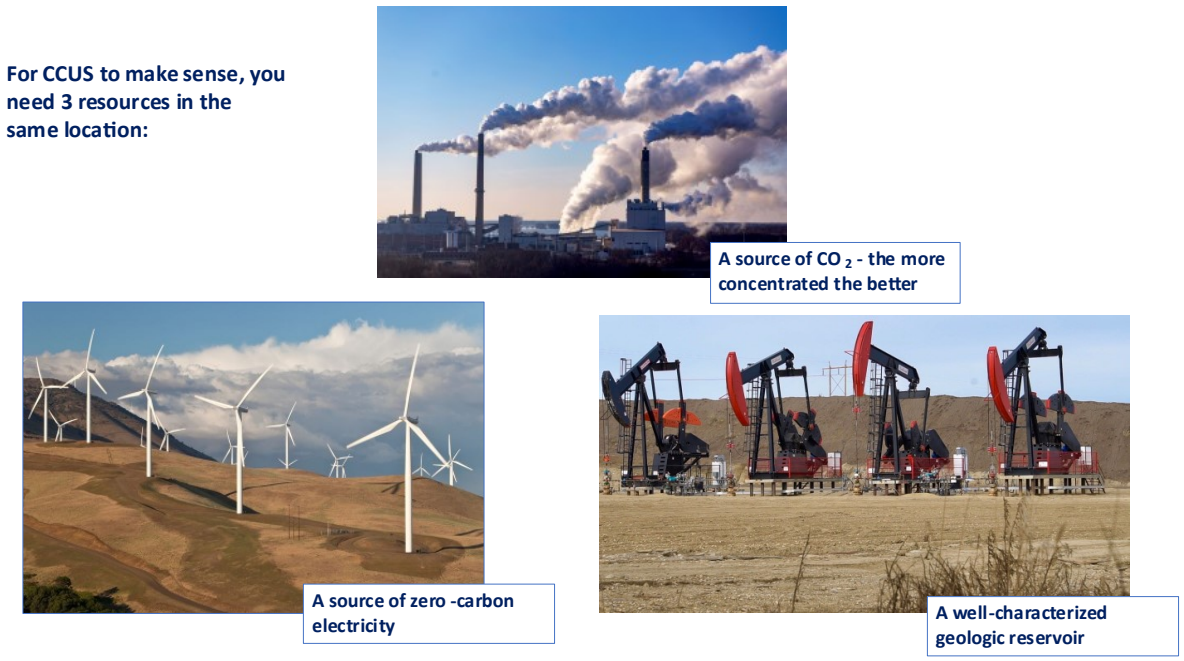
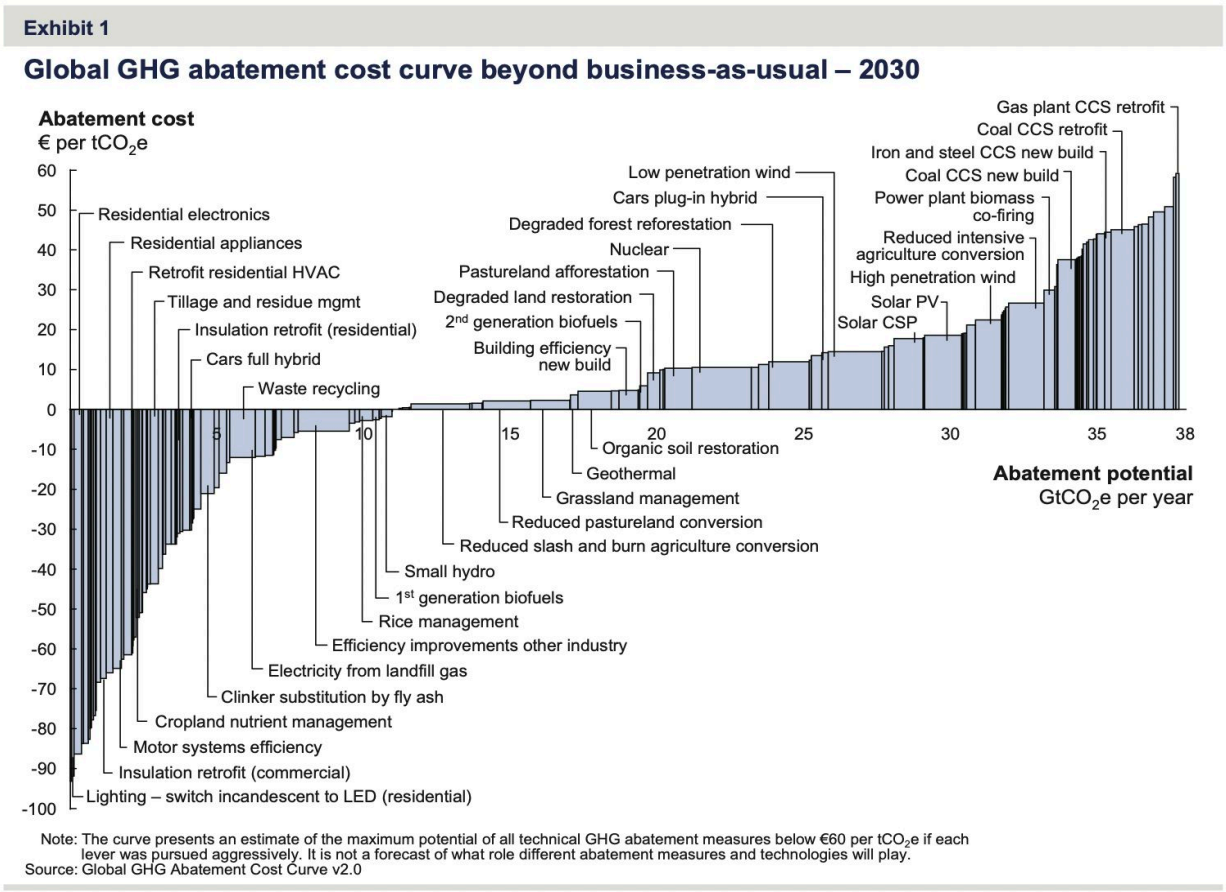
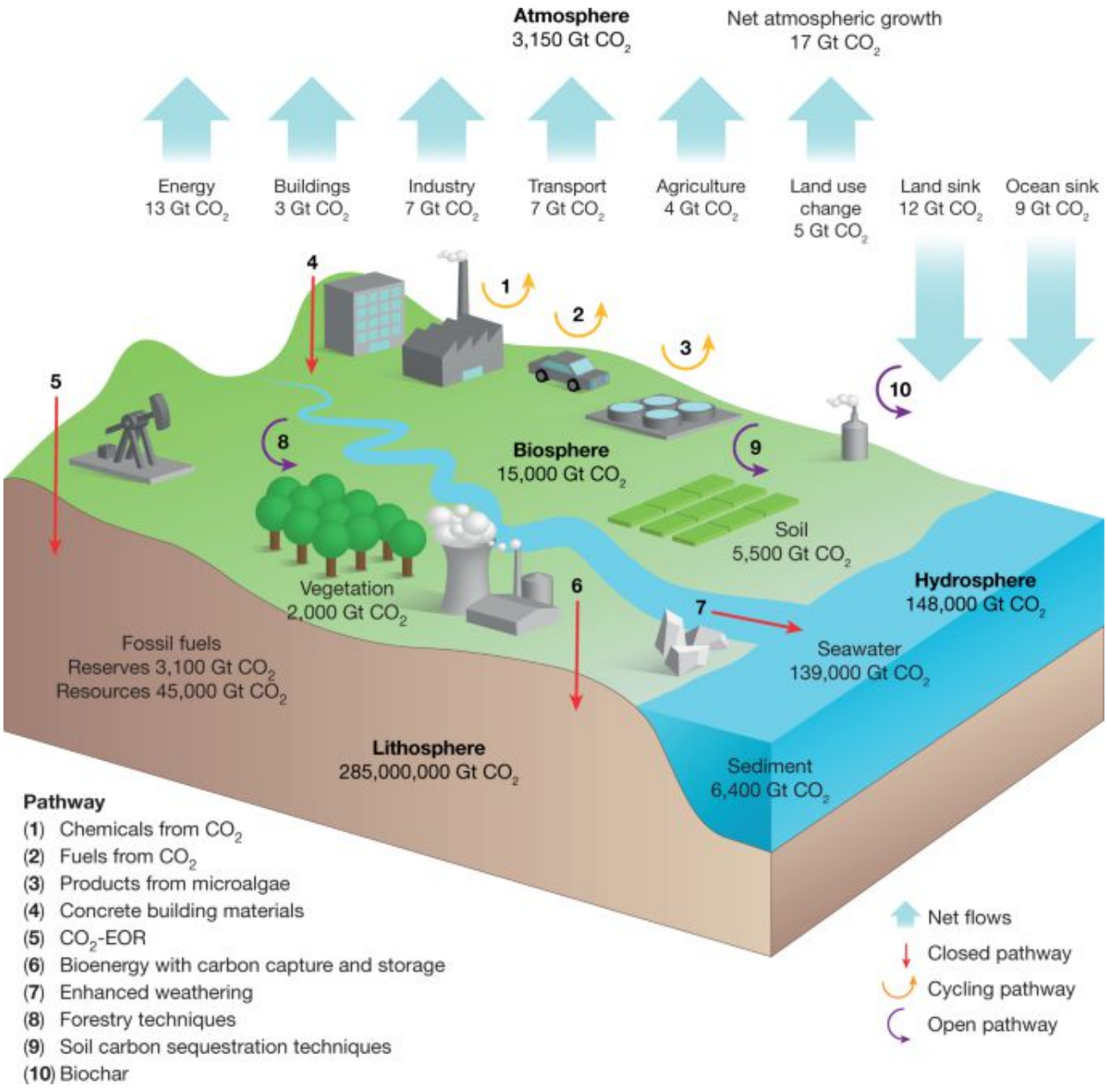


Exhibit 2 Pathways to a Low-Carbon Economy



Source: *https://www.cbd.int/financial/doc/Pathwaystoalowcarboneconomy.pdf*

Exhibit 3 Stocks and net flows of CO_2 including potential utilization and removal pathways.



Source: https://www.nature.com/articles/s41586-019-1681-6