Carbon Capture and Storage: The Climate and Environmental Costs

Presentation for the Environmental Justice Advisory Committee of the California Air Resources Board

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Carbon Capture is Not New

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REVIEW OF ENVIRONMENTAL PROTECTION ACTIVITIES FOR 1978-1979

There is no doubt that increases in fossil fuel usage and decreases in forest cover are aggravating the potential problem of increased CO_2 in the atmosphere. Technology exists to remove CO_2 from stack gases but removal of only 50% of the CO_2 would double the cost of power generation.

Patented Jan. 12, 1954

2,665,971

UNITED STATES PATENT OFFICE

2,665,971

PRODUCTION OF PURE CARBON DIOXIDE

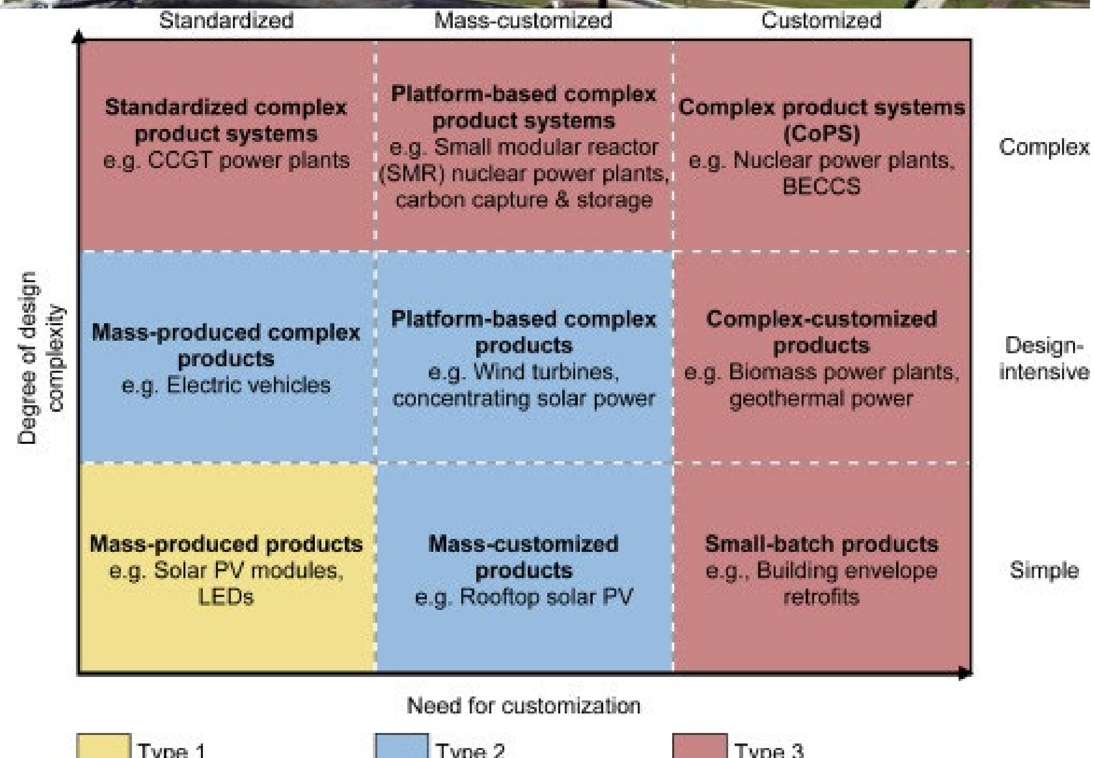
Warren K. Lewis, Newton, and Edwin R. Gilliland, Arlington, Mass., assignors to Standard Oil Development Company, a corporation of Delaware

Application May 12, 1949, Serial No. 92,812

6 Claims. (Cl. 23—150)

PROPRIETARY TO IMPERIAL OIL AND AFFILIATES

Carbon Capture is Not Simple



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Climate and Environmental Concerns Regarding Carbon Capture and Storage

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Carbon Capture does not do what its proponents claim it does

- Low capture rates
- Poor utilization capacity
- Challenges with transportation and storage

Even if it did, Carbon Capture would not be an adequate climate solution

- Limited application
- Upstream and downstream emissions

Carbon Capture has significant non-climate impacts that must be considered

- Air pollution
- Water use
- Solid waste
- Carbon dioxide leaks

CCS has a long history of over-promising and under-performing

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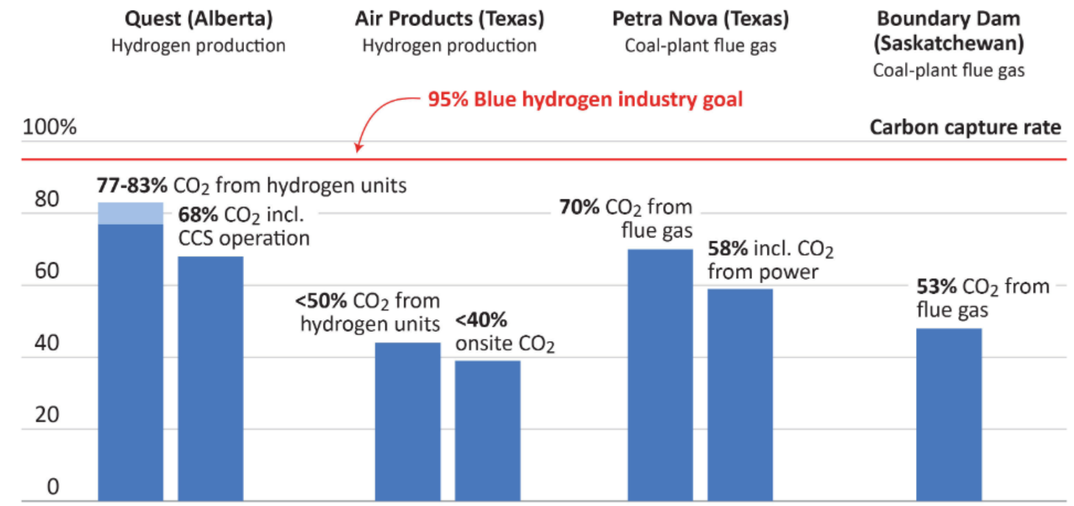
Reality Check: Real-World CO_2 Capture Far Below Promised Rate



Carbon Capture and Storage (CCS) projects' poor report card

Project	Capacity (MtCO2 p.a.)	Performance
Natural Gas processing		
1986 Shute Creek	7	Lifetime under-performance of 36%
1996 Sleipner	0.9	Performing close to the capture capacity
2004 In Salah	1.1	Failed after 7 years of operation
2007 Snøhvit	0.7	Performing close to the capture capacity
2019 Gorgon	4	Lifetime under-performance of ~50%
Industrial sector		
2000 Great Plains	3	Lifetime under-performance of 20–30%
2013 Coffeyville	0.9	No public data was found on the lifetime performance.
2015 Quest	1.1	Performing close to the capture capacity
2016 Abu Dhabi	0.8	No public data was found on the lifetime performance.
2017 Illinois Industrial (IL-CCS)	1	Lifetime under-performance of 45–50%
Power sector		
2014 Kemper	3	Failed to be started
2014 Boundary Dam	1	Lifetime under-performance of ~50%
2017 Petra Nova	1.4	Suspended after 4 years of operation

Source: IEEFA. The Carbon Capture Crux: Lessons learned. September 2022.

CCS projects face operational problems at the capture and storage sites

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Problems plagued U.S. CO2 capture project before shutdown -DOE document

By Nichola Groom

August 6, 2020 7:03 PM EDT · Updated 4 years ago

Aa

Since Petra Nova started up in 2017, it suffered outages on 367 days, according to a Department of Energy technical report compiled in March. Issues with the carbon-capture facility accounted for more than a quarter of the outage days, followed by problems with the plant's dedicated natural gas power unit, according to the report.

Chevron's troubled carbon capture and storage at Gorgon set to worsen in 2023

Chevron expects the performance of its troubled seven-year attempt to bury carbon dioxide from its Gorgon gas export plant to dip in 2023 after a poor year when it only operated at one-third of its design capacity.

The forecast was based on the need to restrict the rate of injecting carbon dioxide two kilometres under the island to manage the pressure in the formation and keep "induced microseismicity" – or feint earth tremors – within allowed limits.

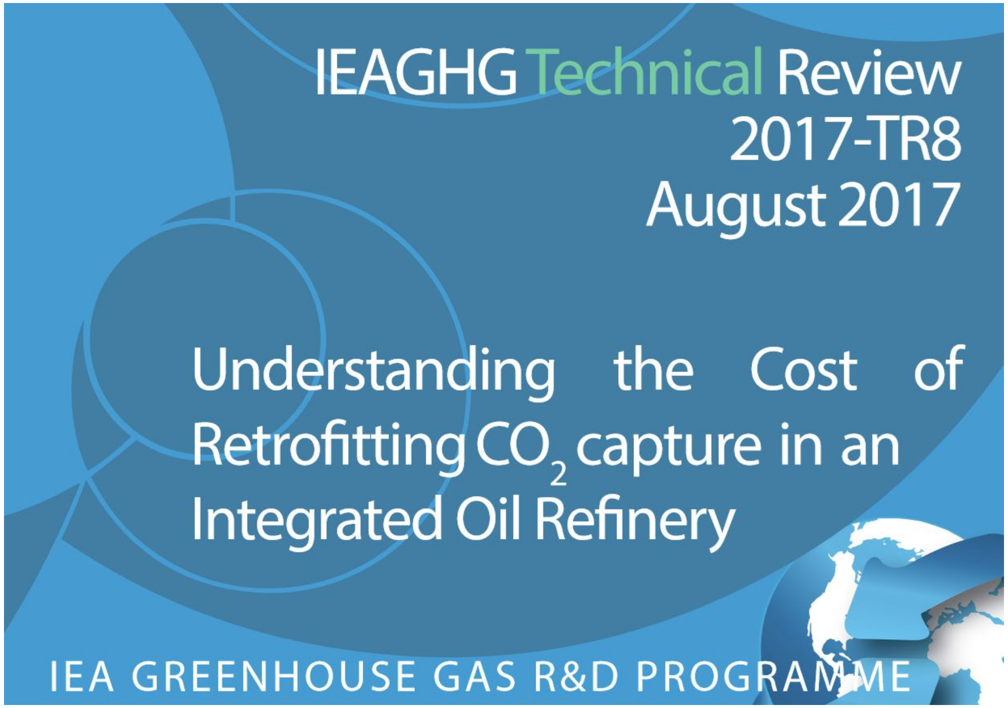
Carbon capture is only applied to some parts of the industrial process

Table 6. Key technical characteristics of the CO_2 capture cases for Base Case 1

	Case 01-01	Case 01-02	Case 01-03
Units considered for CO_2 capture	A1	A1+A2	A1+A2+A3
Amount of CO_2 captured (kt_{CO2}/y)	316	499	566
Percentage of refinery emissions captured (%)	43.3	68.4	77.7
Amount of CO_2 avoided (kt_{CO2}/y)	209	330	375
Percentage of refinery emissions avoided (%)	28.7	45.3	51.5

Table 12. Key technical characteristics of the CO_2 capture cases for Base Case 4

	Case 04-01	Case 04-02	Case 04-03	Case 04-04	Case 04-05	Case 04-06
Units considered for CO_2 capture	D1	D1+D3+D4	D1+D2+D3 +D4+D5	D5	D1+D3 +D4+D5	D1+D2 +D3+D4
Amount of CO_2 captured (kt_{CO2}/y)	740	1,485	2,777	886	2,376	1,886
Percentage of refinery emissions captured (%)	*19.1*	*38.4*	*71.7*	*22.9*	*61.4*	*48.7*
Amount of CO_2 avoided (kt_{CO2}/y)	481	975	1,847	600	1,579	1,243
Percentage of refinery emissions avoided (%)	*12.4*	*25.2*	*47.7*	*15.5*	*40.8*	*32.1*



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Carbon Capture only addresses one part of the emissions chain

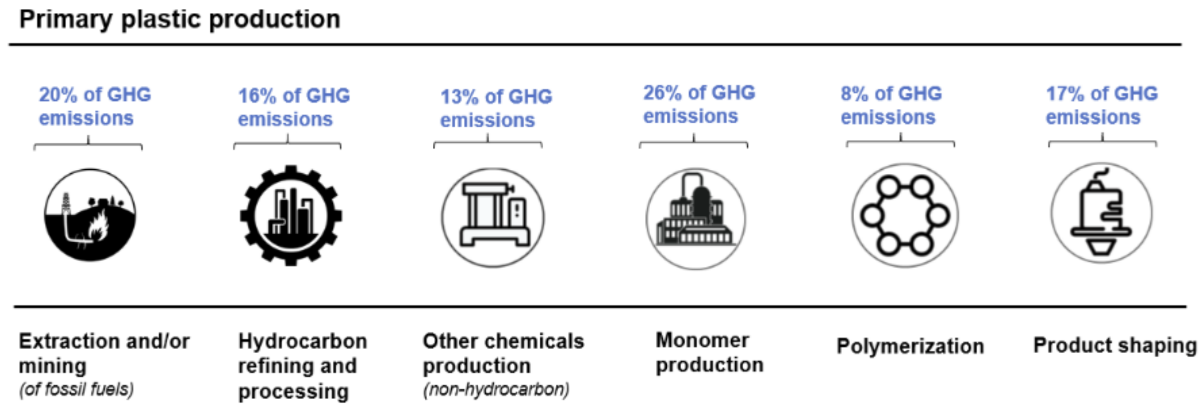
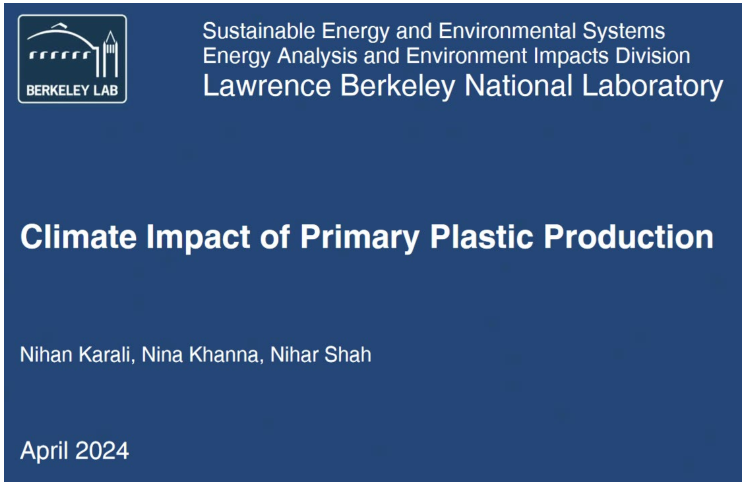


Figure ES- 3. GHG emissions shares of plastic production stages in 2019.

Notes: In this analysis, "Extraction and/or mining" refers to fossil fuel (i.e., crude oil, natural gas, and coal) extraction and/or mining step. "Hydrocarbon production" refers to refining and processing of fossil fuels for hydrocarbons (e.g., naphtha and ethane) used for the production of monomers. "Other chemicals production" refers to production of non-hydrocarbon materials (e.g., acetic acid, formaldehyde, and chlorine) used for the production of some monomers. "Monomer production" refers to the production of monomers (e.g., ethylene and propylene), which are the building blocks of polymers. "Polymerization" describes the process by which monomers are chemically combined to form larger molecules called polymers (e.g., polyethylene (PE) and polypropylene (PP)). "Product shaping" refers to the stage where polymers are processed and transformed into final products.



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Enhanced Oil Recovery is the only commercial market for captured carbon dioxide

2023 FACILITIES LIST

Operational

Facility	Country	Operational date	Facility industry	Capture, transport and/or storage capacity (Mtpa CO_2)	Facility storage code
Occidental Terrell	USA	1972	Natural Gas Processing	0.5	Enhanced Oil Recovery
Enid Fertilizer	USA	1982	Hydrogen / Ammonia / Fertiliser	0.2	Enhanced Oil Recovery
ExxonMobil Shute Creek Gas	USA	1986	Natural Gas Processing	7	Enhanced Oil Recovery
MOL Szank Field	Hungary	1992	Natural Gas Processing	0.16	Enhanced Oil Recovery
Equinor Sleipner	Norway	1996	Natural Gas Processing	1	Dedicated Geological Storage
Great Plains Synfuels Plant and Weyburn-Midale	USA	2000	Hydrogen / Ammonia / Fertiliser	3	Enhanced Oil Recovery
Core Energy CO_2-EOR South Chester plant	USA	2003	Natural Gas Processing	0.35	Enhanced Oil Recovery
Equinor Snohvit	Norway	2008	Natural Gas Processing	0.7	Dedicated Geological Storage
Petrobras Santos Basin Pre-Salt Oil Field	Brazil	2008	Natural Gas Processing	10.6	Enhanced Oil Recovery
Arkalon CO_2 Compression Facility	USA	2009	Ethanol	0.5	Enhanced Oil Recovery
Longfellow WTO Century Plant	USA	2010	Natural Gas Processing	5	Enhanced Oil Recovery
Gary Climate Solutions Bonanza BioEnergy	USA	2012	Ethanol	0.1	Enhanced Oil Recovery
Yanchang Integrated Demonstration	China	2012	Chemical	0.05	Enhanced Oil Recovery
Air Products and Chemicals Valero Port Arthur Refinery	USA	2013	Hydrogen / Ammonia / Fertiliser	0.9	Enhanced Oil Recovery
Contango Lost Cabin Gas Plant	USA	2013	Natural Gas Processing	0.9	Enhanced Oil Recovery
Coffeyville Gasification Plant	USA	2013	Hydrogen / Ammonia / Fertiliser	0.9	Enhanced Oil Recovery
PCS Nitrogen Geismar Plant	USA	2013	Hydrogen / Ammonia / Fertiliser	0.3	Enhanced Oil Recovery
SaskPower Boundary Dam	Canada	2014	Power Generation and Heat	1	Enhanced Oil Recovery
Saudi Aramco Uthmaniyah	Saudi Arabia	2015	Natural Gas Processing	0.8	Enhanced Oil Recovery
Shell Quest	Canada	2015	Hydrogen / Ammonia / Fertiliser	1.3	Dedicated Geological Storage

Operational

Facility	Country	Operational date	Facility industry	Capture, transport and/or storage capacity (Mtpa CO_2)	Facility storage code
Xinjiang Dunhua Karamay	China	2015	Chemical	0.1	Enhanced Oil Recovery
ADNOC Al-Reyadah	United Arab Emirates	2016	Iron and Steel Production	0.8	Enhanced Oil Recovery
ADM Illinois Industrial	USA	2017	Ethanol	1	Dedicated Geological Storage
CNPC Jilin Oil Field	China	2018	Natural Gas Processing	0.6	Enhanced Oil Recovery
Chevron Gorgon	Australia	2019	Natural Gas Processing	4	Dedicated Geological Storage
Qatargas Qatar LNG	Qatar	2019	Natural Gas Processing	2.2	Dedicated Geological Storage
Enhance Clive Oil Field	Canada	2020	CO_2 Transport / Storage	1.12	Enhanced Oil Recovery
NWR Sturgeon Refinery	Canada	2020	Oil Refining	1.6	Enhanced Oil Recovery
WCS Redwater	Canada	2020	Hydrogen / Ammonia / Fertiliser	0.3	Enhanced Oil Recovery
Wolf Alberta Carbon Trunk Line	Canada	2020	CO_2 Transport / Storage	14.6	Enhanced Oil Recovery
China National Energy Guohua Jinjie	China	2021	Power Generation and Heat	0.15	Dedicated Geological Storage
Climeworks Orca	Iceland	2021	Direct Air Capture	0.004	Dedicated Geological Storage
Sinopec Nanjing Chemical	China	2021	Chemical	0.2	Enhanced Oil Recovery
Yangchang Yan'an CO_2-EOR	China	2021	Chemical	0.1	Enhanced Oil Recovery
Entropy Glacier Gas Plant	Canada	2022	Natural Gas Processing	0.2	Dedicated Geological Storage
Red Trail Energy Richardton Ethanol	USA	2022	Ethanol	0.18	Dedicated Geological Storage
Sinopec Qilu-Shengli	China	2022	Chemical	1	Enhanced Oil Recovery
Yangchang Yulin CO_2-EOR	China	2022	Chemical	0.3	Dedicated Geological Storage
China National Energy Taizhou	China	2023	Power Generation and Heat	0.5	Enhanced Oil Recovery
CNOOC Enping	China	2023	Natural Gas Processing	0.3	Dedicated Geological Storage
Sinopec Jinling Petrochemical (Nanjing Refinery)	China	2023	Oil Refining	0.3	Enhanced Oil Recovery

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Carbon capture represents a threat to air quality

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The carbon capture process requires significant additional energy

"CO2 capture costs present a key challenge… The capital cost of a coal or gas electricity generation facility with CCS is almost double one without CCS. **Additionally, the energy penalty increases the fuel requirement for electricity generation by 13–44%, leading to further cost increases."** [Ch. 6, at 6-38]

6.1.4.1.2 Environmental Considerations

Economic infeasibility notwithstanding, Chevron Phillips asserts that CCS can have detrimental effects on the environment. Specifically, carbon capture and compression results in an energy penalty of approximately 30 percent[9]. For the cracker project, this energy penalty would result in generation of not only 30% more GHGs to generate the required steam energy to operate the plant, but also would increase emissions of NO_x, CO, VOC, PM_{10}, SO_2, and ammonia by an equivalent percentage. Considering that the plant is in an ozone nonattainment area, generation of 30 percent more NO_x and VOC is environmentally detrimental. Further, adding 30 percent more steam generation capacity to the project necessitates construction of a second VHP boiler, thus requiring a larger footprint and more construction disturbance to the soil.

Carbon capture increases industrial water requirement

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IPCC Working Group III:

"CCS requires considerable increases in some resources and chemicals, most notably water. Power plants with CCS could shut down periodically due to water scarcity. **In several cases, water withdrawals for CCS are 25–200% higher than plants without CCS** (Rosa et al. 2020b; Yang et al. 2020) due to energy penalty and cooling duty. The increase is slightly lower for non-absorption technologies. **In regions prone to water scarcity such as the Southwestern USA or Southeast Asia, this may limit deployment and result in power plant shutdowns during the summer months** (Liu et al. 2019b; Wang et al. 2019c)."

Carbon capture creates liquid and solid waste

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PRELIMINARY DETERMINATION SUMMARY

Monoethylene Glycol Plant
Lotte Chemical Louisiana LLC
Westlake, Calcasieu Parish, Louisiana
PSD-LA-801 (M-1)

In addition to being an extremely expensive technology, CCS would also result in adverse and environmental impacts. As noted above, a substantial amount of electricity (and therefore fuel) would be required to power the process equipment needed to separate and compress CO_2. Generation of this electricity would result in significant criteria pollutant emissions. In addition, amine-based scrubbing generates large volumes of wastewater, which would have to be treated and discharged to a nearby water body, and solid waste, which eventually must be disposed in a landfill. For these reasons, CCS has been eliminated from further consideration.

Carbon dioxide is a potent risk to communities through which it is piped and under which it is injected

‘Wake-up call’: pipeline leak exposes carbon capture safety gaps, advocates say

Estimated 2,548 barrels of carbon dioxide leaked from Exxon pipeline in Louisiana on 3 April, triggering alarm among residents

'Foaming at the mouth': First responders describe scene after pipeline rupture, gas leak

Illustration by Hokyoung Kim for HuffPost

The Gassing Of Satartia

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Thank You!

For further questions or inquiries, please email:

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