Occidental Petroleum's Carbon-Neutral Oil: Leading the Transition to Cleaner Energy

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By
Alexandra Cresci

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

ADVISOR
Pedro Franciso, Department of Engineering and Society

Introduction

The Permian Basin region of West Texas and southeastern New Mexico is composed of more than 7,000 fields from which nearly 40% of the nation's oil supply is extracted ("Permian Basin", 2022). Occidental Petroleum, also known as Oxy, seeks to build the world's largest direct air capture (DAC) project in the Permian Basin (Ector County, Texas), set to start operations in 2025. Oxy aims to capture 1 million metric tons of CO_2 per year and utilize the captured greenhouse gas in a process called enhanced oil recovery (EOR) to extract oil from depleted reservoirs (Valle, 2022). Occidental Petroleum's project is particularly significant, not only because of the ambitious scale of the direct air capture facility, but also because Oxy is one of the largest oil producers in the U.S. leading progress in reaching impressive climate change emission reduction goals. Oxy is one of the three oil and gas companies whose long-term targets were identified by the Transition Pathway Initiative as aligned with the 1.5ºC degree pathway in their November 2021 report (*Occidental Petroleum Corporation - Climate Change 2022*, 2022). However, there is a question of whether Occidental Petroleum's carbon-neutral oil production design can help meet target Paris Climate Goals despite potentially negative environmental effects. Operations are not currently underway, so it is not certain if the target carbon-neutral emissions will actually be achieved, given the entire lifecycle of the oil, including construction of the plant, transportation of materials, and oil extraction. The detrimental environmental impacts of enhanced oil recovery, lack of government regulations and oversight on EOR, continued reliance on fossil fuels, and delay of the transition to renewable energy are also concerns associated with the promise of carbon-neutral oil which should be considered.

Background and Significance

During the life of a producing oil field, several production stages are employed to most efficiently recover the maximum amount of oil. Initially, oil flows naturally to the surface due to existing reservoir pressure. As reservoir pressure drops, the field is flooded with water to increase the pressure and displace oil. Carbon dioxide enhanced oil recovery (CO_2-EOR) is a technology most commonly applied in the final stage (tertiary recovery) of development of mature oil fields whereby, in a miscible process, the fluid is injected at a pressure above the minimum miscibility pressure and reservoir temperature and mixes with the oil as a solvent agent to form a low viscosity, low surface tension fluid that can be more easily displaced. A significant percentage (as much as 50%) of the injected CO_2 remains trapped in the ground by mechanisms such as capillarity, dissolution, and the geologic structure, and can be considered geologically stored CO_2. The CO_2 which mixes with the oil that is produced is separated from the oil and re-injected in a loop, with nearly all (over 95%) of the purchased CO_2 delivered to the oil field eventually being permanently sequestered in the deep geologic formation (Núñez-López, 2019). CO_2 can be acquired for enhanced oil recovery from either direct point sources, such as capturing exhaust gases from coal-fired power plants, or from atmospheric concentrations as with direct air capture. In 2019, Oxy invested in Carbon Engineering's DAC technology which utilizes a proprietary air contactor design to pull ambient air into the system and into contact with a flowing film of aqueous KOH sorbent which absorbs the CO_2 from the air (Keith et al., 2018).

Paired with Carbon Engineering's design, Oxy Petroleum's carbon-neutral petroleum production process is an innovative solution to the climate crisis which places oil and gas companies in an unexpected position to be leaders in a new direction of sustainable energy. Climate models show that removing CO_2 from the atmosphere at a large scale will be critical for limiting global warming to 1.5 or even 2 degrees Celsius. Based on the IPCC modeling, it is expected that global oil consumption will decrease substantially by 2050. However, even in scenarios where emissions are aligned with the goal of limiting global warming to 1.5 degrees Celsius above pre-industrial levels, there will still be a considerable amount of oil consumption due to the fact that oil is deeply embedded in many sectors of the global economy, such as transportation, shipping, and manufacturing. While alternative energy sources such as wind and solar power are rapidly expanding, it will take time and significant investment to fully replace oil in these sectors. Main barriers to large-scale deployment of carbon capture technology is its cost, so government incentives and passage of the Inflation Reduction Act are key in enabling Occidental to plan construction of 100 DAC facilities by 2035. Occidental expects to spend $1.1 billion on their DAC project under construction in Ector County, Texas. Occidental's first DAC plant progress is closely watched by the oil industry for its unprecedented scale. Its goal of capturing up to 1 million tonnes of CO_2 per year is 100 times greater than all 18 DAC plants operating worldwide combined according to the International Energy Agency (Valle & Soni, 2022).

Research Methods

Evidence Collection

The evidence collection method used to answer the research question is literature review surrounding one major case study. I chose the method of literature review on one case study to narrow the scope of my research. Literature review is useful in this case to study the life cycle assessment (LCA) of Occidental's process since there is a lot of existing evidence on the effects of enhanced oil recovery. LCA is a process that assesses the environmental impact that occurs throughout a product's lifecycle, from raw materials acquisition through production, use, final treatment, recycle, and disposal. Case legal, legal rulings, and policy documents will also be useful since government subsidies are highly influential in the production of Oxy's oil.

Data Analysis

Data analysis methods include ethical and sustainability assessment. These methods were chosen since the research question targets the ethics and sustainability long-term of Oxy's production process and the continued use of fossil fuels.

Results and Discussion

Actor-Network Theory

Actor Network Theory (ANT) is a theoretical framework which posits that objects, ideas, processes, and any other relevant non-human factors are seen equally as important in creating social phenomena as humans. It describes situations and technologies in the context of the many interactions between these human and non-human actors in shifting networks of relationships. One of the key concepts in ANT is the idea of "translation," which refers to the process by which actors are enrolled in a network and their characteristics and interests are redefined in relation to other actors. Translation is a crucial element in the construction and maintenance of networks because it allows the formation of an "alliance between human and nonhuman entities, or actors in Latour's terms, that hybridize the various actors into something other, something transformed, whether subtly or obviously" (Dakers, 2019). This framework was chosen because the research question is addressed by examining the relationship between and transformation of the roles of government officials, environmental impacts, environmental justice groups, policies, stakeholders in the company, and the Paris Climate Agreement when given agency in the network surrounding Occidental's direct air capture and oil recovery operations.

Production Process and Emission Analysis

Currently, EOR is the largest industrial use of captured CO_2, whereby pressurized fluids are injected into existing reservoirs to bond with the oil and improve the flow to the surface. EOR can reverse the decline of mature oil fields and recover up to 60% of the oil in a reservoir while sequestering 90 – 95% of the injected CO_2 in the ground (*Could Squeezing More Oil Out of the Ground Help Fight Climate Change*?, 2019). An estimated 60% of total U.S. crude oil production is attributed to EOR, making it the most common oil recovery practice in the United States (Geraci et al., 2017). Occidental has the world's largest CO_2 management operation, safely and permanently sequestering approximately 20 million tons of CO_2 annually in EOR operations. Plans for two geologic storage Monitoring, Reporting, and Verification plans for simultaneous CO_2-EOR and sequestration were the first-ever plans of their kind approved by the EPA, providing a transparent evaluation of these operations (*Climate Report 2020 Pathway to Net-Zero*, 2020).

Occidental has advanced product sales for the plant, including carbon removal credit purchases from Airbus, Shopify, and ThermoFischer. Oxy also reached an offtake agreement with SK Trading International for an opportunity to purchase net-zero oil and entered an agreement with Origis Energy to provide zero-emission solar power for the DAC plant and other projects in the Permian Basin (*Occidental, 1PointFive to Begin Construction of World's Largest Direct Air Capture Plant in the Texas Permian Basin,* 2022).

An important actor in the development of Oxy's plant is the government, particularly tax credits outlined in the Section 45Q of the United States Internal Revenue Code designed to incentivize deployment of carbon capture, utilization, and storage. In 2022, the US introduced significant stimulus with the Inflation Reduction Act to expand and extend the 45Q tax credit. These 2022 changes provide up to $85 per tonne of CO_2 permanently stored and $60 per tonne used for enhanced oil recovery or other industrial uses of CO_2, given emission reductions are demonstrated. The credit amount significantly increases for direct air capture: $180 per ton permanently stored and $130 per tonne for used CO_2. Additionally, the capacity requirements for plants were reduced, making it easier for smaller plants to claim the tax credit, and a seven-year extension was introduced, meaning that projects have until January 2033 to begin construction in order to claim the credit (*Section 45Q Credit for Carbon Oxide Sequestration – Policies*, 2022).

At the same time, the Inflation Reduction Act also expanded existing production credits for renewable energy, placing an effective credit rate of 2.6 cent per kWh in 2022 for solar energy and $0.60 to $3.00 per kilogram of qualified clean hydrogen production facilities which meet certain wage requirements, and depending on the lifecycle greenhouse gas emissions rate (*2022 Instructions for Form 8835*, n.d.).

Detrimental Environmental Considerations

While Occidental's carbon capture proposal and EOR operation has been mostly celebrated as a success for reducing fossil fuel-related emissions, this view fails to consider the lack of public attention regarding EOR, the dangers to groundwater which will disproportionately affect people of color and environmental justice communities, the lack of oversight and regulation, and the long-term effects on CO_2 emissions. These considerations highlight the importance of the role played by the government, environmentalists, and fossil fuel lobbyists in developing new carbon capture and EOR operations.

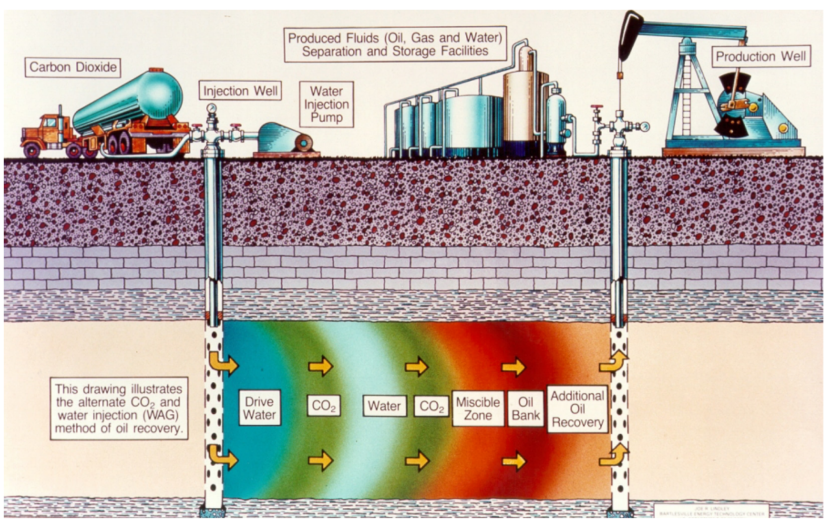
In 2018, environmentalist actors wrote a letter titled "Congress Must Stop Subsidizing Enhanced Oil Recovery," signed by over 30 environmental, health, and social justice organizations targeting proposed expansion of the Section 45Q Tax Credit which subsidizes EOR, pointing to concerns over "water protection, insufficient climate protections, and a lack of financial accountability for companies claiming the credit" (Redman, 2018). Although the petition to exclude the extension of the tax credit failed, the documentation of opposition to subsidization of fossil fuel operations remains an important actor. Although the U.S. Environmental Protection Agency regulates EOR, "regulations of EOR activities are outdated and do not effectively safeguard groundwater." The lack of even a uniform definition of EOR and related technologies means that data is often unreliable and incomplete. Underfunded state regulatory programs and scarce media attention on EOR have resulted in little review of its regulations since the 1980s when the Safe Drinking Water Act was first enacted (Geraci et al., 2017).

An effect of the improper state of regulations on EOR is the impact injected high pressure fluids has on underground aquifers. Every method used for Enhanced Oil Recovery (EOR) carries a certain level of risk of blowouts, which may lead to leakage or surface expressions, such as disruption and seepage of oil, steam, or fluid at the recovery sites. A blowout refers to the uncontrolled release of oil or natural gas from an oil well into the environment, either into the atmosphere or underground formations, and it can result in various forms of pollution, including air, noise, surface, and groundwater pollution, depending on the scale and location of the incident. To prevent blowouts, the federal EPA UIC regulations require the installation of blowout prevention equipment. The migration of injection fluids into underground sources of drinking water (USDWs) is troublesome because these fluids may contain harmful substances, such as salt content, oil and grease, inorganic and organic toxic compounds, and naturally occurring radioactive material. If there is a leak in the subsurface, a contaminant could be carried by production fluids from a producing formation and, in some instances, end up in a water source. Blowouts from CO_2 injection can also have additional implications for air quality. In addition to being a greenhouse gas, large CO_2 releases can harm local wildlife, people, and equipment.

The most common form of CO_2-EOR is water alternating gas injection which is especially water intensive, requiring the injection of an average of roughly 13 barrels of water for every barrel of oil produced. A diagram illustrating water alternating gas injection is presented below. The reaction between CO_2 and water can result in the formation of carbonic acid, which can be harmful in high concentrations, and lowers the pH in the formation creating a corrosive environment increasing the risk of other equipment leaks and blowouts (Geraci et al., 2017).

Figure 1

Diagram of water alternating gas injection (Al-Netaifi, 2008).



Dangerous effects are manifesting in Texas from hydraulic fracturing injections, which involves the injection of wastewater similar to water alternating EOR but has a greater impact on modifying the structure of the aquifer. A farmer who irrigates his crops and draws his drinking water from the ground experienced a tremor in recent years which left a broad bump and a half-mile crevice in his land, raising fear that underground storage spaces could fracture and leak toxic contents into aquifers and wells. Decades of research have linked injection wells associated with fracking to earthquakes, but much less is known about how the increasing presence of EOR injection wells combined with the destabilizing effect of fracking in the Permian Basin will affect groundwater (Baddour, 2023).

Another actor in play is fence-line community residents- who are low-income and predominantly of color. Environmental advocates have long asserted that the impact of fossil fuel pollution is unfairly distributed, with communities of color bearing a disproportionate burden. A study compiled by the Clean Air Task Force reports that more than 1 million Black people live within a half a mile of an oil or gas facility, as a result they are at much higher risk of cancer, asthma, and other respiratory diseases. Black people are 75% more likely to live in so-called "fence-line" communities next to industrial facilities which release toxic pollutants including formaldehyde (Baptiste, 2017). In the late 1990s, Oxy attempted to drill for oil in northeastern Columbia and the U'wa indigenous people pursued legal action to prevent drilling without their consent. In 2007 in Peru, indigenous Achuar plaintiffs alleged that the Corrientes River Basin was polluted by Oxy for 30 years by the dumping of "850,000 barrels per day of toxic oil by-products directly into rivers and streams used by the Achuar for drinking, bathing, washing, and fishing" (Donaghy, 2020).

A dynamic carbon life cycle analysis published in *Energies* journal in 2019 evaluates the potential of CO_2-EOR to reduce greenhouse gas emissions without compromising oil production goals. In a life cycle analysis of CO_2-EOR, it is important to consider the emissions and environmental impact throughout a product's life cycle, from the extraction, processing, and transport of the fuel necessary to operate the air capture plant, the fuel and materials associated with construction and maintenance, CO_2 transport to the field, EOR operations, crude oil transport to refinery, and product combustion/usage. The life cycle analysis performed in Energies examined only the gate-to-grave system, which starts the system at CO_2-EOR operations and ends at product use, therefore it does not account for direct air capture operations.

It was reported that CO_2-EOR is net carbon-negative early on- anywhere from six to eighteen years- and then is carbon-positive as oil production declines (Núñez-López, 2019).

Carbon Engineering, which is the basis for Occidental's direct air capture design performed a brief life cycle assessment of CO_2 emissions for a pure sequestration scenario excluding any oil-producing operations. Accounting for emissions associated with construction, disposal, combustion emissions for methane-heated process operations, and leakage during transport, injection, and geological storage, the net net result was that around 0.9 tons of CO_2 were permanently sequestered for each ton captured from air (Keith et al., 2018).

Conclusion

Actor-network theory considers both human and non-human elements equally as actors within a network, arguing that the concern is mapping the way in which actors define and distribute roles and how association between actors determines the power of the network. A network builder (often, engineers) assemble a network to accomplish a goal or solve a problem (Dakers, 2019). Actor-network theory can be helpful as a framework to argue how human and non-human actors play a role in the public opinion and future development of Occidental's carbon capture and EOR plans. By investing in CCUS technologies and nature-based solutions, Oxy aims to significantly reduce the carbon footprint of the oil and gas industry. However, there are still many challenges and uncertainties associated with this approach, and it remains to be seen whether carbon-neutral oil can truly deliver on its promise of a sustainable energy future. There is not currently a detailed life cycle analysis of a direct air capture plant combined with enhanced oil recovery, but evidence from Núñez-López's report combined with estimates from Keith et al.'s direct air capture report indicates that this system has potential to optimize their operations for carbon-neutrality, but are far from achieving carbon-negative. Carbon emissions are central to the research question of Occidental's sustainability, but, in this network, government support transforms from subsidizing sustainable carbon sequestration techniques to supporting unsustainable short-term interests of oil and gas companies. Actors such as agricultural workers in the Permian who depend on threatened aquifers for irrigation and drinking water and also depend on oil and gas to run their engines- their home and lifeblood thrown in peril by the substance which fuels it. The corporate history of Occidental, just like the oil industry as a whole, is one of evading responsibility for its failures, lobbying for government assistance, and extracting profits at the ultimate expense of vulnerable communities. Entangled in a complicated network, all the actors involved transform their roles when viewed through the lens of sustainability long-term, and it's clear that while there is a certain place for Occidental's carbon-neutral oil, it must be accompanied by strict regulation to safeguard air and water resources, protect fence-line communities, and carve a larger presence for government support for renewable energy long-term. Without strong climate action, governmental regulation, and community support to achieve a managed decline of fossil fuel production, fossil fuels will continue to inflict negative environmental effects even if achieving carbon-neutrality.

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