A Case for Carbon Capture, Utilization and Sequestration Technologies

Carbon Capture, Utilization and Storage or Sequestration (CCUS) encompasses a set of proven technologies that permanently remove CO_2 from our atmosphere, predominantly by sequestering it securely underground.

The importance of CCUS has been recognized globally since early applications began in the late 1970s and the 1980s as a critical solution to meeting our emissions-reduction goals. There are 26 projects in operation around the world today. During 2020, 12 new large-scale facilities in development were added to the Institute's project database from the United States alone, but none in California.[1] It is essential that California develop a predictable, sustainable, and cogent roadmap for CCUS in order to achieve our 2045 carbon neutrality goals.

CCUS IN NUMBERS

26

large-scale CCUS facilities operating globally. 39 more in development.[2]

These 26 facilities have a CO_2 capture capacity of **40 million tonnes** per annum (Mtpa)

CCUS is the only technology able to **decarbonise** the industrial sector

17 new commercial facilities entered the project pipeline globally since 2019. 12 of 17 in the U.S.

The Situation

Over the next two decades, global population and gross domestic product (GDP) are expected to grow significantly. Many outlooks anticipate a 25% to 30% increase in global energy demand in the next two decades as well as a need to address rising greenhouse gas (GHG) emissions.[3]

The National Petroleum Council states in their 2019 roadmap report that as global economies and populations continue to grow, the world faces the dual challenge of providing affordable, reliable energy while addressing the risks of climate change.

1 Global CCS Institute "Global Status of CCS 2020" https://www.globalccsinstitute.com/wp-content/uploads/2020/12/Global-Status-of-CCS-Report-2020_FINAL_December11.pdf
2 Global CCS Institute "Global Status of CCS 2020" https://www.globalccsinstitute.com/wp-content/uploads/2020/12/Global-Status-of-CCS-Report-2020_FINAL_December11.pdf
3 NPC Report 2019 "Meeting the Dual Challenge: A Roadmap to At-Scale Deployment of CARBON CAPTURE, USE, AND STORAGE" https://dualchallenge.npc.org/

The Solution

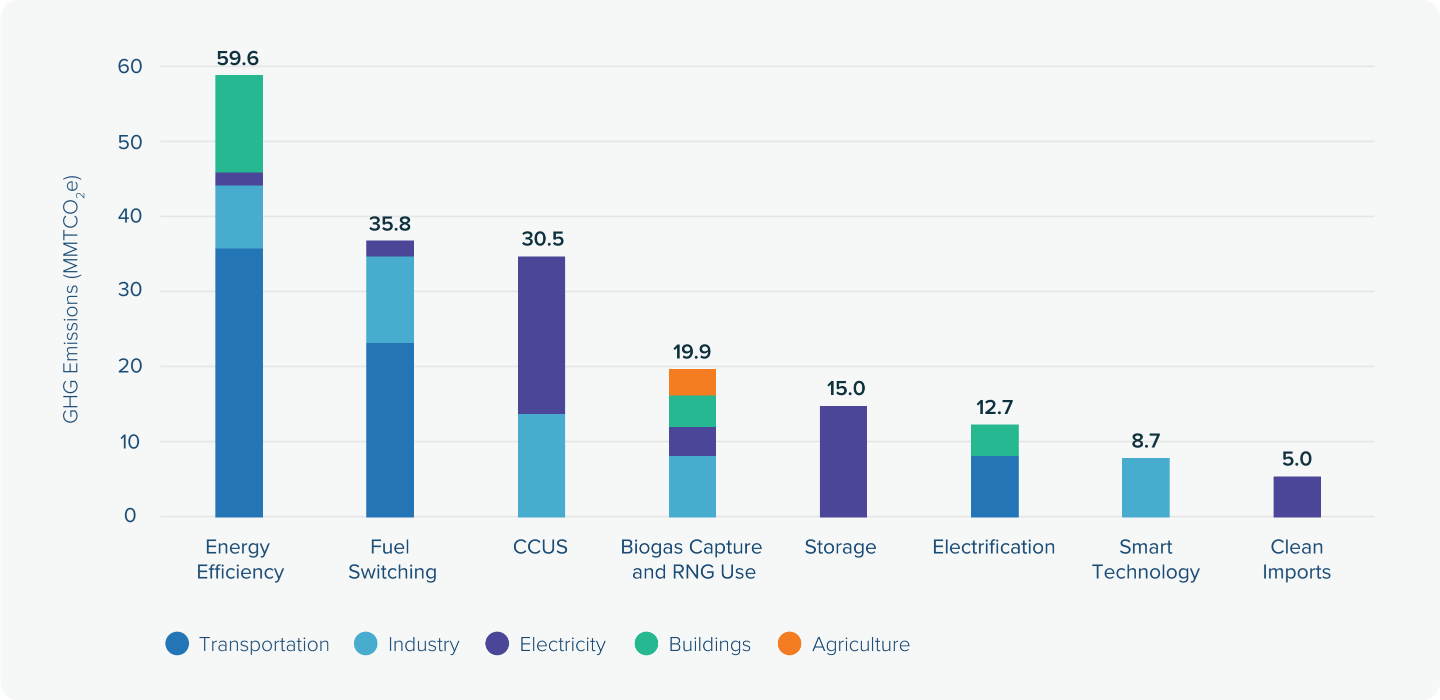
According to the International Panel of Climate Change (IPCC) September 2019 report, Global Warming of 1.5°C, net-zero CO_2 emissions are not credibly achievable without major contributions from negative-carbon technologies.[3]

The Global CCS Institute (GCCSI) thinktank cites the IPCC's studies, as well as those from the International Energy Agency, as evidence of the critical role that CCUS must play in meeting our global emissions reduction goals.

Simply put, CCUS is a "climate game-changer."[4] As one of the few technologies able to cost-effectively mitigate CO_2 and reduce or eliminate emissions from large-scale industrial sources, CCUS has the unique capacity to deliver commercial returns in a new energy economy where technologies like hydrogen production and bioenergy are starting to gain traction.

For California, CCUS is among the top three strategies for decarbonizing, according to the Energy Futures Initiative. Most scientists say that without these, according to EFI, "there's no way we will limit global warming to the 1.5-to-2-degree Celsius target set in the 2015 Paris Agreement" and emissions are still going in the wrong direction. While carbon capture is not "a silver bullet solution, it is an important tool for reversing this harmful trend."[5]

EFI also notes that every one of these strategies is critical and needs to be on the table as we continue discussing viable pathways to reach our climate goals.



Source: EFI 5/19 Pathways for Deep Decarbonization in California, Energy Futures Initiative]

3 Intergovernmental Panel on Climate Change (IPCC) 2019 Report https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Summary_Volume_Low_Res.pdf ; and Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_Chapter2_Low_Res.pdf

4 GCCSI https://www.globalccsinstitute.com/why-ccs/

5 Energy Futures Initiative https://energyfuturesinitiative.org/; Clearing the Air Report 2019; CCS Fact Sheet "Everything You Wanted to Know About Carbon Capture"

The Urgency

Is CCUS really needed now, at a time when we are seeing remarkable improvements in the cost and performance of key renewable technologies like solar and wind? The answer is unequivocally, yes.

Great strides have already been made and California's 2030 climate targets are within reach, but CCUS will be integral to achieving the state's aggressive Carbon Neutrality goals. International climate change bodies (IPCC and IEA) confirm that CCUS is essential to mitigating climate change and reinforce the fact that our targets cannot be reached without deployment of all clean technologies, including CCUS.[6]

The technology and the oil and gas industry's role and readiness for CCUS are strategic imperatives. But while the industry is technically ready to be part of the solution moving forward, the state has some policy hurdles to overcome to get CCUS up and running, such as:

- ✓ Creating a single source permitting process
- ✓ Clearing a predictable, sustainable credit pathway
- ✓ Considering CCUS within the Cap & Trade program structure
- ✓ Creating a streamlined CEQA process

The reason why it is so critical to address these barriers now is because the size of the required negative emissions is daunting, according to a June 2020 report titled "Getting to Neutral" from Livermore Laboratory Foundation and the ClimateWorks Foundation.[7] Worldwide, the report states, we will need to remove around 1 billion tons of CO_2 in 2030, 10 billion tons in 2050, and 20 billion tons in 2100.

100x

To achieve these emissions targets, the number of industrial scale CCUS projects would need to increase a "hundredfold" to more than **2,000 sites needed globally by 2040** — according to the IEA's World Energy Outlook 2019 report.[8]

California can pioneer these technologies and take the lead in deploying CCUS as a real, viable climate solution, if we can act on this opportunity now and continue building on our long history of aggressive policies for energy efficiency, renewables and carbon reduction.

A Case for Cost Efficiency

CCUS is a more cost-effective way than most to address climate change and will help California be a "Climate Leader," if it can significantly catch up with the rest of the world. The case for cost efficiency is examined in the GCCSI report[9], stating CCUS is cheaper than intermittent renewables on a like-for-like total system cost basis, and costs continue to decrease as more facilities commercialize. The report states: "Since the Boundary Dam CCS facility in Canada began operations in 2014, savings of as much as 30% have been identified for construction of a like (or follow-up) facility. This demonstrates the declining costs of deployment. As a simple law of economics, costs will continue to fall as more facilities come onstream. What is expensive is not doing anything at all."

6 GCCSI https://www.globalccsinstitute.com/wp-content/uploads/2020/07/Global-CCS-Institute_KeyMessages_2020.pdf

7 Livermore Laboratory Foundation and the ClimateWorks Foundation report "Getting to Neutral, Options for Negative Carbon Emissions in California" https://www-gs.llnl.gov/content/assets/docs/energy/Getting_to_Neutral.pdf, August 2020

8 "World Energy Outlook 2019." International Energy Agency, Nov. 2019 https://www.iea.org/reports/world-energy-outlook-2019. Accessed 29 May 2020.

9 GCCSI "Global Status of CCS: 2017 – Join the Underground" 2017 https://www.globalccsinstitute.com/wp-content/uploads/2018/12/2017-Global-Status-Report.pdf

Grounded in Facts

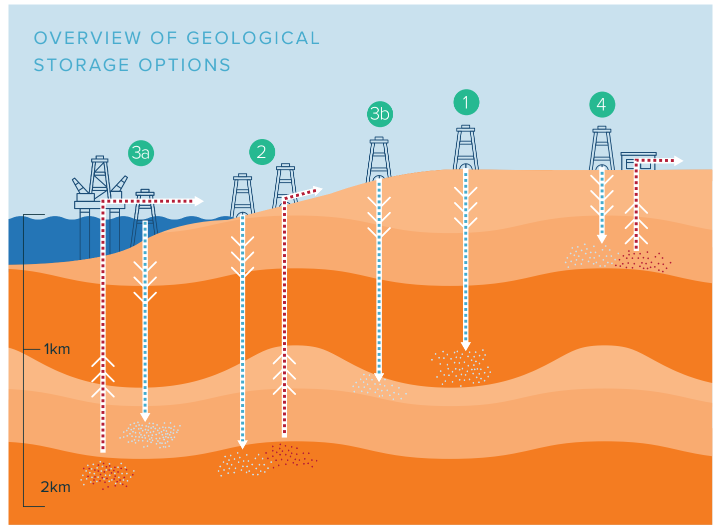
Underground CO_2 storage capacity has been the big question to date, with many assuming it is one of the biggest challenges impeding the acceleration of CCUS facilities, but the reality is there is more underground storage capacity than is actually needed to meet current climate targets.

In particular, California's reservoirs are well-suited for carbon storage because they have the pore space and optimal geology. According to Steve Bohlen, California's State Geologist, in testimony provided to the California Legislature Senate Committee on Environmental Quality Hearing on California's Climate Change Policies in February of 2019[10], California is blessed with excellent geology, and studies indicate that the state's depleted hydrocarbon reservoirs alone could sequester over 2 billion tons of CO_2, which equates to 20 years at 50 million tons of CO_2 per year. These reservoirs are well understood and have existing infrastructure that could enable rapid deployment of CCUS.

In fact, the GCCSI reports a large proportion of the world's key CO_2 storage locations have now been vigorously assessed and almost every high-emitting nation has demonstrated substantial underground storage capacity.

Furthermore, the National Petroleum Council states in their Roadmap for CCUS deployment that most of the lower 48 states have some subsurface CO_2 storage potential. While estimates of U.S. storage vary, experts generally agree that it is adequate to store hundreds of years of CO_2 emissions from U.S. stationary sources.

For the oil and gas industry specifically, storage capacity in California is already well established, and according to IPCC policy maker summary report[11], the technologies needed for CCUS are already compatible with most current energy infrastructures.



IPCC: Figure SPM.4. Overview of geological storage options (based on Figure 5.3) (Courtesy CO_2 CRC).

"We see CCS as a proven, viable technology to help the state in both the short and long the term to deal with industrial and transportation emissions, as well as a critical enabler for carbon-neutral or carbon-negative solutions...The stark reality of climate change and the extreme urgency to reduce emissions in California and globally demand that we include CCS in our portfolio and take proactive steps to deploy it alongside the many other tools."

Steve Bohlen
CALIFORNIA'S STATE GEOLOGIST

10 "California Legislature Senate Committee on Environmental Quality Hearing on California's Climate Change Policies February 20, 2019" https://senv.senate.ca.gov/sites/senv.senate.ca.gov/files/llnl-ar-768148.pdf

11 IPCC Policy Maker Summary Special Report https://www.ipcc.ch/site/assets/uploads/2018/03/srccs_summaryforpolicymakers-1.pdf

The Definitions

CCUS is among the technologies that most scientists say that without it, there's no way we will limit global warming to the set targets. CCUS supply chains can have many forms, but here are the building blocks:

CAPTURE

CO_2 is produced in combination with other gases during industrial processes, including hydrocarbon-based power generation, or is captured directly out of the air. CO_2 capture involves the separation of the CO_2 from these other gases. This separation can be accomplished using many different technologies, the most common of which is amine absorption. Once the CO_2 is separated, it is typically dehydrated to avoid corrosion and then compressed or refrigerated so that it behaves like a liquid, making it ready for transport.

USE

While most CO_2 captured over the next few decades will likely be stored, it can also be used to produce valuable products and services. Examples of CO_2 use include building materials, carbon nanotubes and syngas, which is a synthetic gas mixture of hydrogen, carbon monoxide and very often carbon dioxide. CO_2 use is currently an outlet for only a small fraction of the captured CO_2, but may provide a meaningful option with further market and technology development.

TRANSPORT

In most cases, captured CO_2 will need to be transported from the capture location to a different location where it can be stored or used. This can be accomplished by using pipelines operating at a pressure that enables the CO_2 to remain in a dense phase. Alternatively, CO_2 can be transported using rail, trucks, or marine vessels.

STORAGE

There are multiple pathways for CO_2 storage. Compressed CO_2 is injected into carefully selected subsurface geological formations for safe, secure, and permanent storage. CO_2 can also be used to produce oil in a process known as enhanced oil recovery (EOR). Operational experience indicates that approximately 99% of the CO_2 used in EOR is ultimately trapped in hydrocarbon-producing geologic formations.

The Industry's Role

The oil and natural gas industry is at the forefront of CCUS and stand ready to tackle this immense challenge and significantly increase the deployment. The industry has the people and leaders with the right expertise and experience to identify and evaluate the subsurface for safe storage of CO_2, manage large-scale permitting of projects, efficiently procure materials and manage supply chains, construct large-scale capital-intensive projects, and safely operate complex facilities. Additionally, in many locations the industry has well-situated infrastructure already in place for handling large volumes of gas and liquids.

California's oil and gas industry is no stranger to innovation and is uniquely positioned to lead in this task, with a long history of aggressive policies for efficiency, renewable energy and carbon reduction, along with geology and a leading workforce ideally suited to the task.

By all accounts, there is no doubt that large-scale CCUS technologies will require significant investment and the cooperation of multiple industries and government working together. With the oil and gas industry's leadership, expertise, and infrastructure, overall costs will come down over time as more research is done, the technology continues to develop, and efficiencies are born out of economies of scale. Over the long term, CCUS investments will promote economic growth, create domestic jobs, protect the environment and enhance energy security.

Laying the Groundwork

The oil and gas industry is working to advance the technologies for CCUS by continuing to pursue the practice as a recognized solution essential to meeting our global emissions reduction goals.

Partnering on hundreds of projects to increase the understanding of the science, engineering application, and economics of CCUS, WSPA'S member companies continue to fund research and development in support of proven and emerging CCUS technologies to bring this vision to life for a more sustainable energy future for us all. Here are some examples:

Chevron is one of the leading energy companies working to advance the technologies that will underpin the deployment of industrial-scale CCUS. The company has invested approximately $1.1 billion in CCUS projects that are expected to reduce GHG emissions by about 5 million metric tons per year, roughly equivalent to the GHG emissions of 620,000 U.S. homes' annual electricity usage.

California Resources Corporation is actively designing and permitting California's first CCUS project and will be sequestering carbon by mid-decade. This project will capture CO_2 from the 550 MW Elk Hills Power Plant and inject into underground oil formations, displacing remaining oil and permanently trapping CO_2. This project will have far-reaching economic benefits for both Kern County and California as well as proving the commercial viability of CCUS for a natural gas combined cycle power plant.

ExxonMobil is the world leader in carbon capture, capturing more CO_2 than any other company since 1970 and working on a portfolio of carbon capture technologies in collaboration with others. Since 2000, ExxonMobil has invested approximately $10 billion in projects to research, develop and deploy lower-emission energy solutions. The company continues to expand collaborative efforts with more than 80 universities, five energy centers and multiple private sector partners around the world to explore next-generation energy technologies. Recently the company announced that its scientists, along with the University of California, Berkeley and Lawrence Berkeley National Laboratory, have discovered a new material that could capture more than 90% of CO_2 emitted from industrial sources, such as natural gas-fired power plants, using low-temperature steam, requiring less energy for the overall carbon capture process.

In 2019, **Shell** successfully completed a one-year pilot project to separate CO_2 from the exhaust gases of a biomass power plant in Vienna, Austria. The project captured 0.7 tons of CO_2 per day. In its first four years of operations, Shell and its global partner Quest captured and safely stored deep underground more than 4 million tons of CO_2, ahead of schedule. That is roughly equal to the emissions from about one million cars. For its facility in Canada's Alberta flatlands, Quest has stored more CO_2 than any other onshore CCUS facility with dedicated geological storage in the world. It is a milestone that has been reached ahead of schedule and at a lower cost than expected.

Valero Energy Corporation and BlackRock Global Energy & Power Infrastructure Fund III are partnering with Navigator Energy Services to develop an industrial scale carbon capture pipeline system ("CCS"). The initial phase is expected to span more than 1,200 miles of new carbon dioxide gathering and transportation pipelines across five Midwest states with the capability of permanently storing up to 5 million metric tonnes of carbon dioxide per year. Pending third party customer feedback, the system could be expanded to transport and sequester up to 8 million metric tonnes of carbon dioxide per year.

> *"This exciting advance for carbon capture technology is an outstanding example of how scientists with diverse expertise from universities, national labs, and industry can come together to solve fundamental research challenges. We are grateful to have had such long-term research support from ExxonMobil, without which this discovery would not have been possible. I hope this success will serve to encourage further partnerships between industry and academic research labs."*

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