GLOBAL CCS INSTITUTE

2019 POLICY REPORT

THE LCFS AND CCS PROTOCOL: AN OVERVIEW FOR POLICYMAKERS AND PROJECT DEVELOPERS

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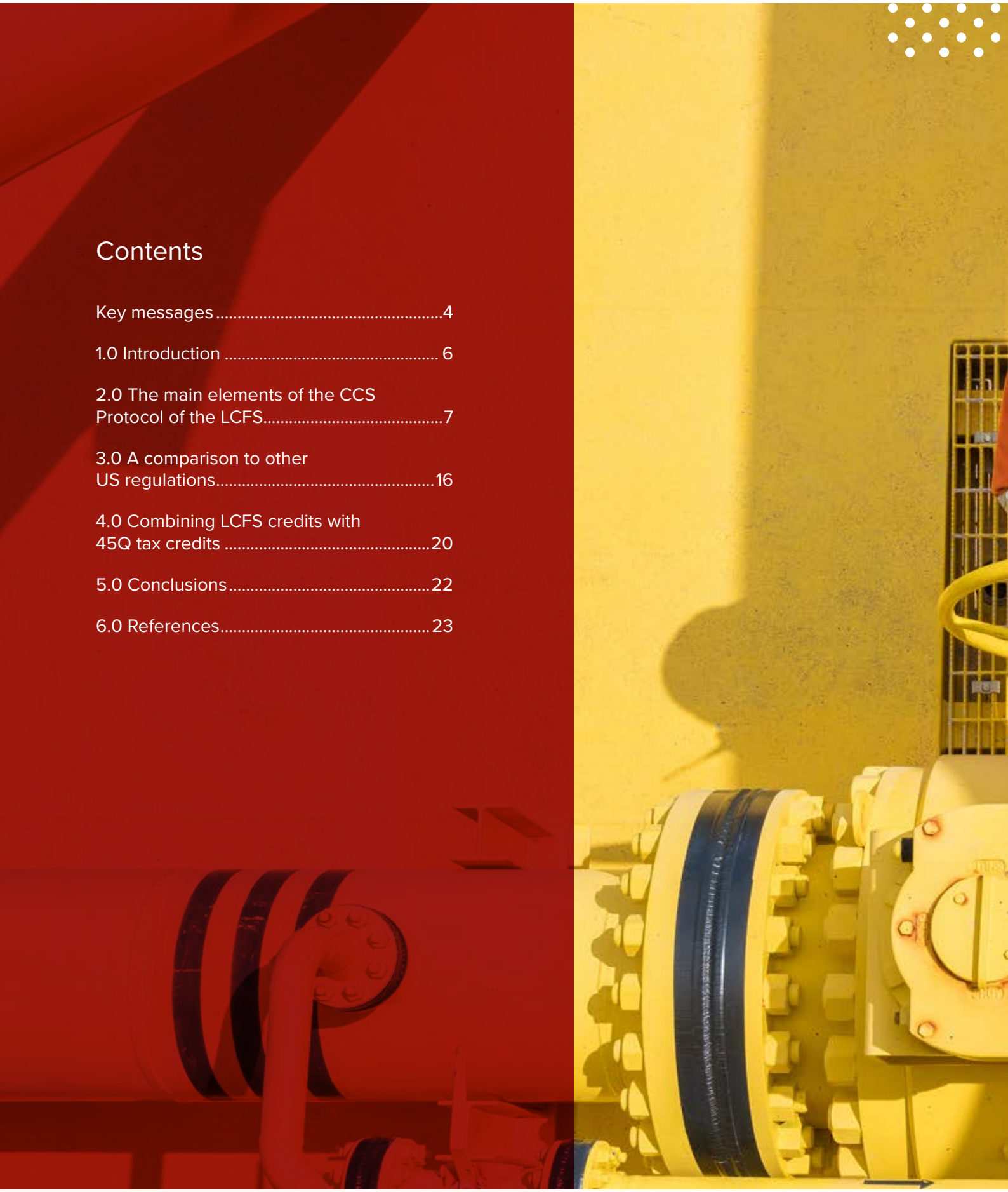


KEY MESSAGES

1. The Low Carbon Fuel Standard ("LCFS") is one of several policies in California that originate from the Global Warming Act of 2006. It places lifecycle carbon intensity targets on all transportation fuels sold in California, with the aim of diversifying the State's fuel mix, reducing petroleum dependency, and reducing GHG emissions and other air pollutants. Fuels that have a lower carbon intensity than the carbon intensity target generate credits and fuels with a higher carbon intensity than the target generate deficits.

2. In 2018, the LCFS was amended to enable CCS projects that reduce emissions associated with the production of transport fuels sold in California, and projects that directly capture CO_2 from the air, to generate LCFS credits. These changes came into effect in January 2019. To qualify, projects need to meet the requirements of the CCS Protocol which is subordinate to the LCFS Regulation Order. The changes have attracted attention from policymakers in other jurisdictions and CCS project developers keen to understand the program, particularly given the credits have been trading on average between $122/tCO_2$ and $190/tCO_2$ in the past 12 months to February 2019.

3. This report provides a summary of the main elements of the CCS Protocol, to help improve awareness and understanding of how CCS projects could access revenues by generating and selling credits under the LCFS. It also provides a comparison to other regulations and incentives in the US associated with the injection and geologic sequestration of CO_2 that project operators must comply with or can benefit from.

4. CCS projects must apply for and receive Permanence Certification before they can claim credits under the LCFS. To receive certification, operators are required to meet several minimum site selection criteria, to prepare, maintain and comply with a range of site-specific plans throughout the lifecycle of the project, and to submit regular reports to the California Air Resources Board ("CARB"). Operators must monitor the site for at least 100 years post-injection and only sites in which the fraction of CO_2 retained in the storage complex is very likely[1] to exceed 99% over 100 years post-injection will be approved.

5. The number of credits a project can claim is specified in the accounting requirements of the CCS Protocol. CCS projects must contribute between 8% and 16.4% of the credits they generate to a Buffer Account which provides a reserve that can be drawn on to maintain the environmental integrity of the LCFS in the event of CO_2 leaking from a storage complex. In addition, operators are required to hold a financial instrument, such as insurance, that covers the cost of performing corrective action, plugging wells, post injection site care and closure, and emergency and remedial response, based on the cost of hiring a third party to conduct those activities. The financial instrument would, for example, cover the costs of maintaining and closing the site in the event the operator goes out of business before site closure has been granted.

[1] Greater than 90% probability.

6. The relationship between the credits obtained under the LCFS and those generated under the US Federal Government's 45Q scheme has been raised, with several commentators highlighting the potential opportunity from combining or "stacking" LCFS credits and 45Q tax credits. The 45Q scheme provides tax credits in 2019 worth \$31/tCO_2 for CCS projects that inject CO_2 into dedicated geological storage and \$19/tCO_2 for CO_2 utilization and direct air capture projects. The value of credits rises linearly, to \$50/tCO_2 and \$35/tCO_2 respectively by 2026 and with inflation thereafter.

7. To be eligible to claim 45Q tax credits a project operator must demonstrate the secure geological storage of CO_2 and the IRS is currently consulting on the requirements an operator would need to satisfy to demonstrate this. Under the current proposal, where CO_2 is injected underground, the operator would need to be in possession of either a Class II or Class VI permit as required under the Underground Injection Control ("UIC") Program. They would also need to have an EPA-approved site-specific monitoring, reporting and verification plan, as required under Subpart RR of the GHG Reporting Program. The IRS is seeking views on whether to designate alternative pathways to demonstrate secure geological storage including the use of standards developed by the International Organization for Standardization.

8. The CCS Protocol's permanence requirements go beyond the federal requirements for both Class II and Class VI wells. For example, the minimum post injection site care period for Class VI wells is 50 years rather than the Protocol's 100-year requirement, and the focus of the Class VI well requirements is on the protection of drinking water resources rather than public health and the environment more generally. The differences are greater with respect to the federal requirements for Class II wells which have no post-injection site care requirements. CCS projects in the US with a Class II or Class VI permit and complying with the Subpart RR monitoring and reporting regulations may therefore need to change their operations, reporting, financial cover or administrative processes to qualify for the LCFS.

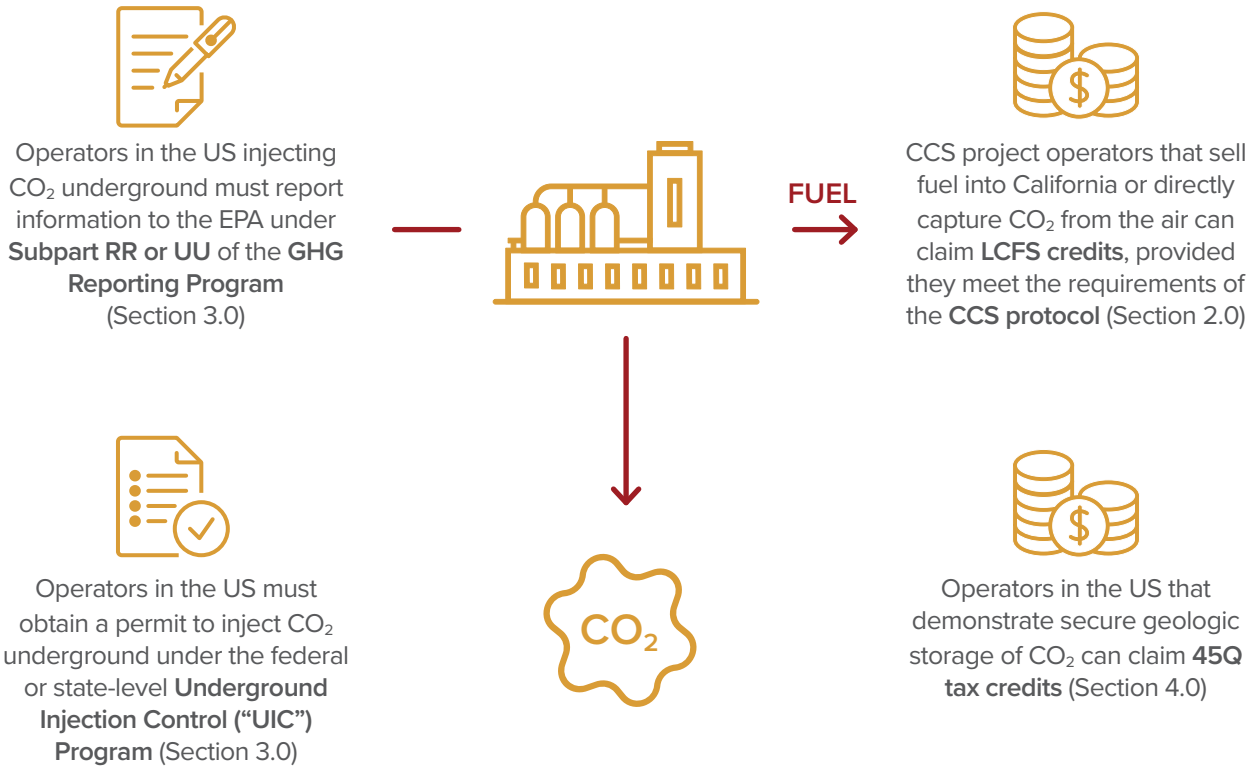
1.0 INTRODUCTION

This report provides a summary of the CCS Protocol of the California Low Carbon Fuel Standard ("LCFS") and how it compares to other significant regulations and policies in the US associated with the injection and geologic sequestration of CO_2. The other regulations and policies covered include the Underground Injection Control ("UIC") Program, GHG Reporting Program and 45Q tax credits. An illustration of how these regulations and policies fit together and the sections of the report in which they are discussed is provided in Figure 1.

The report was written to inform policymakers and CCS project developers interested in understanding the main elements of the regulations and the requirements a CCS project would need to fulfill to generate LCFS credits. The report necessarily simplifies the regulatory text and interested readers are encouraged to read the LCFS Regulation Order and CCS Protocol in full to get a better understanding of the detailed requirements of the regulations.

The report is structured as follows. Section 2.0 describes the main elements of the CCS Protocol, including eligibility, permanence, and reporting and verification requirements, as well as the approach project operators need to take to estimate the number of credits that can be claimed for their project. Section 3.0 compares the permanence requirements of the CCS Protocol with the requirements of the Underground Injection Control Program, with which all US projects injecting CO_2 underground must comply. Section 4.0 draws on this analysis to assess the similarities and differences between the eligibility and operating requirements project operators would need to meet to qualify to generate LCFS credits and 45Q tax credits, and the potential value from 'stacking' these credits. Section 5.0 concludes the report.

Figure 1: An illustration of how the regulations and policies in this report relate to one another[2]



[2] Direct Air Capture projects are an exception as they are not required to sell transportation fuel into the California market to generate credits (see Section 2.1).

2.0 THE MAIN ELEMENTS OF THE CCS PROTOCOL OF THE LCFS

2.1. An introduction to the LCFS and CCS Protocol

The Low Carbon Fuel Standard ("LCFS") was introduced by Executive Order in 2007. It is one of several policies in California designed to reduce greenhouse gas ("GHG") emissions as required by Assembly Bill 32, the 2006 Global Warming Solutions Act. The program is administered by the California Air Resources Board ("CARB") which under the Clean Air Act has primacy to regulate GHG emissions in California.

The LCFS is a market-based policy that sets annual carbon intensity benchmarks on transport fuels sold, supplied or offered for sale in California. The benchmarks reflect the full lifecycle emissions of transportation fuels and include all GHG emissions associated with producing, distributing, and using the fuel, expressed as grams of CO_2e per megajoule ("MJ"). The benchmarks fall over time up to 2030 with the aim of reducing the carbon intensity of the State's transport fuel mix by 20% by 2030, relative to 2010 levels.

Separate benchmarks are placed on gasoline, diesel and jet fuel, and the respective fuels that replace them. Fuels with a carbon intensity that is lower than the relevant annual benchmark generate credits and fuels with a carbon intensity that is higher than the relevant benchmark generate deficits.

Providers of clean, alternative fuels that already meet the relevant 2030 carbon intensity benchmark are exempt from the LCFS but may opt-in to the program to receive credits for the fuels they sell in California.[3] Electricity, biogas and renewable propane all fall into this category of fuels, as do fuels produced with innovative production methods.[4]

Fuel providers that produce, import, distribute or sell transportation fuels in California must on an annual basis have enough credits to compensate for any deficits created by the sale of carbon intensive fuels. These fuel providers are referred to as Regulated Parties under the LCFS. To ensure they have sufficient credits in a given year, a Regulated Party can:

- use credits banked from previous years, if available;
- buy credits from another Regulated Party in California, or a provider of clean, alternative fuels that has opted into the LCFS;
- increase the volumes of fuels they sell that have a carbon intensity below the benchmark, or reduce the volumes of fuels they sell that have a carbon intensity above the benchmark;
- change production processes for the fuels they produce, to make them less carbon intensive; or
- transfer the obligation through written contract to another party.

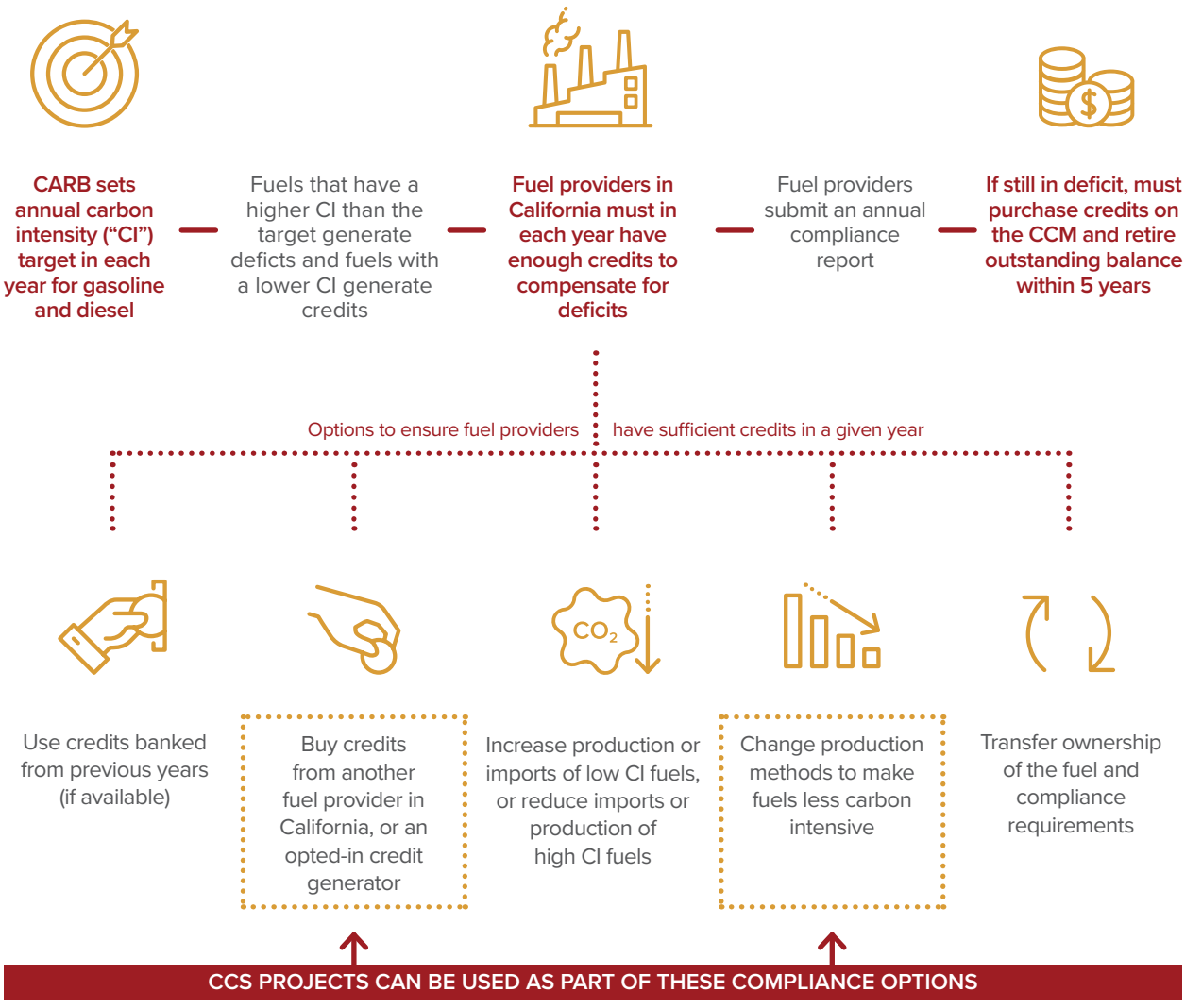
[3] Other exemptions include fuels used for military vehicles and equipment, locomotives, ocean going vessels, as well as propane, non-biomass-based fuel, conventional jet fuel and fuels for which sales are below 420 million MJ/year.

[4] Innovative production methods include the use of low carbon intensity process energy sources. It also includes CCS, which is the main subject of this report.

Credits banked from previous years are held on the LCFS Reporting Tool and Credit Bank & Transfer System ("LRT-CBTS") and are available indefinitely until used to meet annual targets. The LRT-CBTS is also used to record information on credit transactions between Regulated Parties, including the price and volume of every credit transaction. This information is aggregated and published by CARB, providing a transparent price signal to potential credit generators. Credit prices have been highly volatile over the past year, with monthly average prices ranging from $122/$tCO_2$ to $190/$tCO_2$.[5]

Regulated Parties must report quarterly on fuel transactions and submit annual compliance reports to CARB via the LRT-CBTS. If a fuel provider has a shortage of credits after taking account of all credits retired in the calendar year and any purchased up to the end of April the following year,[6] they must purchase their pro-rata share of their outstanding obligation on the Credit Clearance Market ("CCM"). The Credit Clearance Market is a cost-containment mechanism that provides an additional route to compliance, with the cost of credits capped at $200/$tCO_2$ in 2016 prices, rising with inflation. If the fuel provider is not able to purchase enough credits from other Regulated Parties on the Credit Clearance Market, they must retire the remaining balance of their obligation, with interest, within five years.

Figure 2: Summary of how the LCFS works and how CCS projects can be used to meet targets



[5] Taken from Monthly LCFS Credit Transfer Activity Reports from March 2018 to February 2019 available at: https://www.arb.ca.gov/fuels/lcfs/credit/lrtmonthlycreditreports.htm.
[6] Known as "carryback" credits.

In 2018, the LCFS was amended to allow CCS projects to generate LCFS credits by reducing the emissions associated with the production of transport fuels or by directly capturing CO_2 from the air, provided they meet the requirements specified in the CCS Protocol. These changes came into effect in January 2019. A summary of how CCS projects could generate credits and support compliance within the broader context of the LCFS is provided in Figure 2. The extension of the LCFS has attracted interest from both policymakers and CCS project developers and may provide a strong financial incentive to support the increase in deployment of CCS needed to meet climate targets at the lowest possible cost. A broad range of CCS projects can qualify to generate credits under the LCFS, provided they sequester the captured CO_2 onshore, in either saline or depleted oil and gas reservoirs, or oil and gas reservoirs used for CO_2-enhanced oil recovery ("CO_2-EOR").

Credits can be generated under one of two crediting methods. Operators can opt-in to receive project-based credits, receiving the number of credits equal to the emissions reductions they achieve from the project (see Section 2.3). Alternatively, operators can generate credits under the fuel pathway approach, which requires them to apply for a new fuel pathway carbon intensity score that they can claim credits against. Some projects are restricted to particular types of crediting schemes, as illustrated in Figure 3.

Direct Air Capture ("DAC") projects anywhere in the world can generate credits by opting in to the LCFS. These projects are an exception to the LCFS as they are not required to sell transportation fuel into the California market to generate credits. In actual fact, CO_2 derived from direct air capture that is converted to fuels is not eligible for project-based crediting under the LCFS and would need to apply for a separate fuel pathway to be eligible to generate credits.

CCS projects at refineries and at oil and gas production facilities must apply for credits under the Refinery Investment Credit Program and Innovative Crude Provision respectively. These project-based crediting schemes place additional restrictions on applicants, such as minimum size thresholds or limiting the point in time from which projects are eligible.

All other projects, such as ethanol production with CCS, have similar eligibility requirements to DAC projects, but can either claim credits under a project-based or fuel pathway approach. Similar to projects at refineries and oil and gas production facilities, these projects can be located outside of California, but can only claim credits for the proportion of transport fuel sold into the Californian market.

Figure 3: Different types of CCS projects that can qualify to generate credits under the LCFS

	DIRECT AIR CAPTURE PROJECTS	CCS AT OIL & GAS PRODUCTION FACILITIES	CCS AT REFINERIES PROJECTS	ALL OTHER CCS PROJECTS (E.G. CCS WITH ETHANOL)
Location of CCS project	Anywhere in the world	Anywhere, provided they sell the transportation fuel in California	Anywhere, provided they sell the transportation fuel in California	Anywhere, provided they sell the transportation fuel in California
Storage site	Onshore saline or depleted oil and gas reservoirs, or oil and gas reservoirs used for CO_2-EOR			
Credit method	Project-based	Project-based, under the Innovative Crude Provision	Project-based, under the Refinery Investment Credit Program	Project-based or fuel pathway
Earliest date which existing projects eligible	Any	2010	2016	Any
Requirements	Project must meet requirements specified in the CCS Protocol			
Additional restrictions	None	Must achieve minimum CI or emission reduction	None	None

2.2. Permanence requirements of the CCS Protocol

To be eligible to claim credits, a CCS operator must first demonstrate that the sequestration site is suitable to permanently store CO_2 and that they have the plans and financial resources in place to manage any residual risk of CO_2 leakage throughout the lifetime of the project. This is achieved by applying for and receiving Sequestration Site Certification and CCS Project Certification, collectively referred to as Permanence Certification.

The sequestration site must meet several minimum selection criteria to be eligible to receive Permanence Certification. For example, the site must be of sufficient volume, porosity, permeability and injectivity to receive the total anticipated volume of CO_2, have a minimum injection depth of 800m or depth corresponding to the conditions where CO_2 exists in a supercritical state, and have a confining system free from transmissive faults or fractures. In addition, only sites in which the fraction of CO_2 retained in the storage complex is very likely (greater than 90% probability of occurrence) to exceed 99% over 100 years post-injection will be eligible to generate credits under the LCFS.

Alongside the minimum site selection criteria, the project must also satisfy an expansive set of requirements throughout the project lifetime to receive and maintain Permanence Certification. This includes maintaining, updating and submitting changes to plans throughout the project, constructing wells in accordance with the specified standards, undertaking testing and monitoring to ensure mechanical integrity at the site is maintained and that there are no leaks, plugging wells in a way that protects against leaks, and monitoring the site for at least 100 years post-injection. These requirements remain until site closure has been granted and the operator is released of their post-injection site care duties. A summary of the main elements of the permanence requirements over the lifecycle of the project is shown in Figure 4.

Applications for Permanence Certification must be submitted jointly by the capture and storage operator and must be verified by a CARB approved third party prior to submission. A professional geologist must certify that the data submitted as part of the Sequestration Site Certification are true, accurate and complete, and that the risks identified in the Site-Based Risk Assessment are sufficiently monitored or remediated in the Emergency and Remedial Response Plan.[7] A professional engineer must certify that the information submitted under the CCS Project Certification is sufficiently robust and that, in their professional judgement, the CCS project is able to meet the permanence requirements of the CCS Protocol.[8]

[7] Professional geologists must be licensed under Chapter 12.5 of Division 3 of the California Business and Professions Code §§ 7800 – 7887.
[8] Professional engineers must be licensed under Chapter 7 of Division 3 of the California Business and Professions Code §§ 6700 – 6799.

Figure 4: A summary of the main aspects of the permanence requirements of the CCS Protocol

PHASE OF PROJECT	SUMMARY OF REQUIREMENTS
Site characterization and risk assessment	• Project operators must submit detailed information on the geological and hydrologic characteristics of the storage site and a Formation Testing and Well Logging Plan to explain how they will confirm these characteristics. • Project operators must complete a risk assessment and risk management plan that quantifies the risk of CO_2 leakage up to 100 years post-injection. A project cannot qualify for the LCFS if its risk management plan includes a risk with a High classification. • Computational modelling of the CO_2 plume must be done in accordance with the Protocol.
Well construction and corrective action	• Wells must be constructed such that they prevent the movement of fluids into or between any unauthorized zones, allow the use of appropriate testing devices and workover tools, and permit continuous monitoring of pressure at specific locations at the site. • Deviations in construction from the Well Construction Plan must be approved by the Executive Officer before Permanence Certification is granted. • All materials used in the construction of wells must be compatible with the fluids they may come into contact with, meet or exceed API, ASTM International, or comparable standards, and be of sufficient structural strength to last the design life of the project. • Several tests on injection wells must be performed prior to commencing CO_2 injection to confirm the characteristics of the site, ensure conformance with well construction requirements, and establish accurate baseline data (e.g. step-rate and pressure fall off tests). • Prior to injection, the operator must complete corrective action on all wells that either penetrate the storage complex or are within its surface projection and are determined to need corrective action. A report must be submitted demonstrating how corrective action was applied to deficient wells prior to Permanence Certification being granted.
Operation	• The injection pressure must not exceed 80 percent of the fracture pressure of the sequestration zone, except when approved by the Executive Officer. • Injection must not initiate fractures in the confining system, cause movement of the injection or formation fluids out of the storage complex, or unacceptably increase the risk of significant induced seismicity. • The mechanical integrity of wells must be maintained at all times, except during maintenance. In the event of a loss of mechanical integrity or suspected leak, the operator must implement its emergency plan. It must immediately cease injection in the affected well(s), take all reasonable steps to determine whether there has been any leakage of CO_2, notify the Executive Officer within 24 hours and restore and demonstrate mechanical integrity prior to resuming injection. • Routine well maintenance must be conducted at least every 6 months.
Testing and monitoring	• The CCS Project Operator must prepare, maintain, and comply with a plan for testing and monitoring to ensure that the CCS project is operating as certified and that the CO_2 injected is permanently sequestered. Monitoring must continue for at least 100 years post-injection. • Injection rate and volume, and wellhead and downhole pressure must be monitored continuously during the operation of the well. • The CO_2 plume must be reevaluated and revalidated at least every 5 years to confirm the plume is within the storage complex. • Internal mechanical integrity of a well must be demonstrated prior to injection, and at least every 5 years thereafter. External mechanical integrity must be demonstrated within 3 months after injection commences and every year thereafter. • Well materials must be tested for corrosion at least once every 5 years. • Wellheads, valves, pipelines and surface equipment must be inspected at least annually.
Well plugging and abandonment	• The CCS project operator must prepare, maintain and comply with a plan to plug all injection, production and monitoring wells associated with the CCS project. • The operator must notify the Executive Officer at least 30 days before plugging, converting or abandoning a well. Written approval must be received before plugging can be completed. • Within 60 days of plugging a well, the operator must submit a well plugging report confirming the plugging method used and that the well was found to be free from leaks.
Post-injection site care and site closure	• Once all injection activity has been completed, the project operator must comply with their previously submitted post-injection site care and site closure plan. • All injection and production wells must be plugged within 24 months of injection completion. Monitoring wells may remain open during the post-injection site care period. • No sooner than 15 years post-injection, the operator may submit evidence to CARB to demonstrate that the CO_2 plume has stabilized. If approved, all remaining open wells may be plugged and abandoned (securely and permanently sealed). The operator must implement a leak detection strategy thereafter. • Site closure may only occur at least 100 years after injection has been completed. Once approved, the operator is released of their post-injection site care duties.

2.3. Calculating the emissions reductions of the project

The accounting requirements of the CCS Protocol set out the approach to estimating the GHG emissions reductions from CCS projects. The emissions reductions can be used directly to calculate the total number of LCFS credits a project generates, where the project is in a project-based crediting scheme such as under the Refinery Investment Credit Program, Innovative Crude Provision or is a DAC project. Alternatively, the emissions reductions can contribute to a reduction in the carbon intensity of a fuel and be included in the application for a new fuel pathway, against which credits can be generated. The calculations for the number of credits for both approaches is summarized below, where the energy economy ratio takes account of differences in the ability of a fuel to be converted to drive.[9]

Project based crediting

Number of credits (tCO_2) = GHG emissions reductions from project

Fuel pathway crediting

Number of credits (tCO_2) = (CI of benchmark - CI of fuel) * Energy economy ratio * Conversion factor

The annual GHG emissions reductions from a CCS project are calculated by subtracting the GHG emissions associated with the process of capturing, transporting and injecting CO_2 from the amount of CO_2 equivalents ("CO_2e") that is injected in that year. In the context of the CCS Protocol, GHG emissions include emissions of carbon dioxide ("CO_2"), methane ("CH_4"), nitrous oxide ("N_2O"), volatile organic compounds ("VOC") and carbon monoxide ("CO"). Both direct and indirect emissions are included within the calculation of the emissions from the project, as illustrated in Figure 5.

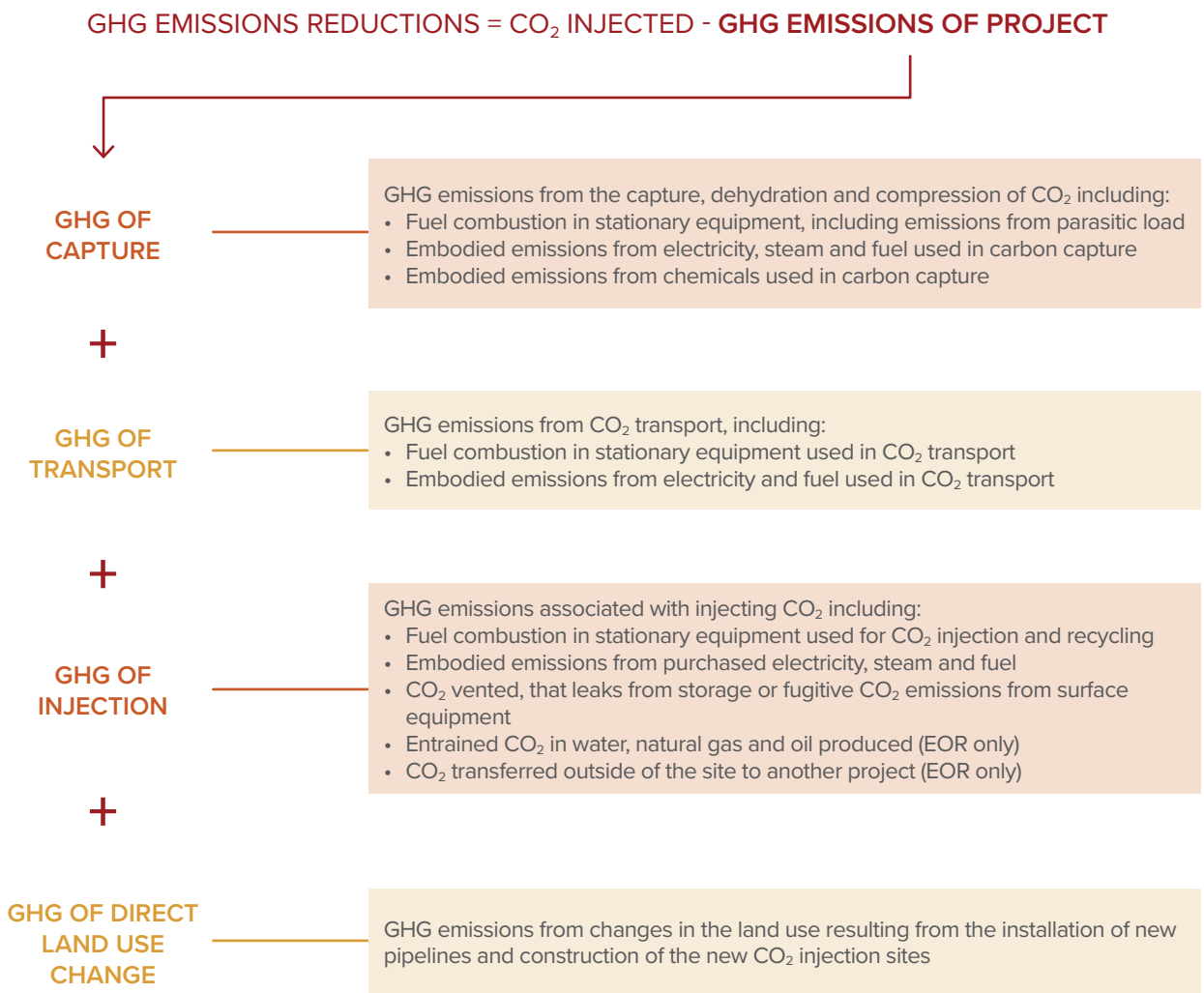
The emissions associated with the capture, transport and injection of CO_2 are estimated using the CA-GREET model available on the CARB website. The CA-GREET model includes data on the global warming potential of different GHG emissions to convert them into CO_2e, as well as emissions factors to calculate the embodied emissions from electricity and fuel use in the capture, transport and injection processes.

The emissions associated with direct land use change resulting from the installation of new pipelines and construction of new CO_2 injection sites are calculated using the Global Trade Assessment Project model or CARB approved land use emission factors. While the CCS Protocol only includes direct land use change, when the feedstock used for the production of a transportation fuel results in land use change, such as ethanol, this change will be factored into the carbon intensity of the fuel elsewhere in the calculations.

There will be some instances where the project applicant will need to adjust the inputs and outputs of the CA-GREET model to deal with a specific accounting issue or take account of data that is not in the model. This includes instances where the injected CO_2 comes from multiple capture sources with different GHG emissions which would need to be calculated separately and combined to estimate the relevant emissions for the project. Similarly, it includes instances where pipelines serving the storage complex transport CO_2 to multiple sites, where values need to be pro-rated to only include the emissions attributable to the project. For these exceptions the CCS Protocol sets out the approach that project developers are required to take.

[9] CARB (2018), Public Workshop to Discuss Implementation: Low Carbon Fuel Standard, Available at: https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/112818presentation.pdf.

Figure 5: Approach to estimating the GHG emissions reductions from CCS under the CCS Protocol



2.4. Contributions to the Buffer Account, and financial and insurance mechanisms required

CCS projects seeking credit issuance under the LCFS must contribute a percentage of the LCFS credits they generate to the Buffer Account. The Buffer Account provides a reserve that can be drawn on in the event that credits issued are no longer valid due to the leakage of CO_2, in order to maintain the environmental integrity of the LCFS. In addition to credits from CCS projects, the Buffer Account includes credits remaining from deactivated accounts, a provision for year-to-year differences between reported and verified operational carbon intensities, and any credits deleted or modified by the Executive Officer.

CCS projects are required to contribute between 8% and 16.4% of the credits they generate to the Buffer Account. The amount they contribute depends on the project risk rating, based on the potential for CO_2 leakage associated with different types of risks and project-specific circumstances. These risks include the financial risk of the company, the social risk of the project in terms of its location globally, the quality of the site in terms of its geological characteristics, the management of the facility and the integrity of the CCS project wells. It is for project operators to conduct the risk assessment and report this to CARB, along with the implied contribution they will make to the Buffer Account.

The credits generated by CCS projects can be invalidated if the CO_2 associated with them migrates outside of the storage complex or is released to the atmosphere. For the period up to 50 years post-injection, the invalid credits are first taken from the contribution to the Buffer Account made by the CCS project when the credits were issued. In instances where the volume of the leakage is larger than the number of credits contributed to the Buffer Account, a project operator must retire sufficient credits to cover the outstanding balance by either purchasing additional credits or using credits they have generated. After 50 years post-injection, the contributions made by all parties to the Buffer Account would be used to cover any credits found to be invalid due to leakage and the project operator would not be required to retire any additional credits. CO_2 is then considered permanently stored once it has remained in the storage site for at least 100 years. The 100-year assumption is consistent with IPCC guidance and other sequestration projects, such as the forestry offset protocol.[10,11]

In addition to the contributions to the Buffer Account, throughout the lifetime of the project the CCS project operator must maintain sufficient financial instruments that provide cover to address the potential endangerment to public health and the environment from CO_2 leakage. Specifically, the instruments must be sufficient to cover the cost of performing corrective action, plugging wells, post injection site care and closure, and emergency and remedial response, based on the cost of hiring a third party to conduct those activities. This would, for example, cover the future costs of the project should the operator cease to exist prior to site closure being granted.

A range of financial instruments can be used to satisfy this requirement as stated in the Protocol, including for example a trust bond, surety bond, letter of credit, insurance, self-insurance or escrow account. When using a third-party instrument to demonstrate financial responsibility, the CCS Project Operator must provide proof that the third-party provider meets certain financial conditions. A separate set of financial conditions needs to be met should the operator want to use self-insurance as the financial mechanism.

The operator is required to maintain a detailed written estimate of the cost of the activities described above and update it within 60 days of any changes to the plans on which it is based. If the estimate falls, the operator may release funds tied up in the financial instrument, subject to approval from CARB. If the estimate increases, the operator must within 60 days update their cover to the higher amount, either using the existing or a new instrument.

[10] CARB (2018), Final Statement of Reasons, pp. 594-607. Accessed 19 March 2019. Available at: https://www.arb.ca.gov/regact/2018/lcfs18/fsorlcfs.pdf.
[11] IPCC, Land Use, Land-Use Change and Forestry. Accessed: February 17, 2018. Available: http://www.ipcc.ch/ipccreports/sres/land_use/index.php?idp=74.

2.5. Reporting and verification of emissions reductions

For crediting purposes, CCS operators are required to submit quarterly or annual reports throughout the lifetime of the project, depending on how often the project elects to undergo verification. Reports must include information on the injection rate and volume, analysis of the CO_2 stream and all metered measurements for the calculation of GHG emissions reductions. Data must be uploaded in the LRT-CBTS data management portal within the first 45 days after the end of the reporting period and project reports submitted within 3 months of the end of the reporting period.

All projects must submit an annual compliance report within 4 months of the end of a calendar year. This is separate from the annual compliance report that fuel providers must submit under the LCFS. The annual report includes the information described above and provides additional information on a range of topics.

This includes information on any storage reevaluation or corrective action undertaken, any events that have led to the implementation of the emergency plan, and results from inspections and tests over the previous year. A summary of the reporting requirements is shown in Figure 6.

All reports must be verified by an approved verification body. The verification body is required to review all plans, assessments and reports to ensure they meet the requirements of the CCS Protocol and LCFS Regulation Order, and summarize their findings in a verification report. Verification reports must be submitted within 8 months of the end of the reporting period.

Figure 6: Summary of the quarterly and annual reporting requirements of the CCS Protocol

INFORMATION REPORTED FOR CREDITING AND VERIFICATION	Reported quarterly or annually	• All metered measurements for calculation of GHG emission reductions • Injection rate and volume data • Analysis of CO_2 stream
INFORMATION REPORTED TO SATISFY REQUIREMENTS FOR PERMANENCE	Reported annually	• All measurements required in quarterly reports and summary of their credit position • A summary of any incidents that may have triggered a storage complex reevaluation • A summary of any incidents that required implementation of the emergency plan • External mechanical integrity well results every year, and internal mechanical integrity checks at least every 5 years • Results of pressure fall-off tests at least every 5 years • A report on any corrective action undertaken • A summary of inspections undertaken on wellheads, valves and pipelines

3.0 A COMPARISON TO OTHER US REGULATIONS

All projects in the US that inject CO_2 underground must apply for and receive a permit in accordance with the Underground Injection Control ("UIC") Program. This means that any US project applying for LCFS credits must also meet the requirements of the UIC Program.

The UIC Program was created under the authority of the Safe Drinking Water Act ("SDWA"). Under the SDWA, the EPA developed minimum federal requirements to protect public health by preventing injection wells from contaminating underground sources of drinking water.

There are six different well classifications under the UIC Program, with Class II and Class VI being most relevant in the context of CO_2 injection.[12] Class II wells are those that are used to inject fluids associated with oil and gas operations, including wells used for enhanced recovery of oil and natural gas. Class VI wells are those used for the injection of CO_2 into geological formations, for the primary purpose of long-term storage. The Federal regulations for Class II wells have been in force since the 1980s and Class VI well regulations were later added in 2010.[13]

States can apply for primary enforcement authority, often called primacy, to regulate injection activities. Forty-one states have EPA approved primacy programs for Class II wells and one state, North Dakota, has an approved primacy program for Class VI wells.[14] For all other states, the EPA directly implements the Class II and Class VI program. The promulgation of state-level programs means an operator with CO_2 injection operations in multiple states may need to meet different requirements for each well, particularly with respect to Class II permits.

Operators injecting CO_2 underground in the US must also report to EPA under the Greenhouse Gas Reporting Program. Subpart RR of the program, which applies to CO_2 injected for the purposes of geologic sequestration such as Class VI wells, requires operators to report annually on the amount of CO_2 injected, produced and emitted to calculate the total amount of CO_2 sequestered. Operators must also develop an EPA-approved monitoring, reporting and verification ("MRV") plan which includes extensive modelling and monitoring of the CO_2 plume, to detect any surface leakage and ensure the environmental integrity of the project. Class II wells are only required to report information on the CO_2 received for injection as required under Subpart UU of the Greenhouse Gas Reporting Program but can opt-in to Subpart RR.

There are several significant differences between the federal requirements for Class II wells that report under Subpart RR and the permanence requirements of the LCFS, as shown in Figure 7. For example, the requirements for Class II wells are less prescriptive, such that they are open to broader interpretation. The scope of financial responsibility for Class II wells under the SDWA is narrower, as financial mechanisms need only cover the endangerment to underground sources of drinking water rather than to the environment and public health. Operators of Class II wells are also not required to fulfill any specific post-injection site care duties under the federal regulations. For these reasons a CCS project that meets the minimum federal requirements of a Class II permit and reports under the Subpart RR regulations may not be eligible to qualify for the LCFS without significant changes to their operations.

The requirements for Class VI wells are more closely aligned to the CCS Protocol and in places the text in the Protocol has been copied directly from the UIC regulations.

[12] Class IV wells, which are shallow wells used to dispose hazardous or radioactive wastes, were banned in 1984 such that, technically, there are only five types of well.
[13] https://www.epa.gov/uic/class-vi-wells-used-geologic-sequestration-CO_2.
[14] https://www.epa.gov/sites/production/files/2019-04/documents/primacy_status_revised_april17_2019_508c.pdf.

However, there are some notable differences such that an operator with a Class VI permit will not automatically meet the permanence requirements of the CCS Protocol. For example:

- The post-injection site care period for Class VI wells is 50 years, or potentially shorter where agreement with the EPA is reached. An operator with a Class VI permit wishing to qualify for the LCFS will need to extend their post-injection site care plan to at least 100 years post-injection and monitor the site for the duration of that period. They will also need to provide financial assurance cover for the extended period, either by extending their existing financial assurance mechanism(s) or providing a separate mechanism to cover potential costs for the remainder of the period.
- Similar to Class II wells, the Class VI regulations only require the operator to maintain a financial instrument to address the endangerment of underground sources of drinking water. The operator may need to amend the financial instrument in place, or provide an additional instrument, to cover the broader financial responsibility under the CCS Protocol.
- The operating requirements of the Class VI regulations allow for a maximum injection pressure of 90% of the fracture pressure, rather than the default 80% in the CCS Protocol. Injection pressures above 80% are permitted under the CCS Protocol but require prior approval from the Executive Officer.

Figure 7: Similarities and differences between federal requirements for Class II and Class VI wells, and the CCS Protocol

PHASE OF PROJECT	CLASS II WELLS CO_2 INJECTED FOR EOR	CLASS VI WELLS DEDICATED GEOLOGICAL STORAGE
Permitting	Operators must provide similar information to receive a permit, but requirements are less prescriptive providing some potential for differences in the information provided	Similar extent of information required to CCS Protocol
Well construction and corrective action	Similar requirements to CCS Protocol	Similar requirements to CCS Protocol
Operation	Injection pressure during operation not to exceed the maximum injection pressure rather than 80%. No reference to the action required in the event of an emergency	Injection pressure during operation not to exceed 90% of the maximum injection pressure rather than 80%, but actions to take during an emergency are the same
Testing and monitoring	Observations of injection pressure and flow rate required on a less frequent basis than in the CCS Protocol, and no testing and monitoring plan required	Similar requirements to CCS Protocol
Plugging and abandonment	All wells must be plugged prior to abandonment, but process and information to be reported is less detailed	Similar requirements to CCS Protocol
Post-injection site care and closure	There are no specific post-injection site care obligations for Class II wells	Post-injection site care responsibilities are similar, except that the post-injection site care period is 50 years (subject to the EPA discretion) rather than the 100 years specified in the CCS Protocol
Insurance and financial mechanisms	Text on financial mechanisms is similar, but the terminology used for the costs to be covered by the mechanism is different and may be open to interpretation. In addition, the mechanism needs only cover the cost of endangerment to drinking water resources and not the environment and public health as specified in the CCS Protocol	Text on financial mechanisms is identical, except that the financial mechanism needs only cover the cost of endangerment to drinking water resources and not the broader definition of environment and public health as specified in the CCS Protocol
Reporting	Similar requirements to CCS Protocol (when reporting under Subpart RR)	Similar requirements to CCS Protocol

CASE STUDY

THE LCFS, UIC PROGRAM AND GHG REPORTING PROGRAM

An ethanol producer located in the US sells ethanol into the California market to be blended with gasoline. The producer is considering investing in carbon capture equipment at their biorefinery. They want to be able to generate LCFS credits and at the same time meet the requirements of the UIC Program and GHG Reporting Program.

As the project is located in a state that has not sought primacy to implement the UIC Program for Class VI wells, the producer applies for a Class VI permit from the EPA. They also submit an MRV plan to the EPA as required under Subpart RR of the GHG Reporting Program. The MRV plan includes extensive modelling and monitoring of the CO_2 plume to detect any surface leakage to ensure the environmental integrity of the project. The EPA issue a Class VI permit for the project and approve the MRV plan.

The producer also applies for and receives Permanence Certification under the CCS Protocol from CARB. The post-injection site care plan and financial instrument they submit covers a minimum of 100 years post-injection, as required by the CCS Protocol, which goes further than the requirements of the Class VI permit. The producer owns and operates the storage site where the CO_2 is being injected, so does not need to submit the application with a separate storage operator.

Before the producer can claim any credits, it must apply for a new fuel pathway to be established under the LCFS against which they can claim credits. A fuel pathway for ethanol without CCS already exists so they only need to provide one fuel pathway application. They calculate the lifecycle emissions associated with ethanol production with CCS and use the CA-GREET and GTAP model to calculate the carbon intensity value of the fuel. Applying CCS to the fermentation and distillation process in the biorefinery reduces the carbon intensity of the fuel from 79gCO_2e/MJ to 63gCO_2e/MJ.[15]

The application for the fuel pathway is approved and the producer starts injecting CO_2 from mid-2020. They opt to verify emissions for the LCFS on a quarterly basis. They submit data for Q3 of 2020 into the LRT-CBTS by mid-November 2020 and submit their first quarterly report to CARB by the end of December 2020. Shortly after submitting their report, they provide a verification statement from a third party that confirms the project has met the requirements in the CCS Protocol.

[15] Lifecycle emissions of corn ethanol production are taken from https://www.arb.ca.gov/fuels/lcfs/background/basics-notes.pdf. Assumes a 50% reduction in biorefinery emissions, drawing on analysis by S McCoy (2016).

They calculate the number of credits to be awarded in two steps. First, they subtract the carbon intensity of the fuel with CCS (63 gCO_2e/MJ) from the carbon intensity benchmark for gasoline in that year ($92gCO_2e/MJ$). They then multiply this by the volume of fuel produced and a conversion factor to transfer the value into tCO_2 credits generated. On the basis of this calculation they estimate they are eligible to 10,000 LCFS credits.

CARB approve the claim and the operator is awarded 10,000 LCFS credits for Q3 2020. As they are a low risk site, they surrender 8%, or 800, of the credits to the Buffer Account. They sell half of the remaining LCFS credits generated to a Regulated Party in California for $\$150/tCO_2$ and pledge the other half to be sold on the Credit Clearance Market.

In March 2021 and every year thereafter, the operator is required to submit an annual report to the EPA under Subpart RR of the Greenhouse Reporting Program. At the end of April 2021 in each year the operator must submit an annual compliance report to CARB. The Credit Clearance Market goes ahead in June and July of 2021 and the value of credits in the market reaches the $\$200/tCO_2$ price cap (adjusted for inflation).

4.0 COMBINING LCFS CREDITS WITH 45Q TAX CREDITS

Several commentators have noted the potential opportunity for projects in the US to combine or 'stack' LCFS credits and 45Q tax credits. In combination, LCFS credits and 45Q tax credits could provide CCS project developers in the US with a strong financial incentive to capture CO_2 emissions and invest in CCS.

The 45Q tax credit was introduced under the Energy Improvement and Extension Act of 2008 and recently amended under the Bipartisan Budget Act in 2018. It provides capture operators with credits for each tonne of CO_2 stored or utilized, including for CO_2-EOR, which can be used to reduce the capture operator's tax liability. If a capture operator's tax liability is less than the value of the tax credits received, the capture operator can transfer the tax credits claimed to the storage operator or sell them on the tax equity market.

In contrast to the price of LCFS credits that vary from day-to-day based on the supply and demand in the market, the value of 45Q tax credits is fixed ahead of time. Under the changes made through the Bipartisan Budget Act, the value of tax credits rises linearly from \$31/tCO_2 and \$19/tCO_2 respectively in 2019 for CO_2 stored in dedicated geological storage and injected for utilization purposes, to \$50/tCO_2 and \$35/tCO_2 respectively in 2026. Thereafter, the value of the tax credit rises with inflation, as shown in Figure 8.

The 45Q tax credit scheme is open to power plants, industrial plants and DAC facilities, provided they meet the minimum eligibility requirements specified in the Internal Revenue Code. This includes the need for new projects to be under construction by 1 January 2024 and meet minimum annual capture thresholds.

Figure 8: 45Q tax credit values in each year (US\$/tCO_2)[15]

	2019	2020	2021	2022	2023	2024	2025	2026	2026 onwards
Dedicated geological storage	31	34	36	39	42	45	47	50	Indexed to inflation
CO_2-EOR	19	22	24	26	28	31	33	35	
Other CO_2 utilization processes	19	22	24	26	28	31	33	35	

[15] Adapted from Energy Futures Initiative (2018), Advancing Large Scale Carbon Management: Expansion of the 45Q Tax Credit.

To qualify to claim 45Q tax credits, project operators need to demonstrate the secure geologic storage of emissions. The Internal Revenue Service ("IRS") is currently consulting on the requirements an operator would need to satisfy to demonstrate this, along with other changes required to implement the changes resulting from the passage of the Bipartisan Budget Act. Under the consultation proposal, secure geological storage is defined as requiring an EPA-approved MRV plan.[16]

This would be achieved by having either a Class II permit and EPA-approved MRV plan or a Class VI permit and an EPA-approved MRV plan, as required for operators in the US injecting CO_2 underground and reporting under Subpart RR of the GHG Reporting Program.

There are several differences between the eligibility requirements for 45Q and the LCFS, as summarized in Figure 9. This may mean there are some CCS operators in the US that would not be able to claim both 45Q tax credits and LCFS credits.

Figure 9: Comparison of the eligibility requirements and scope of the LCFS and 45Q

	LCFS	45Q
GEOGRAPHIC SCOPE	Any location globally, provided sequestration site is onshore and transport fuel sold in California (except for DAC projects)	Any location in the United States
TYPES OF CCS PROJECT	Any fuel production facility or Direct Air Capture facility that captures CO_2 and either stores it in a dedicated geological site or uses it for CO_2-EOR	Any industrial or Direct Air Capture facility that either stores CO_2 in a dedicated geological site or uses it for CO_2-EOR or other utilization purposes
MINIMUM PROJECT SIZE	Any project size, except for projects applying under the Innovative Crude Provision which must meet minimum size thresholds	Projects are required to meet the following annual minimum capture thresholds in tonnes of CO_2: Power generators (500,000); Industrial and Direct Air Capture plants (100,000); Industrial Pilot Plants (25,000)
EMISSIONS COVERED	Carbon dioxide, methane, nitrous oxide, volatile organic compounds and carbon monoxide	Carbon dioxide and carbon monoxide
QUALIFICATION PERIOD RESTRICTIONS	None	Only facilities for which construction begins before January 1 2024 are eligible
CREDIT GENERATION DURATION	Duration of the injection period	12 years
CREDIT BUFFER & INVALIDATION	Operators must contribute between 8% and 16.4% of credits generated to a Buffer Account and retire credits to cover any leaks that occur up to 50 years post-injection	IRS is currently consulting on the approach to the recapture of tax credits in the event of leakage
PERMANENCE REQUIREMENTS	Demonstrated through receiving and maintaining Permanence Certification under the LCFS	IRS is currently consulting on the permanence requirements

[16] IRS (2019), Request for Comments on Credit for Carbon Oxide Sequestration, Notice 2019-32.

5.0 CONCLUSIONS

The Low Carbon Fuel Standard ("LCFS") is one of several policies in California that originate from the Global Warming Act 2006. It places lifecycle carbon intensity targets on all transportation fuels sold in California, with the aim of diversifying the State's fuel mix, reducing petroleum dependency, and reducing GHG emissions and other air pollutants. Fuels that have a lower carbon intensity than the carbon intensity target generate credits and fuels with a higher carbon intensity than the target generate deficits.

The recent amendment to the program to allow CCS projects to generate LCFS credits represents a significant policy development for CCS. With credits trading at up to $\$190/tCO_2$ over the past year, the changes could provide a significant source of revenue and support the increase in deployment of large-scale CCS projects. Whether this happens will depend on the costs of complying with the requirements in the CCS Protocol, which will only be known once operators have started the process of applying for the program. For this reason, the LCFS is likely to be a hot topic for years to come for both policymakers and CCS project operators.

Several commentators have highlighted the additional opportunity from combining or 'stacking' LCFS credits and 45Q tax credits. At prevailing credit values, this could provide an incentive for CCS projects equivalent to over $\$200/tCO_2$. While the IRS has yet to issue guidance and regulations covering all aspects of 45Q, under their current proposal project operators in the US may need to go beyond the minimum requirements for claiming 45Q tax credits if they are to qualify for the LCFS. This partly reflects CARB's intent for the CCS Protocol to be an internationally applicable standard and not just limited to California or the US or tied to existing regulations.

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