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Subject: California Air Resources Board (ARB) Accounting and Permanence Protocol for Carbon Capture and Geologic Sequestration under Low Carbon Fuel Standard (LCFS) [DRAFT]

Thank you for allowing Red Trail Energy LLC to participate in the November 6th Public Workshop to discuss ARB's 2018 LCFS Preliminary Draft Regulatory Amendment Text. We greatly appreciated the opportunity to provide feedback on ARB's efforts to incorporate carbon capture, utilization, and/or storage (CCUS) into the LCFS Program. The following list details the requested technical comments, questions, and concerns regarding the subject document (hereafter referred to as the "Draft Protocol"), based on our expertise and experiences in commercial-scale CCUS implementation.

General Language

- The Draft Protocol language seems to be directed to and applicable for CCUS activities proposed within the State of California boundaries but implies by omission that the rules could be applicable to CCUS projects located in other states that apply for pathways within the LCFS program. Thus, the language as written provides no indication as to how CCUS projects beyond California's borders will be regulated and managed, if differently than those within California borders.

- In addition, the Draft Protocol seems significantly more severe than U.S. Environmental Protection Agency (EPA) Underground Injection Control (UIC) Class VI rules for dedicated storage and Class II rules that apply to associated storage (e.g., enhanced oil recovery [EOR]). The Draft Protocol proposed rules and regulations may therefore be challenged by the other states as duplicative, excessive, and beyond the State of California's legislative power, especially as other states such as North Dakota (final primacy anticipated in January 2018) and Wyoming seek primacy and implement their own CCUS programs.

- It is recommended that ARB revise the Draft Protocol language prior to submittal to the legislative process in January 2018 as follows:
  - Insert language for an exclusion from, or exception to, or modification for compliance to the Draft Protocol for those CCUS projects seeking benefit from the LCFS program but actually located outside the physical boundaries of the State of California.
  - Develop language in an established Memorandum of Understanding (MOA, or other such legal agreement device), to be signed between the State of California and the state providing CCUS regulatory oversight for projects outside California state borders, which clearly identifies and sets the legal roles, responsibilities, and accountabilities between the states and provides accounting and permanence to meet LCFS compliance.
  - ARB should ensure the Draft Protocol complies with Assembly Bill 32 direction, that is, to eliminate duplicative requirements with the other state(s) providing CCUS project regulatory oversight.

- Use of the word "must" should be minimized, particularly with regard to employment of specific methods or techniques, especially for monitoring and accounting, which does not allow for the utilization of advanced technologies currently in development or to be developed in the future. Suggest rewording to describe desired metrics to be met with examples of currently available technologies/techniques.

- Discussion of faults/fractures identification and monitoring should also clarify whether those present are currently open or active.

Comments by Section

- **Page 7:** "The purpose of the [Draft Protocol] is to establish a methodology by which to determine whether a [CCUS] project will result in permanent sequestration of carbon dioxide (CO_2) and, if so, how to calculate the greenhouse gas (GHG) benefits from such a project under the [LCFS]."

For the sake of clarity, the Draft Protocol should group CO_2 storage projects into two broad categories, (1) dedicated storage and (2) associated storage (EOR). The above sentence implies that the current document and the LCFS program exclude associated storage such as EOR. Furthermore, the current version of California-modified Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (CA-GREET) [August 2, 2017, CA-GREET 3.0], does not include a feedstock/fuel that specifies, "incremental oil produced via CO_2 EOR where the CO_2 is captured from an anthropogenic source." The LCFS is designed to encourage the use of cleaner low-carbon fuels in California, encourage the production of those fuels, and therefore, reduce GHG emissions.

The recommended nomenclature helps to add specificity to the language within the Draft Protocol, reducing confusion and directing the applicant toward the correct life cycle pathway:

- For example, under the dedicated storage scenario, mitigation of GHG emissions is the primary purpose of underground injection. Storage of CO_2 generally targets deep saline formations. Under this scenario, there are no additional products to consider in the system, which simplifies the life-cycle analysis (LCA) calculations. In other words, the amount of CO_2 captured, or equivalently, the amount of CO_2 injected and stored in the formation, can be directly credited as a net emission reduction when calculating the life cycle emissions of the source.
- Alternatively, under the associated storage scenario, GHG mitigation is a secondary aspect of injection operations, typically at EOR sites where storage of CO_2 in an oil reservoir is incidental to the EOR process. Associated storage produces incremental oil, which affects the LCA calculations because the emission reductions must be allocated to both the upstream source and the oil producer. If 100% of the emission reduction is allocated to the upstream source, then there is no emission benefit for the oil producer. Conversely, if 100% of the emission reduction is allocated to the oil producer, then there is no emission benefit for the upstream source. An equitable allocation can be derived through a technique called "displacement," which requires careful attention in the LCA for CCUS when there are multiple products in the system, such as the power-oil system example.

- **Page 22–23, Figure 2.** This system model does not adequately reflect a combined upstream/EOR system. LCAs assign environmental burdens to a single product (e.g., ethanol). However, in the case of CO_2 EOR, the system produces oil as a coproduct. Consequently, it is not possible to decouple upstream processes from downstream processes such as crude oil transport, refining, fuel transport to point-of-sale, and fuel combustion.

- **Page 22:** "For example, GHG emissions associated with crude oil transport from the CO_2 EOR facility and subsequent refining are not accounted for within the project boundary."

Similar to the issues discussed above, the different products in a system cannot be decoupled. As described by the U.S. Department of Energy's (DOE's) National Energy Technology Laboratory (NETL), "NETL has studied the system (captured fossil power coupled with CO_2-EOR) extensively and recommends system expansion with displacement: (1) System expansion alters system boundaries to include all co-products; (2) With displacement, the system receives a credit for the GHGs emitted via the conventional product route for co-products; (3) This analysis expands the boundaries of the system to include displacement of one of the co-products, leaving us with the desired product (power or fuel)."[1]. In the absence of a system boundary that includes the downstream components of the crude oil system, it is not possible to properly allocate the emission credit for CO_2 storage in the oil reservoir to the upstream product (e.g., ethanol).

- **Page 25:** "In addition to CO_2, CH_4, and N_2O, CA-GREET treats volatile organic compounds (VOC) and carbon monoxide (CO) as GHGs because they are eventually oxidized to CO_2."

Common GHG gas accounting focuses on CO_2, CH_4, and N_2O, expressing the sum of these three molecules as "CO_2 equivalents" (CO_{2e}) using the Intergovernmental Panel on Climate Change (IPCC) 100-year global warming potentials (GWP) of 34 and 298 for CH_4 and N_2O, respectively.[2] For example, the most recent version of Argonne National Laboratory's GREET Model, upon which CA-GREET is based, separately calculates the following[3]:

- Consumption of total resources (energy in nonrenewable and renewable sources), fossil fuels (petroleum, natural gas, and coal together), petroleum, coal, natural gas, and water.
- Emissions of CO_{2e} GHGs – primarily CO_2, CH_4, and N_2O.
- Emissions of seven criteria pollutants: VOCs, CO, nitrogen oxides (NO_X), particulate matter with size smaller than 10 micron (PM_{10}), particulate matter with size smaller than 2.5 micron ($PM_{2.5}$), black carbon (BC), and sulfur oxides (SO_X).

Despite tracking quantities of VOCs and CO, the current version of GREET does not convert these compounds into CO_{2e}. It is not clear how to convert emissions of VOCs and CO into CO_{2e}, as the IPCC and other widely referenced sources do not provide conversion factors for these compounds. Consequently, VOCs and CO should not be included in the GHG accounting.

- **Page 30:** "To be conservative, $CO_{2,leakage}$ must be considered to be equal to the detection limit of the equipment used to detect leaks in the project's monitoring plan, absent any detected leaks."

The final point of measurement for CO_2 is at the injection wellhead, which measures the volume or mass of CO_2 injected into the target injection horizon. This would be equivalent to the first term in

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[1] Skone, T., 2015, A life cycle analysis perspective of CCUS – goal and scope definition: Strategic Energy Analysis and Planning International Energy Agency, London, November 12, 2015.

[2] Myhre, G., Shindell, D., Bréon, F.-M., Collins,W., Fuglestvedt, J., Huang,,J., Koch,,D., Lamarque, J.-F., Lee, D., Mendoza, B., Nakajima, T., Robock, A., Stephens, G., Takemura, T., and Zhang, H., 2013, Anthropogenic and natural radiative forcing. *In:* Climate change 2013: The physical science basis. Contribution of working group I to the fifth assessment report of the Intergovernmental Panel on Climate Change. Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V., and Midgley, P.M., eds. Cambridge, United Kingdom, and New York, New York, USA, Cambridge University Press.

[3] Argonne National Laboratory, 2017, The greenhouse gases, regulated emissions, and energy use in transportation model. https://greet.es.anl.gov/ (Accessed November 2017).

Equation 1 of the Draft Protocol: $GHG_{reduction} = CO_{2,injected} - GHG_{project}$. For example, if 1 million tons of CO_2 is injected, then $CO_{2,injected}$ is equal to 1 million tons. If there is no evidence of leakage, then $CO_{2,leakage}$ should be assumed to be zero in Equation 6 (derivation of GHG emissions associated with CO_2 injection). Applying the detection limit (DL) or some multiple of the DL (e.g., 0.5 DL) unfairly penalizes the CCS project. The above sentence should be rewritten to read, "Absent any detected leaks, $CO_{2,leakage}$ may be considered to be equal to zero."

- **Page 70**: "Project Operator must ensure that injection pressure does not exceed 90 percent of the fracture pressure of the sequestration zone so as to ensure that injection does not initiate or propagate existing fractures in the sequestration zone."

Consider revising to state that the operator should prove with a reasonable degree of certainty (e.g., through results of well tests and other studies that assess the risks of tensile failure and shear failure), that injection will avoid initiating a new fracture or propagating an existing fracture in the confining zone or cause the movement of injection fluids, rather than specifying a specific percentage, as testing of some geologic storage complexes may show higher or lower limits to be acceptable.

- **Page 81:** "Continuous measurement of the gas flow rate, gas composition, and gas density, where continuous measurement is defined as a minimum of one measurement every 15 minutes."

Some of these requirements may not be possible or practical, i.e., gas composition measurement and density are better monitored through changes in continuous pressure, rate, and volume measurement.

- **Page 88–90:** *Surface and Near-Surface Monitoring*

Consider revising the determination of a monitoring frequency/program to be based on the performed risk assessment as opposed to baseline results. For example, climate cycles can cause natural variation in near-surface monitoring results and isotopic analyses do not require baseline results for comparison. In addition, the term "useful" should be elaborated.

Surface air monitoring of point sources is discussed, presumably to find fugitive emissions. Success in detection is unlikely as fugitive emissions that cannot be found in traditional ways will be too small to detect in the atmosphere, especially on a windy day.

- **Page 95:** "After injection is complete, the GCS Project Operator must continue to conduct monitoring as specified in this section and the Executive Officer approved Post-Injection Site Care and Site Closure Plan for a minimum of 100 years."

More than 50 years postinjection, which is the EPA Class VI statute, will likely be difficult to enforce, particularly for CCUS projects located out of state. Unlike the forestry industry, geologically stored CO_2 showing stability (i.e., little or no movement) by a time frame of 50 years postinjection will not experience a reverse in stability beyond this time frame. In addition, 100 years is a disincentivizing time frame for fuel producers looking at markets that have the potential to change within just a few years.

Record keeping and data management may also be a challenge, particularly for a minimum 100 years monitoring postinjection, especially given the exponential advancement of technology over time.

We look forward to working with you further as the California LCFS Program continues to develop pathways that include CCUS. Please contact me with any questions at (701) 974-1105 or dustin@redtrailenergy.com

Sincerely,

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