**Comments to ARB on Quantitative Methodology, Accounting.**
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The following are a list of informal comments/reactions to the discussion during the April 5 workshop held in Sacramento and by webinar on April 5. If you have any questions, please feel free to call me at (603) 986-5689 or send me an email at bruce@catf.us

**GENERAL--MRV**

- The best way to avoid atmospheric leakage is prevention—site selection and risk analysis that serves to ensure that the storage complex is robust with excellent injectivity, adequate space and redundant seals where appropriate. Moreover, a robust storage site should be receptive to monitoring techniques and approaches for tracking subsurface injected CO2—for some sites subsurface CO2 tracking may prove too challenging. Moreover, in storage projects with legacy wells located in or adjacent to the field, a field survey should be undertaken, all wells should be located, evaluated, and wellbore integrity or secure plugging and abandonment fully demonstrated, making necessary repairs where needed. Any storage complexes falling short of these goals should be rejected.

- There should be an adequate 3-D monitoring area/volume outboard of the storage "compartment" (both saline and EOR) to facilitate tracking of CO2 plume, pressure fronts, or brine movement. Importantly, this should include abandoned wells and geologic vulnerabilities beyond the storage project that could be impacted by adverse CO2 plume migration.

- Surficial monitoring methods (e.g. soils gas fluxes) may prove to be ineffective for ensuring storage integrity due to the difficulty of establishing baselines and distinguishing a natural signal from a leakage as a result of natural seasonal fluxes in soil gases. Therefore, while surface monitoring may provide public confidence, if CO2 is detected at the surface, it could be a false signal, and if not it could be too late. Therefore, subsurface plume tracking is critical and should not be relied upon at the expense of subsurface monitoring. Surface monitoring should be deployed strategically to assess store security in high risk areas such as by legacy wells, and triggered when CO2 is known to be adversely migrating into less secure zones that could conduct CO2 to the surface. Systematic deployment of surface arrays of soil monitors will be ineffective and costly. A remedial action /investigation/mitigation plan should be prepared in advance of operations should adverse plume migration be observed.

**ACCOUNTING**

- The only CO2 that should be credited for sequestration should be anthropogenic/captured, generated from human processes, that would be otherwise vented.

- Leakage should be defined as venting of CO2 emissions to the atmosphere. Unexplained movement of CO2 in the subsurface—but that remains in the subsurface-- should not *automatically* be treated as leakage for the purposes of credits, but, instead trigger further investigation and mitigation. Migration out of the intended storage compartment, but still geologically contained could still acceptable for crediting purposes if its whereabouts and volumes can be reasonably determined. However, if there is inadequate evidence of permanent containment, emissions sequestered should be discounted or disallowed for credit.

- In the event of atmospheric leakage, accurate quantification/ prediction of total CO2 leakage for the purposes of credits under the CA QM could be challenging. Therefore, the QM approach should be pragmatic—and in the process provide a disincentive to use risky sites. For example: CA might consider: (1) a reduction in credit that is based on the modeled *maximum possible leakage* aggregated over time, or further, (2) a "*haircut"* which pre-establishes decrements in creditable CO2 storage based on estimated maximum possible leakage (in (1). E.g. if the leakage is estimated in the range of 0-20%, then a haircut of 20% is debited, etc.

- There is a misconception by some that only half of a volume/mass of initially injected CO2 is stored in EOR applications. This viewpoint does not recognize that CO2 is separated and recycled and remains within the recycling system. As CO2 is separated and recycled, the initial volume of CO2 is progressively stored over repeated cycles until it asymptotically approaches 100%--less any CO2 lost. Thus, in the QM credit accounting rubric it will be unnecessary to attempt to create a mass balance by accounting for recycled CO2.

- Regarding establishment of baselines from which leakage might be quantified, we suggest ARB review PTRC publications by Dr. Katherine Romanak (UT Austin Gulf Coast Carbon Center) on the "process-based" methodology for leakage detection that may reduce the need for baselines -- that may be difficult to establish given seasonal fluxes in biogenic CO2 and methane. This approach may be particularly useful in brownfields. See, e.g. https://www.iea.org/media/workshops/2014/ccsregnet/Romanak_IEA_regul

atory.pdf and
http://www.sciencedirect.com/science/article/pii/S1876610213005699
We would be happy to put ARB staff in touch with Katherine.

**EOR STORAGE APPLICATIONS**

- In EOR facilities, compliance with the Greenhouse Gas Reporting Rule Subpart RR, rather than subpart UU, should be required for credit in addition to ARB's QM. Of course measures taken to satisfy the QM and RR would likely overlap substantially.

- One means for monitoring storage integrity and accounting for injected CO2 in an EOR field is a mass-balance approach where injector well volumes are balanced by production well production volumes.

- It was stated at the workshop that CO2 moving off an EOR lease should be considered emitted/leaked. We agree that if CO2 can no longer be tracked, credit should not be given to the estimated missing volume. However, if the location and security of CO2 moving off lease can be documented and tracked the storage credit should still be given.

- The upfront evaluation of wellbore mechanical integrity in and near brownfields (old oil fields) is one of the most critical components of a storage project. Project wells and nearby legacy wells should be identified/ built/repaired/monitored and maintained to high standards both to resist corrosive CO2 and the reduce change of leakage from poorly constructed or damaged wellbores and casings. We look forward to the workshop on well integrity, which should cover both the identification, remediation and surveillance of existing wells, and the construction standards and operational mechanical integrity monitoring for new wells.

- In the event that ARB should consider CO2 emitted from EOR facilities where water-alternating-gas (WAG) injection is used (e.g. Permian Basin), the emitted/vented CO2 related to the energy used for water handling injection must be parsed out from the energy used from the separation and recompression of CO2.

- In EOR storage projects, the storage project may commence during the EOR project and end within it as well. This will require more complex accounting, since credit would be granted during the project—and before the plugging and abandonment of all holes and the project itself. To date there have been very few (none?) CO2 EOR projects that have ended.