ENCLOSURE

Requested Revisions to Clean Energy Systems (CES) Class VI Permit Application and Attachments

This document identifies the changes to CES's Class VI permit application and attachments that EPA anticipates will be needed based on CES's responses to EPA's technical questions in requests for additional information (RAIs) 1 through 5. Due to the iterative nature of the permit application development and collection of site characterization data, this document is presented in two sections. The first section describes the "pre-construction" changes that EPA requests to be made in an updated permit application that CES will provide prior to EPA's issuance of a permit to construct the well. The second part of this document lists the "pre-operation" changes that will need to be made to the geologic characterization and the project plans based on the results of pre-operational testing, which EPA will review prior to authorizing injection in the Mendota well.

PRE-CONSTRUCTION UPDATES (ANTICIPATED TO BE MADE NOW)

General: please incorporate all clarifications and updated figures, tables, etc. that were provided in responses to the RAIs into the updated permit application and attachments.

Geologic Site Characterization

- Please incorporate all of the clarifications to the geologic description in CES's responses to RAI 1 into the updated permit application. Also, incorporate the revisions CES described in their responses to RAI 5, with the following changes:
  - In Figures 2a–2d, EPA recommends maintaining the same wellbore position in Figure 2b (likely scenario) and Figure 2c (modeled scenario) to demonstrate the most likely depositional scenario and well location proposed for the modeling effort. Also, please retain the inserted sand polygon in Figure 2c to demonstrate possible reservoir connectivity and the conservative modeling approach (see p. 10 of CES's response).
  - Please confirm that no additional data on perforation depths for wells API 3900052, 3900053, and 3900057 and the two production wells at Gill Ranch Gas Field mentioned in the Conservation report is available in existing well data repositories (IHS, Enverus, etc.). If the perforation depths are available, please note at what depth and approximate geologic formation the perforations occur (p. 19 of CES's responses to RAI 5).
  - Regarding seismic history, please discuss the amount of time over which the microseismic baseline will be determined and why this duration was chosen. Assuming the microseismic baseline will only capture geologically-recent seismicity, also attempt to establish an historic seismicity baseline using USGS and CEMA seismic data, integrated with known/interpreted faults in the AoR (p. 31 of CES's responses to RAI 5).
- Please provide a description of the advantages and limitations of the Heterogeneous Rock Analysis for facies assignment and the resulting facies porosity assignments.

Operating Procedures

- Incorporate the updated tables in the response to RAI 3 into the operating procedures.
- Update the "Summary of Requirements Class VI Operating and Reporting Conditions" with a revised annulus pressure of 5,777 psi.
- Provide the type and name of the steady state multiphase simulation software used to determine the gas gradient of 0.376 psi/ft.

AoR and Corrective Action Plan

- Please update the plan overall to incorporate the clarifications provided in responses to EPA's questions in RAIs 3, 4, and 5. Also, confirm that all updated tables and figures are included and the inconsistences in Table 1 of the responses to RAI 3 are addressed.
- Revise the procedures and timing for AoR reevaluations and triggers for unscheduled AoR reevaluations as described in the responses to RAI 3 and RAI 5.
- Update the corrective action plugging schematics for the Amstar and BB Co 1 wells to reflect the use of CO_2-resistant cement.
- Include the verified locations of water wells in the AoR.

Testing and Monitoring Plan

CO_2 Stream Analysis

- Add Ar, H_2, and δ13C to the injectate analysis parameters in Table 1 of Attachment C.

Corrosion Monitoring

- Update the long-string equipment coupon description in Table 5 of Attachment C.

Pressure Fall-Off Testing

- Clarify that PFOTs will be conducted every 5 years.

Groundwater Quality Monitoring

- Include the updated site map in Figure 4-1 from the response to RAI 4.
- Update Table 6 to match Table 4-2 in Appendix A of the response to RAI 4.
- Add zinc, specific gravity, turbidity, hardness, and water density to the groundwater quality monitoring parameters in Table 7 of Attachment C.
- Update the statement on Page 17 as follows: "To meet the requirements at 40 CFR 146.95(f)(3)(i), Clean Energy Systems will also monitor groundwater quality, geochemical changes, and pressure in the first USDWs immediately above the injection zone(s)."

CO_2 Plume and Pressure Front Monitoring

- Please revise Table 9 of Attachment C as follows:
  - Add injection profile monitoring (Spinner) surveys in INJ1.
  - CO_2 monitoring in OBS1 will occur quarterly in years 0 to 2 and annually thereafter.
  - Add DAS as a plume monitoring technique.
- Add the following parameters mentioned in the pre-operational testing objectives to characterize the geochemistry of the Panoche Formation to Table 10: resistivity, turbidity, total hardness, and dissolved gases (H_2S, CO_2, O_2, etc.).
- Add pressure monitoring in ACZ1 to Table 11 of Attachment C.
- Describe the planned resolution and extent of the 3D seismic surveys.
- Describe how VSP and 3D seismic date will be integrated to track plume movement.

Quality Assurance Procedures

- Remove total hydrocarbons and SO_2 from the injectate parameters in the QASP.

Injection Well Plugging Plan

- Incorporate revisions to Table 2 of Attachment D (plugging details for Plug #2).
- Include the revised injection well and monitoring well plugging schematics presented in CES's responses to RAI 4 and RAI 5.
- Revise the narrative description of plugging procedures as described in the responses to RAI 4 and RAI 5.

Post-Injection Site Care and Site Closure Plan

- Include the recommended revisions to the non-endangerment demonstration criteria described in the responses to RAI 3.
- Update tables related to post-injection groundwater quality monitoring and CO_2 plume and pressure front monitoring to match those in the Testing and Monitoring Plan (see above).
- Add DAS as a plume tracking technique to Table 4 of Attachment E.
- In Table 6 of Attachment E, add OBS 1 to the DTS row and change DTS monitoring to 10-year monitoring, in line with the pulsed neutron logging plan.

Emergency and Remedial Response Plan

- Section 4.1 should reference risk register scenario 1.
- Please add "Limit access to wellhead to authorized personnel only" to section 4.1 and the magenta and red levels of the seismicity table.
- In section 4.2, "Limit access to wellhead to authorized personnel only" should be under the response action, not the description of the scenario.
- Add pressure monitoring and surface and periodic visual inspections to the response actions for the "Potential Brine or CO_2 Leakage to USDW" scenario as described in the response to RAI 5.
- Note that the control room technician is a 24-hour number.
- Please fix the typographical errors throughout the text.

Injection Well Construction Plan

- Incorporate updated schematics and Tables 13 and 14 and the associated narratives from the responses to RAI 4.
- Incorporate the well schematics and tables for the monitoring wells into the plan.
- Update the injection well schematic to show continuous monitoring gauge placement and type (per Figure 5-1 of response to RAI 4).
- Provide all relevant well construction design, scope, and execution information prior to commencing monitoring well construction.

Pre-Operational Testing Plan

The following updates to the formation testing plan are needed to incorporate the site characterization objectives described in the responses to RAI 1. Please include the names of the formations/zones that will be subject to each measurement/evaluation method described in the plan, as applicable.

- *To support the geomechanical and petrophysical characterization*, specify the core analysis methods (e.g., mercury injection capillary pressure, fracture analysis, triaxial compression testing, stress, ductility, rock strength, elastic properties, and in situ fluid pressures, etc.) that will be used.
- *To characterize the mineral composition of the injection zone,* describe the proposed coring program (i.e., coring method, number of core barrels to be used if whole core, core depths, total footage, etc.) and the evaluation methods to be used.
- *For the seismic risk evaluation,* incorporate geomechanical information (dipole sonic logs), formation microimager (FMI) logs, and microseismic monitoring into the analysis. If a VSP is planned, please specify the type and intended analysis.
- Describe the following data collections to *verify CO_2 stream compatibility with subsurface fluids and minerals:*
  - Autoclave CO_2-water-rock reaction experiments with core and water samples.
  - Aqueous chemistry data that will be used to calibrate geochemical modeling.
  - BET measurements on the core samples.
- Describe *baseline geochemical testing* to confirm the TDS content of the Jergins and Blewett formations within the Moreno Shale.

The following updates to the well testing plan are needed:

- Add caliper logs to the logging program before surface, intermediate, and long string casing are installed.
- Add temperature logging after each casing string is set and cemented.
- Incorporate the requested changes to PFOT procedures in Attachment G and Attachment C.
- Remove all references to a "petition" in the PFOT procedures.

Financial Responsibility Demonstration

- Submit revised and documented third-party cost estimates.
- Provide draft financial instruments.
- The financial instruments will need to be at least partially funded before EPA authorizes construction of the injection well.

PRE-OPERATION UPDATES (ANTICIPATED TO BE MADE AFTER ISSUANCE OF A CONSTRUCTION PERMIT AND FOLLOWING PRE-OPERATIONAL TESTING)

Below are the changes that EPA anticipates will need to be made to CES's Class VI permit application and attachments based on the results of pre-operational testing, which EPA will review prior to authorizing injection at the Mendota well.

Geologic Information

Faults and Fractures

- Perform 3D geomechanical modeling based on data collected via well logs, geomechanical core analysis, and shale gouge ratio, combined with 3D seismic data to better characterize the faults in the area and determine their sealing capacity and that they are non-transmissive.
- Better define the locations, the extent of faulting, and geometry of Fault 1 and all faults within the AoR based on 3D seismic surveys.
- Determine the nature of the displacement of Fault 13 via combining 3D seismic data interpretation with a geomechanical model calibrated to core and well test data, using analytical or numerical stress analysis.
- Demonstrate the sealing capacity of Fault 13 based on core data collected during drilling of the monitoring and injection wells.

Depth, Areal Extent, and Thickness of the Injection and Confining Zones

- Confirm the thicknesses and depths of the injection and confining zones through seismic imaging and information gained during drilling of the injection well and deep monitoring well.

Hydrologic and Hydrogeologic Information

- Based on analysis of formation water samples collected during drilling of the injection and monitoring wells, determine the base of the lowermost USDW and confirm that available resistivity logs and data from nearby fields are representative of the Mendota site.
- Verify the salinities of the permeable Jergins and Blewett formations within the Moreno Shale to confirm that none are USDWs.

Geochemistry

- Use the results of water analysis in the injection zone to provide inputs for the geochemical modeling and determine whether available data from nearby fields is representative of the Mendota site.

Geomechanical and Petrophysical Characterization

- Use site-specific measurements of capillary pressure and information on fractures, stress, ductility, rock strength, elastic properties, and in situ fluid pressures within the confining zone to support an evaluation of confining zone integrity.
- Use laboratory core data on porosity and permeability for the injection and confining zones to confirm the representativeness of the available data from nearby oil fields, support calibration to well logging data, and support development of the porosity distribution in the geomodel.
- Use core and well log data to identify vertical heterogeneity in porosity and permeability.
- Use well logging data to support log-based porosity and permeability calculations and calibration to core analyses.
- Verify the estimates of irreducible water that were presented in the permit application.
- Include a more detailed explanation regarding the cores, their quality, and the laboratory results to clarify how robust those data will be for calibration of the log-based estimates.

Mineralogy, Petrology, and Lithology of the Injection and Confining Zones

- Characterize the mineralogy and lithologies of the injection and confining zones based on core samples collected during drilling of the injection well and deep monitoring well.

Seismic History and Seismic Risk

- Incorporate geomechanical information (dipole sonic logs), formation microimager (FMI) logs, and micro-seismic monitoring into the analysis of seismic risk.
- Perform a seismic risk profile evaluation that explains how the project:
  - Has a geologic system that is free of known faults and fractures and capable of receiving and containing the volumes of CO_2 proposed to be injected;
  - Will be operated and monitored in a manner that will limit risk of endangerment to USDWs, including risks associated with induced seismic events;
  - Will be operated and monitored in a way that, in the unlikely event of an induced event, risks will be quickly addressed and mitigated; and
  - Poses a low risk of inducing a felt seismic event.

Facies Changes in the Injection or Confining Zones

- Based on core data and log data and 3D seismic interpretation, characterize the geologic units, including the geometry, thicknesses, and extents of the sand and shale units and the vertical extent of the facies and facies changes to confirm that these are consistent with current understanding of the depositional history and facies changes at the Mendota site.
- Determine if there are any heterogeneities within the Second Panoche Sands that could affect its suitability for injection, including facies changes that could facilitate preferential flow.
- Refine the geomodel and characterization of subsurface heterogeneity as needed based on collected seismic, core, and well logging data.

Structure of the Injection and Confining Zones

- Confirm the lateral thickness and homogeneity of the injection and confining zones based on 3D seismic, well log, and core data.

CO_2 Stream Compatibility with Subsurface Fluids and Minerals

- Use fluid chemistry and mineralogic data, pressure, temperature, and pH conditions at depth via core sampling and formation testing in the characterization and monitoring wells as inputs to the geochemical modeling.

Confining Zone Integrity

- Confirm mineralogy, porosity, permeability, capillary entry pressure, and geomechanical properties of the Moreno Shale based on core sampling and laboratory measurements to confirm that the Moreno Shale will retain its integrity at planned operating conditions (i.e., injection pressures).

- Calculate log-based estimates of VCL, porosity, permeability, and TDS for all shale units that can provide containment.
- Test for changes in capillary entry pressure due to reaction of the Moreno Shale with the injectate via laboratory experiments.
- Determine the fracture pressure of the Moreno Shale via the poroelastic stress equation using a geomechanical model with rock properties calibrated to geomechanical core test data.

Operating Procedures

- Revise the operating parameters as needed based on the results of pre-operational testing.

AoR and Corrective Action Plan

- The updated AoR model should reflect the "commitments" made in responses to the RAIs (e.g., horizontal and vertical permeability estimates, potential use of reactive transport modeling, updated facies modeling, description of sensitivity analysis and results). The AoR and Corrective Action Plan should clarify/include the following:
  - Provide the DOE saline storage equation and confirm that the DOE saline storage equation is applied to each cell in the geocellular model.
  - Indicate the level of uncertainty in the estimate (i.e., an upper bound, lower bound, or middle range estimate) and what factors might cause the storage capacity to differ from this estimate.
- Finalize information on corrective action at the Amstar and BB Co 1 wells, including:
  - Demonstrate proper plugging of the wells.
  - Update plugging schematics for the wells to reflect the depth of the deepest USDW.
  - Update schematics to reflect surface casing inner diameters.

Testing and Monitoring Plan

CO_2 Stream Analysis

- Update injectate analytical parameters as needed per the final CO_2 injectate composition.

Corrosion Monitoring

- Revise the description of the coupon materials as needed following well construction.

Continuous Monitoring to Demonstrate Internal Mechanical Integrity

- Adjust the maximum pressure thresholds for continuous monitoring and annulus pressure monitoring as needed based on the final operating conditions.

Groundwater Quality Monitoring

- Include the final locations of the monitoring wells based on updated site characterization and including, but not limited to, cultural surface data; 3D seismic data; well log analysis; and structural, facies, petrophysical, and dynamic models.

CO_2 Plume and Pressure Front Monitoring

- If the Fourth Panoche (the alternate injection zone) is selected, OBS 1 should penetrate and be screened in that sand. Likewise, pressure/temperature monitoring in that zone would be necessary as well.
- Clarify which seismic methods will be used (i.e., VSP and/or surface seismic survey).

Air/Soil or Other Testing and Monitoring

- If uncertainties about the geologic setting are identified based on the results of pre-operational testing, the need for air and/or soil gas monitoring or other monitoring may be reconsidered.

Quality Assurance Procedures

- Revise the QASP to include the details of the temperature and oxygen activation procedures to demonstrate external MI (including specific calibration procedures for OA logging) after drilling and logging are completed.
- Update the QASP as needed to address changes to testing and monitoring based on the results of pre-operational testing and monitoring.

Injection Well Plugging Plan

- Revise the plan and well schematics to represent actual depths of the Moreno and Panoche Formations, the selected injection zone, and the base of the lowest USDW based on pre-operational logging and testing.
- Update the plugging procedures for the injection and monitoring wells as needed based on the final well construction after these wells are drilled and completed.
- Update the plugging schematics if injection is to the Fourth Panoche (alternate injection zone).

PISC and Site Closure Plan

- Update all figures based on the results of updated modeling to be performed as additional site data are collected.
- Address each of the criteria at 40 CFR 146.93(c) based on the site-specific data collected if an alternative PISC timeframe is proposed.
- Update the post-injection groundwater monitoring and plume and pressure front tracking strategies if needed based on EPA's final decision on an alternative PISC timeframe.
- Update tables related to post-injection groundwater quality monitoring and CO_2 plume and pressure front monitoring to match any changes to the Testing and Monitoring Plan based on updated modeling and final site characterization.

Emergency and Remedial Response Plan

- Revise the plan as needed based on the results of pre-operational testing.
- Use the results of the seismic risk analysis as needed to inform emergency response planning.

Injection Well Construction Report

- Update schematics for the monitoring wells as needed based on the results of pre-operational formation testing.
- Demonstrate that the selected well component materials are compatible with formation fluids that may be encountered and that they can resist corrosion for the duration of the project based on the results of pre-injection formation testing.
- Modify the surface casing depth/cementing specifications if needed to reflect the base of the lowermost USDW as determined during pre-operational formation water sampling.
- Revise the well construction materials and cement as needed based on final information about the composition, properties, and corrosiveness of the injectate.
- The final construction schematics should reflect CES's decision to inject into the Second Panoche (the primary injection target) or the Fourth Panoche (the alternate injection zone).
- The well schematics and final well construction plans should include the selected shut-off devices.

Financial Responsibility Demonstration

- Revise the cost estimates as needed based on the final well construction, AoR delineation, and updates to any project plans.
- Fully fund all financial responsibility instruments before injection is authorized.