Occidental Petroleum Corporation

10889 Wilshire Boulevard, Los Angeles, California 90024
Phone 310.443.6304 • Fax 310.443.6333
elliott_heide@oxy.com

Elliott Heide
Assistant General Counsel

April 15, 2010

VIA OVERNIGHT COURIER

Terrence O'Brien
Deputy Director
California Energy Commission
Siting, Transmission and Environmental Protection Division
1516 Ninth Street, MS 16
Sacramento, CA 95814-5515

Re: Hydrogen Energy California Project Siting Application

Dear Deputy Director O'Brien:

This letter transmits information responsive to your letter dated March 4, 2010, to Occidental Petroleum ("Occidental"), regarding a carbon dioxide ("CO_2") enhanced oil recovery ("EOR") project proposed by Occidental's subsidiary, Occidental of Elk Hills, Inc. ("OEHI"), as that project pertains to the pending Application for Certification for the Hydrogen Energy California ("HECA") project. Specifically, we are providing you the following items:

1) Attachment 1, setting forth answers to the specific questions raised in your March 4th letter;
2) OEHI's CO2 EOR Preliminary Project Description (Pre-FEED Stage);
3) reports of technical studies and academic white papers analyzing the potential for CO_2 EOR as a form of sequestration; and
4) a sample Class II Underground Injection Control Permit Application (non-confidential) relative to the proposed OEHI CO_2 EOR Project.

Because of the voluminous nature of the data, Items 2, 3 and 4 are being submitted in electronic format on compact discs.

As indicated in my letter to you dated March 23, 2010, efforts are still underway to develop proposed measuring, monitoring, verification and well abandonment standards for consideration by stakeholders in the HECA project siting process. We will provide you with the proposed standards as soon as they are finalized.

Regarding distribution of the information enclosed with this letter, we request that Rod Jones, Project Manager for the HECA project, make any or all of the information referenced in this letter available on the HECA Project docket, as appropriate.

Sincerely,

Elliott Heide

Elliott Heide
Assistant General Counsel

Enclosures

cc: Rod Jones, Project Manager
Dockets Unit
California Energy Commission
1516 Ninth Street, MS 4
Sacramento, CA 95814-5515

Bridgett Luther, Director, Department of Conservation
801 K Street, MS 24-01
Sacramento, CA 95814

Elena Miller, Supervisor, Division of Oil, Gas and Geothermal Resources
801 K Street, MS 20-20
Sacramento, CA 95814-3530

CO_2/EOR Process

1. **What is the nexus between enhanced oil recovery and sequestration as it pertains to Oxy's proposal?**

   Geologic "sequestration" is a term commonly used to describe the physical and chemical process that results in the trapping of a fluid or gas within a geologic formation. Enhanced oil recovery ("EOR") involves the injection of fluids or gases into a hydrocarbon-bearing geologic formation for the purpose of facilitating oil production. As described more fully below, the EOR process using CO_2 as an injectant results in sequestration of the injected CO_2.

   The HECA project involves the capture of CO_2 from an integrated gasification combined cycle power generating facility and the compression and transport of such CO_2 to Occidental of Elk Hills, Inc. ("OEHI"). OEHI operates a large, mature oil production field in the Elk Hills Unit near Bakersfield, California (approximately 4 miles from the HECA project) and is proposing to extend existing EOR operations at the Elk Hills Unit by using CO_2 from the HECA project to facilitate oil production (the "OEHI CO_2 EOR Project").

   The OEHI CO_2 EOR Project will improve oil recovery at the Elk Hills Unit through the use of a closed-loop system involving surface and subsurface facilities for injection, production, processing, separation, compression and reinjection of CO_2. The injected CO_2 – which is in a fluid-like state – reduces the viscosity and enhances mobility of oil to improve extraction. CO_2 is not emitted into the atmosphere during the CO_2 EOR process or after operations cease, other than de minimis fugitive losses from equipment, theoretical operational upsets, and well maintenance. Injected CO_2 becomes physically sequestered in pore space voided by oil and other fluids produced in the EOR operation, as well as through other geochemical trapping mechanisms.

   During the operational phase of an EOR project, some volume of CO_2 that has been injected into an oil-bearing target formation through injection wells is extracted (along with hydrocarbons and other gases and fluids) through production wells. Injected CO_2 that is subsequently extracted remains a valuable commodity and is not vented to the atmosphere. Instead, using a closed-loop system, it is separated from the hydrocarbons and other extracted gases and fluids, and then reinjected into the oil-bearing target formation for additional EOR use. With every injection cycle 30-50 percent of the injected CO_2 volume becomes sequestered in the target formation, making it unrecoverable. Due to the high fraction trapped on each pass, it takes only a few cycles for essentially all of the initial amount of injected CO_2 to become completely sequestered. For example, if half of the amount of injected CO_2 is sequestered on each recycle pass, by the tenth cycle, more than 99.8% of the initial amount of injected CO_2 would be sequestered.

The trapping effect is an unavoidable characteristic of the CO_2 EOR process, one that creates a persistent demand for additional CO_2 over the course of the EOR operation. This predictable demand and geologic permanence is why CO_2 EOR is an ideal technology for sequestering CO_2 emissions.

2. **What percentage of the injected carbon dioxide remains trapped in the oil wells/rock formation during the CO_2 EOR process, and is it considered sequestration?**

   As described more fully above, geologic sequestration of fluids and gases is a physical and chemical process, and CO_2 EOR results in sequestration of CO_2. During the life of a CO_2 EOR project, injected CO_2 is either trapped in the subsurface or contained within the above-ground facilities. While some volume of CO_2 could be lost in above-ground processes due to equipment fugitive emissions, theoretical operational upsets, and well maintenance, these losses represent only a very small percentage in proportion to the total CO_2 stored. Following completion of CO_2 EOR operations, including decommissioning of wells, essentially all CO_2 injected over the life of the project will be trapped in the target formations and sequestered. For further discussion of this topic, please refer to the technical studies and academic white papers included with OEHI's April 15th submission.

3. **What percentage of CO_2 that is initially injected is expected to be captured and re-injected into the wells?**

   Approximately 50-70 percent of CO_2 injected in a target formation each cycle is captured and reinjected.

4. **Will the CO_2 EOR be operating 24 hours/ day?**

   The OEHI CO_2 EOR Project is expected to operate 24 hours per day during the life of the HECA project, subject to scheduled maintenance and unscheduled outages.

5. **What percentage of time over a year is the process expected to operate without interruption?**

   OEHI plans to have redundant injection facilities and wells and a backup target formation so that the OEHI CO_2 EOR Project can operate without interruption. Thus, as mentioned above, OEHI expects to operate the OEHI CO_2 EOR Project 24 hours per day during the life of the HECA project, subject to scheduled maintenance and unscheduled outages.

6. **How frequently will maintenance and overhaul activities be scheduled which could affect the CO_2 EOR process? Will Oxy still be able to take**

CO_2 when wells are closed for maintenance or an unexpected malfunction occurs?

In its existing operations, OEHI conducts maintenance and work-over activity on a regular and ongoing basis and plans to continue doing so throughout the life of the OEHI CO_2 EOR Project. Such activities are not expected to limit OEHI's ability to accept and inject all volumes of CO_2 delivered by HECA during the life of the HECA project. As indicated above, OEHI plans to have redundant injection facilities wells and target formations so that the OEHI CO2 EOR Project can operate without interruption.

Site Assessment

1. **What site characterization process (e.g., site assessment, subsurface characterization, etc.) will be used by Oxy to determine which wells will be used for the CO_2 EOR Project?**

For more than 30 years, hydrocarbon gases and water have been used for EOR operations at the Elk Hills Unit in the same oil-bearing target formations that will be used for the OEHI CO_2 EOR Project. This operating history has demonstrated the confinement of such injectants to the target formations. In addition, OEHI's evaluation of risks associated with potential leakage pathways in the target formations has verified the appropriateness of the Elk Hills Unit for CO_2 injection and storage.

OEHI's reservoir characterization work includes analysis of:

- CO_2 injection pilot study that confirmed containment of CO_2 in the target Stevens reservoirs
- Stratigraphy, structure, depth, thickness, pressure, porosity, geomechanical and fluid flow properties of the injection zones and confining zone
- Sealing capacity of the confining zone (from petrophysical logs and seismic interpretation)
- Natural and induced seismicity (See: HECA regional seismicity study for the Elk Hills Field in Appendix F of HEI AFC Application)
- Transmissive faults and confirmation that none intersect the confining zone in areas where CO_2 injection occurs
- Well construction and plugging history of all wells which penetrate the confining zone
- Compositional analysis of injection and reservoir fluids
- Computer simulation of CO_2 trapping mechanisms

2. **How many oil wells are expected to be used annually by Oxy for CO_2 EOR?**

   It is currently expected that there will be up to 38 injection wells and 56 production wells during the initial phase of the OEHI CO_2 EOR Project. In later phases of the project, OEHI expects to operate up to a total of 250 injection wells and 310 production wells annually.

3. **What would be the anticipated life-cycle of the wells used during CO_2 EOR?**

   With ongoing well maintenance and work-overs, OEHI expects that each well will continue in service for as long as hydrocarbon production from that well is economic. OEHI expects that the target formations will be economically producible for 30 or more years.

4. **What is the capacity of the wells to be injected with CO_2?**

   OEHI currently estimates that injection wells will be able to inject between 2-20 million cubic feet of CO_2 per day depending on well-specific reservoir permeability.

CO2 Transfer and Storage

1. **How many tons of CO_2 per year is projected to be transported through the CO_2 pipeline to the custody transfer point in the Elk Hills Field?**

   Approximately 2 million tonnes per year.

2. **What happens to any excess received from the HECA CO_2 pipeline and how would it be stored and used by Oxy?**

   OEHI will be able to accept and utilize all CO_2 produced from the HECA plant for the OEHI CO_2 EOR Project.

Monitoring, Mitigation, and Verification (MMV)

1. **What type of subsurface monitoring techniques (e.g., sensors) will be used by Oxy to manage the performance risks (e.g., containment, leakage, fracturing of cap rock, etc.), associated with CO_2 in the wells?**

   OEHI is working with credible and experienced NGO stakeholders to develop a proposed set of MMV criteria. The product of that effort will be submitted to the CEC for consideration in the course of the HECA siting process.

2. **What would be the average rate of damage caused to the wellhead and casing from high pressure injection of CO_2 into the wells?**

   Wellheads with CO_2 compatible metallurgy and corrosion-resistant coatings that are design-rated for the permitted injection pressure will be used on the injection wells, which will provide effective protection of wellhead and down-hole components over their service life. Casing in the injection wells is protected by cement on the exterior and the interior will be isolated from CO_2 by the injection packer. All producing wells, including wellheads, will have adequate design pressure rating and will be protected by the injection of corrosion inhibitor chemicals to maintain mechanical integrity.

3. **What practices and safety measures would be used to prevent or minimize injection of CO_2 to the non-target areas of the reservoir and surrounding geologic features at the Elk Hills Field?**

   Many practices and safety measures will be used to prevent or minimize injection of CO_2 to non-target areas, including perforating and stimulating injection wells in only the desired injection interval and conducting well surveys to ensure that injected CO_2 is entering the targeted Stevens reservoirs. In addition, the Elk Hills Unit benefits from the presence of numerous producing wells, including many wells producing from horizons above and below the Stevens reservoirs. These wells will act as observation points to provide immediate evidence of predicted and/or unpredicted subsurface CO_2 movement. Actual real-time data will be gathered from existing and new wellbores through the following processes:

   - Monitoring of wellhead and annular pressures of wells completed in the Stevens reservoirs, supplemented by downhole pressure and temperature where available
   - Monitoring of wellhead and annular pressures of wells completed in reservoirs vertically adjacent to the Stevens reservoirs, supplemented by downhole pressure and temperature measurements in these offset reservoirs where available
   - Well integrity monitoring, including cement bond logging upon initial well completion
   - Produced fluid compositional analysis

   OEHI will also engage in the following containment verification activities:

   - Characterization of rock stress and strength through acquired geomechanical data
   - Material Balance analysis
   - Monitoring plan for collection of subsurface pressure, reservoir fluid chemistry and other data as necessary to demonstrate and predict behavior of the injected CO_2

- A leak detection plan that will include monitoring of wells and produced fluids in reservoirs adjacent to the Stevens reservoirs to provide early detection of any CO_2
- Static and dynamic subsurface modeling to characterize migration of injected fluids through the reservoir. These three-dimensional, multiphase flow, numerical simulation models of the Elk Hills Field extend to sufficient depth to fully characterize the Stevens injection zone and confining zone and are of sufficient areal size to allow full characterization of the injected CO_2 and any associated pressure front resulting from the injection of CO_2 over the life of the OEHI CO_2 EOR Project. The models can be further described as follows:
    - A static model which accurately represents the pre-CO_2-injection, 3-dimensional subsurface geologic horizons characterized by distributed petrophysical properties (porosity, permeability, etc.) as well as their reservoir properties (fluid saturations, pressure, temp, solubility, etc.), significant faults and their transmissivities (those which could compartmentalize the injection zone or act as a leakage pathway), and location of injection and production wells.
    - A dynamic model, which utilizes the static model for a starting point and accounts for the injection of CO_2 and the production of hydrocarbons over the life of the OEHI CO_2 EOR Project, run at sufficient time intervals to demonstrate the movement of CO_2 and the pressure front over time, and run until the CO_2 and pressure front stabilizes and injection zone pressure is insufficient to push CO_2 into any adjacent geologic horizons.

Stewardship

1. Who will have ownership of the pore space, mineral rights, etc. associated with the CO_2 EOR process?

OEHI is the majority owner (78 percent) of the Elk Hills Unit, and Chevron owns the remaining 22 percent. OEHI is the exclusive operator of the Elk Hills Unit on behalf of Occidental and Chevron.

Mineral interest ownership is typically the dominant ownership interest in real property. Mineral interest owners are generally entitled to access and use the mineral-bearing formation in any manner necessary to facilitate exploitation of minerals. For EOR operators, this ownership interest includes the right to use and occupy pore space with fluid or gas injectants for the purpose of enhanced hydrocarbon production. In addition, the Elk Hills Unit owners own both the surface and mineral interests for the entire area encompassing the target injection formation.

2. **At the end of the active operation when the CO_2 supply is finished, how will Oxy decommission the wells?**

   OEHI will decommission the wells in accordance with the appropriate DOGGR regulations and any additional conditions accepted by OEHI to enable the permitting and operation of the HECA project.

3. **What technologies and procedures will Oxy use to ensure long-term isolation, as well as monitor and insure the CO_2 storage integrity?**

   Please refer to OEHI's responses to the questions above relating to MMV.

4. **How will long-term liability issues associated with CO_2 storage be addressed?**

   Any "long-term liability" associated with CO_2 EOR that results in sequestration is indistinguishable from that which may exist for other EOR projects involving fluid or gas injection. As such, OEHI believes existing regulatory and liability mechanisms adequately address concerns about any long-term liability associated with OEHI's proposed CO_2 EOR activities.

5. **What measure will Oxy use to monitor the storage site and how long after site closure does Oxy expect to continue monitoring?**

   Please refer to OEHI's responses to the questions above relating to MMV.