

Greenhouse Gas Emission Reduction Creation Report for the Monell Enhanced Oil Recovery (EOR) Project for CY 2004

**Anadarko E&P Company LP
Sweetwater County, Wyoming**

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This creation report describes the Greenhouse Gas (GHG) emission reductions achieved by Anadarko E&P Company LP (Anadarko) Monell enhanced oil recovery project during calendar year 2004.

1. Project Description

1.1 Overview

In 2004, Anadarko, a wholly owned subsidiary of Anadarko Petroleum Corporation, began operation of an Enhanced Oil Recovery (EOR) project at its Monell field in Sweetwater County, Wyoming. This project involves the injection of carbon dioxide (CO₂) into the oil field to increase the production of oil. The CO₂ that is used for injection comes from a source that would otherwise vent it to the atmosphere. Therefore, implementation of the Monell EOR project serves as a means of reducing atmospheric CO₂ emissions. The EOR process represents a form of geologic CO₂ storage (i.e., sequestration) since the CO₂ that is produced with the oil is re-injected into the field. At the end of the life of the field, the injected CO₂ will be maintained within the field.

1.2 Description

The Monell field was originally developed for conventional oil and gas production. In recent years, water flooding has been used in the field to improve production, although before implementation of the EOR project few operating wells remained. The first phase of the Monell CO₂ flood, as described in the 2003 Plan of Development, consists of 27 injection wells (water alternating with gas), 38 production wells, and two horizontal water injection wells to isolate the CO₂. The planned EOR project will significantly increase oil production from the levels prior to its implementation.

Carbon dioxide for the Monell EOR project comes from a gas processing plant at the Shute Creek field near Labarge, Wyoming. This plant is used to treat raw natural gas to create a marketable commodity. The process involves the removal of CO₂ from the raw gas. This CO₂ would normally be vented to the atmosphere as a waste product after it is separated from raw natural gas. With the implementation of the Monell EOR project, additional CO₂ is instead compressed and transported via pipeline to the Monell field.

The CO₂ is introduced into the pipeline at the gas plant at a sufficiently high pressure that no booster compression of the CO₂ is needed along the route to the Monell field. At the Monell field, the CO₂ is metered and merged with the recycle gas from the EOR operation and the pressure is boosted to 2500 psig (pounds per square inch gauge) prior to injection. After injection, much of the CO₂ returns to the surface through the production wells as the CO₂ is miscible with oil. The gas produced with the oil (containing CO₂ and hydrocarbons) is separated, recompressed, and re-injected in the field. In the initial operation of the project, when relatively small amounts of CO₂ were being produced with the oil, the gas associated with the oil was sold to a gas processor. CO₂ leaving the field in this way is accounted for as an emission in the Monell emission reduction protocol.

The EOR process includes vapor recovery units (VRUs) to control atmospheric emissions. These units capture gaseous emissions from the oil and water storage tanks and from the vents of glycol dehydrators. This captured gas is compressed and added to the gas for re-injection. Therefore, under normal operating conditions, there are no intentional emissions of the injected CO₂. All of the CO₂ that is metered at the entrance to the field will be stored in the field.

The EOR process will be implemented in the field in a series of phases. Upon cessation, injection will stop and the field will be closed in a manner so as to contain the injected CO₂.

1.3 Location

Both the Monell field and the source of the CO₂ are located in the U.S. state of Wyoming. The Monell field is in Sweetwater County, Wyoming, near the city of Rock Springs. The gas plant where the CO₂ would otherwise be vented is near LaBarge, Wyoming in Lincoln County.

1.4 Project Contact Information

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2. Description of the Methodology

The CO₂ acquired for enhanced oil recovery projects represents a reduction in emissions when that CO₂ would otherwise have been vented to the atmosphere. The implementation of an EOR project increases GHG emissions from several sources, however, both at the source of the CO₂ and at the field where it is injected. At the gas plant, GHG emissions will increase due to the need to compress the CO₂ for transport in the pipeline. If the CO₂ were being vented, this compression would not be needed; the gas would simply be vented at atmospheric pressure.

Within the oil field itself, emissions will result from the compressors used to recycle the gas produced with the oil. In addition, emissions that occur from the venting of oil and water storage tanks, and from any CO₂ that remains in the oil or is discharged with produced water need to be accounted for. During the initial start-up of the field, before the gas produced with the oil is recycled for injection, any CO₂ in the gas will be sent to a gas plant along with the hydrocarbon gases. This CO₂ is assumed to be emitted to the atmosphere. Small quantities of fugitive releases can also be expected.

The procedures for quantifying the emission reductions are described in detail in the *Greenhouse Gas Emission Reduction Protocol for the Monell Enhanced Oil Recovery (EOR) Project* (August 2004) prepared for Anadarko Petroleum by Battelle. This protocol describes the methodology

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and equations to be used for calculating the net GHG emission reductions from the project accounting for both the reduction in emissions from injecting the CO₂ and the increase in emissions that occurs through the implementation of the project.

3. Mandatory Criteria

3.1 Real

The emission reductions that result from the Monell EOR project are real because they result from the implementation of the project using CO₂ for injection that would otherwise be vented to the atmosphere.

3.1.1 Activity

The Monell EOR project reduces GHG emissions by taking CO₂ that would otherwise be emitted to the atmosphere and sequestering it in a geological formation. The CO₂ is injected in the Monell oil field to enhance the production of oil. When the CO₂ returns to the surface with the oil, it is separate from the oil and reinjected. This process will continue until the field stops producing oil, at which time the CO₂ will be sealed in the depleted reservoir.

3.1.2 Leakage

The issue of leakage is addressed in the protocol for quantifying the GHG emission reductions from the project. Leakage results in several ways from EOR projects. New emissions associated with the compression of the injected and recycled gas will result from the EOR process. Since the source of the CO₂ is outside of the oil field, the project boundary has been drawn sufficiently broadly to cover these emissions.

In addition to these increases in emission, leaks in the literal sense of the word also need to be addressed in accounting for emission reductions from geological sequestration. Such leaks include fugitive losses from the piping systems used to transfer the CO₂ and recycle gas, as well as possible leaks from the reservoir itself. Quantification of these leaks is described in the protocol and the net emission reductions are calculated after accounting for these leaks.

3.2 Measurable

The GHG emission reductions from the Monell EOR project are readily quantifiable. The quantity of CO₂ injected, and its composition, are measured routinely, and the activity data needed to calculate the emissions associated with the project are also monitored.

The Monell protocol describes in detail how the emission reductions are calculated for the project and how the actual emissions with the project compare with the baseline emissions that would have occurred in the absence of the project.

The Monell EOR emission reductions for calendar year 2004 are summarized in the table below. Net emission reductions are just over 241 thousand tonnes of CO₂-equivalent. The negative

values in the table correspond to the quantity of GHG sequestered, the positive values represent the GHG emissions that result from implementing the project.

2004 GHG Emissions and Reductions from the Monell EOR Project

CO₂	Combustion	Indirect	Miscellaneous	Venting	Total (tonne):
<i>Monell Field</i>	2,627	-264,504	721	19,718	-241,439
<i>Gas Plant</i>	19,289	0	0	0	19,289
Total (tonne):	21,915	-264,504	721	19,718	-222,150

CH₄	Combustion	Indirect	Miscellaneous	Venting	Total (tonne):
<i>Monell Field</i>	0	-981	0	79	-903
<i>Gas Plant</i>	0	0	0	0	0
Total (tonne):	0	-981	0	79	-903

CO₂e	Combustion	Indirect	Miscellaneous	Venting	Total (tonne):
<i>Monell Field</i>	2,628	-285,115	725	21,374	-260,388
<i>Gas Plant</i>	19,296	n/a	n/a	n/a	19,296
Total (tonne):	21,923	-285,115	725	21,374	-241,092

3.2.1 Emission Reduction Calculations

The emission reduction calculations for the Monell EOR project are described in the protocol. The calculations are performed using the SANGEA™ Emissions Estimation System. This software tool is being made available to oil companies by the American Petroleum Institute to assist companies in conducting GHG emission inventories.

The calculation methods in the SANGEA™ Emissions Estimation System are based on the *Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Gas Industry* published by API (2004). The accuracy of the SANGEA™ tool and its consistency with the *Compendium* were verified by API before releasing to the industry.

The calculation of emission reductions for the Monell EOR project are based on the difference between the actual emissions and what emissions would have been in the absence of the project. Since the quantity of CO₂ that is acquired for injection equals the amount that would have been emitted in the absence of the project, the starting point for calculating the reductions is the measured amount of acquired CO₂. As described in the protocol, leakages are subtracted from the quantity of gas acquired for injection to arrive at the net GHG emission reductions.

3.3 Verifiable

The GHG emission reductions for the Monell field are verifiable because they are calculated in a transparent way and the data on which the calculations are made can be readily audited. As

described in the protocol, standard means are used for quantifying the net emission reductions associated with the project.

As a new installation, the Monell EOR project has incorporated into it a sophisticated monitoring system for operating the project. This system provides and stores data relevant to both the operation of the field and the calculation of the GHG emission reductions. The types of data inputs used to calculate the emission reductions are described in the protocol.

The use of the SANGEA™ Emissions Estimation System contributes to the verifiability of the reductions. The system requires that audit trail information be entered for activity data used to calculate emissions. This audit trail information is stored with the input data and will facilitate the verification the raw input data by a third party.

4. Other Information

4.1 Ownership

Anadarko Petroleum Corporation claims ownership of the emission reductions from the Monell project based on the fact that it is the party that is implementing the project that results in the CO₂ being sequestered. This is consistent with the way ownership of emission reductions has been assigned for other similar projects.

4.2 References

Monell Unit 2003 Plan of Development (POD), Sweetwater County, Wyoming. Report to the Bureau of Land Management, Casper Wyoming, August 4, 2003, by Anadarko E&P Company, The Woodlands, Texas.

Greenhouse Gas Emission Reduction Protocol for the Monell Enhanced Oil Recovery (EOR) Project. Prepared for Anadarko E&P Company LP, a wholly owned subsidiary of Anadarko Petroleum Corporation, by Battelle, Lexington Massachusetts. August 2004.

API, 2004. *Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Gas Industry.* American Petroleum Institute, Washington, D.C. February 2004

SANGEA™ Emissions Estimation System. See <http://ghg.api.org>