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U.S. SENATE COMMITTEE ON
ENERGY AND NATURAL RESOURCES

HEARING ON THE POLICY ASPECTS OF CARBON CAPTURE, TRANSPORTATION, AND SEQUESTRATION AND RELATED BILLS, S. 2323 AND S. 2144

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Denbury Resources, Inc., ("Denbury") appreciates this opportunity to share with Members of the Senate Committee on Energy and Natural Resources its views on policy aspects of carbon capture, transportation, and sequestration (hereinafter collectively referred to as "CCS"). As Senior Vice President, Reservoir Engineering for Denbury, I oversee all reservoir engineering, land functions and acquisition activities; am responsible for securing and contracting sources of anthropogenic CO_2; and coordinating our government relations. Denbury is currently the largest oil producer in the State of Mississippi and the one of the largest injectors of carbon dioxide ("CO_2") in terms of volume in the United States. Denbury's primary focus is enhanced oil recovery ("EOR") utilizing CO_2. At the present time we operate ten (10) active CO_2 enhanced oil projects, nine in the State of Mississippi and one in the State of Louisiana.

Denbury also owns the largest natural deposit of CO_2 east of the Mississippi River, called Jackson Dome in central Mississippi, which we extract and transport through approximately 350 miles of dedicated CO_2 pipelines for use in EOR. Denbury is also in the process of designing or constructing an additional 375 miles of CO_2 pipelines in order to expand our operations into additional fields throughout the Gulf Coast of the United States. Finally, the Committee may be interested to know that Denbury is working with the federal Department of Energy and various research universities on several Phase II and Phase III demonstration projects in the Regional Carbon Sequestration Partnership Program. While our business model focuses primarily on the transportation and sequestration components of CCS, we also are very familiar with the capture component both in terms of (1) the compression demands of transportation and sequestration and (2) our enhanced oil operations, which recycle large volumes of CO_2 in order to recover additional volumes of oil. Given this background, Denbury is pleased to share its perspective on various policy aspects of CCS and the proposed legislation before the Committee today.

A thorough understanding of both (1) the physical processes by which CO_2 is obtained, transported and injected for purposes of EOR and/or permanent storage, and (2) the economics that underlie existing and future EOR-related use of CO_2 is essential to any consideration of potential policy issues. The significant and varying costs associated with CCS - whether in conjunction with EOR or not - are perhaps the single largest obstacle to developing CCS infrastructure beyond the limited, discrete projects currently in operation. From Denbury's perspective, it is critical that any contemplated state or federal regulation not increase these costs and impede private sector development of the CCS infrastructure necessary to meet the demands of our energy hungry and potentially carbon-constrained world.

As explained in greater detail below, the current regulatory structure surrounding CO_2 consists of state and federal provisions that cover discrete aspects of CCS. For instance, the over 3,500 miles of dedicated CO_2 pipelines currently in use were constructed and are operating under rules and guidelines for safety issued by the Department of Transportation's Office of Pipeline Safety; with pipeline siting issues significantly impacted by state eminent domain laws; and with CO_2 injection wells permitted and approved by individual state government divisions or departments of Underground Injection Control, utilizing the standards and policies issued by the Environmental Protection Agency. While this system may appear patch-work and non-comprehensive, the current structure is entirely appropriate, as CCS is very much still in its infancy. This predominantly state-law-based system should suffice for many years to come. Thus, Denbury supports the recommendations of the Interstate Oil and Gas Compact

Commission's 2005 Regulatory Framework for States. With few exceptions, such as funding research and further study of the issues involved as both bills propose, and given the current system of regulations and natural physical and economic constraints likely to exist for years to come, federal policymakers might best further national energy and carbon capture goals by deferring broad legislation or regulation while CCS is in this nascent phase.

I. Capture / Compression

In thinking about the policy aspects of CCS, it is useful to separate the various components of CCS and to identify what issues within each merit particular attention, distinguishing between EOR-related CCS and CCS in saline or other formations where appropriate. The starting point for any type of CCS is to capture the CO_2. Denbury currently obtains all of its CO_2 from its natural deposit at Jackson Dome. Certain existing and some evolving technologies allow CO_2 emitted from various manufacturing processes to be captured. The combustion or gasification of hydrocarbon-based fuels such as coal, petcoke or other hydrocarbons produces particularly large volumes of CO_2 at varying levels of quality and purity. As new capture-inclusive projects are constructed, Denbury plans to acquire thousands of metric tons of CO_2 each day for use in EOR.

Aside from the threshold questions of how to properly classify CO_2 and whether and to what extent to restrict emissions, from Denbury's perspective, the capture of CO_2 presents no policy issue. Rather, the capture component presents a significant economic issue: First, capture technology is expensive. The byproduct of hydrocarbon combustion or gasification is a stream of gases and other impurities that contains various quantities of CO_2. In order for CO_2 to be usable in EOR it must be injected in a relatively pure form. Similarly, CO_2 injected into deep saline reservoirs must be in a relatively pure form to maximize the storage space available to be filled with CO_2. Thus, a significant component of the capture cost is the cost to separate and purify the CO_2 to be injected. The lower the percentage of CO_2 in the stream of gases and the greater the amount of impurities in the stream the greater the cost of capture. Second, most technologies capture the CO_2 at a lower pressure than is required to either enter a typical CO_2 pipeline or to inject into a deep saline reservoir or EOR project. The costs of the compressors and the power necessary to drive them are significant -- approximately \$7.50/ton of the estimated \$20/ton total cost[1] for CO_2 that is transported moderate distances. Therefore, the compression costs associated with CO_2 capture are slightly more than one-third (33%) of the total CCS cost for the least expensive sources of anthropogenic (man-made) CO_2. Additional compression costs are incurred to maintain pressure in pipelines and again when CO_2 is pressured up to sufficient level for EOR reservoir injection. In sum, without some means of reducing the cost of captured anthropogenic CO_2 significantly, infrastructure development will likely remain stagnant.

To address this issue, last year the Finance Committee approved a tax credit for the capture and sequestration of CO_2 of \$10.00/ton in connection with EOR and \$20/ton for non-EOR projects for up to 75,000,000 tons sequestered. From Denbury's perspective, this would be sufficient to incentivize construction of additional pipelines from emission sites to geologic

[1] Total costs of CCS varies substantially by source of CO_2 - to upwards of \$70/ton - and even across proposed gasification projects because of variances in each process. This figure represents an estimate of the lowest-cost industrial-sourced CO_2.

sequestration sites in connection with EOR activities. Unfortunately, this provision was not included in the energy legislation ultimately signed into law in December. We hope that Congress will address the issue of CCS costs in 2008, especially those associated with capture and compression, and note that proposed projects from gasification through to sequestration have the potential to create hundreds and perhaps thousands of jobs across the country. On this point, S. 2144 directs the Secretary of Energy to study technical and financing issues related to the construction and operation of CO_2 pipelines and sequestration facilities. While this will be helpful to policymakers, the legislation should also direct the Secretary to consider these same issues in relation to CO_2 capture, separation, purification and compression.

II. Transportation

The most economical way to transport CO_2 is through pipelines at pressures in excess of 1100 psi so that the CO_2 is transported as a supercritical fluid (dense phase). At pressures in excess of 1100 psi and temperatures common for CO_2 pipelines, CO_2 is a supercritical fluid which means that the CO_2 has properties of both a liquid and a gas. Larger volumes of CO_2 can be transported through CO_2 pipelines in this dense phase than can be transported as a gas. Given the pressure requirements to maintain CO_2 in the dense phase, CO_2 pipelines are generally operated at pressures greater than 2,000 psi. This pressure is well in excess of the average operating pressure of a natural gas pipeline, though the material used to manufacture both types is the same.

A. Safety

CO_2 is not as dangerous to transport as some other gases, such as hydrogen and natural gas because it is not explosive, flammable or poisonous. The primary safety issue with transporting CO_2 is asphyxiation caused by a leak in a pipeline. Although there have been a few accidents, releases and leaks reported, none of the dozen leaks that occurred from 1986 to 2006 resulted in significant injury. The characteristics of anthropogenic CO_2 and natural CO_2 are essentially the same. Thus, whether natural CO_2 or anthropogenic CO_2 is being transported in a CO_2 pipeline for the purposes of being delivered to an enhanced oil recovery project or being delivered to a deep saline reservoir sequestration project is irrelevant to the safe construction and operation of a CO_2 pipeline. At the present time there exist over 3,500 miles of dedicated CO_2 pipelines, most of which have been transporting CO_2 for over 20 years -- and some for over 30 years -- with an excellent safety record. We do not see any evidence to suggest that the current regulatory framework that oversees construction and operation of CO_2 pipelines should be modified. To the extent that consideration of safe handling, transportation, and sequestration issues by the Department of Energy, as S. 2144 directs, will address any lingering misconceptions about the relative safety of dense phase CO_2, it will facilitate public understanding and acceptance of CO_2 pipelines and sequestration projects.

B. Siting

At the present time federal eminent domain authority does not extend to CO_2 pipelines. Several states have provided eminent domain authority to CO_2 pipeline owners to assist in getting CO_2 pipelines constructed. While this is helpful in constructing *intrastate* pipelines,

individual state eminent domain powers may not extend to *interstate* pipelines that are just traversing through a state with no origin or terminus there. For this reason and due to the long distances across state lines that separate potential CO_2 emission capture sites from potential EOR locations, federal eminent domain authority may ultimately be required to develop a nationwide CO_2 pipeline infrastructure. In addition, some mechanism may be necessary to address the siting of pipelines and CCS generally on federal lands. S. 2144 directs the Secretary of Energy to study CO_2 pipeline siting issues, which should facilitate a thoughtful approach by policymakers.

C. Rates

Any contemplation of federal regulation of CO_2 transportation rates and pipelines similar to the regulations that currently exist for natural gas, oil or products pipelines is premature, as there is no interconnected system of CO_2 pipelines to which to apply any such regulation, nor prospects for development of one for many years, nor reasonable prospects for development of a "retail" market for CO_2 with large numbers of "users" of the CO_2. At the present time there are very limited areas with existing CO_2 pipelines and limited industrial CO_2 emissions being captured (North Dakota Gasification). The vast majority of the existing CO_2 pipelines are transporting natural CO_2 from natural underground CO_2 production sources that are owned and operated by the CO_2 pipeline owner -- generally for use in enhanced recovery projects also owned and operated by the CO_2 pipeline owner. In cases where the owner of the CO_2 pipeline has CO_2 production volumes in excess of its own EOR requirements, the excess CO_2 volumes are sold to EOR operators in other projects or to industrial gas suppliers. This limited number of regional CO_2 shippers and consumers stands in marked contrast to the numerous and geographically widespread producers and consumers of oil and natural gas products.

It would be a substantial mischaracterization to suggest that the U.S. has an integrated CO_2 pipeline system similar to the fully integrated natural gas, oil or hydrocarbon products pipeline systems which have their transportation rates regulated by the Federal Energy Regulatory Commission ("FERC"). The natural gas, oil and product pipeline systems today consist of hundreds of thousands of miles of pipelines with significant interconnects between individual pipeline systems to accommodate the transfer of natural gas, oil or products from one pipeline system to the other. In contrast, existing CO_2 pipeline systems are a tiny fraction of that size (3500 miles) and are not interconnected. (see Attachment No. 1) Several pipelines delivering CO_2 for enhanced oil recovery in the Permian basin of west Texas are interconnected at Denver City, where CO_2 can be transferred from one pipeline to another. The other CO_2 pipeline systems in Wyoming, North Dakota, Oklahoma, and Mississippi are not connected to the Permian basin pipeline system or to each other. Thus, today no national CO_2 pipeline system exists and no federal regulation to ensure access is necessary.

Natural gas, oil and hydrocarbon products pipelines were constructed in a similar manner to today's CO_2 pipeline systems. Individual pipeline systems were developed to transport natural gas, oil or products from production sites to consumption sites in their infancy. Only after a significant period of time, were these individual systems eventually interconnected to allow the transfer from one pipeline system to the other. Although the Federal Power Commission and eventually the FERC was granted jurisdiction over the transportation rates for natural gas, oil and hydrocarbon products, the combination of regulating rates and requiring open access has only

existed since 1985. Several decades passed between the time that individual pipelines were constructed and eventually interconnected to create an integrated intrastate pipeline system. CO_2 pipelines should also be given room to grow before FERC-like regulation is contemplated.

D. Costs

The construction and installation of CO_2 pipelines is a capital intensive effort, the costs of which have increased in recent years for a variety of reasons, including rising steel prices, construction costs and energy prices. By way of example, Denbury's 93 mile, 20 inch Freestate pipeline (see Attachment No. 2) completed in 2006 cost approximately $30,000 per inch-mile, resulting in an effective transportation rate of approximately $3.50/ton at full capacity. The initial 37 mile segment of Denbury's 24 inch Delta pipeline was completed in 2007 at a cost of approximately $55,000 per inch-mile. We estimate that our planned 314 mile, 24 inch Green Pipeline that will run from Donaldsonville, Louisiana to Hastings field in southeast Texas will cost approximately, $100,000 per inch-mile resulting in an effective transportation rate of approximately $7/ton at full capacity. While the length (pumping stations to maintain adequate pressure add an additional $1 to $2 per ton to transportation costs), route obstacles and type of terrain all added to the estimated cost of the Green pipeline, the fact remains that such endeavors, even under the best of circumstances are extremely costly and take years of careful planning. As stated above, S. 2144 directs the Secretary of Energy to study technical and financing issues related to the construction and operation of CO_2 pipelines. Such information should prove useful to policymakers seeking to understand the significant costs involved in developing the infrastructure of CCS. Also, any study of CO_2 pipeline financing issues will undoubtedly encounter the tax code impediment discussed in the next section.

E. Taxation

Today, a substantial portion of all CO_2, natural gas, oil and products pipelines in the U.S. are owned and operated by companies that are organized as Publicly Traded Partnerships commonly referred to as Master Limited Partnerships ("MLPs"), which through their lower cost of capital have been an important financing source for building these assets. Section 7704 of the tax code permits MLPs to be taxed so that income and tax liabilities are passed through to the partners, even though the MLPs are large public entities, provided 90 percent or more of the MLP's gross income is derived from certain qualifying activities. These activities include exploration, development, processing and transportation of natural resources, including pipelines transporting gas, oil, or products thereof (see Sec. 7704(d)(1)(E)). While this provision covers the processing and pipelining of "natural" CO_2, it is unclear whether it covers anthropogenic CO_2. Because of this uncertainty, much of the existing CO_2 pipeline capacity (that owned by MLPs) cannot currently be used to transport anthropogenic CO_2 from emissions sites -- at least not without significantly higher tax costs than other pipeline assets in the industry.

Last year, as part of its energy tax package, the Senate Finance Committee adopted a modification to include industrial source CO_2 in the definition of qualifying income (see Sec. 817 of the Energy Enhancement and Investment Act of 2007, June 19, 2007). However, Congress ultimately failed to include that package of provisions in the Energy Independence and Security Act of 2007 (P.L. 110-140). Without this modification of the tax code, a substantial

portion of the pipeline industry will most likely not contribute capital to the construction of the CO_2 pipeline infrastructure necessary to facilitate CCS through transportation of anthropogenic CO_2. We strongly urge Members of the Energy and Natural Resources Committee to work with their colleagues on the Finance Committee and the House Ways and Means Committee to accomplish this important clarification.

III. Injection / Sequestration

Enhanced oil recovery utilizing CO_2 requires multiple injection wells throughout a unitized field or reservoir. CO_2 injection wells are permitted and approved by each State's division or department of Underground Injection Control utilizing the standards and policies issued by the EPA. CO_2 injection wells utilized in tertiary oil recovery (a.k.a. EOR) are permitted and approved as Class II Injection wells. Such wells have been in existence for over 30 years. The CO_2 sequestration commercial demonstration projects proposed in S. 2323 and enacted in the Energy Independence and Security Act of 2007 should yield additional helpful data on the ability of EOR and saline reservoirs to sequester CO_2.

In 2005, the Interstate Oil and Gas Compact Commission ("IOGCC") issued its recommendations concerning CO_2 injection wells in EOR and non-EOR applications. The IOGCC has recommended that future CO_2 regulation should build upon the primarily state-based regulatory framework already in place, due to states' decades of experience with CO_2 EOR, natural gas storage, and acid gas injection. We concur with their recommendation that for future CO_2 injections in EOR projects, the existing regulatory framework should not be modified. The IOGCC recommended that for non-EOR CO_2 injections, additional regulatory requirements may need to be considered since these types of applications may not have a defined period of injection as does EOR. We also concur with the IOGCC recommendation that CO_2 injection wells for non-EOR applications should be permitted and approved as a sub-class of Class II injection wells or a new classification but not permitted as Class I or V injection wells.

Generally, every CO_2 well drilled is required by state regulations to set and cement a surface casing string below the Underground Source of Drinking Water (USDW) depth to protect the fresh water and ground water intervals. Cement is required to be circulated back to the surface to insure that all potential zones above the USDW depth that contain freshwater are protected. Only after setting the surface casing are wells drilled to the depth required to produce oil and gas or to inject CO_2. Once the well reaches total depth an additional casing string is cemented in the well to provide additional protection to the freshwater intervals and to produce or inject through. We believe existing laws and regulations provide sufficient protection of the fresh water and ground water reservoirs from the injection of CO_2 in EOR operations or, for that matter, in deep saline reservoirs.

The potential for significant migration or leakage from an EOR operation is extremely remote due to the geological nature of oil and gas reservoirs and the existing mechanism that has trapped the oil or gas. At the present time oil and gas operators are required under their mineral leases and state regulations to properly plug and abandon wellbores within a reasonable period after oil and gas operations cease. Responsibility for re-plugging an improperly plugged well remains with the oil and gas operator for an extremely long period of time and, in practice,

remains as long as the oil and gas operator is in existence. Such responsibility should be essentially the same for deep saline reservoir injection. However, the detailed geologic and engineering information required by states for EOR projects does not exist for saline reservoirs. Thus, information about deep saline reservoirs will have to be developed, taking into account that CO_2, being less dense than saline water, will segregate due to gravitational forces and migrate to the highest subsurface position in the reservoir. As noted above, S. 2323 proposes, and the Energy Independence and Security Act of 2007 provided for, commercial demonstration projects, as well as a national CO_2 storage capacity assessment. These undertakings should yield important data currently lacking on saline reservoirs.

IV. Conclusion

The U.S. economy will continue to require massive amounts of energy well into the future and thus the country needs to use all of its resources to produce the energy it requires given economic and environmental realities. EOR is already playing an important role in this regard -- taking a waste product and using it to increase domestic energy production -- and can do so on a far greater scale, with little action required by federal policymakers. The most important step Congress can take at present is to amend Section 7704(d)(1)(E) of the tax code to make clear that anthropogenic CO_2 is included.

The two bills being considered by the Committee today, S. 2144 and S. 2323, are clearly intended to provide meaningful vehicles to better understand the issues central to CCS and we commend the Committee for focusing on them. While we agree that additional research and further study are worthwhile - as both bills propose - we do not believe there is a need for comprehensive federal regulation, as Section 5 of S. 2323 proposes. Of course, there are areas where federal oversight will likely be necessary, such as management of CO_2 on and under federal lands. For the most part, however, Congress should simply provide necessary incentives and mechanisms to foster the development of CCS, allowing states to continue to oversee various aspects with which they already have significant experience.

Attachment No. 1

U.S. CO_2 Pipeline Map

Attachment No. 2

Denbury's CO_2 Pipelines