To: Docket EPA-HQ-OAR-2013-0495
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Subject: Geographic Availability

1 Introduction

Geologic sequestration (GS) is technically feasible in different types of geologic formations including deep saline formations (formations with high salinity formation fluids) or in oil and gas formations, such as where injected carbon dioxide (CO_2) increases oil production efficiency through a process referred to as enhanced oil recovery (EOR). CO_2 may also be used for other types of enhanced recovery, such as for natural gas production. Both deep saline and oil and gas formation types are widely available in the United States, although there are some specific geographic exceptions. Additionally, formations such as unmineable coal seams also offer the potential for geologic storage.[1]

Figure 1 depicts the geographic extent of potential CO_2 sequestration in deep saline formations, oil and gas reservoirs, and unmineable coal seams, as identified by the Department of Energy, National Energy Technology Laboratory (NETL), Carbon Utilization and Storage Atlas, Fourth Edition (2012). An explanation of the Atlas and NETL methodology is provided in Section 2. Figure 1 also shows the locations of counties where active CO_2 EOR operations are occurring, based on data reported to the EPA Greenhouse Gas Reporting Program (subpart UU -Injection of Carbon Dioxide). Also shown is the area within 100 kilometers from potential GS formations.[2] Existing CO_2 pipelines are shown on the map, along with the locations of planned pipelines, or pipeline projects that are currently being considered. As shown in Figure 1, there are 39 states for which potential onshore and offshore deep saline formation storage resources have been identified. EOR operations are currently being conducted in 12 states. An additional 17 states have geology that may be amenable to EOR operations. There are 18 states within 100 kilometers of an active EOR location and 13 states have operating CO_2 pipelines.

A few states do not have geologic conditions suitable for GS, or may not be located in proximity to these areas. However, in some cases, demand in those states can be served by coal-fired power plants located in areas suitable for GS, and in other cases, coal-fired power plants are unlikely to be built in those areas for other reasons, such as the lack of available coal or state law restrictions against coal-fired power plants. If an area does not have a suitable GS site, EGUs can either transport CO_2 to GS sites via CO_2 pipelines or they may choose to locate their units closer to GS sites and provide electric power to customers through transmission lines. Figure 2 shows the location of high voltage electrical transmission lines (greater than 230 Kilovolts) within the continental United States, and illustrates the extensive network of power transmission lines available to electric generating facilities.

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[1] Other types of opportunities include organic shales and basalt.

[2] The distance of 100 kilometers reflects assumptions in DOE-NETL cost estimates which the EPA used for cost estimation purposes. See "Carbon Dioxide and Transport and Storage Costs in NETL Studies", DOE/NETL-2014/1653 (May 2014).

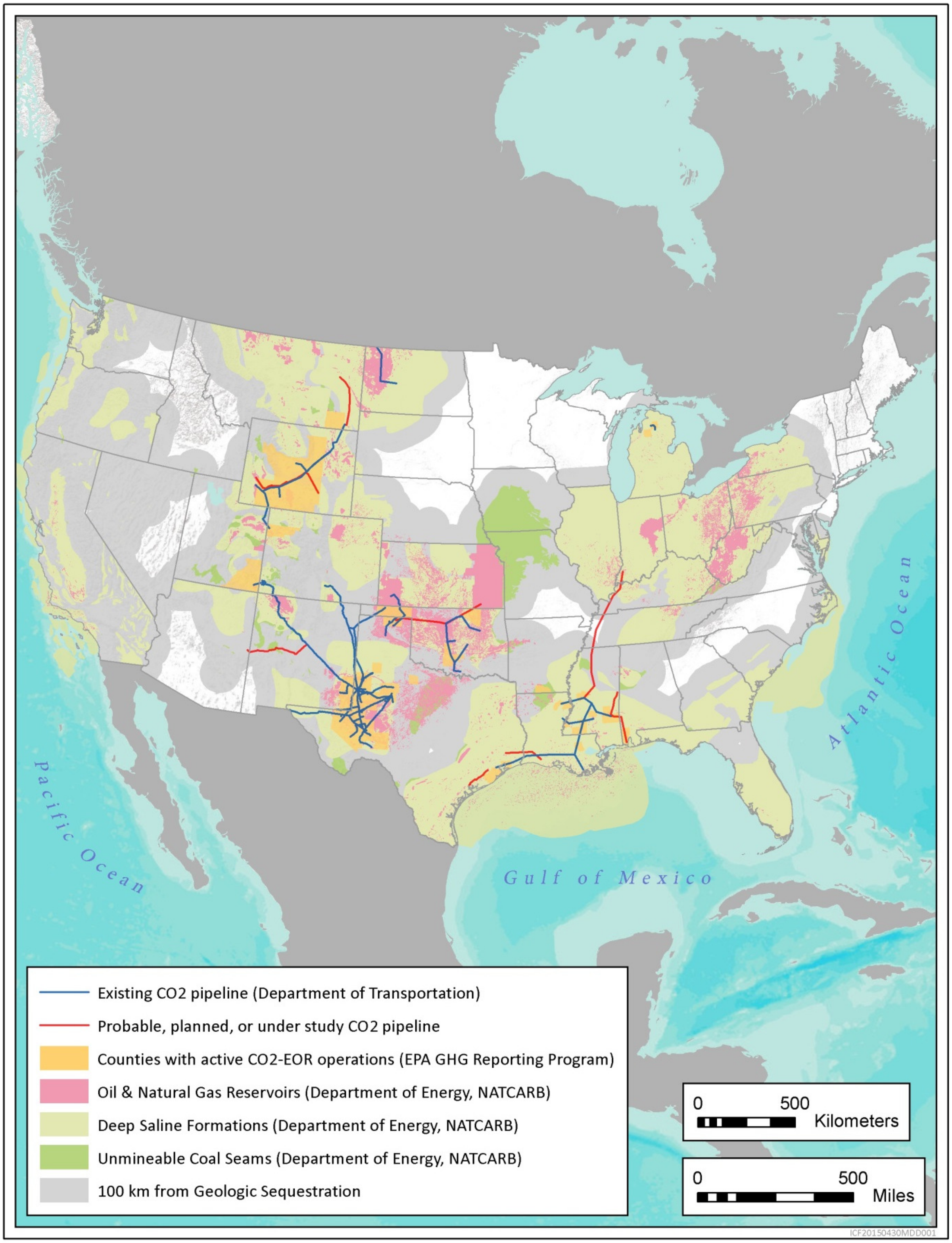

Figure 1 – Geologic Sequestration in the Continental United States

Figure 2 – Electrical Transmission Lines Across the Continental United States[3]

2 Geologic Sequestration

[3] Ventyx Velocity Suite Online. April 2015.

The DOE and the United States Geological Survey (USGS) have independently conducted preliminary analyses of the availability and potential GS capacity in the United States.

National Carbon Sequestration Database and Geographic Information System (NATCARB) and National Energy Technology Laboratory (NETL) Atlas Storage Resource Estimates

DOE estimates are compiled by the DOE's National Carbon Sequestration Database and Geographic Information System (NATCARB) using volumetric models and published in a Carbon Utilization and Storage Atlas. The resource estimates in the Atlas were developed to provide an assessment of CO_2 geologic storage potential across the United States. The latest version of the Atlas, published in November 2012, includes the most current and best available estimates of potential GS capacity determined by a methodology applied consistently across all seven of the DOE Regional Carbon Sequestration Partnerships (RCSPs).[4] The methodology defines a CO_2 storage resource estimate as the fraction of pore volume of porous and permeable sedimentary rocks available for CO_2 storage and accessible to injected CO_2 via wellbores.

The RCSPs have evaluated CO_2 storage resources in most states. However, the RCSPs are voluntary organizations and storage potential was not assessed in particular states due to a variety of factors: some states did not participate because they do not have adequate storage resources; other states did not assess storage as little oil and gas development has been done in the state due to low resource availability; other states did not submit storage assessments as they did not have the expertise nor the data to participate. For example, the deep saline storage potential (including offshore areas) for Alaska, Connecticut, Hawaii, Maine, Massachusetts, Minnesota, Nevada, New Hampshire, Rhode Island, and Vermont has not been assessed. Similarly, the storage potential of oil and gas reservoirs in Alaska, Connecticut, Delaware, Hawaii, Idaho, Iowa, Maine, Massachusetts, Minnesota, Missouri, Nevada, New Hampshire, North Carolina, Oregon, Rhode Island, South Carolina, Vermont, and Washington has not been assessed; and unmineable coal seam storage potentials in California, Connecticut, Delaware, Hawaii, Idaho, Maine, Massachusetts, Minnesota, Nevada, New Hampshire, New York, North Carolina, Oregon, Rhode Island, South Carolina, South Dakota, and Vermont have not been assessed. Several of these states have a potential storage resource, but the amount is not currently reflected in the NETL estimates. New Jersey and Wisconsin were assessed and had little to no storage capacity.

The NETL methodology for estimating storage resources uses a volumetric approach. The method requires information on the area of each potential saline formation or horizon within a geologic basin along with the formation's thickness and porosity (pore space). Additionally, other specific parameters unique to oil and gas fields and coal seams are needed to compute the estimated CO_2 storage resource. A storage coefficient (referred to as the efficiency factor) is applied to the theoretical maximum volume in an effort to determine what fraction of the pore space can effectively store CO_2. Each potential storage resource must meet basic criteria including (1) adequate pressure and temperature conditions in the formation to

[4] http://www.netl.doe.gov/research/coal/carbon-storage/carbon-storage-infrastructure/rcsp

keep the CO_2 liquid or supercritical; (2) presence of a suitable seal system, such as a caprock, to limit vertical flow of the CO_2 to the surface; and (3) a combination of hydrogeologic conditions to isolate the CO_2 within the saline formation. Other factors including isolation (depth) from shallow potable groundwater, the maximum allowed injection pressure imposed by regulatory agencies to avoid fracturing the formation at the injection well (reservoir pressure), and caprock or seal capillary entry pressure are also considered. Carbon dioxide storage resource estimates consider only physical trapping of CO_2 (structural trapping, hydrodynamic trapping, and residual trapping). Chemical trapping mechanisms (dissolution and mineralization were not considered in the methodology. A minimum and maximum storage volume was estimated for each saline resource by applying a low formation efficiency factor (only 0.51 percent of the pore space is available for CO_2 storage) and a high efficiency factor (5.5 percent of the available pore space is available for CO_2 storage). A full description of the NETL methodology is presented in "Summary of the Methodology for Development of Geologic Storage Estimates for Carbon Dioxide," and is available at: http://www.netl.doe.gov/File%20Library/Research/Coal/carbon-storage/natcarb/geologic-storage-estimates-for-carbon-dioxide.pdf.

NATCARB provides access to publically available data presented in Atlas.[5] Maps and data files depicting the location and extent of potential saline storage areas, oil and gas producing areas, and unmineable coal seams can be downloaded and used for advanced geographic analysis of the data.

The Atlas shows storage potential of approximately 2,296 billion metric tons to more than 20,092 billion metric tons of CO_2 in the United States from deep saline formations, oil and gas reservoirs, and unmineable coal seams. This estimate includes estimates for onshore storage and offshore storage in federal waters. Deep saline formations offer the largest GS potential; DOE estimates that areas of the United States with appropriate geology have a sequestration potential of at least 2,035 billion metric tons of CO_2 in deep saline formations. Table 2.1 shows total CO_2 storage resource by state based on analysis by NETL.

[5] http://www.netl.doe.gov/research/coal/carbon-storage/natcarb-atlas

Table 1 – Total CO_2 Storage Resource (DOE-NETL)[6]

	Million Metric Tons*	
State	**Low Estimate**	**High Estimate**
ALABAMA	122,490	694,380
ALASKA	8,640	19,750
ARIZONA	130	1,170
ARKANSAS	6,180	63,670
CALIFORNIA	33,890	420,630
COLORADO	37,610	357,190
CONNECTICUT	not assessed by DOE-NETL	not assessed by DOE-NETL
DELAWARE	40	40
DISTRICT OF COLUMBIA	not assessed by DOE-NETL	not assessed by DOE-NETL
FLORIDA	102,740	555,010
GEORGIA	145,340	159,050
HAWAII	not assessed by DOE-NETL	not assessed by DOE-NETL
IDAHO	40	390
ILLINOIS	10,020	116,820
INDIANA	32,020	68,210
IOWA	10	50
KANSAS	10,880	86,340
KENTUCKY	2,920	7,650
LOUISIANA	169,500	2,103,980
MAINE	not assessed by DOE-NETL	not assessed by DOE-NETL
MARYLAND	1,860	1,930
MASSACHUSETTS	not assessed by DOE-NETL	not assessed by DOE-NETL

[6] The United States 2012 Carbon Utilization and Storage Atlas, Fourth Edition, U.S Department of Energy, Office of Fossil Energy, National Energy Technology Laboratory (NETL).

Table 1 – Total CO_2 Storage Resource (DOE-NETL), cont.

	Million Metric Tons*	
State	**Low Estimate**	**High Estimate**
MICHIGAN	19,050	47,210
MINNESOTA	not assessed by DOE-NETL	not assessed by DOE-NETL
MISSISSIPPI	145,010	1,185,030
MISSOURI	10	170
MONTANA	84,580	912,720
NEBRASKA	23,770	113,240
NEVADA	not assessed by DOE-NETL	not assessed by DOE-NETL
NEW HAMPSHIRE	not assessed by DOE-NETL	not assessed by DOE-NETL
NEW JERSEY	0	0
NEW MEXICO	42,760	359,090
NEW YORK	4,640	4,640
NORTH CAROLINA	1,340	18,390
NORTH DAKOTA	67,090	147,480
Offshore Federal Only	489,840	6,440,090
OHIO	13,460	13,460
OKLAHOMA	56,950	244,550
OREGON	6,810	93,700
PENNSYLVANIA	22,100	22,100
RHODE ISLAND	not assessed by DOE-NETL	not assessed by DOE-NETL
SOUTH CAROLINA	30,100	34,180
SOUTH DAKOTA	8,760	24,030
TENNESSEE	430	3,860
TEXAS	443,800	4,329,930
UTAH	25,470	240,910
VERMONT	not assessed by DOE-NETL	not assessed by DOE-NETL
VIRGINIA	440	2,910
WASHINGTON	36,620	496,730
WEST VIRGINIA	16,650	16,650
WISCONSIN	0	0
WYOMING	72,690	684,850
U.S. Total	**2,296,680**	**20,092,180**

* States with a “zero” value represent estimates of minimal CO_2 storage resource. States that have not yet been assessed by DOE-NETL have been identified.

USGS Storage Resource Estimates

In 2013, the USGS completed its evaluation of the technically accessible GS resources for CO_2 in U.S. onshore areas and state waters using probabilistic assessment. The USGS methodology defines technically accessible storage as the mass of CO_2 that can be stored in the pore volume of the storage formation taking into account present-day geologic knowledge and engineering practice and experience. The assessment used a geology-based examination of all sedimentary basins in the onshore and State waters area of the United States that contain potential storage formations that meet specific criteria including depth (3,000 feet to 13,000 feet deep), thick regional seals, and saline formation water (total dissolved solids greater than 10,000 milligrams per liter). The storage estimates were divided into buoyant trapping, where CO_2 can be trapped in structural or stratigraphic closures, and residual trapping, where CO_2 can be held in place by capillary pore pressures in areas outside of buoyant traps. Probability percentiles were calculated representing the 5-, 50-, and 95-percent probabilities, respectively, that the true storage resource is less than the value presented. A mean value of storage for each storage type was also calculated. Storage in oil and gas formations was considered in the assessment, however, only the amount of CO_2 at that could replace the volume of known hydrocarbon production was assessed and quantified. This represents a conservative estimate because it does not include assessment of GS associated with enhanced oil recovery (EOR).

Like the NETL methodology, the USGS storage estimates did not include chemical trapping (mineralization or dissolution) or potential storage in shales or basalt. Several basins, including areas of California, Washington, Oregon and Idaho were not assessed. The methodology differs from the NETL methodology in that it does not include an estimate of the CO_2 storage potential in “unmineable coal seams”, or offshore federal waters, and does not consider EOR. Storage estimates were reduced to account for potential USDWs that may be present. A summary of the methodology and results of the USGS assessment can be found at http://pubs.usgs.gov/circ/1386/.

USGS estimates a mean of 3,000 billion metric tons of subsurface CO_2 sequestration potential from buoyant and residual trapping and 11 billion metric tons from known oil and gas recovery replacement. Storage resources are dominated by medium permeability residual trapping resources which accounts for 89 percent of the total resources. The Coastal Plains Region of the United States contains the largest storage resource of any region. Within the Coastal Plains Region, the resources from the U.S. Gulf Coast area represent 59 percent of the national CO_2 storage capacity.

Summary of Findings

The DOE and USGS analyses of the availability and potential CO_2 sequestration capacity in the United States show that the potential for geologic sequestration of CO_2 in the United States is large and the resource is widely available throughout the country. These resource estimates represent the technical maximum potential, although other considerations such as pore space availability and ownership, economics, and legal constraints will factor in to which fields are developed within each geographic basin.

Geologic storage in deep saline formations has been identified in onshore and offshore areas of the US in both the NETL and USGS storage assessments.

Oil and gas reservoirs are potential CO_2 storage resources because they have held hydrocarbons for thousands to millions of years and hence have properties potentially suitable for CO_2 storage. The reservoir characteristics of older fields are well known as a result of exploration and many years of hydrocarbon production and in many areas infrastructure already exists for CO_2 transportation and storage. The NETL and USGS CO_2 storage resource studies include estimates of CO_2 storage in depleted oil and gas fields, and storage as part of ongoing EOR activities.

In 2011, DOE sponsored a study[7] to analyze the geographic availability of applying EOR in 11 major oil producing regions of the United States, including several areas that are not currently applying EOR. The study developed a national EOR resource assessment from reservoir simulations of CO_2 floods of 1,800 onshore reservoirs and over 4,000 off shore sands and found that there is an opportunity to significantly increase the application of EOR to areas outside of current operations. The study found that one of the limitations to expanding CO_2 use in EOR is the lack of availability of CO_2 in areas where oil and gas reservoirs are most amenable to CO_2 flooding. The EPA analyzed the state-by-state results of the study and identified 17 additional states where oil and gas fields are amenable to EOR.

Many states have coal resources that are uneconomical to mine or cannot be extracted due to technological barriers. Coal preferentially adsorbs CO_2 over methane, which is naturally found in coal seams and can become trapped, forming the basis for CO_2 storage in coal seams. Enhanced coalbed methane recovery is similar to EOR because it provides an economic benefit from the recovery and sale of the methane gas, which helps to offset the cost of CO_2 storage. DOE's RCSPs have documented the location of approximately 56 to 114 billion metric tons of potential CO_2 storage resource in unmineable coal seams in 21 states.[8]

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[7] "Improving Domestic Energy Security and Lowering CO2 Emissions with "Next Generation" CO2-Enhanced Oil Recovery", Advanced Resources International, Inc. (ARI), 2011. Available at: http://www.netl.doe.gov/research/energy-analysis/publications/details?pub=df02ffba-6b4b-4721-a7b4-04a505a19185.

[8] The United States 2012 Carbon Utilization and Storage Atlas, Fourth Edition, U.S. Department of Energy, Office of Fossil Energy, National Energy Technology Laboratory (NETL).

3 CO_2 Pipelines

CO_2 pipelines are the most economical and efficient method of transporting large quantities of CO_2.[9] CO_2 has been transported via pipelines in the United States for nearly 40 years. Over this time, the design, construction, operation, and safety requirements for CO_2 pipelines have been proven, and the U.S. CO_2 pipeline network has been safely used and expanded. Many miles of pipelines are currently under construction or planned, further expanding the network in the United States.

Existing Pipelines

The Pipeline and Hazardous Materials Safety Administration (PHMSA) reported that in 2013 there were 5,195 miles of CO_2 pipelines operating in the United States. This represents a 7 percent increase in CO_2 pipeline miles over the previous year and a 38 percent increase in CO_2 pipeline miles since 2004. Twenty-eight companies currently operate CO_2 pipelines in 13 states, to support transportation of natural and anthropogenic CO_2 from source areas to CO_2 EOR locations. The Cortez pipeline is the longest CO_2 pipeline and begins at the McElmo Dome CO_2 field in southwest Colorado and traverses 502 miles through New Mexico ending at the Denver City Texas CO_2 Hub, where it connect with several other CO_2 pipelines. The Cortez pipeline was constructed in 1982. Other large pipelines connect natural CO_2 sources in south central Colorado, northeast New Mexico, and Mississippi to oil fields in Texas, Oklahoma, New Mexico, Utah and Louisiana.

Anthropogenic CO_2 from natural gas processing plants, fertilizer plants and ethanol facilities is also transported to oil and gas fields through a series of pipelines that are generally shorter than pipelines from natural CO_2 source areas. Large pipelines in Wyoming, Texas and Louisiana carry anthropogenic gas from gas plants and refineries to the EOR projects. Many smaller pipelines carry gas from anthropogenic sources to central distribution facilities or to EOR projects, including the examples below:

- Four gas processing plants in the southern part of the Permian Basin in Texas, referred to as the "Val Verde Plants" supply CO_2 for EOR projects in the Permian Basin through an 82 mile pipeline.
- A fertilizer plant in Coffeyville Kansas supplies CO_2 via a 68 mile dedicated pipeline to the North Burbank Unit in northeast Oklahoma.
- Two separate CO_2 facilities, a fertilizer plant in Borger, TX and an ethanol plant in Liberal, KS supply CO_2 to several EOR projects in Oklahoma and Texas via 173 miles of dedicated pipelines.
- A fertilizer plant in Velma Oklahoma supplies CO_2 for EOR projects in southern Oklahoma via a 145 mile pipeline.

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[9] Report of the Interagency Task Force on Carbon Capture and Storage (August 2010), page 36.

Planned Pipelines

The increased demand for CO_2 to support EOR projects, and availability of new anthropogenic sources of CO_2 has provided new opportunities for CO_2 transport companies to expand the CO_2 infrastructure. Several companies have recently proposed several hundred miles of dedicated CO_2 pipeline in Colorado, Louisiana, Montana, New Mexico, Texas, and Wyoming. Some projects are already under construction, some are in the permitting and planning stage and some are still in the evaluation and study phase. Examples are identified below.

Kinder Morgan has reported several proposed pipeline projects including the proposed expansion of the existing Cortez CO_2 pipeline, crossing Colorado, New Mexico, and Texas, to increase the CO_2 transport capacity from 1.35 billion cubic feet per day (Bcf/d) to 1.7 Bcf/d, to support the expansion of CO_2 production capacity at the McElmo Dome production facility in Colorado. The Cortez pipeline expansion is expected to be placed into service in 2015.[10]

Denbury reported that the company utilized approximately 70 million cubic feet per day (Mcf/d) of anthropogenic CO_2 in 2013 and that an additional approximately 115 Mcf/d of anthropogenic CO_2 may be utilized in the future from currently planned or future construction of facilities and associated pipelines in the Gulf Coast region.[11] Denbury also initiated transport of CO_2 from a Wyoming natural gas processing plant in 2013 and reported transporting approximately 22 Mcf/d of CO_2 in 2013 from that plant alone.[12]

Denbury completed the final section of the 325-mile Green Pipeline for transporting CO_2 from Donaldsonville, Louisiana, to EOR oil fields in Texas.[13] Denbury completed construction and commenced operation of the 232-mile Greencore Pipeline in 2013; the Greencore pipeline transports CO_2 to EOR fields in Wyoming and Montana.[14] A project being constructed by NRG and JX Nippon Oil & Gas Exploration (Petra Nova) would capture CO_2 from a power plant in Fort

[10] "Form 10-K: Annual Report Pursuant to Section 13 or 15(d) of the Security and Exchange Act of 1934, For the Fiscal Year Ended December 31, 2014", Kinder Morgan, February 2015. Available at: http://ir.kindermorgan.com/sites/kindermorgan.investorhq.businesswire.com/files/report/additional/KMI-2014-10K_Final.pdf.

[11] "2013 Annual Report", Denbury, April 2014. Available at http://www.denbury.com/files/doc_financials/2013/Denbury_Final_040814.pdf.

[12] "CO_2 Sources", Denbury, 2014. Available at: http://www.denbury.com/operations/rocky-mountain-region/co2-sources-and-pipelines/default.aspx.

[13] http://www.denbury.com/operations/gulf-coast-region/Pipelines/default.aspx.

[14] "CO_2 Pipelines", Denbury, 2014. Available at: http://www.denbury.com/operations/rocky-mountain-region/COsub2-sub-Pipelines/default.aspx.

Bend County, Texas for transport to EOR sites in Jackson County, Texas through an 82-mile CO_2 pipeline.[15] The project is anticipated to commence operation in 2016.[16]

4 Coal-by-Wire

As discussed in the proposal, electricity demand in states that may not have geologic sequestration sites may be served by coal-fired electricity generation built in nearby areas with geologic sequestration, and this electricity can be delivered through transmission lines. This method, known as "coal-by-wire," has long been used in the electricity sector because siting a coal-fired power plant near the coal mine and transmitting the generation long distances to the load area is generally less expensive than siting the plant near the load area and shipping the coal long distances.

For example, we noted in the proposal: "There are many examples where coal-fired power generated in one state is used to supply electricity in other states. For instance, historically, nearly 40 percent of the power for the City of Los Angeles was provided from two coal-fired power plants located in Arizona and Utah. In another example, Idaho Power, which serves customers in Idaho and Eastern Oregon, meets its demand in part from coal-fired power plants located in Wyoming and Nevada." 79 FR at 1478.

In this section, we explore in greater detail the issue of coal-by-wire and the ability of demand in areas without geologic sequestration to be served by coal generation located in areas that have access to geologic sequestration. Figure 1 of this TSD depicts areas of the country with: (1) existing CO_2 pipeline; (2) probable, planned, or under study CO_2 pipeline; (3) counties with active CO_2-EOR operations; (4) oil and natural gas reservoirs; (5) deep saline formations; (6) unmineable coal seams; and (7) areas 100 kilometers from geologic sequestration. As demonstrated by Figure 1, the vast majority of the country has existing or planned CO_2 pipeline, active CO_2-EOR operations, the necessary geology for CO_2 storage, or is within 100 kilometers of areas with geologic sequestration. A review of Figure 1 indicates limited areas that do not fall into these categories.

As an initial matter, we note that the data included in Figure 1 is a conservative outlook of potential areas available for the development of CO_2 storage in that we include only areas that have been assessed to date. Portions of the United States – such as oil and gas storage potential in Alaska - have not yet been assessed and thus are depicted as not having geological

[15] "The West Ranch CO_2-EOR Project, NRG Fact Sheet", NRG, 2014. Available at: http://www.nrg.com/documents/business/pla-2014-west-ranch-fact-sheet.pdf.

[16] "WA Parish Carbon Capture Project", NRG, 2015. Available at: http://www.nrg.com/sustainability/strategy/enhance-generation/carbon-capture/wa-parish-ccs-project/.

formations suitable for CO_2 storage, even though assessment could in fact reveal additional formations.[17]

As one considers the areas in Figure 1 that fall outside of the above enumerated categories, in many instances, we find areas with low population density, areas that are already served by transmission lines that could deliver coal-by-wire, and/or areas that have made policy or other decisions not to pursue a resource mix that includes coal. In many of these areas, utilities, electric cooperatives, municipalities, and other load-serving entities have a history of joint ownership of coal-fired generation outside the region or contracting with coal and other generation in other areas to meet their demand. Some of the relevant areas are in RTOs[18] which engage in planning across the RTO, balancing supply and demand in real time throughout the RTO. Accordingly, generating resources in one part of the RTO such as a coal generator can serve load in other parts of the RTO, as well as load outside of the RTO. As we consider each of these geographic areas here, we make key points as to why this final rule does not negatively impact the ability of these regions to access new coal generation to the extent that coal is needed to supply demand and/or those regions seek to include new coal-fired generation in their resource mix.

Upper Northwest

This region includes a large portion of Idaho, with smaller areas in Washington, Oregon, and Montana. The specific areas identified in this region tend to have a lower population density, which would indicate a lower demand for electricity and therefore a likely low demand for new coal generation. To the extent that it is needed to supply electricity demand, new coal generation can be constructed in areas with geologic sequestration available and delivered to this region via the highly interconnected western grid. Washington’s only coal-fired generator –

[17] The data in Figure 1 is based on estimates compiled by the DOE’s National Carbon Sequestration Database and Geographic Information System (NATCARB) and published in the United States 2012 Carbon Utilization and Storage Atlas, Fourth Edition. As discussed in the TSD, deep saline formation potential was not assessed for Alaska, Connecticut, Hawaii, Maine, Massachusetts, Minnesota, Nevada, New Hampshire, Rhode Island, and Vermont. Oil and gas storage potential was not assessed for Alaska, Connecticut, Delaware, Hawaii, Idaho, Iowa, Maine, Massachusetts, Minnesota, Missouri, Nevada, New Hampshire, North Carolina, Oregon, Rhode Island, South Carolina, Vermont, and Washington. Unmineable coal seams were not assessed for California, Connecticut, Delaware, Hawaii, Idaho, Maine, Massachusetts, Minnesota, Nevada, New Hampshire, New York, North Carolina, Oregon, Rhode Island, South Carolina, South Dakota, and Vermont. We are assuming for purposes of our analysis here that they do not have storage potential in those formations.

[18] In this discussion, we use the term RTO to indicate both ISOs and RTOs.

Centralia - is located in western Washington and both of its generating units are scheduled to shut down in the next 10 years.[19]

We note that a large portion of this area is served by the Idaho Power, Avista, and Rocky Mountain Power, as well and multiple cooperatives and municipalities. Idaho Power and Avista provide good examples of both joint-ownership of coal generation as well as coal-by-wire. Idaho Power is served by three coal plants located in Wyoming, Oregon, and Nevada.[20] Avista's service territory includes parts of eastern Washington and northern Idaho. According to Avista, nine percent of its generation is supplied by coal.[21] Avista owns 15 percent of two of the Colstrip Steam Electric Station units in Colstrip, Montana.[22]

Small Areas in Nevada and Utah

This region includes small areas in Nevada and Utah, which have low population density and therefore less electricity demand than other more populous areas in the country. Rocky Mountain Power, which is a subsidiary of Berkshire Hathaway Energy, serves much of Utah. Berkshire Hathaway Energy and its subsidiaries and affiliates own coal-fired power plants that generate electricity to serve load. Nevada is served by multiple entities including electric cooperatives and municipalities as well as NV Energy. This region is part of the highly interconnected western grid with transmission lines crossing it, making coal-by-wire readily available. For example, Intermountain Power Agency owns the Intermountain Power Project in western Utah which largely serves Utah and Southern California.[23] Another example is Deseret Power, a regional generation and transmission cooperative, which supplies electricity to its members and other bulk energy customers in Arizona, Colorado, Nevada, Utah, and Wyoming.

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[19] *Bills in Washington State Seek to End Use of Coal*, N.Y. Times, Feb. 14, 2015, *available at* http://www.nytimes.com/2015/02/15/us/politics/bills-in-washington-state-seek-to-end-use-of-coal.html?_r=0.

[20] Idaho Power, *Coal-Fired Plants*, *available at* https://www.idahopower.com/AboutUs/EnergySources/Coal/coal.cfm (last visited July 22, 2015). Idaho Power owns shares of the Jim Bridger coal plant in Wyoming, the Boardman coal plant in Oregon, and the North Valmy coal plant in Nevada. *Id.*

[21] Avista, *Avista's Diverse Energy Mix*, *available at* https://www.avistautilities.com/inside/resources/energymix/Pages/default.aspx (last viewed July 22, 2015).

[22] Avista, *Reliable, Lower-Cost Coal*, *available at* https://www.avistautilities.com/inside/resources/energymix/Documents/Reliable,%20Lower-Cost%20Coal.FS%2011.6.14.pdf (last viewed July 22, 2015).

[23] Multiple entities in Utah, including cooperatives, Utah Power & Light Company (PacifiCorp), and numerous municipalities purchase coal-fired generation from this facility. Intermountain Power Agency, *Generation Entitlement Shares*, *available at* http://www.ipautah.com/participants/.

Deseret owns interests in coal generation, as well as its own facility, that it uses to supply this electricity.[24]

Southwest

The southwestern region of Figure 1 includes a section of Arizona as well as a small part of New Mexico. As can be seen in Figure 2, this area has extensive transmission infrastructure, enabling the area to be served by outside coal plants. Most of the load in Arizona - including Phoenix, the most populous part of this area - is served by the Arizona Public Service (APS) or the Salt River Project, each of which owns shares of coal plants in other areas with geologic sequestration available. Specifically, Arizona Public Service owns shares of coal plants in Arizona and New Mexico,[25] and Salt River Project owns shares of coal plants in Arizona, New Mexico, and Colorado.[26] Other entities such as Tucson Electric Power, Trico Electric Cooperative, UNS Electric, Sulphur Springs Valley Electric Co-op also have service territories in this area.[27] Mexico has instate coal generation with the majority of the state having geologic sequestration available.

Upper Midwest

This region includes Minnesota, most of Wisconsin, the Upper Peninsula of Michigan, and parts of North Dakota, South Dakota, Nebraska, and Iowa. Most of the areas of this region shown in Figure 1 are located in an RTO[28] or are in the process of joining an RTO,[29] which provides open access to transmission service and a large set of resources within the RTO to

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[24] Deseret Power Electric Cooperative, *Power to Succeed, Now and in the Future*, *available at* http://www.deseretgt.com/profile/profile.php.

[25] APS jointly owns the Four Corners Power Plant on the Navajo Indian Reservation west of Farmington, New Mexico. APS also owns part of the Cholla Power plant in northeastern Arizona and the Navajo Power Plant in northern Arizona. APS, *Coal-Fueled Power Plants*, *available at* https://www.aps.com/en/ourcompany/generationtransmission/generation/Pages/home.aspx (last visited July 22, 2015).

[26] Salt River Project, *Facts about SRP*, *available at* http://www.srpnet.com/about/Facts.aspx.

[27] Arizona Corporation Commission, *State of Arizona-Electric Map*, *available at* http://www.azcc.gov/divisions/utilities/electric/map-elect.pdf (last visited July 22, 2015).

[28] In this discussion, we use the term RTO to indicate both ISOs and RTOs.

[29] FERC, *MISO Electric Market: Overview and Focal* Points, *available at* *http://www.ferc.gov/market-oversight/mkt-electric/midwest/elec-mw-reg-des.*pdf; FERC, *Southwest Power Pool Electric Market: Overview and Focal Points*, *available at* http://www.ferc.gov/market-oversight/mkt-electric/spp/elec-spp-reg-des.pdf; SPP, *FERC Approves Integrated System Joining SPP* (Nov. 12, 2014), *available at* http://www.spp.org/publications/FERC%20approves%20IS%20membership.pdf (noting FERC's approval of the Integrated System, made up of the Western Area Power Administration-Upper Great Plains, Basin Electric Power Cooperative, and Heartland Consumers Power, joining SPP).

serve load. The two RTOs in this area are MISO and SPP, both of which engage in planning across the RTO, balancing supply and demand in real time throughout the RTO. Accordingly, generating resources in one part of the RTO such as a coal plant often serve load in other parts of the RTO, as well as load outside of the RTO. Both MISO and SPP have a number of coal-fired power plants in areas with access to geologic sequestration. If a new coal unit is built in an area with geologic sequestration, this supply can serve load both inside and outside areas with available sequestration. Just as current coal facilities in SPP and MISO can inject electricity onto the grid and that electricity can serve load in areas without coal facilities, new coal plants built in RTO areas with geologic sequestration available can serve load in areas without sequestration available. For example, Wisconsin is in MISO with the southern part of the state as well as many surrounding areas having geologic sequestration available. Further, this area has extensive transmission infrastructure that includes coal-fired power plants outside of this area (e.g., lignite plants in North Dakota).[30]

Central

This area includes small parts of Missouri, Arkansas, and Tennessee. Parts of this area are in MISO, providing the opportunity to serve load through a diverse set of resources including coal-fired electricity, as discussed above. The eastern part of this central area is served at wholesale by the Tennessee Valley Authority, which is a large federal entity that functions like an RTO with numerous generation assets and whose transmission network includes areas with geologic sequestration available. Moreover, this area is crossed by transmission lines and ringed by coal fired power plants at or near its border.

Southeast

Figure 1 also indicates areas in the southeast that do not have geologic sequestration, including parts of Alabama, Georgia (including Atlanta), South Carolina, and North Carolina. As Figure 2 indicates, this area is served by an extensive network of transmission infrastructure that can deliver electricity from a diverse resource mix. Additionally, most of this area is served by Alabama Power, Georgia Power, Duke Energy Progress, and South Carolina Electric and Gas, each of which are large companies with numerous generating assets, including coal-fired assets and allowing diverse resources throughout the balancing authority to serve load.

Mid-Atlantic

Figure 1 indicates that parts of Virginia, Maryland, Pennsylvania, and New Jersey are lacking geologic sequestration. Again, as noted previously, Figure 2 indicates that there is extensive transmission infrastructure in this area that delivers electricity throughout the region. This area is served by PJM, a large RTO. Currently, existing coal-fired units in West Virginia,

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[30] For example, Basin Electric owns the Antelope Valley Station, a 900 MW lignite-based electric generating facility near Beulah, ND. Lignite Energy Council, *Antelope Valley Station*, *available at* https://www.lignite.com/mines-plants/power-plants/antelope-valley-station/.

Kentucky, Pennsylvania, and Ohio provide electricity onto the electric grid to serve electricity load in PJM. Additionally, generators in the western parts of PJM, which has geological sequestration available, historically have provided a large amount of generation in the RTO. Similarly, new coal generation could be sited in areas with geologic sequestration while allowing this new generation to serve other areas without geologic sequestration through the extensive transmission infrastructure.

New York

Figure 1 indicates that the eastern part of New York does not have available geologic sequestration. This area is part of NYISO, which, similar to other RTOs, has a diverse resource mix to meet system demand. New York's resources include a very small amount of coal-fired generation.[31] Additionally, this area, like many others on the grid, imports electricity from surrounding areas.[32] Portions of New York, as well as surrounding areas such as Pennsylvania, have access to potential geologic sequestration. Therefore new coal generation could be built in those areas and serve load in the eastern part of New York.

Moreover, New York is a member of the Regional Greenhouse Gas Initiative (RGGI), which is a market-based regulatory program to reduce greenhouse gas emissions, which indicates that the state is moving away from generation facilities that have high CO_2 emissions. Further, New York has adopted CO_2 limits on new coal-fired power plants, which essentially can be met only through the installation of CCS.[33]

New England

This area includes Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, and Maine. All of these states are members of RGGI, which is the first market-based regulatory program in the U.S. to reduce greenhouse gas emissions, giving a clear indication that New England is moving away from electric generation that has high CO_2 emissions.

Coal-fired power plants may have more unfavorable economics in this area than in some other areas of the country. For example, this area does not have coal supplies, so that coal must be transported into this area from Appalachia or elsewhere. Additionally, some existing coal-fired power plants with recently added pollution controls such as SO_2 scrubbers are still choosing to close for economic reasons: Brayton Point Power Station (Somerset, Massachusetts) is scheduled to close in May, 2017 and Mt. Tom (western Massachusetts)

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[31] EIA, *New York: State Profile and Energy Estimates – Profile Analysis* (July 16, 2015), *available at* http://www.eia.gov/state/analysis.cfm?sid=NY.
[32] EIA notes that more half of New York's energy is supplied by other states and Canada. *Id.*
[33] Scott DiSavino and Jim Marshall, *NY adopts CO_2 rules that limit new coal power plants*, Reuters, June 28, 2012, *available at* http://www.reuters.com/article/2012/06/28/us-utilities-newyork-carbon-coal-idUSBRE85R1GF20120628.

recently closed. According to ISO New England's 2015 Regional Electricity Outlook, "Rising costs associated with oil and coal and the advanced age of many of the power plants that use these fuels make it difficult for these resources to compete against newer, more efficient generators - primarily natural gas units. For this reason, coal and oil units are now run mainly to meet peak demand, when natural gas plants are unavailable, or when natural gas price spikes surpass oil prices. The region's coal- and oil-fired generators represent about 28% of capacity in the region, but only produced about 6% of its electricity in 2014 - and very few coal units are left."[34] Moreover, ISO New England stated, "The natural gas price spikes in recent winters have led to oil- and coal-fired units being more economical and thus selected in the energy market to run more frequently in winter. (See page 29.) This revenue stream could delay retirements for some resources; however, it's unclear how long the trend will continue or whether it will be enough to counter other economic and regulatory pressures. For example, once oil resources run more than 9% of the time, expensive capital investments may be required in order to meet air quality regulations. In some cases, state regulations restrict the number of hours that dual-fuel units can burn oil. And over time, the Regional Greenhouse Gas Initiative's cap and trade program for carbon dioxide emissions could make oil and coal less economic fuels."[35]

EIA has also noted the trend towards natural gas and Canadian hydroelectric generation in New England over the last decade.[36] This region is seeing older, less efficient, traditional resources such as coal retire. New England states have several reasons to further limit their use of electricity generated from fossil fuels. "Constraints on some of the pipelines delivering natural gas into New England have contributed to higher natural gas prices and made electricity relatively more expensive. Also, all New England states have renewable portfolio standards (or in Vermont, a nonbinding goal) requiring that a certain percentage of their electricity comes from renewable sources."[37] Additionally, entities are also proposing to build transmission between the United States and Canada to increase access to Canadian hydropower. For example, Champlain VT, LLC (doing business as TDI-New England) applied in 2014 for a Presidential Permit to build the New England Clean Power Link which it stated would bring "clean, affordable hydropower to Vermont and the New England marketplace."[38] To the extent that ISO-NE wanted to utilize coal-fired generation, we note that it is interconnected to PJM which has both currently-existing coal generation available, as well as geologic sequestration.

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[34] ISO New England, *2015 Regional Electricity Outlook*, at 19 (Jan. 2015), *available at* http://www.iso-ne.com/static-assets/documents/2015/02/2015_reo.pdf.

[35] *Id.* at 20.

[36] Energy Information Administration, *New England relying more on natural gas along with hydroelectric imports from Canada* (Aug. 22, 2014), *available at* http://www.eia.gov/todayinenergy/detail.cfm?id=17671.

[37] *Id.*

[38] Champlain VT, LLC Application for Presidential Permit (May 20, 2014), *available at* http://energy.gov/sites/prod/files/2014/07/f17/PP-400%20TDI-New%20England%20Application%20with%20Appendices_0.pdf.