TENASKA® TRAILBLAZER PARTNERS, LLC

Report to the

Global CCS Institute

Bridging the Commercial Gap For Carbon Capture and Storage

July 2011

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Abstract

The addition of carbon capture equipment to a coal-fueled electric generating station affects the station's economics in several ways. On the negative side, it significantly increases capital, operating and maintenance costs, while consuming a large amount of electricity that otherwise would be available for sale. On the plus side, it provides a stream of carbon dioxide that, in at least some cases, can provide a substantial source of revenue.

This report discusses the economic realities facing the Tenaska Trailblazer Energy Center (Trailblazer or Project), the first proposed new-build pulverized coal plant in the United States to incorporate a commercial-scale carbon dioxide capture plant into its the initial design. It reviews the markets for both electricity and carbon dioxide, and discusses the governmental support that may be needed to bridge the gap between the Project's likely costs and revenues.

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Table of Contents

1.0 Introduction

One of the biggest challenges with the implementation of coal-fueled electric generation projects with post-combustion carbon capture and storage is simple economics. The addition of carbon capture equipment increases capital, operating and maintenance (O&M) costs and significantly reduces the amount of electricity available for sale. In areas where enhanced oil recovery (EOR) efforts have created a market for carbon dioxide (CO_2), some – but likely not all – of these costs can be recovered.

The Tenaska Trailblazer Energy Center (Trailblazer or Project), a 600 MW net supercritical pulverized coal electric generating station under development in Nolan County, Texas, United States of America (USA), was strategically located to tap both the growing Texas electricity market and the largest and most robust CO_2 market for EOR in the world.

Trailblazer will sell electricity into the Electric Reliability Council of Texas (ERCOT) market and will sell CO_2 into the Permian Basin of Texas, where it will be used in EOR efforts and ultimately stored underground permanently.

The Project will produce enough electricity to power 600,000 Texas homes and capture 85 to 90 percent of the CO_2 (approximately 5.75 million tons, or 5.22 million metric tons) that otherwise would be emitted into the atmosphere. The Project is being developed by Tenaska, Inc., (Tenaska) and is owned by Tenaska Trailblazer Partners, LLC. Tenaska Trailblazer Partners, LLC is owned 65 percent by affiliates of Tenaska and 35 percent by Arch Coal Inc.

1.1 Developer Overview

Since its founding in 1987, Tenaska has successfully developed and constructed 15 power generating facilities, totaling more than 9,000 MW. Today, Tenaska operates eight power generating facilities totaling 6,700 MW that it owns in partnership with other companies. Tenaska also provides and is involved in:

- energy risk management services;
- asset acquisition and management;
- natural gas marketing;
- power and biofuels marketing;
- fuel supply;
- natural gas exploration;
- production and transportation systems; and
- electric transmission development.

In 2009, Tenaska had gross operating revenues of United States Dollars (USD)$7.9 billion and assets of approximately USD$2.8 billion. In 2009, *Forbes* magazine ranked Tenaska as 16th among the largest privately-held USA companies, based on 2008 revenues. For further information see: http://www.tenaska.com.

1.2 Partner Overview

In March 2010, Arch Coal acquired a 35 percent share of Tenaska Trailblazer Partners, LLC, from affiliates of Tenaska. St. Louis-based Arch Coal is the second largest USA coal producer, with revenues of USD$2.6 billion in 2009. Through its network of mines in the Powder River Basin (PRB), Arch supplies cleaner-burning, low-sulfur coal to USA power producers to fuel roughly eight percent of the nation's electricity. The company also ships coal to domestic and international steel manufacturers as well as international power producers. For further information see: http://www.archcoal.com.

In total, Arch Coal contributes about 16 percent of the USA' coal supply from 11 mining complexes in Wyoming, Utah, Colorado, West Virginia, Kentucky and Virginia.

Arch Coal controls a vast domestic coal reserve base totaling 4.7 billion tons. Of that total, 88 percent is low in sulfur and nearly 83 percent meets the most stringent requirements of the USA Federal *Clean Air Act*, without the application of expensive scrubbing technology.

In addition to becoming a valued partner, Arch Coal also will provide low-sulfur PRB coal to the Project under a 20-year coal supply agreement.

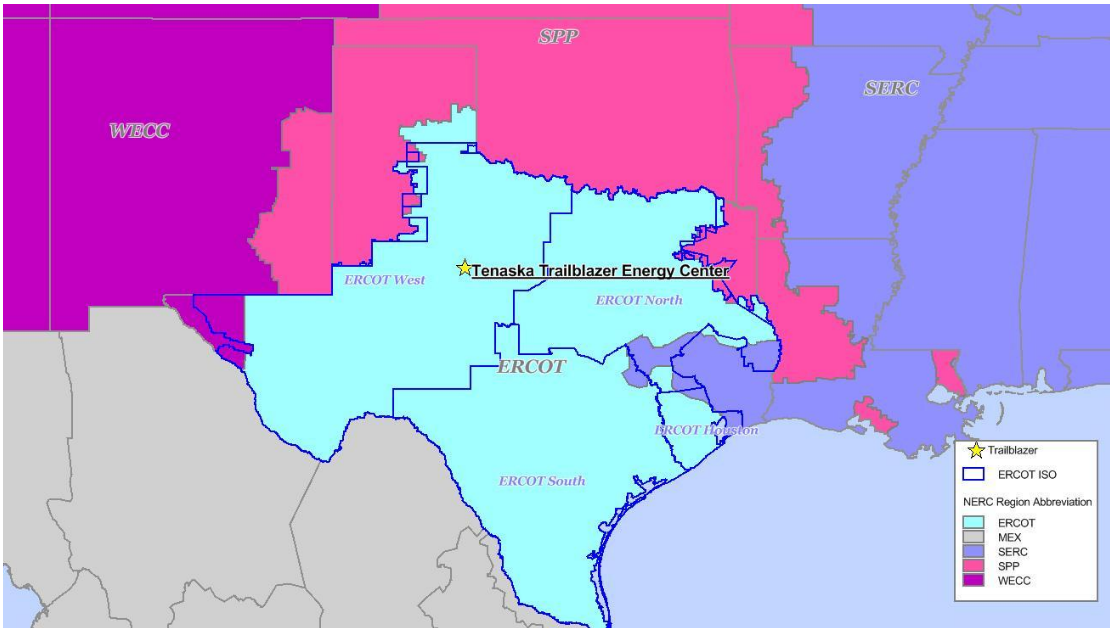
1.3 ERCOT Market

1.3.1 ERCOT Overview

Trailblazer will be electrically interconnected to ERCOT. As shown in Figure 1.3.1, ERCOT manages the flow of electric power to 23 million Texas customers representing 85 percent of the state's electric load and 75 percent of the Texas land area. As the independent system operator for the region, ERCOT schedules power on an electric grid that connects 40,500 miles of transmission lines and more than 550 generation units. ERCOT also manages financial settlement for the competitive wholesale bulk-power market and administers customer switching for 6.6 million Texans in competitive choice areas.

ERCOT's members include consumers, cooperatives, independent generators, independent power marketers, retail electric providers, investor-owned electric utilities (transmission and distribution providers), and municipal-owned electric utilities. For more information, see www.ercot.com.

FIGURE 1.3.1 – ERCOT Map



Source: Energy Velocity

The ERCOT market is a competitive, energy only market. In each hour, units bid into the market a price at which they will be willing to operate. The market dispatches units beginning with the lowest bids and ending with the highest bid required to meet demand in a given hour. **Every unit that is dispatched to run during any given hour gets paid the bid price of the highest-priced unit that dispatched.** In order to increase their chances of being dispatched, bidders in the ERCOT market typically bid in at a price that covers only their fuel and variable operating costs. Capital costs are recovered through the difference between a unit's bid price and the bid price of the highest-priced unit dispatched.

1.3.2 ERCOT Market Analysis

As described further in Section 4.0, the ERCOT market analysis was conducted by Tenaska's internal market analysis group utilizing two well-known electric pricing models, Aurora^{XMP} and PowerWorld™, as well as Tenaska's internally developed proprietary knowledge of the ERCOT market.

1.4 CO_2 Market

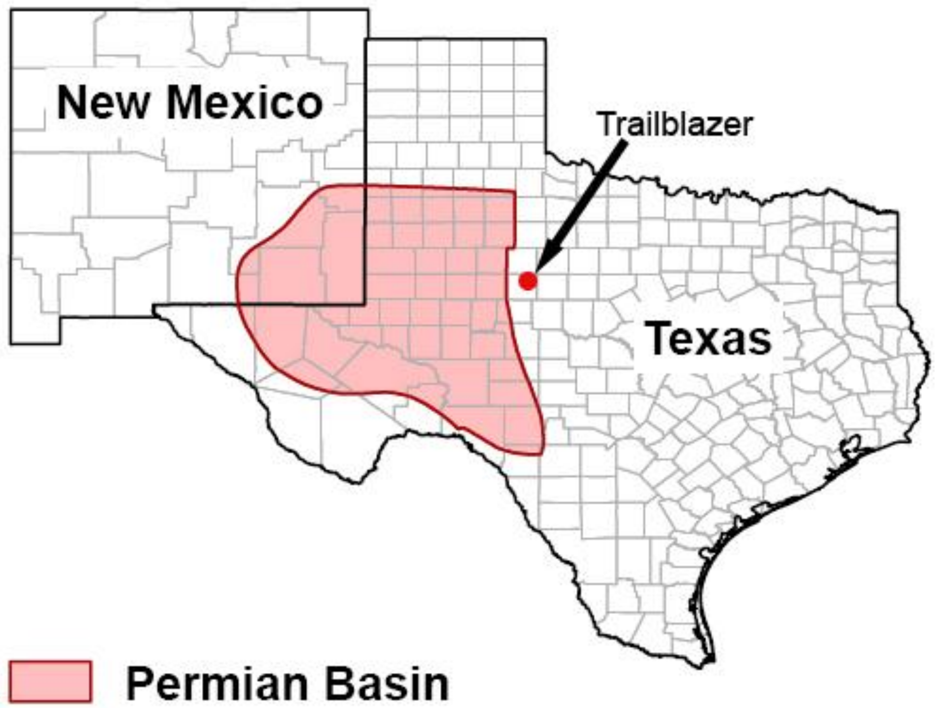
1.4.1 CO_2 Market Overview

Tenaska intends to sell its captured CO_2 for use in EOR efforts in the Permian Basin. The Permian Basin is one of the most prolific oil basins in North America and the world. It encompasses a surface area in excess of 86,000 square miles (138,400 square kilometers) and includes all or parts of 52 counties located in West Texas and southeastern New Mexico. Structurally, the Permian Basin is bounded on the south by the Marathon-Ouachita Fold Belt, on the west by the Diablo Platform and Pedernal Uplift, on the north by the Matador Arch, and on the east by the Eastern Shelf of the Permian

(Midland) Basin and west flank of the Bend Arch. The basin is about 260 miles by 300 miles (420 kilometers by 480 kilometers) in area.[1]

Figure 1.4.1 is a map showing the location of the Permian Basin.

FIGURE 1.4 – Map of Permian Basin



Source: http://www.searchanddiscovery.net/documents/2008/08165breton/index.htm?q=%2Btext%3Abreton
(approximate Trailblazer location added)

The first commercial scale CO_2 floods in the world were located in the Permian Basin and were initiated in 1972. Today, oil producers in the Permian Basin purchase more than 1.7 billion cubic feet (35 million tons per year) of new CO_2 every day and produce more than 65 million barrels of oil annually using EOR techniques. Most recently, success in using CO_2 to produce oil from residual oil zones (ROZ) have amplified the demand for CO_2 in the Permian Basin.

To date, most of the CO_2 that has been used in the Permian Basin for EOR has come from natural domes developed by the major oil producers. These natural sources of CO_2 are mostly owned by the major oil companies and are becoming depleted over time.

1.4.2 CO_2 Market Analysis

The CO_2 market analysis section of the report was authored by Steve Melzer, a geological engineer with a 25-year background in oil and gas exploration, production and consulting. Mr. Melzer also has performed research both within the oil and gas industry and with the USA Department of Defense. His particular areas of expertise involve reservoir characterization, CO_2 flood performance and CO_2 geologic sequestration. In 1977, Mr. Melzer formed Melzer Consulting to advise companies regarding the multifaceted business issues of CO_2. He has authored many papers and articles; the most recent papers dealing with emerging opportunities related to CO_2 flooding in residual oil zones below the oil/water contact. His list of clients includes many major and large independent oil companies, the U.S. Department of Energy and Defense, The University of Texas, and several CO_2 flooding, capture and transportation companies. Mr. Melzer resides in Midland, Texas, in the heart of the Permian Basin. For further information, see http://www.melzerconsulting.com.

2.0 Purpose and Goals

The purpose of this report is to provide insight into Trailblazer's economics and the challenges associated with building a first-of-its-kind, commercial-scale, greenfield coal-fueled power plant with carbon capture. Given the commercially sensitive nature of this subject, the goals of this report are to:

- Provide an overview of Trailblazer's current markets for both electricity and CO_2;
- Discuss the governmental support that the Project has received, as well as further support that may be needed to bridge the gap between the Project's likely costs and revenues; and
- Give an overall sense for the economic situation Trailblazer faces without going into details that could limit the Project's ability to negotiate commercial contracts and obtain financing.

3.0 Executive Summary

Trailblazer is expected to be the first new-build coal-fueled power plant to incorporate a commercial-scale CO_2 capture plant into the initial design. It is being designed to capture 85 to 90 percent of the CO_2 that otherwise would be emitted into the atmosphere.

Given the significant additional costs associated with building and operating a carbon capture plant in conjunction with a coal-fueled power plant, it is instructive to understand the real-world economics facing this first-of-its-kind project.

3.1 Electricity Market

Trailblazer will sell the power it produces into the West Zone of the ERCOT market. Using two well-known electric pricing models, Aurora^{XMP} and PowerWorld™, Tenaska has produced an analysis of the ERCOT market that predicts:

- the next units that would be built through 2030 to meet additional demand, based on capital and operating costs;
- the frequency with which Trailblazer could expect to be dispatched through the same timeframe, based on its operating costs; and
- the revenues Trailblazer could expect to achieve through 2030, based on its expected dispatch and a price forecast for the West Zone.

It should be noted that this analysis assumes no overall price on carbon emissions, as the enactment of USA cap and trade legislation that would have provided such a price no longer seems likely in the near term.

3.1.1 New Unit Additions

Tenaska's analysis shows that economics, taking both capital and operating costs into consideration, favor the construction of only new natural gas-fueled plants to meet rising electricity demand in ERCOT through 2030. This is largely due to projected low natural gas prices during that period, and the absence of any price for CO_2 emissions. This highlights the need for governmental policies that place value on adding baseload resources and capturing CO_2.

3.1.2 Trailblazer Dispatch

Tenaska's dispatch analysis shows that Trailblazer's dispatch costs would be among the lowest of all ERCOT generators, due to the additional revenue it will earn from the sale of CO_2 into the Permian Basin EOR market. This CO_2 revenue allows Trailblazer to offset the majority of its fuel and variable O&M costs, and places it at the lowest end of the dispatch stack. The analysis allows Tenaska to confidently predict that Trailblazer would operate at least 90 percent of the time.

3.1.3 Revenues

Using publicly available natural gas price and ERCOT energy demand forecasts, Tenaska forecasts power prices in the ERCOT West Zone ranging from USD$37.45/megawatt hour (MWh) in 2013 to USD$77.57/MWh in 2030 (in nominal USD). This forecast is based on publicly available data only. As such, it does not include Tenaska's proprietary views on natural gas prices or ERCOT energy demand, and therefore does not represent Tenaska's view on future power prices in ERCOT.

3.2 CO_2 Market

Trailblazer will sell approximately 5.75 million tons of CO_2 annually into the Permian Basin CO_2 market – the most mature and robust CO_2 market in the world. Tenaska retained Steve Melzer, a well-known geological engineer whose expertise includes reservoir characterization, CO_2 flood performance and CO_2 geologic sequestration, to provide the CO_2 market analysis for this report.

Mr. Melzer concludes that new sources of anthropogenic CO_2 are critical to the growth of conventional CO_2 EOR reservoirs and development of the ROZs that are just beginning in the Permian Basin. Mr. Melzer also points out that mature CO_2 Enhanced Oil Recovery (CO_2 EOR) regions such as the Permian Basin have the advantage of proven reservoirs, as well as excellent oil response to CO_2 injection, and can therefore pay higher prices for CO_2.

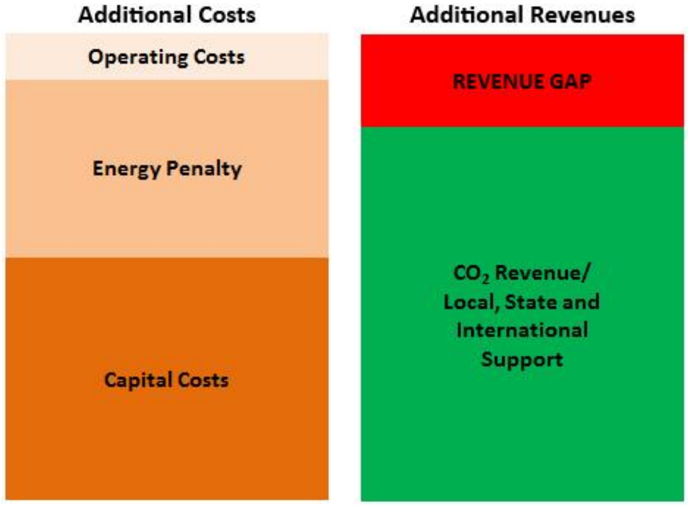
3.3 Government Support

Based on current prices for electricity and CO_2, government support will be required to make Trailblazer economically viable. Trailblazer already enjoys support at the local and state level, in the form of tax incentives and other policies that encourage the development of clean energy projects. At the federal level, however, the situation is much less certain. Statements from the current administration supporting clean coal have not translated into policies with sufficient certainty to support Trailblazer's financing. Cap and trade legislation, which likely would provide sufficient additional revenue to bridge the revenue gap, seems to be stalled for the foreseeable future. Existing tax credits run out once credits have been claimed for a certain number of tons of CO_2. Since there is no way to determine when those credits will be exhausted, these existing tax credits do not provide the certainty that financial institutions require.

3.4 The Revenue Gap

Currently, there is a gap between the additional costs associated with a carbon capture plant and the revenue that can be achieved by selling CO_2. Although Tenaska considers precise information about its costs and revenue forecasts confidential, Figure 3.4 shows, on a very gross level, what the revenue gap looks like. Figure 3.4 assumes no revenue in the value of avoiding carbon emissions.

FIGURE 3.4 – Carbon Capture Plant Revenue Gap



4.0 ERCOT Market Analysis

4.1 Methodology

Tenaska has combined the strengths of two well-known electric pricing models with its own proprietary data to create a powerful "toolkit" for forecasting electric market pricing. Major components of Tenaska's forecasting methodology are as follows:

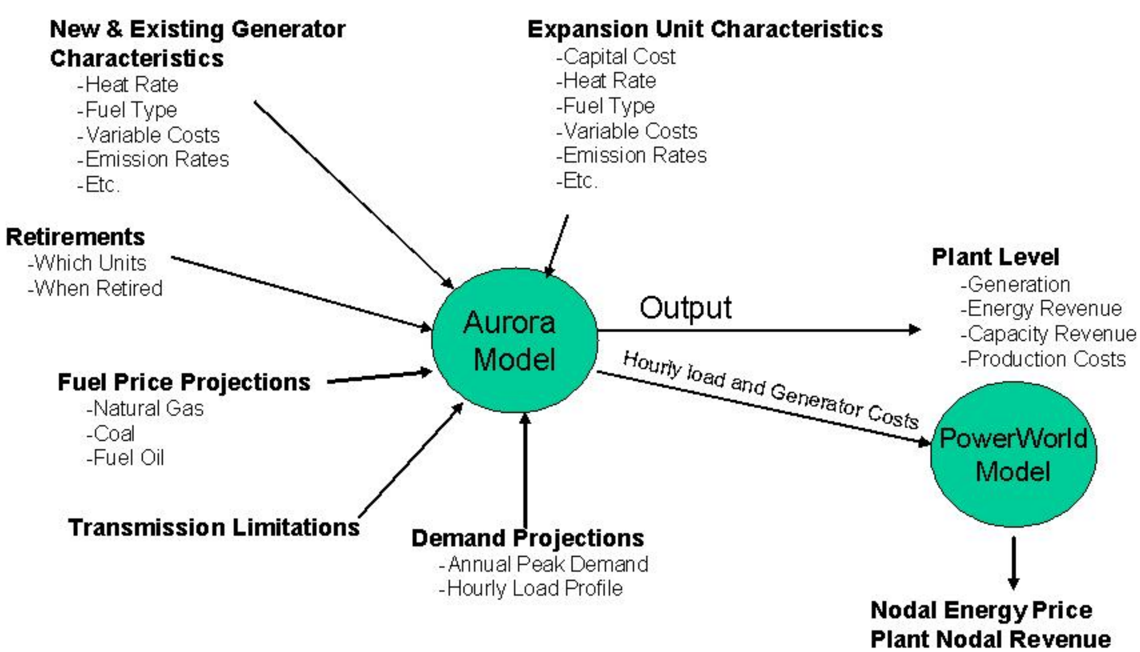
- The Aurora^{XMP} model forecasts long-term regional electricity prices;
- The PowerWorld™ model checks intra-regional price estimates and provides nodal price forecasts in the ERCOT market; and
- Tenaska's internal expertise customizes available project data

4.1.1 The Aurora^{XMP} Model

The Aurora^{XMP} model, developed by EPIS, Inc. (EPIS), forecasts energy prices based on the marginal cost of dispatch within the existing resource stack.

As shown in Figure 4.1.1, Aurora^{XMP} inputs include new and existing generator characteristics, retirements, expansion unit characteristics, fuel price projections, demand projections and transmission limitations. Aurora's™ outputs include hourly load and generator costs, which are fed into the PowerWorld™ model, and plant-level information on generation, revenues and production costs.

Figure 4.1.1 – Aurora Inputs and Outputs



4.1.2 The PowerWorld™ Model

The PowerWorld™ model takes the hourly load and generator costs provided by the Aurora^{XMP} model and re-dispatches electric generators to resolve transmission constraints. PowerWorld™ will forecast nodal energy prices and plant revenues based on this re-dispatched system.

PowerWorld is an extremely visual, high-voltage power system simulation and analysis package. The core of the software is a powerful solution engine, capable of efficiently performing power flow analysis on systems containing up to 100,000 buses.

PowerWorld provides the ability to optimally dispatch the generation in an area or group of areas while simultaneously enforcing transmission line and interface limits. PowerWorld can then calculate the marginal price to supply electricity to a bus, while taking into account transmission system congestion.

4.1.3 Proprietary Tenaska Data

Tenaska has used its extensive experience in the electric and gas markets to develop specific, accurate information not available to the general public. Quantitative proprietary data is incorporated into both the Aurora^{XMP} and PowerWorld™ models, yielding more accurate results. In addition, Tenaska's electric transmission and marketing experts have unique insights that assist in interpreting the data produced by both models, providing more useful conclusions. Tenaska's internal natural gas and energy demand forecasts have been replaced in this analysis the USA Department of Energy (DOE) Energy Information Administration's (EIA) Natural Gas Price forecast and ERCOT's energy demand forecast. These are widely accepted third-party forecasts that are publicly available

4.2 ERCOT Market Considerations

4.2.1 ERCOT Nodal Implementation and Design

In an effort to improve reliability and improve wholesale market efficiency and transparency, ERCOT launched its nodal market on December 1, 2010. The nodal market replaced the zonal market that ERCOT had used since 2001. ERCOT's system is the first to use a common information network that allows utilities to interactively view and report changes in grid operations. ERCOT states that the "enhancements to overall market efficiency should translate into substantial savings for consumers." A Public Utility Commission of Texas (PUCT)–commissioned analysis by an independent consultant estimated the nodal system will save consumers USD$5.6 billion over the first 10 years. According to an ERCOT press release these savings will realized by:

- Improved use of generation resources through unit-specific dispatch – selecting individual units based on lowest price rather than on generation portfolios;
- More efficient management of transmission congestion through market-based mechanisms;
- More accurate price signals that better indicate where new generation and transmission is most needed (and where it is not) for managing congestion and maintaining reliability; and

- Improved ability to efficiently and reliably integrate the increasing quantities of intermittent resources, such as wind and solar generating facilities.

In the prior zonal market design, ERCOT had four price zones and energy schedules grouped in portfolios, rather than by individual unit. The nodal market captures prices at more than 8,000 "nodes" or any point where energy is added or taken out of the grid, including transmission lines, generators, electrical busses, breakers, switches and other similar devices defined in the network model.[2]

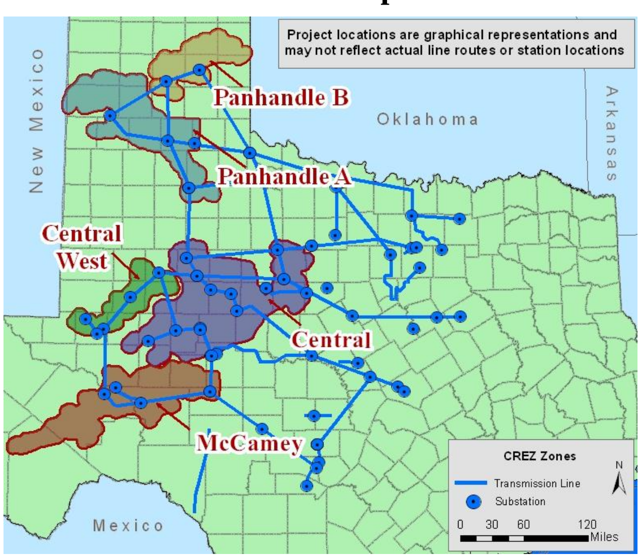
4.2.2 Texas Renewable Portfolio Standard

In 1999 Texas adopted rules for a Renewable Energy Mandate. The Public Utility Commission of Texas (PUCT) established a renewable portfolio standard (RPS). The RPS was then updated in 2005. The RPS established a renewable-energy mandate of 5,880 MW by 2015. This mandate has already been exceeded. The state of Texas currently has more than 9 GW of operating wind capacity.

4.2.3 Competitive Renewable Energy Zones

In 2008, the PUCT assigned USD$4.93 billion of Competitive Renewable Energy Zone (CREZ) transmission projects to be constructed. The CREZ projects are designed to transmit 18,456 megawatts (MW) of wind power from West Texas and the Panhandle to highly populated metropolitan areas in Texas.[3] The CREZ transmission projects are a key component to the forecasted power prices in the study. Currently, wind capacity in West Texas is constrained from moving to population centers in the central, eastern and southern parts of the state. This has caused an oversupply of power in the ERCOT West Zone and has resulted in lower prices in that zone. The CREZ transmission projects will allow wind capacity in the West to flow east to areas with higher prices. This will help alleviate the oversupply situation in the ERCOT West Zone, and thus will have a positive impact on prices in the ERCOT West Zone, which is where the Trailblazer project is located. Figure 4.2.3 is from the PUCT. It illustrates the CREZ projects that are expected to be completed.[4]

FIGURE 4.2.3 – CREZ Map



4.3 ERCOT Market Assessment Assumptions

4.3.1 Supply

4.3.1.1 *Existing Resources*

Tenaska began its analysis of existing resources by reviewing information available from Ventyx, a leading source of energy information. Tenaska then supplemented the Ventyx data with its own knowledge of the ERCOT system, to arrive at its list of existing resources. Table 4.3.1.1 shows the existing resources modeled in the analysis, broken down by fuel type:

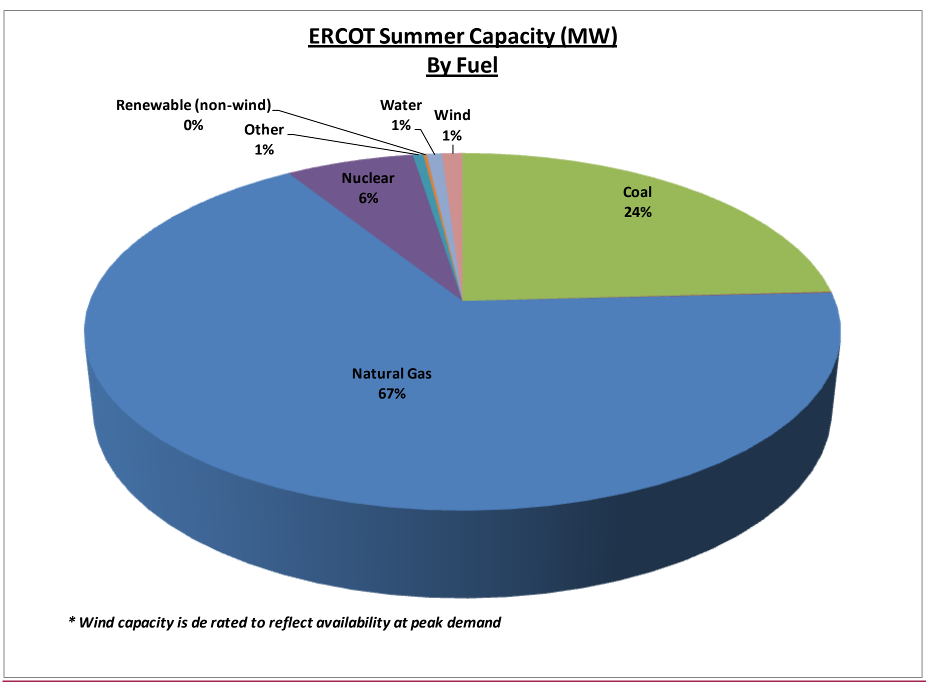
TABLE 4.3.1.1 – Existing ERCOT Resources

Fuel	Summer Capacity (MW)
Coal	18,935
Fuel Oil	53
Natural Gas	52,363
Nuclear	5,091
Other	409
Renewable (non-wind)	134
Water	599
Wind*	816
Total	**78,400**

** Wind capacity is de-rated to reflect availability at peak demand*

Figure 4.3.1.1 shows a graphical representation of this data.

FIGURE 4.3.3.1 – Existing ERCOT Resources



4.3.1.2 *Expected Capacity Additions*

Known Additions

Tenaska began its projection of capacity expansions by identifying capacity additions that currently are under construction. Tenaska considers such projects to have an extremely high probability of actually reaching commercial operation. Announced projects not yet under construction were not considered in the analysis, as it is extremely difficult to determine which announced projects actually will be built. Using only capacity additions under construction provides a defendable view of the market. Tenaska also obtained information on projects currently under construction from Ventyx and supplemented the Ventyx data with its own knowledge of the ERCOT systems. Table 4.3.1.2 shows the known capacity additions.

TABLE 4.3.1.2 – Known ERCOT Capacity Additions

Plant Name	Primary Fuel	Summer Capacity (MW)	Online Year
Aspen Power Lufkin Waste Wood Facility	Wood	50	2011
Jack Energy Facility	Natural Gas	565	2011
Nacogdoches Power Electric Generating Plant	Wood Waste Solids	100	2012
Point Comfort Cogeneration (NuCoastal)	Petroleum Coke	286	2011
Sandy Creek Energy Station	Coal	900	2012

Projected Generic Capacity Additions

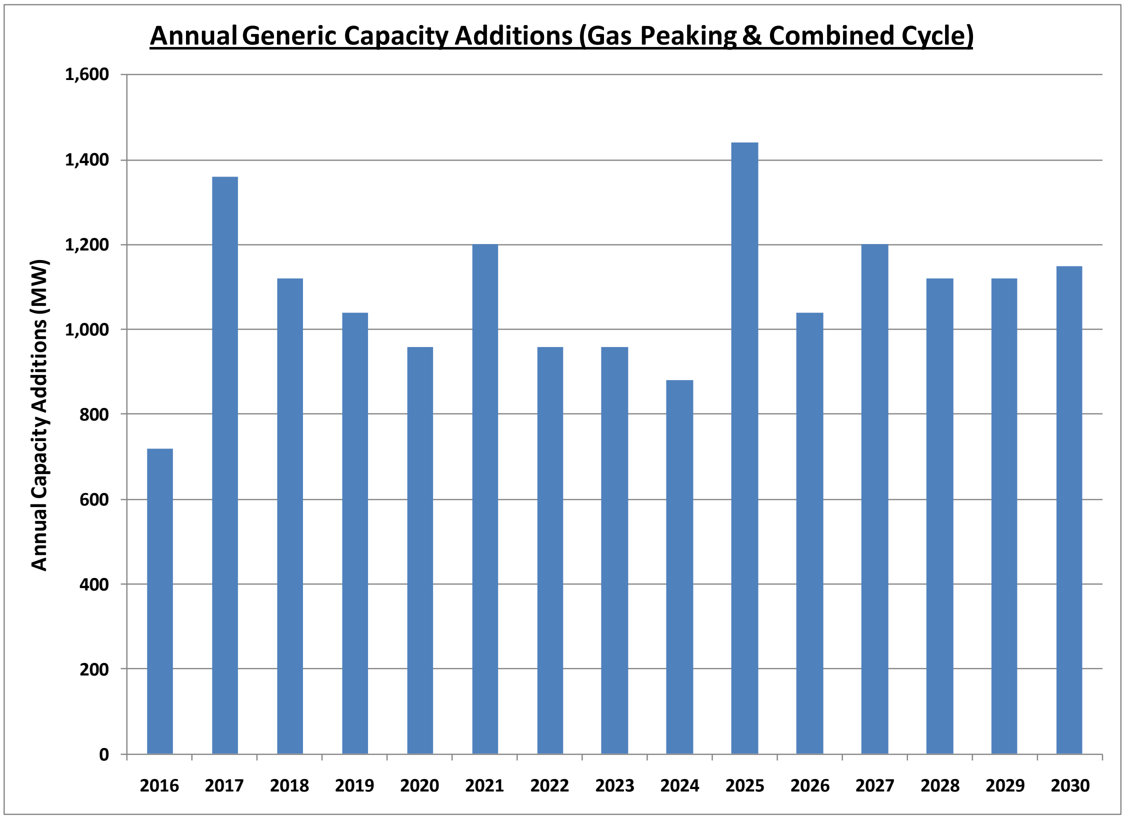
Tenaska used the long-term system expansion capability within Aurora^{XMP} to determine the optimal mix of new resources to be added to the market over time so that market reserve margins do not drop below a minimum reserve margin target. ERCOT currently has a minimum reserve margin target of 13.75%. Aurora^{XMP} chooses from new resource alternatives based on the net present value of hourly market values. Aurora^{XMP} compares those values to existing resources in an iterative process to optimize the set of new units.

Tenaska used proprietary input characteristics of potential new generation additions, including unit capacities and heat rates, variable O&M, fixed O&M, and operating characteristics related to the model's commitment logic. Technologies considered include natural gas-fueled combined cycle and peaking units, coal (with CO_2 capture), nuclear, solar, and wind. The model was constrained so that it did not consider the addition of a traditional pulverized coal facility without carbon capture, as Tenaska believes it is unlikely that future coal plants will be constructed in Texas without CO_2 capture. Given the current lack of impetus in the USA toward cap and trade or other pricing mechanisms, the analysis assumes no price on carbon emissions.

Through 2030, Aurora^{XMP} selected only natural gas-fired unit additions, largely because of the low natural gas prices projected during that period. Lower natural gas prices only serve to widen Trailblazer's commercial gap, and highlight the need for government policies that recognize the value of building baseload resources and capturing CO_2.

The results of this analysis are shown graphically in Figure 4.3.1.2.

FIGURE 4.3.1.2 – Projected ERCOT Capacity Additions



Retirements

The analysis takes into account the very small number of announced retirements in ERCOT. It should be noted that MWs to be retired represent an extremely small percentage of the total ERCOT supply. They do not affect the results of the analysis in a meaningful way because their high dispatch costs result in little or no actual dispatch into the market.

4.3.2 Demand

For annual demand growth, Tenaska used the *2010 ERCOT Planning Long-Term Hourly Peak Demand and Energy Forecast.* The monthly and hourly demand shapes were taken from EPIS. They are based on historical data from Federal Energy Regulatory Commission (FERC) Form 714, EIA 411 filings for demand and energy as well as reported hourly load from independent system operators. Figure 4.3.2.1 shows the projected ERCOT peak demand for each year of the study period. Figure 4.3.2.2 illustrates the hourly and monthly shape applied to the annual demand forecast for the year 2015.

FIGURE 4.3.2.1 – Forecasted ERCOT Peak Demand

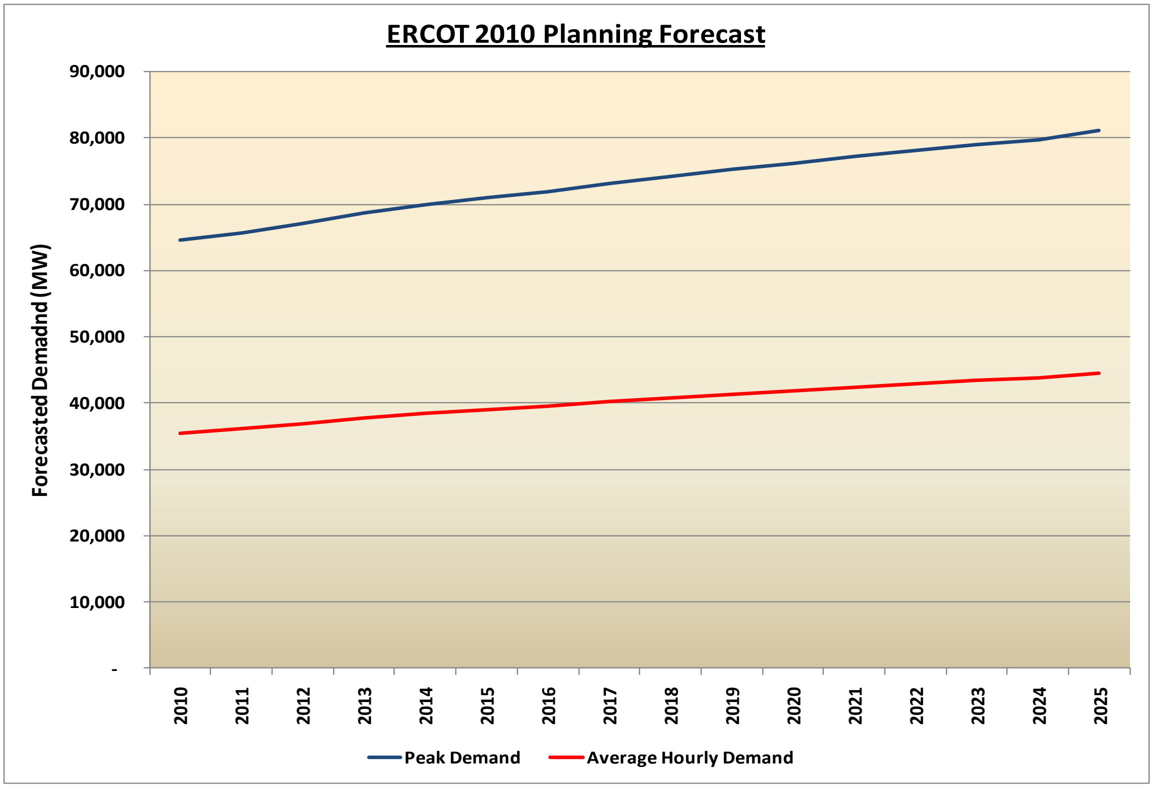
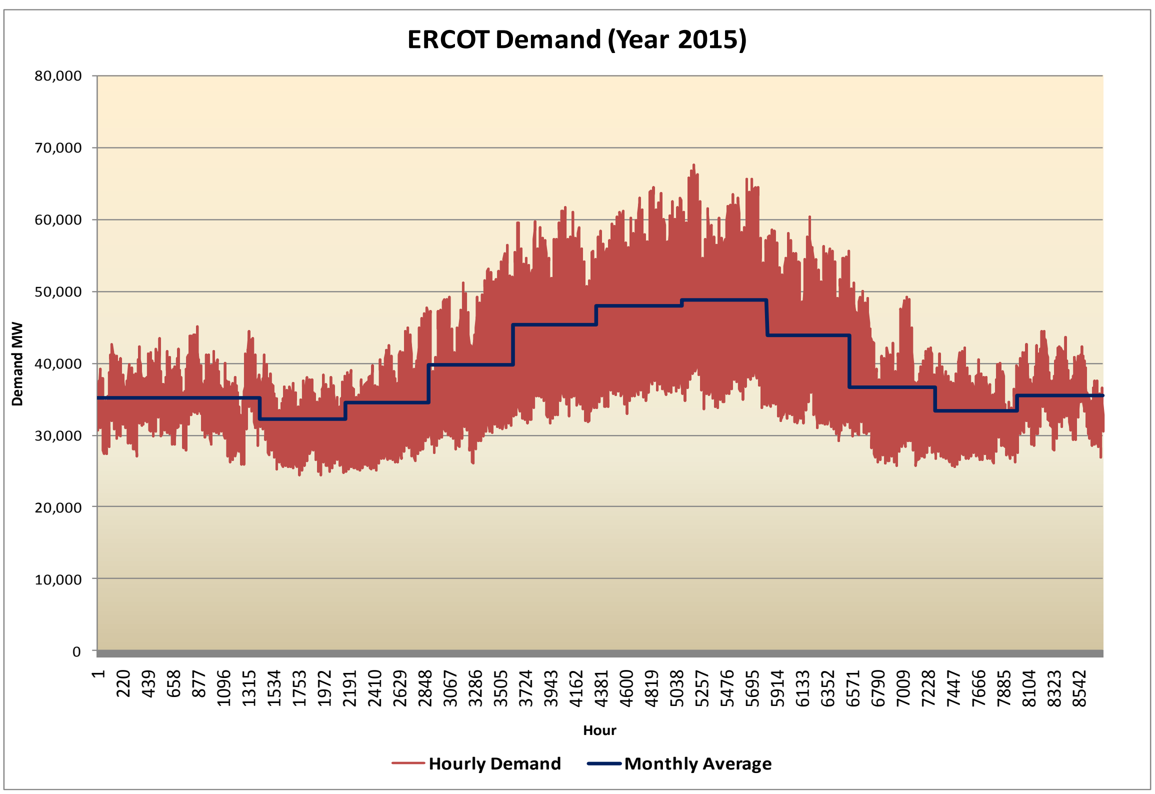


FIGURE 4.3.2.2 – ERCOT Hourly Demand Shape Example, Year 2015



4.3.3 Emissions Pricing

Emissions price forecasts from Wood Mackenzie and CERA have been used as inputs in the model for both sulfur dioxide (SO_2) and nitrogen oxide (NO_x) emissions. Both third party forecasts are well respected and provide insight into emissions prices beyond the traded forward market. There is no price for CO_2 emissions assumed in the forecast. This is due to the fact that proposed Federal action on a cap and trade program for CO_2 has stalled, which has left uncertainty in the market over what the cost of CO_2 will be for generators in the future. It would be expected that any price on CO_2 would directly increase prices in ERCOT. This would directly increase energy margins for the Project, because it will be able to capture almost all of its CO_2 while marginal gas/coal units that set the price in ERCOT do not have CO_2 capture and have greater CO_2 emission rates.

4.3.4 Projected Fuel Prices

As discussed above, one of the key drivers for the valuation of the Project is the fuel price forecast. Tenaska used the EIA's 2011 Annual Energy Outlook Early Release for the natural gas price forecast. Tenaska applied its proprietary gas basis assumptions to the EIA forecast to develop the regional gas price. Tenaska also uses plant-level coal price forecasts provided by Wood Mackenzie to accurately model the delivered cost of coal to all coal units in ERCOT. Wood Mackenzie's coal price forecast is not made publically available so Figure 4.3.4.1 shows the gas and coal pricing used by the EIA to show the relative fuel price difference as projected by the EIA.

FIGURE 4.3.4.1 – EIA Fuel Price Forecast (USD)

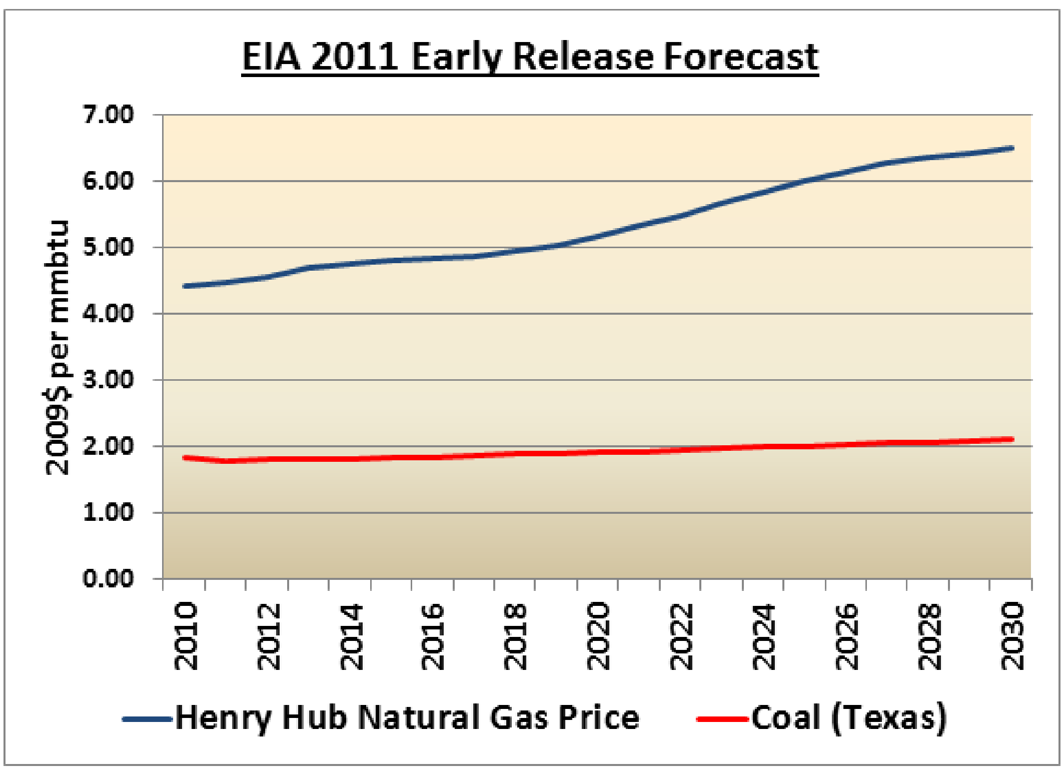
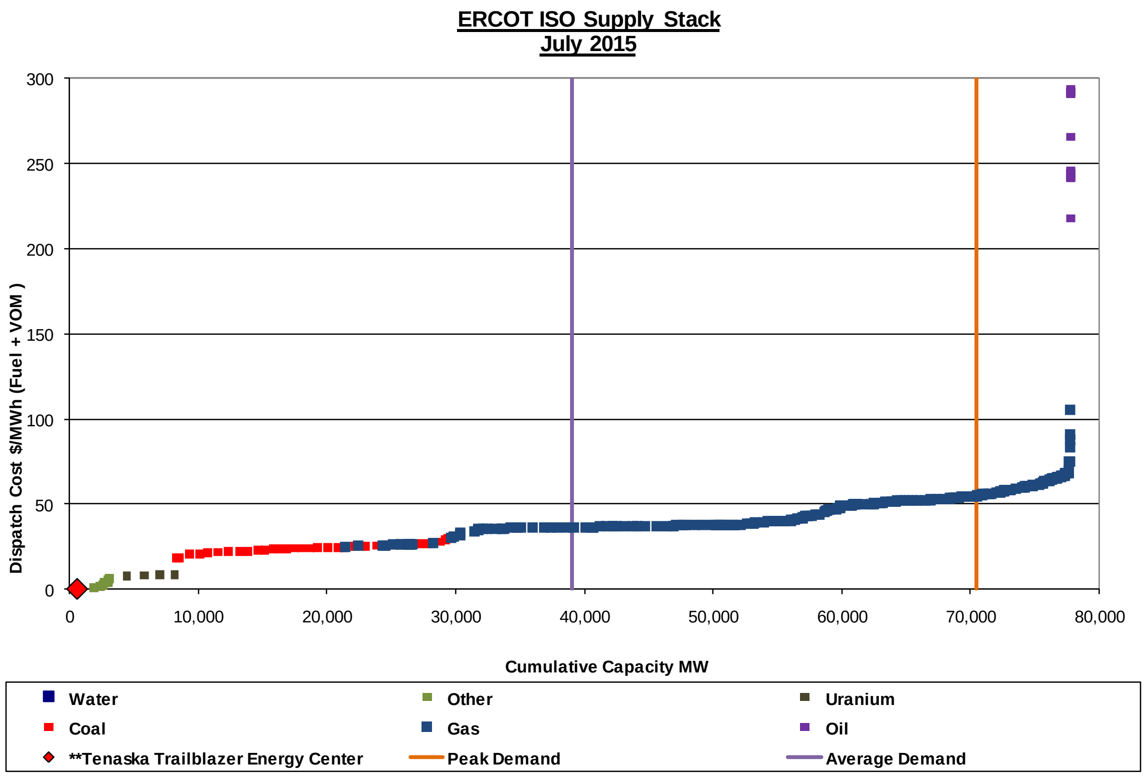


Figure 4.3.4.2 incorporates the assumed market fundamentals and shows where the Project ranks from a dispatch cost perspective relative to the rest of the generating facilities in ERCOT. As discussed in Section 1.3.1, an energy-only market like ERCOT incents units to bid based on their variable operating costs to ensure that the units get called to dispatch.

FIGURE 4.3.4.2 – Trailblazer Dispatch Cost Relative to other ERCOT Generation



Trailblazer is able to bid into the market at a lower cost than other generators due to the additional revenue it will receive from sales of CO_2 for EOR. This CO_2 revenue allows Trailblazer to offset the majority of its fuel and variable O&M costs. Average coal dispatch costs in the chart equal USD$24/MWh in the year 2015. So while Trailblazer's capital costs make the Project uneconomic, as discussed in Section 7, its low fuel and variable O&M costs, along with the revenues it will receive from CO_2 sales, would allow it to bid in to the market at a price that would ensure that the Project would dispatch virtually all the time and receive the clearing price for the highest cost unit each day. The difference between Trailblazer's dispatch costs and the market clearing price allows Trailblazer to recover some of its fixed costs.

4.4 Results

By simulating hourly supply and demand and incorporating each unit's forecasted dispatch cost, the model is able to produce an hourly power price forecast for the study period that is incorporated into Trailblazer's energy revenue for the hours it dispatches to the market. It should be noted again that for this report the model used publicly available information, rather than Tenaska's proprietary information, for several key model inputs. Therefore, the prices shown in Table 4.4 below do not represent Tenaska's view on the forecasted power prices in ERCOT. They do, however, provide an indicative indication of the pricing Trailblazer might see in the market.

TABLE 4.4 – Annual Forecasted Power Prices (USD) in the ERCOT West Zone

ERCOT West Zone Modeled Power Prices (nominal $/MWh)

Year	Price
2013	37.45
2014	38.81
2015	40.55
2016	42.30
2017	43.70
2018	45.64
2019	47.62
2020	50.51
2021	53.21
2022	55.98
2023	59.23
2024	62.23
2025	65.15
2026	68.18
2027	71.25
2028	73.71
2029	75.76
2030	77.57

5.0 Permian Basin CO_2 Market Analysis

5.1 Introduction

The Permian Basin region of the southwestern U.S. can be characterized as a very large, mature, carbonate reservoir dominated, prolific oil basin. True to its namesake, about 50 percent of its 30 billion barrels of produced oil have come from the Permian carbonate reservoirs, with most of it coming from the highly productive San Andres formation at roughly 5,000-foot (1,524 meter) depth.

In 1972, an experiment was attempted at large scale to produce post-waterflood oil in what has since become known as CO_2 EOR. The recovery method utilized by-product CO_2 captured from some natural gas plants in the southern reaches of the Permian Basin and transported via pipeline 200 miles (322 kilometers) away to the first large-scale CO_2 EOR flood in the world, the Scurry Area Canyon Reef Operators Committee (SACROC) flood.

From those early days of observation, the Permian Basin CO_2 EOR industry has grown to more than 60 producing projects purchasing more than 1.7 billion cubic feet (48 million cubic meters (mcm) or 35 million tons per year) of new CO_2 every day and producing more than 65 million barrels of oil per year. The Permian Basin still dominates worldwide flooding today with just under two-thirds of the oil being produced and 50 percent of the total worldwide projects.

The technology for CO_2 flooding was tightly controlled by the oil majors until the 1990s when a concerted effort was undertaken to transfer the technology to smaller companies. Today, the majors mostly have been replaced by large independents such as Occidental (Oxy), Kinder Morgan, and Denbury Resources. Hess, Chevron, Exxon and Conoco still retain interests and remain as important players either in the supply, transportation, and/or production sides of the industry.

The excitement surrounding CO_2 EOR has risen to a new level in recent years. Three factors are contributing:

1) new higher tiers of oil pricing;
2) interests in finding a subsurface home for CO_2 that would otherwise be emitted to the atmosphere; and
3) the awareness that large, new commercial reservoir targets lie below the oil/water contact in many fields.

The expansion of CO_2 EOR is moving slowly due to the capital-intensive nature of the business and limitations on CO_2 supply and pipeline infrastructure that exist in all regions of the USA and the world.

The partnership that exists between industrial sources of CO_2 and the EOR industry has been slow in developing. The cultures of power generation and oil are very different, with one generally being a regulated industry and the other being a very private and entrepreneurial one. Forging cooperation has come with difficulties, although companies like Tenaska and projects like Trailblazer are making progress.

The commercial sale of CO_2 to the EOR industry appears sufficient to justify capture for new supplies only where the off-take, waste CO_2 is relatively pure and/or high pressure. Coal power plants have many advantages in terms of large quantities of CO_2 to help justify the high capital expenditures, but they are challenged by the production of CO_2 emission streams at generally low pressures. As a result, coal power plants wishing to capture their CO_2 for use in the EOR market must make significant capital expenditures to compress the CO_2 prior to transportation. Despite this disadvantage, where a large and viable market exists for coal power plant CO_2, as in the Permian Basin, progress is being made. The "demand pull" for CO_2 seems, at least for now, to be replacing carbon taxes or cap and trade ('capture push') as the mechanism for jumpstarting the CCS industry. Nowhere is that more evident than in the Permian Basin with its huge demand market for CO_2.

5.2 Permian Basin and Worldwide CO_2 Flooding History

In the USA, CO_2 EOR technologies have been demonstrated to be profitable in commercial-scale applications for more than 30 years. Large-scale CO_2 EOR was first demonstrated in the Permian Basin of West Texas with the SACROC and North Cross floods in the early 1970s. Since then, CO_2 EOR has been deployed selectively throughout the world, but very extensively in the Permian Basin since the mid-1980s. Historic CO_2 EOR projects have largely injected high purity, low cost CO_2 obtained from natural CO_2 reservoirs, but an increasing percentage of natural gas byproduct CO_2 is also being injected. An extensive CO_2 pipeline network has been developed in the Permian Basin region to meet the growing CO_2 requirements of the CO_2 EOR sub-industry.

The most comprehensive public review of the status of EOR projects around the world is the biennial EOR survey published by the Oil and Gas Journal; the most recent issue of which was published in April 2010.[5] According to this survey, 105 CO_2 EOR projects currently provide nearly 250,000 barrels per day of incremental oil production from EOR in the USA. Of these, the vast majority, 100 projects producing 240,000 barrels per day, are miscible[6] CO_2 EOR projects.

It is well known that water and oil do not mix together. The technical term used for this is immiscible. However, other gaseous and liquid substances have the property of mixing with oil and are thereby "miscible." This miscibility property is dependent not only on the nature of the two substances but the pressure and temperature at which they come in contact. CO_2 and many oils are miscible at common reservoir pressures.

When CO_2 is injected into a well and moves out into the water-flooded region, it will contact oil that was bypassed by the water. The oil that is contacted becomes a mixed substance and takes on new properties independent from either the single phase CO_2 or the oil. The mixed substance can mobilize the oil by making it lighter and free to move off the rock surfaces to the producing wells. The moving oil/CO_2 continues to contact oil, freeing more oil as it progresses, with the mobilized oil all being driven along from the injector wells to the producing wells.

Twelve years ago, production from CO_2 EOR was only 170,000 barrels per day from 60 projects. Since 1986, over 1.3 billion barrels of incremental oil has been estimated to have been recovered using this technology.

Figure 5.2.1 provides the location of the currently active USA CO_2EOR projects (inclusive of the Weyburn and Midale projects in Canada), and including the large serving pipelines together with the sources of CO_2 supply.

Figure 5.2.2 tracks the steady growth in CO_2 EOR production in the USA and Permian Basin for the past 25 years, noting that the Permian Basin dominated worldwide projects through 2005 and started to become less dominate as new EOR interest ramped up in the Gulf Coast and the Rockies. Notably, this CO_2 EOR growth was sustained in spite of two oil price crashes, the first in 1986 and the second in 1998. With only a few exceptions, CO_2 EOR projects continued to operate through the periods of low prices, and increased their CO_2 purchases after resumption of "normal" oil pricing. It is significant to note that low oil prices did not deter underlying growth in the CO_2 EOR industry, but only curtailed acceleration of the growth.

FIGURE 5.2.1 – USA CO_2 Sources and EOR Regions

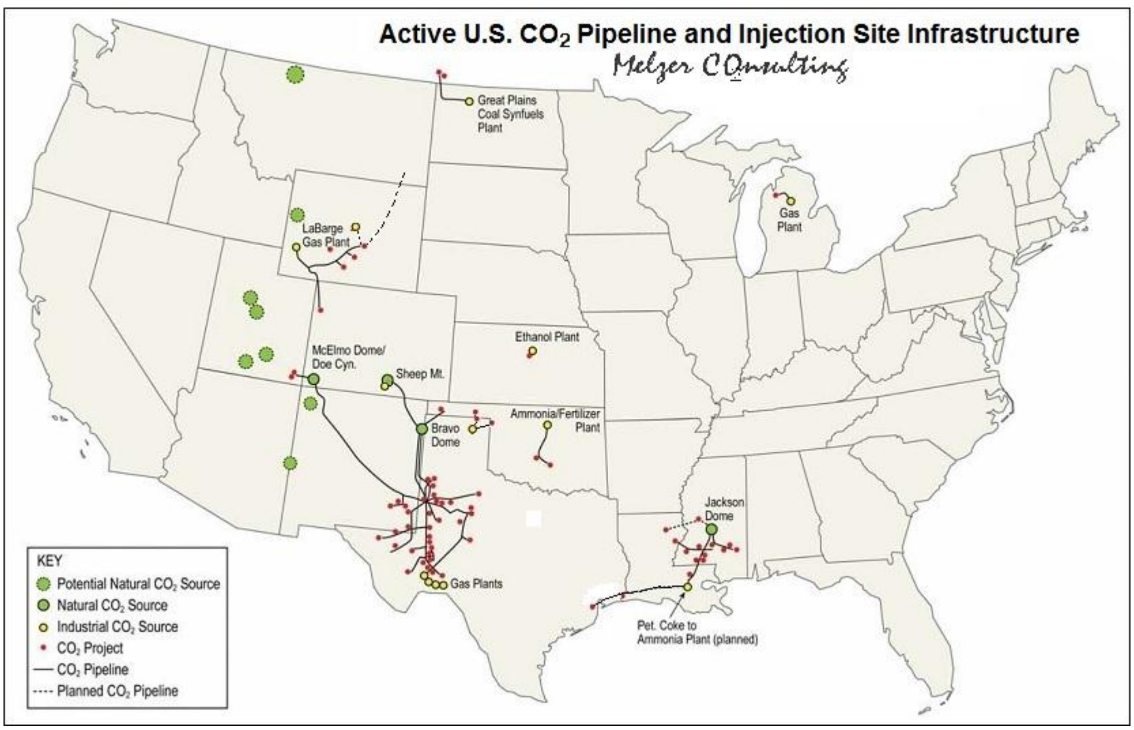
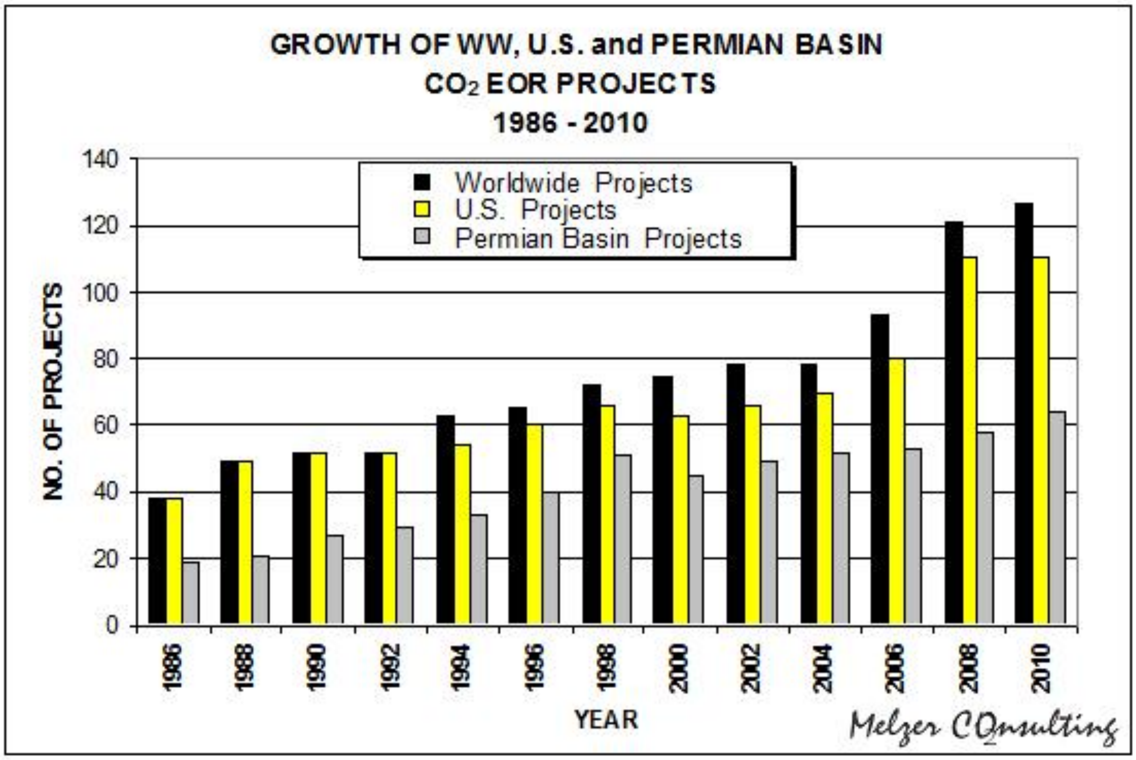


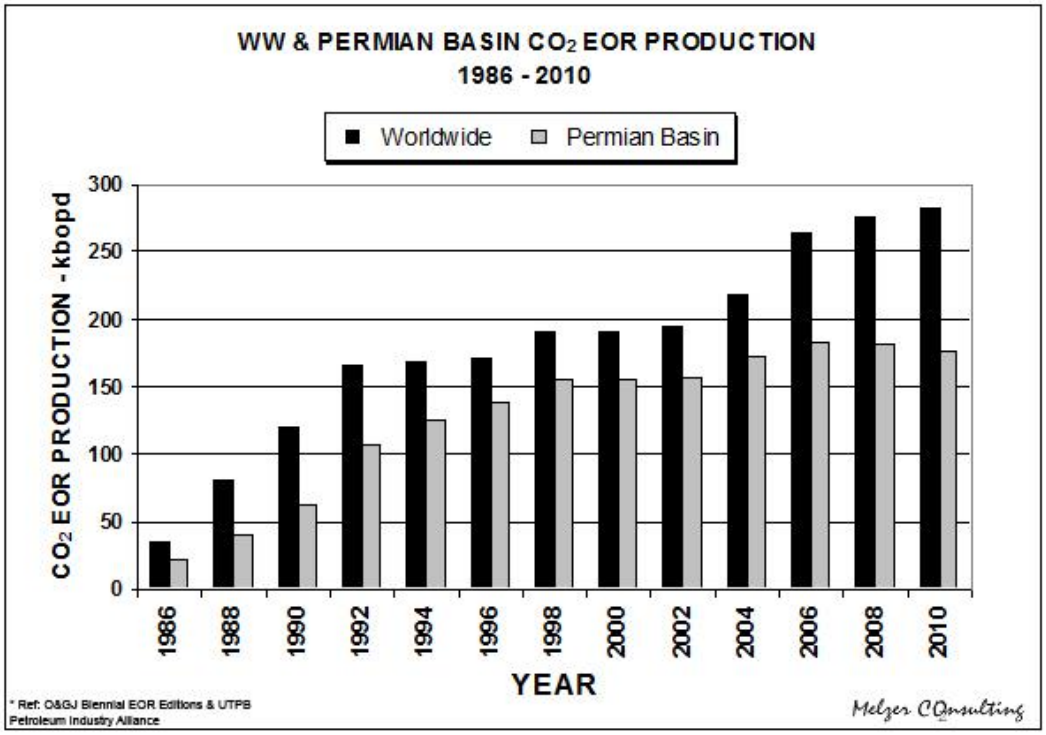
FIGURE 5.2.2 – Growth of CO_2 EOR Projects



A look at the CO_2 EOR production (Figure 5.2.3) illustrates that the great majority of CO_2 EOR production has been in and is still being produced from the Permian Basin. The observable Permian Basin decline in recent years is a very interesting occurrence that Melzer Consulting believes is due to a combination of:

1) the lack of sufficient supply of CO_2 to sustain increasing project growth; and
2) maturation of existing projects which are less efficient on a per million cubic feet (mcf) basis but yet quite economical in today's oil price environment.

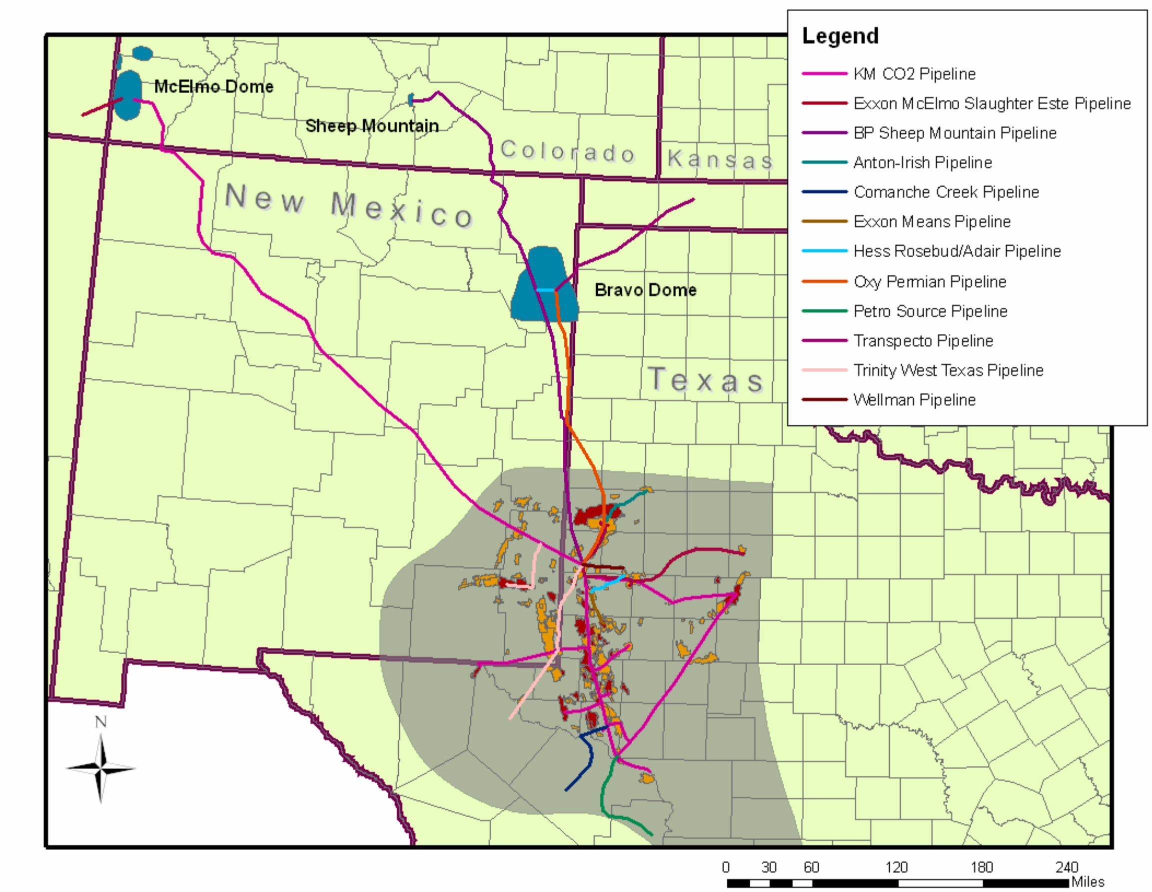
Figure 5.2.3 – Worldwide and Permian Basin CO_2 EOR Production



As previously mentioned, the birth of the worldwide CO_2 EOR industry occurred in the Permian Basin with two large-scale projects in the early 1970s. A group of oil companies led by Shell and Gulf effectively converted a waste stream of by-product CO_2 from natural gas processing facilities in the southern portion of the Permian Basin into a useful commodity by capturing, compressing and routing it via the first CO_2 pipeline to the North Cross unit near McCamey, Texas, and then on to Snyder, Texas and the SACROC unit in Scurry County. The response of the reservoirs to the CO_2, especially in the carefully observed four-pattern area of SACROC, convinced several other major oil companies of the viability of CO_2 injection.

Based on these results, plans were conceived to bring several large underground sources of natural CO_2 to the region. These very pure (>95%) supplies of CO_2 came from Bravo Dome in northeastern New Mexico, Sheep Mountain in south central Colorado, and McElmo Dome in southwestern Colorado. Locations of these supplies are shown in Figures 5.2.1 and 5.2.4.

FIGURE 5.2.4 – Location of Oil Fields and CO_2 Supply Pipelines in the Permian Basin



With these new supplies, the next phase of activity witnessed several key fields deployed into CO_2 EOR operations. Most notable of these were the Wasson, Seminole and Slaughter fields, all Permian-age San Andres formation fields; each with 1-3 billion of barrels of original oil in place. It is also notable to observe that CO_2 flooding is continuing on these projects today, some 25-plus years after original implementation.

5.3 Current Permian Basin EOR Projects and CO_2 Supply

The Permian Region of West Texas and southeastern New Mexico has evolved to be the largest CO_2 EOR region and CO_2 marketplace in the world. There are 105 CO_2 EOR projects (both miscible and immiscible) in the USA, of which 61 projects, producing more than 182,000 barrels per day, are currently active in the Permian Basin, as shown in Figure5.2.3[7]. Some of these fields have been producing oil using CO_2 for almost 30 years. A list of these fields is provided in Table 5.3.1.

TABLE 5.3.1 – Listing of Actively Producing CO_2 EOR Floods in the Permian Basin

	Operator	Field	State	County	Start Date	Area, Acres	No. Wells Prod.	No. Wells Inj.	Total Prod., b/d	Enh. Prod., b/d
CO_2 Miscible										
1	Apache	Adair	TX	Gaines	1997	5,338	90	61	2,350	
2	Apache	Adair	TX	Gaines	2004	2,550	11	11	420	
3	Apache	Slaughter	TX	Hockley/Terry	5/85	569	43	21	600	580
4	Apache	Slaughter	TX	Hockley/Cochran	6/89	8,559	259	164	5,800	4.000
5	Chevron	Mabee	TX	Andrews/Martin	1/92	3,600	220	85	3,100	2,000
6	Chevron	Slaughter Sundown	TX	Hockley	1/94	5,500	155	144	5,950	4,747
7	Chevron	Vacuum	NM	Lea	7/97	1,084	48	24	4,500	2,950
8	Chevron	Dollarhide (Devonian) Unit	TX	Andrews	5/85	6,183	83	66	2,420	1,970
9	Chevron	Dollarhide (Clear Fork “AB”) Unit	TX	Andrews	11/95	160	21	4	230	124
10	Chevron	Reinecke	TX	Borden	1/98	700	32	8	977	830
11	ConocoPhillips	South Cowden	TX	Ector	2/81	4,900	43	22	450	250
12	ConocoPhillips	Vacuum	NM	Lea	2/81	4,900	192	103	6,200	5,200
13	Energen Resources	East Penwell (SA) Unit	TX	Ector	5/96	1,020	49	30	1,626	827
14	ExxonMobil	Means (San Andres)	TX	Andrews	11/83	8,500	484	284	10,000	8,700
15	Fasken	Abell (Devonian)	TX	Crane	4/09	809	21	19	180	85
16	Fasken	Hanford	TX	Gaines	7/86	1,120	23	26	400	400
17	Fasken	Hanford East	TX	Gaines	3/97	340	7	4	60	30
18	Fasken	Hanford (San Andres)	TX	Gaines	7/09	113	8	4	280	
19	Fasken	River Bend (Devonian)	TX	Crane	4/09	400	9	10	290	20
20	George R. Brown	Post-Montgomery Unit	TX	Garza	11/09	1,778				
21	Great Western Drilling	Twofreds	TX	Loving/Ward/Ree ves	1/74	4,392	32	9	170	170
22	Hess	Seminole Unit – Main Pay Zone	TX	Gaines	7/83	15,699	408	160	16,500	16,500
23	Hess	Seminole Unit – ROZ Phase 1	TX	Gaines	7/96	500	15	10	1,200	1,200
24	Hess	Seminole Unit – ROZ Phase 2	TX	Gaines	4/04	480	16	9	1.700	1,700
25	Hess	Seminole Unit – ROZ State 1	TX	Gaines	12/07	2,380	47	29	1,000	1,000
26	Kinder Morgan	SACROC	TX	Scurry	1/72	49,900	391	444	29,580	26,530
27	Occidental	Alex Slaughter Estate	TX	Hockley	8/00	246	21	11	270	220
28	Occidental	Anton Irish	TX	Hale	4/97	4,437	151	90	5,800	2,800
29	Occidental	Cedar Lake	TX	Gaines	8/94	2,870	167	87	4,500	2,500
30	Occidental	Central Mallet Unit	TX	Hockley	1984	6,412	182	136	2,750	1,930
31	Occidental	Cogdell	TX	Scurry/Kent	10/01	2,684	93	59	5,600	5,500
32	Occidental	El Mar	TX	Loving	4/94	6,000	29	29	308	301
33	Occidental	Frazier Unit	TX	Hockley	12/84	1,600	67	52	1,059	650
34	Occidental	GMK South	TX	Gaines	1982	1,143	18	14	490	140
35	Occidental	Igoe Smith	TX	Cochran	9/05	1,235	52	24	790	430
36	Occidental	Levelland	TX	Hockley	9/04	1,179	95	62	1,800	950
37	Occidental	Mid Cross – Devonian Unit	TX	Crane/Upton/ Crockett	7/97	1,326	11	5	430	376

	Operator	Field	State	County	Start Date	Area, Acres	No. Wells Prod.	No. Wells Inj.	Total Prod., b/d	Enh. Prod., b/d
38	Occidental	N Cross – Devonian Unit	TX	Crane/Upton	4/72	1,155	26	16	1,225	1,223
39	Occidental	North Cowden	TX	Ector	2/95	465	40	17	535	326
40	Occidental	North Dollarhide Devonian	TX	Andrews	11/97	1,280	29	20	1,150	650
41	Occidental	North Hobbs	NM	Lea	3/03	3,100	125	75	7,300	5,300
42	Occidental	S. Cross – Devonian Unit	TX	Crockett	6/88	2,090	71	38	5,922	5,859
43	Occidental	Salt Creek	TX	Kent	10/93	12,000	150	102	7,450	6,600
44	Occidental	Sharon Ridge	TX	Scurry/Kent	2/99	1,400	25	26	600	450
45	Occidental	Slaughter (H T Boyd Lease)	TX	Cochran	8/01	1,240	35	23	950	630
46	Occidental	Slaughter Estate Unit	TX	Hockley	12/84	5,700	184	166	3,800	2,270
47	Occidental	Slaughter North West Mallet	TX	Cochran/Hockley	2008	1,048	39	24	1,085	180
48	Occidental	Slaughter West RKM Unit	TX	Hockley	2006	1,204	51	33	1,764	325
49	Occidental	Smith Igoe	TX	Cochran	8/05	177	6	2	210	100
50	Occidental	South Wasson Clearfork	TX	Yoakum	10/84	4,720	104	56	1,400	0
51	Occidental	South Welch	TX	Dawson	9/93	1,160	87	73	720	670
52	Occidental	T-Star (Slaughter Consolidated)	TX	Hockley	7/99	1,700	51	31	2,500	1,000
53	Occidental	Wasson Bennett Ranch Unit	TX	Yoakum	6/95	1,780	197	160	5,440	4,715
54	Occidental	Wasson Denver Unit	TX	Yoakum/Gaines	4/83	27,848	1,008	580	28,500	25,274
55	Occidental	Wasson ODC Unit	TX	Yoakum	11/84	7,800	326	289	9,348	8,682
56	Occidental	Wasson Willard Unit	TX	Yoakum	1/86	8,500	271	212	4,511	3,700
57	Occidental	West Welch	TX	Gaines	10/97	240	0	0	0	0
58	OrlaPetco	East Ford	TX	Reeves	7/95	1953	8	4	128	128
59	Whiting Petroleum	North Ward Estates	TX	Ward/Winkler	5/07	16,300	816	816	7,800	4,700
60	XTO Energy	Goldsmith	TX	Ector	12/96	330	16	9		
61	XTO Energy	Cordona Lake	TX	Crane	12/85	2,084	44	23	1,050	350
62	XTO Energy	Wasson (Cornell Unit)	TX	Yoakum	7/85	1,923	96	64	1,700	875
63	XTO Energy	Wasson (Mahoney)	TX	Yoakum	10/85	640	49	27	875	1,350
				Total Miscible		**268,443**	**7,447**	**5,182**	**216,468**	**171,967**
CO_2 Immiscible										
64	Kinder Morgan	Yates	TX	Pecos	3/04	26,000	551	121	26,295	4,000
				Total Immiscible		**26,000**	**551**	**121**	**26,295**	**4,000**
	TOTAL MISCIBLE + IMMISCIBLE					**294,443**	**7,998**	**5,303**	**242,763**	**175,967**

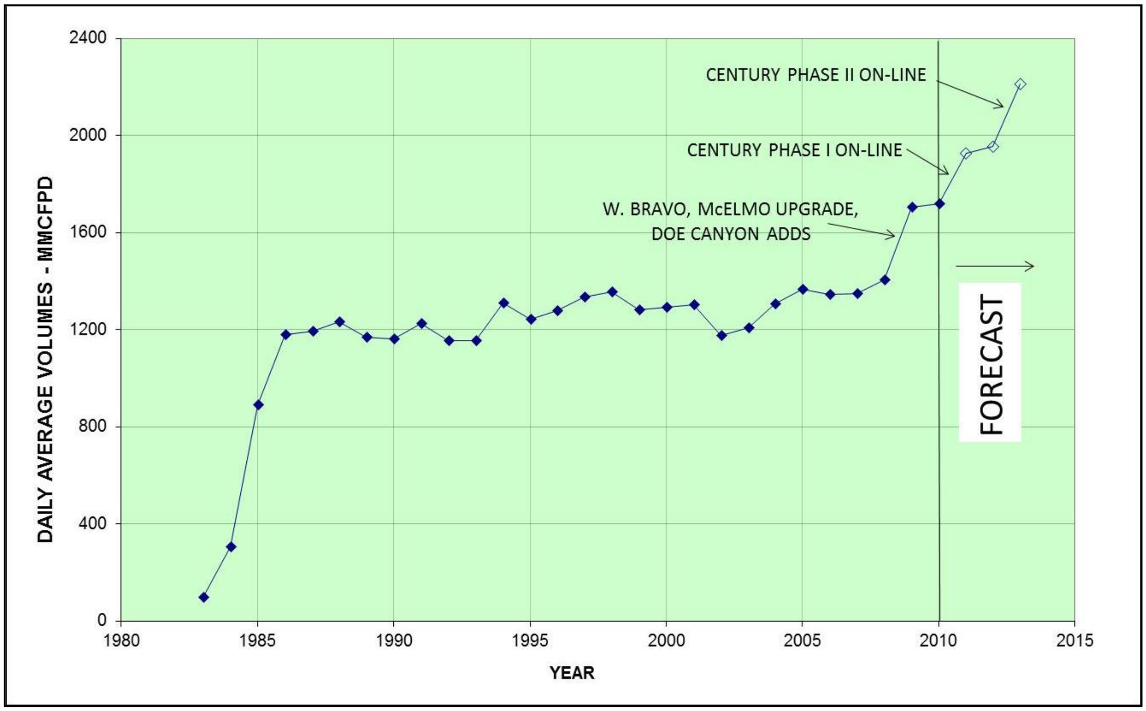
SOURCE: Oil & Gas Journal Annual Production Report, April 19, 2010; Melzer Consulting and UTPB Petroleum Industry Alliance (5/2010)

The projects in these Permian Basin fields are estimated to have purchased a record volume of approximately 1.73 billion cubic feet per day (Bcfd) (49 million cubic meters per day (MMcmd)) of CO_2 for EOR in 2010. Melzer Consulting calculates that, to date, more than 11 trillion cubic feet (Tcf) (311 billion cubic meters), or 630 million short tons (572 million metric tons), of CO_2 have been injected into Permian Basin fields. To give one an idea of the size of that market, the current **daily** volume of CO_2 purchases in the

Permian Basin is equivalent to the output of six Trailblazer-sized plants/capture facilities.

From the years 1986 through 2008, CO_2 supplies to the Permian Basin EOR industry were effectively flat (gradual inclining sales) and averaged about 1.3 Bcfd (3.68 MMcmd) per day. Figure 5.3.1 recaptures that history and one can note that the sales didn't begin to increase sharply until 2009. A closer look at the supply and demand along with a discussion about the sources of newly added and potential future supplies – after 2009 – is provided later in this report.

FIGURE 5.3.1 – Permian Basin CO_2 EOR Volumes Sold



Approximately 90% of the CO_2 supplies have been provided by the "big four" suppliers: KinderMorgan, ExxonMobil, Oxy, and SandRidge. In recent years, Hess and Trinity CO_2 have joined the list with the latter emerging as a "proxy" supplier by way of aggregating some supplies from small interest owners in McElmo Dome and a small natural gas plant recovery plant, La Veta, near the Sheep Mountain source field in south central Colorado.

The breakdown of this supply by CO_2 source is shown in Figure 5.3.2 and Table 5.3.2. As shown, the vast majority of these supplies (1.15Bcfd or 33 MMcmd) come from McElmo Dome. Oxy's Bravo Dome (combined in Figure 5.3.2 with Hess' West Bravo Dome) is next and the remaining four make up the difference in roughly equal volumes.

FIGURE 5.3.2 – Breakdown of Permian Basin CO_2 Supplies for CO_2 EOR by Supply Source in 2009

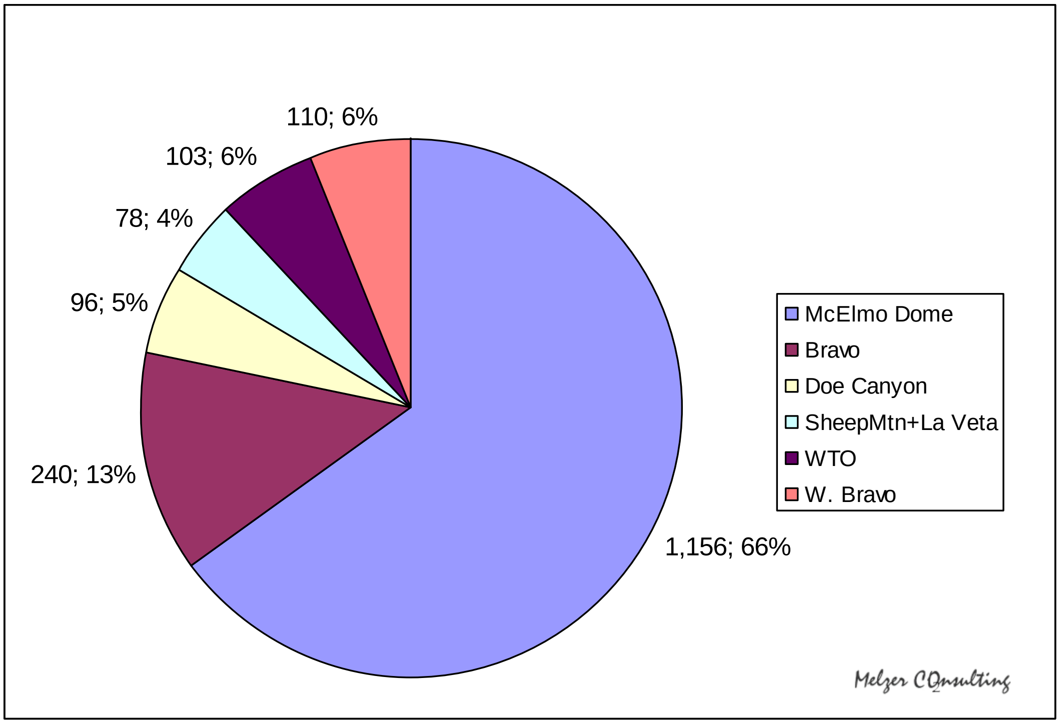


TABLE 5.3.2 – Permian Basin CO_2 Supply Sources and Estimated Delivery Capacity in 2009

	2010 Average Daily Volumes (MMcfd)	Estimated Capacities (MMcfd)
Cortez Pipeline		
McElmo Dome	1,150	
Doe Canyon	100	
	1,205	1,300
Sheep Mountain Pipeline		
Sheep Mountain + La Veta	50	
W. Bravo	110	
	160	500
Bravo Pipeline		
Bravo Dome	220	330
West Texas Overthrust (WTO)	100	120
TOTAL	**1,730**	**2,250**
Potential Excess Pipeline Capacity		520

The CO_2 source field infrastructure is critical, but the pipeline network provides another important component to the CO_2 EOR sub-industry. With some relatively minor exceptions, the pipelines are owned by the same owners and in approximately the same percentages as the source fields. However, the pipelines in Lea County, New Mexico are a significant exception, with Trinity CO_2 LLC exclusively owning a major block of 113 miles (182 kilometers). Their pipeline network in the western portion of the Basin currently delivers about 1/15th of the Permian Basin volumes to the EOR projects.

Table 5.3.2 illustrates the excess capacities of the large CO_2 pipelines from the sources. As shown, there is little to no excess capacity available on the Cortez pipeline delivering supplies from McElmo Dome and Doe Canyon. Additional pump stations were added in early 2009 to get 300 million cubic feet per day (MMcfd)(8.5 MMcmd) more capacity, bringing total capacity to about 1.3 Bcfd (37 MMcmd). Kinder Morgan has said publicly that they might be able to further increase capacity to about 1.5 Bcfd (42.5 MMcmd), with more pump stations, providing some potential for additional capacity.

Noting that the Cortez line is at its current throughput capacity; additional drilling at McElmo Dome and Doe Canyon will be only to maintain volume throughput. On the other hand, Bravo and Sheep Mountain pipelines have excess capacity, and the limiting factors there are the deliverability of wells at the source fields. Oxy and SandRidge (the WTO) are currently commissioning the Century plant to increase processing capacity of the low Btu (CO_2-contaminated methane) for both natural gas and CO_2 sales.

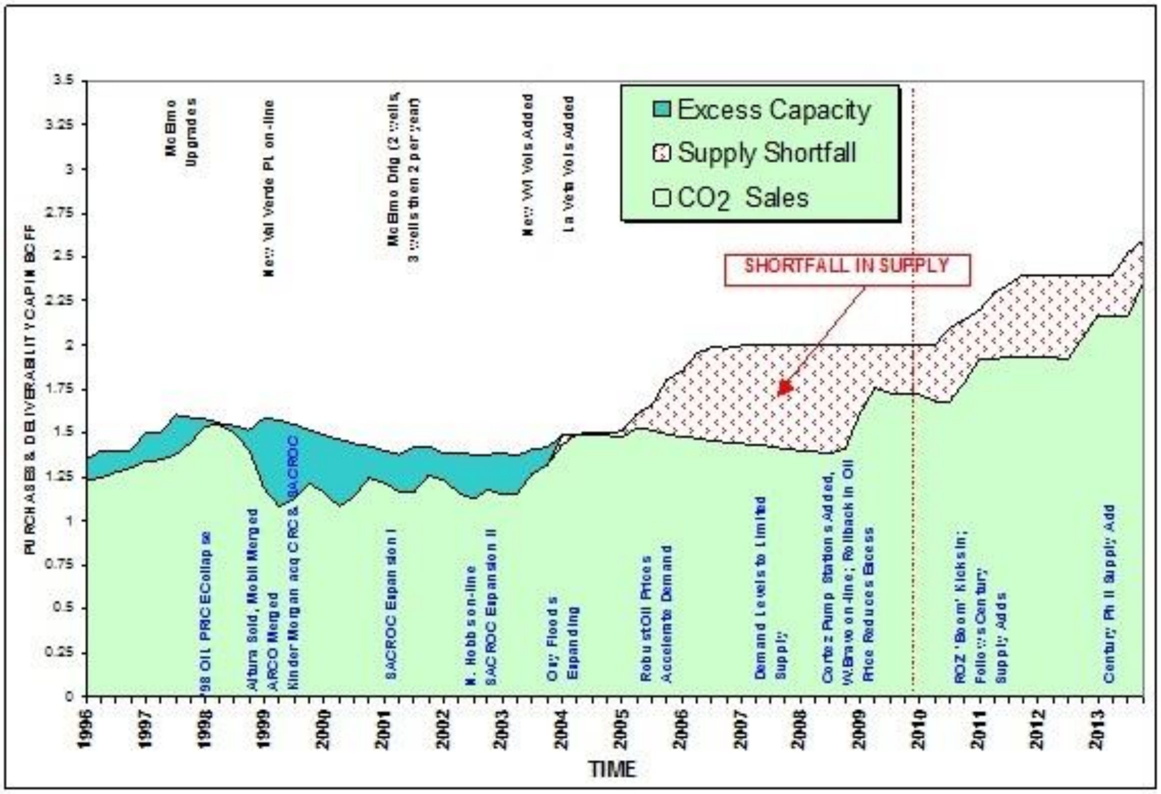
Although there is plenty of excess capacity in the northern portion of the Sheep Mountain line, flow is constrained by the declining productivity of the wells in the Sheep Mountain field, which is not being offset by additional supplies from the nearby and smaller La Veta field. Capacity on lower portion of the Sheep Mountain line is about 500 MMcfd (14 MMcmd) and the Bravo Pipeline is about 330 MMcfd (9 MMcmd), giving a total capacity of about 830 MMcfd (23 MMcmd) for these two. However, initial potential flow rates on new wells from both West Bravo and Brova Dome suggest regionally depleted reservoir pressures. It is therefore unlikely that additional deliverability from the Bravo Dome area will be forthcoming.

The capacity of the Val Verde pipeline is approximately 120 MMcfd (3 MMcmd), so there is little to no excess capacity on this line. However, industry intelligence indicates that Oxy will build new capacity designed to move volumes to the Central Basin pipeline, perhaps along either the Val Verde or Comanche Creek pipeline rights-of-way with the capacity to move expanded Century plant volumes. The Century plant expansion was planned to be under construction in 2011 but is at least postponed to 2012 based upon economics of the natural gas industry. The new Century plant CO_2 tailgate specifications will meet the Kinder Morgan Central Basin Pipeline (CBP) specifications and allow the CO_2 to move north, unlike the current CO_2 from the legacy plants which are precluded from entering the CBP. Removal of the H_2S to levels below 20 ppm was a key cost issue on this important plant design consideration.

As illustrated in Fig. 5.3.1, the growth in the CO_2 EOR market in the Permian Basin over the period 1985 to 2004 was slow; hampered by oil price crashes (in 1986 and 1998), uncertainties associated with future oil prices, and the lack of widespread operator knowledge of and comfort with CO_2 EOR technologies.

However, the situation has since changed. After nearly two decades where available CO_2 supplies to the Permian Basin outpaced demand in CO_2 EOR projects, since 2005 there has been a shortfall of CO_2 supply (see Fig. 5.3.3).

FIGURE 5.3.3 – CO_2 Supply and Demand History and Near-Term Projections for the Permian Basin



Today, the single largest barrier to expanding CO_2 flooding in the Basin is the lack of substantial volumes of reliable and affordable CO_2. This is despite the fact that several supply market responses have been taken to attempt to address this limitation. To recap:

- Kinder Morgan added three pump stations along the Cortez line, completed its Doe Canyon drilling and CO_2 processing plant and added several new McElmo Dome wells in southwestern Colorado, all in early 2008. The Doe Canyon volumes added 100-120 MMcfd (2.8-3.4 MMcmd) of CO_2 supply availability to the Permian Basin and the McElmo Dome drilling added another 200 MMcfd (5.6 MMcmd) of CO_2 production capacity. The pump stations allow a throughput upgrade to Cortez to get to 1,300 MMcfd (37 MMcmd).

- In the last two years, Hess has developed the West Bravo CO_2 source field in an attempt to deliver about 110 MMcfd (3 MMcmd) of new CO_2 for expanding injection into the deeper ROZ in the San Andres formation in the Seminole field.

As for the future, several potential projects have been in discussion which could also help to partially alleviate CO_2 shortages in the mid to long-term.

- Enhanced Oil Resources Inc. announced a memorandum of understanding for developing a pipeline with SunCoast Energy Corp. to transport 350 MMcfd (10 MMCmd) of CO_2 nearly 350 miles (563 kilometers) from its St. Johns, Arizona helium and CO_2 field to the Permian Basin.[8] The Chupadera Mesa project just east of Socorro in central New Mexico offers another helium play that could be developed. Both of these projects face some well completion challenges, reserve questions and questionable plant/pipeline economics.

- In June 2008, SandRidge Energy announced its agreement with Oxy to build a CO_2 treatment plant and associated CO_2 compression and pipeline facilities in Pecos and Terrell Counties in Texas, providing Oxy with a dedicated CO_2 stream for CO_2 EOR. The design of the Century plant calls for two stages of construction with an initial inlet plant capacity to start at about 300 MMcfd (8.5 MMcmd) (~1/2 CO_2) , but could ramp up to 1,000 MMcfd (28.3 MMcmd).[9] The development schedule and resultant CO_2 volumes beyond the initial phase will be dictated by natural gas prices.

The implied backdrop for all the source expansion planning is the large potential demand for CO_2 EOR enhancements of existing projects, along with the addition of new ones. As shown in more detail below, the anticipated potential for expansion in CO_2 demand to CO_2 EOR is high, based on the robust oil pricing forecasts and the backlogged list of planned, on-going and expanding projects in the Basin.

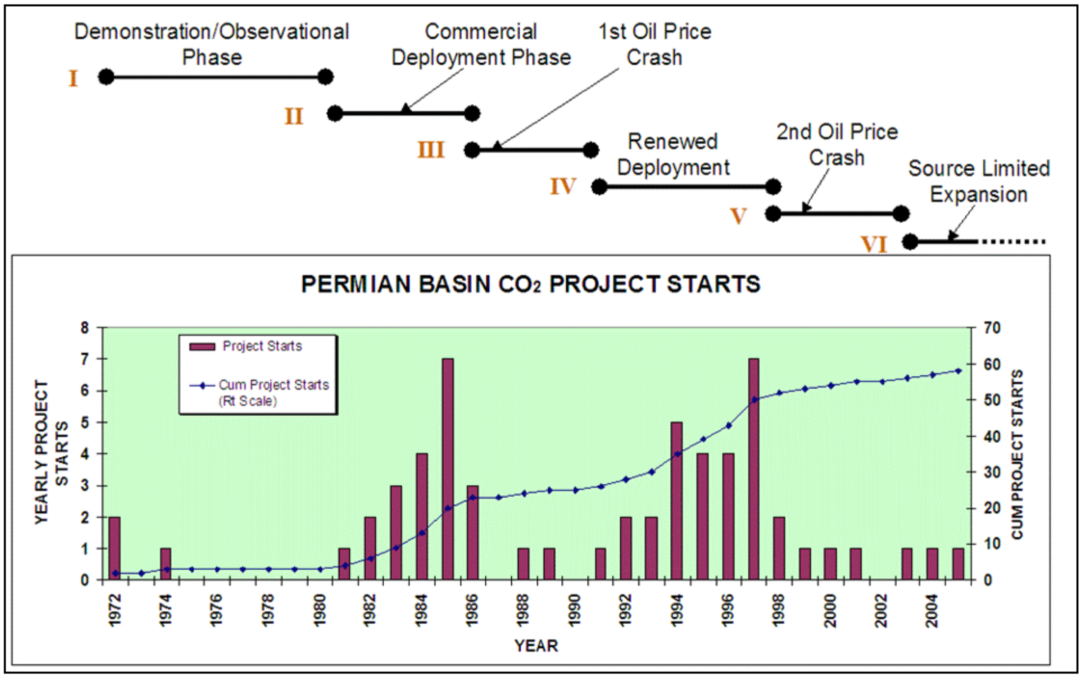
5.4 Potential Basin-Wide CO_2 Supply Growth – Long Term

As discussed already, unsatisfied demands on the CO_2 supplies within the Permian Basin were not a factor in new supply projects until 2005. The unmet demands were not understood in a collective sense even within the industry and, further, were unknown or misunderstood outside of the industry. The conventional thought about CO_2 EOR was that it was a small niche industry that was challenged to compete with low priced oil from abroad. As a result, companies with possible incremental CO_2 supplies were unaware of the growth potential of the marketplace. Most of those perceptions are changing now as reflected in interests from clean coal development companies (e.g., Tenaska) and some other utilities that are considering post combustion capture projects on existing plants. The concept of a "demand pull" for CO_2 capture is gaining some traction over the commonly perceived, environmentally conceived, "capture push" of climate change interests. The quantities of CO_2 that can make a difference for growing EOR companies will require the large, point source capture projects like Trailblazer. Again, recognition of the full and long-term demand potential of EOR is a key to the commissioning of such projects.

5.4.1 Typical EOR Project Development Sequences

To illustrate the possible development sequence for a group of prospects, Fig. 5.4.1 categorizes the phases of historical CO_2 EOR deployment in the Permian Basin. It can be noted that this is also representative of other relatively mature EOR regions such as Wyoming and Mississippi, except that both effectively avoided the necessity of (and skipped) Phase I. This simplification is intended to show the long term nature of the CO_2 EOR business, how projects proceed, and how there have been "starts and stops" in response to oil price fluctuations. Fig. 5.3.3 also shows that in the last few years, new project starts in the Permian Basin have been minimal, primarily the result of limited expansion of CO_2 sources for CO_2 EOR.

FIGURE 5.4.1 – The Phases of CO_2 Enhanced Oil Recovery Development in the Permian Basin



At the individual project level, it is difficult to lay out the full project life cycle for a CO_2 EOR project in the Permian Basin because few have yet to run through the entire cycle. CO_2 EOR projects that started in the early 1980s are still purchasing CO_2. Original forecasts for many of the larger fields would have shown these fields on total recycle and/or chase water by now; most are still purchasing CO_2 as they continue to inject and produce commercial oil.

The recent higher oil prices have justified on-going project expansions into less desirable portions of fields and implementation of second tier reservoirs (first tier reservoirs being those that are economic at a sub USD$20/bbl oil price) that were challenged to be economic in the sub USD$20/bbl oil pricing environment. Furthermore, well patterns currently under flooding stay in injection/production status longer. Improvements in technologies for conformance control have also aided in keeping patterns under flood. As a result, the industry is able to "squeeze out" more oil from these fields, and allow startups of smaller projects. In addition, the technology to efficiently conduct flooding, long protected within the oil majors, is now being successfully used by the large- and intermediate-sized independent oil companies as well.

The timing for development of CO_2 EOR projects has been traditionally very dependent on the perceptions of available of CO_2. This applies both to the development of new CO_2 EOR projects within a basin, as well as the timing of well pattern expansions within an individual field project. Moreover, project development is also often highly dependent on the availability of investment capital, field services like drilling and workover rigs, and materials and construction workers for development of CO_2 processing, recycling, compression, and distribution facilities.

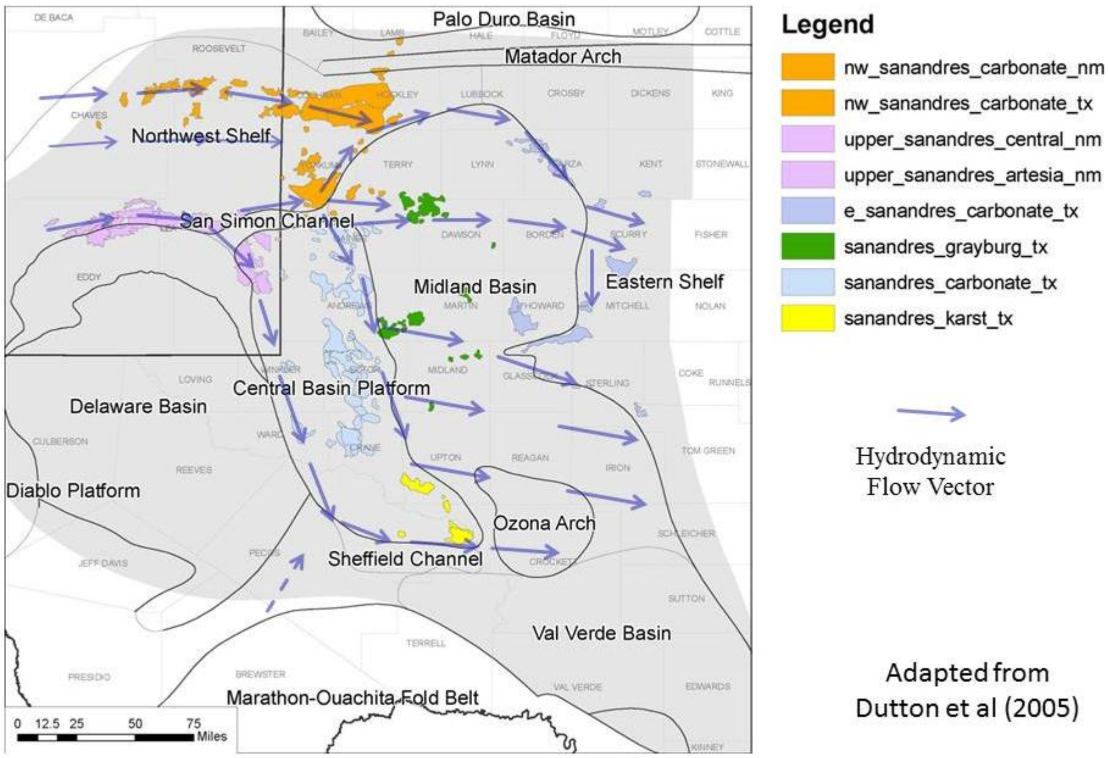
5.4.2 New Reservoir (CO_2 Demand) Developments

Commercial demonstration projects in the Permian Basin are changing the long-held view that CO_2 EOR is a niche industry, incapable of providing adequate demand for CO_2 to justify big capture projects. A very large part of the future Permian Basin demand story has to do with vertical expansion of the old anchor fields. It was historically recognized that the oil/water contacts (OWCs) were defined in the 1950s and 1960s based upon operators' desire to avoid the operational investments associated with handling large water volumes. Wells were drilled to a depth so as to avoid production of significant volumes of water. It was expected that oil could be produced below those intervals and several oil majors began to experiment with those intervals. The moniker of the day was to call those intervals transition zones and Shell extended the CO_2 flood at the Denver Unit 150 feet (45.7 meters) below the OWC in the mid-1990s. Hess did the same at Seminole with two pilots; however, they recognized that the term transition zone did not seem to explain the distribution of oil below the OWC and called the 300 foot (91.4 meter) thick interval the ROZ. Results of this early work were closely held until the 2006 time frame when the DOE issued a report that explained the possible origins of these intervals and the commercial (CO_2 EOR) significance of them[10]. The net effect of this 'revelation' has been to expand fields deeper and add new requirements for CO_2 on top on the existing demands for development of main pay zones.

Recent insights have demonstrated that the origin of these zones is not limited to vertical extensions of existing fields as would be expected using the concept of transition zones. But the origin of these zones lies in what is commonly termed Mother Nature's waterflooding that occurred long after the original basin-wide subsidence and oil entrapment phase and after the post entrapment tectonics (uplift) in the western reaches of the Permian Basin (New Mexico). This resulted in vast areas (referred to as hydrodynamic fairways in Figure 5.4.2) with residual oil zones hundreds of feet thick but without a main pay zone. Recent studies are showing the oil saturations are found to be quite comparable in these "greenfield" areas to those swept intervals in man's waterfloods and the ROZs beneath the main pay zones in existing fields.

When one couples the new oil price regime today with the maturation of CO_2 EOR technologies, the concerns over oil supplies for the future, the large targets below existing fields and between fields, and the environmental component of CO_2 storage during CO_2 EOR, companies with significant field assets in the Permian Basin are in a unique position to begin development a long range strategic plan for CO_2 EOR. New large supplies of CO_2 are critical.

FIGURE 5.4.2 – Permian Basin with Theorized Upper Permian Hydrodynamic Fairways



5.4.3 Characterization of Source Risks/Opportunities

With the exception of the natural gas separation plants in the southern Permian Basin, all the past CO_2 supply sources have come from natural domes developed by the majors to support their large oil producing assets. It was expected that, as those mature "anchor" fields wound down on their purchases, that the next tier of projects would be implemented and take advantage of the existing source and pipeline infrastructure. To a minor degree that scenario has occurred. But, those large anchor field assets: Slaughter, Wasson, Seminole, Means, and SACROC, have retained their purchases well beyond their expected terms. And now they are expanding vertically into the ROZ. To prove the point, the vertical expansion at the Seminole field has required Hess to develop a new source, the West Bravo Dome, to obtain the necessary CO_2 supplies. Today, with the newly gained knowledge of the thickness of the ROZs, oil can be produced economically from these fields for the foreseeable future, so it may be a very long wait for the large anchor fields to disappear from the list of top CO_2 purchasers.

So where will the new sources come from? As mentioned, the St. John's Anticline and/or Chupadera Mesa are possible additions. But both have been challenged by concerns over reserve and development risks. What appear to be more likely to develop in the long term are large point sources from coal-fueled power plants. Worldwide interests for development of clean coal plants can be led by the USA or, alternatively, by other countries with large coal resources. The huge mineable coal reserves in the USA would suggest that at least some new large projects will be developed here. Climate change legislation is not likely in the near term, so very large federal and state incentives for early action are likely to replace a "carbon price" and facilitate "first mover" plant implementations. Some key questions include: will the incremental economics of CO_2 sales to EOR spur some of these projects to deliver CO_2 to the Permian Basin? Will the well-positioned Permian Basin EOR companies join in an alliance with those plants?

The CO_2 transportation world has evolved in the same way that the existing CO_2 source entities have, i.e., to serve the upstream oil producing assets. While the current large transporters, KinderMorgan, Oxy, and ExxonMobil, also serve as CO_2 brokers in connecting suppliers to producers, they often do this for internal use in their own EOR floods. These "Big 3" are also perceived as oil producers first and, as such, are often viewed as competitors in producing oil which can lead to a lack of full trust and confidence within the competing producers seeking an affordable supply of CO_2.

There has been an interesting exception to the "Big 3." In the past, Trinity CO_2, LLC has postured themselves as a primary provider of CO_2 for a group of oil producers like Chevron, XTO, Apache and Legado. Although the CO_2 volumes they transport and broker are smaller than the "Big 3," their network of clients is just as large. Their corporate model is an interesting one for companies considering capture projects. A recent announcement[11] would suggest that Trinity might begin to use their transportation assets to facilitate becoming an upstream oil producer. Thus, it would now appear that the entire list of current Permian Basin CO_2 suppliers and transporters are motivated first by full utilization of their existing supplies; encouraging other floods or even new supplies could be viewed as jeopardizing their growth objectives.

Oxy, like many CO_2 companies, has been feeling the pinch of tight, hard-to-contract CO_2 supplies. This has caused some curtailment of new CO_2 supplies to many fields, and has led Oxy to seek contracts for less-than-optimal short-term supplies to obtain needed CO_2 volumes. Like Hess at West Bravo, they are now developing their own alternative source at the Century plant through their alliance with SandRidge.

Consolidations are continuing to occur in the oil producing marketplace. The recent announcement of the mergers between Denbury and Encore and the one between Exxon and XTO are the most recent examples that affect USA and Permian Basin assets. Encore was not a CO_2 EOR player, but had several projects amenable to flooding, and had just made the jump to lock in a CO_2 source (the Madden Field's Lost Cabin gas plant) in Wyoming. Denbury is one of the most capable of the CO_2 EOR-focused companies and, if choosing not to divest of the Encore Permian Basin assets, the merged company could become a large player in the Permian Basin as well as in a new area (northern Rockies) in a relatively short amount of time. XTO operated (caretaking) three CO_2 floods (coincidentally acquired from Exxon this past decade: Wasson Mahoney, Cordona Lake, and Goldsmith) but was not an aggressive CO_2 EOR company. Further questions include: will XTO change their posture or will Exxon regain enthusiasm for Permian Basin oil production? If so, where will the CO_2 come from?

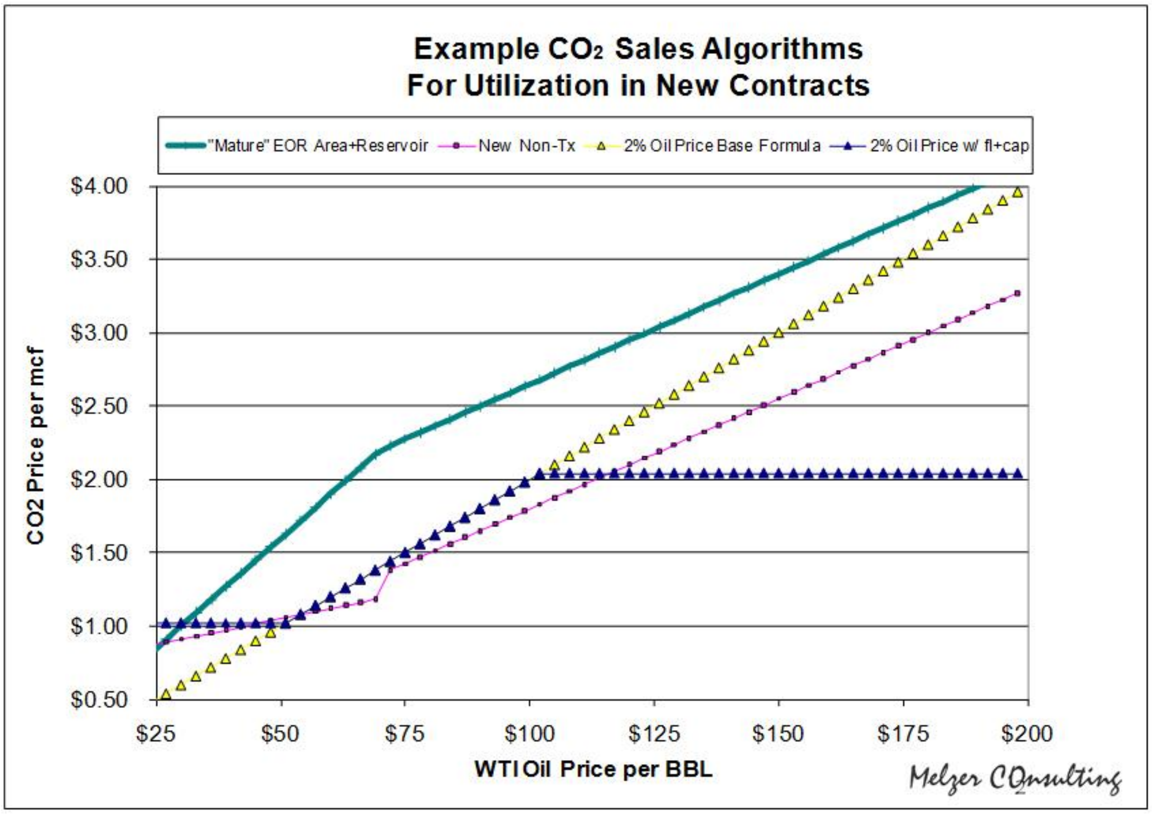
Because shortages of CO_2 are curtailing new CO_2 EOR projects, new CO_2 providers may find themselves in a position to be a desired partner for EOR companies. Historically, the EOR companies developed their own CO_2 sources, like McElmo and Bravo Domes, in order to conduct their EOR projects. They historically have not been in a mindset to, for example, develop a coal-fueled power plant. CO_2 shortages are one driver that may change that mindset. Another driver may be that EOR companies want to provide CO_2 storage ("offsets") for a portion of the oil they produce. That approach might lead to CO_2 EOR and CCS becoming synonymous with long-term corporate strategies. Alliances with anthropogenic CO_2 capture companies may be part of that scenario. Such alliances could result in both the capture and EOR companies sharing equity in the respective projects and may include the transporting company as well. Such an integrated company would necessarily need to possess a lot of multi-disciplined talent and experience but examples in other industrial sectors exist

5.4.3.1 *More Costly Injectants and CO_2 Pricing Considerations*

The water flooding of oil reservoirs was a technology widely deployed in the 1950s and 60s. CO_2 flooding came along two decades later and changed the cost equation because of the significantly more expensive injectant. The incremental expenses come from both the initial purchase price and the recycle costs. But the CO_2 offers some advantages over water as it mixes with the oil and allows most of the oil contacted by the CO_2 to be "swept" from the rock and carried along to the producing wells. Since water and oil do not mix, much of the oil in the reservoir is bypassed by the water. But because CO_2 is more expensive than water, it requires closer surveillance within the reservoir to be sure that it is indeed at work liberating oil. It is also the reason that the mantra of CO_2 flooding has been to minimize the CO_2 volume per barrel of oil produced so as to increase profitability of the flood. New observation methodologies for CO_2 floods were required and developed in order to assure oil producers that the CO_2 was effectively sweeping the reservoir and contacting sufficient volumes of oil.

The performance metrics and surveillance methods for optimization of CO_2 in the reservoir are needed but some restraints on monitoring a flood is required or the economics of the flood can be compromised. When oil prices are robust, surveillance can be minimal and the floods can be run less efficiently but remain economically successful. However, when oil prices are low, operators need to find ways to increase flood efficiency and/or reduce costs. One way to cut costs was to develop a price to be paid for the CO_2 that recognized volatility of oil prices, for example, a CO_2 price dependent on oil prices. Flooding companies would be willing to share some of the EOR project upside revenues when oil prices were high if the supplier would share some of the downside risk. Some oil price algorithms were developed for such a purpose and several examples are shown in Figure 5.4.3.

FIGURE 5.4.3 – Example CO_2 Sales Algorithms for Utilization in New Contracts



NOTE: All dollar figures in Figure 5.4.3 are in $USD. One tonne is equal to 19.25 mcf.

As shown in Figure 5.4.3, many of the pricing relationships have more complex formulae but a commonly used rule of thumb algorithm is CO_2 price = 2% of the posted project equivalent oil price. A base price is usually included to protect the supplier's infrastructure costs of delivery while a "collar" price is occasionally invoked to balance out the base price concept and provide purchasers' the upside should prices move substantially higher.

Finally, with the coming days of anthropogenic CO_2 sourcing, some reliability discounting principles are entering into the marketplace. Scheduled downtime for plant maintenance is one thing but sudden and frequent 'outages' can be quite harmful to the economics of a successful CO_2 EOR project. While naturally-sourced CO_2 field is in the mainline business of providing CO_2, anthropogenic sources are, by definition, producing a non-CO_2 primary product and the CO_2 is likely ancillary to that industrial product. It should be noted, however, that precedents for successful and reliable plants do exist (Shute Creek in Wyoming, USA and Dakota Gasification in North Dakota, USA).

5.4.3.2 *Other Considerations and Risk Factors*

Within the oil industry in general and the CO_2 flooding sub-industry in particular, the price of oil is almost unanimously considered the largest risk factor faced. Since price is a function of demand, it could be helpful to scope oil demand risk in the following framework:

> ***Case I: Oil as a "Clear and Present Danger":*** Worldwide and USA policies are implemented which could evolve to discourage oil (and coal) production and the use of CO_2 EOR. Under this scenario, existing oil incentives could be removed and regulations around emissions (from both production and plant operations) would be increased while fees and taxes would also be increased. The inevitable results of this case would be that new EOR investment dries up and existing operations move to an accelerated decline mode.
>
> ***Case II: Healthy Business Continues:*** EOR using CO_2 continues as a healthy business with limited negative consequences from policy changes. Oil price drives new investment where affordable CO_2 is available from incremental expansion of natural sources and relatively pure (economic) anthropogenic CO_2 capture. The net effect of any carbon legislation, regulation and energy tax policy is not material relative to the value of oil as a transportation fuel.
>
> ***Case III: Aggressive CCS:*** Worldwide and US policies are implemented which incentivize capture and storage of large CO_2 volumes. CO_2 EOR is qualified as storage within a clear legal and regulatory framework. Transportation issues are resolved and a pipeline infrastructure develops; EOR is seen as one piece of a near term bridge to large scale capture and storage throughout the USA, and eventually, a more sustainable energy future.

Under Case I, oil (and coal) producers would face a dramatically uncertain environment due to unfavorable national or state policy actions. One example would include the imposition of direct or indirect taxes on domestic oil (and coal), disadvantaging USA barrels against imported ones. CO_2 EOR operations are expensive and small changes in the tax laws can make large differences to project profitability. Another risk has to do with the current proposal by the USA Environmental Protection Agency (EPA) to include natural source CO_2 field as emission sources of greenhouse gases. Although the industry views the CO_2 as moving from one underground secure setting (the source field) to another (the oil producing field), the proposal would require possibly expensive monitoring of CO_2 to demonstrate the net volumetrics involved in the storage (retention) underground. There exists even a possibility that the 'incidental' CO_2 storage (retention) during CO_2 EOR operations would be disallowed and the source field and/or oil producers would have the commensurate liability of the greenhouse gas volumes they handle.

With Case I as the pessimistic view of oil's (and EOR's) future, either Case II or III outlines fairly robust CO_2 EOR growth. Clearly, one of the significant upsides for growth is the large number of potential CO_2 candidate fields within short distances of existing pipelines. Under Case II, tier 1 projects would move forward under current supply constraints. Under Case III, effectively all potential CO_2 EOR assets would get developed but on an extended time scale dependent on industrial plant CO_2 capture projects. In addition to the San Andres ROZs, other deeper pay zones below the San Andres formation (Glorieta, Clearfork and Abo in particular) offer some additional and large CO_2 EOR potential for the future.

Historically, existing producing fields have been viewed only through the perspective of their main pay zones. It is very appropriate to re-examine CO_2 EOR targets considering the new oil price regime, technology, and Case III upsides which include projects like Trailblazer. While it is true that much needs to be learnt about next generation energy from coal (for example, post-combustion capture), there is no better place to do the projects than in an area with shortages of commodity CO_2.

5.5 Permian Basin CO_2 Market Summary

With the new oil pricing environment and changing perceptions about robust targets for CO_2 EOR, capture companies can find themselves in a strategic position to formulate alliances and joint ventures as their projects move forward. Mature CO_2 EOR regions have the advantage of proven reservoirs and, as such, can afford to pay higher prices for CO_2. EOR companies without adequate supply contracts are commonplace in an area such as the Permian Basin.

Downside risks to forming the CCS/EOR joint ventures/alliances include lower oil prices, possible federal and state policies disadvantaging oil as an energy source for transportation fuels, and developing a somewhat complex and technically oriented staff/business unit that will provide only small returns in the near term. Upsides include a rather unique opportunity for a joint environmental and natural resources development strategy, something very uncommon in today's world. A position in a business with both environmental solutions (CO_2 storage) while participating in a huge EOR growth opportunity could find rewards worldwide.

6.0 Government Support

Absent a major, sustained increase in oil prices (and an attendant major, sustained increase in CO_2 prices) and/or electric prices, government support will be required to make the Project economic. Local and state governments have a standard toolkit of economic incentives at their disposal to encourage the development of large, capital intensive projects, and the State of Texas has adopted additional incentives to encourage the construction of clean energy projects, but these alone are not sufficient to bridge the current gap. This section of the report looks at the government support currently available to Trailblazer, and discusses what additional support likely will be necessary to make the Project economic.

6.1 Local Government Support

Trailblazer is located in unincorporated Nolan County, Texas USA. Although it is located outside the city of Sweetwater, it is within the limits of the Sweetwater Independent School District.

6.1.1 Nolan County Tax Abatements

The Texas Legislature provides that counties may grant tax abatements for up to 10 years to support economic development efforts. At its two Texas combined-cycle plants, Tenaska received 75 percent county tax abatements for their first 10 years of operation. Tenaska received the same abatement from Nolan County for Trailblazer. It is not clear whether carbon capture equipment will be considered under Texas law as pollution control equipment, and therefore be exempt from inclusion as taxable property. Regardless, the value of this abatement over the 10-year abatement period certainly will be in the tens of millions of USD.

6.1.2 Sweetwater Independent School District Tax Abatement

One of the benefits of being an Advanced Clean Energy Project (ACEP), as defined by the Texas Legislature and discussed in Section 6.2 below, is the ability to receive an abatement of school district property taxes. Schools in Texas are largely funded by property taxes. An ACEP is eligible to receive an abatement of school property taxes for eight years, with the state making up the lost property taxes to the school district. This abatement is substantial when applied to a USD$4 billion project.

6.2 State of Texas Support

In 2007, the Texas Legislature passed House Bill (HB) 3732, which set standards for ACEPs and provided tax, financial and regulatory incentives to projects that could meet those standards. To qualify as an ACEP, a project must:

- Reduce SO_2 emissions by 99 percent;
- Reduce mercury emissions by 95 percent;
- Meet a NO_x emission rate of no more than 0.05 pounds/million British Thermal Units;
- Render CO_2 capable of capture, sequestration or abatement; and
- Use coal, biomass, petroleum coke, solid waste, or fuel cells using hydrogen

derived from these fuels.

In 2009, the Texas Legislature passed additional legislation to provide incentives to projects that capture CO_2. That legislation included:

- HB 469, which:
    1) Modifies the definition of an ACEP to require a CO_2 capture rate of at least 50 percent, rather than just being capable of capture;
    2) provides sales tax exemptions to ACEPs for equipment that captures, transports and stores CO_2;
    3) provides that the first three projects achieving a 70 percent carbon capture rate will qualify for a USD$100 million franchise tax credit; and
    4) provides a 30-year, 75 percent severance tax exemption for oil recovered using CO_2 captured from man-made emission sources.
- Senate Bill 1387, which provides a framework for regulation of CO_2 sequestration and storage between the Texas Railroad Commission and the TCEQ.

These provisions lay a strong foundation of support for the Project.

6.3 USA Federal Support

Although local and state incentives are extremely important to the Project, they are not sufficient to bridge the current gap between the additional cost of the carbon capture plant and the revenues the Project will realize from the sale of CO_2. In order to offset the added costs of this first-of-its-kind carbon capture plant, either some value must be placed on the reductions of greenhouse gases that this project provides, or direct, policy-based inducements need to be developed to encourage early CCS deployment and ultimate commercialization. Under current conditions, Trailblazer cannot move forward without such support, unless the market prices for CO2 and electricity change significantly.

A discussion of some of the policies/legislation that have been or are being considered at the USA federal level to help address the gap follows.

6.3.1 Cap and Trade

Cap and trade is an environmental policy tool that sets a mandatory cap on emissions while providing sources with flexibility in how they comply. Examples of successful cap and trade programs include the USA's nationwide Acid Rain program and the regional NO_x Budget Trading Program in the Northeastern USA. For instance, according to the EPA, SO_2 emissions from Acid Rain Program sources have fallen from 17.3 million tons in 1980 to about 7.6 million tons in 2008, a decrease in emissions of 56 percent[12].

There have been two recent major CO_2 cap and trade proposals before the USA Congress – the American Clean Energy and Security Act (Waxman-Markey) and the American Power Act (Kerry-Lieberman). Waxman-Markey passed the USA House of Representatives in July 2009, but failed to get any traction in the USA Senate. Kerry-Lieberman was issued as a draft bill in the USA Senate in May 2010, but never gained any momentum there. Either of these bills would have provided sufficient incentives to move Trailblazer forward.

6.3.2 Section 45Q Tax Credits

The Energy Improvements and Extension Act of 2008, as amended by the American Recovery and Reinvestment Tax Act of 2009, enacted Section 45Q of the USA Internal Revenue Code, which provides tax credits for taxpayers that capture $CO_2$from an industrial source that otherwise would be released into the atmosphere and dispose of the CO_2 in secure geological storage within the USA. Internal Revenue Service Notice 2009-83, which discusses the credits for CO2 sequestration under Section 45Q, is included as Exhibit 1 to this report.

Section 45Q provides for a tax credit of USD$20 per metric ton of qualified CO_2 that is captured and disposed of in secure geologic storage, and USD$10 per metric ton of qualified CO2 that is captured and used as a tertiary injectant in a qualified EOR project then disposed of in secure geologic storage.

For Trailblazer, which expects to capture 5.75 million tons of CO_2 per year for use in EOR projects, this would mean a credit of USD$57.5 million per year in tax credits.

Importantly, and from a financing perspective quite problematically, the 45Q tax credits are available only for the first 75,000,000 metric tons of qualified CO_2 for which the credits are applied. Once that threshold is reached, no more credits would be available. Because of the uncertainty associated with how long (if at all) these tax credits would be available, they would not be considered as a revenue source in a financing.

There are some attempts being made in Congress to modify the 45Q tax credit program to provide the certainty that would be required to help projects obtain financing. It remains to be seen whether those efforts will be successful.

6.3.3 Clean Energy Standard

In March 2011, President Barack Obama issued his “Blueprint for a Secure Energy Future,” which is attached as Exhibit 2 to this report. The document sets a national goal of generating 80 percent of the USA’s electricity from “clean energy sources, including renewable energy sources like wind, solar, biomass, and hydropower; nuclear power; efficient natural gas; and **clean coal**.” (emphasis added).

It also proposes a Clean Energy Standard, which would work by giving power plants clean energy credits for every megawatt-hour of electricity they generate from clean energy. Clean energy credits would be issued for electricity generated from renewable sources and nuclear power, with partial credit for generation from efficient combined-cycle natural gas plants and fossil fuel plants that capture and store CO_2.

It is unclear whether the President’s Clean Energy Standard will gain the necessary support to become law. It also is unclear whether a market for clean energy credits would be sufficient by itself to bridge the revenue gap.

6.4 International Support

In recognition of Trailblazer's importance as an early CCS project, the Project was selected by the Global CCS Institute to receive an AU$8.03 million grant to fund the FEED study for the Project's carbon capture plant. In return for the grant, the Project agreed to share knowledge gained through the development process with the Global CCS Institute, in order to assist others in the acceleration of CCS projects throughout the world. Although the amount of the grant is modest relative to the overall cost of the Project, it sends a powerful message to the Project's USA governmental constituencies that this Project is important and worthy of support.

7.0 The Revenue Gap

The sections above have explored the potential revenues Trailblazer could receive for its two main products – electricity and CO_2. The other side of the equation is the additional costs associated with constructing and operating a CO_2 capture plant in addition to a greenfield coal-fueled electric generating station.

As indicated previously, Tenaska considers its revenue forecasts to be confidential and proprietary information. The same is true of its construction and operating costs. Even so, Tenaska is willing to provide some general information to help the Global CCS Institute's members gain insights into the challenges facing projects such as Trailblazer.

In general, the addition of a carbon capture plant adds about 30 percent to a project's capital costs. It adds somewhere around 10 percent to a project's operating costs. Finally, and most importantly, operation of the carbon capture plant consumes a significant amount of the electricity (about 25% of net output) that otherwise would be available for sale (the energy penalty).

On the plus side, assuming a project is located where its captured CO_2 is a saleable product and not a waste stream, the Project gains an additional revenue stream from CO_2 sales. In the State of Texas, there are state and local incentives available to ACEPs that provide some additional revenue. However, the revenues achieved through CO_2 sales plus available state and local incentives are not sufficient to make up for the increased capital and operating costs and the energy penalty caused by the carbon capture plant's consumption of electricity. Figure 6.0 shows in a very general way the relative impacts a carbon capture plant has on costs and revenues.

FIGURE 6.0 – Revenue Gap

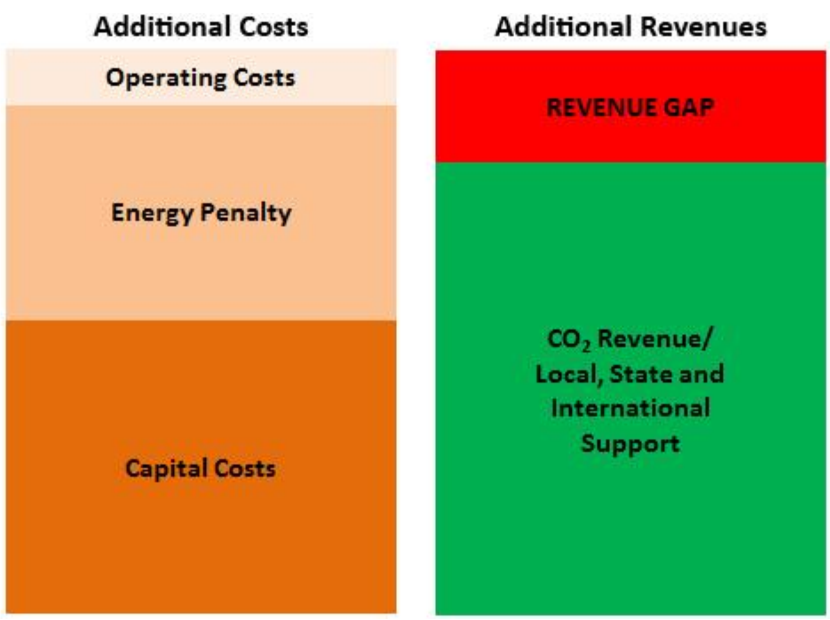


Figure 6.0 shows the current gap that needs to be filled in order for Trailblazer to be

economic. Today, that gap can be filled in one of three ways:

1) If oil prices continue to increase, CO_2 revenues potentially could increase enough to bridge the gap;
2) Electric prices could increase enough to bridge the gap; or
3) Federal policies could change to bridge the gap. In the future, technological improvements and/or a reduced risk premium as technology matures also could help bridge the gap.

8.0 Relevance to Carbon Capture and Storage

Trailblazer will be the first new pulverized coal plant to incorporate a full-scale carbon capture plant into its initial design. As such, the real world knowledge gained by understanding the market dynamics facing the Project will be invaluable to the overall goal of advancing projects worldwide that will capture and store CO_2.

An understanding of the ERCOT market and Trailblazer's place in that market should assist policy makers as they consider the types of incentives that may be required to make carbon capture projects financially viable.

In addition, the Project's location near one of the most robust CO_2 market in the world allows a detailed look at how CO_2 markets should work efficiently and effectively and provide information that could be used by developing CO_2 markets.

9.0 Conclusions

Using its own proprietary information, well-known electrical models and information from a highly respected Permian Basin CO2 expert, Tenaska draws the following conclusions about Trailblazer's economics:

- Based on current oil and electric prices and federal support, using a net present value cost evaluation, Tenaska's models would not build a coal-fired plant with carbon capture in ERCOT between now and 2030. However, the models clearly show that if Trailblazer is built, it could be confident that it would operate with a high capacity factor, as revenues from its CO_2 sales would offset almost all of the Project's variable operating costs;
- The development of ROZs and the demand for CO_2 the ROZs will generate give Tenaska a high level of confidence that it will be able to sell all of the CO_2 Trailblazer produces into the Permian Basin EOR market;
- Based on current CO_2 pricing in the Permian Basin, CO_2 revenues will not be sufficient to make up for the significant additional costs associated with Trailblazer's carbon capture plant. If oil prices were to climb significantly, it is possible that at some price level CO_2 revenues would be able to bridge that gap; and
- It is highly likely that some kind of federal policy that sets a price on carbon emissions or provides direct inducements with sufficient certainty will be required to make the economics of the Trailblazer project work. Currently, no such policy exists.

10.0 Acronyms and Citations

10.1 Acronyms

Acronym	**Definition**
ACEP	Advanced Clean Energy Project
Bcfd	Billion Cubic Feet Per Day
CCS	Carbon Capture and Storage
CO_2	Carbon Dioxide
CO_2 EOR	CO_2 Enhanced Oil Recovery
CPB	Kinder Morgan Central Basin Pipeline
CREZ	Competitive Renewable Energy Zone
DOE	United States Department of Energy
EIA	Energy Information Agency
EOR	Enhanced Oil Recovery
EPA	United States Environmental Protection Agency
EPIS	EPIS, Inc.
ERCOT	Electric Reliability Council of Texas
FERC	Federal Energy Regulatory Commission
HB	House Bill
Kerry-Lieberman	American Power Act
Mcf	Million Cubic Feet
Mcm	Million Cubic Meters
MMcfd	Million Cubic Feet per Day
MMcmd	Million Cubic Meters per Day
MW	Megawatt
MWh	Megawatt hour
NO_x	Nitrogen oxides
O&M	Operations and Maintenance
OWC	Oil/Water Contacts
PRB	Powder River Basin
Project	Tenaska Trailblazer Energy Center
PUCT	Public Utility Commission of Texas

Acronym	**Definition**
ROZ	Residual Oil Zone
RPS	Renewable Portfolio Standard
SACROC	Scurry Area Canyon Reef Operators Committee
SO_2	Sulfur dioxide
TCF	Trillion Cubic Feet
Tenaska	Tenaska, Inc.
Trailblazer	Tenaska Trailblazer Energy Center
USA	United States of America
USD	United States Dollars
Waxman-Markey	American Clean Energy and Security Act
WTO	West Texas Overthrust

10.2 Citations

[1]Ball, Mahlon M., "Permian Basin Province (044),"
http://certmapper.cr.usgs.gov/data/noga95/prov44/text/prov44.pdf

[2]http://www.ercot.com/news/press_releases/2010/nr-12-01-10

[3]http://www.texascrezprojects.com/

[4]http://www.texascrezprojects.com/overview.aspx

[5]Moritis, Guntis, "CO_2 Miscible, Steam Dominate Enhanced Oil Recovery Processes," *Oil and Gas Journal*, April 19, 2010, pp 36-40.

[6]It is well known that water and oil do not mix together. The technical term used for this is immiscible. However, other gaseous and liquid substances have the property of mixing with oil and are thereby "miscible." This miscibility property is dependent not only on the nature of the two substances but the pressure and temperature at which they come in contact. CO_2 and many oils are miscible at common reservoir pressures.

When CO_2 is injected into a well and moves out into the waterflooded region, it will contact oil that was bypassed by the water. The oil that is contacted becomes a mixed substance and takes on new properties independent from either the single phase CO_2 or the oil. The mixed substance can mobilize the oil by making it lighter and free to move off the rock surfaces to the producing wells. The moving oil/CO_2 continues to contact oil, freeing more oil as it progresses. Over time, the rock can be "cleaned" with only single digit percentages of oil left behind - the mobilized oil all being driven along from the injector wells to the producing wells.

[7] Oil & Gas Journal Annual Production Report, April 19, 2010

[8]Enhanced Oil Resources Inc., "EOR Announces Approval Of St. Johns Helium/CO2 Unit In Arizona," press release issued April 16, 2009 (http://www.enhancedoilres.com/news/EOR-nr-Apr162009.pdf) and http://www.suncoastenergy.com/PDF/CO2Pipeline.pdf.

[9]SandRidge Energy, Presentation at Investor/Analyst Meeting, March 3, 2009.

[10] http://fossil.energy.gov/programs/oilgas/publications/eor_co2/ROZ_Melzer_Document_with_figures.pdf & http://www.residualoilzones.com/resources/index.html.

[11]http://www.trinityco2.com/Morgan%20Stanley%20Private%20Equity%20and%20Trinity%20CO2%20 Announce% 20Strategic%20Partnership.pdf.

[12]http://www.epa.gov/capandtrade/