Abstract

The objective of carbon capture and sequestration (CCS) is to reduce emissions to the atmosphere through the sequestration of carbon dioxide (CO2) in deep geologic formations. Recent studies of life-cycle emissions from CCS projects that sequester CO2 captured from coal-fired power generation through EOR show that net emissions from this process are positive due to the CO2 emissions embodied in produced oil. For geologic sequestration through enhanced oil recovery (GS-EOR) to be effective, life cycle GHG emissions from the system must be small and consumption of the energy produced should not result in larger emissions than would otherwise happen in the absence of the GS-EOR project. In the best case, where relatively high emissions intensity oil and electrical generation are being displaced, the emissions reduction potential is greater than the amount of CO2 purchased by the project; however, where a relatively light crude and carbon free marginal generation is being displaced, the GS-EOR project results in an emissions increase. As a matter of public policy, if reducing emissions of CO2 is of great importance, encouraging GS-EOR will not be as effective as geologic sequestration in deep saline aquifers, or other means of reducing emissions that do not result in increased production of fossil fuels. Nonetheless, it is likely that GS-EOR projects will happen in the absence of emissions reduction incentives because they bring other benefits. The nature and scope of a GHG reduction program will determine the accounting approach needed to accurately estimate the emissions from GS-EOR, but in general, components that do not fall under an emissions cap will need to be accounted for via life cycle assessment. While further study is needed, it appears that allocating the emissions reduction to an electric power generator would be less complex and more effective that allocating it to the oil or fuels producer.

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1. Introduction

The objective of carbon capture and sequestration (CCS) is to reduce emissions to the atmosphere through the sequestration of carbon dioxide (CO2) in deep geologic formations. While deep saline formations may provide the...
storage capacity needed for CCS to play a major long-term role in reducing greenhouse gas (GHG) emissions, in the near term, there is significant economic pressure to couple the development of CCS in the United States (USA) with the demand for CO₂ used in enhanced oil recovery (EOR). In the USA, the market for CO₂ for EOR is substantial and growing. Approximately 60 Mt of CO₂ was purchased in 2009, roughly double the amount sold in 2004, with 10 Mt coming from anthropogenic sources [1]. For decades CO₂ for EOR was extracted from natural geologic CO₂ deposits, but with higher oil prices, aging U.S. oil fields, and dwindling natural CO₂ supplies, demand for CO₂ now outpaces supply [1]. Unlike geologic sequestration (GS) in deep saline aquifers, geologic sequestration through enhanced oil recovery (GS-EOR) results in increased production of a valuable product—crude oil—and the emissions from this oil must be considered when judging the effectiveness of GS-EOR as a climate mitigation technology.

Linking carbon capture at power plants or other industrial facilities with EOR has clear benefits: in the near term, the cost of deploying of CO₂-capture technologies could be offset by CO₂-sales [2]; infrastructure built today for EOR could complement the development of saline aquifer sequestration in the future; laws and regulations surrounding EOR in the U.S. today are clear [3]; and, experience from injection of CO₂ for EOR will aid in understanding and managing CO₂ injection into saline aquifers [4]. However, recent studies of life-cycle emissions from CCS projects that sequester CO₂ captured from coal-fired power generation through EOR show that net emissions from this process are positive due to the CO₂ emissions embodied in produced oil [5]. This means that GS-EOR can only be viewed as a means of reducing GHG emissions if the energy and fuels produced by the GS-EOR project—oil and electric power, for example—displace more GHG intensive fuels. Furthermore, use of the term displacement implies that the energy or fuels produced by GS-EOR is not additional production, but rather displaces energy that would be produced otherwise—a plausible assumption as long as the quantity of oil produced by GS-EOR is very small compared to total worldwide oil production.

For geologic sequestration through enhanced oil recovery (GS-EOR) to be effective life cycle GHG emissions from the system must be small and consumption of the energy produced should not result in larger emissions than would otherwise happen in the absence of the GS-EOR project. So in the case of a GS-EOR project importing CO₂ from a coal fired electric power plant, this means that the emissions from coal production and transport, electricity generation, CO₂ capture and transport, oil production and refining, and oil combustion (likely as transportation fuels), must be less than the emissions if an equivalent amount of electricity was produced by the displaced generation technology, and an equivalent amount of oil was produced by the marginal producer and consumed. In other words, accurately quantifying the emission reductions produced by GS-EOR depends on the carbon intensity of the electricity and oil that are displaced, and on ensuring that emissions from all components of the system are considered.

This paper addresses how the net emissions from GS-EOR projects coupled with electric power generation can be estimated, how emissions from GS-EOR projects should be handled and, if emissions reductions occur, policy and regulatory consideration for how they might be allocated between power and oil producers.

2. Estimating Emissions Reductions from GS-EOR coupled with electric power generation

A precise estimate of the net emissions from GS-EOR must necessarily include the greenhouse gas emissions from associated activities both upstream and downstream of the GS-EOR project. For a GS-EOR project coupled with a coal-fired power plant, these processes include coal production and transport, combustion at power plant, CO₂ transport, EOR operations, oil refining, and ultimately combustion of the produced oil. Figure 1 shows these process steps for the coupled power and GS-EOR project [5].

CO₂-flood EOR uses CO₂ to improve recovery of oil from reservoirs that have undergone primary and usually, but not always, secondary production (i.e., driven by pressure depletion or artificial lift, and water injection, respectively). After the reservoir has undergone primary and secondary recovery, typically 40% to 60% of the original oil in place remains trapped in the reservoir—EOR allows an additional 10% to 15% of the original oil in

1 We will refer to EOR projects designed and operated to permanently sequester CO₂ from the atmosphere as GS-EOR projects to differentiate them from EOR projects undertaken strictly to increase recovery of oil. This is an important differentiation because GS-EOR projects should and, in the USA, and are likely to be subject to different monitoring, verification, and accounting requirements than EOR projects.

2 While CCS can be applied to many industrial processes, we consider coal fired power generation in this article because application of CCS in the electric power sector would bring the largest benefit. Worldwide, nearly 70% of electricity is generated from fossil fuels, of which over 60% is coal [6]—a relatively inexpensive, abundant, and carbon intensive source of energy.
place to be recovered [7]. CO₂ is injected through a well into the target reservoir; the CO₂ mixes with oil in the reservoir, extracting oil that would otherwise be trapped in the rock and creating a mixture that flows more readily; and the CO₂-oil mixture, along with reservoir brine, is brought to the surface at a production well. At the surface, the produced fluid mixture is collected, separated by phase, and the crude oil treated through the addition of chemicals such as emulsifiers to prepare it for sale. Depending on the size of the oil field, there may be thousands of wells. For example, at the Wasson Denver Unit in Texas, USA—the largest EOR project (by production)—there are over 1000 injection wells and nearly 600 production wells [8].

Traditional EOR projects are designed to minimize the amount of CO₂ that must be purchased; thus, CO₂ separated from the produced oil is compressed and recycled for injection along with new CO₂. Recycling of produced CO₂ at the surface introduces opportunities for CO₂ to escape to the atmosphere, and some CO₂ will almost certainly escape during separation of CO₂ from produced oil and brine. Typically around 0.16 and 0.42 metric tons of CO₂ are purchased to produce one barrel of oil, and upwards of 50% of the CO₂ purchased is recycled and reinjected.

Figure 1. The processes assessed to determine net emissions of a coupled power and GS-EOR system, from Jaramillo et al. [5].

Because emissions reductions from a coupled electric power and GS-EOR come from displacement of more carbon intensive energy sources (produced from processes not shown in Figure 1), the mass of CO₂ purchased by a GS-EOR project is not equal to the mass of GHG emissions avoided in the economy. To accurately estimate emissions avoided based on the amount purchased, a conversion factor is needed. In essence, this is the efficiency of emissions reduction from GS-EOR, and we define it as:

\[ \eta \equiv \frac{M_{\text{avoid}}}{M_{\text{purch}}} \]

The mass of GHG emissions avoided are the emissions from the GS-EOR system subtracted from the sum of the GHG emissions avoided by not otherwise generating the electricity produced at the power plant and not otherwise producing and consuming oil that is produced via GS-EOR:

3 The gaseous stream separated from the produced oil also contains light hydrocarbons, and often hydrogen sulfide gas (H₂S), which may be separated from the recycled CO₂. Light hydrocarbons include methane, ethane, and those typically referred to as Natural Gas Liquids (NGLs), such as propane and butane, which are liquids under ambient conditions.

4 There are 53 kg of CO₂ per thousand standard cubic feet (mscf) of CO₂, thus, this corresponds to 3-8 mscf of CO₂ per barrel of oil. Estimates for net and gross CO₂ utilization are highly dependent on the project. See 9. McCoy, S.T., *The Economics of CO₂ Transport by Pipeline and Storage in Saline Aquifers and Oil Reservoirs*, in *Engineering & Public Policy*. 2008, Carnegie Mellon University: Pittsburgh, PA. p. 267.
The emissions from the system are the sum of atmospheric emissions (i.e., not including sequestered CO₂) from the system shown in Figure 1. This sum can be written as:

\[ M_{\text{avoid}} = M_{\text{disp, oil}} + M_{\text{disp, e}} - M_{\text{sys}} \]

\[ M_{\text{sys}} = M_{\text{prod, coal}} + M_{\text{trans, coal}} + M_{\text{comb, coal}} + M_{\text{trans, CO₂}} + M_{\text{EOR}} + M_{\text{trans, oil}} + M_{\text{refine}} + M_{\text{comb, oil}} \]

Table 1 details the resulting emissions reduction intensities for three sets of displaced oil and electricity CO₂ emissions intensity for four cases described and analyzed elsewhere [5, 9]. These results clearly show that the emissions reduction efficiency of a coupled GS-EOR system is highly dependent on the specifics of the EOR project (primarily the CO₂ utilization rate), the marginal barrel of oil displaced, and MW of electricity displaced. In the best case, where relatively high emissions intensity oil and electrical generation are being displaced, the emissions reduction potential is greater than the amount of CO₂ purchased by the project. In the worst case, where a relatively light crude and carbon free marginal generation is being displaced (i.e., renewables or nuclear), the GS-EOR project results in an emissions increase.

Table 1. The emissions reduction efficiency of four GS-EOR cases for three differing sets of displaced oil and electricity generation life cycle CO₂ intensities. Based on the four cases presented in [9] analyzed using the methods described in [5].

| Marginal Barrel Displaced (kg CO₂e/bbl) | Marginal Generation Displaced (kg CO₂e/MWh) | η | Northeast Purdy Unit | SACROC Unit-Kelly Snyder Field | Ford Geraldine Unit | Joffre Viking Unit |
|----------------------------------------|---------------------------------------------|---|---------------------|-------------------------------|--------------------|-------------------|
| **Current Average Consumption-USA (529)** | Current Average Generation-USA (652) | 71% | 68% | 70% | 73% |
| **Canadian In-Situ SCO (600)** | Uncontrolled IGCC (894) | 140% | 128% | 137% | 145% |
| | NGCC (425) | 87% | 75% | 83% | 92% |
| Saudi Arabian Light (521) | Uncontrolled IGCC (894) | 94% | 92% | 93% | 95% |
| | NGCC (425) | 41% | 38% | 40% | 42% |
| | Carbon-free Electricity (0) | -8% | -10% | -8% | -7% |

In a case with growing energy demand, where GS-EOR facilitates addition of electric generation and oil to markets, there will not be displacement of other oil or electricity from the market. Moreover, the displaced energy source must remain displaced globally within a time source relevant to climate change. For example, a marginal barrel of oil that would be produced today in Canada—but is not, due to increased domestic production in the USA from GS-EOR—that is produced in a decade for Chinese consumption is not displaced for the purposes of accounting for emissions from GS-EOR.

3. Using GS-EOR as a tool to achieve emissions reductions

Energy displacement is clearly a complex matter. Without detailed economic modeling that captures the complexity of oil production and use and electricity production and management it is difficult to be certain what sources, if any, will be displaced. For example, drastically increasing domestic production of oil in the USA through large scale deployment of GS-EOR, as proposed by some [10], would have an impact on oil prices and, consequently, impact global demand for oil. The potential rebound in consumption would clearly impact the amount of energy displaced by oil produced via GS-EOR. As a matter of public policy, if reducing emissions of CO₂ is of great importance, encouraging GS-EOR will not be as effective as geologic sequestration in deep saline aquifers, or
other means of reducing emissions that do not result in increased production of fossil fuels. Nonetheless, it is likely that GS-EOR projects will happen in the absence of emissions reduction incentives because the benefits of increasing oil production alone are a sufficient incentive [1, 2]. Moreover, it seems likely that GS-EOR projects could be designed to increase the CO₂ utilization, and consequently the amount sequestered, by optimizing operation and design of the project [11-13], or by coupling them with deep saline formation storage. Additionally, as noted in the introduction, experience with GS-EOR will contribute to the geologic sequestration knowledge base and, insofar as demand for CO₂ encourages deployment of capture technology, with increase experience with capture systems.

Policy mechanisms are available to increase the likelihood that GS-EOR results in emissions reductions, such as ensuring that sources of low carbon electricity are not displaced by power coupled to GS-EOR. In fact many states in the USA already require power distributors to buy all renewable power that is generated, in order to meet state renewable portfolio standards. California, for example, has a renewable portfolio standard that requires 33% of the electricity purchased in the state by 2020 to be produced with renewable resources [14]. Given these factors, it is prudent to develop accounting protocols that ensure the net emissions from systems involving GS-EOR are accurately estimated and properly attributed.

4. Accounting for GS-EOR in an emissions reduction program

To encourage economy-wide reduction of GHG emissions, a GHG accounting system should accurately account for GHG emissions across the life cycle GS-EOR. This objective is complicated by other important considerations, such as the need to integrate GS-EOR into existing GHG reduction programs, and the imperative to insure that the GHG accounting system treats all real emissions reductions equally. In addressing these (and other) tradeoffs, GHG accounting for GS-EOR must answer two basic questions:

1. How much credit— if any —should be given for each ton of CO₂ purchased for GS-EOR? and,
2. Who should receive the credit?

The answer to the first question depends on the specifics of the GS-EOR system (as illustrated in Table 1), and on the design of the GHG reduction program. The answer to the second is “one or the other, but not both”—it is a policy choice linked to the design of the GHG reduction program.

The amount of credit that should be given for each ton of CO₂ purchased for GS-EOR should accurately reflect the emissions avoided across the life cycle of the system. The nature and scope of the GHG reduction program will determine the accounting approach needed to accomplish this objective, by specifying which emission sources are regulated and how they are regulated. The two main options are either a cap and trade type program, which could be economy wide or only applied to certain emission sources, or sectoral emissions intensity standards such as electric power portfolio standards or low carbon fuel standards. If all emission sources were covered under an economy wide emissions cap, with comparable emission reporting thresholds, then the credit would simply equal the quantity of CO₂ sequestered. Life cycle emissions of the system as a whole would be captured under the economy wide cap, and all components of the system would face the same carbon price.

Conversely, if none of the emission sources within the system boundary are subject to emission limits, then protocols that apply the method used in Section 2 can be devised to take into account the life cycle emissions of GS-EOR with displacement of electricity and oil (or other fuels, if relevant). For example, similar protocols have been proposed to account for CCS in the Kyoto Protocol Clean Development Mechanism [15]. This approach captures the upstream emissions from all process steps and, thus addresses emissions increases to provide for energy for CO₂ capture and compression as well as the specifics of the electricity and oil displaced by GS-EOR.

The intermediate case, where the GHG reduction program covers some, but not all, of the components of the system (e.g. electricity production is covered, but coal mining or transportation fuels are not) is more challenging, and most relevant, because this is the path that has been adopted in the EU, and proposed in the USA. In this case, the GHG accounting protocols should adjust the credit given for GS-EOR in order to account for the difference in GHG emissions that GS-EOR causes outside the boundaries of the GHG reduction program.⁶ Theoretically, no

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⁵ We use the term *credit* in a generic sense to designate the party who can “claim” the GHG reductions produced by GS-EOR, either to sell as offsets or count as avoided emissions, depending on whether the emission source is inside or outside a GHG reduction program.

⁶ GHG emissions that are induced outside the boundary of a GHG reduction program are sometimes referred to as *leakage*, although this term is not to be confused with leakage in the context of GS operations.
crediting adjustment is needed for displacement of products covered by the GHG reduction program. For example, as long as the electricity sector is covered, all generation will have to meet the cap and thus overall emissions cannot increase.

The magnitude of the necessary adjustment would depend on the relative emission intensities of the processes that fall outside GHG reduction program. For example, where GHG emissions are limited for electricity production, but not for petroleum extraction and refining, or transportation, the appropriate credit for one ton of CO₂ purchased for GS-EOR would depend on the emissions factors for extraction, refining, and combustion of petroleum products, but not on the emissions at the power plant. The GHG impact would be calculated differently if the CO₂ source is not electricity, but another source of CO₂, where the displaced product could be natural gas or ethanol.

Complications also arise if components of the system are subject to different GHG reduction programs, for example if electricity must meet a portfolio standard and a low carbon fuel standard is set for transportation. In this case, if the electricity portfolio standard and the low carbon fuel standard do not imply the exact same value on GHG emissions—determined by the shadow price on the emissions constraint—it greatly complicates calculating the appropriate credit adjustment, and creates incentives to shift emissions to the “cheaper” sector. Thus, accounting for GS-EOR will be less accurate under a system of sectoral performance standards than under a unified cap and trade system encompassing the same sectors.

5. Allocating emissions reductions from GS-EOR

Under an emission reduction program, credit for emission reductions achieved by GS-EOR could go either to the CO₂ generator (electrical power or other industrial source), or to the petroleum producer. While industry sources tout the potential of GS-EOR to simultaneously produce “clean coal” and “green oil” (e.g., see [10, 13]), GHG accounting rules must rigorously prevent double counting. As mentioned above, GHG accounting for GS-EOR is reasonably straightforward if: (1) none of the emission sources within the system boundary are subject to emission limits; or (2) if they are all under the same emission reduction program. There are two primary policy options when an emission reduction program covers some, but not all components of the GS-EOR system.

1. Credit goes to the CO₂ generator. This option could apply if there was a GHG emissions reduction program that regulated electric power production and other large stationary CO₂ sources. It would designate CO₂ exported for GS-EOR as avoided emissions, after applying a discount factor to correct for increased emissions that fall outside the GHG reduction program.

2. Credit goes to the petroleum producer. This option could apply if there was a GHG emissions reduction program that regulated emissions from petroleum combustion, largely in the transportation sector, such as a low carbon fuel standard or cap on embodied emissions from transport fuels. It would credit the quantity of CO₂ sequestered to emission reduction obligations of the petroleum producer, after correcting for increased emissions that fall outside the GHG reduction program.

The relative merit of these two approaches for allocating emission reductions depends on their ability to:

- Encourage economy wide emission reductions
- Ensure accurate and equitable emissions accounting
- Support simple, easily implemented accounting procedures
- Function effectively with the existing GHG reduction program(s);
- Accommodate captured CO₂ from various sources

Additional analysis is needed to fully evaluate the likely outcomes of allocating emission reductions to CO₂ generators versus to petroleum producers, but several qualitative observations can be made.

While an economy-wide emissions cap would facilitate the simplest, most equitable and most accurate GHG accounting for GS-EOR, climate policy is trending to regulate electric power production and other large stationary CO₂ sources first. This is true in the EU, the Regional Greenhouse Gas Initiative in the eastern USA, and the climate and energy bill passed by the U.S. House of Representatives in 2009. Policy measures to regulate GHG emissions

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7 See Andress et al. for a description of how low carbon fuel standards or caps could be implemented in the transportation sector. Andress, D., T.D. Nguyen, and S. Das, Low-carbon fuel standard—Status and analytic issues. Energy Policy, 2010. 38(1): p. 580-591.
from petroleum combustion lag, because they are more costly than those for large point sources [17], and are more technically and politically complex [16]. Thus, accounting protocols that allocate credit to CO₂ generators appear more realistic in the near-term. This approach has the potential to encourage economy wide GHG emission reductions as long as: (1) each ton of CO₂ exported for GS-EOR is discounted to correct for the full life cycle emissions of all the system components outside emission reduction program; and (2) additional policy measures, such as requirements for electricity distributors to buy all renewable electric power that is generated, ensure that GS-EOR doesn’t displace lower carbon electricity.

If low carbon fuel standards or other policy measures to regulate combustion of petroleum were to be instituted, the option to allocate credit for GS-EOR to petroleum producers would become theoretically possible, but this would be a complex policy environment where major components of the GS-EOR system are subject to different GHG emission regulations, potentially undermining the goal of encouraging economy-wide reductions. Generally, allocating emission reductions from GS-EOR to petroleum producers faces a number of hurdles. Because the policy options for regulating emissions from combustion of petroleum are so complex and indirect (vehicle efficiency, low-carbon fuel standards incorporating multiple fuel sources), accounting protocols for GS-EOR would need to be significantly more complicated, and their accuracy would be more difficult to ensure.

6. Conclusions

Irrespective of the climate impacts of EOR, the price of oil is such that EOR projects are economically attractive [1, 2]. A scarcity of natural CO₂—the traditional source for EOR—has driven EOR operators to consider purchasing increasing volumes of CO₂ captured from industrial sources (including power generation) and industrial sources to use EOR as a means of geologic sequestration (i.e., GS-EOR). However, as we have demonstrated GS-EOR may not, in all cases, result in an emissions reduction and any emissions reduction that happens is contingent on displacement of more GHG intensive sources of oil (and fuel or electricity) by those produced from the system employing GS-EOR. Thus, as a matter of policy, if reducing emissions of CO₂ is of great importance, encouraging GS-EOR will not be as effective as geologic sequestration in deep saline aquifers, or other means of reducing emissions that do not result in increased production of fossil fuels.

Given that EOR will continue to be used, it is critical that the life cycle emissions are properly considered when awarding projects credit for avoided emissions. In a regulatory environment where all emissions across the entire life cycle of a GS-EOR project are covered by a GHG emissions cap, there is no need for special treatment (e.g., discounting) of the amount of CO₂ purchased by the project, and the amount purchased is equal to the emissions avoided. However, it is not likely that this will be the case in the USA and, therefore, the amount of CO₂ injected will need to be discounted by the emissions that occur from un-capped processes in the life cycle. While further study is needed, it appears that in the latter environment, allocating the emissions reduction to an electric power generator would be less complex and more effective that allocating it to the oil or fuels producer.

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8. References

[1] Moritis, G., More CO₂-EOR projects likely as new CO₂ supply sources become available. Oil and Gas Journal, 2009. 107(45): p. 41-47.
[2] McCoy, S.T. and E.S. Rubin, The effect of high oil prices on EOR project economics. Energy Procedia, 2009. 1(1): p. 4143-4150.
[3] Marston, P.M. and P.A. Moore, From EOR to CCS: The Evolving Legal and Regulatory Framework for Carbon Capture and Storage. Energy Law Journal, 2008. 29(2): p. 421-490.
[4] Hovorka, S.D., et al., Comparing carbon sequestration in an oil reservoir to sequestration in a brine formation--field study. Energy Procedia, 2009. 1(1): p. 2051-2056.
[5] Jaramillo, P., W.M. Griffin, and S.T. McCoy, Life Cycle Inventory of CO₂ in an Enhanced Oil Recovery System. Environmental Science and Technology, 2009. 43(21): p. 8027-8032.
[6] International Energy Agency, *Key World Energy Statistics 2009*. 2009, OECD: Paris, France.
[7] Blunt, M.F., F.J. Fayers, and F.M. Orr, *Carbon Dioxide in Enhanced Oil Recovery*. Energy Conversion and Management, 1993. 34(9-11): p. 1197-1204.
[8] Moritis, G., *More US EOR projects start but EOR production continues decline*. Oil and Gas Journal, 2008. 106(15): p. 41-46.
[9] McCoy, S.T., *The Economics of CO₂ Transport by Pipeline and Storage in Saline Aquifers and Oil Reservoirs*, in *Engineering & Public Policy*. 2008, Carnegie Mellon University: Pittsburgh, PA. p. 267.
[10] Kuuskraa, V. and R. Ferguson, *Storing CO₂ with Enhanced Oil Recovery*. 2008, National Energy Technology Laboratory: Pittsburgh, PA.
[11] Kovscek, A.R. and Y. Wang, *Geologic storage of carbon dioxide and enhanced oil recovery. I. Uncertainty quantification employing a streamline based proxy for reservoir flow simulation*. Energy Conversion and Management, 2005. 46: p. 1920-1940.
[12] Kovscek, A.R. and M.D. Cakici, *Geologic storage of carbon dioxide and enhanced oil recovery. II. Co-optimization of storage and recovery*. Energy Conversion and Management, 2005. 46: p. 1941-1956.
[13] Kuuskraa, V., R. Ferguson, and T. Van Leeuwen, *Storing CO₂ with Next Generation CO₂-EOR Technology*. 2009, National Energy Technology Laboratory: Pittsburgh, PA.
[14] DOE, *DSIRE: Database of State Incentives for Renewables & Efficiency*. 2010, U.S. Department of Energy.
[15] Groenenberg, H., S. Bakker, and H. de Coninck, *How to include CCS in the CDM? Baseline methodologies and institutional implications*. 2008, Energy research center of the Netherlands.
[16] Andress, D., T.D. Nguyen, and S. Das, *Low-carbon fuel standard-Status and analytic issues*. Energy Policy, 2010. 38(1): p. 580-591.
[17] Morrow, W.R., et al., *Analysis of Policies to Reduce Oil Consumption and Greenhouse-Gas Emissions from the U.S. Transportation Sector*. 2010, Belfer Center for Science and International Affairs: Cambridge, MA.