

ENHANCED OIL RECOVERY
THROUGH CARBON CAPTURE
AND STORAGE

EOR

An Opportunity for Alberta

JANUARY 2009

TABLE OF CONTENTS

Executive Summary	4
Introduction	6
Conclusion	7
Recommendations	7
Background	10
A. Climate Change and Emissions Management Act	10
B. Federal Regulatory Framework	11
C. Carbon Capture & Storage (CCS)	12
D. Enhanced Oil Recovery (EOR)	13
EOR and CCS Expertise and Experience in Alberta and Other Jurisdictions	14
A. Canada CO ₂ EOR Projects	14
B. EOR Pilot Projects in Alberta	16
C. U.S. CO ₂ EOR Projects	18
CCS with EOR and without EOR	20
A. Advantages of utilizing EOR to meet CCS	20
B. Economic Benefits to EOR and Alberta	22
C. Obstacles to EOR for CCS	23
Solutions for EOR Implementation	25
A. Existing Regulations	25
B. Existing Facilities and Infrastructure	26
C. Economic Incentives	26
D. Regulatory Framework	35
E. Harmonization of Provincial & Federal Regulation	35
References	36
Glossary of Terms	37
Acknowledgement & Thanks	39



Message from Board Chair and the Energy Resource Committee

Alberta Economic Development Authority (AEDA) is pleased to deliver the report, ***Enhanced Oil Recovery (EOR) through Carbon Capture and Storage (CCS) — An Opportunity for Alberta.***

The AEDA Energy Resource Committee members have identified this as an opportunity for Alberta to be a leader in reducing emissions while at the same time generating increased energy development and stimulating the economy.

This report explores the opportunity for Alberta to capitalize in an emerging area as well as meeting the goal of reducing greenhouse gas emissions. It has been estimated that the Canada-wide potential for CCS could be as high as one-third to one-half of Canada's projected greenhouse gas emissions in 2050. EOR can be a vital building block to help achieve this goal.

The benefits of utilizing EOR are identified in this report and we encourage the government to review the 13 recommendations put forward in this report. AEDA offers to continue to be part of this process and seeks to assist the government in moving this initiative forward.

Sincerely

Bob Brawn
Chair,
Alberta Economic
Development Authority

Irene Lewis
Chair,
Energy Resource
Committee



EXECUTIVE SUMMARY



THE GOVERNMENT OF ALBERTA HAS COMMITTED to reducing greenhouse gas emissions in Alberta. Large industrial emitters account for 47% of Alberta's GHG emissions. Scientists and engineers have determined that Carbon Capture and Sequestration (CCS) is the best available method of reducing industrial emissions in Alberta. The cost of carbon capture on a per project basis is in the hundreds of millions of dollars, and there are over one hundred large facilities (and growing) that will require CCS. To address this, the Government of Alberta has announced a \$2 billion CCS Fund to kick-start the implementation and testing of CCS initiatives within the province.

The Energy Resource Committee of Alberta Economic Development Authority (AEDA) has studied the concept of utilizing Enhanced Oil Recovery (EOR), as a means of achieving CCS in a faster and more economical way. EOR using CO₂ injection will recover incremental conventional oil that will not be produced with current water flood techniques. Utilizing CO₂ in EOR is the only method of CCS that will produce a valuable commodity to offset a portion of the cost to capture the CO₂ and will pay royalties to Alberta. It will also strengthen Alberta's economy by extending the life of its oilfields, providing employment in rural areas, reducing water use and increasing Alberta's GDP. EOR offers significant potential for both storing carbon and generating major economic benefits. Alberta's unique geography, coupled with available industry expertise, provides a dual opportunity to sequester CO₂ in underground geological formations and to do so in conjunction with EOR projects that can generate both economic and environmental benefits to the province. The close proximity of CO₂ sources to EOR fields and the ability to utilize existing pipelines, gathering systems and wells also poses a distinct opportunity for Alberta EOR projects.

"... the best available method of reducing industrial emissions in Alberta. ..."



Alberta has an opportunity to become a world leader in CCS technology.

Alberta has an opportunity to become a world leader in CCS technology. Combining EOR with CCS in the early stages will give Alberta an opportunity to offset the high cost of CCS with the increased royalty and tax revenues generated from the production of incremental conventional oil. It is estimated that CO₂ EOR could produce an additional 1.5 to 2.5 billion barrels of oil, a 2 to 2.5 fold increase in Alberta's conventional oil reserves. Harnessing these advantages will allow Alberta to expedite the implementation of wide-scale CCS and to show immediate progress in terms of sequestered CO₂. **It is estimated that CCS using EOR could store 20 to 30 million tonnes per year of CO₂ equal to 8 to 12 Weyburn projects or the equivalent of 5 to 7.5 million cars from the road in every year of peak operation.**

Based on its research and evaluation, AEDA has determined that there is a very compelling case to utilize EOR in the province's initiative to implement wide-scale CCS and submits the following recommendations:

- ☞ Build upon and adapt the existing energy and environmental regulations to reduce cost and lead times to implementation.
- ☞ Ensure a streamlined regulatory framework and the resources are in place to review and approve projects that can adapt and utilize existing facility infrastructure on a timely basis.
- ☞ Prepare a policy and vision statement for the Alberta government's involvement in building a coherent CCS Implementation Plan and communicate that CCS Plan to Albertans and to industry stakeholders so that they can understand, buy into and support it.
- ☞ As part of Alberta's CCS Plan, provide economic and regulatory incentives to stimulate and accelerate EOR-CCS Projects, using the Royalty Framework, a mineral rights reversion program and public funding to augment private funding.
- ☞ Develop rules to compel mineral owners and lessees to take a reasonable position on CO₂ EOR Unitization.
- ☞ Introduce a Regulatory Framework to provide earlier certainty and expedite required regulations to address unresolved issues.
 - o Standards for injection and storage monitoring, measurement and verification.
 - o Allocation of Short Term & Long Term Liability between Industry and the Crown.
 - o Set out a Strategy for Federal- Provincial Harmonization of greenhouse gas issues.
- ☞ Prioritize EOR-CCS to exploit its economic and implementation advantages in initial CCS.
- ☞ Ensure Early Initiators of EOR are incented and not penalized for taking the lead with early action.
- ☞ Appoint a CCS Secretariat to identify government departments and agencies to be involved in regulating EOR-CCS projects and act as a liaison to identify bottle-necks and expedite processes.
- ☞ Set Out Timelines for Implementation.



This report will discuss and analyze the benefits of utilizing EOR as a means of accelerating the wide scale implementation of CCS in Alberta.

I N T R O D U C T I O N

As part of its review of the issues surrounding EOR and CCS, the Energy Resource Committee of AEDA held a workshop on September 9, 2008 to share knowledge, ideas and strategies on using Carbon Capture and Storage (CCS) for Enhanced Oil Recovery (EOR). Several members of industry attended along with committee members and government representatives. Three companies with significant EOR expertise and experience made presentations. The workshop identified several challenges for CCS and EOR as well as specific changes for rules and policies that would be required to accelerate the adoption of CCS and EOR.

This report will discuss and analyze the benefits of utilizing EOR as a means of accelerating the wide scale implementation of CCS in Alberta. It will examine the short and long term economic benefits of EOR and CCS in Alberta as a way of unlocking Alberta's resource and industrial potential. Challenges will be highlighted, and specific opportunities for action will be identified to address those challenges. The report begins with the conclusion of the Energy Resource Committee, followed by its 13 Recommendations for action. A thorough discussion of the background of CCS and EOR, Alberta's experience and expertise in EOR, the experience of other jurisdictions with EOR and solutions for implementing EOR in CCS follows and supports the 13 recommendations.





C O N C L U S I O N

After carefully reviewing the research, presentations and workshop information that has been assembled by the Energy Resource Committee of AEDA, its volunteers and consultants, the committee concluded that there are overwhelming reasons for supporting the rapid and wide-scale implementation of EOR as a mechanism to achieve rapid deployment of CCS. Industry in the province is being required at all levels of government to reduce their emissions intensity sharply. CCS is currently the only known way to accomplish this without unduly constraining the development of the energy industry and other large emission industries in Alberta. The province has a unique opportunity to build a CCS network that will not only reduce emissions, but also generate increased energy development and economic prosperity. Based on reasonable projections of incremental production volumes and prices, **there is no question that the government could recoup its entire \$2 billion investment in CCS and generate a return for Albertans that will continue for decades.**

R E C O M M E N D A T I O N S

1. **Build upon and adapt the existing energy and environmental regulations**

Alberta should draw upon existing energy and environmental regulations to implement CCS in EOR and pure CCS projects and use early experience to adapt and build a comprehensive suite of CCS regulations.

2. **Prioritize projects that can adapt and utilize existing facility infrastructure**

Ensure a streamlined regulatory framework and the resources are in place to review and approve projects that can adapt and utilize existing facility infrastructure on a timely basis. This will reduce construction costs, lead times and accelerate the receipt of royalty revenues.

3. **Provide Economic Incentives to stimulate and accelerate EOR Project Adoption**

(a) Utilize Royalty Framework

- (i) Alberta should follow Saskatchewan's lead and implement similar royalty schemes and fiscal incentives to entice EOR ventures into the province. The investment of hundreds of millions of dollars by producers will be much less attractive if they can get a better deal elsewhere.

The province has a unique opportunity to build a CCS network that will not only reduce emissions, but also generate increased energy development and economic prosperity.



“... will directly impact the direct return on funds invested and could be the difference between investing funds and spending funds..”

- (ii) When reviewing the CO₂ Projects Royalty Credit Regulation, the government should amend the royalty structure for EOR to calculate EOR royalties on a project basis, similar to a unit construct, so that there is an incentive for overall production increases, thereby increasing overall royalties.
- (iii) The retention of the EOR Royalty Credit under the new Royalty Framework is insufficient when deducted against significantly increased royalties and will be ineffective unless royalty rates are decreased for EOR projects.

(b) Utilize Public Funding to Augment Private Funding

The government should require financial commitment and support by CCS participants. The government should consider a matching program for expenditures on approved CCS and EOR projects. The matching may not follow a 50-50 formula throughout the project, but may vary from phase to phase to best support the project at critical times.

4. Ensure Maximum Incorporation of EOR

The ratio of EOR projects in the initial stages of CCS will directly impact the direct return on funds invested and could be the difference between investing funds and spending funds.

5. Ensure Pilot Projects are incented to move to commercial scale and are not penalized for taking early action.

Early adopters and initiators of environmental programs have been penalized for early action in the past and left with stranded or worthless assets. This must be avoided in the implementation of CCS.

6. Amend Regulatory Scheme to require EOR recovery programs

The Crown Deeper Rights Reversion Model can be used effectively to ensure that vast reserves of remaining oil in place are recovered using EOR.

7. Address issue of credit ownership for all components of CCS

Each component of CCS (Capture, Transportation and Storage/Sequestration) should, unless the parties have contracted otherwise, be entitled to a pro-rata share of the carbon credits/offsets generated. The pro-rata share should be based upon the parties' relative share of the capital and ongoing operating costs.

8. Expedite Regulation amendments to clarify unresolved issues

- (a) Confirm EOR-CCS pore space ownership rests with mineral owner(s)
- (b) Short and Long Term Liability
 - (i) Short Term Operational Liability – Industry
 - (ii) Long Term Liability – Crown



9. Expedite Unitization

Develop rules to compel mineral owners and lessees take a reasonable position on CO₂ EOR unitization. Streamline procedure for expediting unitization and adjudicate ownership and participation issues in the same fashion as surface rights issues

10. Appoint a CCS Secretariat

- (a) Secretariat should identify government departments and agencies to be involved in regulating EOR-CCS projects
- (b) Secretariat to assign individuals to act as a liaison between industry and government departments and agencies to identify bottle-necks and expedite processes

11. Overall Policy and Regulatory Framework Paper

The government should prepare a policy statement to address its intentions regarding EOR's role in CCS, similar to what was done with the Energy Strategy, but with more concrete detail. In conjunction with this, a communication strategy needs to be developed to communicate the policy to Albertans and stakeholders in plain language that can be easily understood. This policy should include or lead to a Regulatory Framework to provide industry and stakeholders with the degree of certainty they require for planning and decision-making. The communication strategy should also communicate in plain language the concrete sequestration results that are already being achieved by early movers in the energy private sector.

12. Federal Provincial Harmonization

The government should set out its position and strategy for harmonization with the federal regulatory framework, in particular, the incentives that will be offered for pilots and commercial implementation and its position on adhering to certain federal standards that are more stringent, such as the inclusion of CCS in all new oil sands and coal-fired electrical generation facilities.

13. Timelines

The government should set out its objectives for timelines for the following critical path items:

- (a) Number of months to present regulatory framework for EOR in CCS;
- (b) Number of months to draft and execute industry agreements for Pilot and Commercial Projects;
- (c) Number of months to introduce draft regulations; and
- (d) Number of months to bring final regulations into effect.



BACKGROUND




A. CLIMATE CHANGE AND EMISSIONS MANAGEMENT ACT

The United Nation's Intergovernmental Panel on Climate Change (IPCC) has determined that anthropogenic (caused by humans) greenhouse gas (GHG) emissions are contributing to climate change and global warming. Governments around the world have responded to mounting pressure to recognize climate change and are beginning to take steps to reduce GHG emissions in their jurisdictions and abroad. Regulation of large source industrial emissions is seen as one of the easiest and most direct ways to accomplish large-scale reductions of GHG emissions in Canada. In July 2007, Alberta became the first jurisdiction in North America to regulate the emission of greenhouse gases when it introduced its Specified Gas Emitters Regulation (SGER) pursuant to the Climate Change and Emissions Management Act, (CCEMA)¹.

The SGER regulates large industrial emitters (LIE's) that emit over 100,000 tonnes of GHG annually. Ninety-nine LIE's reported a total of 110 million tonnes of GHG emissions in 2004. This represented 47% of all GHG emissions in Alberta and 64% of all industrial emissions².

The SGER requires LIEs to reduce their emissions intensity (EI) by 12% for established facilities (facilities that completed their first year of operations before January 1, 2000). No reduction is required for the first three years of operations for new facilities (facilities completing their first year of operations after January 1, 2000) and then 2% is required for each additional year of operations, up to 10%. These emission intensity reductions are measured against a baseline emission intensity ("BEI") established for the facility. The BEI for an established facility is based on the ratio of the total annual emissions to production for 2003-2005³.

Under the SGER, failure of an LIE to comply with prescribed emission reductions results in a fine of \$200 / tonne of GHG released over the emissions intensity limit. The SGER sets out a number of compliance options that are intended to provide the regulated emitter with some flexibility in meeting its reduction targets. The emitter can choose to do one or any combination of the following:

-  reduce its actual emission intensity;
-  purchase Technology Fund Credits at \$15 / tonne of GHG emission reduction required; or
-  purchase Emission Offset Credits.



B. FEDERAL REGULATORY FRAMEWORK

On Monday, March 10, 2008, the Government of Canada released the final version of its Regulatory Framework on air emissions⁴ (the “Regulatory Framework”). The focus is to reduce greenhouse gas emissions to 20% below 2006 levels by 2020⁵. The Regulatory Framework targets and timelines are more aggressive than Alberta’s and draft regulations are scheduled to be published in January 2009, to become binding on January 1, 2010. There are questions about how Alberta’s regulations will harmonize with the federal Regulatory Framework, and how it will mesh with the anticipated program to be introduced by the new U.S. government.

Like Alberta, the Regulatory Framework has adopted an emissions intensity reduction approach, rather than an absolute reduction approach. It will require existing facilities to achieve EI reductions of 18% below 2006 levels by 2010, followed by continuous annual EI improvements of 2% thereafter, capping out at 26%.

New facilities are defined more restrictively as facilities whose first year of operation was 2004 or later. These facilities will be granted a three year grace period during which no EI targets will apply. This means that facilities completing first year operations in 2000-2003 will not qualify for the three year grace period as they do in Alberta. Notably, new facilities will also include major expansions constituting more than a 25% increase in a facility’s physical capacity as well as major transformations to a facility that involve significant changes to its processes.

Further, EI targets for new facilities will be based on a cleaner fuel standard to encourage continuous emissions intensity reductions over time. The method of applying this cleaner fuel standard has yet to be disclosed. For upstream oil and gas and natural gas pipelines, it will be applied using a sector-specific approach. For the oil sands, its application will be process-specific, with a separate standard being applicable to each of mining, in situ recovery and upgrading.

The Regulatory Framework incorporates lower emission thresholds for regulation and will capture upstream oil and gas facilities that emit only 3,000 tonnes of CO₂ equivalent (CO₂e) per facility or produce 10,000 barrels of oil equivalent (boe) per day per company. These proposed thresholds are significantly more stringent than the current Alberta regulatory threshold of 100,000 tonnes of CO₂e per year per facility, and will capture a much larger number of companies that are not currently required to reduce emissions. This is a key reason that CCS will be such an important emission reduction tool for Alberta industry.



... estimated that the Canada-wide potential for CCS could be as high as one-third to one-half of Canada's projected greenhouse gas emissions in 2050.

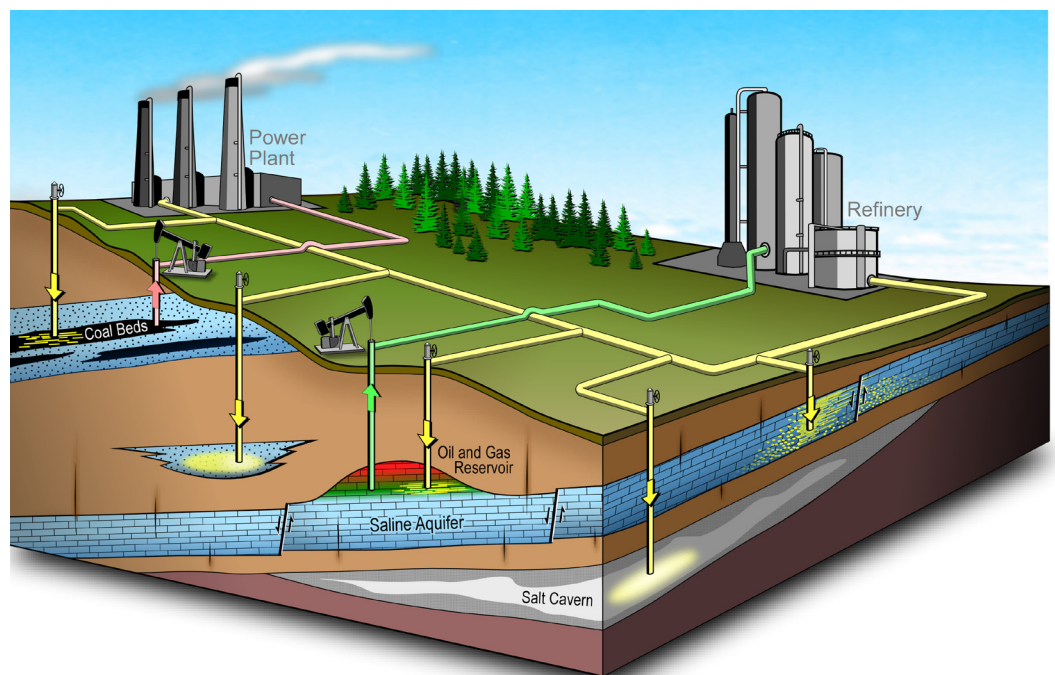
The Regulatory Framework recognizes the role of CCS in meeting overall EI reduction targets, and references the recent report of the ecoEnergy Carbon Capture and Storage Task Force⁶ which estimated that the Canada-wide potential for CCS could be as high as one-third to one-half of Canada's projected greenhouse gas emissions in 2050. Although the Regulatory Framework discusses incentives for new facilities brought on stream in 2004 or later to adopt CCS, the federal government's financial commitment has not yet been announced and current commitments are dwarfed by Alberta's \$2 billion commitment to CCS. The Regulatory Framework sets targets based on the implementation of CCS for in situ facilities and upgraders in the oil sands sector and for new coal-fired electrical generation plants that begin operating in 2012 or later. While the exact nature of these targets has not yet been determined, they are intended to become operative in 2018. Effectively, all oil sands and coal-fired generation facilities starting operations in 2012 or later are expected to incorporate CCS.

C. CARBON CAPTURE & STORAGE (CCS)

The decisions to regulate and reduce CO₂e emissions both provincially and federally and the mounting pressure to do so internationally, provides the context under which rapid deployment of CCS is seen as critical. Both levels of government are focused on CCS as a key

Graphic courtesy - Alberta Geological Survey (AGS)

Rather than being emitted into the air by a power plant or a refinery, CO₂ is separated from other emissions, dehydrated, compressed and transported by pipeline (yellow) where it can be injected into geological formations to help increase production from coals beds or oil and gas reservoirs. Or it can be injected one to two kilometers deep into porous rock formations where it is sealed and monitored by experts to ensure there is no leakage or impact on public safety or the environment.





EOR offers significant potential for both storing carbon and generating major economic benefits.

tool in achieving large-scale emission reductions over the next 40 years. If Alberta does not find a way to reduce its GHG emissions, it risks not being able to fully exploit its vast hydrocarbon resource base and its ambitious plan for the Heartland industrial complex will be in jeopardy. Right now, CCS is seen as the most powerful tool to reduce Alberta's CO₂ footprint.

CCS involves the capture of CO₂ at the plant from its flue or process streams and the diverting of it into a gathering and transportation system to be injected into secure underground geological formations. The underground injection alternatives include deep saline aquifers and hydrocarbon reservoirs. As discussed below, both deep saline sequestration and hydrocarbon reservoir sequestration has been done successfully in Canada and abroad. The injection process must be carefully managed to avoid damage to underground water and hydrocarbon reservoirs. Post injection closure is perhaps the most important stage of CCS and must be carefully managed and monitored to avoid incidents of leakage of CO₂ back into the atmosphere.

Alberta's GHG emissions reduction plan calls for annual reductions of 50 million tonnes per year by 2020 and 200 million tonnes of reductions from a business as usual scenario by 2050. Almost all of the initial 50 million tonnes in reduction by 2020 are expected to come from CCS. Fifty million tonnes per year is equivalent to more than the 20 times the annual source CO₂ injected in Weyburn.

D. ENHANCED OIL RECOVERY (EOR)

The federal government and many Canadians view CO₂ primarily as a pollutant or waste product that needs to be dealt with. However, for hydrocarbon rich provinces such as Alberta, Saskatchewan and B.C., CO₂ is also a resource and may present a complementary opportunity to use the CO₂ in enhanced oil recovery. EOR offers significant potential for both storing carbon and generating major economic benefits. Although the storage potential of hydrocarbon reservoirs is not as large as the capacity of deep saline aquifers, it is still significant and has been estimated at approximately 3 billion tonnes for gas reservoirs and ½ billion - 1 billion tonnes for-CO₂ EOR reservoirs⁷. As such, it would be incorrect to conclude that opportunities to utilize EOR to further CCS and accelerate its rollout are not significant. There can be no question that even ½ billion tonnes of storage constitutes considerable capacity. It is also significant considering that the storage target for CCS is only 5 million tonnes of CO₂ annually by 2015 (1.25 million cars per year).



EOR can assist Alberta achieve its 50 million tonne reduction target by 2020 by contributing an estimated 20-30 million tonnes of sequestered CO₂ each year.

EOR using CO₂ is a tertiary recovery process that involves the injection of CO₂ to flood mature reservoirs and force up the petroleum substances that would otherwise remain unrecoverable. Under primary recovery methods, less than 20% of the resources are recovered from a reservoir on average⁸. EOR can increase the ultimate oil recovery substantially to produce more resources from the reservoir. EOR using CO₂ can also be used to stimulate the production of natural gas from coal deposits (coal bed methane).

EOR can assist Alberta achieve its 50 million tonne reduction target by 2020 by contributing an estimated 20-30 million tonnes of sequestered CO₂ each year, 8 – 12 Weyburn projects. This is approximately half of the projected reductions for 2020 and is the equivalent of removing over 5 – 7.5 million cars from the road each year.

EOR AND CCS EXPERTISE AND EXPERIENCE IN ALBERTA AND OTHER JURISDICTIONS

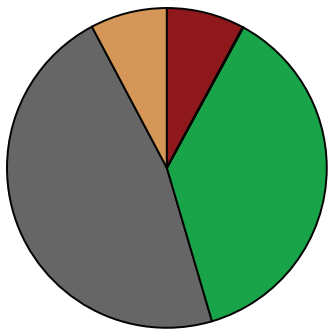
A. CANADA CO₂ EOR PROJECTS

Although there are approximately 98 commercial CO₂ EOR projects in North America, only seven of those are located in Canada. Together they account for production of approximately 35,000 barrels/day.

The largest Canadian commercial CO₂ EOR project is located at Weyburn, Saskatchewan and is operated by EnCana. It uses 95% pure CO₂ imported from a Dakota Gasification Company plant in Beulah, North Dakota via a 325 km pipeline. Enhanced recovery operations at Weyburn began in 2000 with source CO₂ injection of approximately 5,000 tonnes/day, source injection rates were increased in 2006 and are currently about 6,500 tonnes/day (2.4 million tonnes per year). The 50-year-old Weyburn field initially contained an estimated 1.4 billion barrels of original oil-in-place (OOIP). Prior to commencement of the CO₂ EOR project, 370 million barrels had been recovered. **Current production levels following the implementation of CO₂ injection have risen 60% to over 28,000 barrels/day, a production level not seen in 35 years.** The incremental production from the field associated with the CO₂ injection is estimated to be 160 million barrels over the next 30 years⁹. That equates to \$12 billion in production



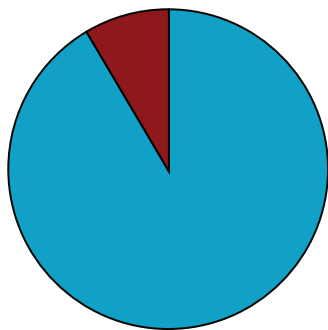
Original Oil in Place (Larger Pools)



(millions of barrels)

- Weyburn (1400)
- Beaverhill Lake (6500)
- Pembina Cardium (8000)
- Redwater D-3 (1300)

Potential CO₂ EOR Oil Recovery



(millions of barrels)

- Alberta (2000)
- Weyburn (160)

at an average price of \$75 per barrel. To date, over 10 million tonnes of CO₂ have also been sequestered in the Weyburn field and the estimated gross storage capacity of the field is approximately 55 million tonnes¹⁰. The incremental production from this field will add billions of dollars to the Saskatchewan economy while permanently sequestering CO₂ that would otherwise have been emitted. The government of Saskatchewan has played a key role in bringing this project to life by giving pre-payout royalty and tax concessions. The Petroleum Technology Research Centre (PTRC) based in Regina is conducting scientific research in conjunction with the International Energy Agency (IEA) to confirm the suitability of the Weyburn Unit for long term CO₂ storage and develop recommended protocols for CO₂ storage during EOR operations. Thus far the results of this program have been positive.

The second largest commercial CO₂ EOR project in Canada is run by Apache Corporation at the Midale field in southern Saskatchewan. The Midale project began commercial operations in the fall of 2005, although experimentation was conducted in the 1950's and pilot and demonstration projects were carried out in the 1980's and 1990's. Using a 26 km offshoot of the CO₂ pipeline between Beulah and Weyburn, it is also able to obtain its CO₂ supply from the Dakota Gasification Company plant in North Dakota.

The original oil-in-place in the Midale field was estimated at 515 million barrels, of which 130 million had been produced prior to the commencement of CO₂ EOR operations. The CO₂ EOR project, injecting 1,800 tonnes of CO₂ per day by 2006, is expected to produce an incremental 60 million barrels of oil and extend the life of the field by about 25 years. Further, the Midale project is estimated to sequester in excess of 10 million tonnes of CO₂ over the life of the project¹¹.

The third largest source CO₂ injection into an EOR project in Canada, and the largest in Alberta, is an experimental project run by Glencoe Resources Ltd. at its Ponoka/Chigwell in Central Alberta. The Glencoe project acquires CO₂ from the petrochemical complexes of MEGlobal/Dow Chemicals Company and Nova Chemicals Corp. at Prentiss and Joffre, Alberta. Current injection rates are approximately 0.35 million tonnes per year. Interestingly, a large portion of the 80 km pipeline transporting CO₂ from its capture site to the Ponoka/Chigwell field used an existing pipeline that previously



operated in other applications, making the Glencoe project a model of responsible development¹². Pilot work has achieved reservoir response and is now beginning to produce incremental oil, with production beginning to exceed original reservoir production rates¹³. According to Glencoe, there are 5,268 million barrels of OOIP within a 50-mile radius of their project, and 15,587 million barrels of OOIP within a 75-mile radius (3 and 11 times the OOIP of Weyburn, respectively). Even with modest incremental recovery, the potential for EOR is significant.

The first CO₂ EOR project in Canada started as a pilot in January 1984 and was commercialized in 1991 in the Joffre Viking field east of Red Deer, Alberta. Penn West Petroleum operates the project using CO₂ from two of the Nova Chemical Corp Ethylene plants at Joffre. It is the only commercial CO₂ EOR project in Canada using industrial emissions originating in Canada and has stored about one million tonnes of CO₂ over the past 25 years. The project is a true tertiary application and is recovering an additional 12 – 25% of the OOIP from an abandoned field¹⁴.

B. EOR PILOT PROJECTS IN ALBERTA

CO₂ EOR will require new techniques to optimize recovery from mature oil fields. Operators, with assistance from the provincial and in some cases, federal government have been operating pilots for the last four years to determine the best way to implement CO₂ EOR in various pools around the province.

Some of the best pools for CO₂ EOR are located in Beaverhill Lake (BHL) Pools in the Swan Hills region of Alberta and originally contained over 6.5 billion barrels of light sweet oil. The most suitable areas of these pools have been previously flooded with hydrocarbon miscible solvent, making them unique CO₂ EOR candidates. Three operators have run or are operating pilots in previously solvent flooded areas to determine if additional oil and injected methane, ethane and propane can be recovered economically. Devon commenced a pilot in the Swan Hills BHL field in October 2004 to determine if CO₂ could recover additional oil and injected hydrocarbon miscible solvent from an area that had previously had significant hydrocarbon miscible solvent injection. The pilot is now complete with encouraging results. Pengrowth commenced operation of a pilot in the Judy Creek field in February 2007 that is continuing to meet expectations. Penn West is pilot testing the use of CO₂ areas in South Swan Hills BHL field that have previously utilized a hydrocarbon



Assuming favourable commodity prices and timely regulatory approvals, CO₂ injection could commence as early as 2010.

miscible solvent flood. The objective is to investigate the possibility and economic viability of recovering additional oil, by injecting CO₂ zones with higher remaining oil in place, that may not have been effectively swept by the past hydrocarbon miscible flooding. The strategy will focus on improving the vertical sweep by the use of CO₂ instead of hydrocarbon solvent. The South Swan Hills CO₂ pilot came on-stream mid year 2008. The additional recovery of 5% from the BHL pools would add about 30% to Alberta's current light medium oil reserves. These massive deep pools could also permanently store a large volume of CO₂.

The Pembina Cardium oil field is the largest conventional oilfield in Canada, and contained about 8 billion barrels of light sweet OOIP. The geology in the field presents many challenges to the implementation CO₂ EOR. Penn West is testing the use of CO₂ in a vertical well pilot in the Pembina Cardium that started March 2005 and was funded in part by Alberta's Innovative Energy Technologies Program (IETP) and the federal government. Penn West recently expanded its CO₂ pilot program to include the use of horizontal wells to determine if improved economics can be achieved through better sweep efficiency and faster oil response time. The pilot will utilize vertical injectors with horizontal producers and came on-stream recently in 2008. ARC Resources is conducting a preliminary field evaluation to aid in the design of a CO₂ EOR pilot using horizontal injection wells in another area of the Pembina Cardium that has different geological characteristics. Assuming favourable commodity prices and timely regulatory approvals, CO₂ injection could commence as early as 2010¹⁵.

In July 2008 ARC Resources commenced a CO₂ EOR pilot project in the Redwater D-3 field that is located very close to Ft. Saskatchewan. Results from the pilot are expected by 2011. Redwater is the third largest conventional oilfield in Alberta (1.3 billion barrels OOIP). It also sits on top of a huge saline aquifer that could store an estimated billion tonnes of CO₂¹⁶.

The Beaverhill Lake, Pembina Cardium and Redwater D-3 pools referenced previously contains over 11 times the OOIP of Weyburn. However because of different geology and development history the total CO₂ enhanced oil recovery and CO₂ storage is expected to be 5 – 8 times that of Weyburn.

In December 2004 Apache Canada commenced injection of high CO₂ acid gas into pinnacle reefs in the Zama area of northwestern Alberta. Over 700 small reef oil pools



exist in this area of the province that might be amenable to this process. Acid gas from gas processing plants in the area is being stored in this project.

In September 2004 Anadarko Canada (now Canadian Natural Resources) commenced injection of CO₂ into an Enchant Arcs pool in southern Alberta. Other Enchant Arcs pools exist in this area of the province to allow expansion of the project. CO₂ from the Hays gas processing plant is being stored in this project.

The Ponoka/Chigwell, Joffre, Zama and Enchant projects have shown the potential for CO₂ EOR in the numerous smaller oil pools in Alberta.

C. U.S. CO₂ EOR PROJECTS¹⁷

Of the 98 commercial CO₂ EOR operations being conducted in North America, 91 are located in the U.S. and most of those are in the Permian Basin of west Texas. Other significant areas for CO₂ EOR are in Wyoming and Mississippi. Approximately 75% of CO₂ EOR floods in the U.S. utilize naturally occurring CO₂ from reservoirs developed specifically to produce CO₂. The source of CO₂ for sequestration and EOR in Alberta is from industrial sources, giving us a unique experience. Total production from CO₂ EOR in the U.S. is approximately 240,500 barrels/day, which equates to \$6.5 billion in annual production revenues, based on an average price of \$75.00 per barrel.

Although there are a number of significant CO₂ EOR projects operating in the U.S., the following represent some of the more significant examples.

The world's first CO₂ EOR Project started in January 1972 at the Chevron operated SACROC field in Scurry County, Texas. Kinder Morgan currently operates the project, which was reported to be producing over 24,000 barrels/day of oil in April 2008. The second project was started by Shell in April 1972 in the North Cross field, also located in the Texas Permian Basin. This project is also still operating and was reported to be producing over 800 barrels/day of oil in April 2008.

Chevron Corporation has been injecting CO₂ into its Rangely field in northwestern Colorado since 1986. CO₂ is obtained from Exxon's Shute Creek gas sweetening plant at LaBarge, Wyoming and transported 177 miles via pipeline. Current injection rates are approximately 2,600 tonnes/day but have been as high as 7,850 tonnes/day. The initial cost of the project was \$158 million, about half of which was incurred in the construction



of a CO₂ recompression facility. From an estimated 1.9 billion barrels of oil-in-place, Chevron has extracted approximately 800 million barrels and expects to recover an additional 114 million barrels through its CO₂ EOR operations.

Another operation sourcing CO₂ from Exxon's Shute Creek plant is Anadarko Petroleum Corporation's CO₂ EOR operations in Wyoming. Anadarko injects nearly 15,700 tonnes/day of CO₂ into its Salt Creek and Monell fields, transporting purchased CO₂ approximately 125 miles across Wyoming in a 16-inch pipeline. Aggregate production from these fields is currently 9,000 barrels/day, and Anadarko has also completed a successful CO₂ pilot test at its Sussex field in Wyoming.

Privately held Chaparral Energy, Inc., based in Oklahoma City, operates CO₂ EOR projects in Oklahoma. CO₂ is sourced from an ammonia fertilizer plant in Texas and an ammonia plant at Enid, Oklahoma. Chaparral is currently injecting approximately 1,360 tonnes/day into its 4 Oklahoma fields and has identified 54 other properties with CO₂ EOR potential. Current production associated with its CO₂ EOR activities is about 1,100 barrels/day. Chaparral has also begun to acquire ownership interests in CO₂ pipeline networks in both Oklahoma and Kansas and is in the process of constructing an ethanol plant in Oklahoma in partnership with the Oklahoma Farmers Union Sustainable Energy LLC that will produce approximately 367 tonnes/day.

In 2007, Whiting Petroleum Corporation commenced CO₂ EOR injection into its North Ward Estes field in Texas. It began injection at a rate of 520 tonnes/day and expects to increase this rate to up to 5,200 tonnes/day by the end of 2008. Current production from the North Ward Estes field is 5,050 boe/day. Whiting also operates a CO₂ EOR injection project in Postle, Oklahoma, injecting 6,800 tonnes/day and achieving production of 5,800 boe/day. It expects to be able to raise production at Postle to 10,000 boe/day by 2011.

Denbury Resources Inc., an independent oil and gas company operating in the U.S. Gulf Coast region, focuses on both the use and supply of CO₂ for tertiary recovery operations. CO₂ is naturally sourced from its wholly owned Jackson Dome site in Mississippi, which is able to supply approximately 36,700 tonnes/day of CO₂ into Denbury's pipeline network. Denbury's production in 2007 was 17,425 barrels/day from about 10 producing fields, and it has plans to increase CO₂ EOR production to 60,000 barrels/day and expand its pipeline network into Louisiana and Texas. In 2008, Denbury



started construction on a \$100 million pipeline to deliver CO₂ to northern Louisiana. In 2009, it will begin construction on the \$700 million “Green Line” pipeline from Baton Rouge to Houston, expected to be in service in 2010. Longer term, Denbury intends to expand its focus to include industrial CO₂ sources and expects to have the capacity to deliver up to 100,000 tonnes/day of CO₂.

Another company involved primarily in the transportation of CO₂ is Kinder Morgan, currently the largest transporter and marketer of CO₂ in the U.S. Its principle sources of CO₂ are natural sources known as the McElmo Dome bordering Utah and Colorado and the Bravo Dome in New Mexico. Using its network of over 1,100 miles of pipelines, Kinder Morgan is able to deliver more than 21,000 tonnes/day, primarily to clients in West Texas and New Mexico. It also has a CO₂ reserve base exceeding 250 million tonnes.

CCS WITH EOR AND WITHOUT EOR

A. ADVANTAGES OF UTILIZING EOR TO MEET CCS

There are a number of key advantages for utilizing EOR as an initial method of CCS:

(a) EOR is currently being implemented successfully

EOR is being successfully implemented in Alberta and other jurisdictions. The technology and regulatory framework already exist in Alberta to initiate and expand these projects, which means that less lead-time will be required for implementation. Companies using EOR have already completed their selection studies of the mature reservoirs and are piloting or implementing projects in these reservoirs. These companies are facing obstacles such as the cost and availability of CO₂ and these obstacles can be removed or mitigated quickly with government assistance.

Alberta already has regulations in place under the Oil and Gas Conservation Act for the approval and operation of EOR projects that can be utilized immediately to approve CO₂ injection schemes. This can be augmented at a later date by new regulations for permanent CCS, or the scheme could use the same regulatory process as is currently used for approving acid gas injection and disposal schemes once the EOR project is completed.



Alberta already has regulations in place under the Oil and Gas Conservation Act for the approval and operation of EOR projects that can be utilized immediately to approve CO₂ injection schemes.

(i) *Examples of Successful EOR in Alberta*

Glencoe Resources Ponoka/Chigwell EOR project is an example of innovation and ingenuity to stimulate production in a mature oil field and to sequester 0.35 million tonnes of CO₂ annually in the process. Penn West Petroleum is still operating and expanding the Joffre EOR project discussed above. Both of these projects have proven that EOR can be successful in Alberta.

The Weyburn and Midale CO₂ EOR projects discussed above are both models of success that involved the assistance of the Saskatchewan government. There is no reason this success cannot be duplicated in Alberta with the assistance of its government.

(ii) *More EOR Projects Planned for Alberta*

Enhance Energy Inc. is planning EOR projects in 3 mature oil fields (Clive D2, Clive D3 and Bashaw). Enhance estimates that combined, its Clive and Bashaw anchor projects have 150 million barrels of oil in place and that they will achieve incremental recovery of up to 25 million barrels, while sequestering up to 15 million tonnes of CO₂. The revenue potential of an incremental 25 million barrels of oil production is approximately \$1.8 billion at an average price of \$75 per barrel. Royalty revenues for the province could be as high as \$234 million, based on an average 12.5% royalty rate over the term of production.

Enhance Energy is planning a CO₂ trunk line that will run from upgrading, fertilizer and chemical plants in the Alberta Heartland to anchor EOR projects in central and southern Alberta. Enhance projects that this trunk line will facilitate the recovery of 1 billion barrels of light oil reserves, while sequestering millions of tonnes of CO₂ in EOR reservoirs and additionally, 900 million tonnes of pure CCS in depleted hydrocarbon reservoirs. Enhance projects the trunk line will allow for the production of billions of barrels of upgraded bitumen (at lower CO₂ emissions than conventional light oil production)¹⁸. The cost of the trunk line is estimated at \$300 million, with total project cost, including the Clive and Bashaw field developments, estimated to be \$800 million. However, as noted, the trunk line is viewed by Enhance as instrumental in unlocking another billion barrels of light oil reserves from other EOR projects.



(b) Alberta has existing EOR Expertise

The Alberta Research Council and various companies are conducting studies of deep geological formations that will be appropriate for pure CCS. CCS has already been undertaken successfully in Alberta through Acid Gas injection. Over 3 million tonnes of CO₂ has been injected in western Canada since 1995 with approximately 0.5 million tonnes a year currently being injected, much of which occurs in Alberta. This expertise and knowledge, in addition to the existing EOR project expertise, can be utilized to immediately implement EOR CCS projects once supplies of CO₂ pure enough for EOR are made available. For this reason, it makes sense to implement carbon capture technologies at plants that can be tied into EOR fields quickly and cost effectively. This will ensure that the 5 million tonne annual target can be met by 2015 and will foster public confidence in CCS technology as a real and effective tool to address escalating GHG emissions.

(c) Alberta has existing EOR infrastructure

The mature oil fields that are candidates for EOR projects already have existing infrastructure in place from the production of those fields. Wellbores are in place that can be used for injection and reduce costs by not requiring new wellbores to be drilled. Pipeline, gathering and processing systems are in place to exploit the oil production and recycle the CO₂ volumes that are produced with the oil. It is possible that some of the existing pipelines that have been abandoned but that have easements already in place could be utilized in the transportation of CO₂. Glencoe Resources has done this very effectively, again, reducing the cost of implementing CCS while achieving the overall environmental goal of recycle and re-use. There is some urgency to utilizing these old wellbores before they are abandoned to avoid the need to drill new wells. In using existing infrastructure, corrosion issues need to be addressed and existing equipment may need to be modified or replaced to withstand corrosion.

(d) Reduction of water requirements

CO₂ EOR project reduces the amount of source water required for oil recovery as injection of source CO₂ reduces the source water required for voidage replacement.

B. ECONOMIC BENEFITS TO EOR AND ALBERTA

EOR represents an opportunity to unlock some commercial value for capturing and injecting CO₂. The gain in production of previously unrecoverable petroleum will extend the life of existing conventional oil fields and provide employment in rural areas in proximity to



By focusing some of its expenditure on carbon capture and transportation that can feed EOR projects, the government can recoup its expenditure through royalties that may otherwise not occur.

these fields. The tax revenues and royalties to be generated from EOR will be significant and will help offset the cost of CCS. In the early stages, when the cost of CCS will be in the hundreds of millions per project, it makes sense to attempt to defray some of these up front capital costs with EOR revenues and royalties, and then to potentially re-invest a portion of these royalties into expanding and accelerating CCS.

The province of Alberta has committed to spending \$2 billion into CCS and has taken a leading role in the world in doing so. This is something that Albertans can be very proud of. The government has an opportunity to leverage this \$2 billion expenditure for the benefit of all Albertans. By focusing some of its expenditure on carbon capture and transportation that can feed EOR projects, the government can recoup its expenditure through royalties that may otherwise not occur. These EOR royalties or a portion of them can be re-invested again and again to expand Alberta's CCS network and ensure that the engines of our economy are not carbon constrained. By doing this, the government can turn its \$2 billion expenditure into an income generating annuity that will pay Alberta for years to come. Re-payment will not only come through the EOR royalties, but through

- ☞ royalties from oil sands and heavy oil production;
- ☞ upgrading and refining with CCS; and
- ☞ petrochemical and petroleum product manufacturing occurring in the planned eco-industrial heartland complex, all of which will be in jeopardy without CCS due to stricter emissions regulations and negative public opinion. Accelerating CCS by having a revenue stream dedicated to doing so means that oil sands and other heavy oil projects can be brought on line without the risk of emissions constraint. The ability to capture and sequester large volumes of carbon will mean that more upgrading, refining, petrochemical and petroleum product manufacturing can be done right here in Alberta, without the negative side effects of increased emissions.

C. OBSTACLES TO EOR FOR CCS

Not all initial CCS projects may have an EOR component. There are opportunities to reduce large amounts of CO₂ emissions through CCS at coal-fired power plants and these CO₂ streams will require further purification for EOR. It is not certain whether or not the CO₂ from these generating plants can be purified economically in order to be suitable for EOR. However, EPCOR reports that it expects its amine scrubbing process



will produce pure CO₂ of a quality acceptable for EOR. Since coal-fired power plants are such a large source of Alberta's CO₂ emissions, it is important that capture technology be developed and tested in the early stages in order to address this large source of emissions.

One of the largest obstacles to the rapid deployment of CCS is the overwhelming capital cost. Most CCS projects are expected to be in the magnitude of hundreds of millions of dollars. The lion's share of that cost (70-80%) is the cost of installing and operating the equipment to capture the CO₂. Cost varies depending on the purity of the CO₂ stream produced - gasification-derived CO₂ is the cheapest and flue gas the most expensive. LIEs are unwilling to take on those costs unless they have incentive or are legally required to do so. At this stage, the maximum cost of releasing carbon into the atmosphere in Alberta is only \$15/tonne (outside of the \$200/tonne penalty scenario). This is only a fraction of the cost of capturing and sequestering it, which is estimated to be in the range of \$80/tonne in the early years¹⁹. The CCS Council has reportedly stated in a recent draft report that the cost to CCS could be as high as \$200/tonne²⁰. At such a low regulated price per tonne, LIEs are not economically motivated to invest their shareholders dollars into CCS. There is a gap of about \$65/tonne between the lower-end cost of CCS and the current \$15/tonne cost of compliance. According to ICO2N, the cost of CCS with EOR is closer to \$25/tonne²¹. This represents a dramatic savings for the participants and a pathway to implementing CCS on a more cost effective basis in the early years.

Notwithstanding the foregoing, there are limited, readily available sources of CO₂ that are pure enough or can be purified economically to be suitable for EOR. The largest current proximate supply is in the Prentice and Joffre areas at the MEGlobal, DOW Chemicals and Nova Chemicals plants. Penn West and Glencoe Resources have already built pipelines to transport all of the pure streams of CO₂ from these plants to EOR projects. Agrium's plant in the Heartland is also capable of supplying pure CO₂, but no pipeline exists to transport it to EOR projects yet²². Enhance Energy's planned trunk line would not only transport Agrium's CO₂, but other Heartland area upgrader's CO₂. Additional pure CO₂ sources from oil sands upgraders exist north of Fort McMurray, but require a long trunk line to EOR sites.



The next largest obstacle to wide-scale implementation of EOR projects using CO₂ will be the cost of the CO₂ to the producers. Emitters investing in capturing CO₂ want to recoup their cost of producing pure streams of CO₂ –at least \$80/tonne). EnCana has stated that in order for a CO₂ EOR project to be viable, the cost of the CO₂ has to be in the range of \$20 - \$40 per tonne on a net basis²³. That means that if the cost of CO₂ was \$55/tonne, under the current Alberta SGER, the EOR project could recoup \$15/tonne by claiming or selling the associated offsets and have a net price of \$40/tonne. That still leaves a gap of at least \$25/tonne. If carbon offsets had a value that more closely resembled the cost of removing carbon, this gap would shrink and could possibly be eliminated.

Finally, the recent economic downturn and the falling price of oil has conspired to make it very difficult for companies to obtain or risk the up front capital required for these projects and, if sustained, will dramatically reduce revenue from EOR. This underscores the urgent need for front end government funding in order to ensure that large-scale CCS projects will be commenced. The risk for industry to invest at the front end is increased by the current uncertainty of U.S. environmental policy and its impact on Canada's plan to regulate GHG emissions. The current political instability of the federal government and the resultant uncertain impact on environmental policy is a huge barrier for early movers to proceed with confidence, without risk of reversal. The lack of direction regarding harmonization between federal and provincial regulations increases uncertainty further.

SOLUTIONS FOR IMPLEMENTATION

A. EXISTING REGULATIONS

As discussed above, the Oil and Gas Conservation Act and its corresponding regulations and ERCB Directives provide a regulatory scheme for approving and operating EOR projects. These regulations can be supplemented in the future when the EOR projects mature into pure CCS. In addition, Alberta should draw on the regulations governing acid gas injection, since this is very similar to CCS, just a different and more toxic gas. There will be additional regulations required to deal with various issues such as pore space ownership, unitization, tenure application process, surface rights, and short and long term liability. However, there are many



This strategy, of appointing a CCS Secretariat, will assist in unlocking the potential of EOR CCS more quickly...

activities already governed in the energy sector that are analogous to the issues to be addressed in CCS and can be used to draw from. These are described in more detail below.

B. EXISTING FACILITIES AND INFRASTRUCTURE

In order to capitalize on the opportunity to accelerate CCS and generate EOR revenues, royalties and spin off benefits, approval of EOR schemes and granting of the necessary permits should be prioritized. Industry has reported that the time periods for processing applications and amendments for EOR schemes can be lengthy, mainly due to a shortage of personnel at the ERCB, Alberta Energy and Alberta Environment. It is felt that the current personnel are doing the best job they can, but are simply spread too thin. As industry and the government lose potentially millions of dollars a month on delayed or suspended EOR projects, (and some projects may even be put in jeopardy due to delays), it makes sense to invest in the additional personnel that are required in order to properly and expeditiously process the various projects that are submitted. These departments and agencies should, in this context, be looked at as a revenue center for the government, rather than a cost center. By expediting the timely processing of these applications, implementation of these EOR can be accelerated.

Certain EOR projects are more ready than others to begin injecting CO₂ and producing oil. Some projects may have some, but not all, of the infrastructures in place to commence operations, yet still have a shorter time to implementation than others. These projects should be identified and assigned an internal project coordinator to ensure that the government is doing everything it can to expedite the project and make sure all departments are working effectively together towards this goal. This assigned project coordinator could also identify bottlenecks in internal government processes and propose recommendations to address them. This strategy, of appointing a CCS Secretariat, will assist in unlocking the potential of EOR CCS more quickly and provide for the recycling of royalty and tax revenues generated back into CCS.

C. ECONOMIC INCENTIVES

(a) Royalty & Fiscal Incentives

The government's \$2 billion CCS fund (the CCS Fund) will be a stimulus to kick-starting CCS projects in Alberta. The current proposed plan to disburse the CCS fund



The government's \$2 billion CCS fund will be a stimulus to kick-starting CCS projects in Alberta.

provides for the majority (60%) of the funding to be disbursed over a 10-year period after start-up. Although this will help industry defray the cost of its investment in CCS, it may not do enough to stimulate it. One of the biggest obstacles to implementing these large CCS and EOR projects is the up front capital required. In the current tight credit environment, it will be very difficult, if not impossible, for certain EOR companies to obtain financing to capitalize their projects. The government can play a major role in removing or reducing this obstacle by assisting projects at the front end as opposed to the back. Understandably, the government does not want to spend on projects that may not end up working, but it may be able to evaluate this risk separately, on a case-by-case basis.

With most of these funds being earmarked for capture technology development and deployment, (where there may be the least industry incentive and opportunity for ROI), the government will need to focus some of the CCS Fund on those projects that otherwise will not proceed (at least in the near term), without funding. Notwithstanding this, the government should attempt to leverage each dollar it spends or foregoes in fiscal and royalty incentives by ensuring that a reasonable portion is allocated to projects that can generate a return most quickly. This is not to discriminate against projects that cannot generate a return in the near term (or ever), but rather to provide the government with a means of funding the expansion of CCS within the province.

EOR companies are concerned that the new royalty framework will have the effect of increasing EOR royalties dramatically. Although allowed deductions will not change, the base royalty rate has increased, which means the EOR deductions are not sufficient to reduce the up-front royalty burden that occurs prior to economic viability. In order to provide an incentive for EOR project owners, the government should consider this issue when reviewing the CO₂ Projects Royalty Credit Regulation. The current construct of the EOR Royalty Relief Program uses the cost of the CO₂ to calculate relief necessary to offset the other incremental costs associated with EOR. This does not work with low source CO₂ cost required to ensure the EOR projects proceed. In addition, the government's requirement to review this regulation by December 31, 2008, is currently causing more uncertainty with industry, such that they are unable to properly plan their projects and expenditures without knowing what changes are coming to the royalty regime that they must operate under. As



such, it would greatly assist the progress of these proposed and pilot EOR projects if the operators could obtain certainty on this issue in the near future.

The federal government has recently eliminated the accelerated capital cost allowance (CCA) for oil sands producers. At the same time, it has initiated an accelerated CCA for certain alternative or renewable energy sources. It is suggested that the Alberta government initiate a dialogue with the federal government to include EOR projects into this accelerated CCA program, or to introduce a program specifically for EOR and energy projects implementing CCS.

(b) Royalty Framework

(i) Oil sands model

The Alberta Government has a special pre-payout royalty for oil sands projects under the Mines and Minerals Act. This royalty was introduced to motivate oil companies to invest the massive amounts of capital required to construct and implement an oil sands project. This low pre-payout royalty allows the oil companies to mitigate their risk and recoup their capital more quickly than if they were subject to the full royalty from the outset. It is arguable that the Alberta oil sands would not have been developed if not for this special royalty regime. The same argument extends logically to the development of EOR in the province, which also has extremely high up front capital costs.

As most EOR projects require large amounts of capital to be invested before production can be obtained, the royalty treatment should be similar to that of oil sands projects. Although EOR production is done through individual wells, EOR is much more akin to a project than individual well production. It isn't until a number of injection wells have been drilled and large volumes of CO₂ are injected that any of the wells will begin producing. Even then, they production can vary dramatically with large spikes followed by significant drops. For this reason, it would not only be helpful if EOR could have a 1% royalty rate prior to payout, but also if the calculation of royalties could be based upon production or sales from the entire project, as opposed to an individual well. This will smooth out the royalty burden and reduce the impact of particular well



production spikes in the early stages of production.

(ii) *Saskatchewan EOR Royalty and fiscal incentive framework*

Saskatchewan is now enjoying two of Canada's most successful EOR projects, (Weyburn and Midale). These projects are producing significant volumes of incremental oil that would not otherwise be produced if not for the Saskatchewan government's willingness to implement a special royalty scheme. According to the IEA Monitoring Project, as of July 31 2008, EnCana's Weyburn Field is producing over 28,000 barrels/day and is at a 35-year production high. This is approximately 20,000 barrels/day more than would be produced without the CO₂ flood. Apache Corp's Midale Field, which is in an earlier stage of CO₂ injection, is reported to be producing about 6,500 barrels/day. The Total CO₂ stored in EnCana's Weyburn Field to July 31, 2008 is 10 million tonnes, while Apache Corp's Midale Field has stored 1.44 million tonnes. The total for both operations is 11.44 million tonnes²⁴.

EnCana has stated that without the accommodation of the government of Saskatchewan, it may not have gone forward on this \$1.5 billion project. The negotiated royalty framework included reclassifying "old oil" and "new oil" and providing a 1% royalty on gross production pre-payout and a 20% royalty on net operating income post payout. EnCana notes the net effective royalty rate is 12-15% after payout. The government also waived PST on CO₂ purchases. The Weyburn CO₂ injection project is expected to produce approximately 160 million barrels of incremental oil over the next 30 years²⁵. That equates to approximately \$12 billion in production at an average price of \$75 per barrel. That production will add billions of dollars to the Saskatchewan economy in the form of spin-off benefits and incremental royalties of approximately \$1.5 billion, while permanently sequestering 55 million tonnes of CO₂ that would otherwise have been vented into the atmosphere. This 55 million tonnes figure includes post EOR CO₂ injection into the reservoir.

The potential benefit to Saskatchewan's economy from the Midale project is the



incremental production of up to 60 million barrels of oil, the potential of up to \$4.5 billion in revenues and \$550 million in royalties for the province.

(c) Utilize Public funding to augment private

The government should consider the commitment of resources that various EOR and CCS participants have invested to date and committed to investing in the future to ensure that the participants that will be receiving funds have a vested interest in seeing the proposed CCS and EOR-CCS projects succeed. EOR projects should contain a long-term plan for permanent CCS after the EOR project has completed its commercial production operations. The government's proposal to allocate the CCS funds in tranches on a pay-for-performance basis is the right idea, but should operate to assist projects more in their early stages by ensuring that they do not run out of capital to implement their projects in a financially viable fashion. The government might want to consider a matching program for expenditures on approved CCS and EOR projects. The matching may not follow a 50-50 formula throughout the project, but may vary from phase to phase to best support the project at critical times.

(d) Exploit Advantages of EOR for Phase I CCS

As noted in the discussion above, **there are numerous economic advantages to implementing CCS through EOR in the initial stage.** The government should ensure that these projects are incorporated to the maximum extent reasonably possible, while still ensuring that the necessary experimentation and proving out of large-scale pure CCS projects (those with no gas or oil recovery) are successfully achieved. This approach is justified in that it will reduce the risk across the initiative and improve the likelihood of achieving the following:

- ☞ immediate and significant CO₂ emission sequestration
- ☞ reduce the lead times to show real progress in the initiative
- ☞ provide a royalty and increased tax base from which to recoup its investment in CCS
- ☞ improve the overall economic picture in Alberta for decades to come
- ☞ stimulate the oil patch and utilize dormant resources from the recent downturn



As noted above, Alberta already has existing regulatory processes for EOR and Acid Gas Disposal. These regulatory processes can and should be utilized and built upon to address the specific issues inherent in EOR and CCS operations. Alberta can utilize its experience in this adaptive process to build a comprehensive suite of CCS regulations.

(e) Leverage Industrial facilities capable of capturing purer streams of CO₂

Although the government has indicated that it is not a priority to build a CO₂ backbone pipeline with the CCS Fund, it should consider the lost opportunity in not beginning the process. Eventually, a pipeline will need to be built between Fort McMurray and the CCS and EOR sites. However, there is a more immediate opportunity to build a pipeline that can be tied into plants emitting 98%+ pure CO₂ immediately. The pure CO₂ transported to EOR projects from such plants can be used to stimulate incremental production and build a royalty base from which the government can begin to recoup its CCS investment. If there are existing pipelines that can be utilized for part of the CO₂ backbone, then these should be explored. It would be short-sighted for the government not to exploit opportunities to recoup its capital when real and viable opportunities exist. This should be a focus for accelerating the rollout of CCS in Alberta and reducing the sunk cost.

(f) Ensure Early Initiators are not penalized for early action

Early adopters and initiators of environmental programs have been penalized for early action in the past and left with stranded or worthless assets. This must be avoided in the implementation of CCS. The CCS fund is an incentive for early action, but those companies that do not participate in the fund in the first round should still be provided with incentives for moving their EOR and CCS projects forward. These incentives can include tax and royalty credits, as well as more effective and efficient administrative processes. Government should ensure that companies risking their capital to undertake innovative and experimental projects should be assisted and not limited by the limited resources of government departments and



regulatory agencies. The government should assign a liaison between each EOR and CCS project and the governmental departments and agencies it will have to deal with. This will reduce inefficiencies and unnecessary delays and will lubricate the wheels of progress. This is essential if Alberta is to meet its tandem goals of wide scale CCS implementation and resource development.

(g) Address issue of credit ownership for all components of CCS

One of the issues that companies involved in the three stages of CCS will have to grapple with is who gets credit for the emission reduction and who owns the credits. Logically, the credits or offsets should be split between the three parties, since they are each responsible for a critical component of the emission reduction. This may be open to negotiation between the three parties, or it could be part of the regulatory scheme. Where the parties cannot agree to an allocation, it may be helpful to have the matter determined by a regulatory body similar to the Surface Rights Board. The regulatory body should take into account the relative investments of each of the three parties relating specifically to the CCS and the relative allocation of short-term and long-term liability between the parties. This approach could guide the regulatory body in making its decision as to a fair and equitable split of credit/offset ownership.

(h) Pore space ownership

As it stands now, pore space ownership is not a major issue in respect to EOR projects. The pore space within geological formations for which the Crown has granted mineral rights appears to rest with the mineral owner under the Mines and Minerals Act. In the context of EOR, this type of ownership makes sense and is in fact what is being utilized currently to determine who has the right to inject CO₂ into geological formations. In the context of freehold mineral ownership, pore space ownership can be less certain, and may be specified in the mineral lease. However, not all leases specifically address this issue. Currently, in order to obtain approval for injection or storage, EOR project owners must either own the mineral rights in the geological formations that they are injecting CO₂ into or they must obtain agreement to unitize the formations with the other mineral rights owners in order to proceed with the EOR scheme within that formation.

This raises issues in respect to the unitization process and the lack of a regulatory



scheme to facilitate voluntary unitization, or where required, forced unitization. It makes sense that the mineral owner retains the pore space ownership in the geological formations in which it owns the mineral rights in order to allow the mineral rights owner to produce the incremental resource from such formation. If this were not the case, the ownership of the minerals would have to revert to the Crown or the freehold owner in order for the Crown or freehold owner to exploit them. As such, it is recommended that the status quo be maintained in respect to Crown lands in order to most effectively accelerate EOR and CCS. However, it would be helpful if a determination of ownership of pore space on freehold lands were made, either by legislation or a ruling of the ERCB. Where there is a dispute as to who has the right to inject into the formation, then such dispute should be resolved using a process similar to that used by the ERCB in the coal bed methane case or similar to the process used by the Surface Rights Board. The regulations should provide for such a process. This process has a proven track record of dispensing fair and expedient decisions.

(i) Short and Long Term Liability

(i) Short Term Operational Liability – Industry

Industry is the logical candidate to bear liability during the operations phase of any CCS project. Given that the project owner is the party in control of the injection and sequestration operation, it is in the best position to manage the risk and deal with any incidents that may occur. This is consistent with the liability regime in the oil and gas sector and has been proven to work well. There is no need to re-invent the wheel in this context and the regulations should clarify that liability during the operations phase rests with the operator/owner of the CCS project. This liability should remain in place during the transitional MMV phase until it can be established that the injection scheme has been completed to the standard of the regulations and is stable and secure.

(ii) Long Term Liability – Crown

Upon completion and decommissioning of the CCS project, including the MMV phase pursuant to the requirements of applicable regulations, the liability for long term monitoring and management should rest with the Crown. This position is based upon a number of factors: (i) long term CCS is for the public good; (ii) IPCC has found that where



sequestration sites have been properly selected, managed and decommissioned, the risk of leakage is very low; and the government is likely to outlive most corporate entities and will be in existence over the long term to monitor and manage sequestration sites. To defray the Crown's burden of long term liability, a fund similar to the Orphan Well fund could be put in place and paid into by the CCS project participants. The long term liability and the process and requirements for transferring liability from the project owner/operator to the Crown should be set out in the regulations. Properly managed, and backed by a participant financed long term liability fund, the government's long term risk should be minimal and manageable.

(j) Use Regulations to Stimulate EOR Projects

There is currently no requirement to conduct secondary or tertiary recovery programs under the Mines and Minerals Act in order to maintain an interest in the mineral rights. In order to stimulate recovery of remaining oil in place in Alberta, the province should amend the regulatory scheme to require existing lessees to investigate and, if feasible, implement enhanced oil recovery programs, or the lease rights in respect thereto revert back to the Crown. This would operate in a manner similar to Crown Deeper Rights Reversions. This would allow companies interested in EOR to gain access to mature pools to optimize the recovery of Alberta's massive reserves of remaining oil in place.

(k) Procedure for expediting Unitization process

The government should determine its policy with respect to advancement of CCS and the integration and exploitation of EOR to achieve its policy objectives respecting CCS sequestration and incremental oil recovery, and then adopt a regulatory process for facilitating and expediting the process of determining reservoir ownership and participation in an EOR scheme, or unitization if required. Participation/unitization is one of the major obstacles for some EOR projects and a major cause of delay in project commencement. EOR companies are wasting a great deal of time and resources attempting to unitize the mineral rights in the target reservoirs. There is currently no "stick" available to the project proponent to compel mineral owners and lessees to deal with the issue or take a reasonable position on unitization. The project proponent can be held ransom and is often forced to try and design around the difficult parties mineral rights. This may not optimize the conservation of the resource or the energy required to obtain it. This situation is



The government should issue a Regulatory Framework that discloses the policies and anticipated regulatory approach that the government expects to implement. This will give industry a reasonable basis for planning and decision-making.

inconsistent with the position of the government on surface rights and needs to be addressed. The government of Saskatchewan has a regulatory scheme for forced unitization and the government of Alberta should consider implementing a similar practice in order to force parties to come to reasonable agreements, failing which, the appropriate board will determine the matter for them.

D. REGULATORY FRAMEWORK

In order to provide industry with some degree of certainty, the government should issue a Regulatory Framework that discloses the policies and anticipated regulatory approach that the government expects to implement. This has been done successfully in other areas such as emissions regulations and will give industry a reasonable basis for planning and decision-making. This can act as an interim measure to fill the gap while regulations and legislative amendments are being drafted, proclaimed or enacted.

E. HARMONIZATION OF PROVINCIAL & FEDERAL REGULATION

Although the government does not control the outcome of harmonization initiatives with the federal government in respect to emission reduction regulation, the government should set out a position and strategy for harmonization with federal regulatory framework that is reasonably achievable and likely. In particular, the incentives that will be offered for pilots and commercial implementation should be set out and rationalized.

As the federal Regulatory Framework on Air Emissions sets out the possibility of equivalency agreements between the two levels of government, the government should determine and disclose if that is route that they expect to take to harmonize the two regulatory regimes. Since the basis of equivalency agreements is that the provincial standards have to be at least as stringent as the federal standards, the government should determine which standards it is willing and able to make more stringent in order to achieve equivalency more quickly and remove as many contentious issues as possible prior to negotiation of the equivalency agreement. If the government does not plan to utilize the equivalency agreement process, it should disclose what its harmonization strategy is so that industry will have some degree of certainty as to what the future holds.



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GLOSSARY OF TERMS

aquifer: An underground sheet of permeable rock through which groundwater runs; often a source of water for wells and springs.

cap-and-trade system: A system that sets a mandatory limit on CO₂ emissions, and provides a market-based mechanism whereby CO₂ emitters can buy and sell emission credits.

carbon capture: The removal of carbon from fossil fuels before combustion or carbon dioxide after combustion.

carbon dioxide equivalents (CO₂): a universal standard of measurement against which the impacts of releasing (or avoiding the release of) different greenhouse gases can be evaluated.

CO₂ enhanced oil recovery: The injection of CO₂ into oil reservoirs to recover additional oil beyond that which would have been recovered by conventional primary and secondary oil recovery methods.

carbon sequestration: The capture and long-term storage of carbon dioxide before it is emitted into the atmosphere sometimes referred to as carbon storage.

carbon tax: A compulsory measure where monetary value is imposed by governments on burning fossil fuels and releasing CO₂ into the atmosphere.

coal-bed methane: Natural gas found in coal seams. It is still in the early stages of development in Alberta and may help meet the growing demand for natural gas.

coal gasification: The process of transforming coal into fuel through the reaction of coal, water and heat.

emissions Intensity (EI): A measurement of greenhouse gas emissions that reports the amount of emissions per unit of economic output, as opposed to "absolute emissions."

enhanced coalbed methane recovery (ECBM): Injecting CO₂ and nitrogen into coalbeds to release methane.

enhanced gas recovery (EGR): injecting CO₂ into pores in a gas reservoir where trapped methane is released and pressure maintained.

enhanced oil recovery (EOR): A process for extracting otherwise inaccessible oil from underground deposits. It may involve water flooding, carbon dioxide injection or other techniques.

flooding: Injecting substances such as CO₂, steam or water to push oil towards the wells.

flue gas: An assortment of gasses resulting from the combustion of fossil fuels

greenhouse gas (GHG): GHGs include water vapor, carbon dioxide CO₂, methane (CH₄) and nitrous oxide (N₂O) emitted through the burning of fossil fuels.

hydrates: A hydrate is a naturally occurring, ice-like crystalline compound in which a crystal lattice of water molecules encloses a molecule of some other substance.



large industrial emitters (LIE): Large emitters of greenhouse gasses. This includes industries such as thermal power generation and petrochemicals .

immiscible CO₂: CO₂ injections make oil swell and become more viscous, improving oil flow but does not mix completely with the reservoir oil.

miscible CO₂: CO₂ combines completely with the crude oil to become one mixture.

migration of CO₂: The movement of CO₂ through a geologic formation, driven by density or a pressure differential.

original oil in place (OOIP): the amount of oil in a reservoir when the reservoir is discovered.

permeability: The capability of a rock (or other material) to allow the passage of a fluid.

porosity: The ratio of the volume of pore space in rock (or other material) to its total volume. Porosity determines a material's ability to absorb a liquid or gas.

royalties: These are monies or the price that the owner of a natural resource charges for the right to develop the resource.

reservoir: A subsurface, porous, permeable rock body surrounded by impermeable rock and containing oil, gas, or water.

saline aquifers: A layer of porous rock that holds an abundance of salt water.

sequestration: The natural or artificial process of storing carbon.

syngas: A mixture of carbon monoxide (CO) and hydrogen (H₂), used as an alternative fuel source to natural gas. It is the product of the gasification of organic material such as coal.

water alternating gas (WAG): A method of flooding that switches between water and gas injection to maximize oil recovery.

wellbores: A long hole drilled into the ground for oil production; also called a borehole.



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AEDA ENERGY RESOURCE COMMITTEE

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Don Lowry – President and Chief Executive Officer, EPCOR Utilities Inc.

Garry Mihaichuk – President and CEO, Toromont Energy Systems

Val Mirosh – Vice President and Special Advisor to the President and COO, NOVA Chemicals Corporation

Alex Pourbaix – President, Energy, TransCanada Corporation

Gerry Protti – Executive Vice-President, Corporate Relations, EnCana Corporation

Chuck Shultz – Chairman and Chief Executive Officer, Dauntless Energy Inc.

Scott Thon – President and Chief Executive Officer, AltaLink Management Ltd.

Steve Wuori – Executive Vice-President, Liquids Pipelines, Enbridge Inc.

PROJECT TEAM

James Cleland – AEDA

Judy Eng-Hum – AEDA

CONSULTANTS

John Goetz, LLB – Burnet Duckworth Palmer

Aaron Rogers, LLB – Burnet Duckworth Palmer

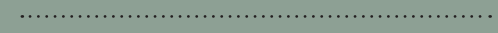
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