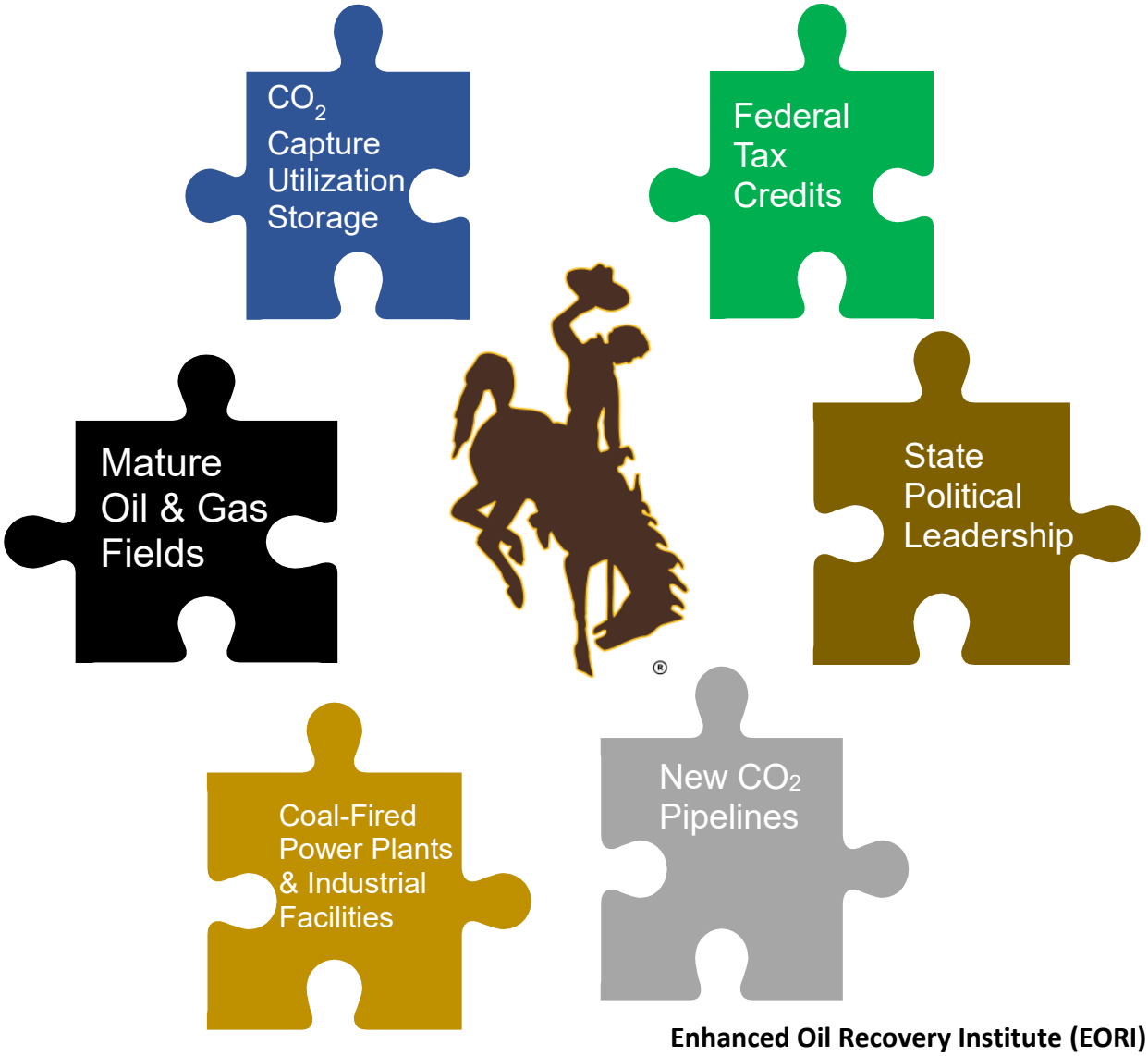
Maximizing Wyoming's Energy Resources

Commoditizing Captured CO_2



Enhanced Oil Recovery Institute (EORI)

2435 King Boulevard, Suite 140

Casper, Wyoming 82604

www.uwyo.edu/eori

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1. Executive Summary

- Wyoming's fossil resources and energy infrastructure are well-suited for utilizing captured carbon dioxide (CO_2) for enhanced oil recovery (CO_2-EOR) projects, given the state's abundant coal reserves, coal-fired electric utilities and industrial facilities, existing CO_2 pipeline network, and mature oil and gas fields.
- CO_2-EOR can significantly increase oil and gas production from many conventionally depleted oil and gas reservoirs in Wyoming.
- Wyoming's coal-fired power plants and gas processing plants can, with technology retrofits and pipeline connections, capture and sell CO_2 to CO_2-EOR operators, generating additional revenue, earning federal tax credits, and likely extending their operational lifetimes while preserving local jobs.
- The storage of CO_2 following CO_2-EOR operations is safe and technically proven and can help Wyoming's fossil energy industry manage the long-term regulatory risks and investor scrutiny associated with climate change.
- The federal and state regulatory landscape is already attractive to CO_2-EOR project developers, but clear and consistent political leadership at the state level is fundamental to sustained success, given the long timeframes and potential challenges involved in project construction, startup, and initial operations.

2. Introduction

A. CO_2 as an Untapped Energy Resource

Wyoming ranks second in total energy production in the United States. It ranks first in coal, eighth in crude oil, sixth in natural gas, and seventh in total potential wind resources. Wyoming is also home to the largest uranium mining operations in the country.

When it comes to energy, the Cowboy State is among the nation's elite.

CO_2 is poised to change that – for better or for worse.

For worse, the issue of climate change is driving new energy policies and environmental regulations seeking to constrain the production of fossil fuels and the CO_2 emitted from their combustion. Financial institutions and investors are pressing fossil energy companies to quantify the risks climate change poses to their business models. Activists are filing lawsuits, staging marches and protests, and changing public perceptions about fossil fuels and the alternatives they hope will replace them.

But for better, technologies exist that can harness the CO_2 produced from fossil fuels to extract new reserves of otherwise unrecoverable oil and gas. These technologies can transform CO_2 from a combustion byproduct to a valuable commodity. Wyoming produces about 65 million tons of CO_2 per year. This is an untapped energy resource, with the potential to boost the state's oil and gas production and generate additional revenue for the state's coal-fired power plants and gas processing plants – extending operational lifetimes and preserving local jobs.

Maximizing Wyoming's energy resources requires the deployment of projects that capture CO_2 from, for example, the stack of a coal-fired power plant, transport it by pipeline to a mature oil and gas field, inject it into the subsurface to produce otherwise unrecoverable incremental oil and gas, and then permanently store the CO_2 in the depleted reservoir.

WYOMING'S CO_2 – DEMAND & POTENTIAL

***Assuming oil at $70 per barrel over 20 years*:**

- 64-116 WY oil and gas fields impacted
- ~300 million tons of CO_2 utilized
- 845-986 million additional barrels of oil produced
- $4.3-4.9 billion in new revenue generated

Source: Enhanced Oil Recovery Institute (EORI)

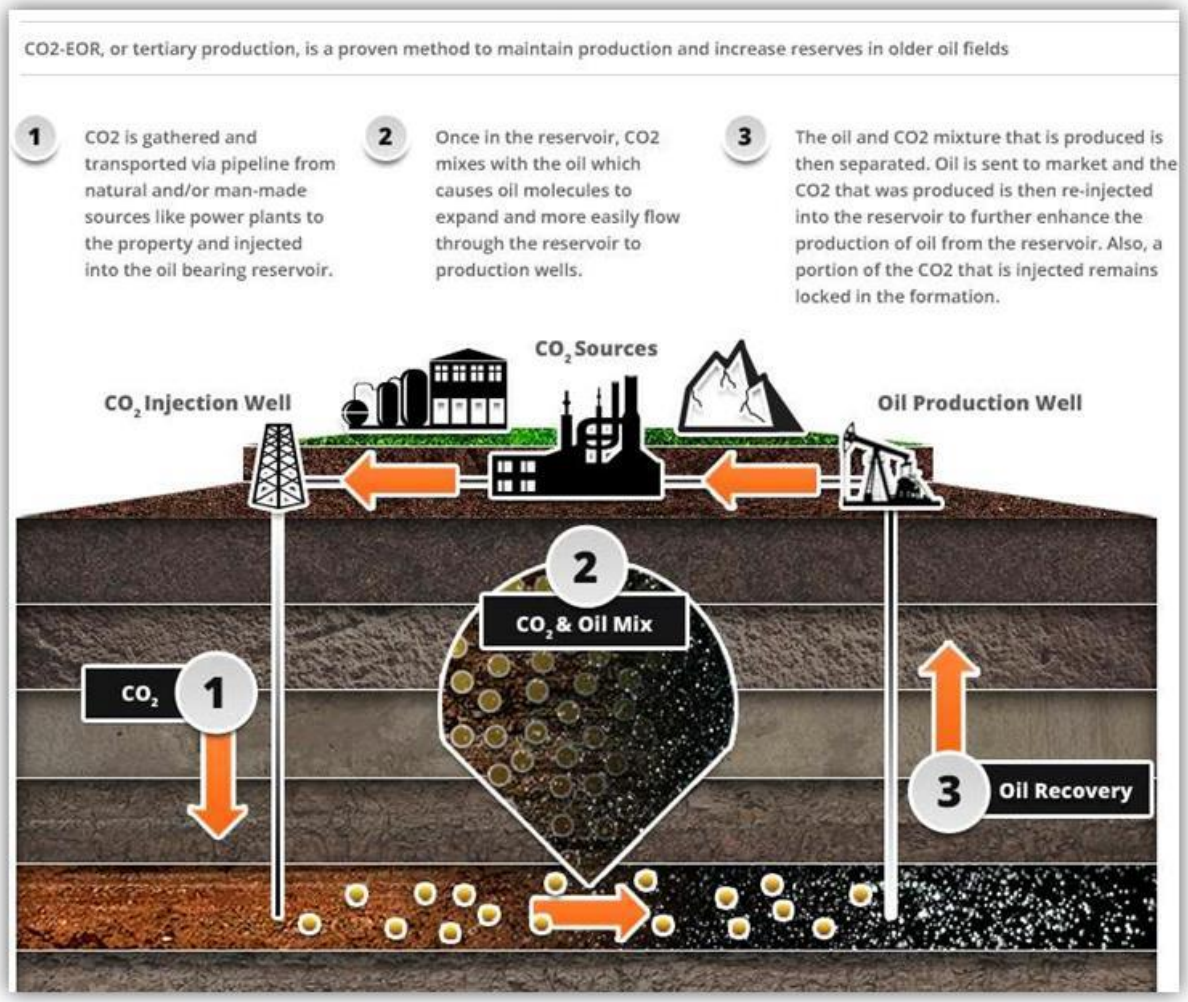
B. Commoditized CO_2 as the Foundation of an Integrated Energy Economy

Commoditizing captured CO_2 involves its capture, transport, utilization, and storage – commonly referred to as CCUS. But in Wyoming, commoditizing captured CO_2 has the potential to be more than its constituent parts. It is better seen as the foundation of an integrated energy economy, where a combustion byproduct is monetized to produce additional energy resources.

Commoditizing CO_2 has the potential to confer a multitude of benefits across Wyoming's energy sector and throughout the state's economy:

- Coal-fired power plants, as CO_2 producers, can sell captured CO_2 as well as electricity, creating new revenue streams.
- Gas processing plants and certain other industrial facilities also can sell captured CO_2, also creating new revenue streams.
- Pipeline operators can earn fees for transporting captured CO_2 to oil and gas fields.
- Oil and gas producers utilizing captured CO_2 for CO_2-EOR can produce additional oil and gas from conventionally depleted oil and gas reservoirs.

- CO_2 producers and CO_2-EOR operators can claim federal tax credits potentially worth tens to hundreds of millions of dollars over the life of their projects.
- Fossil energy companies, by reducing their overall CO_2 emissions with CO_2 capture and storage, can reduce the risks they face from climate-related litigation and regulation, investor activism, and alternative technologies.
- Wyoming can generate more energy for the country and more energy-related revenue for the state through increased oil and gas production.
- Wyoming also, because of the way CO_2-EOR integrates coal mining, power generation, gas processing, and oil and gas production, can create new opportunities for technology innovation, spurring economic growth and job creation beyond the energy sector.



Source: Core Energy LLC

C. Wyoming as a Platform for Commoditizing Captured CO_2

Wyoming's unrivaled combination of vast fossil energy resources, existing energy infrastructure, potential for new infrastructure construction, and knowledgeable approach to energy policy issues make the state an ideal platform for commoditizing captured CO_2.

Technologies exist that can capture, transport, inject, and store CO_2 safely and effectively. Newly expanded federal tax credits under Section 45Q of the Internal Revenue Code can undergird the business case for CO_2-EOR projects, which also may be eligible for grants from the U.S. Department of Energy and other types of public-private partnerships.

Industry leadership is essential, both in designing CO_2-EOR projects vigorously grounded in market realities and in executing complicated CO_2 offtake agreements that link CO_2 producers in power and industrial sectors with oil and gas producers in the field. The issue of climate change plays a role, given the intensifying levels of investor scrutiny many fossil energy companies are facing over regulatory and litigation risks arising from their CO_2 emissions.

At the state level, the regulatory landscape already is attractive to project developers and, historically, has never been a meaningful barrier to energy project development.

But ambitious CO_2-EOR projects sometimes take more than a decade to develop and deploy. These types of large-scale projects are worth the wait. They can deliver direct benefits for Wyoming's energy sector and secondary benefits for the state's construction and service sectors, along with the often unforeseeable benefits that arise whenever a place makes itself a focal point for technology innovation and complex problem-solving.

Nevertheless, clear and consistent political leadership is fundamental to realizing Wyoming's potential as a platform for commoditizing captured CO_2. This includes advocating for Wyoming projects before Congress and federal regulatory agencies, educating and engaging stakeholders, and otherwise being available to help resolve the myriad challenges CO_2-EOR projects can face.

This also includes taking a long-term view of Wyoming's potential for commoditized CO_2 that maintains support for CO_2-EOR projects throughout episodic fluctuations in commodity prices, broader economic swings, presidential administrations, and other political changes. For project developers, more than any specific regulation, initiative, or agency, there may be nothing more important than knowing Wyoming's political leaders will always share in the vision of an integrated energy economy driven by commoditized CO_2.

D. About This Report

This report was prepared by the Enhanced Oil Recovery Institute (EORI) of the University of Wyoming's School of Energy Resources in response to calls by the Governor of Wyoming and the Wyoming Legislature to identify and assess opportunities to attract and help develop new energy projects and other energy-related initiatives in the state. In preparing the report, EORI drew on the advice and support of its Technical Advisory Board (TAB), an advisory task force authorized by WY Stat § 30-8-101 (2017). The report's findings and recommendations are intended for political leaders and policymakers in Wyoming and seek to reflect the expertise, experience, knowledge, and data represented in EORI and the TAB.

3. Key Concepts & Recommendations

The following key concepts and recommendations are based on past projects involving CO_2 capture, transport, utilization, and storage. This includes projects involving coal-based power plants as the source of captured CO_2, as well as industrial facilities, such as gas processing plants, also capable of producing CO_2. (Natural gas-based power plants also can serve as a source of captured CO_2.) But to avoid confusion, unless otherwise noted, the term "facility" is intended to encompass coal- and natural gas-based power plants and industrial plants.

TECHNOLOGY & FINANCE

A. CO_2 Source

- Seek the highest quality sources of captured CO_2 available, balancing purity specifications with the need for sufficiently large volumes.
- Evaluate the condition and performance of the facility to determine whether a CO_2 capture retrofit is technically feasible and cost-effective.
- Avoid new construction of large-scale facilities involving power generation and/or related technologies that have not been tested and demonstrated at scales that are roughly comparable to the scale of the project.

B. CO_2 Capture

- Use capture technologies that have been tested and demonstrated at scales that are roughly comparable to the scale of the project.
- Determine whether the capture technology is likely to be reliable, with maintenance and servicing needs capable of being performed by local contractors and not exclusively by specialists that are few in number and far away.
- Evaluate the capture technology in terms of specific conditions at the project site, such as elevation, temperature, pressure, humidity, and other relevant criteria.

C. CO_2 Transport

- Pursue new CO_2 pipeline construction for potential projects where feasible, drawing on the Wyoming Pipeline Authority's CO_2 pipeline corridor plans.
- Evaluate the specifications for new CO_2 pipelines based on the International Standards Organization's Pipeline Transportation Systems standard (ISO 27913).
- Ensure the captured CO_2 is processed in a form that will minimize its corrosivity and avoid damage to the pipeline.
- Ensure the transported CO_2 is received in a form that will not contaminate oil and gas reservoirs and otherwise be usable by the CO_2-EOR operator.

D. CO_2 Utilization & Storage

- Recognize that many oil and gas fields in Wyoming can benefit from CO_2-EOR and that significant demand exists for steady supplies of utilizable CO_2.
- Recognize that the injection and storage of CO_2 is proven to be safe and effective, given appropriate site selection and characterization.
- Seek projects, where feasible, with the potential to involve multiple sources of captured CO_2 and multiple off-takers for CO_2-EOR.

E. Risk Management

- Design projects with sufficient flexibility to overcome initial technical problems and other delays in construction and startup, particularly involving CO_2 capture equipment and injection and storage during CO_2-EOR operations.
- Identify and disclose project risks and uncertainties to political leaders, regulators, investors, and other stakeholders throughout all stages of project development, permitting, and construction.
- Recognize that CO_2-EOR requires the injection and storage of such large quantities of CO_2 that net CO_2 emissions from the use of the additional oil and gas produced are likely to be negative – *i.e.*, "carbon negative fossil fuels" – which can confer legal and regulatory benefits to coal mining companies, electric utilities, industrial facilities, and oil and gas producers involved in CO_2-EOR projects.

LAW & POLICY

A. Overview

- The extension of federal tax credits in February 2018 have the potential to transform the economics of projects that capture, utilize, and store CO_2.
- Beyond federal tax policy, optimizing federal regulatory standards can remove regulatory barriers, expedite permitting processes, and provide more certainty in determining compliance costs.
- At the state level, the regulatory landscape already is attractive to project developers, particularly with state statutes addressing subsurface ownership and liability issues.
- There are some targeted changes to state tax policy that can further incentivize project development, but other changes should be prefaced by a Strength-Weakness-Opportunity-Threat (SWOT)-type analysis to identify any specific bottlenecks or roadblocks and thereby avoid creating the kind of uncertainty and confusion that often accompanies broad regulatory reform efforts.

B. Federal

In February 2018, Congress extended and expanded an array of federal tax credits under Section 45Q of the Internal Revenue Code for the capture, utilization, and storage of CO_2. New tax credits of $35 per ton of CO_2 captured and utilized for EOR (previously $10 per ton) and $50 per ton of CO_2 stored (previously $20 per ton) and the removal of an annual volumetric cap (previously 75 million tons) can make many CO_2-EOR projects commercially viable and attractive to operators and investors.

For example, a CO_2-EOR project involving the capture and utilization of 500,000 tons of CO_2 per year would generate $175 million in federal tax credits over its first decade of operations. The increase in the value of the federal tax credit, along with the removal of the volumetric cap, is likely to be transformative for CO_2-EOR projects – defraying the costs of the installation and operation of CO_2 capture equipment and pipeline construction and shielding oil and gas revenues from federal tax liability.

Other possible federal actions that would provide further support to CO_2-EOR projects include:

- Allow price stabilization contracts (*i.e.*, contracts for differences) for captured CO_2 sold to CO_2-EOR operators to eliminate market volatility and incentivize private investment.
- Provide eligibility for tax-exempt private activity bonds (PABs) and master limited partnerships (MLPs) to enhance tax benefits and enable project developers to raise capital in public equity markets.
- Prioritize CO_2-EOR projects, including pipeline transportation, in federal programs supporting research, development, and deployment of advanced energy technologies to validate CO_2-EOR as a vital part of the country's energy infrastructure.
- Revise federal regulatory standards involving review of federal actions under the National Environmental Policy Act (NEPA), emissions reporting under the Clean Air Act (CAA), and underground injection and well classification (including state primacy) under the Safe Drinking Water Act (SDWA) to remove regulatory barriers, streamline permitting, and make compliance costs more predictable for CO_2-EOR projects.

C. State

Wyoming has been among the leading states in passing legislation to clarify pore space ownership, injected CO_2 ownership, unitization, mineral rights primacy, and related issues to help minimize risks and uncertainties related to CO_2 storage.

These measures signaled that political leaders in Wyoming understand the challenges facing CO_2 capture, utilization, and storage and are serious about seeing CO_2-EOR projects deployed in the state. This is compelling for CO_2-EOR project developers, since Wyoming's broader regulatory landscape is already attractive for energy projects.

Wyoming can further leverage its position as one of the country's energy leaders by providing clear and consistent political leadership at the state level. This includes championing CO_2-EOR issues before Congress and federal agencies, particularly where federal grants and permitting

issues are involved. This also includes engaging stakeholders in the state and across the western region, such as through *CO_2NNECT: Carbon Capture Pathways to Clean Energy*, and remaining available to help resolve unforeseen challenges that can emerge during project development, construction, and startup phases.

Most of all, this requires maintaining a long-term view of the state's potential for commoditizing captured CO_2 – irrespective of fluctuating commodity prices, broader economic trends, transitions in presidential administrations, and other political changes. For large-scale CO_2-EOR projects that can sometimes take more than a decade to develop and deploy, project developers will feel confident about Wyoming knowing the state's political leaders share in the vision of an integrated energy economy driven by commoditized CO_2.

If Wyoming were to consider other state-level actions for facilitating CO_2-EOR project development, the most common actions other states have considered and taken include the following changes in state tax policy:

- Eliminate sales taxes on equipment purchased to construct or install CO_2 capture equipment or utilize captured CO_2 for CO_2-EOR;
- Eliminate or reduce property taxes on facilities that capture CO_2; and
- Create new financial incentives based on oil and gas production and severance taxes.

For broader state regulatory reforms, Wyoming should proceed with caution. Before taking any action, the state should conduct a SWOT-type analysis to identify specific bottlenecks or roadblocks and formulate precise, highly targeted changes to address them. This will avoid the kind of uncertainty and confusion that often accompanies systemic efforts to revise regulations and reorganize state bureaucracy, which could have a chilling effect on project development in the state.

STAKEHOLDER OUTREACH & ENGAGEMENT

A. Overview

- Stakeholder engagement and trust are critical for CO_2-EOR project development.
- Stakeholder engagement needs to be aligned across government, regulators, project developers, and the public.
- Stakeholder engagement does not guarantee success.

B. Key Issues for Stakeholder Engagement in Wyoming

- Stakeholder landscape in Wyoming for CO_2-EOR projects.
- Social site characteristics and risks that threaten CO_2-EOR project success.
- Potential for state-based financial and legislative support.

C. Examples

For all CO_2-EOR projects, one point is clear: engagement is necessary, and the absence of an inclusive, multi-component stakeholder engagement process can derail even the best projects.

The Regional Carbon Sequestration Partnerships, funded by the U.S. Department of Energy, have excelled at stakeholder engagement by taking a localized approach and forging working relationships with industry, policymakers, lawmakers, non-governmental organizations, and academia. These relationships were able to develop over time and reflect local understandings of infrastructure needs and each region's geology, economy, and social dynamics.

Two examples from the Regional Partnerships stand out. The Plains CO_2 Reduction (PCOR) partnership has done extensive carbon storage associated with CO_2-EOR and conducted effective outreach, including partnering with public television to create documentaries on CO_2-EOR, thereby increasing public understanding of the technologies and their benefits.

The second is the Midwest Geologic Sequestration Consortium (MGSC) partnership, which leads a demonstration project in Illinois that is storing one million tons of CO_2 captured from ethanol production in a saline, non-oil bearing rock formation. The MGSC built longstanding regional relationships and offered capacity building and knowledge sharing programs to further advance CO_2-EOR. The MGSC also contributed to the FutureGen project, which included a competitive, participatory site selection process, which helped attract significant community support by demonstrating societal benefits and engaging stakeholders in project decision-making.

The Petra Nova – W.A. Paris Project, located near Houston, Texas, is a promising model for commoditizing captured CO_2 to integrate coal-fired power generation, pipeline transportation, and increased oil and gas production. *Source:* NRG Energy, Inc.

4. Conclusion

Commoditizing captured CO_2 in Wyoming will benefit coal mining operations, coal-fired electric utilities, industrial facilities, and oil and gas producers – creating new revenue streams for power plants and gas processing facilities and producing more oil and gas in the state.

The newly expanded federal tax credits have the potential to be a game-changer – bolstering the business case for commoditizing captured CO_2 and defraying capital and operational costs around CO_2 capture retrofits and pipeline construction.

As CO_2-EOR projects are deployed, Wyoming's CO_2 emissions will decline, helping fossil energy companies address current and prospective regulatory and litigation risks related to climate change, which are drawing increased attention from financial institutions and investors.

But most profoundly, the sustained pursuit of CO_2-EOR projects will require a level of cooperation across the state's energy landscape that would be unprecedented for Wyoming and, indeed, most anywhere else on earth.

The reward is high, but so is the degree of difficulty. Yet this spirit of enterprise will attract many of the best people and the best companies to Wyoming – creating opportunities for technology innovation that often go hand-in-hand with building big things and solving complex problems. Innovation can be hard to predict, but when it happens, it can be expected to benefit far more than just the state's energy sector.

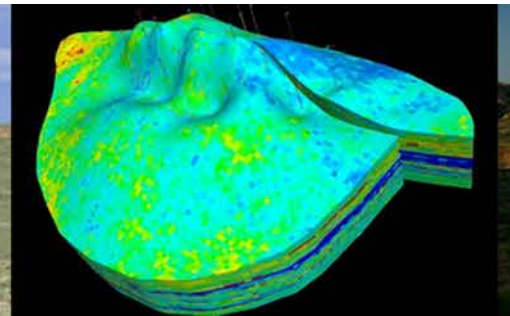
Maximizing Wyoming's energy resources by commoditizing captured CO_2 would be a service to the entire state, the country, and the world.

070 - Enhanced Oil Recovery Commission

Joint Minerals Committee Hearing:

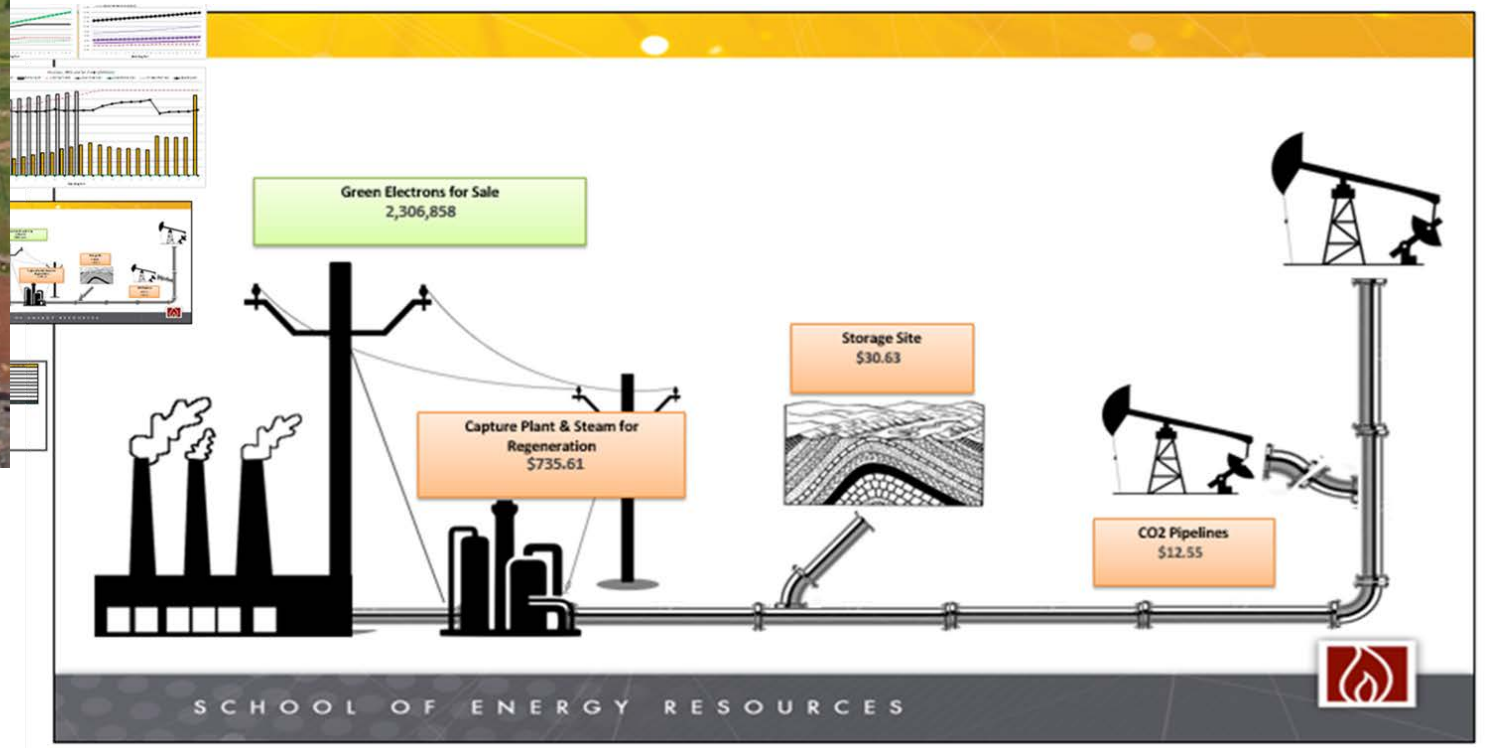
CCUS - 45Q Credit & ITC Updates

May 31, 2018

Provide Support to Legislature & Governor

Dry Fork Station CarbonSAFE Phase II



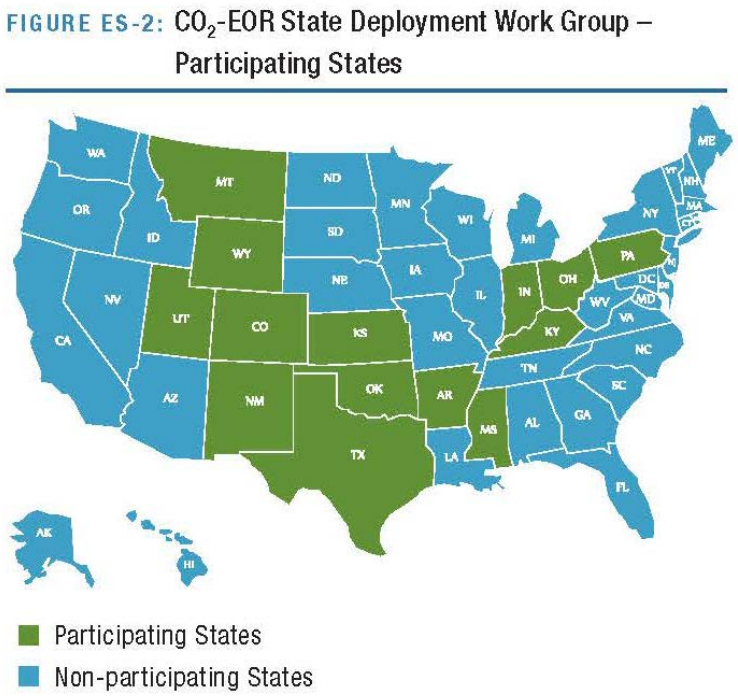
NATIONAL ENERGY TECHNOLOGY LABORATORY

EFFICIENT FUEL ADDITIVES

ITC WYOMING INTEGRATED TEST CENTER

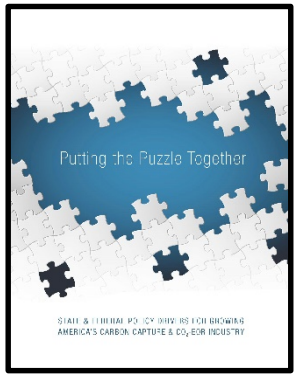
Enhanced Oil Recovery Institute

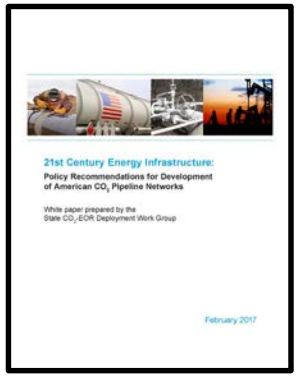
Provide Support to Legislature & Governor

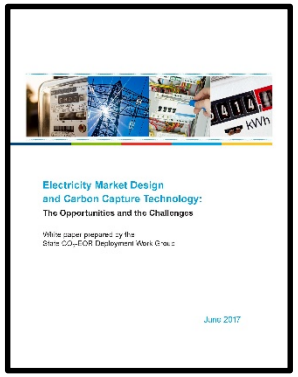


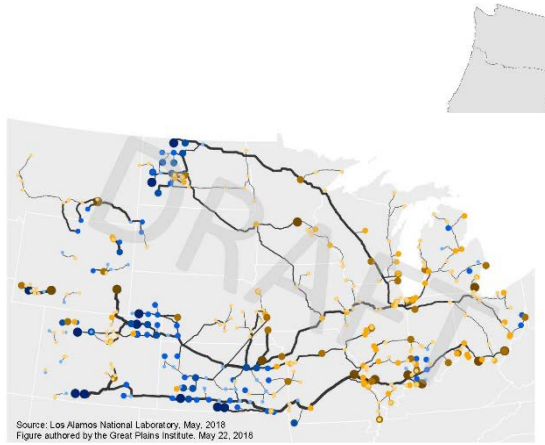
Regional CO_2 Capture Deployment Initiative

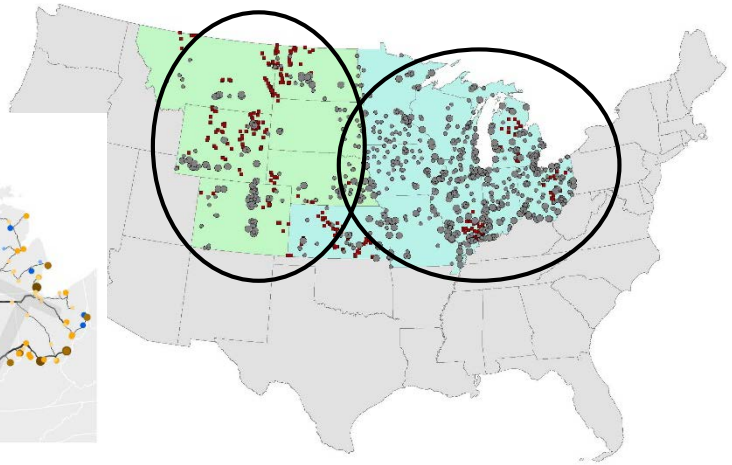
1. Identify Sources of CO2
2. Understand the Cost of CO2 Capture
3. Identify Potential Sinks
4. Identify Potential Source-Pipeline-Sink Networks
5. Visualize Possible Integrated System Designs
6. Regional project economic feasibility











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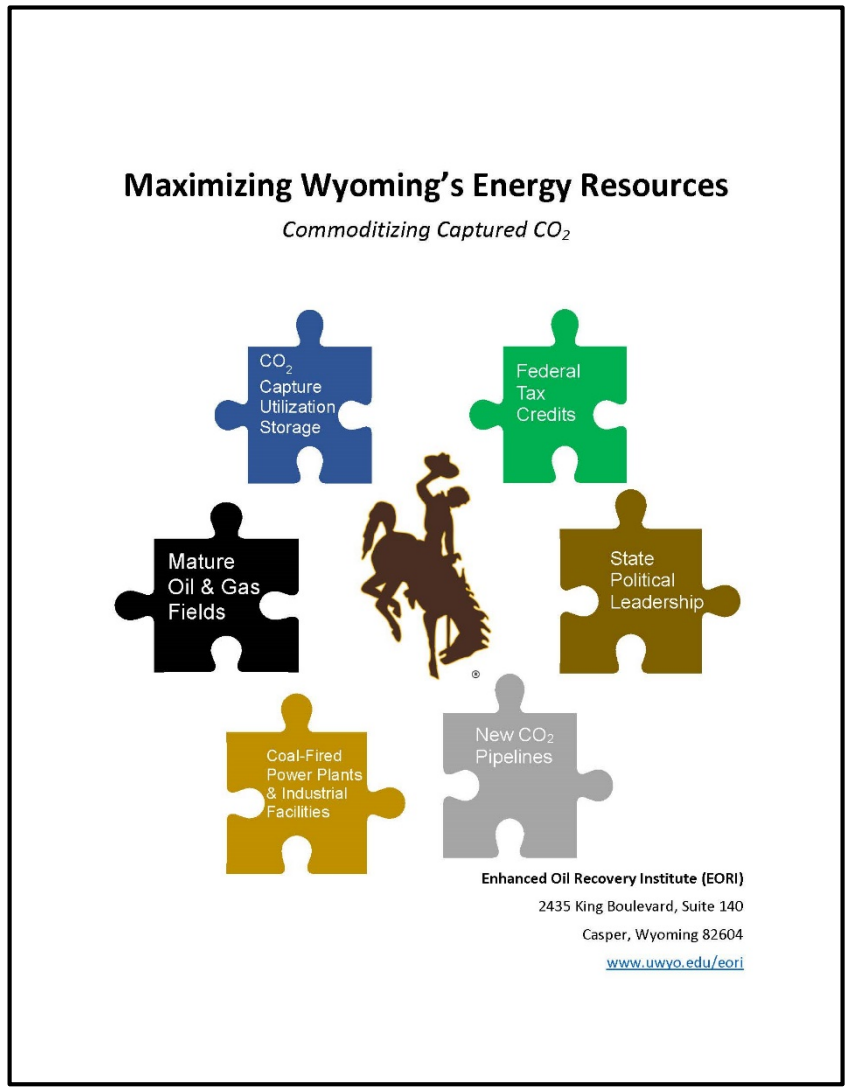
Maximizing WY Energy Resources – Commoditizing Captured CO_2

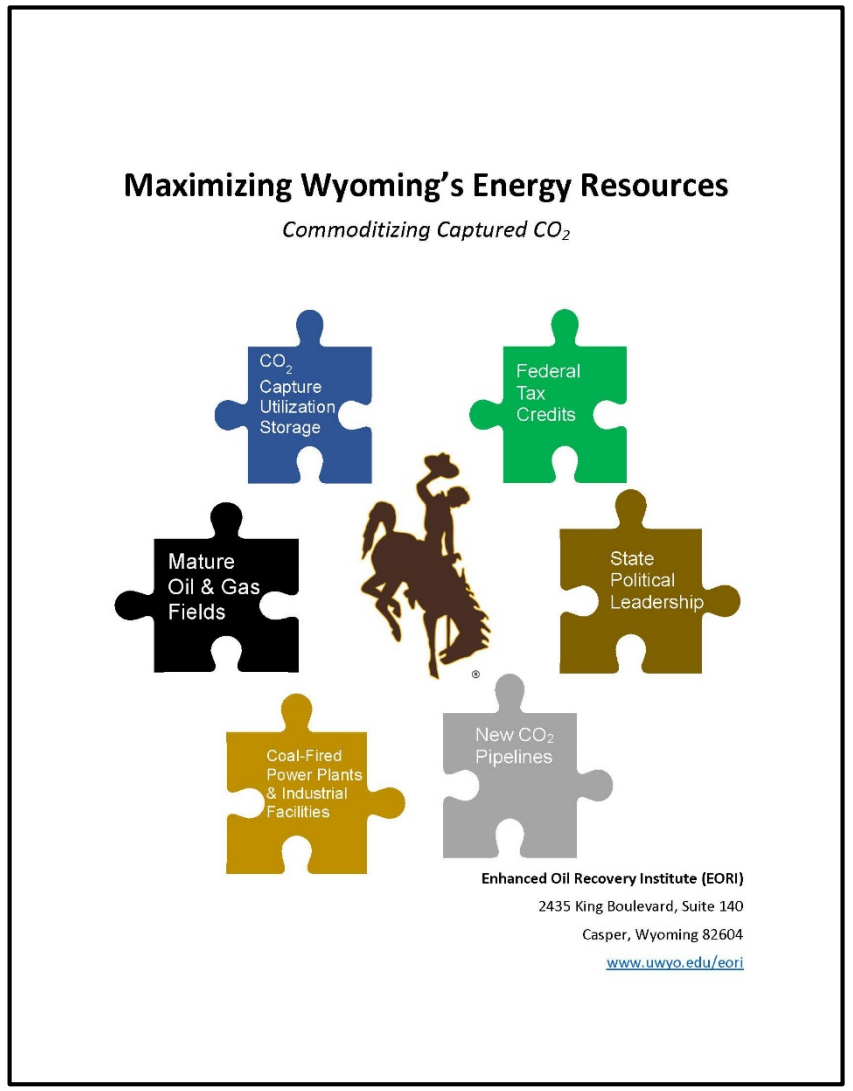
- About this Report
- Prepared by EORI and its Technical Advisory Board (TAB)
- Responds to calls by Gov. Mead and WY Legislature for analysis of new energy opportunities for the state
- Intended for WY political leaders and policymakers



Enhanced Oil Recovery Institute

Maximizing WY Energy Resources – Commoditizing Captured CO_2

- About this Report…
- Provides big picture description of opportunities for WY economy around commoditizing captured CO_2
- Includes TAB recommendations for technology, finance, law and policy, and stakeholder engagement



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Captured CO_2 an Untapped Energy Resource

- WY fossil resources and infrastructure well-suited for utilizing captured CO_2 for CO_2-EOR
  - Abundant coal, coal-fired power plants, gas processing plants, existing CO_2 pipelines, and mature oil and gas fields

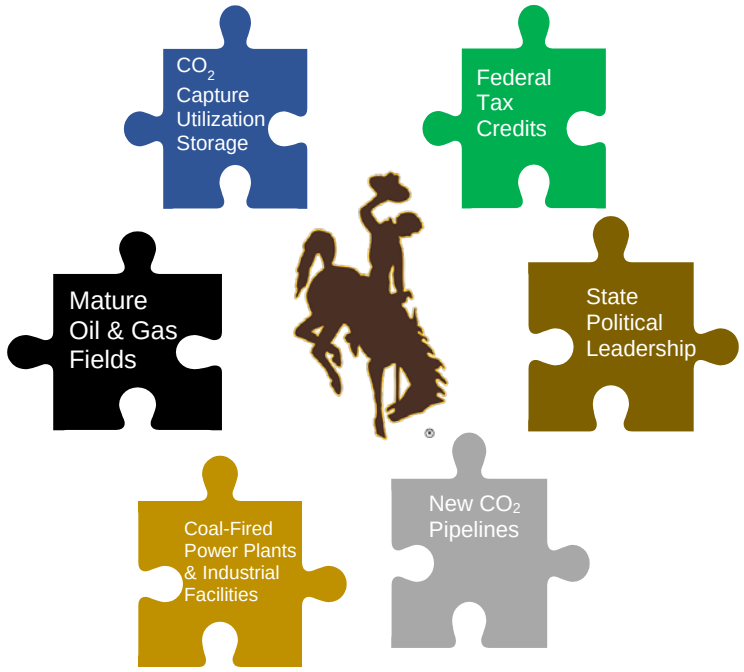
- CO_2 capture commoditizes a combustion byproduct in demand among oil and gas producers
  - CO_2-EOR can boost oil and gas production from many conventionally depleted oil and gas reservoirs in Wyoming

Benefits of Commoditizing Captured CO_2

- Coal-fired utilities and gas processors generate a second revenue stream from selling captured CO_2
  - CO_2 capture retrofits are technically feasible and can extend the lives of certain older plants, preserving local jobs
- Newly expanded federal tax credits change the game for CO_2 capture, utilization, and storage
  - *Example*: CO_2-EOR project utilizing 500,000 tons of captured CO_2 per year could generate $175 million over first decade of operations

Wyoming CO_2 – Demand & Potential

		CO_2 Required (Bcf)	CO_2 Required (Tonnes)	Average of Incremental Production (MMbo)
$80 oil	116 fields	5,604	290,747,211	986
$60 oil	64 fields	4,727	245,246,621	845
$50 oil	36 fields	3,898	202,236,371	704
$40 oil	9 fields	1,269	65,838,367	243



Oil at $70/bbl ($57):

- 64 - 116 Wyoming fields impacted
- ~300 million tonnes CO_2 needed (5Tcf)
- 845 - 986 million barrels incremental production (20 yr)
- $4.3b - $5.1b potential revenue to Wyoming (~$250MM/yr/20yr)

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How Wyoming Can Lead

- Federal and state regulatory landscape already attractive to CO_2-EOR project developers
  - Key federal rules can be written or revised by current administration, and WY legislature already acted a decade ago on subsurface issues

- But clear and consistent state political leadership is fundamental to success for CO_2-EOR projects
  - Regulatory overhaul risks creating confusion and uncertainty; what developers want is a shared vision for commoditizing captured CO_2

How Wyoming Can Lead?

- Innovative carbon capture ***technology selection (ITC)***
- ***CarbonSAFE DOE grant success*** is vital
- CO_2-EOR ***off take agreements*** & infrastructure
- ***Permitting*** is the single biggest issue in any CCUS Project – Wyoming Primacy
- Who are the Wyoming **"Champions"** for this project?
- This is a long & arduous process – ***patience & persistence*** required

Thank You – Questions, Comments, Concerns

Dr. Steven Carpenter, Director
steven.carpenter@uwyo.edu
O: 307-315-6442
C: 513-460-0360

Rob Hurless, Deputy Director
rhurless@uwyo.edu
O: 307-315-6443
C: 307-259-0494