IHS ENERGY

Monthly Progress Report

CO2 EOR, Recovery Economics and Future Economic Impact

Reporting Period: October 1 – October 30, 2015

30 October 2015 ihs.com

Summary of work performed

Research of IHS reports and public sources of information related to CO2 sequestration. The research is focused on the following areas:

- Potential sources of CO2 sequestration in North Dakota and the region
  - Production of CO2 from oil and gas fields
  - CO2 as by-product of natural gas processing
  - CO2 from Lignite gasification
- Carbon market and price outlooks
- Beneficial use of CO2 for North Dakota Lignite-Fired Plants

The research to date has focused on the following IHS proprietary reports and sources of information:

- Carbon Dioxide: Chemical Economics Handbook, IHS (3 Aug 2015)
- Beneficial Use of CO2 for North Dakota Lignite-Fired Plants, EERC (Jan 2012)
- Great Plains Synfuels Plant Factsheet, Dakota Gasification Company
- EPA Clean Power Plan for State of North Dakota
- Carbon Market View, IHS (29 Oct 2015)
- IHS Carbon Markets Outlook, IHS (8 Oct 2015)

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Summary of work performed

Continued research related to CO2 sources by performing in depth IHS proprietary data analysis on CO2 field production forecast. Researched and compared CO2 injection fiscal policy and incentive by states. The research is focused on the following areas:

- Researched CO2 field production and reserves in IHS databases
- Researched natural gas fields with CO2 content over 10%
- Looked at CO2 storage projects
- CO2 injection incentive and fiscal system comparison analysis by state (8 states)
- EPA's Clean Power Plan state compliance gap analysis

The research to date has focused on the following IHS proprietary data/reports and sources of information:

- Additional research sources of CO2 supply:
  - IHS Well and Production Database – providing production history
  - IHS midstream database – pipelines and processing plant data
  - IHS Private Report – Survey of Miscible CO2 EOR Projects in North America (2014)
  - A note on Sources of CO2 Supply for Enhanced-Oil-Recovery Operations, P. Depletro and P. Balash, NETL and M. Wallace, ARI (2012) SPE paper
  - Denbury Corporate Presentation, November, 2015
  - The Growing CO2 – EOR Oil Recovery and CO2 Utilization "Prize" , Vello A. Kuuskraa, Advanced Resources International, Inc. (2013)
  - Carbon Capture and Sequestration: Research, Development, and Demonstration at the U.S Department of Energy (Feb. 2014)
  - IHS Insight November 2015 Special Report – Carbon Capture Snapshot
- Eight States CO2 EOR fiscal system and incentive: Texas, New Mexico, Wyoming, Utah, Louisiana, Arkansas, Alabama, Mississippi
- IHS November 2015 Report – EPA's Clean Power Plant State Compliance Gap Analysis

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Reporting Period: December 1 – December 31, 2015

31 December 2015 **ihs.com**

Summary of work performed

Continuation of November research related to CO2 supply sources by focusing research on current and potential CO2 supply and cost for North Dakota fields. The research includes the following areas:

- Current existing sources of CO2 in North Dakota
  - Dakota Gasification Plant – CO2 captured and used in Weyburn and Midale EOR fields in Canada, including CO2 contracted volume, contract length, and price, and availability to ND fields
- Potential sources of CO2 in North Dakota and estimated capital cost of capture
  - Tier 1 – within North Dakota, six lignite coal power plants CO2 emission rate (~30MMT/Y) and the possibility of converting to a CCS project, the percentage of CO2 that can be captured, and associated capital investments required
  - Tier 1 – within North Dakota, gas processing plants located within Williston Basin CO2 emission rate (0.7MMT/Y) and percentage of CO2 which can be captured
  - Tier 2 – CO2 supply from nearby basins located along pipeline corridor, including Denbury Greencore CO2 pipeline extension plan into North Dakota
- Preliminary cost study to acquire CO2 from natural and industrial sources

The research to date has focused on the following IHS proprietary data/reports and sources of information as previously outlined:

- Additional research sources of CO2 supply to North Dakota and analog CO2 CCS projects from coal power plant from US and Canada and associated costs:
  - MIT Carbon Capture & Sequestration Technologies database
  - The Future of Coal – an Interdisciplinary MIT Study (2007)
  - CO2 Capture in Power Generation – IEA Greenhouse Gas R&D Program
  - Post combustion Emission Control Technologies at Coal-fired Power Plants – IHS Cera June 2013
  - Carbon Dioxide Transport and Storage Cost in NETL studies – NETL 2013
- EPA Green House Gas Database by state (2014)
  - North Dakoda GHG emission by facility (2014)
- CO2 EOR operators investor reports: Denbury Resources, Occidental Petroleum, Cenovus Energy and Encana

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Monthly Progress Report

CO2 EOR, Recovery Economics and Future Economic Impact

Reporting Period: December 1 – January 29, 2016

29 January 2016 **ihs.com**

Summary of work performed

Complete the research on current and potential CO2 sources, costs, and future outlook in North Dakota and the region. Start potential CO2 EOR fields screening in North Dakota and economic model construction. Review technical data on CO2 EOR (mostly miscible floods) methods. The research includes the following areas:

- CO2 Sources and Costs Study - Completed
  - Current existing sources of CO2 in North Dakota
  - Potential sources of CO2 in North Dakota and estimated capital cost of capture from lignite coal power plants
- Review of existing regulations applicable to Oil and Gas in North Dakota, including special provisions regarding CO2 EOR - completed
- Construction Economic model by focusing on the framework, inputs, calculation sequences and outputs – in progress
  - Field level monthly basis economics
  - Model economic assumptions: discount rate, cost escalation, and price deck
  - Inputs assumptions: field level economics, capex, opex, and fiscal system
  - Outputs: NPV10, IRR, State Take, Profitability Index
- Potential CO2 EOR field screening in North Dakota by leveraging IHS proprietary databases with expertise of IHS Fekete reservoir engineers – in progress
- Technical data review on CO2 EOR fields by compyling reservoir and operational data in Texas, Wyoming, North Dakota, and Montana – in progress

The research to date has focused on the following IHS proprietary data/reports and sources of information:

- Additional research sources of CO2 supply to North Dakota and analog CO2 CCS projects from coal power plant from US and Canada and associated costs:
  - EIA OGSM (Oil and Gas Supply Model) 2015 and documentation
  - Carbon Capture Journal – Sep – Oct 2015
  - The Cost of CO2 capture and storage – *International Journal of Greenhouse Gas Control 2015*
  - U.S. Department of Energy W.A. Parish Post-Combustion CO2 Capture and Sequestration Project Draft Environment Impact Statement – 2012

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