CO_2 Injection Surface Facility Design

MGSC Assessment of Geological Carbon Sequestration Options in the Illinois Basin: Phase III

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Presented at the 14th Annual CO_2 Flooding Conference

December 11-12, 2008

Midland, Texas

Presentation Outline

- Project Overview
- Value Proposition – CO_2 for EOR from Ethanol Production Facilities
- Ethanol Production Overview
- Surface Facility Design
  - Design Criteria
  - Equipment Selection
- Current Project Status

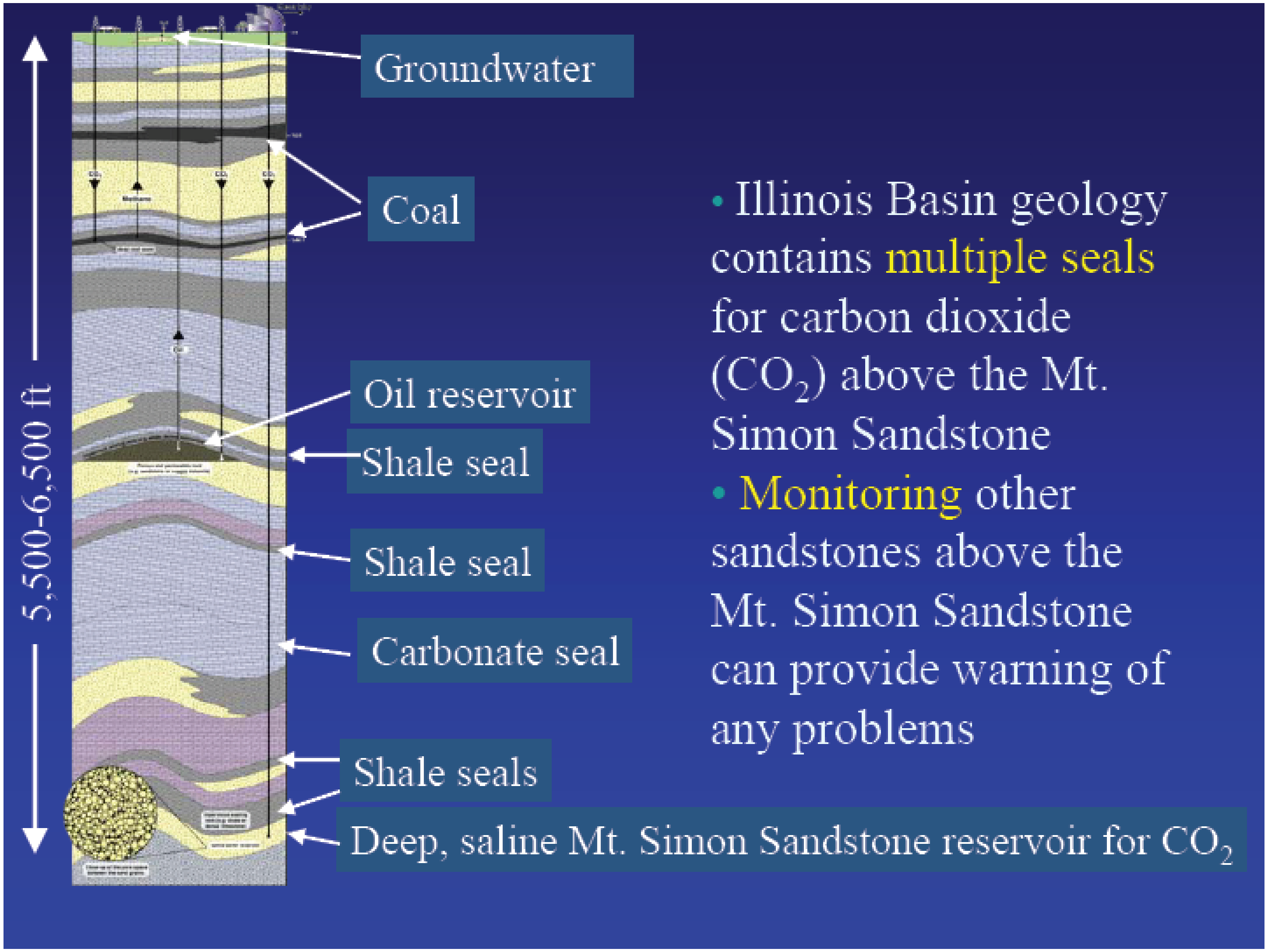
Project Overview

- U.S. Department of Energy Phase III Large-scale sequestration demonstration project
- Capture and storage of 1 MM metric tons CO_2 in saline reservoir over 3 years of injection
- Project Participants
  - Midwest Geological Sequestration Consortium (MGSC)
  - Illinois State Geological Survey (ISGS)
  - Archer Daniels Midland Company (ADM)
  - U.S. Department of Energy – Nation Energy Technology Laboratory (DOE / NETL)
  - Schlumberger Carbon Services
  - Trimeric Corporation
- 7 year project / $84 MM (DOE - $66.7 MM)

Overall Project Objectives

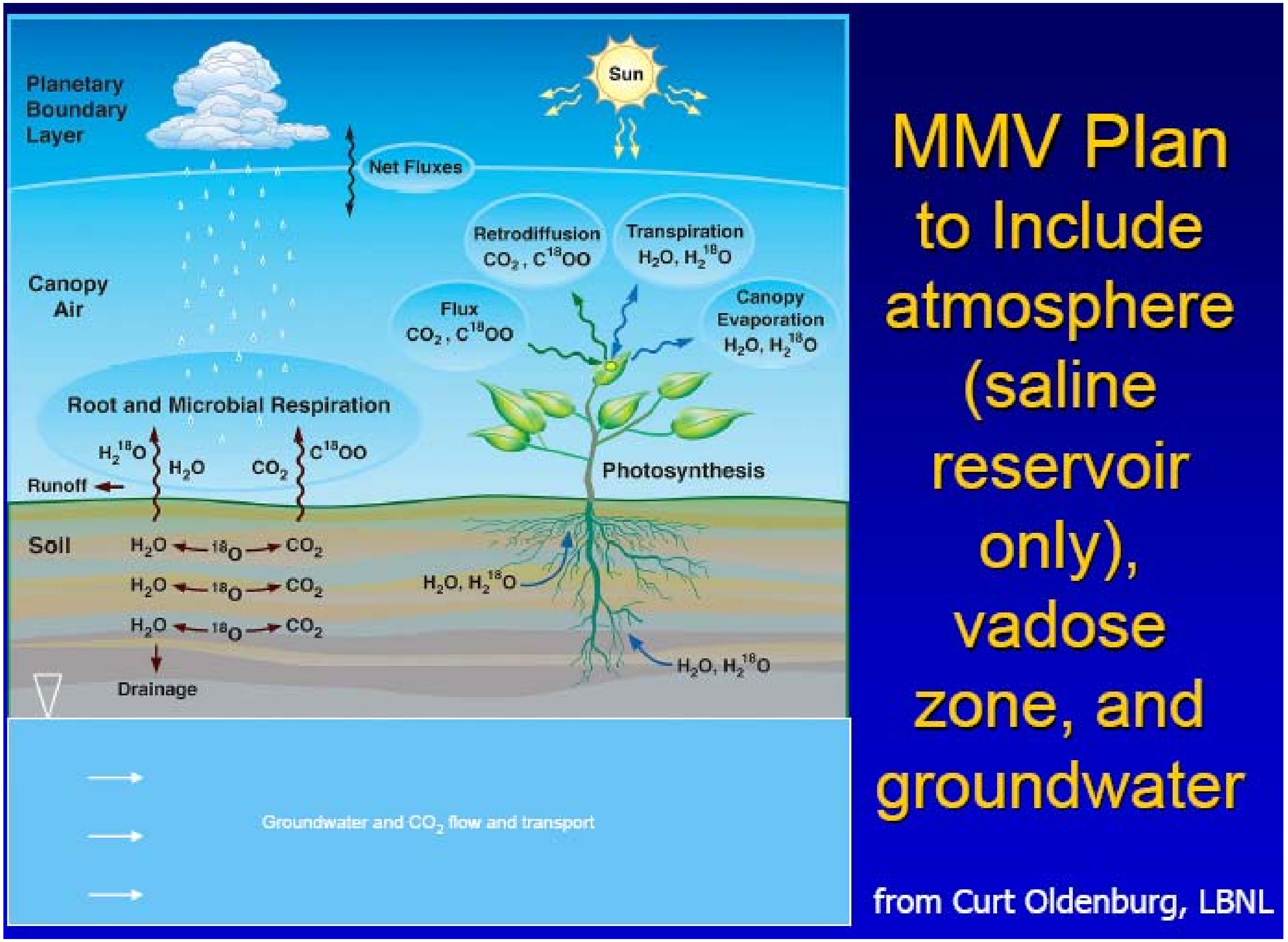
- Help evaluate Carbon Capture and Storage as a means of reducing atmospheric CO_2 concentrations.
- Capture of CO_2 from the ADM Ethanol Plant in Decatur, IL
- Compress, dehydrate and inject of 1 MM metric tons (~20 MMSCFD) of CO_2 over 3 years
- Monitor the effectiveness of CO_2 storage in a deep saline aquifer including 2 years of post injection monitoring

Project Goal – Injection



Source: R. Finley, Carbon Sequestration, FutureGen and coal gasification Development in Illinois Basin, November 2006

Project Goal – Monitoring



Source: R. Finley, Phase II Year 1 Update, October 2006

Why is the capture of CO_2 from ethanol vents important?

- Many Industrial uses for Carbon Dioxide
  - Food & Beverage Industry
  - Oil Recovery
  - Chemical Industry
- Large domes of naturally occurring CO_2 have finite capacity and limited locations

Anthropogenic Sources of CO_2 are abundant and widespread

Examples:

- Coal-fired power plants
- Cement plants
- Coal gasification facilities
- Amine plants
- Refinery vent streams
- Ammonia plants
- Ethanol plants

Value Proposition – CO_2 from Ethanol

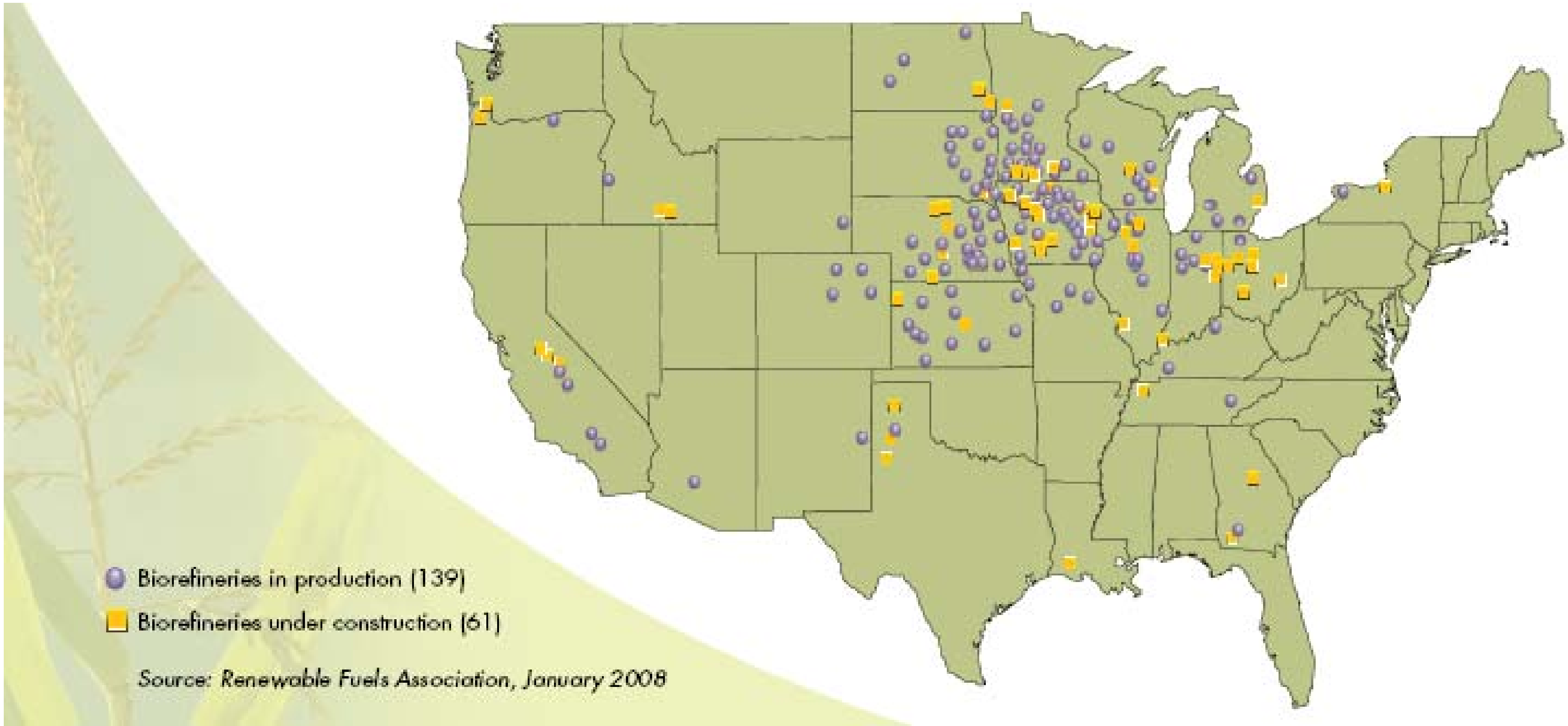
- High Purity – > 99% CO_2
- Low Relative Capture Costs - separation system not required
- Ethanol Production Growth (>30% increase 2006 to 2007)
- Total US Ethanol Production – over 10,400 MMgal/yr*
- Typical 50 MMgal/yr ethanol plant produces ~7 MMSCFD or 370 metric tons / day of recoverable CO_2

However…

- Many Ethanol producers are not located near existing CO_2 pipelines

*Source: Renewable Fuels Association – December 9, 2008

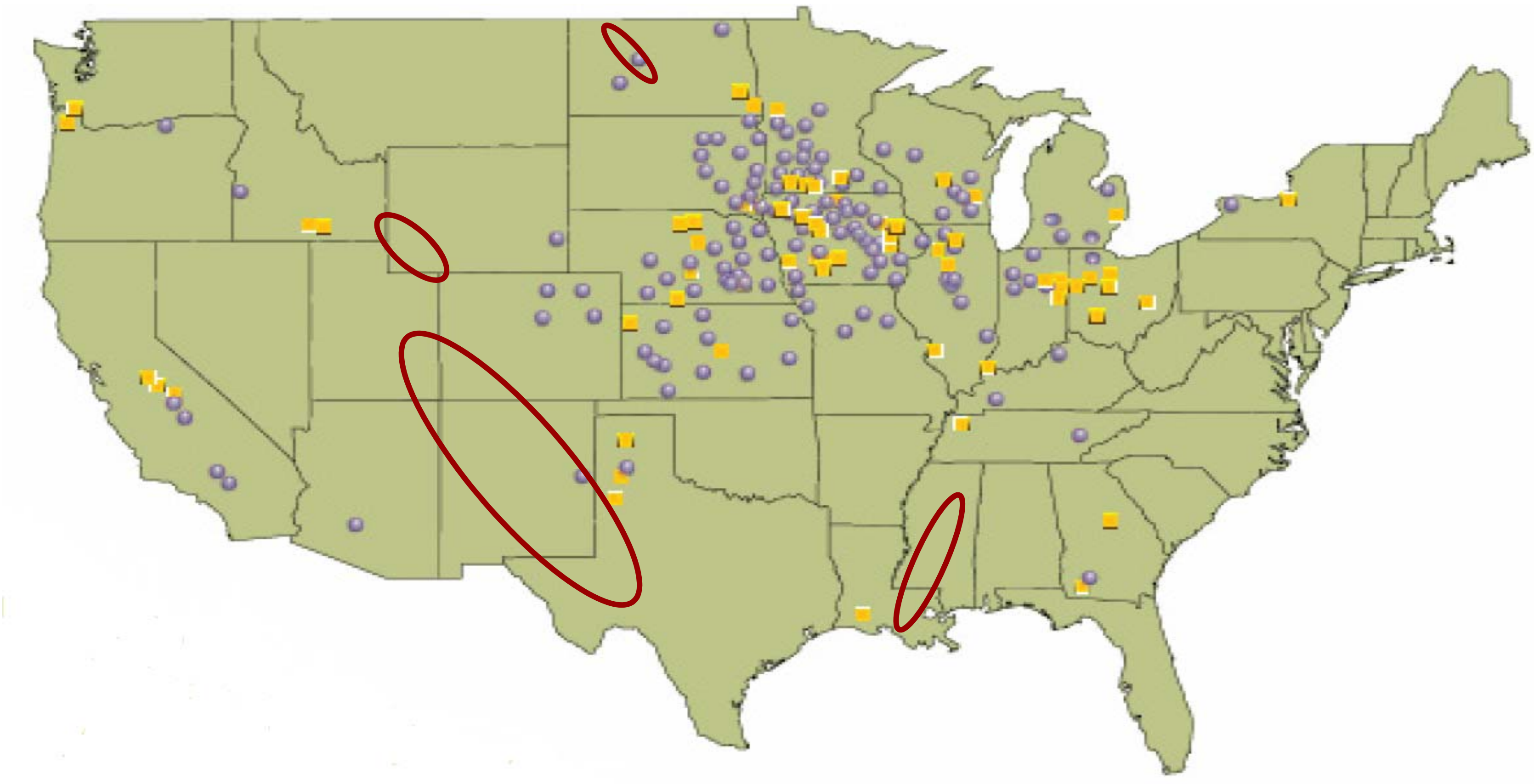
U.S. Ethanol Biorefinery Location



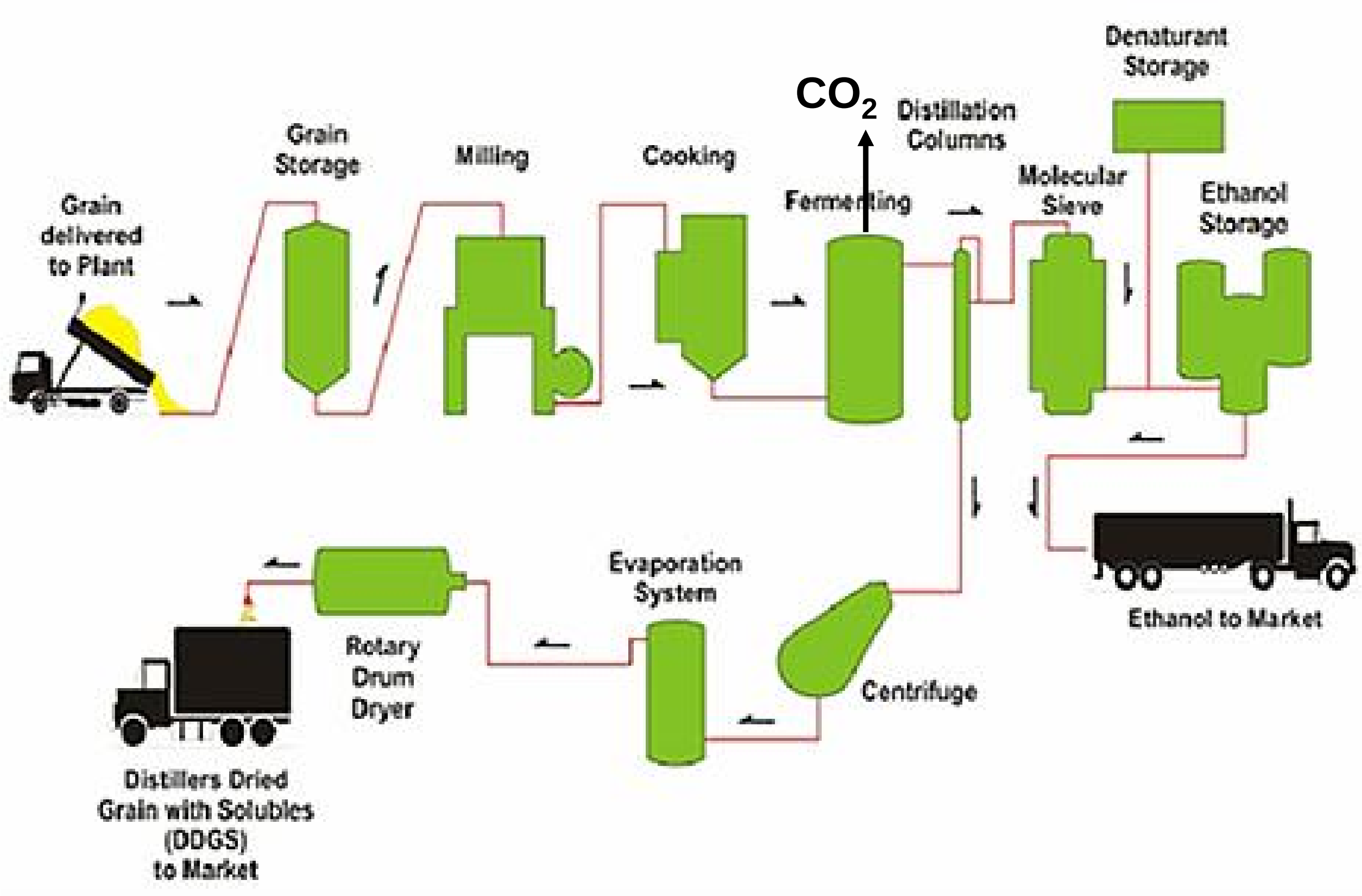
Existing CO_2 Pipelines

Source: Nicholas School of Environment Duke University

CO_2 from Ethanol vs. Existing Pipelines

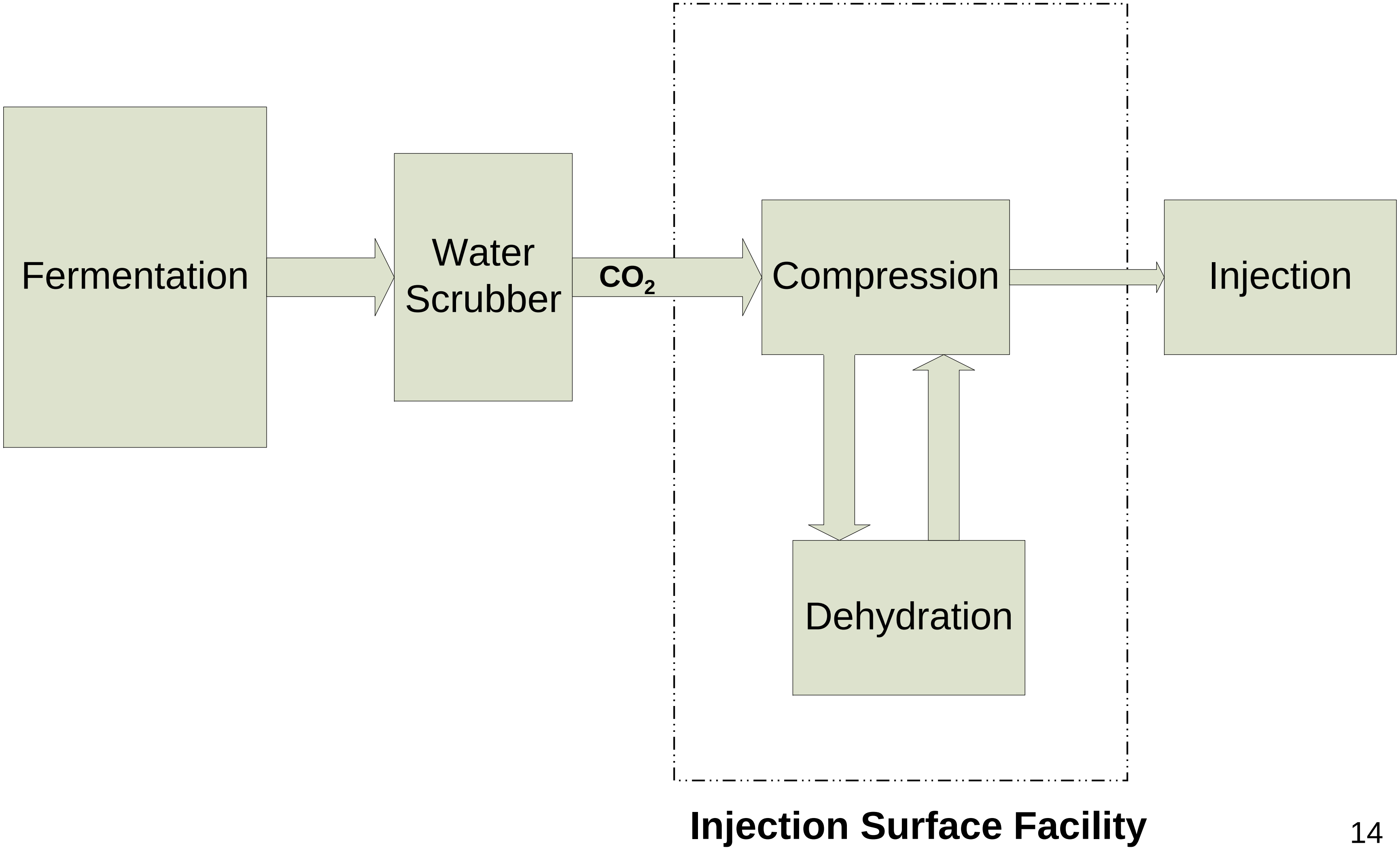


Ethanol Process Overview



Source: http://www.lincolnlandagrienergy.com/ (The Ethanol Process)

Project CO_2 Block Flow Diagram



Injection Surface Facilities Design Requirements

- Inject 1 MM metric tons of CO_2 over 3 year period of time
  - Must deliver 995 metric tons/day (19 MMSCFD) or greater
- Inlet Pressure ~ 1 psig
- Well head pressure 1350 to 2000 psig
- Dehydrate CO_2 - 7 lb of H_2O/MMSCF (~ 150 ppmv)

CO_2 Injection Operational Limits

Component	Limit
Carbon dioxide	99% (minimum)
Nitrogen	500 ppmv
Oxygen	100 ppmv
Water	30 lb/MMSCFD / 630 ppmv (maxiumum)

Project / Site Specific Factors for Design

- Research Project
  - Minimal sparing
  - Highly instrumented
  - 3 years of injection
  - Cooling water available
- Discharge pressure flexibility needed due to undetermined injection pressure requirements

Compression Equipment Selection

- Comparison of several equipment configurations based on:
  - Equipment Purchase Costs
  - Energy Costs
  - Complexity
  - Space Requirement
  - Lead Time

Equipment Options Matrix

- Case 1 – blower, screw, recip
- Case 2 – blower, screw, recip, pump
- Case 3 – blower, screw, recip, chiller, condenser, pump
- Case 4 – blower, recip
- Case 5 – blower, recip, pump
- Case 6 – blower, recip, chiller, condenser, pump

Each case was evaluated for several discharge pressures ranging from 1400 to 2000 psig

Equipment Matrix (Simplified)

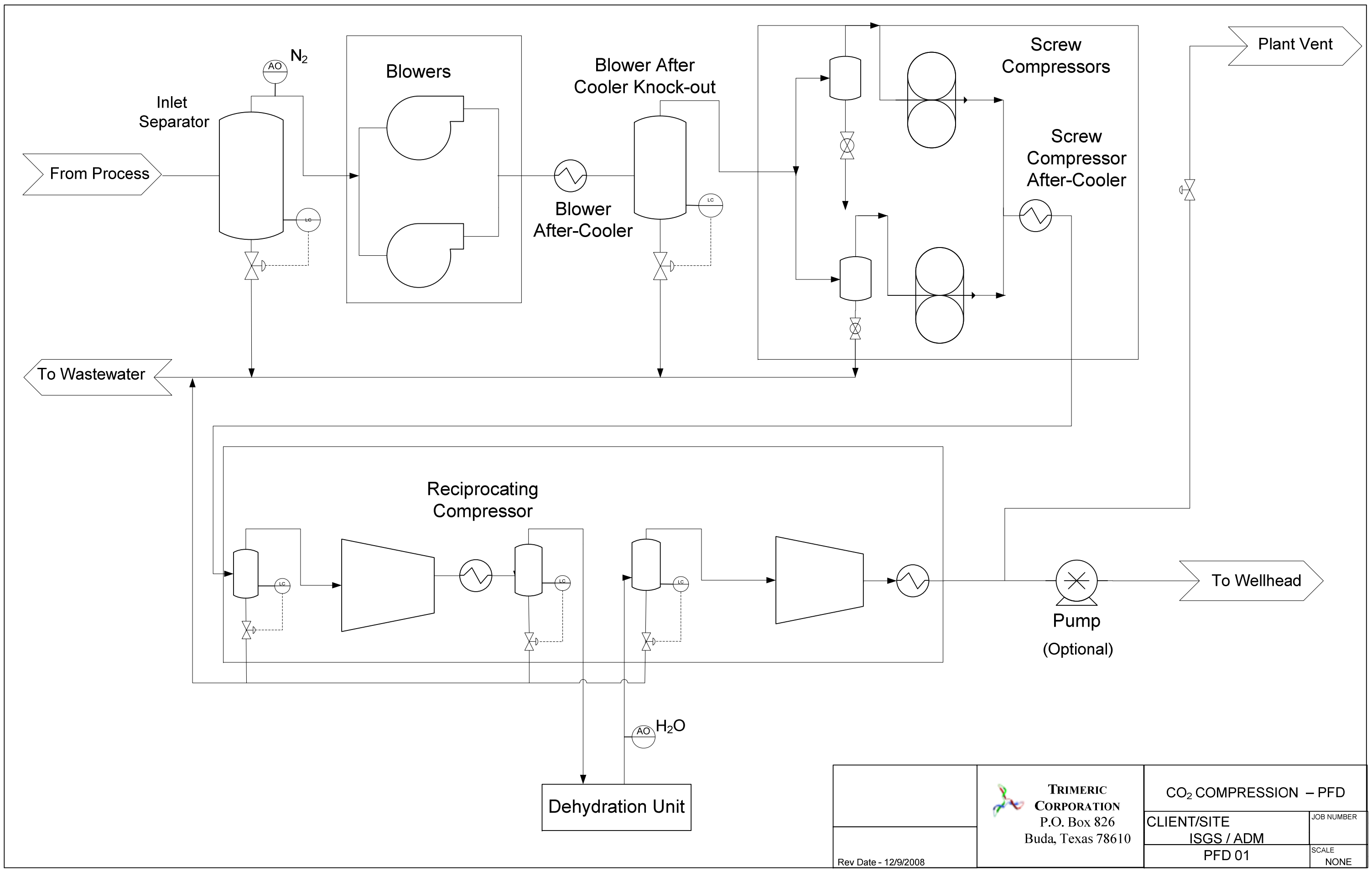
Case #	Booster Blower	Screw	Recip	Chiller & Condenser	Final Stage pump
1a	Yes	Yes	Yes	No	No
1a'	no	Yes	Yes	No	No
2b	Yes	Yes	Yes	No	Yes
3a	Yes	Yes	Yes	Yes	Yes
4a	Yes	No	Yes	No	No
4a'	No	No	Yes	No	No
5b	Yes	No	Yes	No	Yes
6a	Yes	No	Yes	Yes	Yes

Lowest Cost

Selected Equipment

- Blower
  - Single unit or possibly two-50% units
  - Boost vent gas pressure by 10 to 12 psi
- Flooded Screw Compressor
  - Two 50% units in parallel
  - Discharge pressure ~ 275 psig
- Reciprocating Compressor
  - Two Stage
  - Discharge Pressure ~1400 psig
- Triethylene Glycol dehydration unit
  - Fed from outlet of 1^{st} stage reciprocating compressor
- Multi-Stage Centrifugal Pump (if needed)

Process Flow Diagram



Current Project Status

- Major Equipment Bid Process - underway
- Equipment Installation – 4^{th} quarter 2009
- CO_2 Injection – Early 2010

Conclusions

- Minimal sparing results in lower purchased equipment cost
- TEG Dehydration allows for lower cost un-insulated carbon steel pipeline
- Recycle to existing plant vent simplifies flow range capability
- Optional multi-stage centrifugal pump de-couples reciprocating compressor specification from injection pressure requirements
- Estimated capture treating cost: $0.90 – 1.1/Mscf

Questions?

Acknowledgement

- Rob Finley – ISGS
- Scott Frailey - ISGS
- Scott Marsteller - Schlumberger
- Tom Stone – ADM
- Mark Carroll – ADM
- Ron Peterson - ADM