NATIONAL ENERGY TECHNOLOGY LABORATORY

Industrial CO_2 Storage in Mt. Simon Sandstone Saline Reservoir - A Large-Scale Demonstration Project in Illinois

Sai Gollakota and Scott McDonald*

National Energy Technology Laboratory

***Archer Daniels Midland Company**

Eleventh Annual Conference on Carbon Capture, Utilization & Sequestration

April 30 – May 3, 2012 • David L. Lawrence Convention Center • Pittsburgh, Pennsylvania

U.S. DEPARTMENT OF ENERGY

Outline

- **DOE-FE ICCS Program, Area 1 - Large-scale projects**
  - *ADM, Decatur, Illinois (Saline storage) [Illinois ICCS project]*
  - Air Products and Chemicals, Port Arthur, Texas (EOR)
  - Leucadia, Lake Charles, Louisiana (EOR)
- **Two DOE-Sponsored CCS Projects in Decatur, Illinois**
  - *Illinois ICCS Project (lead - ADM) – under construction*
  - Illinois Basin Decatur Project (lead - ISGS) – operating
- **Illinois ICCS Project**
  - Objectives & team members
  - Schedule & flow diagram
  - Monitoring of stored CO_2
  - Community outreach-National Sequestration Education Center
  - Expected benefits

Industrial CCS Program Objectives and Targets

Large-scale CCS from Industrial Sources (Area 1)
American Recovery and Reinvestment Act (ARRA) of 2009

Objectives

- Demonstrate advanced CCS technologies
- Integration with Monitoring, Verification & Accounting (MVA)
- Scope: FEED, Detailed Design, Construction, and Demonstration of Storage Operations

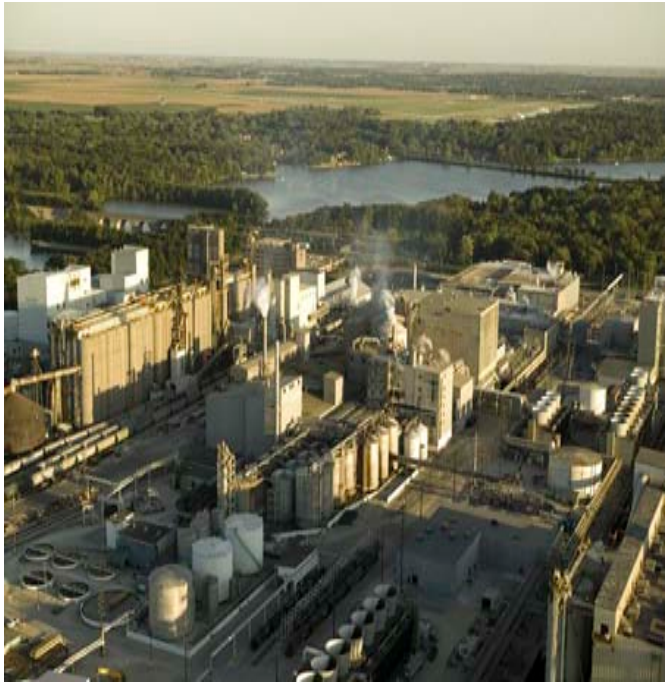
Target

- Industrial sources
  - Produce heat/fuels/chemicals/hydrogen
- One million tons/yr of CO_2 from each plant for CCS

Archer Daniels Midland Company ICCS Area 1

CO_2 Capture from Biofuels Plant

- **Decatur, Illinois**
- **CO_2 is a by-product in the production of fuel grade ethanol via anaerobic fermentation**
- **Up to 90% CO_2 capture – dehydration (via tri-ethylene glycol) and compression (1,000,000 tons CO_2/year)**
- **CO_2 storage in Mt. Simon Sandstone saline reservoir (Start: July 2013)**
- **Total Project: $208 Million**
  DOE Share: $141 Million
- **Status**
  - **Under construction**



Air Products and Chemicals, Inc. ICCS Area 1

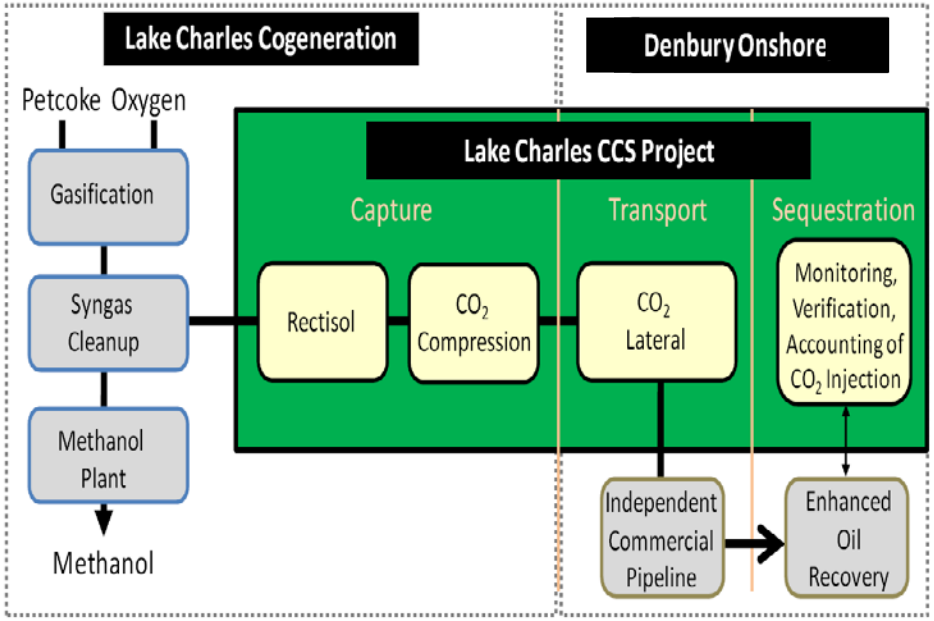
Steam Methane Reforming with CO_2 Capture

- **Port Arthur, Texas (Hydrogen plant located in Valero Refinery)**
- **90% CO_2 capture (Vacuum Swing Adsorption) from 2 steam-methane reformers (SMRs) yielding >1,000,000 tons CO_2/year**
- **Installation of ~28 MWe cogeneration unit to supply ~110,000 lb/hr makeup steam to SMRs and operate VSA and Compression Equipment**
- **EOR in West Hastings oil field (Start: 2012)**
- **Total Project: $431 Million**
  DOE Share: $284 Million
- **Status:**
  - **Under construction**

Leucadia Energy, LLC ICCS Area 1

Lake Charles CCS Project

- Lake Charles, Louisiana
- GE Energy Gasification (5 gasifiers: 4 hot / 1 spare)
- 730 Million gallons / year methanol
- 90% CO_2 capture (Rectisol® process) 4,000,000 tons CO_2/year
- EOR in Texas at the West Hastings oil field
- Total Project: $436 Million
  DOE Share: $261 Million
- Status
  - FEED in progress
  - NEPA in progress



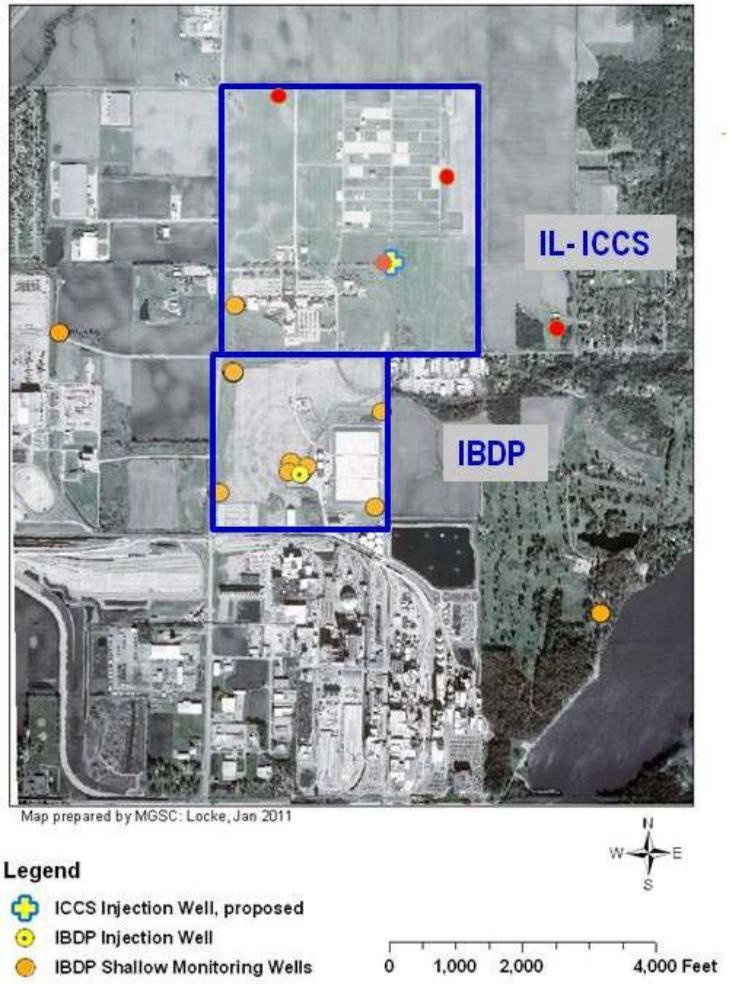
Two DOE-Sponsored CCS Projects in Decatur, Illinois

First CCS Project

Illinois Basin-Decatur Project (IBDP) led by Illinois State Geological Survey

- **Under Midwest Geological Sequestration Consortium (MGSC)**
  - **Cost share from DOE Regional Carbon Sequestration Partnerships**

- **ADM ethanol plant, Decatur, IL**
- **1,000 metric TPD CO_2 capacity**
- **1 million metric tons CO_2 in three years**
- **CO_2 injection into the Mt. Simon Sandstone began in November 2011**
- **IBDP is breaking ground for anthropogenic CO_2 storage in a saline reservoir using cutting-edge sequestration technology**
- **IBDP knowledge base:**
  - **Site geological characterization**
  - **Risk assessment & reservoir modeling**
  - **Engineering design & MVA development**



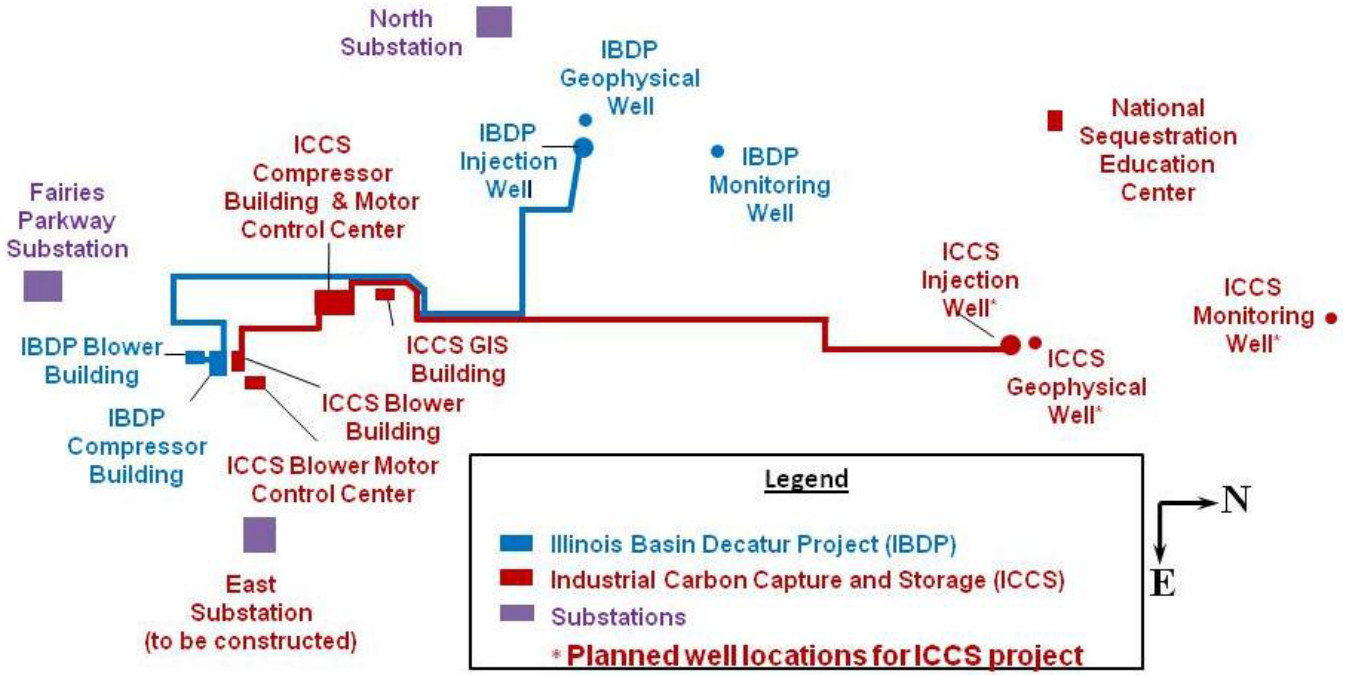
Site map - Courtesy of Illinois State Geological Survey

Two DOE-Sponsored CCS Projects in Decatur, Illinois (contd.)

Second CCS Project – Recovery Act cost share (One million tons per year capacity)

- **Illinois ICCS project, led by ADM, adapts approaches of the IBDP and triples the injection rate to represent the operating capacity necessary for commercial power generating facilities.**

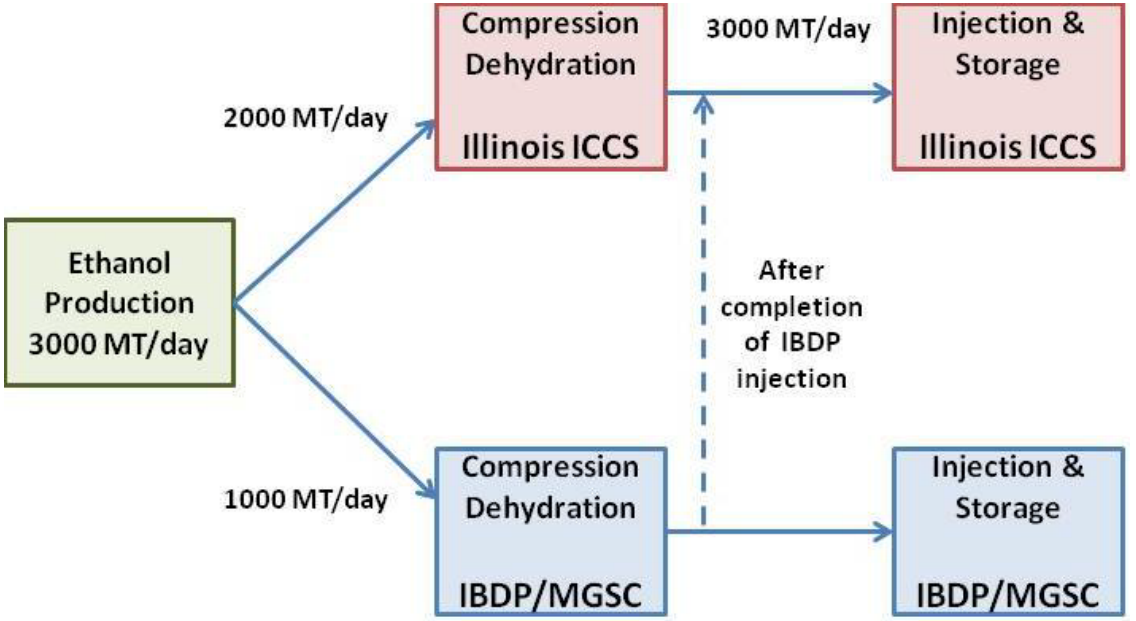
Unique opportunity - Study interaction between the CO_2 plumes and pressure fronts emanating from two injection wells in the same saline formation.



Illinois ICCS Project Objectives

- Design, construct, and operate a new CO_2 collection, compression, and dehydration facility capable of delivering up to 2,000 metric tons of CO_2 per day to the injection site.
- Integrate the new facility with an existing 1,000 metric tons of CO_2 per day compression and dehydration facility to achieve a total CO_2 injection capacity of 3,000 metric tons per day or one million tons annually.
- Implement deep subsurface and near-surface MVA of the stored CO_2.
- Develop and conduct an integrated community outreach, training, and education initiative.

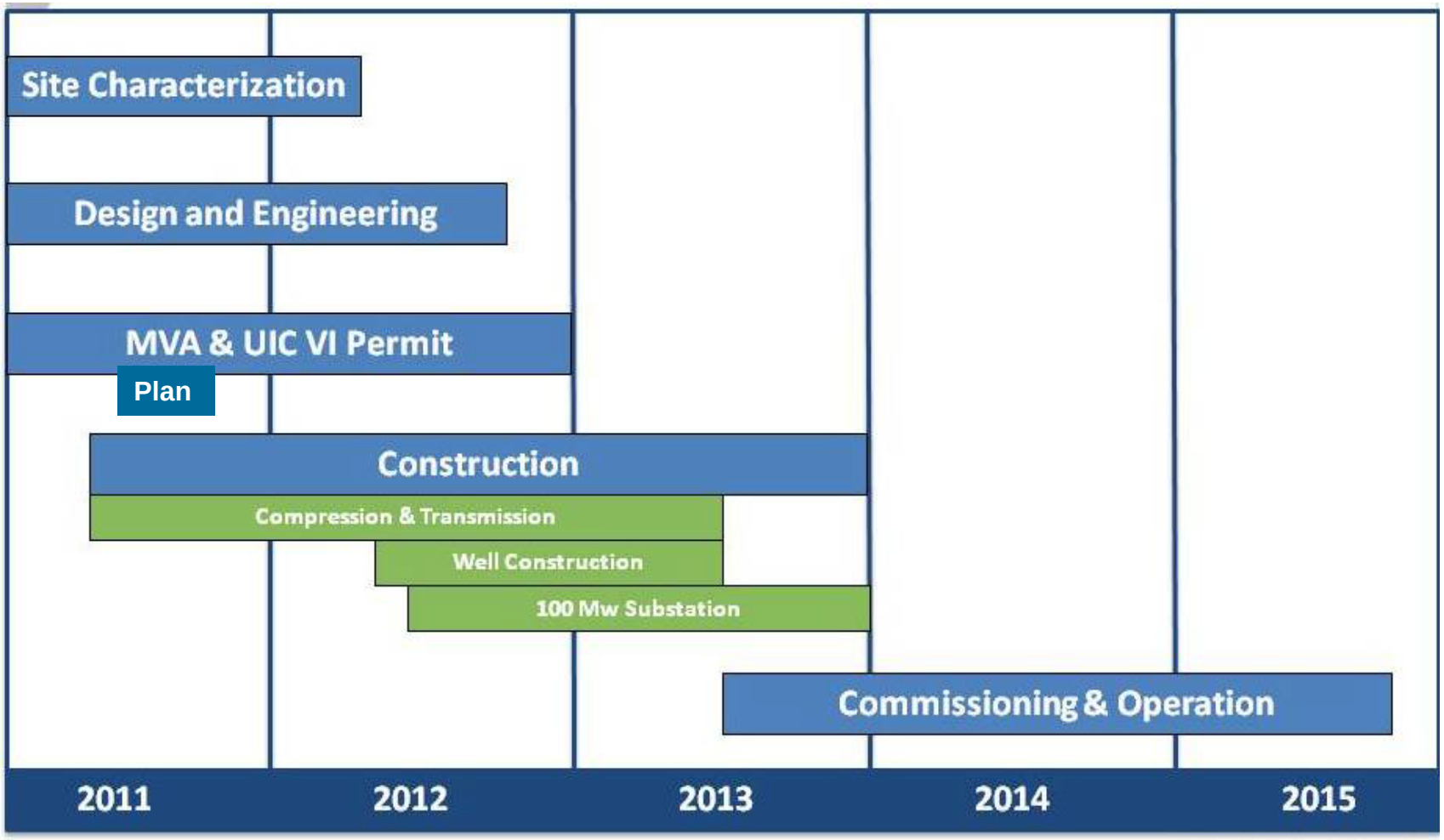
Upon completion of IBDP injection operations, the IBDP compression & dehydration facilities will be integrated with the new ICCS facilities.



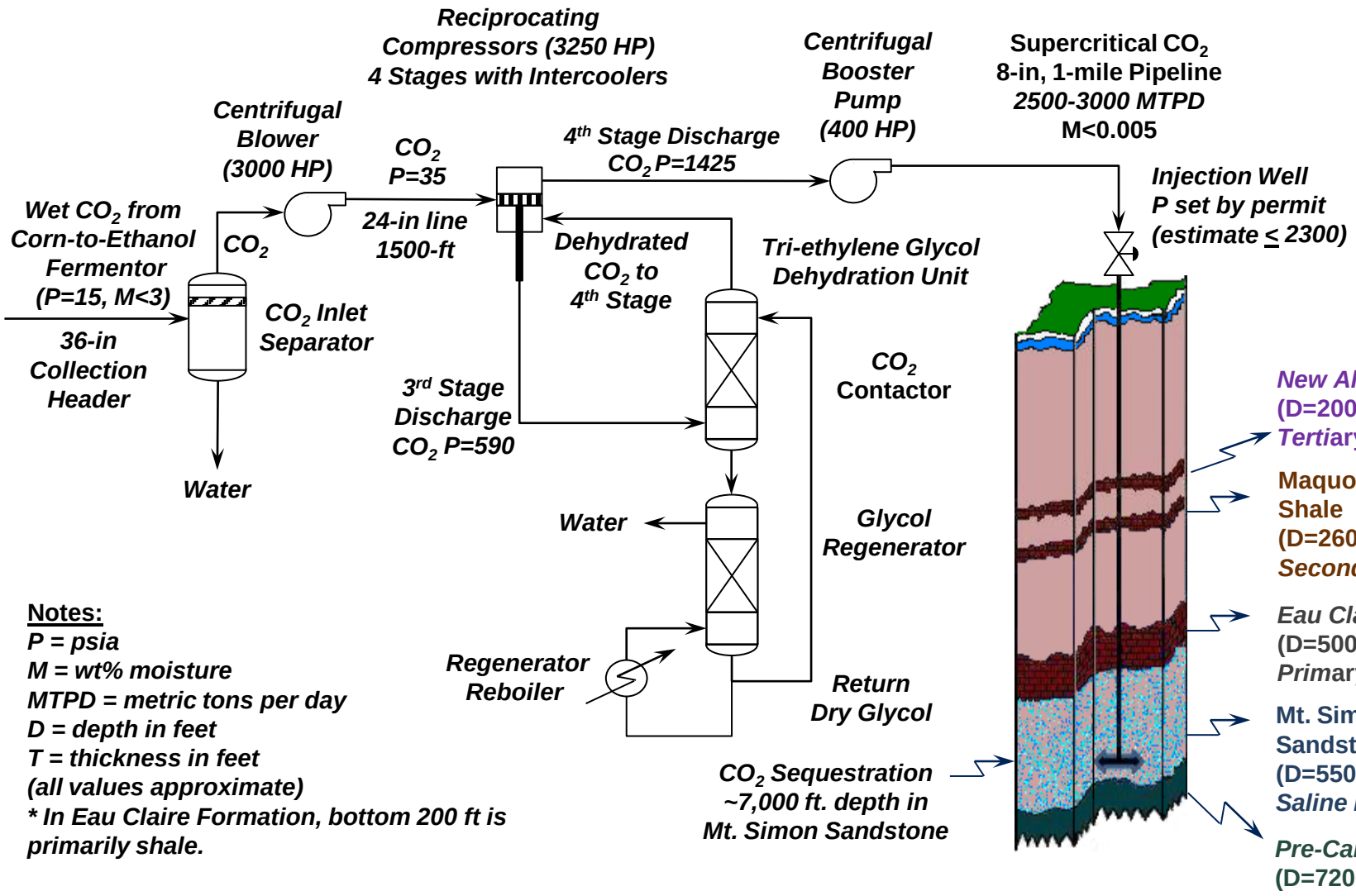
Illinois ICCS Team Members

- **Archer Daniels Midland Company**
  - Overall project implementation
  - Host site for capture and storage
  - Design, construction, and operation of compression and dehydration facilities and substation
  - UIC permit holder
- **Illinois State Geological Survey**
  - Site characterization
  - USDW and near-surface monitoring
  - Subsurface MVA of stored CO_2
  - Outreach and communication
- **Schlumberger Carbon Services**
  - Site characterization
  - Reservoir modeling
  - Design, construction, and operation of the CO_2 injection and monitoring wells
  - Subsurface MVA of stored CO_2
- **Richland Community College**
  - National Sequestration Education Center
  - Community outreach & CCUS training
  - New Associate degree programs in CCUS

Illinois ICCS Project Schedule (DOE Scope)



Illinois ICCS – Simplified Flow Diagram



Notes:
P = psia
M = wt% moisture
MTPD = metric tons per day
D = depth in feet
T = thickness in feet
(all values approximate)
** In Eau Claire Formation, bottom 200 ft is primarily shale.*

Illinois ICCS Project - Monitoring, Verification, and Accounting (MVA)

- **To demonstrate:**
  - CCS is safe, effective, and acceptable for GHG control
  - CO_2 is safely and permanently stored
  - Underground Sources of Drinking Water are protected
- **Activities will include:**
  - Measuring CO_2 injection rates
  - Measuring soil gas, groundwater, and atmospheric CO_2 concentrations
  - Operating monitoring and geophone wells
    - Establishing baseline conditions
    - Modeling reservoir conditions
    - Collecting reservoir pressures & geochemical samples
    - Conducting time lapse seismic surveys
    - Monitoring CO_2 plume and pressure fronts in the subsurface

IL-ICCS Environmental Monitoring Conceptual Framework

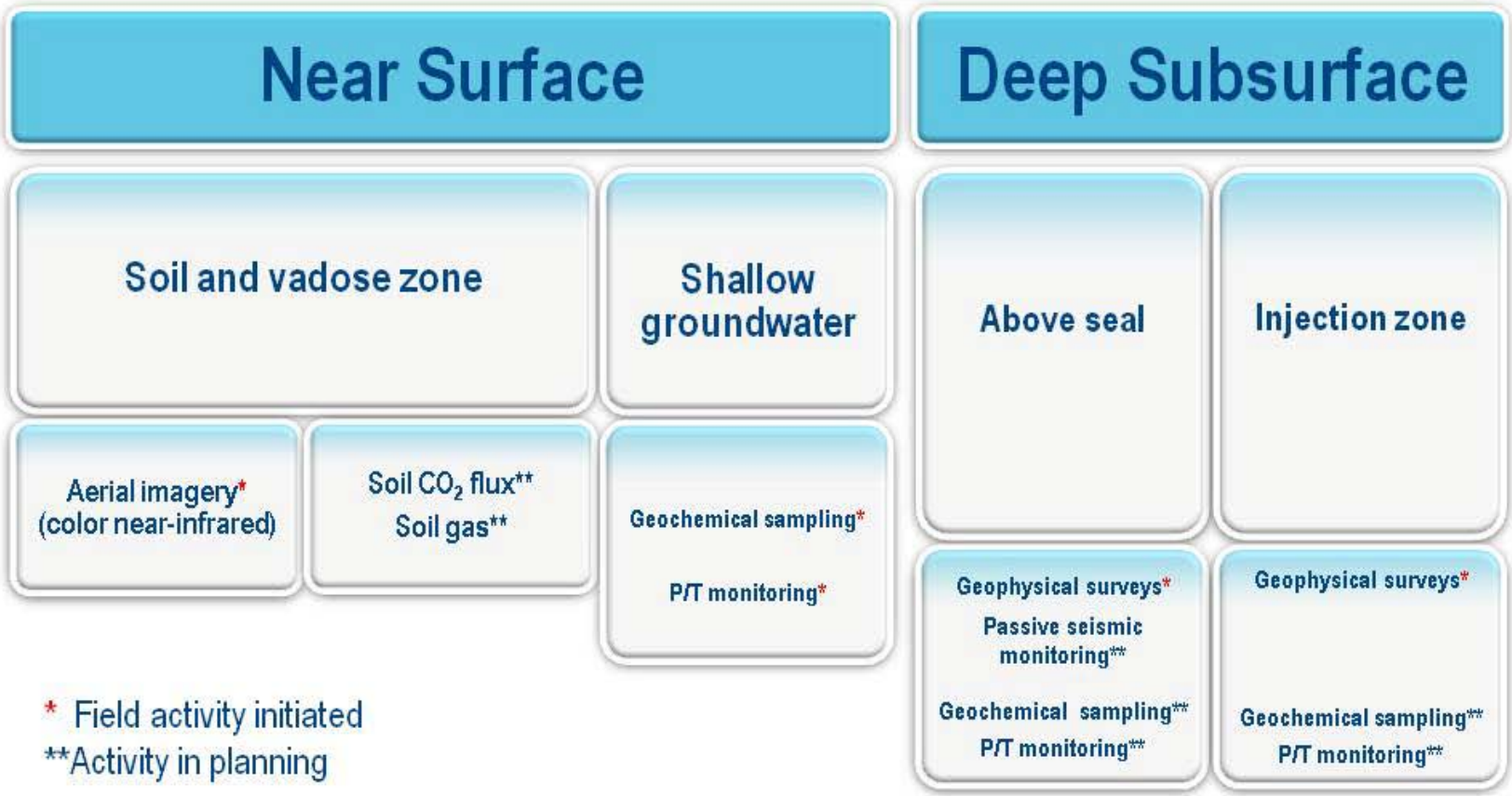
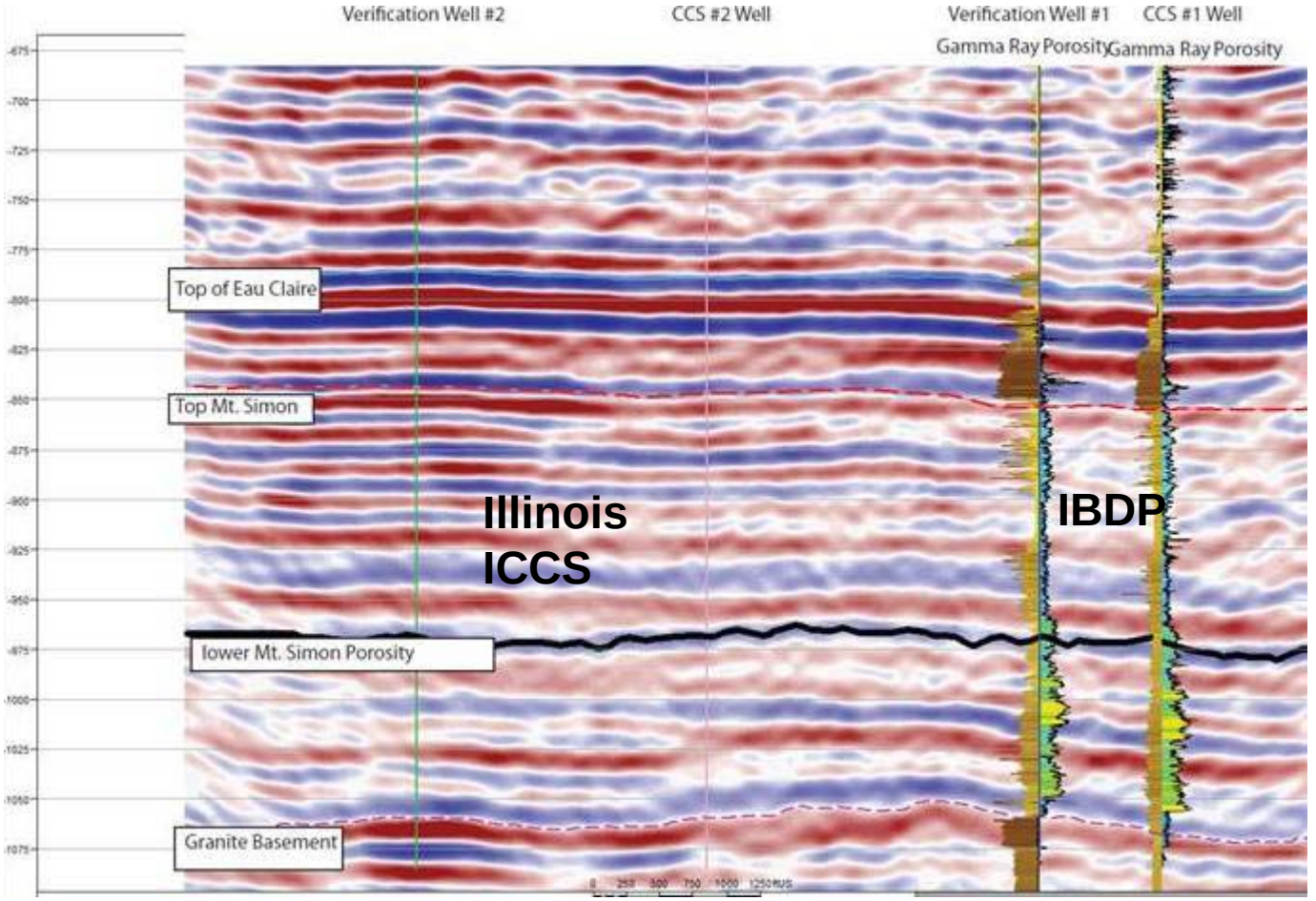


Figure -Courtesy of Illinois State Geological Survey

Interpretation of the Illinois ICCS Site 3-D Seismic Data

(Courtesy of ISGS and Schlumberger Carbon Services)



Depth

Lower
Mt. Simon

South

Did not indicate any seismically resolvable faults in the saline reservoir or in the cap rock seal

(CO_2 will be stratigraphically trapped; plus solubility & residual trapping)

Community/CCUS Outreach
National Sequestration Education Center

- **Conducting an integrated communication, outreach, training, and education initiative to engage local communities to understand CCUS, Illinois ICCS project, and related environmental benefits.**
- **National Sequestration Education Center (NSEC) - Richland Community College – A new education and training facility:**
  - 15,000 sq. ft. center - classrooms, training and laboratory facilities
  - Richland received additional funding from other sources to add renewable energy features, i.e., wind turbine, solar, geothermal, aerobic digestion, and biomass technology to NSEC.
    - Sustainability-oriented design
    - Serve as student laboratories & offset NSEC energy costs
  - Construction to be completed in summer 2012

CCUS Degree Programs
Richland Community College

- **Richland is developing two new degree programs with an emphasis on CCUS:**
  - **Associate of Applied Science -Engineering Technology- Sequestration Specialty (Starts in fall 2012)**
  - **Associate of Science -Sequestration Concentration**

- **Several universities in Illinois have already reviewed and accepted Richland CCUS courses as electives in their degree program(s)**
  - **This recognition allows the students obtaining their 2-year degree from Richland to receive credits for the CCUS courses when they transfer to a 4-year degree program at these universities.**

Illinois ICCS Project – Expected Benefits

- DOE cost share - public benefits
  - Recovery Act funding creating jobs for economic recovery
  - Mitigating risks for the industry to demonstrate the largest integrated, saline storage project in the U.S.
  - Community outreach-CCUS technologies and related environmental benefits
- Because all of the collected CO_2 is produced from biologic fermentation, a significant feature of the Illinois ICCS project is its "negative carbon footprint."
- Validate the Mt. Simon Sandstone saline reservoir site for commercial-scale, long-term geologic storage of CO_2.
  - Collect crucial scientific and engineering data in advance of carbon capture requirements
- Successful implementation of this project:
  - Demonstrates cost advantages/economic viability of CCS at ethanol plants
  - Facilitates exploration of long-term CO_2 utilization options- EOR Illinois Basin
  - Develops a market for utilization of U.S. geologic saline storage capacity
    - Ranges from 1,700 to 20,000 billion metric tons

      (2010 Carbon Sequestration Atlas, NETL)

Illinois ICCS Project Construction Photos

(Courtesy of ADM, ISGS, and RCC)

- **Compressor Building**

- **Switchgear Building**

- **Groundwater Monitoring Well**

- **National Sequestration Education Center - Richland Community College**

Thank You!

- **Industrial Carbon Capture and Storage project:**
  - U.S. Department of Energy Award No. DE-FE-0001547
  - Administered by the DOE's Office of Fossil Energy
  - Managed by the National Energy Technology Laboratory
  - DOE cost share from American Recovery and Reinvestment Act of 2009
- **Cost share agreements:**
  - Archer Daniels Midland Company
  - University of Illinois through the Illinois State Geological Survey
  - Schlumberger Carbon Services
  - Richland Community College
- **Project team members include:**
  - Dr. Robert Finley, Dr. Hannes Leetaru, Sallie Greenberg, Randall Locke, and Pius Weibel (ISGS)
  - Eric Berlin, Scott Marsteller, Ozgur Senel, and Dr. Alan Brown (Schlumberger Carbon Services)
  - Dr. Douglas Brauer and Dr. David Larrick (RCC)
  - Dean Frommelt, Tom Stone, Steve Ryan and Andrea Blank (ADM)

For Additional Information

Office of Fossil Energy
www.fe.doe.gov

NETL
www.netl.doe.gov

NETL Factsheet - Archer Daniels Midland Company:
CO_2 Capture from Biofuels Production and Storage into the Mt. Simon Sandstone
http://www.netl.doe.gov/publications/factsheets/project/ARRA1547.pdf