June 12, 2013

Carbon Dioxide Capture, Utilization, and Storage: An Emerging Economic Opportunity for Fuel Ethanol Plants in the U.S.

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the **ENERGY** lab

2013 International Fuel Ethanol Workshop & Expo (FEW), St. Louis, MO

U.S. DEPARTMENT OF ENERGY

Outline of the Project

- **Fuel ethanol plants in the U.S. produce nearly 40 million tons of carbon dioxide (mostly emitted to the atmosphere).**

- **CO_2 capture, utilization, and storage (CCUS) will provide a new economic opportunity because ethanol plants are well suited to become early adopters of this technology - high purity CO_2 results in low capture costs compared to fossil fuel power plants.**

- **ADM (with DOE support) is proactively pursuing demonstration of this technology on a commercial-scale at its headquarters in Decatur, Illinois.**

Outline of the Project (contd.)

- ADM will capture CO_2 from its ethanol plant in Decatur and geologically sequester it deep underground at a rate of one million tons per year.

- Project scope - design, construction, and integrated operation of the CO_2 compression, dehydration, and injection facilities, and monitoring, verification, and accounting of the stored CO_2.

- The project team members are ADM, U.S. Department of Energy, Schlumberger Carbon Services, Illinois State Geological Survey, and Richland Community College.

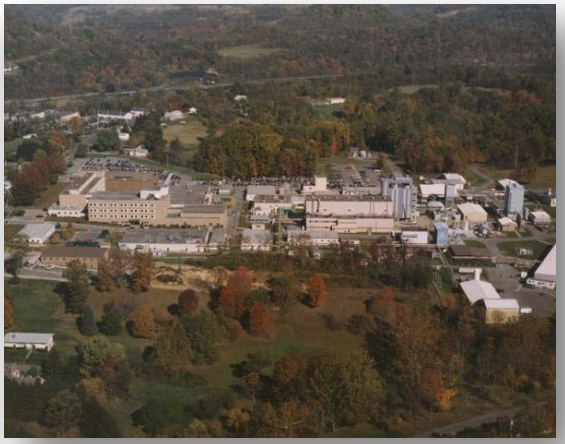
National Energy Technology Laboratory

Where Energy Challenges Converge and Energy Solutions Emerge

- **Full service DOE national laboratory**
- **Dedicated to energy RD&D, domestic energy resources**
- **Fundamental science through technology demonstration**
- **Unique industry – academia – government collaborations**

Oregon

Pennsylvania



West Virginia

Industrial Carbon Capture and Storage

- **DOE-FE ICCS Program, Area 1 - Large-scale projects**
  - American Recovery and Reinvestment Act (ARRA) of 2009
  - Project cost of $208 million (DOE $141.4M; Private: $66.5M)
  - *ADM, Decatur, Illinois (Saline storage) [Illinois ICCS project]*
- **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
- **CCUS for Enhanced Oil Recovery**

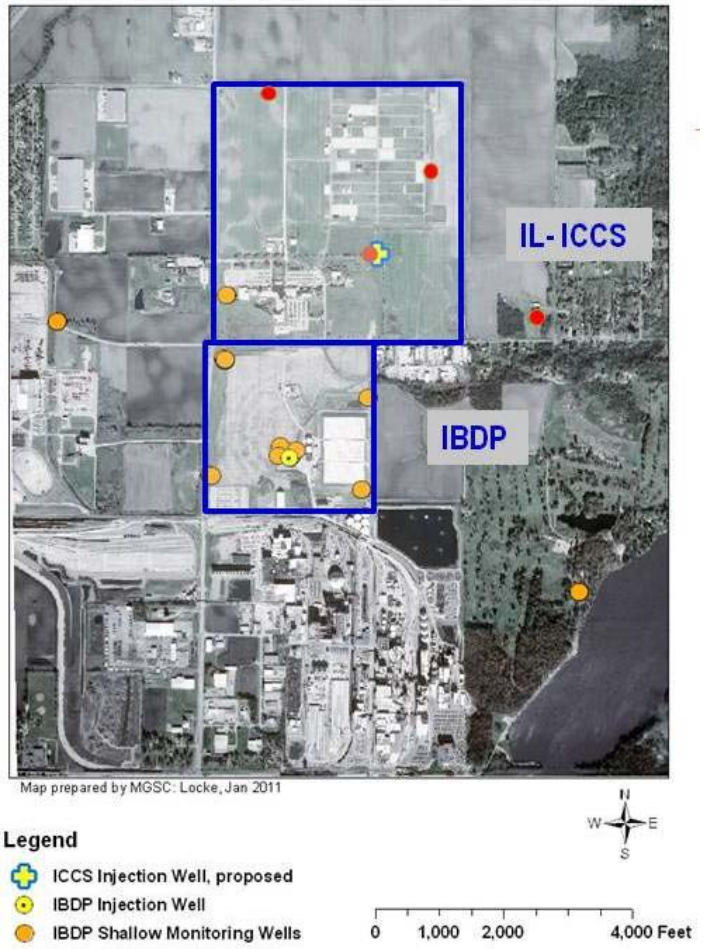
Two DOE-Sponsored CCS Projects in Decatur, IL

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**

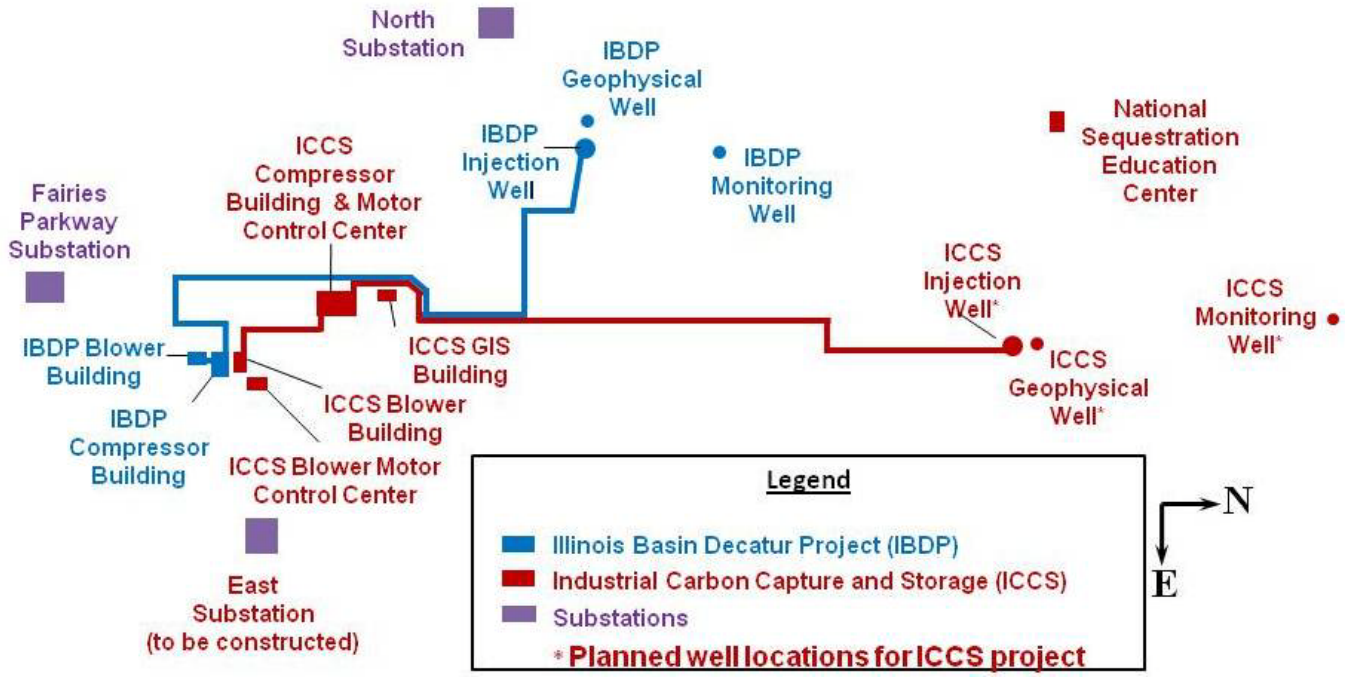
- **ADM ethanol plant, Decatur, IL**
- **1,000 metric TPD CO_2 capacity**
- **1 million metric tons CO_2 in three years**
- **CO_2 injection into the Mt. Simon Sandstone (~500,000 tons as of May 2013)**
- **IBDP knowledge base:**
  - **Site geological characterization**
  - **Risk assessment & reservoir modeling**
  - **Engineering design & MVA development**



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

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

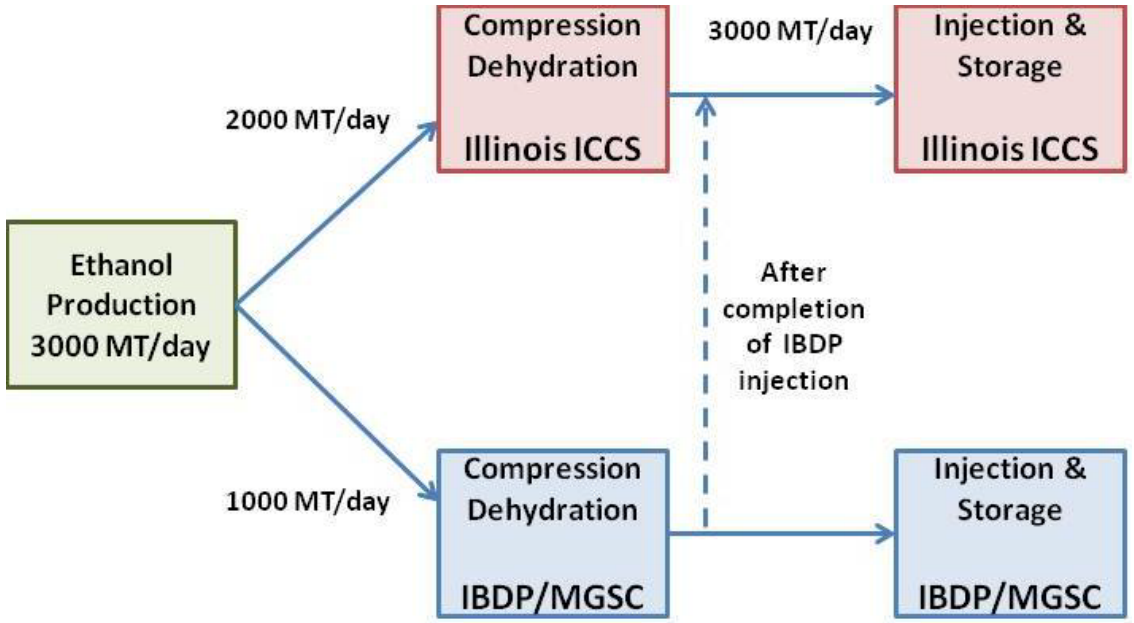
- **Illinois ICCS project, led by ADM, triples the injection rate to represent the operating capacity necessary for commercial power generating facilities.**



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.

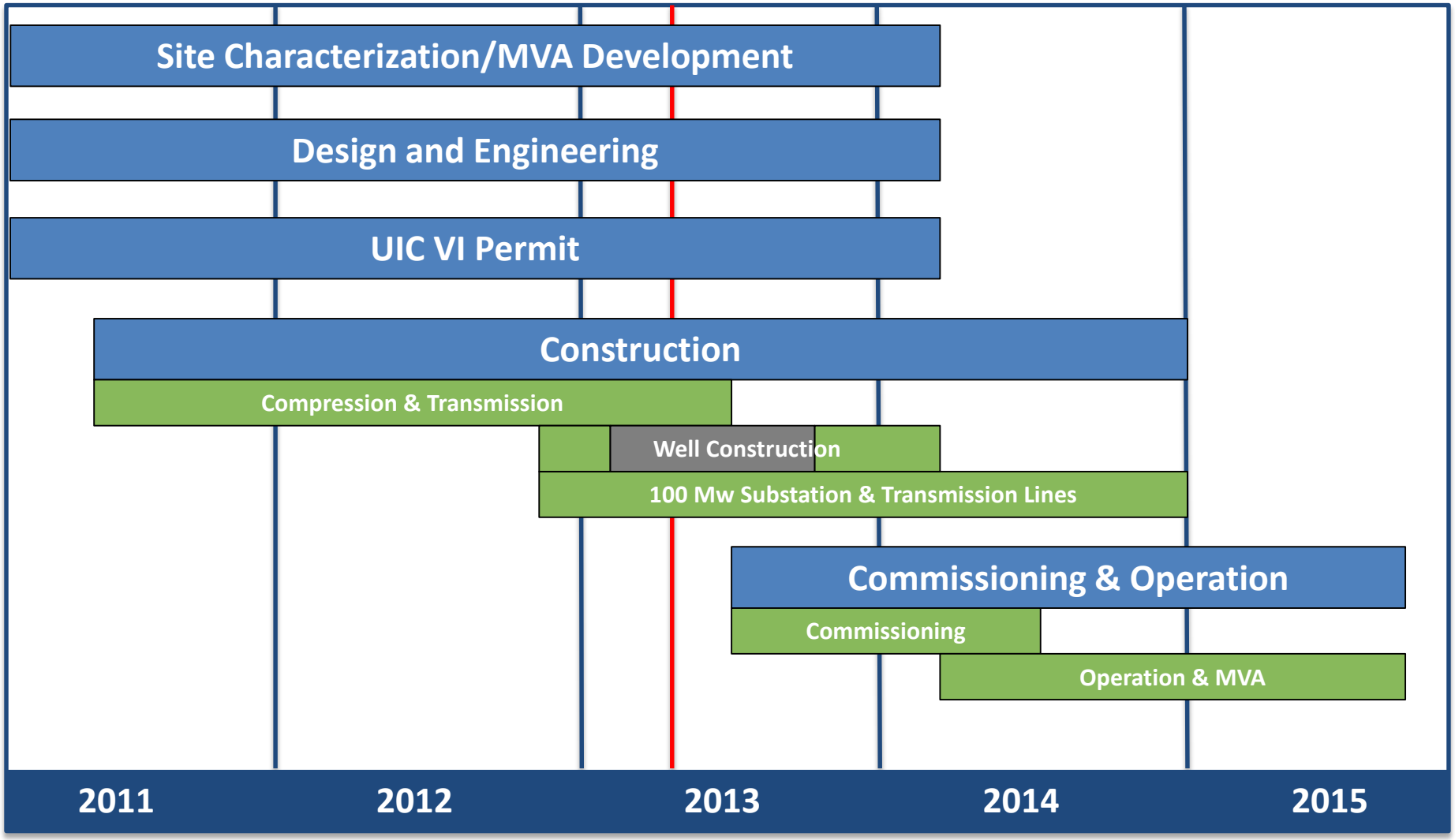
Upon completion of IBDP injection operations, the IBDP compression & dehydration facilities will be integrated with the new ICCS facilities.



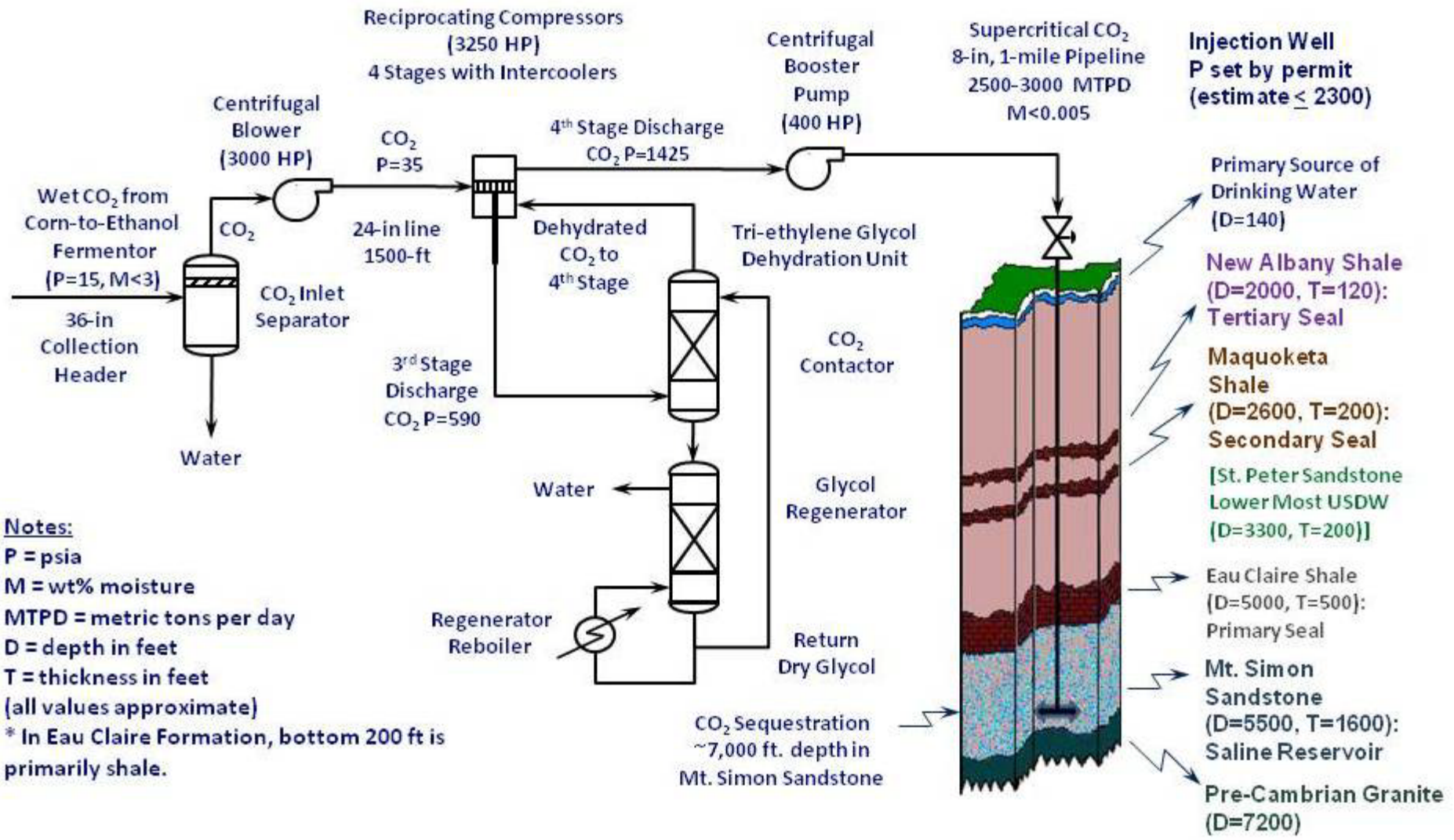
Illinois ICCS Team Members

- **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



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.

Project Photos (June 2013)

Four Compressor Train

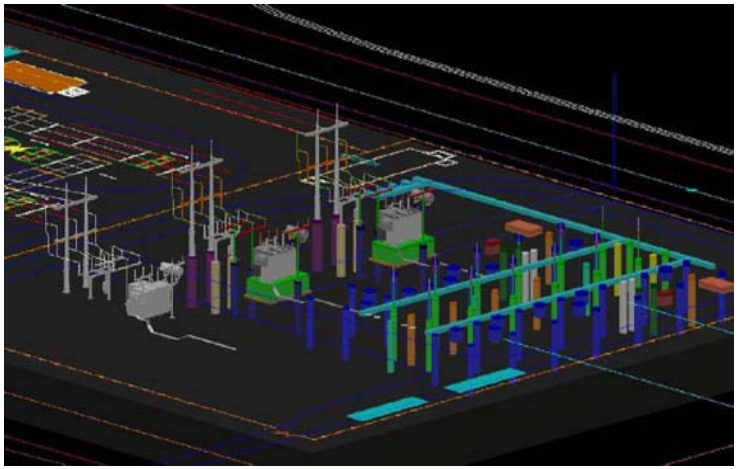
Compressor & Auxiliaries

Dehydration System

8” High Pressure transmission Line

Project Photos (June 2013)

Drilling the Monitoring Well



3-D Diagram of Substation

National Sequestration Education Center

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 and groundwater 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

Environmental Monitoring
Planned Framework

Near Surface		Deep Subsurface	
Soil and Vadose Zone	Ground Water	Above Seal	Injection Zone
Aerial Imagery	Soil CO_2 Flux	Geochemical Sampling P/T Monitoring	Geophysical Surveys Seismic Monitoring P Monitoring	Geophysical Surveys Geochemical sampling P/T Monitoring

Project Monitoring Photos (June 2013)

Shallow Groundwater Sampling

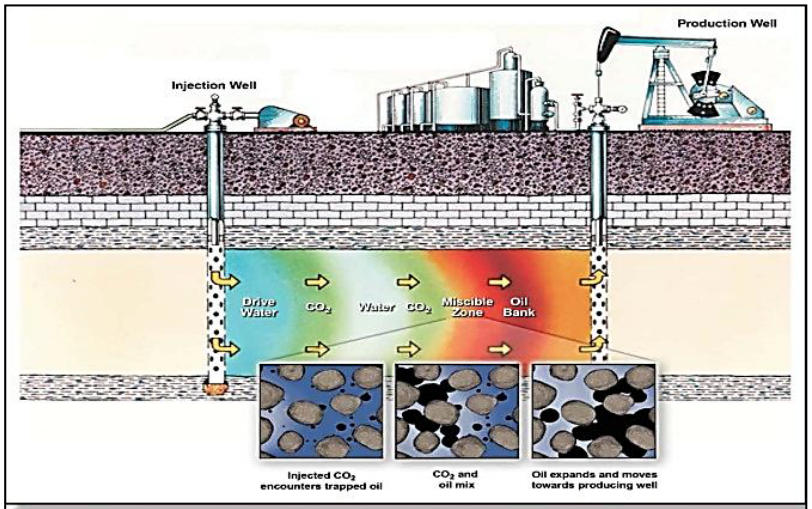
Soil Gas and CO_2 Flux Networks

Public Education and Community Outreach
National Sequestration Education Center

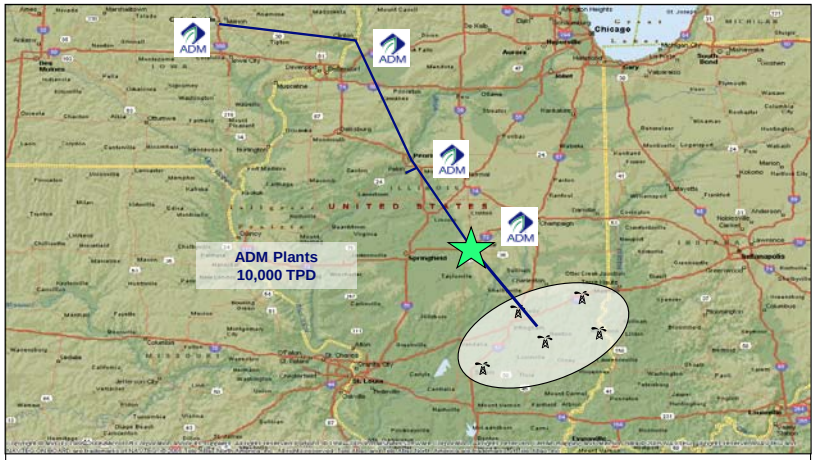
- **Conducting an integrated communication, outreach, training, and education initiative to engage local communities to understand CCUS, Illinois ICCS project, and related environmental benefits.**
- **National Sequestration Education Center (NSEC) - Richland Community College (Decatur, IL) – A new education/training facility:**
  - 15,000 sq. ft. center - classrooms, training and laboratory facilities
- **AAS degree in Engineering Technology with a Sequestration Specialty**
- **AS degree with a Sequestration Concentration (university transfer degree)**

Enhanced Oil Recovery – Southern Illinois Basin

- EOR means injecting CO_2 into an oil bearing formation to thin and displace the oil for easy recovery and collection at the surface.
- Industries and power plants in Illinois Basin produce over 250 million tons of CO_2 annually.
- One ton of CO_2 produces up to 3 bbl of oil.
- Recoverable oil in the Illinois Basin is estimated at 700 million bbl.
- ADM plants alone produce over 10,000 TPD high-purity CO_2 in the Midwest region.
- Currently tax credits are available for both EOR and saline storage of CO_2.



Cross-section illustrating how carbon dioxide and water can be used to flush residual oil from a subsurface rock formation between wells



•Illinois Basin - Oil Producing Region
•Est. Recoverable Oil = 700 million bbls(1)
•Est. CO_2 Requirements = 150 million tons

(1) BASIN ORIENTED STRATEGIES FOR CO2 ENHANCED OIL RECOVERY: ILLINOIS AND MICHIGAN BASIN OF ILLINOIS, INDIANA, KENTUCKY AND MICHIGAN; Advanced Resources International, February 2006

Highlights of the Presentation

- CO_2 capture, utilization, and storage (CCUS) refers to the storage of CO_2 deep underground to reduce atmospheric CO_2 concentrations and to mitigate climate change, while providing economic benefits to the operators.
- Fuel ethanol plants in the U.S., which produce nearly 40 million tons of CO_2 (mostly emitted to the atmosphere), have a unique economic opportunity as early adopters of CCUS.
- Ethanol plants produce high purity CO_2; hence CO_2 capture costs are low. Thus, CO_2 from ethanol plants has a cost advantage compared to other large-scale sources of CO_2, e.g., fossil fuel based power plants.
- CO_2 can be stored in (i) saline reservoirs, and (ii) depleted oil and gas reservoirs. Both options receive tax credits at this time.
- CO_2 used for enhanced oil recovery offers significant economic benefits.
- ADM, the largest ethanol producer in the U.S., is demonstrating the technical and economic viability of carbon capture and storage in Decatur, Illinois, with financial support of U.S. Department of Energy.

Acknowledgement

- **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. Sallie Greenberg, and Randall Locke (ISGS)
  - Eric Berlin and Ozgur Senel (Schlumberger Carbon Services)
  - Dr. Douglas Brauer and Dr. David Larrick (RCC)
  - Steve Ryan and Dean Frommelt (ADM)

For More Information

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