# **Update on US CCS Demonstrations**



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## CCUS Projects Locations, Technology & Cost Share



## Southern Company Services Advanced IGCC with CO<sub>2</sub> Capture

- Kemper County, MS
- 582 MWe (net) IGCC: 2 Gasifiers, 2 Siemens
  Combustion Turbines, 1 Toshiba Steam Turbine
- Mississippi Lignite Fuel
- ~67% CO<sub>2</sub> capture (Selexol<sup>®</sup> process)
  - 3,000,000 tons CO<sub>2</sub>/year
- EOR Denbury Onshore LLC, Treetop Midstream Services LLC
- Total Project: \$3.3Billion
  DOE Share: \$270 Million (8.2%)

### Key Dates

- Project Awarded: January 2006
- Project moved to MS: Dec 2008
- Construction: July 2010
- NEPA ROD: August 2010
- Operations: May 2014



- Plant construction >56% complete; >4,500 construction workers on site
- CO<sub>2</sub> off-take agreements signed
- Lignite mine under development
- Subsystems (water treatment, cooling towers) to begin precommissioning
- Combustion turbine startup: Jul 2013
- Gasifier heat-up: Dec 2013







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## Summit Texas Clean Energy Advanced IGCC-Polygen w/CCUS

- Penwell, Ector County, TX
- 400MWe (gross... 200MWe net to the grid), 0.7 MMT/yr Urea; greenfield IGCC with Siemens gasification & power Block
  - SFG-500 gasifiers (2 x 50%)
  - High H<sub>2</sub> SGCC6-5000F combined cycle (1 x 1)
- Fuel: PRB sub bituminous coal
- 90% CO<sub>2</sub> capture ~2,700,000 tons CO<sub>2</sub>/year
  - 2.2 MM tonnes EOR; 0.5 MM to Urea production
  - 2-stage Water Gas Shift, Linde Rectisol <sup>®</sup> AGR
- EOR: Permian Basin Oilfields
- Total DOE Project: \$1.727 Billion DOE Share: \$450 Million (26%)
- Total Plant Cost ~\$2.6 Billion

### Key Dates

- Air Permit; Dec 2010
- NEPA Record of Decision: Sep 2011
- Financial Close: Jun 2013
- Construction: 3<sup>rd</sup> Q2013
- Operation: Nov 2017

### **Status**

- Urea contract: Jan 2011
- CO<sub>2</sub> contract(s): Nov 2011
- Power off-take contract: Dec 2011
- Chexim signed for debt financing MOU: Sep 2012
- Sinopec signed EPC agreement: Dec 2012



5







## **NRG Energy (CCPI-3)** Advanced Post Combustion CO<sub>2</sub> Capture

- Thompsons, TX (near Houston)
- 240 MWe slipstream at NRG Energy's W.A. Parish power plant (project scale up from original 60 MWe to improve economic)
- Fuel: PRB sub-bituminous coal
- 90% CO<sub>2</sub> capture (KM CDR Process<sup>®</sup>)
  - 1,400,000 tonnes CO<sub>2</sub>/year
- EOR: Hilcorp West Ranch Oilfield
- Total DOE Project: \$775 Million (est.) DOE Share: \$167 Million (21.5%)

### Key Dates

- Project Awarded: May 2010
- Air Permit: Dec 2012
- NEPA Record of Decision: Apr 2013
- Financial Close: Sep 2013
- Construction: Oct 2013
- Operation: Mar 2016



### **Status**

- EOR Host Site acquired: Oct 2011
- 240 MWe FEED completed: Feb 21, 2012
- MHI initiated detailed design: Dec 2012
- NRG-Petra Nova signed engagement letter with a debt financing provider: Dec 2012
- Notice of Final EIS: Mar 8, 2013









# FutureGen 2.0

### Oxy-Combustion w/ CO<sub>2</sub> Sequestration

- Morgan County, IL (western IL)
- 168 MWe repowering of an existing steam turbine generator at Ameren's Meredosia Energy Center
- Fuel: Illinois bituminous/PRB blend
- 90+% CO<sub>2</sub> capture (cryogenic separation) 1,000,000 tons CO<sub>2</sub>/year
- Geologic Storage, Mt. Simon Sandstone saline formation - ~ 30 miles east of power plant
- Total DOE Project: \$1.78 Billion DOE Share: \$1.05 Billion (59%)

### Key Dates

- Project Awarded: October 2010
- NEPA Complete (Planned): Fall 2013
- Financial Close: Summer 2014
- Construction: Fall 2014
- Operation: Summer 2017

- Storage site selected: Oct 2011
- Pre-FEED completed: April 2012
- Preliminary PPA approved by ICC: 12/19/12
- Power plant project novated to FGA: 1/30/13
- Phase II (NEPA, Permitting, Design) authorized: 2/1/13







# **Lessons Learned – Cancelled Projects...**

### Basin

- A change in capture technologies and "cost issues"
- American Electric Power
  - Unable to get cost recovery in the rate base
- Southern Plant Berry
  - Deemed unprofitable





# **Back-Up Slides**





## Archer Daniels Midland Company (ICCS) CO<sub>2</sub> Capture from Biofuel Plant



- Decatur, IL
- CO<sub>2</sub> is a by-product (>99% purity) from production of fuel grade ethanol via anaerobic fermentation
- Up to 90% CO<sub>2</sub> capture; dehydration (via tri-ethylene glycol) and compression
  - 900,000 tonne CO<sub>2</sub> /year
- Sequestration in Mt. Simon Sandstone saline reservoir
- Total Project: \$208 Million

DOE Share: \$141 Million (68%)

### Key Dates

- Phase 2 Awarded: Jun 15, 2010
- FEED Complete: Apr 2011
- NEPA FONSI: Apr 2011
- Construction start: May 2011
- UIC Class VI Injection Well Permit: Aug 2013; UIC Class VI Operating Permit: Jan 2014
- Sequestration start: Feb 2014



### <u>Status</u>

- Construction ~47% complete
- UIC Class VI permit submitted: Jul 2011;
- Two monitoring wells drilled: Nov 2012
- Commissioning compression and dehydration: Jul 2013



10



# Archer Daniel Midland ICCS Construction Photos May 2013



3250-hp 4-stage reciprocating compressor & associated equipment



3000 TPD dehydration - triethylene glycol contactor & regenerator system



Monitoring well drilling-rig arrangement







tage piping in the compressor building

Compressor motor control center & switchgear





Core samples: Top-Eau Claire Shalecaprock seal: Bottom: Mt. Simon SandstonSSUMENSERGY.GOV

# Air Products & Chemicals (ICCS) Steam Methane Reforming with CO<sub>2</sub> Capture



- Port Arthur, TX (Hydrogen plant at Valero Refinery)
- 90%+ CO<sub>2</sub> capture (Vacuum Swing Adsorption) from 2 steam-methane reformers (SMRs) yielding
  - 925,000 tonnes CO<sub>2</sub>/year
- ~30 MWe cogeneration unit to supply makeup steam to SMRs and operate VSA and compression equipment
- **CO**<sub>2</sub> to Denbury for EOR West Hastings oilfield
- Total Project: \$431 Million DOE Share: \$284 Million (66%)

### Key Dates

- Phase 2 Awarded: Jun 15, 2010
- FEED complete: Nov 2010
- Permit By Rule (PBR) and Standard Air Permits issued: May 2011
- NEPA FONSI: Jul 2011
- Construction start: Aug 2011
- Operation start: Dec 2012



### **Status**

- PA-1 initiated operation: Mar 3, 2013
- PA-2 initiated operation: Dec 16, 2012
  - Operating continuously since Dec 31, 2012
  - Total CO<sub>2</sub> delivered (5/14/13): 216,600 tons
  - Full capacity achieved: April 2013
- Final MVA report submitted: Feb 2013





## Hydrogen Energy California Advanced IGCC-Polygen w/CCUS

- Kern County, CA, EOR: Elk Hills oilfield
- 400MWe(gross), 300MWe (net to grid) with load following;
  - greenfield IGCC, 1.0 MMT/yr Urea/UAN
  - MHI oxygen-blown gasifier (1 x 100%)
  - MHI G-class air cooled combustion turbine (1)
- Fuel: Sub-bituminous coal/petcoke
- 90% CO<sub>2</sub> capture 3,020,000 tonnes CO<sub>2</sub>/year
  - 2.57 MM tonnes EOR; 0.45 MM Urea production
  - 2-stage Water Gas Shift, Linde Rectisol <sup>®</sup> AGR
- Use of brackish water for power production; ZLD
- Total DOE Project: \$4 Billion DOE \$408 Million (10%)

### Key Dates

- Project Awarded: Sep 2009
- New Owner, SCS Energy: Sep 2011
- Financial Close: Dec 2013
- Start of Construction: Sep 2014
- Start of Operation: Apr 2019



- NEPA public scoping meeting: Jul 2012
- Power/Fertilizer/CO<sub>2</sub>/EPC discussions in progress
- Draft PSA/EIS: Mar/Apr 2013
- FEED completion: Jun 2013



### Leucadia Energy (ICCS) Petcoke Gasification to Methanol

- Lake Charles, LA
- GE Energy Gasification

(4 gasifiers: 3 hot/1 spare)

- 700 million gallons/year methanol; 110 mmscfd hydrogen
- Fuel; Petcoke
- 89% CO<sub>2</sub> capture (Rectisol<sup>®</sup> process);
  4,500,000 tonnes CO<sub>2</sub>/year
- CO<sub>2</sub> to Denbury pipeline for EOR in Texas at West Hastings oil field
- Total Project: \$436 Million

### Key Dates

- Phase 2 awarded: Jun 17, 2010
- Complete CCUS FEED: Jul 2011
- NEPA ROD: Oct 2013
- Financial close: Oct 2013 (est.)
- Construction: Oct 2013 (est.)
- Operation: Mar 2017 (est.)



- Product off-take contracts finalized (BP, APCI)
- NEPA EIS in progress; Draft EIS public meetings Apr 2013
- FEED in progress for gasification plant



