

#### EERC Partnership for CO<sub>2</sub> Capture (Including Fort Nelson and Zama Project)

Presented at the Carbon Sequestration Leadership Forum Bergen, Norway June 14, 2012

**Energy & Environmental Research Center** 

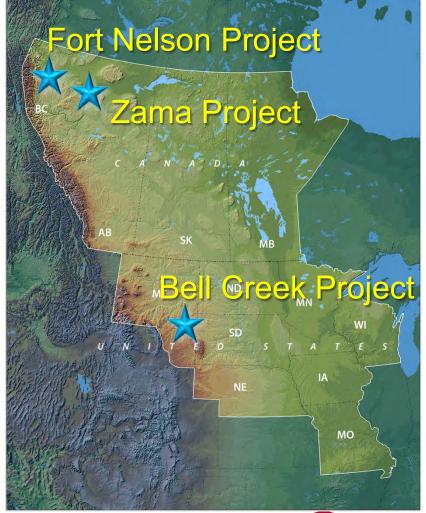
Mike Holmes Deputy Associate Director for Research



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#### Plains CO2 Reduction Partnership (PCOR) Commercial-Scale Demonstration Phase

- Two 1-million-ton/year-orgreater-scale demonstrations
  - Saline
  - Enhanced oil recovery (EOR)
- Ongoing and effective public outreach
- Continuing regional characterization
- Continued involvement in other carbon dioxide (CO<sub>2</sub>) storage projects in the region.
- Continued involvement in carbon capture and storage (CCS) and CO<sub>2</sub>/EOR regulations



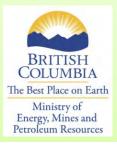


# Fort Nelson Organizational Chart

#### Commercial Partners

#### Regulatory Partners





Natural Resources Canada



#### EERC PCOR Partnership Fort Nelson Demonstration



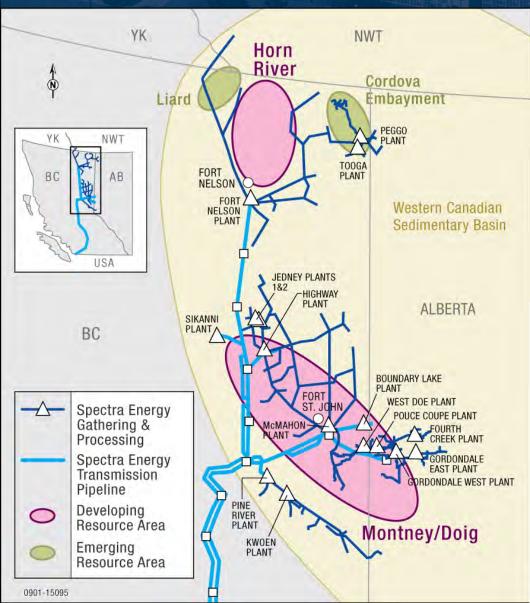
Research Partners







### **Fort Nelson Gas Plant**





- 1 Bcf/d raw gas-processing capacity largest facility of its kind in North America.
- Spectra Energy gathering and processing assets are strategically positioned in the growing Horn River Basin, processing both conventional and unconventional shale gas resources.
- The Fort Nelson CCS project is a potential solution to mitigate CO<sub>2</sub> emissions as shale gas production grows.

# Bell Creek Organizational Chart

#### Commercial Partners

**Bell Creek** 





#### EERC PCOR Partnership Bell Creek Demonstration

#### **Regulatory Partners**

Wyoming Office of State Lands and Investments



Wyoming Oil and Gas Conservation Commission



Montana Board of Oil and Gas Conservation







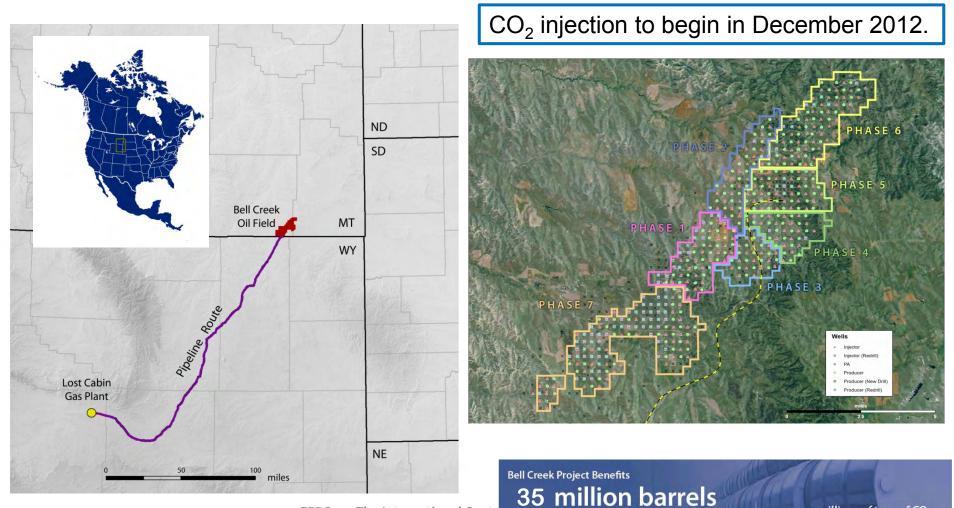






### **Bell Creek Logistics**

232-mile pipeline operational by December 2012.

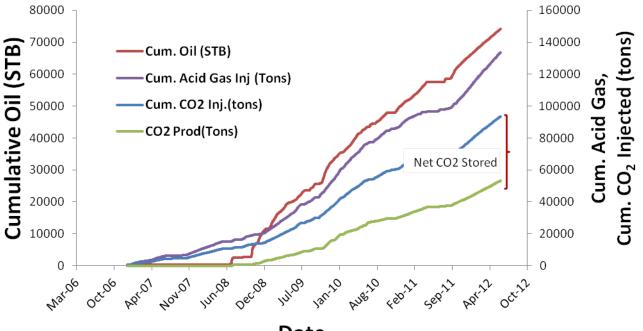


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... millions of tons of CO<sub>2</sub> safely in storage

#### Zama Project Update - Cumulative Injection and Production through May 28, 2012

#### Cumulative Oil and Injected CO<sub>2</sub> Zama F Pool



Date

- Acid Gas Injected: 133,550 tons
   CO<sub>2</sub>: 93,485 tons
- Oil Produced (bbls): 74,202 bbls
- Net CO<sub>2</sub> Stored: 40,357 tons

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### Conclusion

The PCOR Partnership region has huge CCUS potential!



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# Interactive CO<sub>2</sub> Capture Technology Summary

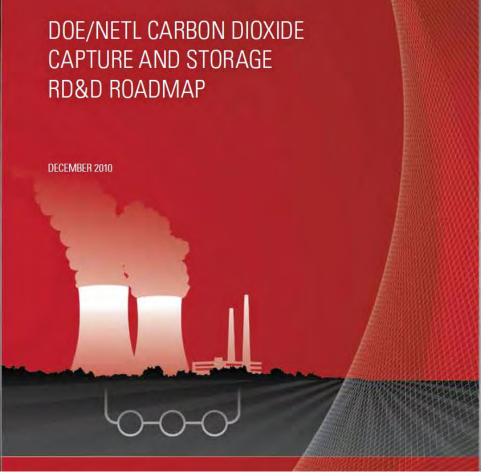
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The CO<sub>2</sub> capture technology document is being adapted for inclusion on the PCOR Partnership Partners-Only Decision Support System. Interactive features will allow the user to access:

- Summaries of the three capture platforms (pre-, during, and postcombustion)
- Summaries of the various technology types ٠ (adsorption, absorption, membrane, cryogenic, etc.)
- Specific technology information
  - Description
  - Development status
  - Developer name(s)
  - Process schematic
  - References



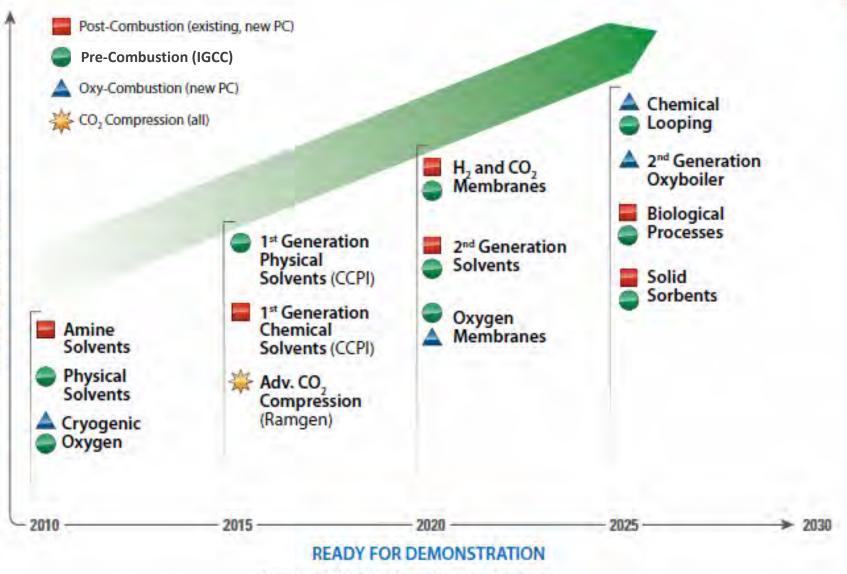
# **DOE NETL Program Goals**



U.S. Department of Energy (DOE) National Energy Technology Lab (NETL) technology goal: "To develop, by 2020, fossil fuel conversion systems that offer 90% CO<sub>2</sub> capture with 99% storage permanence at less than a 10%–35% increase in the cost of energy services."



## **CO<sub>2</sub> Capture Technology Status**



COST REDUCTION BENEFITS

Figure 2-13. DOE/NETL CO., Capture Technology Development

### PCO<sub>2</sub>C Summary

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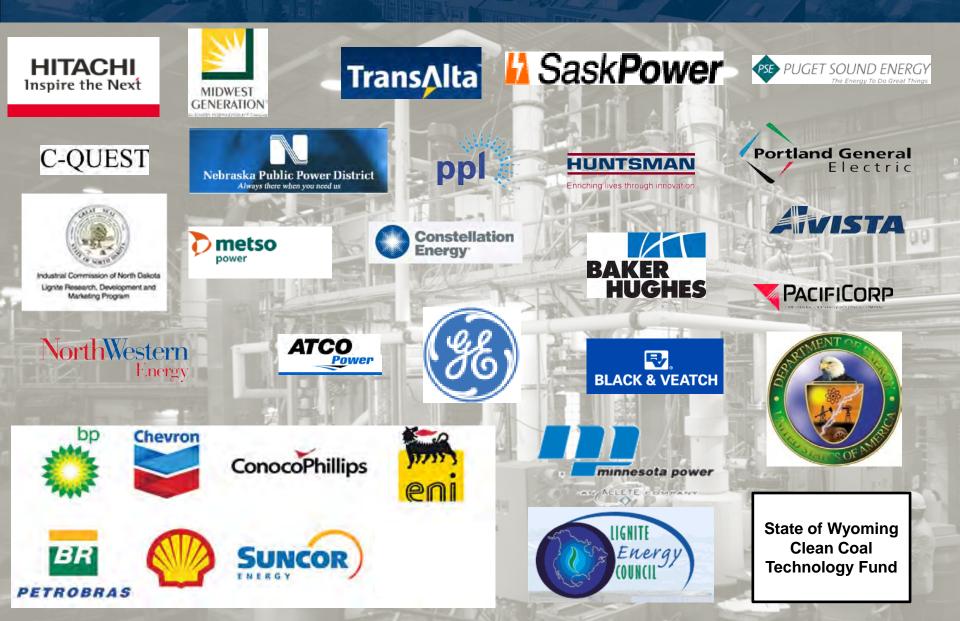
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Advancing the state of  $CO_2$  capture by evaluating and developing those technologies that are nearest to commercial viability for utility applications.

- Multiple-phase program.
- Includes funding from private sector sponsors (27), the North Dakota Industrial Commission, and the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL).
- Identify technology challenges and develop strategies for cost-effective and efficient implementation at the power utility scale.

### PCO<sub>2</sub>C Sponsors

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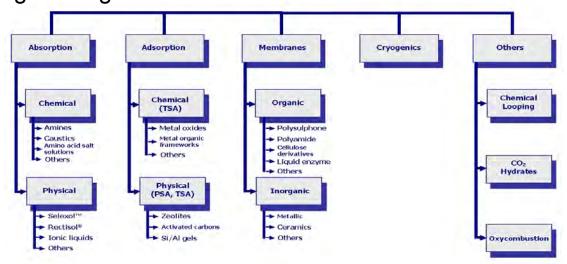


# **Summary of CO<sub>2</sub> Capture Technologies**

#### **Technologies Under Evaluation**

- Solvents
  - Monoethanolamine (MEA) Phase 1
  - Hitachi H3-1 Phase 1 & 2
  - Methyldiethanolamine (MDEA)– piperazine – Phase 1
  - Cansolv Phase 2
  - Huntsman Phase 2
  - ION Engineering Phase 2

- Oxy-Combustion P1 & 2
- Solid Sorbents Phase 2
  - NETL
- Other
  - C-Quest (slurry based) Phase 2
- Solvent Additives
  - Baker Hughes Phase 1
  - Huntsman Phase 1 & 2
  - Advanced Solvent Contactor (NSG)

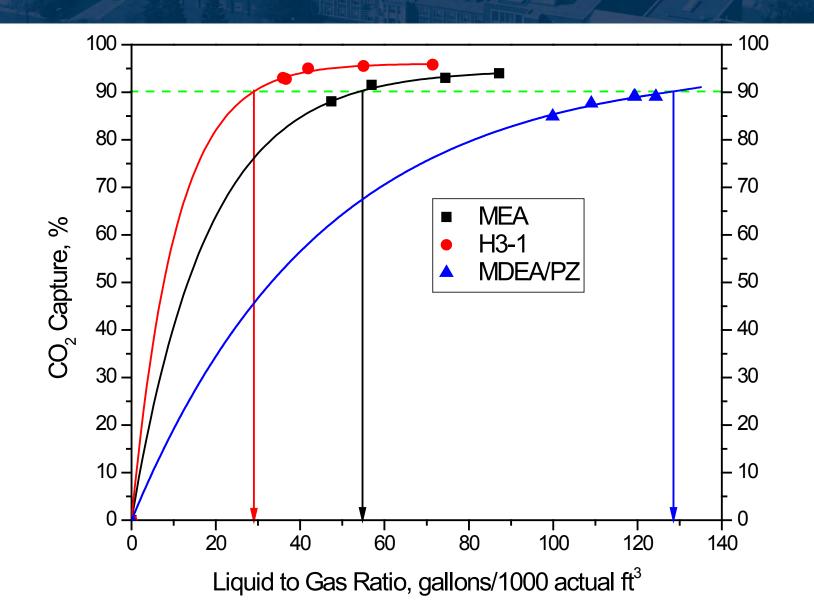




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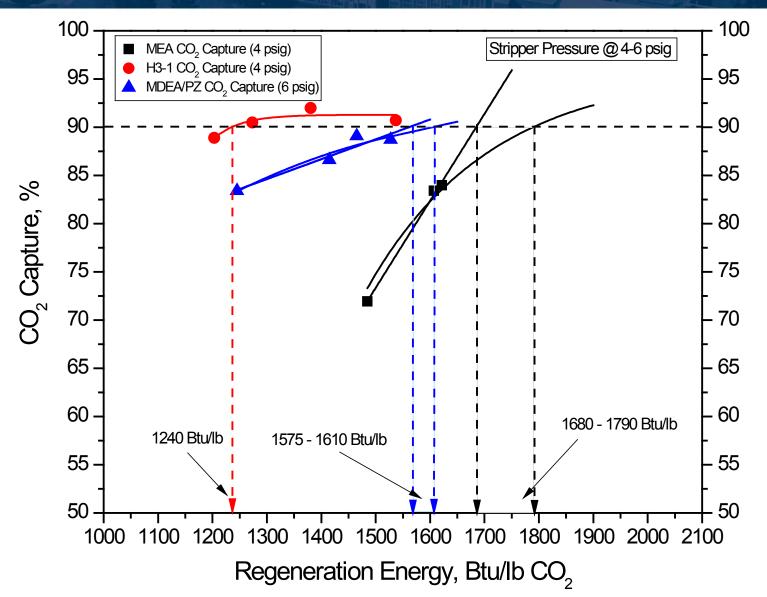


## **CO<sub>2</sub> Capture vs. Liquid-to-Gas Ratio**

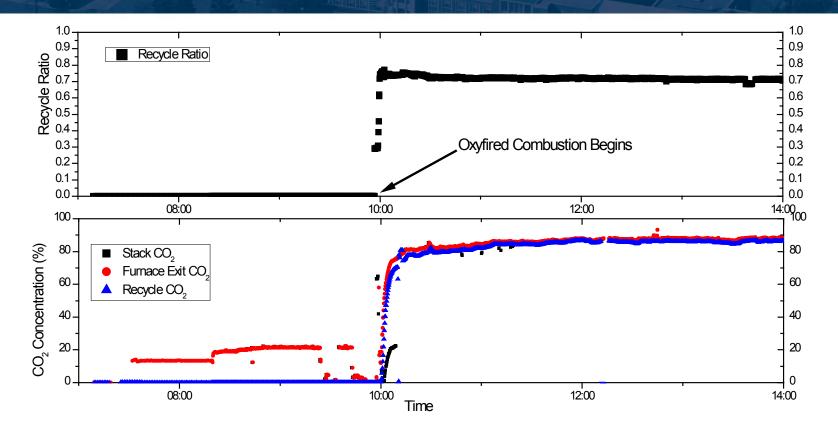


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### CO<sub>2</sub> Capture vs. Regeneration Energy



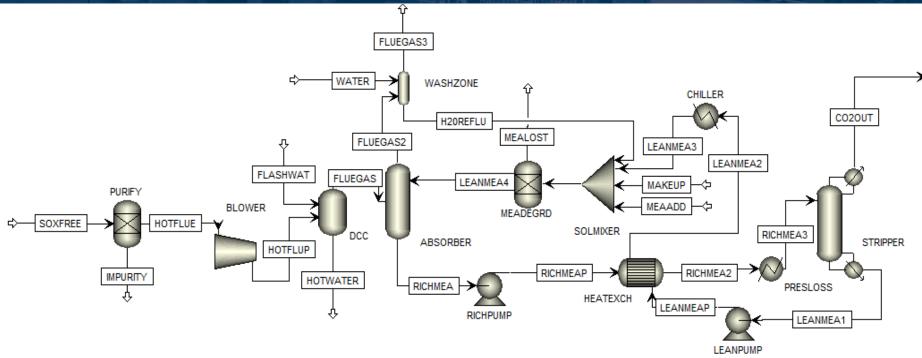
### **Example of CO<sub>2</sub> Concentration**



#### Flue Gas CO<sub>2</sub> Concentration from Run 1046 Using Paintearth Subbituminous



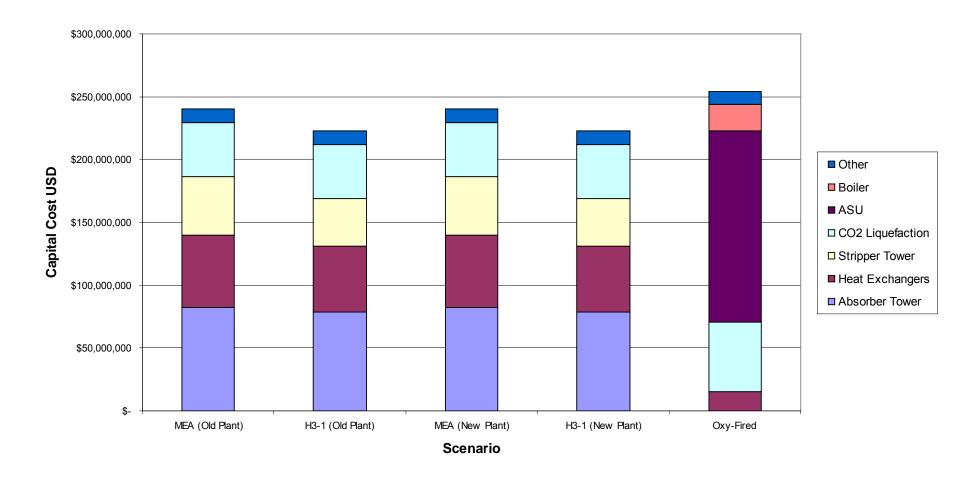
# 500-MW Aspen Plus<sup>®</sup> Model for CO<sub>2</sub> Capture



- 90% of CO<sub>2</sub> is removed from flue gas in absorber tower by MEA solvent.
- MEA losses from degradation are estimated from pilot-scale data.
- Wash zone minimizes MEA evaporation losses in absorber tower.



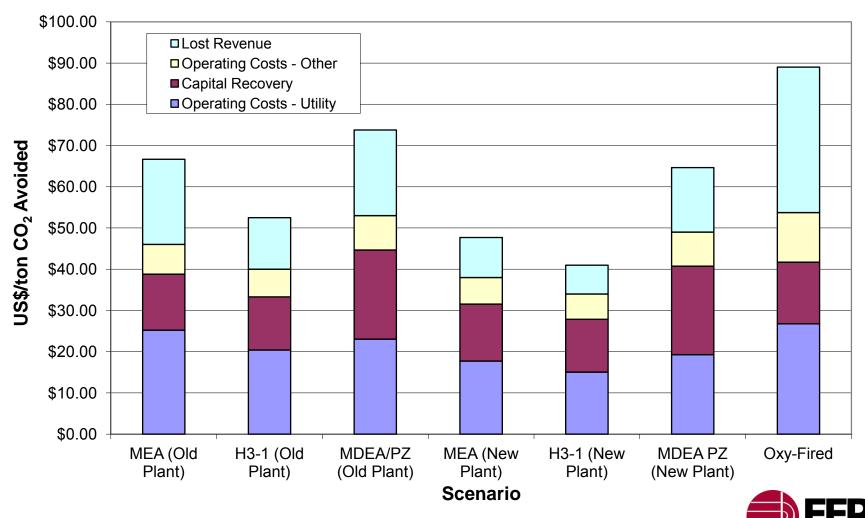
# **Capital Cost Comparison**





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## **Cost of CO<sub>2</sub> Avoided**



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Energy & Environmental Research Center® Putting Research into Practice

#### **Development Focus Areas for CO<sub>2</sub> Capture Implementation in Coal-Fired Power Plants**

- Scale-up
- Energy penalty
  - 20% to 30% less power output
- Cost
  - Current costs are \$40 to \$80 per ton of  $CO_2$  (80% ICOE).
  - Very capital intensive (\$1500 to \$2000/kW).
- Contaminants
- Resource availability and sector readiness
  - Supply of solvents or sorbents will be limited.
  - Manufacture of air separation units (ASUs) and other large equipment will be a handcuff to implementation.
- Regulatory framework
  - Lots of unknowns and liability issues.

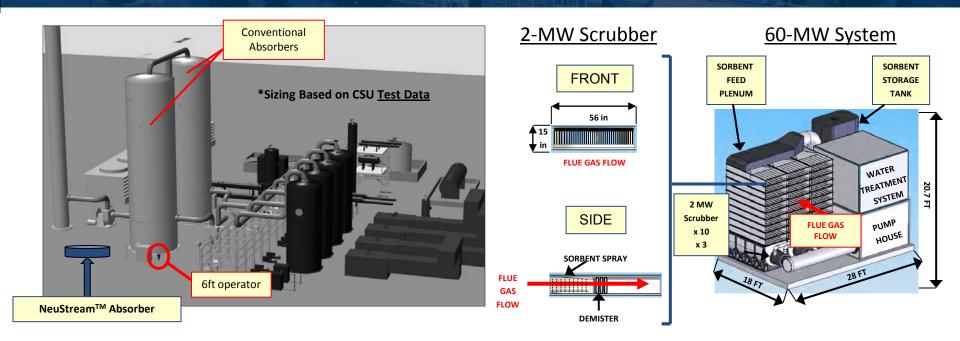


#### **Evaluation of Novel Technologies for CO<sub>2</sub> Capture**

- Neumann Systems Group's NeuStream-C<sup>™</sup> system.
- Pilot-scale evaluation to determine the performance and economics of the NeuStream-C system.
- The end result of the program is focused on the development of lower-cost and more effective capture technologies and their integration into a total system that provides substantial economic and environmental benefits.



## **NeuStream** Capture and Processing Systems



Up to 90% Smaller

**Modular Design** 

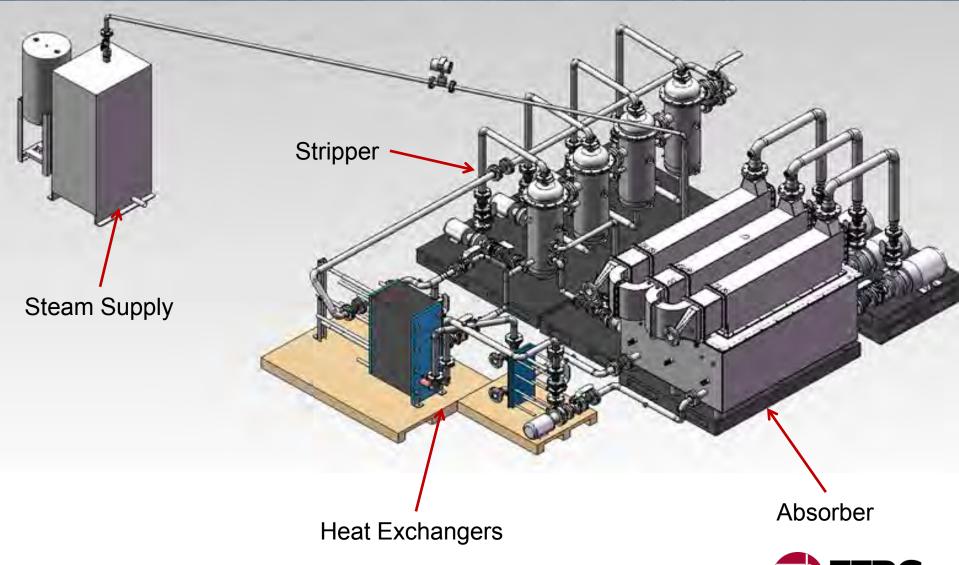
Up to 50% Lower CapEx Up to 40% Lower OpEx

#### Through NSG Mechanical Advancement Useful with Variety of Chemistries



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### **Current System Design**



Energy & Environmental Research Center® Putting Research into Practice

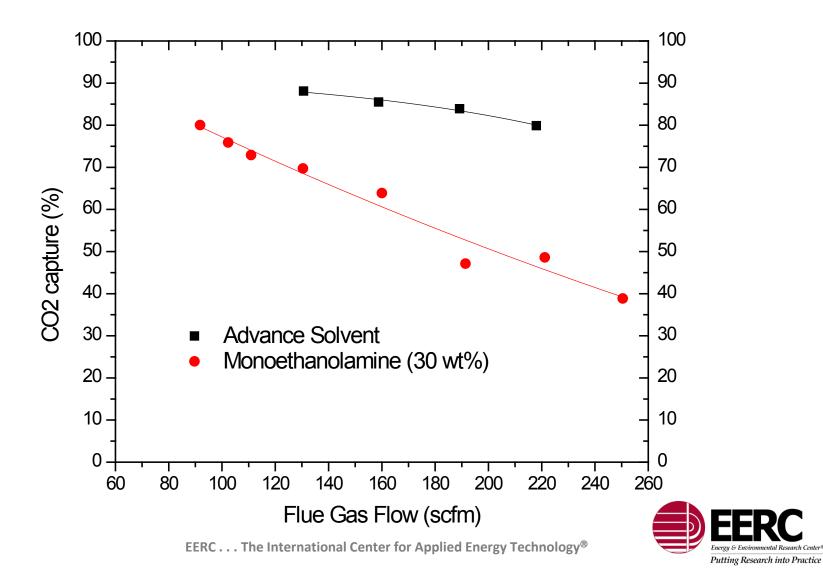
NeuStream-C System

Combustor

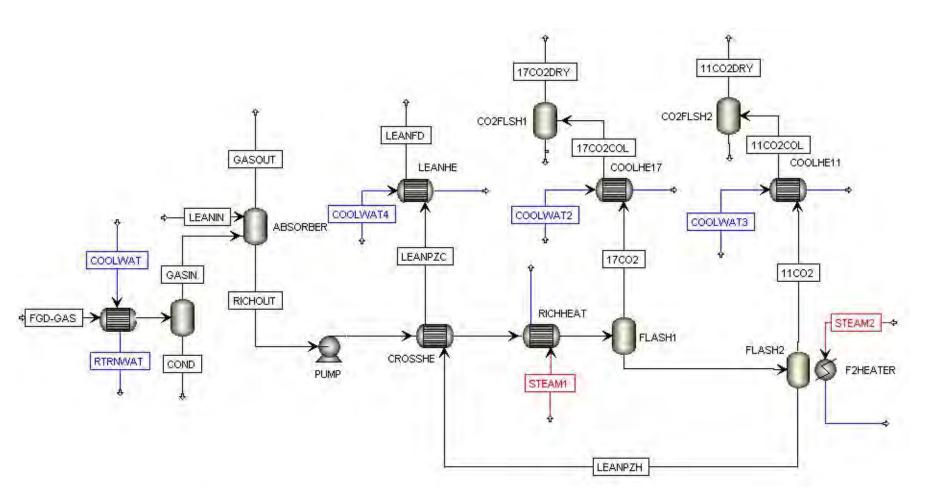
**Conventional Absorber System** 

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#### **Preliminary Capture Results**



### **Preliminary Modeling Results**

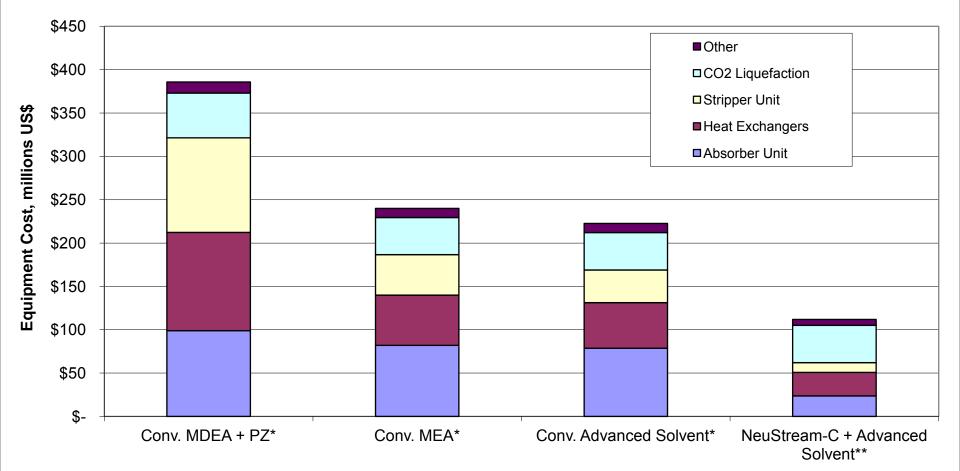




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### **Capital Cost Comparison**



\* Based on  $PCO_2C$  Phase I results scaled up to a 500-MWe plant.

\*\* Based on preliminary data scaled up to a 550-MWe plant.

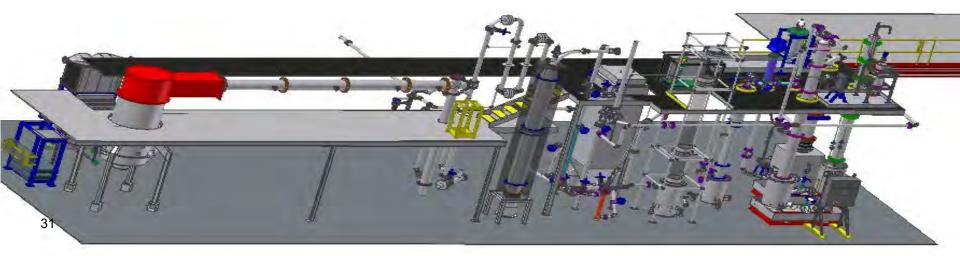
Scenario

# **Partnership for CO<sub>2</sub> Capture: Phase II**

#### **Pilot-scale testing of CO<sub>2</sub> capture technologies**

**Over 10 test campaigns evaluating eight different technologies** 

- Several technologies will be further evaluated, and new novel approaches will be tested.
  - Solvents: Huntsman, Hitachi, CanSolv (Shell), and Advanced Systems (NSG Contactor)
  - Solid sorbents (NETL)
  - Oxy-fired combustion (completed)
  - Other solvent-based technologies: ION Engineering
  - Slurry-based approach (C-Quest)



#### **Contact Information**

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