**LRC-LXIX(69)-B: "PARTNERSHIP FOR $CO_2$ CAPTURE – PHASE II"**

Submitted by: Energy & Environmental Research Center
Request for: $150,000; Total Project Costs: $1,860,000
Project Manager: Brandon M. Pavlish
Project Duration: 18 Months

# RESPONSE TO REVIEWERS' COMMENTS

## 1.0 PROJECT SUMMARY

Growing concerns about the impact of $CO_2$ emissions on global climate change have prompted increased research attention on the development of new technologies for $CO_2$ capture. Postcombustion capture, oxygen-fired combustion, and precombustion capture are among the most popular of the currently used approaches, although most of these are still in small-scale applications. In Phase I of the Partnership for $CO_2$ Capture ($PCO_2C$), the Energy & Environmental Research Center (EERC) proposed to conduct pilot-scale demonstration testing of selected $CO_2$ separation and capture technologies for fossil fuel- and biomass-fired systems. $PCO_2C$ Phase I was aimed at providing government and industry with key technical and economic information to examine the feasibility of technologies as a function of fuel type and system configuration. The technologies tested in the pilot-scale systems at the EERC included solvent scrubbing, solid sorbents, and oxygen-fired combustion. The overall goal of the $PCO_2C$ Program is to identify and help commercialize a range of $CO_2$ capture technology systems that can be implemented in the electric utility fleet to meet environmental emission constraints and requirements of $CO_2$ sequestration. The second phase of $PCO_2C$ involves continuing and new research for the promising technologies identified during Phase I. $PCO_2C$ Phase II utilizes the information gathered during Phase I for the development of lower-cost and more effective capture technologies and also their integration into a total system that provides substantial economic and environmental benefits.

This program involves the following objectives:

- Phase I Completed Objectives
  - Design, fabricate, and test a high-efficiency, flexible scrubber system to evaluate the performance of several scrubbing solvents in flue gas streams derived from selected fossil fuels, biomass, and blends.
  - Conduct testing of oxygen-fired combustion for selected fuels and blends in one or more of the EERC's existing pilot-scale units combined with the capability to test supercritical, ultrasupercritical, and advanced radiant heat exchangers.
  - Evaluate the performance of other $CO_2$ capture technologies.
  - Perform systems engineering modeling to examine efficient and cost-effective integration of $CO_2$ capture technologies in existing and new systems.

- Management and reporting.

- Phase II Proposed Objectives

  - Evaluate promising and novel technologies identified from Phase I.

  - Develop and implement strategies to overcome or minimize the challenges identified in the Phase I technology evaluations.

  - Develop and implement strategies for more efficient $CO_2$ capture system integration to reduce energy consumption and cost.

  - Evaluate several approaches for newly developed or existing strategies for system integration.

  - Evaluate evolving or known strategies to mitigate the challenges identified from Phase I.

  - Investigate and/or develop novel approaches for $CO_2$ capture to demonstrate high-efficiency capture at low cost.

  - Identify the best opportunities for full-scale demonstration of viable $CO_2$ capture strategies.

  - Identify a partner and site to demonstrate promising $CO_2$ capture technologies at demonstration scale.

This project will evaluate the impact of fuel characteristics on the feasibility of selected $CO_2$ capture technologies. The fuel types will include lignite, subbituminous, bituminous, natural gas, petroleum coke, and/or biomass. The test program will deliver information on technical issues and challenges associated with the application of these technologies to the capture of $CO_2$ from flue gas derived from combustion of selected fuels. A complete systems analysis and economic evaluation of the capture process will be performed as a function of technology type, coal type, and plant configuration to enable industries to make appropriate decisions to retrofit existing plants or build new plants. Phase II will utilize the information gathered during Phase I for the development of lower-cost and more effective capture technologies and also their integration into a total system that provides substantial economic and environmental benefits. The specific tasks to achieve the goals and objectives of the project are listed below:

Phase I

Task 1. Postcombustion Test System(s) Design, Construction, and Implementation (completed during Phase I)
  a. Flexible $CO_2$ capture systems
  b. Flexible flue gas cleanup and conditioning system

Task 2. Oxygen-Fired Retrofit (completed during Phase I)
Task 3. Conduct $CO_2$ Capture Technology Testing (completed during Phase I)
Task 4. Systems Engineering and Design (completed during Phase I)
Task 5. Management and Reporting (Phases I and II)

Phase II

Task 6. Evaluation of Promising and Novel Technologies
Task 7. Strategic Studies
Task 8. Commercial Partner-Specific Testing – Emerging Technologies

## 2.0 PHASE I DETAILS

Phase I of the Partnership for $CO_2$ Capture is nearly completed, and a final report will be issued at the end of July. With the incorporation of the final week of testing occurring the first week in June, all Phase I objectives will have been met. Many weeks of testing have occurred to evaluate both oxy-fired combustion utilizing several coal types (as well as natural gas) and solvent absorption-based postcombustion capture. Several solvents have been used to demonstrate the advantages of utilizing an advanced amine-based solvent system. The solvents evaluated include MEA, an advanced amine supplied by Hitachi, a degradation additive to be used with any solvent (provided by Huntsman), and an advanced amine of known components (which can be shared with the project sponsors) supplied by Huntsman. The results from testing help to determine operating performance and identify concerns. These were used not only to calibrate models built in AspenPlus but also help in determining a more realistic economic evaluation. Results from Phase I have been shared with the North Dakota Industrial Commission (NDIC) in the form of status update reports. The final report will be available for public dissemination upon approval by the U.S. Department of Energy and project sponsors. Below is a brief discussion of the Phase I Activities.

### Activity 1 – Postcombustion Test System(s) Construction and Implementation

The goal of Activity 1 was to design, fabricate, and test a high-efficiency, flexible scrubber system to evaluate the performance of several $CO_2$ scrubbing solvents in flue gas streams derived from the combustion of selected coals, biomass, and blends of the two. This goal has been completed. Following testing on the original construction, several modifications were made to help the equipment perform better. This included upgrading the solvent level monitoring equipment, installing a chiller/disengaging section at the top of the modular absorber column, and adding and improving instrumentation throughout the system.

Figure 1. $PCO_2C$ postcombustion capture system.

The fabricated unit, shown in Figure 1, consists of two main columns constructed from 10-in.-i.d.

stainless steel column sections of varying lengths bolted together to achieve a desired total height. Koch-Glitsch IMTP 25 316L stainless steel random packing is loaded in the columns to enhance the liquid–gas contact area and promote better $CO_2$ absorption and regeneration. Packing height, size, and type can easily be modified to accommodate different solvents and test conditions. The columns are designed to handle up to 140 scfm of flue gas generated in the combustion test furnace (CTF). In terms of a $CO_2$ capture system, the scale of this pilot-scale system would be considered a small industrial capture system.

### Activity 2 – Oxygen-Fired Retrofit

The EERC's existing 550,000 Btu/hr suspension-fired pilot-scale unit was retrofitted into an oxygen-fired system to demonstrate and determine the challenges and opportunities of an oxygen-fired platform for $CO_2$ capture and sequestration. The retrofit system has been tested with multiple coal types, and performance has been compared against the same coal in a standard air-fired environment. $CO_2$ levels at the furnace exit have been maintained at over 80% for significant periods of time, but so far testing has not shown the ability to maintain greater than 90% $CO_2$ at sustainable oxygen levels for any significant length of time. The data generated from this activity helped in performing the economic evaluation for performing a retrofit to an existing coal-fired system. These results have been made available to NDIC through a status update report.

### Activity 3 – Conduct $CO_2$ Capture Technology Testing

$CO_2$ capture testing on EERC's pilot-scale system has been performed for both standard MEA solvent and Hitachi's proprietary amine-based solvent, with two additional solvents (provided by Huntsman) to be evaluated the week of May 10th and June 7th. Tests on both solvents ran nearly continuously for multiple days, pausing only for cleaning of the test furnace. $CO_2$ removal rates of over 95% were attained, and the system was kept at over 90% capture for extended durations of time for multiple test conditions. Samples of the solvent were taken before, during, and after testing and are currently being analyzed.

Many of the parameters affecting $CO_2$ capture rates have been manipulated during testing to find optimum running conditions. These parameters are listed in Table 1. Approximate available ranges for each of the test parameters are shown in the right-hand column of the table.

### Activity 4 – Systems Engineering and Design

The goal of Activity 4 was to perform systems engineering modeling to examine efficient and cost-effective integration as well as determine an economic and technical evaluation of the technologies demonstrated.

Models of both the oxygen-fired combustion system and the postcombustion system have been developed using AspenPlus modeling software. The computer models allow $PCO_2C$ team engineers to determine appropriate conditions for physical testing, such as solvent makeup rate, packing bed depth, and solvent flow rate. The models assisted in planning the overall column dimensions as well. The oxygen-fired combustion model assisted in an evaluation of a retrofit of a 500-MW power station to enable oxygen-fired combustion for $CO_2$ capture. The results of this analysis are given in the recently sent Status Update Report. These models continue to be an

**Table 1. Variable Test Parameters**

| CTF System Variations | Typical Range |
|---|---|
| Inlet Gas Flow Rate | 60–130 scfm |
| Inlet Gas Temperature | 100°–120°F |
| $NO_x$ to Columns | 0 to 600 ppm |
| $SO_2$ to Columns | 0 to 600 ppm |
| **Postcombustion System Variations** | **Typical Range** |
| Solvent Flow Rate Through Absorber | 3–8 gpm |
| Condenser Cooling Water Flow Rate | 1–6 gpm |
| Lean Solvent-to-Absorber Temperature | 80°–150°F |
| Stripper Static Pressure | 3–14 psig |
| Steam Heat Duty | 70–200 MBtu/hr |
| Solvent Concentration | As requested |
| Solvent Makeup Rate | 0–500 mL/min |

asset to the operation of the physical testing facility, as well as the evaluation of new technologies. Solvent models are currently being finalized to determine the economic benefits of the advanced amines evaluated during Phase I, with results expected the end of May 2010.

## 3.0 ADDRESSING REVIEWERS' COMMENTS

The reviewers' comments indicated the need for further explanation of the test plan, technologies chosen, and details of the program. Most of the comments can be addressed by a review of the results from Phase I, but at this time, the Phase I results are not open to the public (pending review of current sponsors and the U.S. Department of Energy). The Phase II proposal was written to allow the flexibility to further evaluate the technologies tested during Phase I (the Phase I technologies include solvents from Hitachi, Huntsman, and advanced solvents from the literature as well as oxy-fired combustion) and to evaluate new technologies. Several ongoing discussions are taking place with technology developers that are producing novel methods for enhancing existing capture technologies or new methods of $CO_2$ capture. Phase II was intended to include the opinions of the sponsors who financially support the program; therefore, parts of the program are not completely defined to allow for adjustments to be made based upon sponsor input.

A test plan was created to allow for the necessary data to be gathered independent of the technologies tested. It is the EERC's intent to further evaluate postcombustion capture systems including solvent absorption, solid sorbents, and other novel approaches. An additional focus of Phase II is to integrate these overall systems into existing power plants. This will be done by implementing strategies at the pilot-scale level to determine their impact. This includes the use of waste heat, intercolumn cooling, tower wash sections, and a better overall heat integration within the system. Other integration options may be suggested by our sponsors and working groups. The equipment budget was based on a small percentage of the overall budget and allows for system modifications to be made for the implementation of integration options as well as other novel technologies that may be tested. The overall goal of Phase II is to evaluate technologies

that show enough promise to move to the demonstration scale. At the end of Phase II, a recommendation of technologies will be made to take the next step in commercialization (demonstration), with the intent that a partner site and technology will be chosen for a large-scale demonstration. Further description of the milestones, schedule, and test plan are included below from the project management plan developed for the U.S. Department of Energy funding.

## 4.0 PHASE II MILESTONES

### Activity 5 – Management and Reporting

**Milestone No.:** M14
**Title:** Complete Annual Project Meeting
**Planned Date:** May 13, 2009
**Verification Method:** Annual project meeting will be held, and the results will be discussed.

**Milestone No.:** M15
**Title:** Complete Final Report
**Planned Date:** August 31, 2011
**Verification Method:** Final report will be completed and available for review.

### Activity 6 – Further Evaluation of Promising Technologies

**Milestone No.:** M16
**Title:** Develop $CO_2$ Capture Strategy Working Group
**Planned Date:** June 30, 2010
**Verification Method:** The group will be established and will meet frequently.

**Milestone No.:** M17
**Title:** Identify Most Promising Technologies
**Planned Date:** July 31, 2010
**Verification Method:** A list will be generated from group meetings.

**Milestone No.:** M18
**Title:** Develop $CO_2$ Capture and Integration Strategies
**Planned Date:** October 31, 2010
**Verification Method:** Ideas will be generated and recorded in a report format.

**Milestone No.:** M19
**Title:** Evaluate Developed $CO_2$ Capture and Integration Strategies
**Planned Date:** May 31, 2011
**Verification Method:** Results from testing will be available.

**Milestone No.:** M20
**Title:** Perform Technical and Economic Evaluations of Developed Strategies
**Planned Date:** June 30, 2011
**Verification Method:** Model results will be available.

### Activity 7 – Strategic Studies

**Milestone No.:** M21
**Title:** Determination of $CO_2$ Capture External Factors
**Planned Date:** June 30, 2011
**Verification Method:** Results will be available.

**Milestone No.:** M22
**Title:** Development of Novel Bench-Scale $CO_2$ Capture Technology
**Planned Date:** June 30, 2011
**Verification Method:** Results will be available.

### Activity 8 – Commercial Partner-Specific Testing – Emerging Technologies

**Milestone No.:** M23
**Title:** Identify Commercial Partners
**Planned Date:** June 30, 2011
**Verification Method:** Commercial partners will be available.

**Milestone No.:** M24
**Title:** Identify Critical Technology Needs
**Planned Date:** June 30, 2011
**Verification Method:** Results will be available.

**Milestone No.:** M25
**Title:** Determine and Implement Strategies to Mitigate Identified Technology Needs
**Planned Date:** June 30, 2011
**Verification Method:** Results will be available.

## 5.0 SCHEDULE FOR PHASES I AND II

Period of Performance: July 1, 2008 – August 31, 2010

| Year | 2008 | | | | | | 2009 | | | | | | | | | | | | 2010 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** |
| Activity 1 | | M1 ♦ | M2 ♦ | | | M3 ♦ M4 ♦ | | | | | | | | | | | | | | | | | |
| Activity 2 | | M5 ♦ | M6 ♦ | | M7 ♦ | M8 ♦ | | | | | | | | | | | | | | | | | |
| Activity 3 | | | | | | | | | M9 ♦ | | | | | | | | | | | M10 ♦ | | | |
| Activity 4 | | | | | | | | | | | | | | | | | | | | M11–M13 ♦ | | | |
| Activity 5 | | | | | | | | | | M14 ♦ | | | | | | | | | | | | | |
| Activity 6 | | | | | | | | | | | | | | | | | | | | | | | |
| Activity 7 | | | | | | | | | | | | | | | | | | | | | | | |
| Activity 8 | | | | | | | | | | | | | | | | | | | | | | | |

| Year | 2010 | | | | | | | 2011 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** |
| Activity 5 | | | | | | | | | | | | | | | M15 ♦ |
| Activity 6 | M16 ♦ | M17 ♦ | | | M18 ♦ | | | | | | | M19 ♦ | M20 ♦ | | |
| Activity 7 | | | | | | | | | | | | | M21–M22 ♦ | | |
| Activity 8 | | | | | | | | | | | | | M23–M25 ♦ | | |

♦ = Milestone

Figure 2. Subtask time line.

## 6.0 PHASE II TEST PLAN

| Partnership for $CO_2$ Capture Phase II Preliminary Test Plan | | | | |
|---|---|---|---|---|
| Solvent Testing (Test Period 1) 7 days | | | | |
| Date | Test Condition | Fuel | Technology | Description |
| Day 1 | Solvent testing | TBD[1] | Advanced solvent (either Hitachi, Huntsman, or other) | The system will be fired on a coal TBD by the sponsors, and an advanced solvent will be used. The purpose of this test is to further evaluate performance from Phase I as well as to implement strategies to reduce energy consumption and cost. The data that will be gathered will include but are not limited to the following: 1) heat of regeneration required, 2) solvent flow rates, 3) temperatures, 4) energy consumption (fans, pumps, regeneration), 5) flue gas components ($SO_x$, $NO_x$, $O_2$, $CO_2$, Hg), 6) final $CO_2$ purity, 7) flue gas flow rates, 8) $CO_2$ capture efficiencies, and 9) impact of impurities (solvent degradation). |
| Day 2 | Solvent testing | TBD | | |
| Day 3 | Solvent testing | TBD | | |
| Day 4 | Solvent testing | TBD | | |
| Day 5 | Solvent testing | TBD | | |
| Day 6 | Contingency | | | Two days of testing are reserved in case additional data need to be gathered to reach steady-state conditions. The need for these additional testing days will be evaluated during testing based on the expected results. |
| Day 7 | | | | |

[1] To be determined.

Continued . . .

| Partnership for $CO_2$ Capture Phase II Preliminary Test Plan (continued) | | | | |
|---|---|---|---|---|
| Solvent Testing (Test Period 2) 7 days | | | | |
| Date | Test Condition | Fuel | Technology | Description |
| Day 1 | Solvent testing | TBD | Advanced solvent (either Hitachi, Huntsman, or other) | The system will be fired on a coal TBD by the sponsers, and an advanced solvent will be used. The purpose of this test is to further evaluate performance from Phase I as well as to implement strategies to reduce energy consumption and cost. The data that will be gathered will include but are not limited to the following: 1) heat of regeneration required, 2) solvent flow rates, 3) temperatures, 4) energy consumption (fans, pumps, regeneration), 5) flue gas components ($SO_x$, $NO_x$, $O_2$, $CO_2$, Hg), 6) final $CO_2$ purity, 7) flue gas flow rates, 8) $CO_2$ capture efficiencies, and 9) impact of impurities (solvent degradation). |
| Day 2 | Solvent testing | TBD | | |
| Day 3 | Solvent testing | TBD | | |
| Day 4 | Solvent testing | TBD | | |
| Day 5 | Solvent testing | TBD | | |
| Day 6 | Contingency | | | Two days of testing are reserved in case additional data need to be gathered to reach steady-state conditions. The need for these additional testing days will be evaluated during testing based on the expected results. |
| Day 7 | | | | |

[1] To be determined.

Continued . . .

| Partnership for $CO_2$ Capture Phase II Preliminary Test Plan (continued) | | | | |
|---|---|---|---|---|
| Solvent Testing (Test Period 3) 7 days | | | | |
| Date | Test Condition | Fuel | Technology | Description |
| Day 1 | Solvent testing | TBD | Advanced solvent (either Hitachi, Huntsman, or other) | The system will be fired on a coal TBD by the sponsors, and an advanced solvent will be used. The purpose of this test is to further evaluate performance from Phase I as well as to implement strategies to reduce energy consumption and cost. The data that will be gathered will include but are not limited to the following: 1) heat of regeneration required, 2) solvent flow rates, 3) temperatures, 4) energy consumption (fans, pumps, regeneration), 5) flue gas components ($SO_x$, $NO_x$, $O_2$, $CO_2$, Hg), 6) final $CO_2$ purity, 7) flue gas flow rates, 8) $CO_2$ capture efficiencies, and 9) impact of impurities (solvent degradation). |
| Day 2 | Solvent testing | TBD | | |
| Day 3 | Solvent testing | TBD | | |
| Day 4 | Solvent testing | TBD | | |
| Day 5 | Solvent testing | TBD | | |
| Day 6 | Contingency: baseline | | | Two days of testing are reserved in case additional data need to be gathered to reach steady-state conditions. The need for these additional testing days will be evaluated during testing based on the expected results. |
| Day 7 | | | | |

[1] To be determined.

Continued . . .

| Partnership for $CO_2$ Capture Phase II Preliminary Test Plan (continued) | | | | |
|---|---|---|---|---|
| Evaluation of Other/Novel $CO_2$ Capture Technologies – Solid Sorbents – 10 days | | | | |
| Day 1 | Evaluation of solid sorbents | TBD | TBD | Approximately 10 days of testing are reserved for the evaluation and/or feasibility testing of solid sorbent $CO_2$ capture technologies. Through a separate project at the EERC, the necessary equipment to evaluate the effectiveness of using solid sorbents for $CO_2$ capture has been designed and fabricated. This equipment will be used to evaluate solid sorbents. Currently, the EERC is talking with solid sorbent developers to aquire sorbents for evaluation. Based on the testing, key challenges for each technology will be identified. Other parameters to be evaluated will be determined once the technology for evaluation has been determined by the consortium group. |
| Day 2 | Evaluation of solid sorbents | TBD | TBD | |
| Day 3 | Evaluation of solid sorbents | TBD | TBD | |
| Day 4 | Evaluation of solid sorbents | TBD | TBD | |
| Day 5 | Evaluation of solid sorbents | TBD | TBD | |
| Day 6 | Evaluation of solid sorbents | TBD | TBD | |
| Day 7 | Evaluation of solid sorbents | TBD | TBD | |
| Day 8 | Evaluation of solid sorbents | TBD | TBD | |
| Day 9 | Evaluation of solid sorbents | TBD | TBD | |
| Day 10 | Evaluation of solid sorbents | TBD | TBD | |

[1] To be determined.

Continued . . .

| Partnership for $CO_2$ Capture Phase II Preliminary Test Plan (continued) | | | | |
|---|---|---|---|---|
| Oxygen-Fired Combustion Testing (Task 3) – 7 days | | | | |
| Day 1 | Evaluation of oxygen-fired combustion retrofit | TBD | TBD | Five days of testing have been scheduled to investigate a range of parameters to be ultimately decided upon by the group of sponsers. Several issues arose during Phase I that will be looked at in more detail in Phase II. Strategies to overcome these issues will be evaluated and tested. Air inleakage and oxygen contamination and reuse are examples of some of the issues identified. |
| Day 2 | Evaluation of oxygen-fired combustion retrofit | TBD | TBD | |
| Day 3 | Evaluation of oxygen-fired combustion retrofit | TBD | TBD | |
| Day 4 | Evaluation of oxygen-fired combustion retrofit | TBD | TBD | |
| Day 5 | Evaluation of oxygen-fired combustion retrofit | TBD | TBD | |
| Day 6 | Contingency | | | Two days of testing are reserved in case additional data need to be gathered to reach steady-state conditions. The need for these additional testing days will be evaluated during testing based on the expected results. |
| Day 7 | | | | |

[1] To be determined.

Continued . . .

| Partnership for $CO_2$ Capture Phase II Preliminary Test Plan (continued) | | | | |
|---|---|---|---|---|
| System Integration Testing 7 days | | | | |
| Date | Test Condition | Fuel | Technology | Description |
| Day 1 | System integration testing | TBD | Advanced solvent (either Hitachi, Huntsman, or other) | Several integration options will be investigated during Phase II. These include system modifications to the capture equipment, such as intercolumn cooling, heating, and wash sections. Several other options will be discussed by the working group to be developed during Phase II. |
| Day 2 | System integration testing | TBD | | |
| Day 3 | System integration testing | TBD | | |
| Day 4 | System integration testing | TBD | | |
| Day 5 | System integration testing | TBD | | |
| Day 6 | Contingency | | | Two days of testing are reserved in case additional data need to be gathered to reach steady-state conditions. The need for these additional testing days will be evaluated during testing based on the expected results. |
| Day 7 | | | | |

[1] To be determined.

Continued . . .

| Partnership for $CO_2$ Capture Phase II Preliminary Test Plan (continued) | | | | |
|---|---|---|---|---|
| System Integration Testing 7 days | | | | |
| Date | Test Condition | Fuel | Technology | Description |
| Day 1 | Utilization of “waste heat” | TBD | Advanced solvent (either Hitachi, Huntsman, or other) | Several integration options will be investigated during Phase II. These include system modifications to the capture equipment such as intercolumn cooling, heating, and wash sections. Several other options will be discussed by the working group to be developed during Phase II. |
| Day 2 | Utilization of “waste heat” | TBD | | |
| Day 3 | Utilization of “waste heat” | TBD | | |
| Day 4 | Utilization of “waste heat” | TBD | | |
| Day 5 | Utilization of “waste heat” | TBD | | |
| Day 6 | Contingency | | | Two days of testing are reserved in case additional data need to be gathered to reach steady-state conditions. The need for these additional testing days will be evaluated during testing based on the expected results. |
| Day 7 | | | | |

[1] To be determined.

Continued . . .

| Partnership for $CO_2$ Capture Phase II Preliminary Test Plan (continued) | | | | |
|---|---|---|---|---|
| Novel Technology Testing 7 days | | | | |
| Date | Test Condition | Fuel | Technology | Description |
| Day 1 | Novel technology | TBD | TBD (Several discussions are on-going: system additives, enzyme-based capture, advanced contactor.) | Several discussions are ongoing with developers of novel approaches for $CO_2$ capture. Promising technologies will be chosen for evaluation in the system. These technologies consist of system additives to reduce corrosion and degradation of solvents, enzyme-based capture, advanced contactors, and advanced solvents other than amines. |
| Day 2 | Novel technology | TBD | | |
| Day 3 | Novel technology | TBD | | |
| Day 4 | Novel technology | TBD | | |
| Day 5 | Novel technology | TBD | | |
| Day 6 | Contingency | | | Two days of testing are reserved in case additional data need to be gathered to reach steady-state conditions. The need for these additional testing days will be evaluated during testing based on the expected results. |
| Day 7 | | | | |

[1] To be determined.

Continued . . .

| Partnership for $CO_2$ Capture Phase II Preliminary Test Plan (continued) | | | | |
|---|---|---|---|---|
| Novel Technology Testing 7 days | | | | |
| Date | Test Condition | Fuel | Technology | Description |
| Day 1 | Novel technology | TBD | TBD (Several discussions are on-going: system additives, enzyme-based capture, advanced contactor.) | Several discussions are ongoing with developers of novel approaches for $CO_2$ capture. Promising technologies will be chosen for evaluation in the system. These technologies consist of system additives to reduce corrosion and degradation of solvents, enzyme-based capture, advanced contactors, and advanced solvents other than amines. |
| Day 2 | Novel technology | TBD | | |
| Day 3 | Novel technology | TBD | | |
| Day 4 | Novel technology | TBD | | |
| Day 5 | Novel technology | TBD | | |
| Day 6 | Contingency | | | Two days of testing are reserved in case additional data need to be gathered to reach steady-state conditions. The need for these additional testing days will be evaluated during testing based on the expected results. |
| Day 7 | | | | |

[1] To be determined.