ION Advanced Solvent CO_2 Capture Project

Submitted to:

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North Dakota Industrial Commission
State Capitol
600 East Boulevard Avenue, Department 405
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Proposal Amount $1,000,000

SUBMITTED BY
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ABSTRACT

In laboratory, bench-scale, and small scale pilot testing with coal-fired flue gas, ION's advanced solvent has demonstrated significant benefits and has outperformed other candidate technologies as the leading second generation solvent system for post-combustion CO_2 capture. Regeneration energy requirements have been consistently demonstrated to be greater than 50% less than baseline aqueous – MEA (Aq-MEA) with solvent CO_2 carrying capacities greater than 35% higher than Aq-MEA, with significantly less solvent degradation due to impacts of flue gas impurities (SOx) than Aq-MEA. The primary objective of this project is to test ION's lead CO_2 capture solvent under more realistic somewhat larger slipstream conditions (~ 0.7 MWe) during continuous long-term operation, and to demonstrate significant progress is being made to meet or exceed DOE's goal for second generation solvents of 90% CO_2 capture rate with 95% purity at a cost of \$40/tonne CO_2 captured by 2025. As part of this goal, the project seeks to gather data at pilot slipstream scale of 0.5-1.0 MWe that is considered essential and necessary for scale-up and testing at 10-50 MWe, the next logical scale of testing as stated by DOE. To support this project, ION has assembled a stellar team from the University of North Dakota Energy and Environmental Research Center (EERC), the University of Alabama (UA), and Nebraska Public Power District (NPPD). The project consists of three 15 month segments and is estimated to cost approximately \$20,194,044. \$1,000,000 is being requested by the North Dakota Industrial Commission (NDIC) to support the program.

PROJECT SUMMARY

The primary objective of this project is to test ION's advanced CO_2 capture solvent under more realistic somewhat larger slipstream conditions (~0.7-1.0 MWe) during continuous long-term operation in order to gather the essential and necessary data for the next DOE recommended scale-up size of 10-50MW. To accomplish this objective the following activities will be performed during the project period and will be specifically broken out and explained in detail throughout this proposal.

SLIPSTREAM PROJECT ACTIVITIES:

- Design and fabrication of the 0.7-1.0 MWe (equivalent) slipstream pilot plant
- Scale-up of solvent manufacturing (preparation & mixing)
- Testing, data collection and analysis of solvent performance, degradation and air emission analysis, under various steady-state operational conditions
- Modeling and simulation for the detailed Preliminary and Final Techno-Economic Analyses
- Decommissioning of pilot plant equipment upon completion of solvent testing
- Delivery and presentation of the final project report and Final Techno-Economic Analysis

RELATED OUTCOMES / IMPACTS:

- If successful, the activities in this proposal will support further testing of ION's advanced solvent at the 10-50 MWe level and demonstrate significant progress progress has been made in achieving DOE's performance objectives for 2nd generation solvents by 2025.
- ION expects significant gains in CO_2 capture and experience with the ION solvent and will be at a DOE technology readiness level (TRL) of TRL 6 (prototype demonstration in a relevant environment) at the conclusion of this project and be ready to proceed with testing at the TRL 7 level (prototype demonstration in an operational environment). The Host Site will have realized its goal of establishing itself as a leader in the implementation of CO_2

emission mitigation. ION and DOE will have demonstrated that advanced solvents are capable of meeting, and possibly exceeding, DOE's performance goals for 2025. ION expects that if the performance demonstrated to date can be confirmed in the proposed project, these results will have very significant impact on the speed of implementation of carbon emission controls world-wide.

PROJECT DESCRIPTION

The primary objective of this project is to test ION's advanced CO_2 capture solvent under more realistic somewhat larger slipstream conditions (~ 0.7-1.0 Mw) during continuous long-term operation, and to demonstrate significant progress is being made to meet or exceed DOE's goal for second generation solvents of 90% CO_2 capture rate with 95% purity at a cost of $40/tonne CO_2 captured by 2025. As part of this goal, the project seeks to gather data at pilot slipstream scale of 0.5-1.0 MWe that is considered essential and necessary for scale-up and testing at 10-50 MWe, the next logical scale of testing as stated by DOE. Below are the tasks that are proposed to be completed as part of the ION Advanced Solvent CO_2 Capture Project.

- Task 1.0 - Project Management

Budget Period 1 - Preliminary System Analysis

- Task 2.0 - Initial Slipstream Project Review
- Task 3.0 - Site Selection and Permitting
- Task 4.0 - Final Pilot System Design

Budget Period 2 - Procurement and Construction of Pilot Plant

- Task 5.0 - Procure Pilot Equipment
- Task 6.0 - Pilot Construction
- Task 7.0 - Pilot Plant Shakedown
- Task 8.0 - Final Test Plan Development & Material Procurement

Budget Period 3 - Pilot Plant Operation & Baseline Solvent and ION Solvent Testing

- Task 9.0 - System Operation
- Task 10.0 - Data Reduction and Analysis
- Task 11.0 – Final Systems Engineering Analysis
- Task 12.0 – System Decommissioning and Dismantle

SCOPE OF WORK

This project is broken down into three 15 month budget periods which will be stage-gated throughout the project. A report will be issued to DOE at the end of each budget period, and the project will not move forward until DOE has authorized the next budget period. The project work is comprised of 12 tasks. Task 1 is the project management task and is the only task that will run the duration of the project. Tasks in Budget Period 1 will focus on the preliminary techno-economic analysis of ION's process results to date, host site selection and permitting, and finalization of the pilot and systems designs. Budget Period 2 will focus on the construction and installation of the pilot unit at the host site, pilot shakedown and ION solvent delivery to the site. Budget Period 3 will focus on baseline and ION solvent testing, analysis of the results and completion of the final engineering and techno-economic evaluations.

OVERALL PROJECT - ION ADVANCED SOLVENT CO_2 CAPTURE PROJECT

TASK 1.0 - PROJECT MANAGEMENT

This task addresses coordination, management and planning of project activities that will include, but are not limited to, monitoring and controlling of project scope, technical, budgetary and scheduling activities, project and task planning, asset management, cost tracking, and progress reporting throughout the project period of the award. Submission and approval of required National Environmental Policy Act (NEPA) documentation will be part of this Task. Coordination and planning will be carried out with DOE and project team members. In addition, the Recipient will revise and maintain the Project Management Plan (PMP) in order to reflect changes in the schedule, risk, resources, key technical drivers, technical approach, etc. as needed throughout the performance of the project or at the request of the DOE Project Manager.

Subtask 1.1 - Monitor, Control & Communicate Project Status

This subtask addresses activities for the Recipient to monitor and track progress towards completion for all tasks and activities proposed herein. Project status and progress will be communicated directly to the Recipient's project manager by the site and department leads, project management team, and project team members. The Recipient's project manager will work very closely with the VP of R&D (project CO-Principal Investigator (CO-PI)), VP of Finance & Administration (F&A) and CEO (project Principal Investigator (PI)) to ensure that there is minimal delay in communicating project information to DOE. Should minor delays be encountered that do not affect the overall timing of critical path tasks and milestones, action will be taken by the project management team to accelerate the activities required to get back on schedule. Unforeseen delays that cannot be resolved easily will be immediately communicated to senior management at the Recipient, who will be responsible for communicating and discussing the event with any additional parties (e.g. DOE and project team members) required to determine the best possible path forward, and revisions will be made to the schedule that are acceptable to DOE, the Recipient, and project team members.

Subtask 1.2 – Initial National Environmental Policy Act (NEPA) Documentation

This subtask addresses activities for the Recipient to prepare and submit to DOE the required NEPA documentation for each aspect of the work to be performed at the Recipient and project team locations.

Subtask 1.3 - Financial Management

This subtask addresses activities for financial management of the project to be performed by the Recipient’s management personnel experienced with financial program management functions including: financial planning and budgeting, project costing, proper segregation of costs between direct and indirect, invoicing, and cash flow management. The Recipient’s management personnel are also experienced with purchasing and subcontract management, a critical function to this program.

Subtask 1.4 – Technical

This subtask addresses activities for the Recipient to provide technical direction and oversight of the project. This responsibility will be that of the VP of R&D at the Recipient, who will work closely with the Recipient's executives to ensure technical integrity and timely accomplishment of solvent R&D objectives presented in the SOPO. Technical direction will ensure that experimental design, execution, system operation, sample collection and analysis are sufficient to thoroughly test and quantify target solvent performance metrics as described in the SOPO. Technical oversight includes ensuring that contractors meet quality assurance requirements and performance guarantees, and system components meet design specifications. Project risks will be minimized by working directly with the project management team, site and department leads, and project team members to ensure that experimental design, process design, sample port and instrumentation specifications meet or exceed what is necessary to achieve project goals.

Subtask 1.5 – Administrative

This subtask addresses activities related to the Recipient's financial and administrative personnel, specifically the VP of F&A, Project Accountant and Compliance Manager to work closely with the project team members to administer the fiscal and contract responsibilities related to this project. The VP of F&A and the Recipient CEO/PI will have joint oversight for all financial and administrative activities.

Subtask 1.6 – Legal

This subtask addresses activities related to Recipient negotiations, management, and maintenance of sub-awards and/or sub-contracts with project team members. The Recipient will ensure that appropriate DOE terms, conditions, regulations, and other requirements are included as flowdowns in subcontracts and subawards. The Recipient will ensure contractor compliance with quality assurance requirements, insurance requirements, title to assets and site access. The Recipient will negotiate confidentiality and intellectual property agreement with all of the project participants to ensure that the Recipient has the ability to commercialize all new discoveries made under this project and that DOE and the U.S. Government have their required access to project information and discoveries also made under this project.

Subtask 1.7 - Revision and Maintenance of the Project Management Plan

This subtask addresses activities related to Recipient collaboration with other project team members to revise and maintain the Project Management Plan (PMP) in order to reflect changes in the schedule, risk, resources, key technical drivers, technical approach, risk, etc. as needed throughout the performance of the project or at the request of the DOE Project Manager.

The Recipient will utilize the PMP to assist in management of subtask activities, initiation of activities, tracking of task/activity completion, etc. Revised PMP's will be submitted to DOE and communicated to project team members by the Recipient as necessary and appropriate.

Subtask 1.8 – Health & Safety

This subtask addresses activities for the Recipient to manage a health and human safety program including, but not limited to, semi-annual safety reviews and compliance audits, tracking and documenting incident response, and provide risk assessment for insurance coverage.

Subtask 1.9 – Briefings & Technical Presentations

This subtask addresses activities that the Recipient, with support from project team members, will perform to coordinate, prepare for, present at, and attend the following:

- Kickoff Meeting at Host Site
- Annual Review Meetings (one for BP1, one for BP2, and one for BP3)
- National Conferences (three during BP1, three during BP2, and three during BP3)
- End-of-Project Review Meeting at Host Site

BUDGET PERIOD 1 - PRELIMINARY SYSTEM ANALYSIS

As requested by the DOE, the first budget period will consist of a technical and economic evaluation of the proposed process. Budget Period 1 will consist of three primary tasks (Task 2.0, 3.0, and 4.0).

TASK 2.0 INITIAL SLIPSTREAM PROJECT REVIEW

Subtask 2.1 Initial Techno-Economic Analysis (TEA)

In Subtask 2.1, the initial techno- economic modeling required by the DOE will be completed. Specifically, the study will include a techno-economic analysis of an entire power system at a 550-MW scale. The study will conform to DOE National Energy Technology Laboratory (NETL) guidelines for systems analysis and will be consistent with previous NETL studies. Aspen Plus will be used to generate the mass and energy balance data required to carry out the economic analysis, and Aspen Plus Economic Analyzer (APEA) will be used to size and cost the components. The FOA requires that mass and energy balances be completed around the entire pulverized coal (PC) plant. The EERC already has extensive experience modeling these types of systems with Aspen software; therefore, some of the base models already exist for performing the evaluation (12, 13). The nature of the modeling requested is very detailed; therefore, utilization of the existing base models is a critical component to meeting the 12-week deadline.

Subtask 2.2 Initial EH&S Risk Assessment

The initial EH&S assessment will include an overview of the risks and hazards associated with ION's CO_2 capture technology and will be finalized in Task 11 once testing is complete.

TASK 3.0 SITE SELECTION AND PERMITTING

Activities throughout this task will allow the team to make the final determination of the host site for the test unit and obtain any permits required for the construction, installation and operation of the test unit.

Subtask 3.1 Host Site Selection

The final host site will be selected based on DOE approval and successful contract negotiations with the host site. Based on initial discussions, Nebraska Public Power District (NPPD) has agreed to dedicate the Gerald Gentleman Station as a host site and is committed to providing onsite support for the project.

Subtask 3.2 Pilot Plant Permitting

Upon completion of Subtask 3.1, a final site visit will be performed to discuss any outstanding issues. During this visit, permitting of the pilot slipstream system will be discussed, information required by the Host Site will be assembled and provided to the Host Site, who will be responsible for permitting.

TASK 4.0 FINAL PILOT SYSTEM DESIGN

Subtask 4.1 Updated Modeling Effort for ION Solvent

ION will conduct a series of equilibrium and steady state experiments designed specifically to target information that is required to develop, or can significantly support the final design of the unit. Design parameters will focus on absorber and stripping kinetics and heat loss/management. With the EERC and Dr. Jason Bara (University of Alabama), ION will utilize laboratory scale data and computational simulations to update and refine its Aspen Plus-based model to more thoroughly describe the kinetics and thermal requirements of its advanced solvents. This effort will result in an Aspen-Plus CO_2 capture model, appropriate for ION's solvent, that can be integrated with a 550MW net power system and be able to be utilized in the final techno-economic study. The final model developed will be validated against the pilot slipstream data produced from this project.

Subtask 4.2 Updated Modeling Effort for Advanced Equipment.

ION will work with Dr. Jason Bara and the EERC to update its ASPEN based models to allow simulation of advanced process studies including the use of flash stripper technology in place of a conventional stripper and to allow for consideration and assessment of various heat, water and auxiliary power integration schemes. The models developed in Aspen Plus will allow for rapid comparison of process alternatives and will provide a key tool for developing the most efficient CO_2 capture processes with the advanced solvent. The process schemes developed will be used to develop the final design of the slipstream CO_2 capture system. The information will also be able to be directly utilized in the final techno-economic assessment that will take place in Task 11.

Subtask 4.3 Preliminary Design Assessment

Based on the results from subtasks 4.1 and 4.2 the preliminary design will be reviewed and areas that do not fit the updated model will be determined. The team will address any other issues noticed with the preliminary design, such as material choices, sample locations, foot print, layout, heat loss management, and temperature control. The entire team will have the opportunity to come together and address any issues of the preliminary design and its proposed integration into the power plant. It will be during this task that the team will decide on the final size of system (at least 0.5MW) to be tested based on the budget, footprint, data risk, and solvent requirements. An important aspect of this subtask will be to assess the final items that will be needed for the integration of the unit at the selected host site.

Sub-task 4.4 Final Process Control Design

The final system design will be based on data and information gathered and generated through subtasks 4.1 through 4.3. The absorber and stripper columns will be designed based on compatibility with both 30 wt% aqueous monoethanolamine (MEA) and ION Engineering's advanced CO_2 capture solvent. Subtasks 4.1 and 4.2 will provide kinetic data for ION Engineering's advanced solvent that will feed into the absorber and stripper column design. A modular column design, similar to the design used in previous EERC pilot scale testing, may be employed to facilitate varying column height to provide a greater operational window for the test solvents.

Impurities Clean-up Systems

In order to provide repeatable test conditions, and to provide the best conditions possible for solvent evaluation, impurity clean-up systems will be employed upstream of the CO_2 absorber. The impurity clean-up systems will include an SO_2 polishing scrubber capable of reducing the concentration of SO_2 from 300 ppm down to ≤10 ppm. A direct contact cooler (DCC) will be installed between the polishing scrubber and the CO_2 absorption column. The DCC will function to control the inlet temperature of the flue gas into the absorber.

System Integration

The total slipstream system will be integrated with the power plant to operate as efficiently as possible while still meeting testing requirements for ION and MEA solvent technologies. Process gas for the slipstream will be pulled from the flue gas duct such that it has minimal impact on the overall plant process. Treated gas from the absorber and CO_2 from the stripper will be routed back to the flue gas duct and sent to the stack.

Final Process Flow Diagram

Figure 1 shows a preliminary process flow diagram (PFD). The PFD used for the final system design will be based on the modeling efforts described in subtasks 4.1 – 4.3. The PFD along with the final piping and instrumentation diagram (P&ID) will allow engineers and operators to understand and troubleshoot problems that arise during operation, and provide a medium to clearly communicate the system operations to everyone involved.

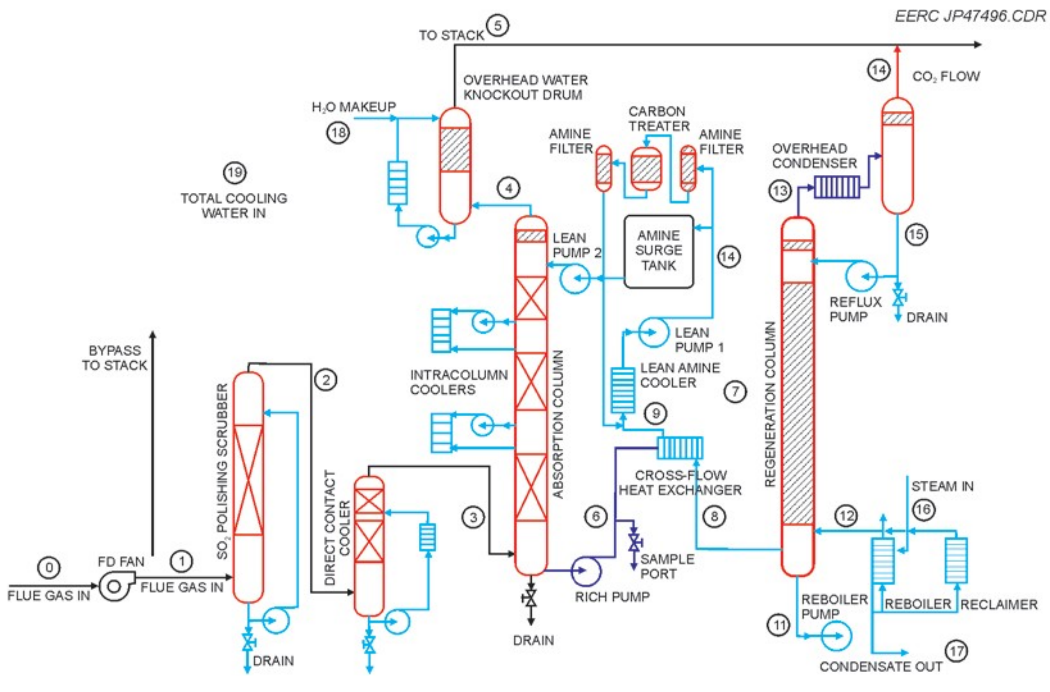

FIGURE 1. PRELIMINARY PROCESS FLOW DIAGRAM

Final System Arrangement and Elevation Sketch

A general arrangement sketch and elevation sketch will also be produced for the slipstream test system. Figure 2 shows a pictorial view of the NPPD host site and Figure 3 shows the proposed location of the slipstream test system at the potential host site, the Gerald Gentleman Station. The approximate proposed location is highlighted by the red area along the South side of the power station. Along with the PFD and P&ID, an operating manual will be developed and readily available at the test site to facilitate safe and effective test campaigns.

FIGURE 2. NPPD HOST SITE

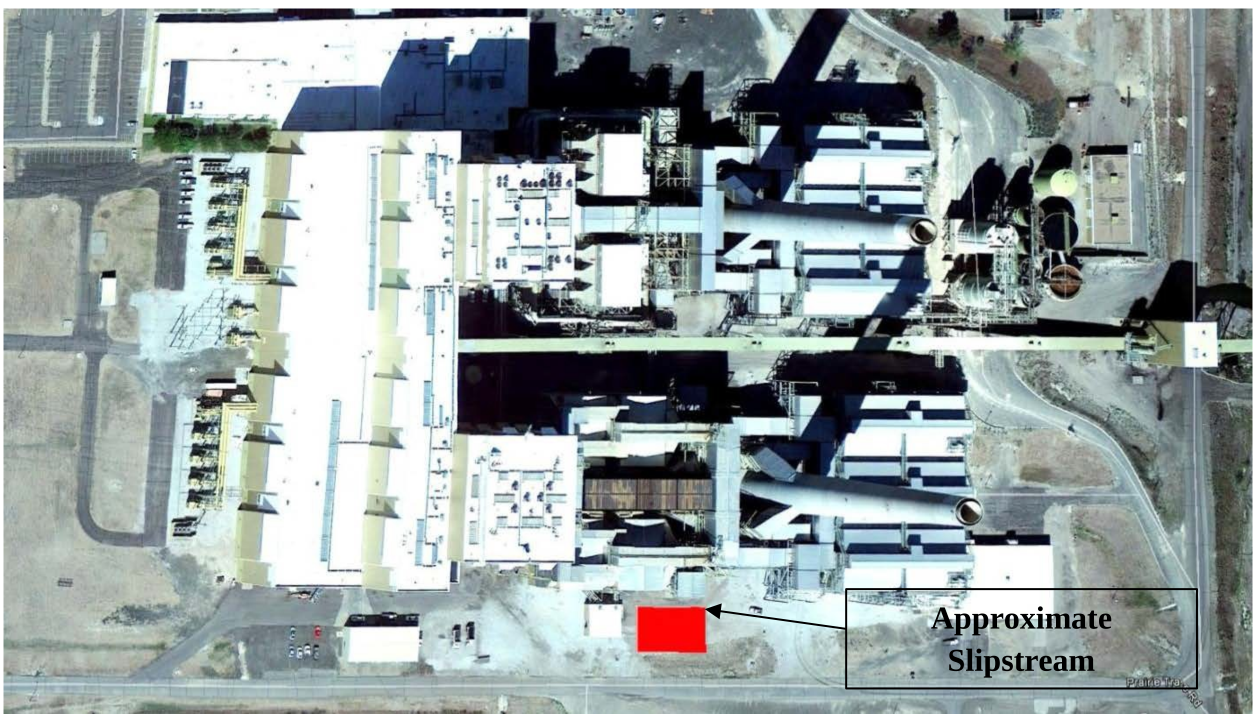

FIGURE 3. PRELIMINARY ELEVATION SKETCH WITH APPROXIMATE PROPOSED SLIPSTREAM SYSTEM LOCATION.

Slipstream System Utility Usage

The final system design developed in subtask 4.4 will dictate the amount and location of all utility usage within the slipstream system, including electricity, steam, cooling water and instrument air. Preliminary estimates show that the system will require up to 75 gal/min cooling water, up to 4,900 ft^3/h natural gas or propane (or ~1 MW electricity) for steam generation, and up to 200 kW electrical power for operation.

Measurement Requirements

System measurements will include temperature, static and differential pressure, fluid flow and tank level. Measurement equipment will be designated based on compatibility with process conditions and results from pilot plant testing and modeling efforts in sub-tasks 4.1 to 4.3. System measurement equipment will include a suite of electronic devices and field readouts to enable data collection and operational monitoring and troubleshooting. Backup measurement equipment will be on hand in case of device failure to allow fully instrumented continuous operation.

Material Choices

Material choice is an important consideration when designing an amine-based CO_2 capture system. For the final slipstream design, all solvent-wetted materials will be compatible with amine based solvents. Most wetted materials will be 316L stainless steel. Gasket and seal materials will be based on solvent compatibility at the specific temperatures of each seal location. Material choices will also give consideration to system pressure. Wall thickness and flange type of the stripper will be selected to ensure a pressure rating described in sub-task 4.2.

Corrosion Impacts and Testing

Corrosion impacts of each solvent technology will be assessed using material test coupons within the system. Initial material choices will be made according to current best practices, but corrosion testing will provide valuable information for potential end users. Location of the corrosion test coupons will be determined within the final system design with consideration given to temperature, pressure and solvent characteristics.

Sample Ports

Solvent samples will be analyzed for corrosion products throughout each test campaign. Liquid samples will be collected throughout the system. Exact placement of each sample port will be described within the final system design. Sample collection ports will be designed to give technology developers data about the process solvent throughout the system. For example, a solvent loading profile through the absorber will be obtained through sample at periodic locations along the length of the absorber.

Determination of Process Conditions

The final system design will determine the process conditions for baseline MEA solvent and ION Engineering's advanced solvent. Process conditions will be determined from modeling efforts and pilot plant operation data.

Subtask 4.5 Analytical Chem/Mobile Lab Design

Portable trailers will be outfitted for use as an onsite analytical chemistry laboratory and system operations (controls). Trailers will be movable by truck and easily setup on site.

Subtask 4.6 Final Pilot System Design and Cost

This subtask addresses activities necessary for the Recipient to determine the final system design and cost including, but not limited to, Pilot, solvent storage, mixing, and disposal, data acquisition system, measurement requirements, sampling ports, measurement equipment, corrosion impact and testing, material choices, determination of process conditions, initial operating manual, etc.

Subtask 4.7 Prepare Final System Design Package

This subtask addresses activities necessary for the Recipient to prepare and submit to the DOE Project Manager the Final Pilot Design Package. Specific requirements for the Final Pilot System Design Package are outlined in the "Deliverables" section below.

BUDGET PERIOD 2

TASK 5.0 PROCURE PILOT SLIPSTREAM EQUIPMENT

Equipment for the pilot slipstream system will be procured and provided by a third party supplier based upon the final system design developed during Task 4.0 and reviewed/approved by DOE in subtask 4.8 of Budget Period 1. If approved by DOE, Sulzer Chemtech (Sulzer) will be selected as the third party supplier to fabricate and provide all major equipment within a modular design. Sulzer has many years of experience designing and fabricating systems of the size proposed and has been instrumental in providing technical and costing information to support this proposal. As part of this task, the project team will work directly with the third party supplier (Sulzer) to provide a system that meets the specifications laid out in the final system design.

TASK 6.0 PILOT PLANT CONSTRUCTION

Subtask 6.1 Host Site Preparation

Upon completion of the final system design and successful review and approval by DOE the system construction will begin. The concrete base of the building will be designed and constructed to provide containment for any accidental spills of solvent or other fluids. Connecting piping will be externally heated and insulated so that flue gas temperatures can be controlled into and out of the test facility. In consultation with the host-provided engineering firm, correct safeguards for fire protection and airflow will be addressed. All aspects of construction, including safety procedures, permits, and general requirements will be discussed and addressed prior to construction initiation.

Subtask 6.2 Pilot Plant Construction & Delivery to Site

The system will be brought to the site by truck, assembled, and removed after completion of testing. ION and the EERC will be onsite during construction and will aid by ensuring that timetables and protocols are followed. Logistical challenges will be handled according to the project management plan and resolved through communication and participation in meetings and discussions with appropriate project team members.

Subtask 6.3 Pilot Plant Installation at Site.

Laboratory, operations and control, and worker break trailers will be sited next to the testing system. Any needed storage tanks and required containment will be sited by the EERC and ION in conjunction with approval of the host site.

Subtask 6.4 – Establish Connections to the Power Plant

This task addresses activities necessary for the Recipient to establish connections between the Pilot System and the host power plant necessary for operation.

TASK 7.0 PILOT PLANT SHAKEDOWN

Task 7.0 includes shakedown and commissioning of the slipstream CO_2 capture facility. This task is crucial to the completion of Budget Period 2 because it will ensure the facility is fully operational in order to begin testing in Budget Period 3. Task 7.0 has been broken up into 7 subtasks:

Subtask 7.1 EH&S

In all operational activities, whether it is shakedown or actual testing, safety of operational staff and plant staff will always be a primary consideration. Safety measures developed during subtask 2.2 will be implemented in subtask 7.1 and gauged for their effectiveness in actual operation. All safety procedures and measures will undergo their own "shakedown" to determine their effectiveness in the test environment. Any safety measures that are decided to be ineffective will be reviewed and addressed during the shakedown period.

Subtask 7.2 Develop Commissioning Plan and Procedures

Shakedown of the system will provide the team with the opportunity to develop protocols for safety procedures, start-up, shut-down and run-time operation. These protocols will be documented and the operating manual will be modified for proper operation of the test system. Among the operating protocols, a sampling protocol will also be developed which will include the amount and frequency of sampling that will occur. It will be important to take appropriate samples in the right locations to monitor for corrosion, solvent degradation, solvent loading, and gas- phase degradation products.

Subtask 7.3 Develop Operational Procedures

This subtask addresses activities necessary for the Recipient to develop Operational, Emergency Start-up, Emergency Shut-Down, Normal Startup, and Normal Shutdown Procedures. Included will be a used solvent disposition plan and cost.

Subtask 7.4 Develop Shakedown Testing Plan and Procedures

This subtask addresses activities necessary for the Recipient to develop a Shakedown Testing Plan and associated procedures for Pilot System Shakedown Testing. The Shakedown Testing Plan will be designed to allow the system to test the Pilot System under expected operating conditions to determine that the system is fully functional and ready for solvent testing.

Subtask 7.5 Pilot System Commissioning

This subtask addresses activities necessary for the Recipient to commission the Pilot System by utilizing the Commissioning Plan and Procedures developed in Subtask 7.2.

Subtask 7.6 Shakedown Testing

This subtask addresses activities necessary for the Recipient to perform the Pilot-Plan System Shakedown Testing utilizing the Shakedown Testing Plan and Procedures developed in Subtask 7.4.

Subtask 7.7 Reference Methods Determination

This subtask addresses activities necessary for the Recipient to establish analytical and sampling reference methods and protocols/procedures to ensure data is of high quality.

Subtask 7.8 QA/QC

This subtask addresses activities necessary for the Recipient to evaluate and refine (if necessary) previously established protocols/procedures used during Shakedown Testing.

Quality assurance for baseline and performance testing will also be developed.

Subtask 7.9 Prepare Final Operating Procedures

This subtask addresses activities necessary for the Recipient to review modifications to the operational procedures discussed in subtask 7.8 and amend the final Operating Procedures as appropriate.

TASK 8.0 – FINAL TEST PLAN DEVELOPMENT & MATERIAL PROCUREMENT

This task addresses activities necessary to develop the Final Test Plan and procure, prepare and deliver ION Solvents to the Host Site for testing.

Subtask 8.1 Procure Solvents for Testing

This subtask addresses activities necessary for the Recipient to procure sufficient solvent quantities with adequate lead time for all planned and contingent test runs.

Subtask 8.2 ION Solvents Preparation & Delivery to Host Site for Testing

This subtask addresses activities necessary for the Recipient to prepare ION Solvents according to specifications and deliver to the Host Site.

Subtask 8.2 Final Test Plan Development

This subtask addresses activities necessary for the Recipient to develop all Baseline and ION Solvent Test Plans. All Test Plans will be reviewed with host site engineers/management prior to finalization.

Subtask 8.4 Pilot System Readiness Review

This subtask addresses activities necessary for the Recipient to prepare and submit to the DOE Project Manager the following information as produced in Budget Period 2:

- Cost of Pilot System procurement, construction, installation and shakedown
- Used solvent disposition plan and cost
- Operational Procedures
- QA/QC results and QA developed for baseline and performance testing

- Analytical and sampling reference methods and protocols/procedures
- Final Test Plans.

Specific requirements are outlined in the "Deliverables" section below.

BUDGET PERIOD 3

TASK 9.0 SYSTEM OPERATION

Subtask 9.1 MEA Solvent Testing

The system will be charged with 30 wt% MEA to perform baseline testing. Baseline testing will consist of two goals: parametric testing to determine proper operational parameters at this scale and determination of the regeneration energy profile. Liquid-to-gas (L/G) ratio, inlet flue gas temperature, and steam input will all be varied to determine CO_2 capture levels. A series of performance curves will be generated showing CO_2 capture versus system operation parameters to deduce the optimum conditions by which to achieve 90% CO_2 capture performance. Parametric testing will occur over the span of four weeks. Two 2-week test periods are planned to complete the parametric testing. A week is planned between the two 2-week test periods to evaluate the data collected and determine what other parametric tests need to be completed, or repeated. This week also allows for maintenance of the equipment and/or adjustments that need to be made as identified by the first two weeks of testing. Following the parametric tests, a two week test is planned to run at steady state to collect a minimum of 90 hours of steady-state condition data with the 30 wt% MEA, while capturing 90% of the CO_2 from the flue gas stream. This data will be used to establish the baseline, benchmark, data by which the ION solvent performance will be compared.

Throughout testing, samples of the solvent will be taken so that analytical procedures can be performed to monitor performance and solvent interactions with the system. The analytical work will include Karl Fischer technique to determine water concentration of the solvent, total inorganic carbon/total organic carbon (TIC/TOC) to determine rich and lean solvent loading, and Fourier

Transform Infrared (FTIR) in conjunction with gas chromatography and mass spectroscopy (GC/MS) to monitor the emission stream for indications of constituents leaving the system and their quantity. FTIR measurements will be accompanied by other wet chemistry gas sampling methods to verify data.

Subtask 9.2 ION Solvent Testing

Upon completion of the benchmark MEA testing, the slipstream system will be loaded with ION's proprietary solvent. Similar to testing performed for baseline MEA, the solvent will then be tested in parametric fashion to generate performance curves for various liquid-to- gas ratios, inlet sulfur concentration, and steam inputs. Two parametric test periods are planned to be followed by a minimum 1400 hour steady-state performance evaluation. Parametric testing will further evaluate sensitivity to inlet flue gas temperature and SO_2 concentration and evaluate projections of heat stable salt formation that may be expected. Data collected during the two parametric periods will then be evaluated and optimum conditions will then be chosen for the steady state performance evaluation. The goal of this test period is to maintain those optimum steady state conditions, maintaining at least 90% CO_2 capture, for at least 1400 h.. Time will be taken between testing periods to evaluate the data, make adjustments to test equipment, and maintain equipment.

Similar to MEA sampling procedure, samples of the solvent will be taken and evaluated for water content and CO_2 loading. Emissions will be monitored in real time to evaluate concentrations of any constituents leaving the system. For the 1400 h test period metal sample coupons will be inserted in select locations of the system and will be analyzed to determine the corrosiveness of the solvent.

TASK 10.0 DATA REDUCTION AND ANALYSIS

All test data, including compilation, backup and archive will be kept on a shared database or server that will be accessible to the project. All experimental test data will be collected and incorporated into spreadsheets along with the relevant sampling and process data such as flue gas volume/pressure, moisture content, percent/partial pressure CO_2, system operations and emissions, etc. Data will be compiled, reduced, analyzed, and interpreted, and plots and correlations will be developed that highlight technology performance as a function of test parameters. Information collected will be further analyzed for overall performance of the system as well as the solvent for continuous 90% capture of CO_2. Limitations of the system (if any) will be noted and discussed.

Preliminary results will be made available to the project team, as tests are completed under Task 9. After all of the data are in their final reduced state, a statistical analysis will be performed on each data set that is of appropriate size. The statistical analysis will include the average, range, and standard deviation for each data set. This will aid in defining confidence and uncertainty of the data. Data will be summarized and made immediately available to ION as requested and further described in Task 11.

Subtask 10.1 Experimental Results from Pilot Operation

Data collected will be used to update the state-point data table. Steady-state test data will be used to assess system operation and parameters such as target or optimal; operating pressures, system temperatures, solvent working capacity, regeneration energy profiles and their dependence on lean solvent loading values.

Subtask 10.2 Quantitative Assessment of Chemical & Thermal Stability for Solvent

Results from performance of the solvent will also be used to evaluate the requirements for flue-gas clean-up (i.e., tolerance of the solvent for SO_2). A thorough examination of all experimental data will be performed and will include evaluation of corrosion, solvent degradation, solvent loading, gas-phase degradation products, regeneration energy, etc. will be included. FTIR will be used monitor the emission stream for indications of constituents leaving the system and their quantity. FTIR measurements will be accompanied by other wet chemistry gas sampling methods to verify data. Coupons that are placed in the slipstream system during the planned steady state performance periods will be removed and analyzed at the completion of the tests.

TASK 11.0 FINAL SYSTEMS ENGINEERING ANALYSIS

Results of the slipstream testing will be used to validate and improve the techno-economic model produced in Task 2.1. Capital and operating costs associated with ION Engineering's advanced CO_2 capture technology will be estimated at the 550-MW scale. Multiple process integration schemes, including the use of low-grade steam for solvent regeneration, will be evaluated with the process model, and the impact on electricity production and the cost of CO_2 capture will be evaluated. Specific deliverables are as follows:

1. Itemized cost of all installed equipment and materials used at the PC power plant including CO_2 capture and compression systems to include pumps, blowers, compressors, vacuum pumps, heat exchangers, refrigeration equipment, absorber/stripper vessels, etc.
2. Estimated supercritical PC plant efficiency with CO_2 capture.
3. Estimated marginal increase in levelized cost of electricity due to CO_2 capture and sequestration relative to NETL Case 11 without capture.
4. Sensitivity analysis identifying critical CO_2 capture technology and operating parameters and their impact on overall pc plant performance.
5. All of the deliverables listed in Attachment 3 of DE-FOA-0000785.

Task 11 will also include a final Environmental Health & Safety (EH&S) assessment which will include a comprehensive overview of the risks and hazards associated with ION's CO_2 capture technology and will detail the risks and mitigation practices recommended for the proposed technology utilizing the data and information collected throughout the course of the project. A Final Technical Report will be prepared and submitted to the DOE according to the guidelines laid out in this FOA and will consist of a discussion of tables, figures, graphs, and plots that summarize and highlight important test results as an outcome of Task 10 & 11.

TASK 12.0 SYSTEM DECOMMISSIONING AND DISMANTLE

The slipstream unit will be decommissioned and dismantled, and transported off of the Host Site to a storage facility agreed upon by DOE and ION. The site that the slipstream unit occupied will be reduced per specifications of the Host Site.

STANDARDS OF SUCCESS

The periodic and final reports shall be submitted in accordance with the attached "Federal Assistance Reporting Checklist" and the instructions accompanying the checklist. In addition to the reports identified on the Reporting Checklist, the Recipient shall provide the following Deliverables outlined in Table 1 to the DOE Project Officer (identified in Block 15 of the Assistance Agreement as the Program Manager):

Table 1 – DE-FE0013303 Project Deliverables	
Task/Subtask	Title/Description
1.7	**Updated Project Management Plan** The project management plan shall be updated **within thirty (30) days of project start** and upon the initiation of each budget period and due with the submission of the continuation application in accordance with the award terms and conditions.
2.1	**Initial Techno-Economic Analysis** Submitted **within 84 days of the definitization** of this award and

	in accordance with Attachment 1.
2.2	**Initial Technology EH&S Risk Assessment** Submitted **within 84 days of the definitization** of this award and in accordance with Attachment 2.
1	**Budget Period 2 Continuation Application** Submitted in accordance with the "Continuation Application and Funding" provision contained within the award terms and conditions.
4.7	**Final Pilot Design Package** Submitted thirty (30) days from completion of the associated task.
1	**Budget Period 2 Continuation Application** Submitted in accordance with the "Continuation Application and Funding" provision contained within the award terms and conditions.
8.4	**Pilot System Readiness Review Package** Submitted thirty (30) days from completion of the associated task.
1	**Budget Period 3 Continuation Application** Submitted in accordance with the "Continuation Application and

	Funding" provision contained within the award terms and conditions.
10.1, 10.2	**<u>Experimental Results from Pilot Operation and Quantitative Assessment of Solvent Chemical & Thermal Stability</u>** Submitted thirty (30) days from completion of the associated task.
11	**<u>Final Techno-Economic Analysis and Final Technology EH&S Risk Assessment</u>** Submitted thirty (30) days from completion of the associated task and in accordance with Attachment 1.

The following information shall be addressed at a minimum in the requested deliverables and reports associated with the Reporting Requirements Checklist and additional deliverables identified above.

- Final Pilot Design Package including:
    - Final Process Flow Diagram, General Arrangement Sketch, and Elevation Sketch (.PDF files legible at 8.5 inches by 11 inches) with written process description;
    - Pilot electricity, heat, and water consumption; waste generation: and management/tie-ins to the existing host facility;
    - Slipstream feed conditions: pressure, temperature, flowrate, gas composition, contaminant levels that represent the actual flue gas from the PC boiler ;
    - Estimated CO_2 delivery conditions: pressure, temperature, flowrate, and gas composition

- Any results from CFD modeling;
    - Start-up, steady-state operation, and shut-down procedures for the proposed pilot process;
    - Protocols, reference methods, measurements, and quality assurance for baseline and performance testing;
    - Used solvent disposition plan and cost;
    - Cost to build
- Experimental results from pilot-scale operations, including all critical data measured
- Updated State-Point Data Table 1
- Identification of flue-gas clean-up requirements (*i.e.* allowable contaminant levels)
- Updated recommendations for system operating pressures (in units of bar), temperatures (in units of ^{o}C) and working capacity (in units of kg CO_2 per kg solvent)
- Quantitative assessment of chemical and thermal stability for solvent:
    - Experimental data under realistic flue gas and regeneration conditions
    - Degradation pathways supported by experimental studies
    - Corrosion testing data
    - Solvent toxicity data
- Updated useful life of solvent (in years) and estimated solvent make-up rate due to degradation and other losses (in units of kg solvent per 1,000 kg CO_2)
- Assessment of projected near and long-term costs of mass-produced solvent and other novel materials (*e.g.*, absorber packing) performed by the vendor(s) supplying these materials
- Concepts for absorption/desorption equipment and any novel heat transfer equipment that might be employed in a commercial version of the process, including:

- Estimated absorber and stripper packing densities (surface area per unit volume in units of m^2/m^3)
- Method of heat removal and heat addition to the absorber and stripper, respectively
- Steam requirements for stripping (in units of kg steam per kg CO_2 captured)
- Estimated pressure drops (in units of bar) for all absorption-cycle components under normal operating conditions
- Estimate of costs of all mass and heat transfer equipment (in units of U.S. dollars)

- Updated description of absorption/desorption models used to predict equipment performance and capacity as required
- Preliminary and Final Techno-Economic Analysis (per guidelines in Attachment 1) based on the initial and final design configurations and operating conditions when integrated into a 550 MW power plant, including:
    - Estimated auxiliary power requirements including refrigeration or cooling for the feed gas, blowers to overcome pressure drop, compressors, vacuum pumps, and
    - Annual operating costs include all make-up chemical costs, replacement material, and water treatment chemicals.
- Estimated commercial-scale capture and compression plant footprint when integrated into a 550 MW power plant, along with assessment of required base PC plant design modifications.
- Preliminary and Final Technology EH&S Assessments (as described in Attachment 2) of the CO_2 capture technology and solvent, including anticipated process for manufacturing the solvent.
- All Deliverables will include as appropriate:
    - documentation of Pilot results and Techno-Economic Analysis

- technology benefits and shortcomings
- recommendations for future R&D addressing shortcomings
- proposed scale-up strategy for next stage of technology testing and demonstration incorporating both CO_2 capture and compression

BACKGROUND

ADVANCED AMINE SOLVENTS FOR CO_2 CAPTURE.

Aqueous monoethanolamine (aq. MEA) is the benchmark for post-combustion CO_2 capture.[1] Although effective at removing CO_2 from low pressure gas streams, aq. MEA suffers from a number of limitations including large energy penalties, solvent losses due to evaporation, degradation and corrosion.[1] Due to the known issues with aqueous monoethanolamine (MEA), a number of alternative amine-based solvents have been proposed which address one or more of the drawbacks associated with aq. MEA solvents. Notable examples include: Econamine, a concentrated, stabilized MEA solvent by Fluor;[5] piperazine,[6, 7] which has been thoroughly studied by Rochelle's group; KS-1,[8] a proprietary solvent under development by Mitsubishi Heavy Industries; and amino acid salts,[9] among others. These solvents all contain water as the bulk of their content (60-70% by mass) with one or more amine-based components and other additives comprising the balance. Each of these solvents can provide improvements in energy efficiency relative to aq. MEA. Yet, because of the large water contents of these solvents, an inherent challenge is to minimize water vaporization and its associated energy loss in the process, and prevent the solvent from concentrating which can cause undesirable effects such as increased viscosity, crystallization and corrosion. Novel solvents containing a low volatility, low viscosity, low cost organic substitute for water plus an amine can provide significant performance improvements relative to largely aqueous-based amine solvents. ION has identified imidazoles as ideal candidates to address this challenge, and propose three component imidazole-amine solvents as a new approach to highly energy efficient CO_2 capture.

N-functionalized imidazoles are a versatile class of organic solvents that have received very little attention for CO_2 capture applications, despite featuring properties common to both amines and other solvents such as ionic liquids (ILs). *N*-functionalized imidazoles feature a large range of tunable properties and many of the desirable properties of ILs, such as very low volatility and chemical / thermal stability, while overcoming critical IL limitations such as cost and viscosity. Imidazole-based solvents have the potential to address all of the solvent research objectives identified by DOE as needed to improve solvent-based CO_2 capture (Table 1).[1]

Table 1: DOE Solvent Research Objectives (Reference 1)		
• Increase CO_2 loading capacity	• Reduce solvent corrosivity	• Increase reaction kinetics
• Minimize regeneration energy	• Reduce solvent degradation	• Increase mass transfer
• Lower capital and operating costs		

Akin to amines, imidazoles can be useful in CO_2 capture applications as they feature a basic nitrogen center. This important feature of imidazoles can be exploited to improve the reactions driving CO_2 capture, and advance DOE research objectives of increasing CO_2 loading capacities and reaction kinetics as well as requiring less regeneration energy. Rate of CO_2 absorption data is provided in Figure 4 which compares a traditional 30% MEA/70% H_2O (blue line) with a similar imidazole based solvent (green line) containing 30% MEA/ 50% 1,2-dimethylimidazole/ 20% H_2O. In support of this hypothesis, as seen in Figure 4 the molar carrying capacity is increased in the imidazole containing solvent and the reaction kinetics appear to be preserved to a greater extent of the reaction and certainly to greater rich loading values.

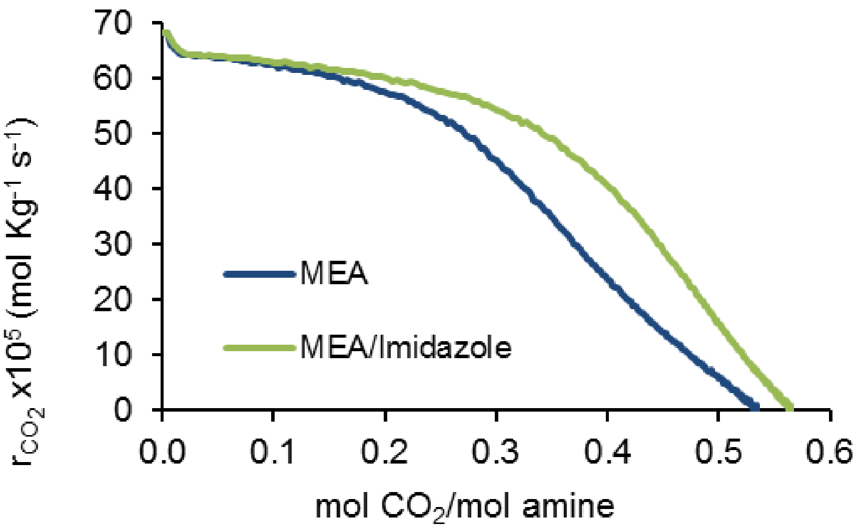

Figure 4 CO_2 ABSORPTION KINETICS FOR MEA-IMIDAZOLE & MEA-H_2O SOLVENTS.

Vapor Pressure – Volatility

At ambient conditions, many *N*-functionalized imidazoles exist as liquids and exhibit very low vapor pressures (<< 1 torr) with boiling points of 200^{o}C or greater.[10-14] In this respect, imidazoles possess one of the most desirable properties for CO_2 capture solvents – extremely low volatility. Resistance to evaporation is a key feature of imidazoles that can make a major contribution to minimize the regeneration energy for CO_2 capture solvents, a DOE solvent research objective.

ION'S BENCH RESULTS

ION has been developing non-aqueous amine solvents for CCS for several years with major support from DOE/NETL (DE-FE0005799) and has recently completed initial parametric and steady-state testing on real flue gas with a first generation imidazole-amine solvent in collaboration with the Energy & Environmental Research Center (EERC) at the University of North Dakota. The results obtained indicate that ION's imidazole-amine solvent yields an energy savings of 48% compared to the energy requirement of aq. MEA. Preliminary economic evaluations indicate that this represents a \$27/ton CO_2 capture cost which is estimated to result in a 37% increase in COE for new construction coal-fired 550 MW power plants with CCS using the ION solvent. These results provide real flue gas results indicating that ION's non- aqueous amine solvents are capable of achieving greater regeneration energy savings than aqueous amine solvents and that these solvents fall within DOE's target for a CO_2 capture cost of < $40. All of these results are documented in a final technical report to DOE and discussed further below[47].

Solvent Performance using Actual Flue Gas at the EERC Facilities

Several test runs were performed at the EERC facilities in order to evaluate ION's most promising CO_2 capture solvent under steady state conditions using actual coal fired flue gas. Four of the early weeks of testing were used to evaluate the solvent in the EERC's current pilot system as is, with no modifications to equipment. Results from these tests indicated very promising reductions in energy required when compared to similar capture while using the monoethanolamine (MEA) solvent (which is currently used as a baseline for relative comparison).

The CO_2 capture system was set up the same way as for the earlier solvents tested in EERC's Phase II program. The direct contact cooler (DCC) was used to control the inlet absorber flue gas to a temperature of 110°F. The gas entered the absorber at the bottom and traveled through ~13 ft. of structured packing provided by Sulzer from the MellaPak™ CC™ line of packing. At the top of the absorber column an indirect cooling section was used to target and maintain various outlet temperatures in order to target a given ΔT between the inlet and outlet gas. Testing from weeks 1 & 4 are discussed in the following sections. More detailed information has recently been published by EERC[47].

Parametric Testing: Identification of Operational Window.

During the first week of testing, several parametric-style tests were performed to evaluate capture performance at varying liquid-to-gas (L/G) ratios and varying energy inputs to the system. Both coal and natural gas combined cycle (NGCC) flue gas were generated in order to evaluate the solvent under both of these types of flue gas throughout the course of this study. Coal-generated flue gas testing utilized a Wyoming Powder River Basin (PRB) coal was fired in order to generate a flue gas stream that contained a range of impurities such as SO_X, NO_X along with other inorganic ions that are commonly known to cause degradation in CO_2 capture solvents.

For Week 1 of testing, the particulate test combustor (PTC) system was equipped with a selective catalytic reduction (SCR) unit to control NO_X levels, an electrostatic precipitator (ESP) to remove the majority of the ash generated, and a wet flue gas desulfurizer (WFGD) to scrub the SO_2 to a level of near zero. Table 2 shows the range of gas conditions at the inlet of the absorber.

TABLE 2. TYPICAL FLUE GAS CONCENTRATIONS AT THE INLET TO THE ABSORBER.

Flue Gas Component	Coal Derived	NGCC Derived	Notes
CO_2	13-15 %	3 - 4 %	All values are on a volume basis and are measured dry.
O_2	3 - 5 %	14 - 15 %	
NO_x	0 - 100 ppm	0 - 100 ppm	
SO_x	0 - 80 ppm	0 ppm	
CO	10 ppm	< 10 ppm	

Identification of Optimal Conditions for Solvent Performance.

Very briefly, Figure 5 and Figure 6 show the results from the first week of testing while firing the PRB coal and treating 75 SCFM and 100 SCFM of flue gas, respectively. The results of this testing were very promising, with the best results achieved with 100 SCFM of flue gas and show a regeneration energy which is 55% lower than that of MEA at 90% capture, with reductions in L/G ratios up to 45% lower. Based on the results from Week 1, a longer- term test run was planned for both the PRB coal and NGCC gas conditions in order to demonstrate steady-state capture for a 72 hr. continuous run for both flue gases.

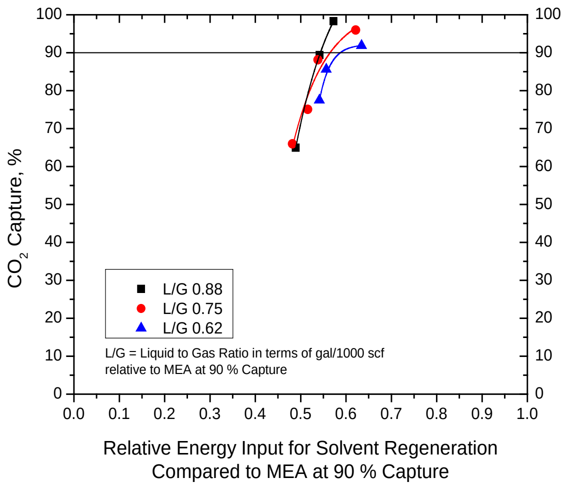

FIGURE 5. SUMMARY OF WEEK 1 PILOT SCALE RESULTS, 75 SCFM FLUE GAS

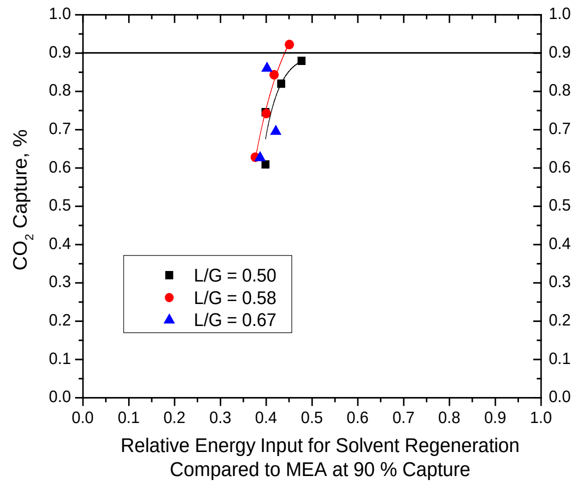

FIGURE 6. SUMMARY OF WEEK 1 PILOT SCALE RESULTS, 100 SCFM FLUE GAS

72-hr Steady State Solvent Evaluation

The Week 4 test of ION Engineering solvent was a 72 hr. test similar to the Week 2 test, maintaining constant system conditions and 90% CO_2 capture if possible. The test was interrupted periodically to clean out the test furnace, ESP, and associated piping daily for approximately 2 hr. intervals. During each maintenance period, the 72 hr. clock was stopped. Solvent samples during the test were collected at 4 hr. intervals during testing. Test results and conditions for Week 4 testing are presented in Figure 7. Coal-derived flue gas flow rate was set to 100 SCFM at the absorber inlet. Regeneration energy input and L/G ratio were each initially set based on test conditions from Week 1 of ION Engineering testing. Adjustments were made at the beginning of the 72 hr. test to L/G and regeneration energy to reach approximately 90% CO_2 capture.

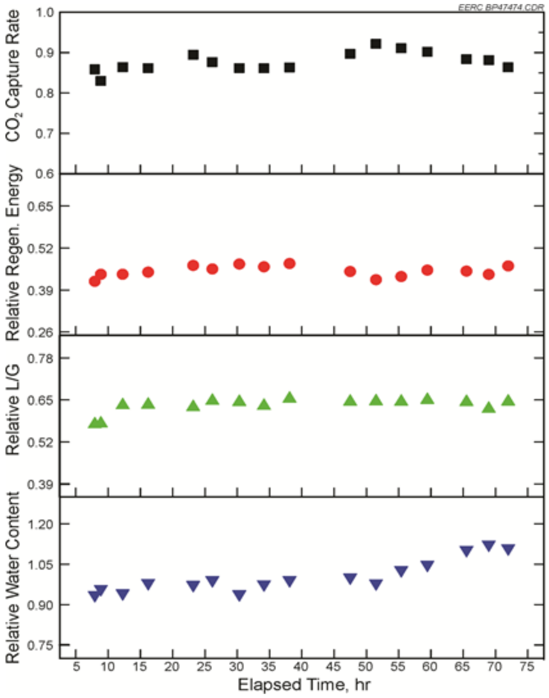

FIGURE 7. STEADY-STATE TEST CONDITIONS FOR 72-HOUR TEST VALUES ARE RELATIVE TO 30 WT% MEA PERFORMANCE AT 90% CO_2 CAPTURE

For the remainder of the test, only small adjustments were made to steam input and solvent flow rates in order to maintain steady-state conditions. Figure 7 shows CO_2 capture was maintained between 85% and 92% throughout the 72-hour test. Compared with baseline testing of MEA at 90% capture on the same equipment, the required regeneration energy for the solvent to reach 90% capture was 65% lower. The L/G ratio was also significantly lower than MEA testing, about 35% lower than MEA. At larger scale, these advantages over 30 wt% MEA will lead to lower capital costs when considering pump sizes and a smaller parasitic load requirement with decreased steam usage.

The plot at the bottom of Figure 7 shows the sample water concentration as a percentage of the initial water concentration to begin the 72 hr. test. Water level in the solvent was maintained within 10% of the starting concentration level, thus demonstrating that water content can be controlled during operation.

Heat Stable Salt (HSS) Salt Formation – SO_X & NO_X Exposure

During Week 4 of testing, concurrent to the 72 hr performance evaluation ION's solvent was exposed to NO_X and SO_X contaminants in the combusted flue gas. SO_X and NO_X levels were systematically increased during this week of testing. Previous MEA benchmarking had been conducted at the EERC using the same test protocol which allowed for comparison of ION's results to those previously determined for the MEA solvent (benchmark). Both organic and inorganic HSS ions were found upon analysis of ION's solvent & the MEA solvent. These ions build up over time during post-combustion capture processes and degrade the solvent. Sulfate (SO_4^{2-}), sulfite (SO_3^{2-}), and thiosulfate ($S_2O_3^{2-}$) HHS ions result from SOx compounds in the treated flue gas. Solvent samples were analyzed for sulfate and thiosulfate. Figure 9 shows sulfate and sulfite concentrations in ION Solvent samples, with absorber inlet flue gas SO_2 concentration shown for reference which can be compared to MEA samples in Figure 8. MEA samples had sulfate concentrations 10- 15x higher than the ION solvent. This represents a significant potential advantage for ION solvent in commercial applications. Finally, both solvents were analyzed for the presence of thiosulfate HSS ions, thiosulfate levels were undetectable in ION Solvent samples, however in the MEA samples thiosulfate levels increased from 25 to 85 ppm, significantly higher than the ION solvent.

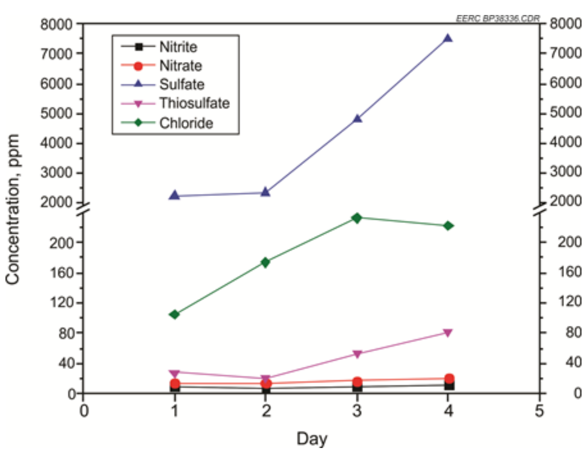

FIGURE 8. CONCENTRATION OF INORGANIC HSS IN AQMEA

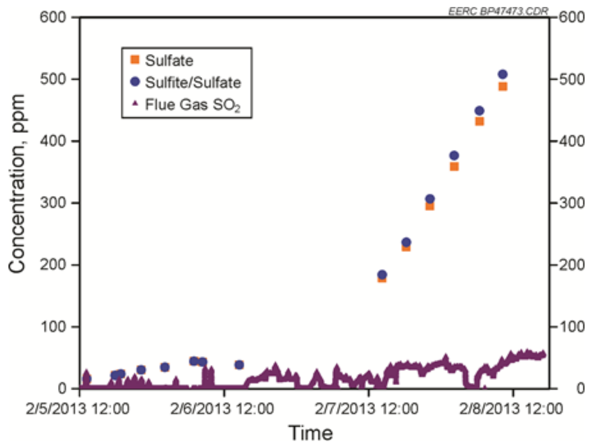

FIGURE 9. CONCENTRATION OF SULFUR HSS IONS IN ION SAMPLES

There was a significant difference in the concentration of chloride (Cl^-) between MEA and ION solvent tests. During MEA solvent testing the concentration of chloride ions in solution was in the range of about 100–220 ppm during the test period, suggesting that a significant amount of the chloride in the flue gas formed a HSS and remained in the SASC system. The ION solvent was tested under similar conditions and showed significantly lower chloride levels which were reported to be below 11 ppm[47] . The fuel used for each test was Antelope PRB subbituminous coal, which typically has a chlorine level of around 20 ppm. There was no significant difference in the appearance of organic HSS ions or nitrate/ nitrite inorganic HSS ions in the MEA or ION Solvent.

PRELIMINARY TECHNO ECONOMIC EVALUATION

The results from the pilot-scale work were evaluated by EERC using the Aspen Process Economic Analyzer (APEA)[47]. Excerpts from EERC's report are presented below.

The Aspen based model was used to develop the mass and energy balance for DOE's Case 10 using ION's advanced solvent. It was determined through the pilot-scale studies that the ION solvent required 75% of the liquid flow requirements of MEA and 57% of the regeneration energy requirements of MEA. This information was used to resize the CO_2 capture, steam cycle, and boiler models to account for lower steam requirements. A reduction in steam usage also reduced the amount of coal needed to generate the steam; therefore, less CO_2 was produced, and even less solvent was needed to capture the CO_2. This process proceeded in an iterative manner until the plant was sized for 90% capture and 550-MW net power output. A complete mass and energy balance around the system is presented along with overall efficiency calculations.

Block Flow Diagram

Figure 10 shows the overall block diagram for the Case 10 ION solvent PC combustion plant with CO2 capture. The block flow diagram does not represent a complete mass balance of the system and is intended as a visual aid for understanding the layout of the power plant. The system modeled represents a PC power plant with a subcritical steam cycle and a CO2 capture system. The boiler is wall-fired, with primary air and secondary air that represents overfire air (OFA) used to control NOx emissions. SCR with ammonia injection is used to control NOx emissions at the boiler exit. A standard pulse-jet baghouse is used for flue gas particulate control. A WFGD with limestone injection is used to control sulfur levels entering the CO2 capture system. Case 10 ION solvent uses a standard absorber tower and stripper column.

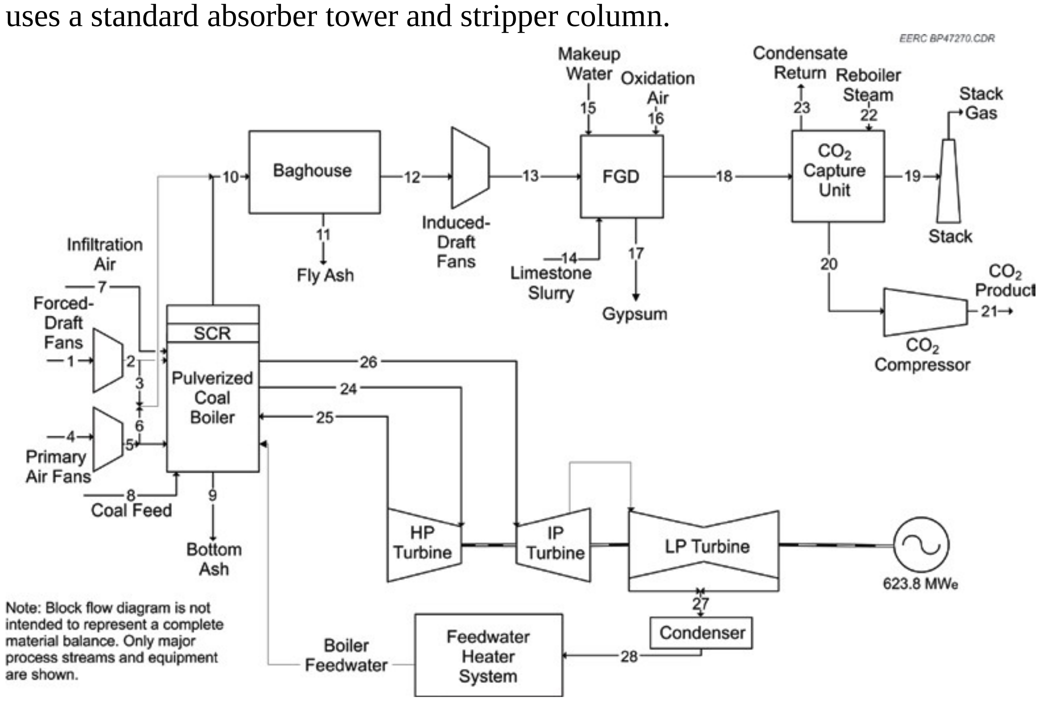

FIGURE 10. BLOCK FLOW DIAGRAM FOR CASE 10 ION SOLVENT, PC COMBUSTION PLANT WITH CO_2 CAPTURE

Heat and Mass Balance Diagrams

Diagrams showing the overall heat and mass balance for the power plant are shown in Figures 11 and 12. The heat and mass balance diagrams follow Case 10 of the DOE report very closely, and the numbers for the figures were derived from the models developed in Aspen Plus. The energy balance information is derived from the Aspen models and also estimated based on the modeling effort. The enthalpy reference point for all streams is natural state at 77°F / 14.7 psia.

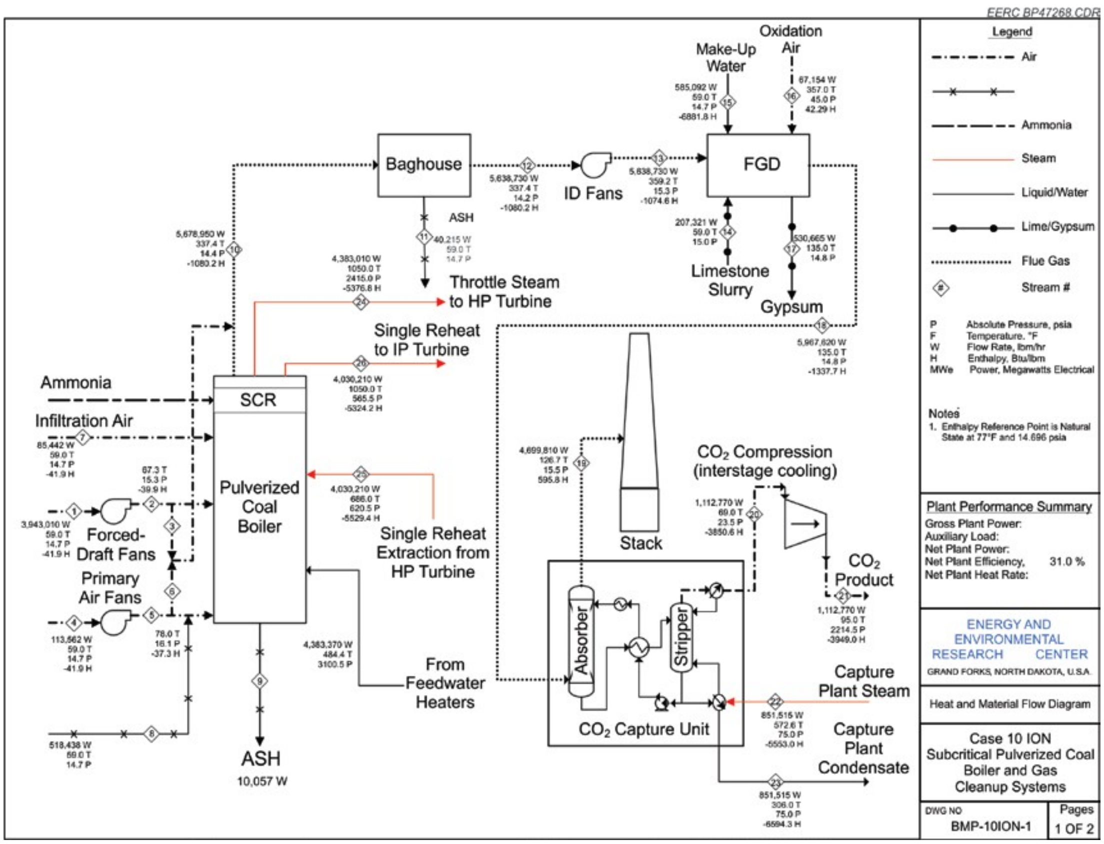

FIGURE 11. COMBUSTOR HEAT AND MATERIAL FLOW DIAGRAM FOR CASE 10 ION SOLVENT.

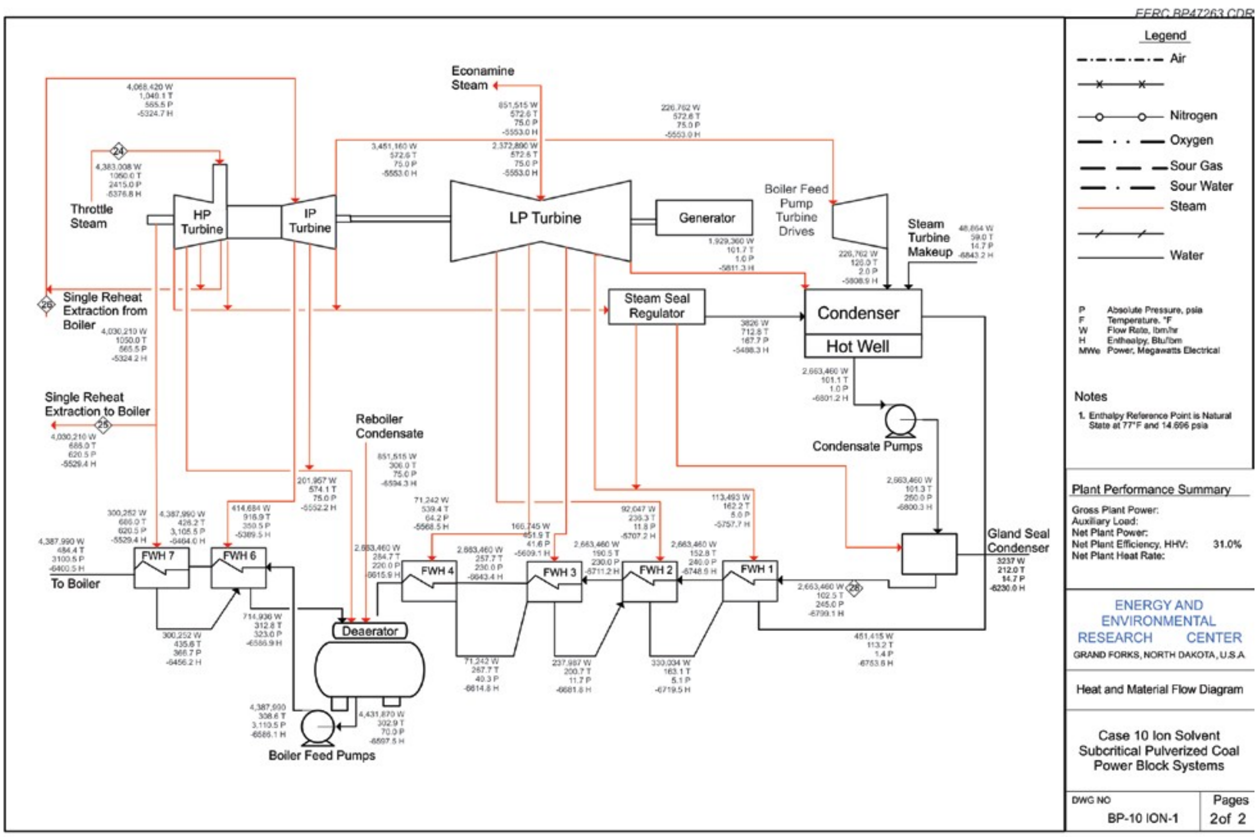

FIGURE 12. STEAM CYCLE HEAT AND MATERIAL FLOW FOR CASE 10 ION SOLVENT.

Modeling Summary and Conclusions

The equipment cost for ION advanced solvent and two others tested by EERC are presented in Table 3[47]. The difference in cost between each case was largely because of the L/G ratio. If less solvent is required per unit volume of gas, then the towers, pumps, and heat exchangers will be smaller in size, which reduces equipment costs. The L/G ratio for ION's advanced solvents was significantly lower than that of MEA. This result was based on the pilot-scale data results and was determined by comparing the capture efficiency at varying solvent flow rates in a fixed-height absorber. Faster kinetics and larger working capacities of these solvents generally lead to an overall reduction in L/G ratios.

Table 4 lists the estimates for annual operating and maintenance costs for each case, along with the result for cost of electricity (COE)[47] calculation in US$/MWh. The fixed operating costs included operating, maintenance, and administrative labor along with annual property taxes and insurance costs. Variable operating costs included annual costs for maintenance materials, chemicals, catalysts, and disposal of waste. 'Fuel' was the annual cost of coal, which was assumed to be Illinois No. 6 at a cost of US$47.80 per ton.

TABLE 3: AMINE CO_2 ABSORPTION SYSTEM EQUIPMENT COSTS

Item	**MEA**	**Cansolv**	**Huntsman**	**ION**
Absorber Towers	US$109,849	US$86,330	US$106,942	US$99,742
Pumps	US$6,983	US$3,488	US$5,920	US$4,542
Heat Exchangers	US$41,786	US$21,813	US$36,293	US$28,127
Stripper Towers	US$30,329	US$29,712	US$29,795	US$27,067
CO_2 Compressor	US$33,373	US$33,373	US$33,373	US$33,373
Amine Reclaimer	US$25,000	US$23,000	US$23,000	US$23,000

TABLE 4: ANNUAL OPERATING AND MAINTENANCE COSTS

	Base Plant Case 9	**MEA Case 10**	**MEA EERC**	**Cansolv**	**Huntsman**	**ION**
TOC	US$1,155,225	US$2,088,676	US$1,913,839	US$1,746,500	US$1,829,142	US$1,696,785
OC_{FIX}	US$33,724	US$56,240	US$53,153	US$48,489	US$49,551	US$44,000
OC_{VAR}	US$22,174	US$39,445	US$37,077	US$33,499	US$34,314	US$30,056
Fuel	US$77,828	US$109,445	US$105,100	US$98,562	US$100,054	US$92,261
COE, US$/ MWh	US$64	US$108	US$100	US$92	US$95	US$88
ICOE[1], %	NA[2]	69%	57%	44%	49%	37%
US$/ton CO_2 Captured	NA	US$45	US$39	US$32	US$34	US$27

[1] Increase in the cost of the electricity [2] Not applicable

The economic modeling included an analysis of DOE's MEA Case 10, which is based on a typical 30 wt% MEA, which does not include any upgrades to the system based on current technology. The MEA EERC case is based on the EERC's model, which was calibrated based on the pilot-scale data, showing the improvements from inter-column cooling and advanced structured packing[47]. The difference between these two cases is shown in Table 4, which shows an overall reduction in

COE of US$8/MWh leading to an overall COE for MEA of 57% (based on 2010 US$). This MEA EERC model was then modified based on the pilot-scale data for the remaining solvents. Reductions of both steam and L/G ratio were modified in the model to mimic the pilot-scale results. Table 5 shows the factors that were used for each solvent as based on the pilot-scale data. The factors are based on MEA capture at 90% in the EERC pilot plant.

TABLE 5: PILOT-SCALE DERIVED PERFORMANCE FACTORS FOR USE IN ADJUSTING THE ASPEN-BASED MODEL

Solvent	**MEA EERC**	**Cansolv**	**Huntsman**	**ION**
L/G Ratio	1	0.62	1	0.75
Regeneration Energy	1	0.79	0.85	0.57

Based on the current results, it is clear that ION's advanced solvent is superior to MEA as well as the other solvents tested by EERC. Capture costs for ION's advanced solvent have an overall ICOE as low as 37%, which is getting close to DOE's target of 35%, and demonstrate a cost of US$27/ton of CO_2 captured (not avoided costs).

DEVELOPMENT PATH

Contingent on future testing and availability of funding, ION's advanced solvent will have significant operating and capital cost advantages over other solvents currently in development. Advantages include significant reductions in parasitic load and liquid flow rates (L/G ratios) which directly translate to smaller more efficient CO_2 capture processes. Make-up water and amine emissions rates will be determined in this project, both of which based are expected to come in lower than other competitive technologies. And lastly, there is the potential that additional solvent, system and integration savings will be identified which in combination with the performance savings already demonstrated will result in further operating and capital cost reductions.

Assuming a traditional aqueous – amine process configuration, the development path is reasonably well understood. Following the proposed slipstream project, ION expects to conduct demonstration testing at the 5-10 MWe scale, followed by testing at the 50 MWe scale which will enable a first of kind plant and subsequent technology commercialization. ION believes full-scale commercial demonstration is attainable by 2025.

QUALIFICATIONS

ION Engineering was formed 5 years ago with the ultimate mission of providing innovative, cost-effective solutions to CO_2 capture from industrial sources, with the first target being post-combustion capture from coal-fired power plants. Based on thermophysical and kinetic studies, laboratory pilot test runs in a 7 gal/hr pilot, test campaigns at EERC using a 0.2 MW coal-fired combustion test facility (CTF), and from modeling activities at ION, UA and EERC; ION has made significant advances with its lead solvent and engineering process. ION is providing the lead solvent, solvent and process expertise, analytical chemistry capabilities, post-combustion testing expertise, modeling expertise, as well as R&D management, financial, administrative and business management expertise to the project.

Dr. Jason Bara is an assistant professor at UA in the Department of Chemical & Biological Engineering. He is the scientific founder of ION, and a recognized world expert in CO_2 capture solvents. He is also the inventor of the current class of molecules ION is advancing in this proposal. He serves as Chair of ION's Science Advisory Board and ION supports his laboratory under a Sponsored Research Agreement with UA. Dr. Bara will serve as an advisor to ION and will conduct specific research related to solvent molecular and physical properties as well as process modeling.

Recognizing the need to add strategic capabilities for a slipstream project of this magnitude, ION has partnered with the EERC to obtain the additional technical and management expertise to conduct this project. Based on recent extensive experience working with EERC, ION is confident that EERC professionals are fully capable to assist with the work described in this proposal and on the process conditions necessary for the successful testing of ION's solvent. EERC will be providing senior project management, senior research management, systems lead engineering, Aspen modeling engineering, data management expertise, data reduction and documentation expertise as well as experienced engineers and operators for the project. EERC will also subcontract the procurement, construction, and delivery of the pilot systems to Sulzer Chemtech, USA (Sulzer) and manage these activities for the project.

The EERC has performed several related projects at various scales to understand, evaluate, and demonstrate CO_2 capture technologies at various stages of development over the last 10 years. These projects have allowed the EERC to become respected and recognized as leaders in the area of CO_2 capture research. EERC has worked with many of the key players in the CO_2 capture space including Hitachi, Huntsman, Cansolv, ION, SaskPower, Black and Veatch, Suncor, Shell, BP, Petrobras, ENI, Chevron, and several other utility partners. The EERC also has a long history in successfully completing field demonstration projects for related technologies at a number of large coal-fired power plants.

Nebraska Public Power District (NPPD) has been a member of the EERC Partnership for CO_2 Capture (PCO_2C) program for a number of years. NPPD is committed to evaluating carbon management by taking a leadership role in the implementation of CO_2 capture and utilization in Nebraska and its industry. Gerald Gentleman Station (GGS) is NPPD's and Nebraska's largest electric generating station and one of the lowest cost providers of coal-fired electricity generation in the U.S. In addition to providing access to post-combustion flue gas and plant utilities, NPPD will be providing oversight for engineering, construction, operations and maintenance, safety, security, procurement, legal reviews and environmental permitting for the project. NPPD will be assisted by Sargent & Lundy who will be acting as the Owner's Engineer.

Sulzer has also been a contributor to EERC's PCO_2C for a number of years. They have over 60 years' experience in the design and supply of specialized equipment for solvent recovery applications and have significant experience in the design and supply of skid-mounted, modular solvent recovery plants (including performance guarantees). Sulzer provides proprietary structured packing for mass transfer vessels offering a combination of low pressure drop and high mass transfer efficiency. Their packing is currently in use at a number of demonstration CO_2 capture facilities in North America and Europe, and was used by ION in their test runs at EERC.

KEY PERSONNEL

The Principal Investigator (PI) for this proposal will be Dr. Alfred (Buz) Brown. Dr. Brown is currently the PI on ION's highly successful bench scale DOE funded CO_2 capture project, "Novel Solvent System for Post-Combustion CO_2 Capture". Dr. Brown is a technical and business founder, has been ION's CEO and Chairman since founding and is an investor in ION. While Dr. Brown's PhD (Univ. Rochester) and Postdoctoral training (Yale Univ.) is in Pharmacology and Toxicology, he has a long and successful history as a researcher and manager of large, multi-organization R&D projects. As ION's CEO, Dr. Brown has ultimate responsibility for ION's R&D, finance, administration, human resources and operations.

Nathan Brown's academic training is in biology, chemistry and chemical engineering. After receiving his BS from the University of Colorado (CU), he worked in the technology commercialization office at CU and was a senior researcher in Chemical & Biological Engineering at CU. Nathan Brown is the Director of R&D at ION and will be Co-Principal Investigator (CO-PI) on this project. For the past two years, he has been responsible for all of ION's research activities in-house and at EERC, as well as ION's collaboration with Dr. Bara at UA. ION plans to hire an experienced Project Manager to support Nathan Brown, as well as a number of engineers and operators who will support many of the project tasks. For all technical aspects of this project, EERC and in turn Sulzer, UA and NPPD will report to Nathan Brown.

All project finance, administrative and legal issues will be managed by ION's Director of

Finance and Administration, Mr. Paul Kelly, CPA. ION currently has a Project Accountant working with Mr. Kelly and ION plans to hire a Contract Compliance Specialist to assist Mr. Kelly with this project. Both Mr. Kelly and ION's Project Accountant have significant government accounting expertise.

The team of EERC personnel responsible for this project will be led by Mr. John Pavlish, Project Manager for EERC's activities. Mr. Pavlish is a Senior Research Advisor and the Director of the Center for Air Toxic Metals® (CATM®) Program at the EERC. Mr. Pavlish is a professional engineer and for nearly 20 years has managed numerous large field demonstration projects. Mr. Pavlish also has over 10 years of power plant design and operation. Mr. Pavlish will also work with ION's Project Manager and Nathan Brown to ensure project objectives are met, provide technical direction and guidance on research and project goals, oversee and track progress and ensure effective communication among project team members.

Mr. John Kay will serve as EERC's Principal Investigator and will be responsible for day-to-day oversight of project technical tasks and activities. Mr. Kay is a Senior Research Manager and has several years of experience working on CO_2 related projects. Mr. Kay will serve as EERC's PI and will assist the project manager to ensure project objectives are met, provide day-to-day technical direction and guidance on research and project goals, and ensure effective communication among technician, engineers, and operators.

Mr. Nathan Fiala will serve as systems lead and will coordinate and oversee design, construction, and installation of the slipstream system. Mr. Fiala is a Research Engineer and has several years of experience working on small to pilot-scale CO_2 systems.

Mr. Josh Stanislowski will serve as the primary modeler for the project and will oversee all modeling activities related to the project. Mr. Stanislowski has a number of years of modeling experience and is intimately familiar with ASPEN, the modeling software that will be used to support this project.

Mr. Jose Strege will oversee management of all data and results generated by the project. Mr Strege has been involved in a number of projects evaluating various technologies on small and large pilot-scale systems.

John H. Swanson is the Generation Strategies Manager at NPPD where he is responsible for evaluating multi-pollutant control equipment advanced technology options, carbon management opportunities, and new generation options including bulk energy storage projects such as compressed air energy storage. Mr. Swanson will serve as the liaison between NPPD and the project.

John M. Meacham is the Engineering Manager at NPPD's Gerald Gentleman Station (GGS) where he is responsible for all on site engineering activities, including daily operations and maintenance support, as well as large and small capital improvement projects. Mr. Meacham will serve as GGS's engineering representative on the project team.

VALUE TO NORTH DAKOTA

In North Dakota, tens of thousands of jobs, billions of dollars in business volume, and tens of millions of dollars in tax revenue are generated by the lignite industry each year. North Dakota produces over 30 million tons of lignite annually, and thousands of tons of lignite are fired by North Dakota power plants daily. Lignite production and use is vital to North Dakota's economy. Lignite combustion produces more CO_2 per Btu of energy as compared to other coals; thus a low-cost effective means of separating CO_2 will be critical to ensure lignite's future use if regulations limit CO_2 emissions in the future. Sponsorship by ND in this scale-up technology demonstration project will show continued support to advance CO2 capture technologies that will lead to cost-effective solutions and options that can be implemented in the future as CO2 regulations are implemented. Involvement in the project will provide ND utilities and coal companies with immediate and emerging information on a second generation CO_2 technology that has promise to greatly reduce energy requirements and significantly lower capital and operating cost. While the technology and data that will be generated as part of the proposed project are believed to be directly applicable and transferrable to ND lignite plants and coals, sponsorship by ND will ensure that participants are fully aware of technology advancements and will further allow them input into the project to ensure that lignite-specific criteria is discussed and considered as the pilot-scale system is designed, constructed, and operated.

The sponsorship of demonstration projects such as this provides the state with immediate access to information needed to make strategic decisions to prepare for the implementation of future regulations. Most of the data that will be generated is universal to coal use, independent of coal type, and directly applicable to the energy production of North Dakota.

MANAGEMENT

ION Engineering will serve as the Prime Contractor for this project with subcontract to EERC, NPPD and UA. Sulzer has been preliminarily selected as the vendor for the procurement, construction and installation of the pilot and will report in to the project via EERC. The relationships of the participating organizations are presented in Figure 13.

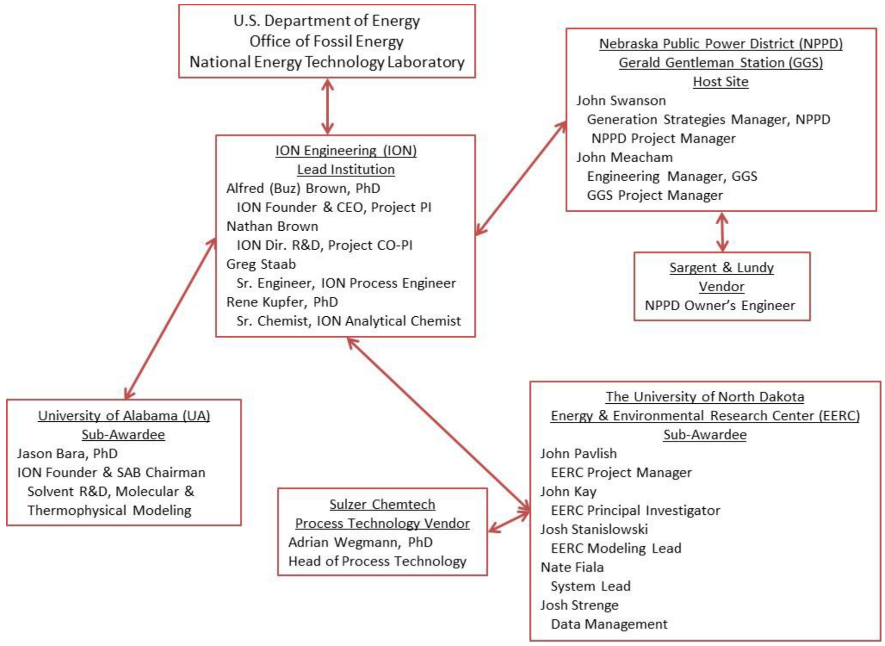

Figure 13. Relationships of Participating Organizations

MANAGEMENT AND COMMUNICATION

Dr. Alfred (Buz) Brown will serve as the project PI. Nathan Brown will serve as the CO-PI and technical project lead. Mr. John Pavlish will be the program manager for all of EERC activities and Mr. John Kay will serve as the PI for all EERC activities. Figure 14 shows the project management structure and lines of communication between the parties and project leads.

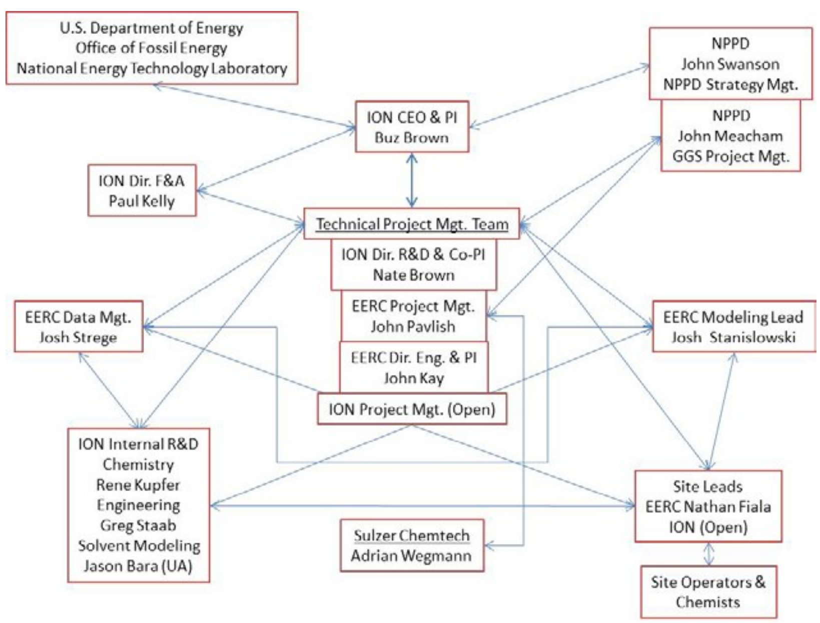

Figure 14. Project Management Structure and Lines of Communication

RESPONSIBILITY FOR SPECIFIC TASKS

Responsibilities for specific tasks are shown on Figure 15. Each task will also have a team lead which will be determined at the start of the program. In addition to reporting to the Technical Project Management Team, task leads will also have direct reporting responsibilities to either Nathan Brown (ION specific tasks) or John Kay (EERC specific tasks).

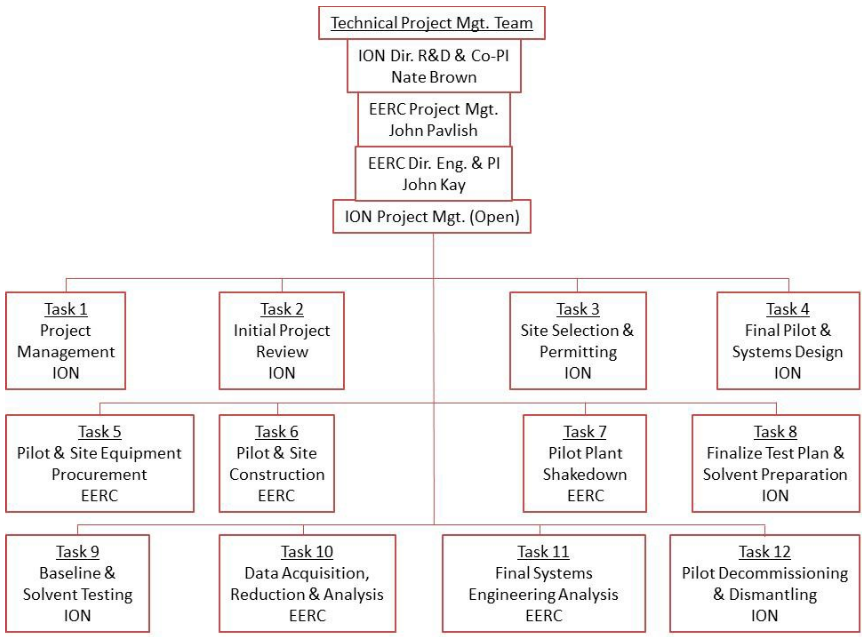

Figure 15. Specific Task Responsibilities

TIMETABLE

The proposed tasks for this project will take 45 months to complete. The project consists of 12 major tasks which are separated in three 15 month budget periods. Task 1, Project Management is the only task that isn’t fully contained within one budget period. The DOE Cooperative Funding Agreement requires that there is a program review at the end of each budget period and that their approval is required before moving on to the activities of the next budget period.

An overview of the schedule and costing by task for the project is shown in Table 6. Details on the costing by task for ION and sub-awardees EERC, University of Alabama and NPPD are in the Detailed Budget Justification sheets in Appendix A.

TABLE 6: ION Slipstream Project Resource Loaded Schedule

ION Engineering CO_2 Capture Slipstream Project
Resource Loaded Schedule

Task	Description	Start Date	Finish Date	Cost
1.0	Project Management and Planning	10/01/13	06/30/17	$ 3,837,676
1.1	Monitor, Control & Communicate Project Status			
1.2	Initial National Environmental Policy Act (NEPA) Documentation			
1.3	Financial Management			
1.4	Technical			
1.5	Administrative			
1.6	Legal			
1.7	Revision and Maintenance of the Project Management Plan			
1.8	Health & Safety			
1.9	Briefings & Technical Presentations			
Budget Period 1		10/01/13	12/31/14	
2.0	Initial Slipstream Project Reviews			$ 205,537
2.1	Initial Techno-Economic Analysis (TEA)	10/01/13	12/31/13	
2.2	Initial Technology EH&S Risk Assessment	10/01/13	10/31/13	
3.0	Site Selection and Permitting			$ 166,630
3.1	Final Host Site Selection	10/01/13	10/31/13	
3.2	Pilot Permitting	10/01/13	09/30/14	
4.0	Final Pilot System Design			$ 2,139,551
4.1	Updated Modeling for ION Solvent	10/01/13	02/28/14	
4.2	Updated Modeling for Advanced Equipment	03/01/14	05/30/14	
4.3	Preliminary Design Assessment	03/01/14	05/30/14	
4.4	Final Process Control Design	04/01/14	08/31/14	
4.5	Mobile Lab Design	03/01/14	08/31/14	
4.6	Final Pilot System Design and Cost	08/01/14	09/30/14	
4.7	Prepare Final Pilot System Design Package	10/01/14	12/31/14	
Budget Period 2				
5.0	Procure Pilot Equipment	01/01/15	06/30/15	$ 6,856,227
6.0	Pilot Construction			$ 991,232
6.1	Host Site Preparation	01/01/15	06/30/15	
6.2	Pilot Plant Construction and Delivery to Site	07/01/15	09/30/15	
6.3	Pilot Plant Installation at the Host Site	10/01/15	12/31/15	
6.4	Establish Connections to Power Plant	10/01/15	12/31/15	
7.0	Pilot Plant Shakedown			$ 508,116
7.1	EH&S	12/01/15	02/28/16	
7.2	Develop Commissioning Plan and Proceedures	12/01/15	02/28/16	
7.3	Develop Operational Procedures	12/01/15	02/28/16	
7.4	Develop Shakedown Testing Plan and Procedures	12/01/15	02/28/16	
7.5	Pilot System Commissioning	12/01/15	02/28/16	
7.6	Shakedown Testing	12/01/15	02/28/16	
7.7	Reference Mathods Determination			
7.8	QA/QC			
7.9	Prepare Final Operating Procedures	12/01/15	03/31/16	
8.0	Final Test Plan Development & Material Procurement			$ 535,239
8.1	Procure Solvents for Testing	01/01/15	06/30/15	
8.2	ION Solvent Preparation & Delivery to Host Site for Testing	07/01/15	12/31/15	
8.3	Final Test Plan Development	01/01/16	02/28/16	
8.4	Pilot System Readiness Review	03/01/16	03/31/16	
Budget Period 3		04/01/16	06/30/07	
9.0	Baseline Solvent and ION Solvent Testing			$ 2,460,177
9.1	Baseline Solvent Testing	04/01/16	08/31/16	
9.2	ION Solvent Testing	09/01/16	03/31/17	
10.0	Data Redcuction and Analysis			$ 1,337,832
10.1	Experimental Results from Pilot Operation	04/01/16	04/30/17	
10.2	Quantitative Assessment of Solvent Chemical & Thermal Stabili	09/01/16	04/30/17	
11.0	Final Systems Engineering Analysis			$ 966,074
12.0	Pilot Decommissioning and Dismantle	05/01/17	06/30/17	$ 189,757

BUDGET

The Ion Advanced Solvent CO_2 Capture Pilot Project (DE-FE0013303) costs are shown in Table 7. In this table costs are presented for the required DOE categories. The costs are the sum of the costs for ION and sub-awardees that are in the Detailed Budget Justification sheets (Appendix A). For this project, DOE costs are capped at $15,000,000 with ION and partners providing the remainder ($5,194,045 or 25.7%) of the project funding. (This DOE program requires a minimum of 20% match.) In this project, NPPD is contributing in-kind match of $750,000 and the University of Alabama is providing $156,448 in match (32%) of their project budget, and therefore the match in Table 7 for NPPD and UA are based on in-kind commitments detailed in Appendix A. Match for all of the remaining categories, including Indirect Charges, are the remainder of the total project match allocated pro-rata against the other budget categories. Indirect Charges in Table 7 are the sum of the of approved indirect rates and charges for each of the project participants (Appendix A). There are two notable exceptions: NPPD is not charging indirect G&A to the project and no indirect charges are being added to the costs of constructing the Slipstream Pilot ($6M).

TABLE 7

ION Engineering: DE-FE001330 Total Project Costs

	DOE COST	COST SHARE	TOTAL	% OF PROJECT COSTS
Personnel	$1,444,604.26	$422,386.74	**$1,866,991**	9.2%
Fringe Benefits	$325,035.95	$95,037.01	**$420,073**	2.1%
Travel	$177,017.10	$51,757.90	**$228,775**	1.1%
Equipment	$489,615.60	$143,158.33	**$632,774**	3.1%
Supplies	$179,202.98	$52,397.02	**$231,600**	1.1%
Contractual				
EERC	$7,582,855	$2,217,145	**$9,800,000**	48.5%
Univ. of Alabama	$335,998	$156,448	**$492,446**	2.4%
NPPD		$750,000	**$750,000**	3.7%
Total Contractual	$7,918,853	$3,123,593	**$11,042,446**	54.7%
Construction	$0.00	$0.00	**$0**	0%

Other Direct Costs	$237,363.28	$69,402.47	**$306,766**	1.5%
Total Direct Charges	$10,771,692	$3,957,733	**$14,729,425**	72.9%
Indirect Charges	$4,228,308	$1,236,312	**$5,464,621**	27.1%
Indirect %	**77.38%**	**22.62%**		
TOTALS:	**$15,000,000**	**$5,194,045**	**$20,194,045**	**100%**

MATCHING FUNDS

All of the participants in this project are deeply committed to post-combustion carbon capture. ION is the solution provider; EERC the leading independent, non-profit testing facility; NPPD is one of the lowest cost providers of coal-fired generation in the U.S. and seeks to maintain its low cost and low carbon generation; Sulzer is already a major supplier of separation equipment, pumps, etc., to the oil, gas and power industries and with a leadership position in the post-combustion CO_2 capture market; and, Dr. Bara seeks to grow his academic career and see his discoveries realized to solve a major global environmental problem.

The project cost is estimated to be $20,194,044 with cost share of $5,194,044 proposed. The financial commitment of cost share is as follows:

- NPPD is committed to contributing in-kind financial support to the project in the amount of $750,000. NPPD will also provide and support the Gerald Gentleman Station as the test host site.
- The University of Alabama is committed to contributing in-kind financial support to the project in the amount of $156,448.
- ION will be contributing cash and cash equivalents to the project up to $4,287,597.
- The EERC is assisting by soliciting cash support from its industrial affiliates.
- In addition, ION has conditional commitments from the North Dakota Lignite Council for $1,000,000 and from the Colorado Economic Development and International Trade for $250,000.

Table 8 shows the committed and proposed match from project participants. The match shown for ION is the difference between the total required match and the match from committed and proposed participants. It is the intent of the parties to continue to seek additional financial support for the project.

TABLE 8

ION Engineering: DE-FE001330 Analysis of Matching Funds				
	DOE COST	COST SHARE	% OF MATCH	% OF PROJECT COSTS
Total Project Costs	**$15,000,000**	**$5,194,045**	**100.00%**	**25.72%**
In-Kind Match				
Univ. of Alabama		$156,448	3.01%	0.77%
NPPD		$750,000	14.44%	3.71%
ION		$3,037,597	58.48%	15.04%
Cash Match				
Colorado OEDIT		$250,000	4.81%	1.24%
Lignite Council		$1,000,000	19.25%	4.95%
Project Totals	$15,000,000	$5,194,045	100.00%	25.72%

Table 9 shows the allocation of match by source and by budget period. With the exception of UA and NPPD, cash cost share will be allocated across all budget categories pro-rata.

TABLE 9

ION Engineering: DE-FE001330 Total Project Costs								
	BUDGET PERIOD 1		BUDGET PERIOD 2		BUDGET PERIOD 3		PROJECT TOTAL	COST SHARE TOTAL
	10-1-2013 - 12-31-2014		1-1-2015 - 3-31-206		4-1-2015 - 6-30-2017			
	TOTAL	COST SHARE	TOTAL	COST SHARE	TOTAL	COST SHARE		
Personnel	$541,633	$0	$525,217	$0	$800,141	$0	$1,866,991	$0
Fringe Benefits	$121,867	$0	$118,174	$0	$180,032	$0	$420,073	$0
Travel	$28,946	$0	$55,162	$0	$144,667	$0	$228,775	$0
Equipment	$272,874	$0	$359,900	$0	$0	$0	$632,774	$0
Supplies	$0	$0	$231,600	$0	$0	$0	$231,600	$0
Contractual							$0	$0
EERC	$798,291	$0	$6,882,560	$0	$2,119,149	$0	$9,800,000	$0
Univ. of Alabama	$151,926	$52,150	$167,005	$52,149	$173,515	$52,149	$492,446	$156,448
NPPD	$232,500	$232,500	$242,500	$242,500	$275,000	$275,000	$750,000	$750,000
Total Contractual	$1,182,717	$284,650	$7,292,065	$294,649	$2,567,664	$327,149	$11,042,446	$906,448
Construction								
Other Direct Costs	$95,588	$0	$95,589	$0	$115,589	$0	$306,766	$0
Total Direct Charges	$2,243,625	$284,650	$8,677,707	$294,649	$3,808,093	$327,149	$14,729,425	$906,448
Indirect Charges	$1,404,510		$1,676,244		$2,383,866		$5,464,620	$0
Cost Share								
ION		$70,342		$2,035,053		$932,202	$0	$3,037,597
Lignite Council		$333,334		$333,334		$333,332	$0	$1,000,000
Colorado OEDIT		$250,000					$0	$250,000
TOTAL FUNDS	**$3,648,135**	**$938,326**	**$10,353,951**	**$2,663,036**	**$6,191,959**	**$1,592,683**	**$20,194,045**	**$5,194,045**
COST SHARE %		**25.72%**		**25.72%**		**25.72%**		**25.72%**

TAX LIABILITY

ION has no outstanding tax liability owed to the State of North Dakota or any of its political subdivisions.

CONFIDENTIAL INFORMATION

No confidential information is currently included in this proposal.

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APPENDIX A

ION ENGINEERING BUDGET JUSTIFICATION

APPENDIX B

EERC ENGINEERING BUDGET JUSTIFICATION

APPENDIX C

UA ENGINEERING BUDGET JUSTIFICATION

APPENDIX D

NPPD ENGINEERING BUDGET JUSTIFICATION

APPENDIX A

OMB Number: 1910-5162
Expiration Date: 01/31/2015

Instructions and Summary

Award Number: __________

Award Recipient: __________

Date of Submission: 2-May-13

Form submitted by: Ion Engineering, LLC

(May be award recipient or sub-recipient)

SUMMARY OF BUDGET CATEGORY COSTS PROPOSED

CATEGORY	Budget Period 1 Costs	Budget Period 2 Costs	Budget Period 3 Costs	Total Costs	Project Costs %	Comments (Add comments as needed)
a. Personnel	$541,633	$525,217	$800,141	$1,866,991	**9.2%**	
b. Fringe Benefits	$121,867	$118,174	$180,032	$420,073	**2.1%**	
c. Travel	$28,946	$55,162	$144,667	$228,775	**1.1%**	
d. Equipment	$272,874	$359,900	$0	$632,774	**3.1%**	
e. Supplies	$0	$231,600	$0	$231,600	**1.1%**	
f. Contractual						
Sub-recipient	$950,217	$7,049,565	$2,292,664	$10,292,446	*51.0%*	
Vendor	$232,500	$242,500	$275,000	$750,000	*3.7%*	
FFRDC	$0	$0	$0	$0	*0.0%*	
Total Contractual	$1,182,717	$7,292,065	$2,567,664	$11,042,446	**54.7%**	
g. Construction	$0	$0	$0	$0	**0.0%**	
h. Other Direct Costs	$95,588	$95,589	$115,589	$306,766	**1.5%**	
Total Direct Costs	$2,243,626	$8,677,707	$3,808,092	$14,729,425	73%	
i. Indirect Charges	$1,404,510	$1,676,244	$2,383,866	$5,464,621	**27.1%**	
Total Project Costs	$3,648,136	$10,353,951	$6,191,958	$20,194,045	**100%**	

Additional Explanations/Comments (as necessary)

a. Personnel

Task # and Title	Position Title	Budget Period 1			Budget Period 2			Budget Period 3			Project Total Hours	Project Total Dollars	Rate Basis
		Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 1	Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 2	Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 3			
1. Task 1 Project Management		4563		$294,410	4763		$325,370	4765		$340,956	14090	$960,736	
	PI (CEO)	600	$126.92	$76,154	650	$133.27	$86,625	650	$139.62	$90,750	1900	$253,529	Approved Salary
	Dir R&D	1200	$67.31	$80,769	1300	$70.67	$91,875	1300	$74.04	$96,250	3800	$268,894	Approved Salary
	Sr. Chemical Engineer 1	315	$67.31	$21,180	315	$70.68	$22,239	315	$74.04	$23,298	944	$66,718	Approved Salary
	Sr. Analytical Chemist 1	315	$48.08	$15,128	315	$50.48	$15,885	315	$52.88	$16,659	944	$47,671	Approved Salary
	Jr. Process Engineer 1	373	$48.08	$17,949	373	$50.48	$18,846	374	$52.88	$19,779	1121	$56,574	Estimated Salary
	Process Operator 1	117	$36.06	$4,219	117	$37.86	$4,430	118	$39.67	$4,681	352	$13,330	Estimated Salary
	Project Manager	1643	$48.08	$79,011	1693	$50.48	$85,470	1693	$52.89	$89,540	5029	$254,021	Estimated Salary
2. Task 2 Initial Slipsteam Project Review		80		$4,769							80	$4,769	
	Sr. Chemical Engineer 1	48	$67.31	$3,231							48	$3,231	Approved Salary
	Project Manager	32	$48.08	$1,539							32	$1,539	Estimated Salary
											0	$0	
3. Task 3 Site Selection and Permiting		200	242.31	15480.85							200	$15,481	
	PI (CEO)	50	$126.92	$6,346							50	$6,346	Approved Salary
	Dir R&D	100	$67.31	$6,731							100	$6,731	Approved Salary
	Project Manager	50	$48.08	$2,404							50	$2,404	Estimated Salary
4. TASK 4 FINAL PILOT-PLANT DESIGN		4615		$226,972							4615	$226,972	
	Sr. Chemical Engineer 1	460	$67.31	$30,963			$0			$0	460	$30,963	Approved Salary
	Sr. Analytical Chemist 1	516	$48.08	$24,808							516	$24,808	Approved Salary
	Jr. Process Engineer 1	84	$48.08	$4,038							84	$4,038	Estimated Salary
	Process Engineer (Aspen) 1	1950	$48.08	$93,748							1950	$93,748	Estimated Salary
	Research Associate 1	960	$31.25	$30,000							960	$30,000	Estimated Salary
	Sr. Chem Engineer 2	645	$67.31	$43,415							645	$43,415	Estimated Salary
5. Task 5 Pocure Equipment					24		$1,212				24	$1,212	
	Project Manager				24	$50.48	$1,212				24	$1,212	Estimated Salary
6. Task 6 Pilot Plant Construction					1968		$107,243				1968	$107,243	
	Sr. Chemical Engineer 1				192	$70.68	$13,570				192	$13,570	Approved Salary
	Jr. Process Engineer 1				677	$50.48	$34,175				677	$34,175	Estimated Salary
	Research Associate 1				480	$32.81	$15,750				480	$15,750	Estimated Salary
	Sr. Chem Engineer 2				619	$70.68	$43,748				619	$43,748	Estimated Salary
7. Task 7 Pilot Plant Shakedown					851		$48,513				851	$48,513	
	Jr. Process Engineer 1				576	$50.48	$29,077				576	$29,077	Estimated Salary
	Sr. Chem Engineer 2				275	$70.68	$19,436				275	$19,436	Actual Salary

Task # and Title	Position Title	Budget Period 1			Budget Period 2			Budget Period 3			Project Total Hours	Project Total Dollars	Rate Basis
		Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 1	Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 2	Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 3			
8. Task 8 Test Plan Dev and Procurement					643		$42,880				643	$42,880	
	Jr. Process Engineer 1				127	$50.48	$6,411				127	$6,411	Estimated Salary
	Sr. Chem Engineer 2				516	$70.68	$36,469				516	$36,469	Approved Salary
9. Task 9 Baseline & Solvent Testing								1704		$118,804	1704	$118,804	
	Sr. Chemical Engineer 1							64	$74.04	$4,739	64	$4,739	Approved Salary
	Jr. Process Engineer 1							48	$52.88	$2,538	48	$2,538	Estimated Salary
	Research Associate 1							160	$34.38	$5,500	160	$5,500	Estimated Salary
	Sr. Chem Engineer 2							1432	$74.04	$106,027	1432	$106,027	Estimated Salary
10. Task 10 Data Reduction & Analysis								4630		$226,454	4630	$226,454	
	Sr. Chemical Engineer 1							80	$74.04	$5,923	80	$5,923	Approved Salary
	Sr. Analytical Chemist 1							320	$52.88	$16,923	320	$16,923	Approved Salary
	Jr. Process Engineer 1							760	$52.88	$40,192	760	$40,192	Estimated Salary
	Process Engineer (Aspen) 1							1950	$52.88	$103,123	1950	$103,123	Estimated Salary
	Process Operator (Jr)							1520	$39.67	$60,292	1520	$60,292	Estimated Salary
11. Task 11 Final Systems Engineering								1567		$74,040	1567	$74,040	
	Sr. Analytical Chemist 1							288	$52.88	$15,229	288	$15,229	Approved Salary
	Jr. Process Engineer 1							480	$52.88	$25,385	480	$25,385	Estimated Salary
	Research Associate 1							480	$34.38	$16,490	480	$16,490	Estimated Salary
	Project Manager							320	$53.01	$16,936	320	$16,936	Estimated Salary
12. Task 12 Pilot Decommissioning								589		$39,887	589	$39,887	
	Jr. Process Engineer 1							176	$52.88	$9,308	176	$9,308	Estimated Salary
	Sr. Chem Engineer 2							413	$74.04	$30,579	413	$30,579	Approved Salary
	Total Personnel Costs	18916		$541,633	16497		$525,217	26510		$800,140.94	0	$1,866,991	

Additional Explanations/Comments (as necessary)

Task 6,7,10,and 11 are all highly critical for the success of the project. While ION was not identified as having primary responsibility for these actives, ION has the greatest knowledge of the solvent process and a high level of technical involvement is necessary.

b. Fringe Benefits

Labor Type	Budget Period 1			Budget Period 2			Budget Period 3			Total Project Fringe Benefit Costs
[redacted]	Personnel Costs	Rate	Total	Personnel Costs	Rate	Total	Personnel Costs	Rate	Total	
Total Personnel	541,633	22.5%	$121,867	525,217	22.5%	$118,174	800,141	22.5%	$180,032	$420,073
			$0			$0			$0	$0
			$0			$0			$0	$0
Total:	$541,633		$121,867	$525,217		$118,174	$800,141		$180,032	$420,073

A federally approved fringe benefit rate agreement, or a proposed rate supported and agreed upon by DOE for estimating purposes is required if reimbursement for fringe benefits is requested. Please check (X) one of the options below and provide the requested information. Calculate the fringe rate and the Total should calculate automatically (if adding rows, ensure the formulas are updated).

__X__ A fringe benefit rate has been negotiated with, or approved by, a federal government agency. A copy of the latest rate agreement is included with this application, and will be provided electronically to the Contracting Officer for this project.

_____ There is not a current, federally approved rate agreement negotiated and available*.

***When this option is checked, the entity preparing this form shall submit a rate proposal in the format provided at the following website, or a format that provides the same level of information; and the rate proposal must support the rates being proposed for use in performance of the proposed project.**

Additional Explanation/Comments (as necessary)

Please use this box (or an attachment) to further explain how your total fringe benefits costs were calculated. Your calculations should identify all rates used, along with the base they were applied to (and how the base was derived), and a total for each (along with grand total).

c. Travel

Purpose of travel	Depart From	Destination	No. of Days	No. of Travelers	Cost per Traveler	Cost per Trip	Basis for Estimating Costs
Budget Period 1							
Domestic Travel							
Kickoff Meeting at NETL	Boulder CO	Pittsburgh PA	2	4	$853	$3,412	Internet prices
Quarterly PM Meeting (BP 1)	Boulder CO	Sutherland NE	1	3	$102	$306	CONUS Per Diem and Mileage
Quarterly PM Meeting (BP 1)	Boulder CO	Sutherland NE	1	3	$102	$306	CONUS Per Diem and Mileage
Quarterly PM Meeting (BP 1)	Boulder CO	Sutherland NE	1	3	$102	$306	CONUS Per Diem and Mileage
Quarterly PM Meeting (BP 1)	Boulder CO	Sutherland NE	1	3	$102	$306	CONUS Per Diem and Mileage
Quarterly PM Meeting (BP 1)	Boulder CO	Sutherland NE	1	3	$102	$306	CONUS Per Diem and Mileage
Kickoff Meeting at Site	Boulder CO	Sutherland NE	2	3	$235	$705	CONUS Per Diem and Mileage
Final host site selection	Boulder CO	Sutherland NE	1	3	$102	$306	CONUS Per Diem and Mileage
Pilot plant permitting	Boulder CO	Sutherland NE	1	3	$102	$306	CONUS Per Diem and Mileage
Team Meetings at EERC	Boulder CO	Grand Forks ND	5	2	$1,056	$2,112	Internet prices
Team Meetings at EERC	Boulder CO	Grand Forks ND	5	2	$1,057	$2,114	Internet prices
Final System Design at EERC	Boulder CO	Grand Forks ND	2	2	$879	$1,758	Internet prices
NETL Carbon Capture Technology Meeting	Boulder CO	Pittsburgh PA	3	4	$1,352	$5,408	Internet prices
National Scientific Meetings	Boulder CO	TBD	3	3	$2,629	$7,887	Internet prices
Project Review Meeting	Boulder CO	Pittsburgh PA	2	4	$852	$3,408	Internet prices
Domestic Travel subtotal						$28,946	
International Travel							
						$0	
International Travel subtotal						$0	
Budget Period 1 Total						**$28,946**	

Purpose of travel	Depart From	Destination	No. of Days	No. of Travelers	Cost per Traveler	Cost per Trip	Basis for Estimating Costs
Budget Period 2							
Domestic Travel							
Review Design, Procurement and Construction wth Sulzer	Boulder CO	Tulsa OK	2	2	$737	$1,474	Internet prices
Review Design, Procurement and Construction wth Sulzer	Boulder CO	Tulsa OK	2	2	$737	$1,474	Internet prices
Review Design and Costing with Sulzer (Sulzer business office	Boulder CO	Houston, TX	2	2	$931	$1,862	Internet prices
Review Design, Procurement and Construction wth Sulzer	Boulder CO	Tulsa OK	2	2	$737	$1,474	Internet prices
Review Design, Procurement and Construction wth Sulzer	Boulder CO	Tulsa OK	2	2	$738	$1,476	Internet prices
Monthly PM Meeting (20 trips)	Boulder CO	Sutherland NE	1	3	$2,040	$6,120	CONUS Per Diem and Mileage
EP&C Construction Technicial meetings	Boulder CO	Tulsa OK	2	2	$739	$1,478	Internet prices
EP&C Construction Technicial meetings	Boulder CO	Tulsa OK	2	2	$739	$1,478	Internet prices
Host Site Construction at Gerald Gentleman Station (GGS)	Boulder CO	Sutherland NE	2	3	$235	$705	CONUS Per Diem and Mileage
Host Site Construction (GGS)	Boulder CO	Sutherland NE	2	3	$235	$705	CONUS Per Diem and Mileage
Host Site Construction (GGS)	Boulder CO	Sutherland NE	2	3	$235	$705	CONUS Per Diem and Mileage
Pilot Plant Shakedown (GGS)	Boulder CO	Sutherland NE	10	3	$1,299	$3,897	CONUS Per Diem and Mileage
Pilot Plant Shakedown (GGS)	Boulder CO	Sutherland NE	10	3	$1,300	$3,900	CONUS Per Diem and Mileage
Pilot Plant Shakedown (GGS)	Boulder CO	Sutherland NE	10	3	$1,301	$3,903	CONUS Per Diem and Mileage
Pilot Plant Shakedown (GGS)	Boulder CO	Sutherland NE	10	3	$1,302	$3,906	CONUS Per Diem and Mileage
Prepare & Deliver Solvents to Site for Testing	Boulder CO	Sutherland NE	5	3	$634	$1,902	CONUS Per Diem and Mileage
Annual Program Reviews at DOE	Boulder CO	Pittsburgh PA	3	4	$1,352	$5,408	Internet prices
NETL Carbon Capture Technology Meeting	Boulder CO	Pittsburgh PA	3	4	$1,352	$5,408	Internet prices
National Scientific Meetings	Boulder CO	TBD	3	3	$2,629	$7,887	Internet prices
Domestic Travel subtotal						$55,162	
International Travel							
						$0	
International Travel subtotal						$0	
Budget Period 2 Total						**$55,162**	
Budget Period 3							
Domestic Travel							
Testing on Site Engineering & Operations (Eng & Ops) Baseline Testing	Boulder CO	Sutherland NE	4	4	$1,831	$7,324	CONUS Per Diem and Mileage
Testing on Site (Eng & Ops) Baseline Testing	Boulder CO	Sutherland NE	4	4	$1,831	$7,324	CONUS Per Diem and Mileage
Testing on Site (Eng & Ops) Baseline Testing	Boulder CO	Sutherland NE	4	4	$1,831	$7,324	CONUS Per Diem and Mileage
Maintenance on Site (Between solvent runs)	Boulder CO	Sutherland NE	5	1	$634	$634	CONUS Per Diem and Mileage
Testing on Site Project Management (PM) Baseline Testing	Boulder CO	Sutherland NE	5	2	$634	$1,268	CONUS Per Diem and Mileage
Testing on Site (PM) Baseline Testing	Boulder CO	Sutherland NE	5	2	$635	$1,270	CONUS Per Diem and Mileage
Testing on Site (PM) Baseline Testing	Boulder CO	Sutherland NE	5	2	$636	$1,272	CONUS Per Diem and Mileage
Weekly PM Meeting 65 Trips	Boulder CO	Sutherland NE	1	3	$6,630	$19,890	CONUS Per Diem and Mileage
I-1 Testing on Site (Eng & Ops) Initial ION Testing	Boulder CO	Sutherland NE	14	4	$1,831	$7,324	CONUS Per Diem and Mileage
I-1 Testing on Site (Eng & Ops) Initial ION Testing	Boulder CO	Sutherland NE	14	4	$1,832	$7,328	CONUS Per Diem and Mileage
I-1 Testing on Site (Eng & Ops) Initial ION Testing	Boulder CO	Sutherland NE	14	4	$1,833	$7,332	CONUS Per Diem and Mileage
Maintenance on Site (Between solvent runs)	Boulder CO	Sutherland NE	5	1	$634	$634	CONUS Per Diem and Mileage
Maintenance on Site (Between solvent runs)	Boulder CO	Sutherland NE	5	1	$634	$634	CONUS Per Diem and Mileage
Maintenance on Site (Between solvent runs)	Boulder CO	Sutherland NE	5	1	$634	$634	CONUS Per Diem and Mileage

Purpose of travel	Depart From	Destination	No. of Days	No. of Travelers	Cost per Traveler	Cost per Trip	Basis for Estimating Costs
I-2 Testing on Site (PM) Initial ION Testing	Boulder CO	Sutherland NE	5	2	$634	$1,268	CONUS Per Diem and Mileage
I-2 Testing on Site (PM) Initial ION Testing	Boulder CO	Sutherland NE	5	2	$634	$1,268	CONUS Per Diem and Mileage
I-2 Testing on Site (PM) Initial ION Testing	Boulder CO	Sutherland NE	5	2	$634	$1,268	CONUS Per Diem and Mileage
Maintenance on Site (Between solvent runs)	Boulder CO	Sutherland NE	5	1	$634	$634	CONUS Per Diem and Mileage
LT Testing on Site (Eng & Ops) up to 1,500 hr ION solvent runs	Boulder CO	Sutherland NE	60	4	$7,949	$31,796	CONUS Per Diem and Mileage
Maintenance on Site (Between solvent runs)	Boulder CO	Sutherland NE	5	2	$634	$1,268	CONUS Per Diem and Mileage
Maintenance on Site (Between solvent runs)	Boulder CO	Sutherland NE	5	2	$634	$1,268	CONUS Per Diem and Mileage
LT Testing on Site (PM) long term solvent runs	Boulder CO	Sutherland NE	5	2	$634	$1,268	CONUS Per Diem and Mileage
LT Testing on Site (PM) long term solvent runs	Boulder CO	Sutherland NE	5	2	$634	$1,268	CONUS Per Diem and Mileage
LT Testing on Site (PM) long term solvent runs	Boulder CO	Sutherland NE	5	2	$634	$1,268	CONUS Per Diem and Mileage
LT Testing on Site (PM) long term solvent runs	Boulder CO	Sutherland NE	5	2	$634	$1,268	CONUS Per Diem and Mileage
LT Testing on Site (PM) long term solvent runs	Boulder CO	Sutherland NE	5	2	$634	$1,268	CONUS Per Diem and Mileage
LT Testing on Site (PM) long term solvent runs	Boulder CO	Sutherland NE	5	2	$634	$1,268	CONUS Per Diem and Mileage
LT Testing on Site (PM) long term solvent runs	Boulder CO	Sutherland NE	5	2	$634	$1,268	CONUS Per Diem and Mileage
LT Testing on Site (PM) long term solvent runs	Boulder CO	Sutherland NE	5	2	$634	$1,268	CONUS Per Diem and Mileage
LT Testing on Site (PM) long term solvent runs	Boulder CO	Sutherland NE	5	2	$634	$1,268	CONUS Per Diem and Mileage
LT Testing on Site (PM) long term solvent runs	Boulder CO	Sutherland NE	5	2	$634	$1,268	CONUS Per Diem and Mileage
System Decommissioning and Dismantle	Boulder CO	Sutherland NE	5	2	$634	$1,268	CONUS Per Diem and Mileage
System Decommissioning and Dismantle	Boulder CO	Sutherland NE	5	2	$634	$1,268	CONUS Per Diem and Mileage
System Decommissioning and Dismantle	Boulder CO	Sutherland NE	5	2	$634	$1,268	CONUS Per Diem and Mileage
System Decommissioning and Dismantle	Boulder CO	Sutherland NE	5	2	$634	$1,268	CONUS Per Diem and Mileage
System Decommissioning and Dismantle	Boulder CO	Sutherland NE	5	2	$634	$1,268	CONUS Per Diem and Mileage
Final Project Review	Boulder CO	Pittsburgh PA	2	4	$850	$3,400	Internet prices
NETL Carbon Capture Technology Meeting	Boulder CO	Pittsburgh PA	3	4	$1,352	$5,408	Internet prices
National Scientific Meetings	Boulder CO	TBD	3	3	$2,629	$7,887	Internet prices
Domestic Travel subtotal						$144,667	
International Travel							
						$0	
International Travel subtotal						$0	
Budget Period 3 Total						**$144,667**	
PROJECT TOTAL						**$228,775**	

Additional Explanations/Comments (as necessary)

d. Equipment

Equipment Item	Qty	Unit Cost	Total Cost	Basis of Cost	Justification of need
Budget Period 1					
FTIR -Spectrum2	1	$24,060	$24,060	Vendor Quote	(ION Analytical Lab & Mobile Lab) - Simple, robust IR. Good field unit, used for ASTM hydrocarbon & lubricant tests in the field. Will allow us to look at organic salts in our solvent, quantification of levels will depend on other molecules present. Task 4.1
Perkin-Mid-IR	1	$31,502	$31,502	Vendor Quote	Gold Standard IR. Will allow us to conduct & quantify detailed kinetic studies of our solvents. Should be able to determine pathway information for CO2-Amine Reaction. Task 4.1
HPLC	1	$85,724	$85,724	Vendor Quote	Organic separations - will be used for solvent degradation analysis. Task 4.1
Liquid Flow Meters - Emmerson	1	$29,493	$29,493	Vendor Quote	ION Test Unit - improved liquid flow telemetry for kinetic studies of ION solvent under steady state operation. Task 4.1
PumpEst	1	$32,000	$32,000	Vendor Quote	ION Test Unit - improved liquid flow operational range . Task 4.1
Scissor Lift	1	$15,582	$15,582	Vendor Quote	ION Test Unit - Lift will provide access to mid & top sections of ION's lab unit for sample collection & general equipment maintenance. Task 4.1
Cast A1 Pipe Heaters	3	$1,504	$4,512	Vendor Quote	Ion Test Unit - Winterized Lab Task 4.1
Drum Heater	1	$50,000	$50,000	Estimate	For Preparation of Solvent Task 4.1
			$0		
Budget Period 1 Total			$272,874		
Budget Period 2					
GC\MS-59773	1	$70,286	$70,286	Vendor Quote	Mobile Lab-Quantification of organic composition of ION solvent during test runs. Task 5.10
Karl Fischer/Acid-Base Titrator	1	$46,161	$46,161	Vendor Quote	Mobile Lab-Quantification of H2O concentration in solvent samples. Task 5.10
Box Trailer	1	$51,153	$51,153	Vendor Quote	Trailers will house Offices & break room for on site operators, engineers & managers. Task 5.10
Box Trailer-Analytical Lab	2	$34,624	$69,248	Vendor Quote	Trailer will house mobile labortary for testing. Second trailer will house the controller of eqiupment. Task 5.10
TIC/SO2/H2S	1	$62,713	$62,713	Vendor Quote	Mobile Lab - Quantification of CO2 loading in solvent samples. Can also determine SO2 & H2S levels in a liquid sample. Task 5.10
GC-78908 Agilent	1	$60,339	$60,339	Vendor Quote	Ion Analytical Lab- Higher sensitivity GC, will be used for solvent degradation analysis. Task 5.7
			$0		
			$0		
			$0		
Budget Period 2 Total			$359,900		
Budget Period 3					

Equipment Item	Qty	Unit Cost	Total Cost	Basis of Cost	Justification of need
			$0		
			$0		
			$0		
			$0		
			$0		
			$0		
			$0		
			$0		
			$0		
			$0		
			$0		
Budget Period 3 Total			$0		
PROJECT TOTAL			$632,774		

Additional Explanations/Comments (as necessary)

e. Supplies

General Category of Supplies	Qty	Unit Cost	Total Cost	Basis of Cost	Justification of need
			Budget Period 1		
			$0		
			$0		
			$0		
			$0		
			$0		
			$0		
Budget Period 1 Total			**$0**		
			Budget Period 2		
Ion Solvent	60	$3,860.00	$231,600	Historical Cost	For Solvent Testing - Task 8.1
			$0		
			$0		
			$0		
			$0		
Budget Period 2 Total			$231,600		
			Budget Period 3		
			$0		
			$0		
			$0		
			$0		
Budget Period 3 Total			$0		
PROJECT TOTAL			**$231,600**		

Additional Explanations/Comments (as necessary)

f. Contractual

Sub-Recipient Name/Organization	Purpose/Tasks in SOPO	Budget Period 1 Costs	Budget Period 2 Costs	Budget Period 3 Costs	Project Total
University of Alabama	Solvent Research and Development modeling and analysis. Task 1, Task 4, Task 10, Task 11	$151,926	$167,005	$173,515	**$492,446**
Energy & Environmental Research Center	Project management, site leads and engineering, Techno-Economic Analysis Modeling, Task 1 - 11	$798,291	$6,882,560	$2,119,149	**$9,800,000**
					$0
					$0
					$0
					$0
	Sub-total	**$950,217**	**$7,049,565**	**$2,292,664**	**$10,292,446**

Vendor Name/Organization	Product or Service, Purpose/Need and Basis of Cost (Provide additional support at bottom of page as needed)	Budget Period 1 Costs	Budget Period 2 Costs	Budget Period 3 Costs	Project Total
Nebraska Public Power District	Vendor providing the hoist site for testing/ historical cost Task 4, 5, 6, 9, 12	$232,500	$242,500	$275,000	**$750,000**
					$0
					$0
					$0
					$0
					$0
					$0
	Sub-total	**$232,500**	**$242,500**	**$275,000**	**$750,000**

FFRDC Name/Organization	Purpose	Budget Period 1 Costs	Budget Period 2 Costs	Budget Period 3 Costs	Project Total
					$0
					$0
	Sub-total	**$0**	**$0**	**$0**	**$0**

Total Contractual		**$1,182,717**	**$7,292,065**	**$2,567,664**	**$11,042,446**

Sub-Recipient Name/Organization	Purpose/Tasks in SOPO	Budget Period 1 Costs	Budget Period 2 Costs	Budget Period 3 Costs	Project Total

AdditionalExplanations/Comments (as necessary)

Sulzer's quote was based on operating conditions at NNPD's power plan t (GGS) and provided by EERC for typical 30% MEA CO2 capture system. A listing of all the major equipment is included in their proposal but specific pricing is not provided. The proposal was made with a +/-10% cost guarantee and a one year performance guarantee. The major activity of Budget Period 1 will be to refine the design and obtain detailed equipment pricing.

g. Construction

Overall description of construction actiivities:

General Description	Cost	Basis of Cost	Justification of need
Budget Period 1			
Budget Period 1 Total	**$0**		
Budget Period 2			
Budget Period 2 Total	$0		
Budget Period 3			
Budget Period 3 Total	$0		
PROJECT TOTAL	**$0**		

Additional Explanations/Comments (as necessary)

h. Other Direct Costs

General description	Cost	Basis of Cost	Justification of need
Budget Period 1			
Legal	$18,750	Historical Estimate	Review IP, Partnership Agreements, Compliance Task 1
Small tools and Parts	$30,000	Historical Estimate	Supplies need to suport, installation, analysis oas desribed in the proposal
Aspen Software	$16,839	Historical Estimate	Portion of Software license
Consulting	$30,000	Historical Estimate	Poject oversite Task 1
Budget Period 1 Total	$95,588		
Budget Period 2			
Legal	$18,750	Historical Estimate	Review IP, Partnership Agreements, Compliance Task 1
Small tools and Parts	$30,000	Historical Estimate	Supplies need to suport, installation, analysis, shakedown as desribed in the proposal
Aspen Software	$16,839	Historical Estimate	Portion of Software license
Consulting	$30,000	Historical Estimate	Poject oversite Task 1
Budget Period 2 Total	$95,589		
Budget Period 3			
Legal	$18,750	Historical Estimate	Review IP, Partnership Agreements, Compliance Task 1
Other Slipstream	$50,000	Historical Estimate	Testing services Task 12
Aspen Software	$16,839	Historical Estimate	Portion of Software license
Consulting	$30,000	Historical Estimate	Poject oversite Task 1
Budget Period 3 Total	$115,589		
PROJECT TOTAL	**$306,766**		

Additional Explanations/Comments (as necessary)

ION's legal budget includes the annual compliance audit which has averaged $15K/yr and the remainder relates to specific project related legal and accounting cost, e.g. contract negotiations with partners.
The category includes coupon & corrosion testing as well as additional solvent degradation studies.
ION's consulting budget includes project related professional fees related to process modeling, simulations, EH&S, NEPA, data management, etc. Average professional cost are estimated at $150/hr based on historical experience.

h. Other Direct Costs

General description	Cost	Basis of Cost	Justification of need
		Budget Period 1	
Legal	$18,750	Historical Estimate	Review IP, Partnership Agreements, Compliance Task 1
Small tools and Parts	$30,000	Historical Estimate	Supplies need to suport, installation, analysis oas desribed in the proposal
Aspen Software	$16,839	Historical Estimate	Portion of Software license
Consulting	$30,000	Historical Estimate	Poject oversite Task 1
Budget Period 1 Total	$95,588		
		Budget Period 2	
Legal	$18,750	Historical Estimate	Review IP, Partnership Agreements, Compliance Task 1
Small tools and Parts	$30,000	Historical Estimate	Supplies need to suport, installation, analysis, shakedown as desribed in the proposal
Aspen Software	$16,839	Historical Estimate	Portion of Software license
Consulting	$30,000	Historical Estimate	Poject oversite Task 1
Budget Period 2 Total	$95,589		
		Budget Period 3	
Legal	$18,750	Historical Estimate	Review IP, Partnership Agreements, Compliance Task 1
Other Slipstream	$50,000	Historical Estimate	Testing services Task 12
Aspen Software	$16,839	Historical Estimate	Portion of Software license
Consulting	$30,000	Historical Estimate	Poject oversite Task 1
Budget Period 3 Total	$115,589		
PROJECT TOTAL	**$306,766**		

Additional Explanations/Comments (as necessary)

ION's legal budget includes the annual compliance audit which has averaged $15K/yr and the remainder relates to specific project related legal and accounting cost, e.g. contract negotiations with partners.
The category includes coupon & corrosion testing as well as additional solvent degradation studies.
ION's consulting budget includes project related professional fees related to process modeling, simulations, EH&S, NEPA, data management, etc. Average professional cost are estimated at $150/hr based on historical experience.

i. Indirect Costs

	Budget Period 1	Budget Period 2	Budget Period 3	Total	Explanation of BASE
Provide ONLY Applicable Rates:					
Overhead Rate	0.0%	0.0%	0.0%		
General & Administrative (G&A)	0.0%	0.0%	0.0%		
FCCM Rate, if applicable	0.0%	0.0%	0.0%		
OTHER Indirect Rate	62.6%	62.6%	62.6%		
Indirect Costs (As Applicable):					
Overhead Costs	$0	$0	$0	$0	
G&A Costs	$0	$0	$0	$0	
FCCM Costs, if applicable	$0	$0	$0	$0	
OTHER Indirect Costs	$1,404,510	$1,676,244	$2,383,866	**$5,464,620**	
Total indirect costs requested:	**$1,404,510**	**$1,676,244**	**$2,383,866**	**$5,464,620**	

A federally approved indirect rate agreement, or rate proposed (supported and agreed upon by DOE for estimating purposes) is required if reimbursement of indirect costs is requested. Please check (X) one of the options below and provide the requested information if it has not already been provided as requested, or has changed. Calculate the indirect rate dollars and the totals should calculate automatically.

___X___ An indirect rate has been approved or negotiated with a federal government agency. A copy of the latest rate agreement is included with this application, and will be provided electronically to the Contracting Officer for this project.

______ There is not a current, federally approved rate agreement negotiated and available*.

***When this option is checked, the entity preparing this form shall submit an indirect rate proposal in the format provided at the following website, or a format that provides the same level of information and which will support the rates being proposed for use in performance of the proposed project. Go to http://www.dcaa.mil/ice.htm for sample indirect cost model.**

Additional Explanations/Comments (as necessary)

ION's approved indirect rate is with the following agency and the contact is below. The provisional rate under DE-FE0005799 for 2013 is 58%. The provisional rate requested for this award is 42.6%.

Department of Energy

National Energy and Technology Laboratory
Thomas J. Gruber M/S 921-107
626 Cochrane Mill Road
Pittsburgh PA 15236-0940

Award No. DE-FE0005799 CFDA No 81.089

Cost Share

Organization/Source	Type (cash or other)	Cost Share Item	Budget Period 1 Cost Share	Budget Period 2 Cost Share	Budget Period 3 Cost Share	Total Project Cost Share
ION Engineering, LLC	Cash		$320,342	$2,035,124	$932,131	**$3,287,597**
The University of Alabama	In Kind	The University of Alabama will provide 32% in kind match for support of Dr. Bara and a graduate student including travel and supplies.	$52,150	$52,149	$52,149	**$156,448**
Nebraska Public Power District	Cash		$232,500	$242,500	$275,000	**$750,000**
Lignite Council	Cash		$333,333	$333,333	$333,334	**$1,000,000**
						$0
		Totals	**$938,325**	**$2,663,106**	**$1,592,614**	**$5,194,045**

Total Project Cost: $20,194,045

Cost Share Percent of Award: 25.7%

Additional Explanations/Comments (as necessary)

APPENDIX B

OMB Number: 1910-5162
Expiration Date: 01/31/2015

Instructions and Summary

Award Number: ____________________

Award Recipient: ____________________

Date of Submission: 25-Apr-13

Form submitted by: Energy & Environmental Research Center
(May be award recipient or subrecipient)

SUMMARY OF BUDGET CATEGORY COSTS PROPOSED

CATEGORY	Budget Period 1 Costs	Budget Period 2 Costs	Budget Period 3 Costs	Total Costs	Project Costs %	Comments (Add comments as needed)
a. Personnel	$298,619	$312,687	$730,505	$1,341,811	13.7%	
b. Fringe Benefits	$168,802	$178,231	$415,855	$762,888	7.8%	
c. Travel	$17,439	$37,719	$201,844	$257,002	2.6%	
d. Equipment	$0	$6,000,000	$0	$6,000,000	61.2%	
e. Supplies	$43,500	$57,250	$52,000	$152,750	1.6%	
f. Contractual						
Sub-recipient	$0	$0	$0	$0	0.0%	
Vendor	$0	$0	$0	$0	0.0%	
FFRDC	$0	$0	$0	$0	0.0%	
Total Contractual	$0	$0	$0	$0	0.0%	
g. Construction	$0	$0	$0	$0	0.0%	
h. Other Direct Costs	$7,406	$6,435	$22,044	$35,885	0.4%	
Total Direct Costs	$535,766	$6,592,322	$1,422,248	$8,550,336	$1	
i. Indirect Charges	$262,525	$290,238	$696,901	$1,249,664	12.8%	
Total Project Costs	$798,291	$6,882,560	$2,119,149	$9,800,000	$1	

Additional Explanations/Comments (as necessary)

a. Personnel

Task # and Title	Position Title	Budget Period 1			Budget Period 2			Budget Period 3			Project Total Hours	Project Total Dollars	Rate Basis
		Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 1	Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 2	Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 3			
1. Project Management													
	Pavlish, J. - Project Mgr	650	$87.76	$57,044	650	$91.07	$59,195	650	$95.21	$61,887			All Salaries
	Kay, J. - Principal Investigator	80	$53.34	$4,267	80	$55.35	$4,428	80	$57.87	$4,630			are based on
	Stanislowski, J. - Res Sci/Eng	0	$45.12	$0	0	$46.83	$0	0	$48.96	$0			actual with
	Strege, J. - Res Sci/Eng	0	$40.68	$0	0	$42.22	$0	0	$44.14	$0			escalation
	Martin, C. - Res Sci/Eng	0	$0.00	$0	0	$53.82	$0	0	$56.27	$0			of 4% annual
	Senior Management	38	$111.06	$4,220	35	$115.25	$4,034	37	$120.48	$4,458			increase
	Research Scientist/Engineer	457	$43.18	$19,733	256	$44.81	$11,471	256	$46.85	$11,994			which is based
	Research Technician	101	$29.15	$2,944	92	$30.25	$2,783	97	$31.63	$3,068			on historical
	Technology Dev Mechanic	0	$35.62	$0	0	$36.96	$0	0	$38.64	$0			averages.
	Undergrad - Res.	0	$10.95	$0	0	$0.00	$0	0	$11.87	$0			
	Technical Support Services	352	$26.04	$9,166	448	$27.02	$12,105	496	$28.24	$14,007			
2. Slipstream Review													
	Pavlish, J. - Project Mgr	24	$87.76	$2,106									
	Kay, J. - Principal Investigator	150	$53.34	$8,001									
	Stanislowski, J. - Res Sci/Eng	120	$45.12	$5,414									
	Strege, J. - Res Sci/Eng	120	$40.68	$4,882									
	Martin, C. - Res Sci/Eng	0	$0.00	$0									
	Senior Management	17	$111.06	$1,888									
	Research Scientist/Engineer	234	$43.18	$10,104									
	Research Technician	44	$29.15	$1,283									
	Technology Dev Mechanic	0	$35.62	$0									
	Undergrad - Res.	80	$10.95	$876									
	Technical Support Services	138	$26.04	$3,593									
3. Site Selection & Permitting													
	Pavlish, J. - Project Mgr	80	$87.76	$7,021									
	Kay, J. - Principal Investigator	80	$53.34	$4,267									
	Stanislowski, J. - Res Sci/Eng		$45.12	$0									
	Strege, J. - Res Sci/Eng		$40.68	$0									
	Martin, C. - Res Sci/Eng		$0.00	$0									
	Senior Management	6	$111.06	$667									
	Research Scientist/Engineer	80	$43.18	$3,455									
	Research Technician	16	$29.15	$466									
	Technology Dev Mechanic		$35.62	$0									
	Undergrad - Res.		$10.95	$0									
	Technical Support Services	1	$26.04	$26									
4. Final Plant & Sytem Design													
	Pavlish, J. - Project Mgr	260	$87.76	$22,817									
	Kay, J. - Principal Investigator	480	$53.34	$25,603									
	Stanislowski, J. - Res Sci/Eng	360	$45.12	$16,243									

Task # and Title	Position Title	Budget Period 1			Budget Period 2			Budget Period 3			Project Total Hours	Project Total Dollars	Rate Basis
		Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 1	Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 2	Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 3			
	Strege, J. - Res Sci/Eng	360	**$40.68**	$14,645									
	Martin, C. - Res Sci/Eng	0	**$0.00**	$0									
	Senior Management	61	**$111.06**	$6,775									
	Research Scientist/Engineer	1036	$43.18	$44,739									
	Research Technician	160	$29.15	$4,664									
	Technology Dev Mechanic	200	$35.62	$7,124									
	Undergrad - Res.	150	$10.95	$1,643									
	Technical Support Services	113	$26.04	$2,943									
5. Procure Equipment													
	Pavlish, J. - Project Mgr				100	**$91.07**	$9,107						
	Kay, J. - Principal Investigator				200	**$55.35**	$11,071						
	Stanislowski, J. - Res Sci/Eng				0	**$46.83**	$0						
	Strege, J. - Res Sci/Eng				0	**$42.22**	$0						
	Martin, C. - Res Sci/Eng				0	**$53.82**	$0						
	Senior Management				15	**$115.25**	$1,729						
	Research Scientist/Engineer				356	$44.81	$15,953						
	Research Technician				39	$30.25	$1,180						
	Technology Dev Mechanic				100	$36.96	$3,696						
	Undergrad - Res.				0	$0.00	$0						
	Technical Support Services				12	$27.02	$325						
6. Site Construction													
	Pavlish, J. - Project Mgr				140	**$91.07**	$12,750						
	Kay, J. - Principal Investigator				360	**$55.35**	$19,926						
	Stanislowski, J. - Res Sci/Eng				80	**$46.83**	$3,747						
	Strege, J. - Res Sci/Eng				80	**$42.22**	$3,378						
	Martin, C. - Res Sci/Eng				0	**$53.82**	$0						
	Senior Management				39	**$115.25**	$4,495						
	Research Scientist/Engineer				446	$44.81	$19,986						
	Research Technician				101	$30.25	$3,055						
	Technology Dev Mechanic				240	$36.96	$8,871						
	Undergrad - Res.				0	$0.00	$0						
	Technical Support Services				17	$27.02	$460						
7. Pilot Plant Shakedown													
	Pavlish, J. - Project Mgr				120	**$91.07**	$10,928						
	Kay, J. - Principal Investigator				260	**$55.35**	$14,391						
	Stanislowski, J. - Res Sci/Eng				120	**$46.83**	$5,619						
	Strege, J. - Res Sci/Eng				120	**$42.22**	$5,066						
	Martin, C. - Res Sci/Eng				80	**$53.82**	$4,306						
	Senior Management				35	**$115.25**	$4,034						
	Research Scientist/Engineer				300	$44.81	$13,443						
	Research Technician				92	$30.25	$2,783						
	Technology Dev Mechanic				360	$36.96	$13,306						
	Undergrad - Res.				0	$0.00	$0						

Task # and Title	Position Title	Budget Period 1			Budget Period 2			Budget Period 3			Project Total Hours	Project Total Dollars	Rate Basis
		Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 1	Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 2	Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 3			
	Technical Support Services				215	$27.02	$5,809						
8. Test Plan & Procurement													
	Pavlish, J. - Project Mgr				80	**$91.07**	$7,286						
	Kay, J. - Principal Investigator				80	**$55.35**	$4,428						
	Stanislowski, J. - Res Sci/Eng				16	**$46.83**	$749						
	Strege, J. - Res Sci/Eng				16	**$42.22**	$676						
	Martin, C. - Res Sci/Eng				16	**$53.82**	$861						
	Senior Management				7	**$115.25**	$807						
	Research Scientist/Engineer				80	$44.81	$3,585						
	Research Technician				17	$30.25	$514						
	Technology Dev Mechanic				0	$36.96	$0						
	Undergrad - Res.				0	$0.00	$0						
	Technical Support Services				13	$27.02	$351						
9. Baseline & Solvent Testing													
	Pavlish, J. - Project Mgr							240	**$95.21**	$22,850			
	Kay, J. - Principal Investigator							600	**$57.87**	$34,721			
	Stanislowski, J. - Res Sci/Eng							160	**$48.96**	$7,834			
	Strege, J. - Res Sci/Eng							160	**$44.14**	$7,062			
	Martin, C. - Res Sci/Eng							160	**$56.27**	$9,003			
	Senior Management							156	**$120.48**	$18,795			
	Research Scientist/Engineer							1400	$46.85	$65,590			
	Research Technician							409	$31.63	$12,937			
	Technology Dev Mechanic							3600	$38.64	$139,104			
	Undergrad - Res.							0	$11.87	$0			
	Technical Support Services							119	$28.24	$3,361			
10. Data Analysis													
	Pavlish, J. - Project Mgr							270	**$95.21**	$25,706			
	Kay, J. - Principal Investigator							380	**$57.87**	$21,991			
	Stanislowski, J. - Res Sci/Eng							240	**$48.96**	$11,750			
	Strege, J. - Res Sci/Eng							540	**$44.14**	$23,832			
	Martin, C. - Res Sci/Eng							700	**$56.27**	$39,389			
	Senior Management							52	**$120.48**	$6,265			
	Research Scientist/Engineer							433	$46.85	$20,286			
	Research Technician							136	$31.63	$4,302			
	Technology Dev Mechanic							0	$38.64	$0			
	Undergrad - Res.							0	$11.87	$0			
	Technical Support Services							52	$28.24	$1,468			
11. Engineering Analysis													
	Pavlish, J. - Project Mgr							240	**$95.21**	$22,850			
	Kay, J. - Principal Investigator							360	**$57.87**	$20,832			
	Stanislowski, J. - Res Sci/Eng							480	**$48.96**	$23,500			
	Strege, J. - Res Sci/Eng							480	**$44.14**	$21,187			
	Martin, C. - Res Sci/Eng							240	**$56.27**	$13,504			

Task # and Title	Position Title	Budget Period 1			Budget Period 2			Budget Period 3			Project Total Hours	Project Total Dollars	Rate Basis
		Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 1	Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 2	Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 3			
	Senior Management							55	$120.48	$6,626			
	Research Scientist/Engineer							733	$46.85	$34,341			
	Research Technician							143	$31.63	$4,523			
	Technology Dev Mechanic							0	$38.64	$0			
	Undergrad - Res.							80	$11.87	$950			
	Technical Support Services							209	$28.24	$5,902			
	Total Personnel Costs	**6048**		**$298,619**	**5913**		**$312,687**	**14443**		**$730,505**	**0**	**$1,341,811**	

Additional Explanations/Comments (as necessary)

Salary estimates are based on the scope of work and prior experience on projects of similar scope. The labor rate used for specifically identified personnel is the current hourly rate for that individual. The labor category rate is the average rate of a personnel group with similar job descriptions. Salary costs incurred are based on direct hourly effort on the project. Faculty who work on this project may be paid an amount over the normal base salary, creating an overload which is subject to limitation in accordance with university policy. As noted in the UND EERC Cost Accounting Standards Board Disclosure Statement, administrative salary and support costs which can be specifically identified to the project are direct-charged and not charged as facilities and administrative (F&A) costs. Costs for general support services such as contracts and IP, accounting, human resources, procurement, and clerical support of these functions are charged as F&A costs. Slight rounding differences may occur due to converting EERC's standard budget into DOE format.

b. Fringe Benefits

Labor Type	Budget Period 1			Budget Period 2			Budget Period 3			Total Project Fringe Benefit Costs
	Personnel Costs	Rate	Total	Personnel Costs	Rate	Total	Personnel Costs	Rate	Total	
Regular Staff	296,100	57.00%	$168,777	312,687	57.00%	$178,231	729,555	57.00%	$415,846	$762,854
Undergraduate Student	2,519	1.00%	$25			$0	950	1.00%	$9	$34
			$0			$0			$0	$0
Total:	$298,619		$168,802	$312,687		$178,231	$730,505		$415,855	$762,888

A federally approved fringe benefit rate agreement, or a proposed rate supported and agreed upon by DOE for estimating purposes is required if reimbursement for fringe benefits is requested. Please check (X) one of the options below and provide the requested information. Calculate the fringe rate and the Total should calculate automatically (if adding rows, ensure the formulas are updated).

__X__ A fringe benefit rate has been negotiated with, or approved by, a federal government agency. A copy of the latest rate agreement is included with this application, and will be provided electronically to the Contracting Officer for this project.

______ There is not a current, federally approved rate agreement negotiated and available*.

***When this option is checked, the entity preparing this form shall submit a rate proposal in the format provided at the following website, or a format that provides the same level of information; and the rate proposal must support the rates being proposed for use in performance of the proposed project.**

Additional Explanation/Comments (as necessary)

Fringe benefits consist of two components which are budgeted as a percentage of direct labor. The first component is a fixed percentage approved annually by the UND cognizant audit agency, the Department of Health and Human Services. This portion of the rate covers vacation, holiday, and sick leave (VSL) and is applied to direct labor for permanent staff eligible for VSL benefits. Only the actual approved rate will be charged to the project. The second component is estimated on the basis of historical data and is charged as actual expenses for items such as health, life, and unemployment insurance; social security; worker's compensation; and UND retirement contributions.

c. Travel

Purpose of travel	Depart From	Destination	No. of Days	No. of Travelers	Cost per Traveler	Cost per Trip	Basis for Estimating Costs
Budget Period 1							
Domestic Travel							
Kickoff Meeting	Grand Forks	North Platte	3	2	$1,823	$3,646	All estimates are based on a
Site Visits	Grand Forks	North Platte	3	2	$1,898	$3,796	combination of current quotes
NETL Carbon Capture Technology Meeting	Grand Forks	Pittsburgh, PA	3	2	$1,711	$3,421	from the Internet or travel agency,
Project Review Meeting	Grand Forks	Pittsburgh, PA	3	2	$1,711	$3,421	GSA per diem rates, and UND
Conference	Grand Forks	Unknown	5	1	$3,155	$3,155	travel guidelines and procedures.
						$0	Please see the detailed budget
						$0	and budget notes for more
						$0	information.
Domestic Travel subtotal						$17,439	
International Travel							
						$0	
International Travel subtotal						$0	
Budget Period 1 Total						**$17,439**	
Budget Period 2							
Domestic Travel							
NETL Carbon Capture Technology Meeting	Grand Forks	Pittsburgh, PA	3	2	$1,711	$3,421	
Pilot System Construction / Installation	Grand Forks	North Platte	14	4	$4,549	$18,196	
Shakedown Tests	Grand Forks	North Platte	14	3	$4,316	$12,947	
Conference	Grand Forks	Unknown	5	1	$3,155	$3,155	
						$0	
Domestic Travel subtotal						$37,719	
International Travel							
						$0	
International Travel subtotal						$0	
Budget Period 2 Total						**$37,719**	
Budget Period 3							
Domestic Travel							
End of Project Meeting	Grand Forks	North Platte	3	2	$1,823	$3,646	
NETL Carbon Capture Technology Meeting	Grand Forks	Pittsburgh, PA	3	2	$1,711	$3,421	
Conference	Grand Forks	Unknown	5	2	$3,155	$6,310	
Baseline MEA Parametric Testing - 4 weeks - Lead Operator	Grand Forks	North Platte	14	2	$3,849	$7,698	
Baseline MEA Parametric Testing - 4 weeks - Operator	Grand Forks	North Platte	22	2	$6,477	$12,954	
Baseline MEA Benchmark Testing - 2 weeks - Lead Operator	Grand Forks	North Platte	14	1	$3,849	$3,849	
Baseline MEA Benchmark Testing - 2 weeks - Operator	Grand Forks	North Platte	22	1	$6,477	$6,477	
MEA Testing	Grand Forks	North Platte	14	3	$4,549	$13,647	
ION Testing - Project Manager - 2 trips	Grand Forks	North Platte	7	2	$2,862	$5,724	

Purpose of travel	Depart From	Destination	No. of Days	No. of Travelers	Cost per Traveler	Cost per Trip	Basis for Estimating Costs
ION Testing - Principal Investigator - 4 trips	Grand Forks	North Platte	7	4	$2,862	$11,448	
ION Testing - Principal Investigator - 2 trips	Grand Forks	North Platte	14	2	$4,549	$9,098	
ION Testing - Operator - 14 trips	Grand Forks	North Platte	14	14	$8,398	$117,572	
						$0	
						$0	
Domestic Travel subtotal						$201,844	
International Travel							
						$0	
International Travel subtotal						$0	
Budget Period 3 Total						**$201,844**	
PROJECT TOTAL						**$257,002**	

Additional Explanations/Comments (as necessary)

d. Equipment

Equipment Item	Qty	Unit Cost	Total Cost	Basis of Cost	Justification of need
Budget Period 1					
			$0		
			$0		
Budget Period 1 Total			$0		
Budget Period 2					
Slipstream system	1	$6,000,000	$6,000,000	Vendor Quote	Task 5: The slipstream system is needed to perform testing as stated throughout the proposal.
			$0		
			$0		
			$0		
Budget Period 2 Total			$6,000,000		
Budget Period 3					
			$0		
			$0		
Budget Period 3 Total			$0		
PROJECT TOTAL			**$6,000,000**		

Additional Explanations/Comments (as necessary)

e. Supplies

General Category of Supplies	Qty	Unit Cost	Total Cost	Basis of Cost	Justification of need
			Budget Period 1		
Printer cartridges, paper, folders, data			$0		
storage items directly charged to the project.	1	$3,500.00	$3,500	historical estimate	Items charged directly to the project for use by research staff
			$0		
Aspen Software	1	$40,000.00	$40,000	historical estimate	Portion of software license
			$0		
Budget Period 1 Total			**$43,500**		
			Budget Period 2		
Printer cartridges, paper, folders, data			$0		
storage items directly charged to the project.	1	$2,500.00	$2,500	historical estimate	Items charged directly to the project for use by research staff
			$0		
Temperature thermocouples	1	$7,500.00	$7,500	historical estimate	Supplies needed to support review, installation, construction,
Misc. instrumentation	1	$8,500.00	$8,500	historical estimate	shakedown and analysis as described in the proposal
Support structures - railings, stairs, etc.	1	$3,500.00	$3,500	historical estimate	
Piping, tubing, gaskets	1	$10,250.00	$10,250	historical estimate	
Misc. nuts, bolts clamps, wiring	1	$7,000.00	$7,000	historical estimate	
Valves, pressure gauges	1	$4,500.00	$4,500	historical estimate	
Testing materials	1	$4,500.00	$4,500	historical estimate	
Hardware, gauges	1	$4,500.00	$4,500	historical estimate	
Misc. safety & protection items	1	$1,500.00	$1,500	historical estimate	
Logging instrumentation	1	$3,000.00	$3,000	historical estimate	
			$0		
Budget Period 2 Total			$57,250		
			Budget Period 3		
Printer cartridges, paper, folders, minor			$0		
Computer items directly charged to the project	1	$6,500.00	$6,500	historical estimate	Items charged directly to the project for use by research staff
			$0		
Aspen Software	1	$15,000.00	$15,000	historical estimate	Portion of software license
			$0		
Piping, tubing, gaskets	1	$20,000.00	$20,000	historical estimate	Supplies needed to support review, installation construction,
Chemicals, solutions, glassware, gases	1	$10,500.00	$10,500	historical estimate	shakedown and analysis as described in the proposal
			$0		
			$0		
Budget Period 3 Total			$52,000		
PROJECT TOTAL			**$152,750**		

Additional Explanations/Comments (as necessary)

f. Contractual

Sub-Recipient Name/Organization	Purpose/Tasks in SOPO	Budget Period 1 Costs	Budget Period 2 Costs	Budget Period 3 Costs	Project Total
					$0
					$0
					$0
					$0
	Sub-total	$0	$0	$0	$0

Vendor Name/Organization	Product or Service, Purpose/Need and Basis of Cost (Provide additional support at bottom of page as needed)	Budget Period 1 Costs	Budget Period 2 Costs	Budget Period 3 Costs	Project Total
					$0
					$0
					$0
	Sub-total	$0	$0	$0	$0

FFRDC Name/Organization	Purpose	Budget Period 1 Costs	Budget Period 2 Costs	Budget Period 3 Costs	Project Total
					$0
					$0
					$0
	Sub-total	$0	$0	$0	$0

Total Contractual		$0	$0	$0	$0

AdditionalExplanations/Comments (as necessary)

g. Construction

Overall description of construction actiivities:

General Description	Cost	Basis of Cost	Justification of need
Budget Period 1			
Budget Period 1 Total	**$0**		
Budget Period 2			
Budget Period 2 Total	$0		
Budget Period 3			
Budget Period 3 Total	$0		
PROJECT TOTAL	**$0**		

Additional Explanations/Comments (as necessary)

h. Other Direct Costs

General description	Cost	Basis of Cost	Justification of need
Budget Period 1			
Communications	$500	historical estimate	Long distance telephone, postage
Printing & duplicating	$795	historical estimate	Copies - page rates established annually by university
Food - meetings	$500	historical estimate	Hosted meetings at EERC or on location
Operating Fees - EERC Recharge Centers	$5,611	rates approved annually	Graphics support, shop & operations support
Budget Period 1 Total	$7,406		
Budget Period 2			
Communications	$700	historical estimate	Long distance telephone, postage
Printing & Duplicating	$500	historical estimate	Copies - page rates established annually by university
Operating Fees - EERC Recharge Centers	$5,235	rates approved annually	Graphics support, shop & operations support
Budget Period 2 Total	$6,435		
Budget Period 3			
Communications - long distance, postage	$446	historical estimate	Long distance telephone, postage
Printing & Duplicating - copies	$300	historical estimate	Copies
Operarting Fees - EERC Recharge Centers	$21,298	rates approved annually	Graphics support, shop & operations support
Budget Period 3 Total	$22,044		
PROJECT TOTAL	**$35,885**		

Additional Explanations/Comments (as necessary)

i. Indirect Costs

	Budget Period 1	Budget Period 2	Budget Period 3	Total	Explanation of BASE
Provide ONLY Applicable Rates:					
Overhead Rate	0.0%	0.0%	0.0%		
General & Administrative (G&A)	0.0%	0.0%	0.0%		
FCCM Rate, if applicable	0.0%	0.0%	0.0%		
OTHER Indirect Rate	49.0%	49.0%	49.0%		MTDC
Indirect Costs (As Applicable):					
Overhead Costs	$0	$0	$0	$0	
G&A Costs	$0	$0	$0	$0	
FCCM Costs, if applicable	$0	$0	$0	$0	
OTHER Indirect Costs	$262,525	$290,238	$696,901	$1,249,664	
Total indirect costs requested:	**$262,525**	**$290,238**	**$696,901**	**$1,249,664**	

A federally approved indirect rate agreement, or rate proposed (supported and agreed upon by DOE for estimating purposes) is required if reimbursement of indirect costs is requested. Please check (X) one of the options below and provide the requested information if it has not already been provided as requested, or has changed. Calculate the indirect rate dollars and the totals should calculate automatically.

___X___ An indirect rate has been approved or negotiated with a federal government agency. A copy of the latest rate agreement is included with this application, and will be provided electronically to the Contracting Officer for this project.

______ There is not a current, federally approved rate agreement negotiated and available*.

***When this option is checked, the entity preparing this form shall submit an indirect rate proposal in the format provided at the following website, or a format that provides the same level of information and which will support the rates being proposed for use in performance of the proposed project. Go to http://www.dcaa.mil/ice.htm for sample indirect cost model.**

Additional Explanations/Comments (as necessary)

The F&A rate proposed herein is approved by the U.S. Department of Health and Human Services and is applied to modified total direct costs (MTDC). MTDC is defined as total direct costs less individual capital expenditures, such as equipment or software costing $5000 or more with a useful life of greater than 1 year, as well as subawards in excess of the first $25,000 for each award.

Cost Share

Organization/Source	Type (cash or other)	Cost Share Item	Budget Period 1 Cost Share	Budget Period 2 Cost Share	Budget Period 3 Cost Share	Total Project Cost Share
						$0
						$0
		Totals	$0	$0	$0	$0

Total Project Cost: $9,800,000

Cost Share Percent of Award: 0.0%

Additional Explanations/Comments (as necessary)

OMB Number: 1910-5162
Expiration Date: 01/31/2015

Instructions and Summary

Award Number: ______

Award Recipient: ION Engineering

Date of Submission: ______

Form submitted by: Sub-recipient - The University of Alabama
(May be award recipient or sub-recipient)

SUMMARY OF BUDGET CATEGORY COSTS PROPOSED

CATEGORY	Budget Period 1 Costs	Budget Period 2 Costs	Budget Period 3 Costs	Total Costs	Project Costs %	Comments (Add comments as needed)
a. Personnel	$58,278	$66,695	$70,263	$195,236	**39.6%**	
b. Fringe Benefits	$13,471	$13,471	$12,254	$39,196	**8.0%**	
c. Travel	$8,000	$8,000	$8,000	$24,000	**4.9%**	
d. Equipment	$0	$0	$0	$0	**0.0%**	
e. Supplies	$4,700	$4,650	$4,650	$14,000	**2.8%**	
f. Contractual						
Sub-recipient	$0	$0	$0	$0	*0.0%*	
Vendor	$0	$0	$0	$0	*0.0%*	
FFRDC	$0	$0	$0	$0	*0.0%*	
Total Contractual	$0	$0	$0	$0	**0.0%**	
g. Construction	$0	$0	$0	$0	**0.0%**	
h. Other Direct Costs	$27,787	$30,565	$33,620	$91,972	**18.7%**	
Total Direct Costs	$112,235	$123,381	$128,787	$364,403	$1	
i. Indirect Charges	$39,691	$43,624	$44,728	$128,043	**26.0%**	
Total Project Costs	$151,926	$167,005	$173,515	$492,446	**100%**	

Additional Explanations/Comments (as necessary)

a. Personnel

Task # and Title	Position Title	Budget Period 1			Budget Period 2			Budget Period 3			Project Total Hours	Project Total Dollars	Rate Basis
		Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 1	Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 2	Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 3			
1. Updated modeling for ION solvent				$0			$0			$0	0	$0	
	Prof. Bara (PI)	1	$10,511.00	$10,511	1	$11,565.00	$11,565	1	$12,755.00	$12,754	3	$34,830	
	Graduate Student	5	$2,000.00	$10,000	5	$2,000.00	$10,000	5	$2,000.00	$10,000	15	$30,000	
				$0			$0			$0	0	$0	
				$0			$0			$0	0	$0	
2. Experimental Results from Pilot Operatio													
	Prof. Bara (PI)	1	$10,511.00	$10,511	1	$11,565.00	$11,565	1	$12,755.00	$12,754	3	$34,830	
	Graduate Student	5	$2,000.00	$10,000	5	$2,000.00	$10,000	5	$2,000.00	$10,000	15	$30,000	
3. Final Systems Engineering Analysis													
	Prof. Bara (PI)	0.5	$10,511.00	$5,256	1	$11,565.00	$11,565	1	$12,755.00	$12,755	3	$29,576	
	Graduate Student	6	$2,000.00	$12,000	6	$2,000.00	$12,000	6	$2,000.00	$12,000	18	$36,000	
	Total Personnel Costs	18.5		$58,278	19		$66,695	19		$70,263	0	$195,236	

Additional Explanations/Comments (as necessary)

The time is in months. The University of Alabama personnel do not report their time based on hours. University of Alabama personnel are paid on monthly rates and time worked on research projects is reported in percentages of months.

b. Fringe Benefits

Labor Type	Budget Period 1			Budget Period 2			Budget Period 3			Total Project Fringe Benefit Costs
[redacted]	Personnel Costs	Rate	Total	Personnel Costs	Rate	Total	Personnel Costs	Rate	Total	
Full Time Exempt Staff	34,830	32.00%	$11,146	34,830	32.00%	$11,146	29,576	32.00%	$9,464	$31,756
Graduate Student	30,000	7.75%	$2,325	30,000	7.75%	$2,325	36,000	7.75%	$2,790	$7,440
			$0			$0			$0	$0
Total:	$64,830		$13,471	$64,830		$13,471	$65,576		$12,254	$39,196

A federally approved fringe benefit rate agreement, or a proposed rate supported and agreed upon by DOE for estimating purposes is required if reimbursement for fringe benefits is requested. Please check (X) one of the options below and provide the requested information. Calculate the fringe rate and the Total should calculate automatically (if adding rows, ensure the formulas are updated).

______ **A fringe benefit rate has been negotiated with, or approved by, a federal government agency. A copy of the latest rate agreement is included with this application, and will be provided electronically to the Contracting Officer for this project.**

__X__ **There is not a current, federally approved rate agreement negotiated and available*.**

***When this option is checked, the entity preparing this form shall submit a rate proposal in the format provided at the following website, or a format that provides the same level of information; and the rate proposal must support the rates being proposed for use in performance of the proposed project.**

Additional Explanation/Comments (as necessary)

Fringe benefits were estimated at the rate of 32% for faculty. GRA fringes are 7.70% for summer months plus a set rate of $1357 for insurance. These rates are an estimate of the acutal costs that might be charged, based on an average of UA's actual cost experience.

c. Travel

Purpose of travel	Depart From	Destination	No. of Days	No. of Travelers	Cost per Traveler	Cost per Trip	Basis for Estimating Costs
Budget Period 1							
Domestic Travel							
National Conferences	Birmingham	TBD	4	1	$2,000	$2,000	Internet prices
Project Management Meeting	Birmingham	Boulder, CO	3	1	$1,500	$1,500	Internet prices
Project Management Meeting	Birmingham	Grand Forks, ND	3	1	$1,500	$1,500	Internet prices
Project Management Meeting	Birmingham	Sutherland, NE	3	1	$1,500	$1,500	Internet prices
DOE NETL	Birmingham	Pittsburgh, PA	2	1	$1,500	$1,500	Internet prices
						$0	
Domestic Travel subtotal						$8,000	
International Travel							
						$0	
International Travel subtotal						$0	
Budget Period 1 Total						$8,000	

Purpose of travel	Depart From	Destination	No. of Days	No. of Travelers	Cost per Traveler	Cost per Trip	Basis for Estimating Costs
Budget Period 2							
Domestic Travel							
National Conferences	Birmingham	TBD	4	1	$2,000	$2,000	Internet prices
Project Management Meeting	Birmingham	Boulder, CO	3	1	$1,750	$1,500	Internet prices
Project Management Meeting	Birmingham	Grand Forks, ND	3	1	$1,750	$1,500	Internet prices
Project Management Meeting	Birmingham	Sutherland, NE	3	1	$1,750	$1,500	Internet prices
DOE NETL	Birmingham	Pittsburgh, PA	2	1	$1,500	$1,500	Internet prices
						$0	
Domestic Travel subtotal						$8,000	
International Travel							
						$0	
International Travel subtotal						$0	
Budget Period 2 Total						**$8,000**	
Budget Period 3							
Domestic Travel							
National Conferences	Birmingham	TBD	4	2	$2,000	$2,000	Internet prices
Project Management Meeting	Birmingham	Boulder, CO	3	2	$1,750	$1,500	Internet prices
Project Management Meeting	Birmingham	Grand Forks, ND	3	2	$1,750	$1,500	Internet prices
Project Management Meeting	Birmingham	Sutherland, NE	3	2	$1,750	$1,500	Internet prices
DOE NETL	Birmingham	Pittsburgh, PA	2	2	$1,500	$1,500	Internet prices
						$0	
						$0	
Domestic Travel subtotal						$8,000	
International Travel							
						$0	
International Travel subtotal						$0	
Budget Period 3 Total						**$8,000**	
PROJECT TOTAL						**$24,000**	

Additional Explanations/Comments (as necessary)

d. Equipment

Equipment Item	Qty	Unit Cost	Total Cost	Basis of Cost	Justification of need
			Budget Period 1		
			$0		
			$0		
			$0		
			$0		
			$0		
			$0		
Budget Period 1 Total			$0		
			Budget Period 2		
			$0		
			$0		
			$0		
			$0		
			$0		
			$0		
			$0		
			$0		
			$0		
Budget Period 2 Total			$0		
			Budget Period 3		
			$0		
			$0		
			$0		
Budget Period 3 Total			$0		
PROJECT TOTAL			$0		

Additional Explanations/Comments (as necessary)

e. Supplies

General Category of Supplies	Qty	Unit Cost	Total Cost	Basis of Cost	Justification of need
			Budget Period 1		
Chemicals for testing and analysis	1	$1,500.00	$1,500	Catalog price	Synthesize and mix solvents based on imidazoles and amines
Gases	1	$300.00	$300	Catalog price	Cylinders of gases (CO_2, N_2, O_2, SO_2, etc.) for testing solvent
General laboratory supplies	1	$900.00	$900	Catalog price	gloves, solvents, syringes, items for analytics, etc.
Computer components and software licenses	1	$2,000.00	$2,000	Catalog price	Maintain licenses and purchase software upgrades for higher
			$0		
			$0		
Budget Period 1 Total			**$4,700**		
			Budget Period 2		
Chemicals for testing and analysis	1	$1,500	$1,500	Catalog price	Synthesize and mix solvents based on imidazoles and amines
Gases	1	$250	$250	Catalog price	Cylinders of gases (CO_2, N_2, O_2, SO_2, etc.) for testing solvent
General laboratory supplies	1	$900	$900	Catalog price	gloves, solvents, syringes, items for analytics, etc.
Computer components and software licenses	1	$2,000	$2,000	Catalog price	Maintain licenses and purchase software upgrades for higher
			$0		
			$0		
Budget Period 2 Total			$4,650		
			Budget Period 3		
Chemicals for testing and analysis	1	$1,500.00	$1,500	Catalog price	Synthesize and mix solvents based on imidazoles and amines
Gases	1	$250.00	$250	Catalog price	Cylinders of gases (CO_2, N_2, O_2, SO_2, etc.) for testing solvent
General laboratory supplies	1	$900.00	$900	Catalog price	gloves, solvents, syringes, items for analytics, etc.
Computer components and software licenses	1	$2,000.00	$2,000	Catalog price	Maintain licenses and purchase software upgrades for higher
			$0		
			$0		
			$0		
Budget Period 3 Total			$4,650		
PROJECT TOTAL			**$14,000**		

Additional Explanations/Comments (as necessary)

f. Contractual

Sub-Recipient Name/Organization	Purpose/Tasks in SOPO	Budget Period 1 Costs	Budget Period 2 Costs	Budget Period 3 Costs	Project Total
					$0
					$0
					$0
					$0
	Sub-total	$0	$0	$0	$0

Vendor Name/Organization	Product or Service, Purpose/Need and Basis of Cost (Provide additional support at bottom of page as needed)	Budget Period 1 Costs	Budget Period 2 Costs	Budget Period 3 Costs	Project Total
					$0
					$0
					$0
					$0
	Sub-total	$0	$0	$0	$0

FFRDC Name/Organization	Purpose	Budget Period 1 Costs	Budget Period 2 Costs	Budget Period 3 Costs	Project Total
					$0
					$0
					$0
	Sub-total	$0	$0	$0	$0

Total Contractual		$0	$0	$0	$0

AdditionalExplanations/Comments (as necessary)

g. Construction

Overall description of construction actiivities:

General Description	Cost	Basis of Cost	Justification of need
Budget Period 1			
Budget Period 1 Total	**$0**		
Budget Period 2			
Budget Period 2 Total	$0		
Budget Period 3			
Budget Period 3 Total	$0		
PROJECT TOTAL	**$0**		

Additional Explanations/Comments (as necessary)

h. Other Direct Costs

General description	Cost	Basis of Cost	Justification of need
		Budget Period 1	
Graduate student tuition (1 student)	$27,787	UA current and future rates	1 graduate student to carry out experiments and computations
Budget Period 1 Total	$27,787		
		Budget Period 2	
Graduate student tuition (1 student)	$30,565	UA current and future rates	1 graduate student to carry out experiments and computations
Budget Period 2 Total	$30,565		
		Budget Period 3	
Graduate student tuition (1 student)	$33,620	UA current and future rates	1 graduate student to carry out experiments and computations
Budget Period 3 Total	$33,620		
PROJECT TOTAL	**$91,972**		

Additional Explanations/Comments (as necessary)

Tution is not requested for year 1 since the student is on a fellowship.

i. Indirect Costs

	Budget Period 1	Budget Period 2	Budget Period 3	Total	Explanation of BASE
Provide ONLY Applicable Rates:					
Overhead Rate	0.0%	0.0%	0.0%		The BASE is calculated using Modified
General & Administrative (G&A)	0.0%	0.0%	0.0%		
FCCM Rate, if applicable	0.0%	0.0%	0.0%		
OTHER Indirect Rate	47.0%	47.0%	47.0%		
Indirect Costs (As Applicable):					
Overhead Costs	$0	$0	$0	$0	
G&A Costs	$0	$0	$0	$0	
FCCM Costs, if applicable	$0	$0	$0	$0	
OTHER Indirect Costs	$39,691	$43,624	$44,728		
Total indirect costs requested:	**$39,691**	**$43,624**	**$44,728**	**$128,043**	

A federally approved indirect rate agreement, or rate proposed (supported and agreed upon by DOE for estimating purposes) is required if reimbursement of indirect costs is requested. Please check (X) one of the options below and provide the requested information if it has not already been provided as requested, or has changed. Calculate the indirect rate dollars and the totals should calculate automatically.

______ An indirect rate has been approved or negotiated with a federal government agency. A copy of the latest rate agreement is included with this application, and will be provided electronically to the Contracting Officer for this project.

______ There is not a current, federally approved rate agreement negotiated and available*.

***When this option is checked, the entity preparing this form shall submit an indirect rate proposal in the format provided at the following website, or a format that provides the same level of information and which will support the rates being proposed for use in performance of the proposed project. Go to http://www.dcaa.mil/ice.htm for sample indirect cost model.**

Additional Explanations/Comments (as necessary)

Year 1 - 47% MTDC - Base 120,128 - Total indirect $56,460; Year 2 - 47% MTDC - Base 18,750 - Total indirect 8,813; Year 3 - 47% MTDC - Base 193,050 - Total indirect 90,734 - Total indirect 30,796.

Cost Share

Organization/Source	Type (cash or other)	Cost Share Item	Budget Period 1 Cost Share	Budget Period 2 Cost Share	Budget Period 3 Cost Share	Total Project Cost Share
The University of Alabama	In Kind	The University of Alabama will provide funds to cover the difference of the cost between in-state and out-of-state tuition, and effort of PI in the academic year including salaries, fring benefits and indirect costs	$52,150	$52,149	$52,149	$156,448
						$0
						$0
						$0
						$0
						$0
						$0
						$0
						$0
						$0
		Totals	$52,150	$52,149	$52,149	$156,448

Total Project Cost: $492,446

Cost Share Percent of Award: 31.8%

Additional Explanations/Comments (as necessary)

APPENDIX D

OMB Number: 1910-5162
Expiration Date: 01/31/2015

Instructions and Summary

Award Number: ______________

Award Recipient: ______________

Date of Submission: 2-May-13

Form submitted by: Nebraska Public Power District
(May be award recipient or sub-recipient)

SUMMARY OF BUDGET CATEGORY COSTS PROPOSED

CATEGORY	Budget Period 1 Costs	Budget Period 2 Costs	Budget Period 3 Costs	Total Costs	Project Costs %	Comments (Add comments as needed)
a. Personnel	$50,000	$50,000	$30,000	$130,000	**17.3%**	
b. Fringe Benefits	$17,500	$17,500	$10,000	$45,000	**6.0%**	
c. Travel	$20,000	$10,000	$10,000	$40,000	**5.3%**	
d. Equipment	$5,000	$50,000	$20,000	$75,000	**10.0%**	
e. Supplies	$5,000	$10,000	$10,000	$25,000	**3.3%**	
f. Contractual						
Sub-recipient	$0	$0	$0	$0	*0.0%*	
Vendor	$125,000	$25,000	$25,000	$175,000	*23.3%*	
FFRDC	$0	$0	$0	$0	*0.0%*	
Total Contractual	$125,000	$25,000	$25,000	$175,000	**23.3%**	
g. Construction	$10,000	$50,000	$20,000	$80,000	**10.7%**	
h. Other Direct Costs	$0	$30,000	$150,000	$180,000	**24.0%**	
Total Direct Costs	$232,500	$242,500	$275,000	$750,000	$1	
i. Indirect Charges	$0	$0	$0	$0	**0.0%**	
Total Project Costs	$232,500	$242,500	$275,000	$750,000	**$1**	

Additional Explanations/Comments (as necessary)

a. Personnel

Task # and Title	Position Title	Budget Period 1			Budget Period 2			Budget Period 3			Project Total Hours	Project Total Dollars	Rate Basis
		Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 1	Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 2	Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 3			
1. Task 2.0 Initial Slipstream Project Review				$0							0	$0	
	Lead Engineer	100	$75.00	$7,500							100	$7,500	
	Mechanical Engineer		$75.00	$0							0	$0	
	Electrical engineers		$75.00	$0							0	$0	
	Environmental Engineer		$75.00	$0							0	$0	
2. Task 3.0 Site Selection & Permitting													
	Lead Engineer	100	$75.00	$7,500							100	$7,500	
	Mechanical Engineer	25	$75.00	$1,875							25	$1,875	
	Electrical engineers	25	$75.00	$1,875							25	$1,875	
	Environmental Engineer	160	$75.00	$12,000							160	$12,000	
3. Task 4.0 Final Pilot & System Design													
	Lead Engineer	100	$75.00	$7,500							100	$7,500	
	Mechanical Engineer	50	$75.00	$3,750							50	$3,750	
	Electrical engineers	50	$75.00	$3,750							50	$3,750	
	Environmental Engineer	57	$75.00	$4,250							57	$4,250	
4. Task 5.0 Procure Pilot Plant & Site Equipr													
	Lead Engineer				100	$75.00	$7,500				100	$7,500	
	Mechanical Engineer				100	$75.00	$7,500				100	$7,500	
	Electrical engineers				125	$75.00	$9,375				125	$9,375	
	Environmental Engineer					$75.00	$0				0	$0	
5. Task 6.0 Pilot Plant & Site Construction													
	Lead Engineer				100	$75.00	$7,500				100	$7,500	
	Mechanical Engineer				125	$75.00	$9,375				125	$9,375	
	Electrical engineers				117	$75.00	$8,750				117	$8,750	
	Environmental Engineer					$75.00	$0				0	$0	
6. Task 9.0 Baseline & Solvent Testing													
	Lead Engineer							270	$75.00	$20,250	270	$20,250	
	Mechanical Engineer								$75.00	$0	0	$0	
	Electrical engineers								$75.00	$0	0	$0	
	Environmental Engineer							50	$75.00	$3,750	50	$3,750	
7. Task 12.0 Pilot Decommissioning & Dism													
	Lead Engineer							40	$75.00	$3,000	40	$3,000	
	Mechanical Engineer							15	$75.00	$1,125	15	$1,125	

Task # and Title	Position Title	Budget Period 1			Budget Period 2			Budget Period 3			Project Total Hours	Project Total Dollars	Rate Basis
		Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 1	Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 2	Time (Hours)	Pay Rate ($/Hr)	Total Budget Period 3			
	Electrical engineers							15	$75.00	$1,125	15	$1,125	
	Environmental Engineer							10	$75.00	$750	10	$750	
	Total Personnel Costs	666.667		$50,000	667		$50,000	400		$30,000	0	$130,000	

Additional Explanations/Comments (as necessary)

b. Fringe Benefits

Labor Type	Budget Period 1			Budget Period 2			Budget Period 3			Total Project Fringe Benefit Costs
[redacted]	Personnel Costs	Rate	Total	Personnel Costs	Rate	Total	Personnel Costs	Rate	Total	
Total Personnel	50,000	35.00%	$17,500	50,000	35.00%	$17,500	30,000	33.33%	$10,000	$45,000
			$0			$0			$0	$0
			$0			$0			$0	$0
Total:	$50,000		$17,500	$50,000		$17,500	$30,000		$10,000	$45,000

A federally approved fringe benefit rate agreement, or a proposed rate supported and agreed upon by DOE for estimating purposes is required if reimbursement for fringe benefits is requested. Please check (X) one of the options below and provide the requested information. Calculate the fringe rate and the Total should calculate automatically (if adding rows, ensure the formulas are updated).

______ A fringe benefit rate has been negotiated with, or approved by, a federal government agency. A copy of the latest rate agreement is included with this application, and will be provided electronically to the Contracting Officer for this project.

__X____ There is not a current, federally approved rate agreement negotiated and available*.

***When this option is checked, the entity preparing this form shall submit a rate proposal in the format provided at the following website, or a format that provides the same level of information; and the rate proposal must support the rates being proposed for use in performance of the proposed project.**

Additional Explanation/Comments (as necessary)

NPPD does not have a federally approved rate agreement. NPPD's fringe is their historical fringe for engineers and includes: health, dental, vision and life insurance, 401K plan and significant company contributions to the 401K plan, personal time off and company holidays.

c. Travel

Purpose of travel	Depart From	Destination	No. of Days	No. of Travelers	Cost per Traveler	Cost per Trip	Basis for Estimating Costs
Budget Period 1							
Domestic Travel							
Meeting at ION, Boulder, CO	North Platte	Denver	2	8	$752	$6,016	Internet prices
Meeting at EERC, Grand Forks, ND	North Platte	Grand Forks	2	6	$1,539	$9,234	Internet prices
NETL Carbon Capture Technology Meeting	North Platte	Pittsburgh	4	2	$2,375	$4,750	Internet prices
						$0	
Domestic Travel subtotal						$20,000	
International Travel							
						$0	
International Travel subtotal						$0	
Budget Period 1 Total						**$20,000**	

Purpose of travel	Depart From	Destination	No. of Days	No. of Travelers	Cost per Traveler	Cost per Trip	Basis for Estimating Costs
Budget Period 2							
Domestic Travel							
Meeting at ION, Boulder, CO	North Platte	Denver	2	3	$752	$2,256	Internet prices
Meeting at EERC, Grand Forks, ND	North Platte	Grand Forks	2	2	$1,497	$2,994	Internet prices
NETL Carbon Capture Technology Meeting	North Platte	Pittsburgh	4	2	$2,375	$4,750	Internet prices
						$0	
Domestic Travel subtotal						$10,000	
International Travel							
						$0	
International Travel subtotal						$0	
Budget Period 2 Total						**$10,000**	
Budget Period 3							
Domestic Travel							
Meeting at ION, Boulder, CO	North Platte	Denver	2	3	$752	$2,256	Internet prices
Meeting at EERC, Grand Forks, ND	North Platte	Grand Forks	2	2	$1,497	$2,994	Internet prices
NETL Carbon Capture Technology Meeting	North Platte	Pittsburgh	4	2	$2,375	$4,750	Internet prices
						$0	
Domestic Travel subtotal						$10,000	
International Travel							
International Travel subtotal						$0	
Budget Period 3 Total						**$10,000**	
PROJECT TOTAL						**$40,000**	

Additional Explanations/Comments (as necessary)

d. Equipment

Equipment Item	Qty	Unit Cost	Total Cost	Basis of Cost	Justification of need
Budget Period 1					
Isolation valves for flue gas tie-in to plant	2	$2,500	$5,000	prior invoices	For ultimate connection between pilot and plant - Task 4
			$0		(must be done during plant outage)
			$0		
Budget Period 1 Total			$5,000		
Budget Period 2					
Electrical connections from plant to pilot	1	$15,000	$15,000	estimate based on experience	Necessary to operate pilot - Task 6.1
Water connections from plant to pilot	1	$10,000	$10,000	estimate based on experience	Necessary to operate pilot - Task 6.2
Air connection from plant to pilot	1	$5,000	$5,000	estimate based on experience	Necessary to operate pilot - Task 6.3
Flue gas connections from plant to pilot to plant	1	$20,000	$20,000	estimate based on experience	Necessary to operate pilot - Task 6.4
			$0		
Budget Period 2 Total			$50,000		
Budget Period 3					
Electrical connections from plant to pilot	1	$5,000	$5,000	estimate based on experience	To remove connections from pilot for decomissioning
Water connections from plant to pilot	1	$5,000	$5,000	estimate based on experience	To remove connections from pilot for decomissioning
Air connection from plant to pilot	1	$5,000	$5,000	estimate based on experience	To remove connections from pilot for decomissioning
Flue gas connections from plant to pilot to plant	1	$5,000	$5,000	estimate based on experience	To remove connections from pilot for decomissioning
			$0		
Budget Period 3 Total			$20,000		
PROJECT TOTAL			**$75,000**		

Additional Explanations/Comments (as necessary)

e. Supplies

General Category of Supplies	Qty	Unit Cost	Total Cost	Basis of Cost	Justification of need
Budget Period 1					
Tools, hardware, consumables	1	$5,000.00	$5,000		For plant to slipstream tie-in Task 4
			$0		(must be done during plant outage)
			$0		
Budget Period 1 Total			**$5,000**		
Budget Period 2					
Tools, hardware, consumables	1	$10,000.00	$10,000		For maintenance during solvent testing - Task 9
			$0		
			$0		
Budget Period 2 Total			$10,000		
Budget Period 3					
Tools, hardware, consumables	1	$10,000.00	$10,000		for decommissioning - Task 12
			$0		
			$0		
Budget Period 3 Total			$10,000		
PROJECT TOTAL			**$25,000**		

Additional Explanations/Comments (as necessary)

f. Contractual

Sub-Recipient Name/Organization	Purpose/Tasks in SOPO	Budget Period 1 Costs	Budget Period 2 Costs	Budget Period 3 Costs	Project Total
					$0
	Sub-total	$0	$0	$0	$0

Vendor Name/Organization	Product or Service, Purpose/Need and Basis of Cost (Provide additional support at bottom of page as needed)	Budget Period 1 Costs	Budget Period 2 Costs	Budget Period 3 Costs	Project Total
Sargent & Lundy	NPPD's engineering firm. Involved in design (Task 4.4) permitting (Task 3.2), design (Task 4.4), plant & site construction (Task 6.0), shakedown (Task 7.0), solvent testing (Task 9.0), decomissioning (Task 12)	$125,000	$25,000	$25,000	$175,000
					$0
	Sub-total	$125,000	$25,000	$25,000	$175,000

FFRDC Name/Organization	Purpose	Budget Period 1 Costs	Budget Period 2 Costs	Budget Period 3 Costs	Project Total
					$0
	Sub-total	$0	$0	$0	$0

Total Contractual		$125,000	$25,000	$25,000	$175,000

AdditionalExplanations/Comments (as necessary)

Sargent & Lundy is currently the owner's engineer for NPPD. Average hourly rate is $220.00.

g. Construction

Overall description of construction actiivities:

Prepare host site for installation of slipstream pilot - pliot and tie-ins from power plant

General Description	Cost	Basis of Cost	Justification of need
	Budget Period 1		
Craft labor - electricians, welders, operators	$10,000	Engineering estimates and current labor rates	Scaffolding and labor for electrically operated flue gas tie-ins (Task 4) (need to be done during plant shutdown)
Budget Period 1 Total	**$10,000**		
	Budget Period 2		
Craft labor electricians, welders, operators, pipe fitters	$50,000	Engineering estimates and current labor rates	For pilot plant construction & site construction (Task 6)
Budget Period 2 Total	$50,000		
	Budget Period 3		
Craft labor electricians, welders, operators, pipe fitters	$20,000	Engineering estimates and current labor rates	For decommissioning and dismantle of pilot (Task 12)
Budget Period 3 Total	$20,000		
PROJECT TOTAL	**$80,000**		

Additional Explanations/Comments (as necessary)

h. Other Direct Costs

General description	Cost	Basis of Cost	Justification of need
Budget Period 1			
Budget Period 1 Total	$0		
Budget Period 2			
Utilities (electricity) from host site	$30,000	host site busbar rate @ $27/MWhr	assumes slipstream has 1.0 MW electric steam generator
Budget Period 2 Total	$30,000		
Budget Period 3			
Utilities (electricity) from host site	$150,000	host site busbar rate @ $27/MWhr	assumes slipstream has 1.0 MW electric steam generator
Budget Period 3 Total	$150,000		
PROJECT TOTAL	**$180,000**		

Additional Explanations/Comments (as necessary)

i. Indirect Costs

	Budget Period 1	Budget Period 2	Budget Period 3	Total	Explanation of BASE
Provide ONLY Applicable Rates:					
Overhead Rate	0.0%	0.0%	0.0%		
General & Administrative (G&A)	0.0%	0.0%	0.0%		
FCCM Rate, if applicable	0.0%	0.0%	0.0%		
OTHER Indirect Rate	0.0%	0.0%	0.0%		
Indirect Costs (As Applicable):					
Overhead Costs	$0	$0	$0	$0	
G&A Costs	$0	$0	$0	$0	
FCCM Costs, if applicable	$0	$0	$0	$0	
OTHER Indirect Costs	$0	$0	$0	$0	
Total indirect costs requested:	**$0**	**$0**	**$0**	**$0**	

A federally approved indirect rate agreement, or rate proposed (supported and agreed upon by DOE for estimating purposes) is required if reimbursement of indirect costs is requested. Please check (X) one of the options below and provide the requested information if it has not already been provided as requested, or has changed. Calculate the indirect rate dollars and the totals should calculate automatically.

______ An indirect rate has been approved or negotiated with a federal government agency. A copy of the latest rate agreement is included with this application, and will be provided electronically to the Contracting Officer for this project.

______ There is not a current, federally approved rate agreement negotiated and available*.

***When this option is checked, the entity preparing this form shall submit an indirect rate proposal in the format provided at the following website, or a format that provides the same level of information and which will support the rates being proposed for use in performance of the proposed project. Go to http://www.dcaa.mil/ice.htm for sample indirect cost model.**

Additional Explanations/Comments (as necessary)

NPPD does not have a federally approved indirect rate and is only proposing to charge the project direct costs (including fringe on personnel costs).

Cost Share

Organization/Source	Type (cash or other)	Cost Share Item	Budget Period 1 Cost Share	Budget Period 2 Cost Share	Budget Period 3 Cost Share	Total Project Cost Share
Nebraska Public Power District (NPPD)	In-Kind	NPPD will provide all of the costs in this budget justification up to $750,000 at no cost to the project	$232,500	$242,500	$275,000	$750,000
						$0
		Totals	$232,500	$242,500	$275,000	$750,000

Total Project Cost: $750,000

Cost Share Percent of Award: 100.0%

Additional Explanations/Comments (as necessary)