

**FINANCIAL ASSISTANCE
FUNDING OPPORTUNITY ANNOUNCEMENT**



U. S. Department of Energy

National Energy Technology Laboratory

Bench-Scale and Slipstream Development and Testing of Post-Combustion Carbon Dioxide Capture and Separation Technology for Application to Existing Coal-Fired Power Plants

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Announcement Type: Initial

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Issue Date:	10/13/2009
Letter of Intent Due Date:	Not Applicable
Pre-Application Due Date:	Not Applicable
Application Due Date:	12/03/2009 at 8:00 PM Eastern Time

This Announcement will remain open until the Application Due Date indicated above however, applications may be submitted any time before this Announcement closes.

It is also recommended that application submission begin well in advance (at least 48 hours) of the Announcement closing.

NOTE: REGISTRATION/SUBMISSION REQUIREMENTS

Registration Requirements

There are several one-time actions you must complete in order to submit an application in response to this Announcement (e.g., obtain a Dun and Bradstreet Data Universal Numbering System (DUNS) number, register with the Central Contractor Registration (CCR), and register with FedConnect). Applicants who are not registered with CCR and FedConnect, should allow at least 10 days to complete these requirements. It is suggested that the process be started as soon as possible.

Applicants must obtain a DUNS number. DUNS website: <http://fedgov.dnb.com/webform>.

Applicants must register with the CCR. CCR website: <http://www.ccr.gov/>

Applicants must register with FedConnect to submit their application. FedConnect website: www.fedconnect.net

Questions

Questions relating to the **system requirements or how an application form works** must be directed to Grants.gov at 1-800-518-4726 or support@grants.gov.

Questions regarding the **content** of the announcement must be submitted through the FedConnect portal. You must register with FedConnect to respond as an interested party to submit questions, and to view responses to questions. It is recommended that you register as soon after release of the FOA as possible to have the benefit of all responses. More information is available at <http://www.compusearch.com/products/fedconnect/fedconnect.asp>. DOE/NNSA will try to respond to a question within 3 business days, unless a similar question and answer have already been posted on the website.

Questions pertaining to the **submission** of applications through FedConnect should be directed by e-mail to support@FedConnect.net or by phone to FedConnect Support at 800-899-6665.

Application Preparation and Submission

Applicants must download the application package, application forms and instructions, from Grants.gov. Grants.gov website: <http://www.grants.gov/>
(Additional instructions are provided in Section IV A of this FOA.)

Applicants must submit their application through the FedConnect portal. FedConnect website: www.fedconnect.net
(Additional instructions are provided in Section IV H of this FOA.)

Applicants must apply to one of the specific Areas of Interest (B1; B2; B3; S1; S2; or S3). The required format for the title of the application will be: "Area of Interest [B1; B2; B3; S1; S2; or S3] (Project Title)" See Section IV, C. 1 and 2.

SECTION I - FUNDING OPPORTUNITY DESCRIPTION.....	5
SECTION II - AWARD INFORMATION.....	17
A. TYPE OF AWARD INSTRUMENT.....	17
B. ESTIMATED FUNDING	17
C. MAXIMUM AND MINIMUM AWARD SIZE	17
D. EXPECTED NUMBER OF AWARDS.....	17
E. ANTICIPATED AWARD SIZE	17
F. PERIOD OF PERFORMANCE	17
G. TYPE OF APPLICATION.....	17
A. ELIGIBLE APPLICANTS.....	19
B. COST SHARING.....	19
• PERFORMANCE OF WORK IN UNITED STATES	20
SECTION IV - APPLICATION AND SUBMISSION INFORMATION.....	21
A. ADDRESS TO REQUEST APPLICATION PACKAGE.....	21
B. LETTER OF INTENT AND PRE-APPLICATION	21
1. LETTER OF INTENT.....	21
2. PRE-APPLICATION.....	21
NOT REQUIRED.....	21
C. CONTENT AND APPLICATION FORMS.....	21
1. SF 424 (R&R)	21
2. RESEARCH AND RELATED OTHER PROJECT INFORMATION.....	21
6. PROJECT/PERFORMANCE SITE LOCATION(S)	28
D. SUBMISSIONS FROM SUCCESSFUL APPLICANTS.....	30
E. SUBMISSION DATES AND TIMES.....	30
PRE-APPLICATION DUE DATE: NONE REQUIRED.....	30
F. INTERGOVERNMENTAL REVIEW.....	30

G. FUNDING RESTRICTIONS	30
H. OTHER SUBMISSION AND REGISTRATION REQUIREMENTS.....	31
1. WHERE TO SUBMIT	31
FEDCONNECT	31
2. REGISTRATION PROCESS.....	31
SECTION V - APPLICATION REVIEW INFORMATION	32
A. CRITERIA.....	32
1. INITIAL REVIEW CRITERIA	32
2. MERIT REVIEW CRITERIA.....	32
B. REVIEW AND SELECTION PROCESS	33
1. MERIT REVIEW.....	33
2. SELECTION.....	33
3. DISCUSSIONS AND AWARD.....	33
C. ANTICIPATED NOTICE OF SELECTION AND AWARD DATES.....	33
SECTION VI - AWARD ADMINISTRATION INFORMATION.....	34
A. AWARD NOTICES.....	34
1. NOTICE OF SELECTION.....	34
2. NOTICE OF AWARD.....	34
B. ADMINISTRATIVE AND NATIONAL POLICY REQUIREMENTS.....	34
1. ADMINISTRATIVE REQUIREMENTS	34
2. SPECIAL TERMS AND CONDITIONS AND NATIONAL POLICY REQUIREMENTS	34
C. REPORTING	35
SECTION VII - QUESTIONS/AGENCY CONTACTS.....	36
A. QUESTIONS	36
B. AGENCY CONTACT.....	36

SECTION I - FUNDING OPPORTUNITY DESCRIPTION

Under Statutory Authority of Public Law 95-91 DOE Organization Act, as amended by Public Law 109-58 Energy Policy Act 2005

BACKGROUND

Coal-fired utility boilers generate over 50% of the electricity in the United States. The DOE Energy Information Agency (EIA) projects that the more than 300 GW of coal-fired electricity generating capacity currently in operation will increase to nearly 335 GW by 2030 with only about 3 GW of existing coal-fired plants being retired.¹ Therefore, for the foreseeable future coal will continue to play a critical role in powering the Nation's electricity generation, especially for base-load power plants.

Coal-fired power plants have made significant progress in reducing emissions of sulfur dioxide (SO₂), nitrogen oxide, particulate matter, and recently mercury, since the passage of the Clean Air Act. However, on the near horizon is the possibility for new regulations requiring a reduction in carbon dioxide (CO₂) emissions. Greenhouse gases such as CO₂ have increased over the past century and have been linked to increasing global temperatures. The amount of CO₂ produced from the combustion of fossil fuels in the United States will reach nearly 5.7 billion metric tons in 2009 according to EIA, with about 33% coming from the coal-fired electric power sector.²

In order to address these issues, the Department of Energy's Innovations for Existing Plants Program has been investigating technologies to capture CO₂ from coal-fired power plant flue gas for beneficial use or sequestration of CO₂. The details of the program objectives, projects, and status can be found through the National Energy Technology Laboratory's Innovations for Existing Plants website:
<http://www.netl.doe.gov/technologies/coalpower/ewr/index.html>

OBJECTIVES

This Funding Opportunity Announcement (FOA) is specifically focused on developing technologies for CO₂ capture and purification that can be retrofitted to existing pulverized coal (PC) power plants. This is driven by the fact that existing coal-fired power plants produce a large fraction of the current CO₂ emissions from all fossil-fuel-based sources, and only about 3 GW of the existing coal-fired fleet is projected to retire by 2030. Therefore, it is possible that future climate change regulations could target a reduction in CO₂ emissions from the existing fleet of coal boilers. To prepare for this possibility, cost effective technologies are sought for capturing CO₂ from PC-based power plants. It is anticipated that the technologies developed under this funding opportunity may also have application to new PC plants as well.

Applications are sought for bench-scale development and testing; and slipstream development and testing of advanced post-combustion CO₂ capture technologies. The overall technical and cost goal of this FOA is the development of advanced CO₂ capture and separation technologies that can achieve at least 90% CO₂ removal from the flue gas stream at no more than a 35% increase in cost of electricity (COE) produced at the plant.³ A detailed background on this target can be found on the National Energy

¹ Annual Energy Outlook 2009, Report #:DOE/EIA-0383(2009)

² Annual Energy Outlook 2009, Report #:DOE/EIA-0383(2009)

³ The cost component includes not only the costs associated with CO₂ capture, regeneration, and compression, but also includes CO₂ transportation, storage, and monitoring costs. It should be assumed that the CO₂ will be transported no more than 50 miles from the power plant and would be stored in a saline formation. In a typical CO₂ capture system analysis, the transportation, storage and monitoring costs represent about 4% of the increase in cost of energy services. Therefore, applicants should consider all costs in demonstrating that the proposed technology can achieve the 35% or below cost target.

Technology Laboratory's Innovations for Existing Plants website:
<http://www.netl.doe.gov/technologies/coalpower/ewr/co2/goals.html>

Carbon dioxide capture systems can be divided into three general categories: post-combustion, pre-combustion, and oxy-combustion/chemical looping. This FOA is focusing on post-combustion CO₂ capture for existing PC boilers. Pre-combustion CO₂ capture, oxy-combustion/chemical looping, biological capture, and CO₂ compression projects are **NOT** being sought under this Announcement. Any commercially available CO₂ capture technologies that do not meet the DOE goal of no more than 35% increase in COE are **NOT** being sought under this Announcement.

Specifically, applications are sought in the following Areas of Interest:

Bench-Scale Development and Testing of Post-combustion CO₂ Capture

- Area of Interest B1: Membranes
- Area of Interest B2: Solvents
- Area of Interest B3: Condensed Phase Capture

Slipstream Development and Testing of Post-combustion CO₂ Capture

- Area of Interest S1: Membranes
- Area of Interest S2: Solvents
- Area of Interest S3: Solid Sorbents

A description of technical requirements for applications submitted in each Area of Interest under the subject announcement is provided below. If an applicant wishes to apply under multiple Areas of Interest, a separate and complete application will be required for each Area of Interest submittal, with no need for application reviewers to refer to another application.

Note: It is anticipated that some Applicants may wish to submit proposals for “hybrid” technologies, combining two or more of the areas of interest listed above (examples of which might be the use of membrane contactors in solvent capture systems, solutions combining aspects of solvents and adsorption, phase change, and others). Such submissions are encouraged, and Applicants should consider submitting such applications under the individual Area of Interest corresponding to the more novel of the integrated technologies.

Applicants must apply to one of the specific Areas of Interest (B1; B2; B3; S1; S2; or S3). The required format for the title of the application will be: “Area of Interest [B1; B2; B3; S1; S2; or S3] (Project Title)” See Section IV, C. 1 and 2.

AREAS OF INTEREST

Bench-Scale Development and Testing of Post-combustion CO₂ Capture:

General Requirements

Applications for bench-scale development and testing of post-combustion CO₂ capture shall describe the current level of performance of the proposed technology relative to both CO₂ capture removal efficiency and cost, and the approach to achieving DOE's performance goal. To adequately provide application reviewers a clear understanding of the proposed process and project, **all applications must include** a process or block flow diagram (.PDF file legible at 8.5 inches by 11 inches) and a corresponding process description that clearly describes the proposed bench-scale facility and how the proposed capture process could be cost-effectively integrated along with related CO₂ capture and compression systems into a pulverized coal-fired power plant.

Applications will also be required to provide information relevant to the Area of Interest specific

challenges and requested parameters below. Any data or estimates provided should be supported by citations to previous work performed by the applicant or others, or by example calculations. Numerical values provided should be expressed in *Système International* (SI) units unless otherwise noted.

In addressing this information, the applicant may not have definitive answers to all of these questions. However, they must demonstrate a thorough understanding of the technology being proposed and a sufficient understanding of its applicability to CO₂ capture from PC power plants. This knowledge is considered a necessity for justifying claims relevant to the potential performance of the technology.

Deliverables for bench-scale projects shall include topical reports on project results and the technical and economic feasibility of advancing to subsequent Budget Period(s) of the proposed project. The final Scientific/Technical Report shall include documentation of project results and their significance, systems analyses and benefits, the technical and economic feasibility of scaling up the technology, and the recipient's recommendations for future R&D. Additional deliverables will be required as discussed in Part IV, Section C of this Funding Opportunity Announcement.

Area of Interest B1 – Membranes:

Membrane-based capture uses semi-permeable materials that allow for the selective transport and separation of CO₂ from flue gas. Key technical challenges to the use of membranes to capture CO₂ from coal-fired power plant flue gas include: (1) high flue gas volumetric flow rates; (2) relatively low CO₂ concentration (less than 15% by volume); (3) relatively high purity required for captured CO₂ (greater than 95%); (4) low flue gas feed pressure (i.e., small driving force); (5) even lower permeate gas outlet pressure relative to the required CO₂ delivery pressure; (6) presence of flue gas contaminants (e.g., SO₂, trace elements, residual fly ash, moisture); and (7) the need to minimize the size and cost of the membrane for this large-scale application. Any commercially available CO₂ capture technologies that do not meet the DOE goal of no more than 35% increase in COE are **NOT** being sought under this Announcement.

Key Parameters

Mechanism

- Membrane transport mechanism

Performance

- Membrane characteristics and CO₂ permeance (in GPU - Gas Permeance Units) and selectivity relative to N₂, H₂O, and other gases present in the flue gas stream under realistic operating conditions, including anticipated effects of:
 - Variations in flue gas temperature
 - Gas component interactions
 - Flue gas contaminants (e.g., SO_x, Ar, chlorides, etc.) and water
 - Membrane aging

System Characteristics

- Description of the prospective membrane module (i.e. scale-up), including but not limited to:
 - Expected membrane packing density (membrane area per unit volume)
 - Expected pressure drop on both sides of the membrane under normal operating conditions
 - Mechanical integrity (maximum allowable pressure differential across membrane, and limitations of the “weak link,” an example of which could be seals)
- Process information, including:
 - Expected operating temperatures for the process
 - Special materials of construction for the bench-scale system
 - Other material and energy requirements for operation of blowers; compressors; vacuum

- pumps; circulation pumps; heating, cooling, and refrigeration equipment; etc.
- Useful life and life-limiting factors for the membrane and other system components
- Any wastes that might be generated by the membrane system

Cost/Feasibility

- Rough estimate of materials and manufacturing costs of a membrane module in \$/m²
- Impact on plant performance and the cost of electricity

Area of Interest B2 – Solvents:

Solvent-based systems, typically employing amine-based chemical solvents, are in commercial use for scrubbing CO₂ from industrial flue and process gases. However, solvent-based systems have not been applied for removing large volumes of CO₂ as would be encountered in flue gas from a PC-fired utility boiler. Key technical challenges to the use of solvent-based systems to capture CO₂ from coal-fired power plant flue gas include: (1) high flue gas volumetric flow rate; (2) relatively low CO₂ concentration (less than 15% by volume) (3) presence of flue gas contaminants (e.g., SO₂, trace elements, residual fly ash); and (4) high parasitic steam and power demands for solvent recovery. Any commercially available CO₂ capture technologies that do not meet the DOE goal of no more than 35% increase in COE are **NOT** being sought under this Announcement.

Due to the mature nature of gas absorption technology, applicants must provide as complete as possible picture of the proposed technology so that it may be directly compared against existing physical and chemical solvent-based systems.

Key Parameters

Mechanism

- For chemical solvents, kinetic data for CO₂ absorption/regeneration cycle, including:
 - Pertinent chemical reactions
 - Kinetic data: rate expressions, constants and activation energies
 - If reactions are slow, applicant should discuss approaches to accelerate the reactions

Performance

- Solvent characteristics
 - Theoretical maximum capacity (mass of CO₂ per mass of solvent), actual measured working capacity, and target capacity, with approaches to reaching the target*Theoretical solvent regeneration energy (per mass of CO₂ removed), actual laboratory-measured regeneration energy and target
 - Regeneration energy data as a function of working capacity

System Characteristics

- Physical properties for pure solvent or components of mixed solvents
 - Composition of Mixed Solvents
 - Molecular Weight
 - Boiling Point
 - Heat Capacity
 - Density
 - Viscosity
 - Surface Tension
- Chemical and thermal stability of the solvent
 - Experimental data on the chemical stability of the solvent under realistic flue gas and regeneration conditions
 - Degradation pathways for the solvent, supported by experimental studies
 - Corrosion testing data

- Solvent toxicity data
- Estimated solvent make-up rate due to degradation and solvent loss
- Process information, including:
 - Expected operating temperatures for absorption/stripping processes
 - Steam requirements for CO₂ stripping (energy per mass of CO₂ captured)
 - Special materials of construction for the bench-scale system
 - Other material and energy requirements for operation of blowers; compressors; vacuum pumps; circulation pumps; heating, cooling, and refrigeration equipment; etc.
 - Useful life and life-limiting factors for the solvent and other system components
 - Any wastes that might be generated by the solvent system

Cost/Feasibility

- Estimate of anticipated cost/price and commercial availability of solvent and any other materials (e.g., column packing)
- Impact on plant performance and the Cost of Electricity

Area of Interest B3 – CO₂ Condensed-Phase Capture:

Cooling and condensation can be used as a means of separating CO₂ and other flue-gas components from N₂. For example, at 1 and 10 atmospheres (atm) of pressure pure CO₂, SO₂, NO, N₂ and H₂O will condense at the following temperatures:

Condensation Temperature of Flue-Gas Components⁴

°C (°F)

Pure Gas		1 atm	10 atm
H ₂ O	(gas→liq)	100 (212)	181 (358)
SO ₂	(gas→liq)	-10 (14)	57 (135)
CO ₂	(gas →liq)**	-78.5 (-109)	-40 (-40)
NO	(gas→liq)	-152 (-242)	-124 (-191)
N ₂	(gas→liq)	-196 (-320)	-169 (-272)

** sol @ 1 atm; liq @ 10 atm

In a mixture, these gases will condense out as component enriched mixtures over a range of temperatures; however, fractionation schemes can be designed resulting in the recovery of gas components as nearly pure streams. Solid-liquid-vapor thermodynamic equilibrium data and models can be used to establish design pressures and temperatures to achieve this separation. Cooling to near-cryogenic temperatures may be achieved through the use of an external refrigeration system, through isentropic or isenthalpic expansion of pressurized flue gas, or by other means. Multiple process options are possible for separating the condensed solid or liquid CO₂ from the gaseous N₂. Desirable characteristics of this approach to separating and recovering CO₂ are: (1) the resulting high-purity CO₂ stream may be pumped up to the required sequestration pressure (2,200 psi) as a liquid. A process requiring substantially less energy than systems employing CO₂ gas compression only, and (2) the need to deliver the CO₂ for transportation at very high-pressure enables synergistic opportunities for integrating

⁴ Steam, 40th Edition, Chapter 2—Thermodynamics of Steam, Babcock & Wilcox, 1992
<http://encyclopedia.airliquide.com>

compression and expansion systems to minimize parasitic energy requirements. Any commercially available CO₂ capture technologies that do not meet the DOE goal of no more than 35% increase in COE are **NOT** being sought under this Announcement.

Key technical challenges to CO₂ condensed-phase capture include: (1) minimizing compression requirements for flue gas prior to CO₂ capture; (2) maximizing recovery of energy from refrigeration and cooling; (3) effects of acid gases (corrosion) and flue gas moisture (icing) on refrigeration coils; (4) separating solid and/or liquid phases from the continuous gas phase; (5) achieving high purities and recoveries of CO₂ and other contaminants.

Key Parameters

Mechanism

- Description of thermodynamic principles employed in the process, including proposed operating pressures and temperatures

Performance

- Purity of CO₂ produced or additional systems required to achieve desired CO₂ purity
- Refrigeration or cooling load required

System Characteristics

- Description of equipment used in the separation process, including any special equipment used to:
 - Achieve the condensation of CO₂ and other flue gas components as applicable
 - Separate condensed CO₂ from N₂-rich flue gas
 - Liquefy the CO₂ and pump it up to CO₂ transport pressures
- Process information, including:
 - Expected operating temperatures for the process
 - Special materials of construction for the bench-scale system
 - Other material and energy requirements for operation of blowers; compressors; vacuum pumps; circulation pumps; heating, cooling, and refrigeration equipment; etc.
 - Useful life and life-limiting factors for system components
 - Any wastes that might be generated by the CO₂ capture system

Cost/Feasibility

- Estimate of cost of any non-commercial equipment employed in the process
- Impact on plant performance and the Cost of Electricity

Slipstream Development and Testing of Post-combustion CO₂ Capture (Utilizing actual flue gas)

General Requirements

Applications for the post-combustion slipstream category shall propose development and slip stream testing of CO₂ capture and separation technology using actual flue gas from an existing pulverized coal-fired power station boiler or combustion research facility burning domestic (produced in the U.S.) coal. The minimum slipstream capacity shall be equivalent to 0.5 MWe. The performance testing period shall be a minimum of 2 months at steady-state conditions (i.e., after an appropriate shake-down period). Applications shall demonstrate a thorough understanding of the technology being proposed. Applications shall describe the current level of performance of the proposed technology relative to both CO₂ capture removal efficiency and cost and the approach to achieving the Existing Plants program goal described under objectives above. The application shall provide information relevant to overcoming the technical challenges in achieving the DOE goal described under Objectives, above. Applications shall also demonstrate understanding of upstream and downstream power plant processes and interface requirements for ultimate development and optimized operation of integrated CO₂ capture and compression systems. All slipstream applications **must include**:

Projected technology benefits at a commercial-scale power plant.

1. Results from a detailed systems and economic analysis based on integrating the proposed CO₂ capture technology (using laboratory-scale research data) at 90% CO₂ capture and compression to 2,200 Psi into a commercial-scale (550 MWe) pulverized coal power plant. This section must include:

The technical and environmental performance of the technology,

- a. design basis and plant description
- b. block flow and process flow diagrams (8.5 inches by 11 inches) clearly showing how the proposed CO₂ capture process is integrated into the pulverized coal power plant
- c. component descriptions
- d. stream table
- e. energy balance
- f. mass balance
- g. carbon balance
- h. sulfur balance
- i. water balance
- j. technical performance assessment (e.g., efficiency, effective thermal efficiency, feedstock requirements, product outputs, parasitic loads, etc.)
- k. environmental performance assessment (e.g., air emissions, characterization of any liquid or solid waste streams)
- l. estimated footprint area including CO₂ compression train

The economic performance of the technology,

- a. estimation of capital cost, including contingencies as appropriate
- b. estimation of operating and maintenance costs
- c. estimation of \$/tonne CO₂ captured, \$/tonne CO₂ avoided
- d. estimation of the first-year cost of electricity (COE) and thirty-year levelized COE using a capital charge factor computation
- e. estimation of the percent increase in cost of electricity relative to the non-CO₂ capture reference PC power plant. The non-CO₂ capture reference PC power plant is Case 9 of the "Bituminous Baseline Study" (Cost and Performance Baseline for Fossil Energy Plants, DOE/NETL-2007/1281, May 2007) can be downloaded at:
<http://www.netl.doe.gov/technologies/coalpower/ewr/co2/goals.html>).

Proposed carbon dioxide pilot-scale process

2. Carbon dioxide capture process description to provide application reviewers a clear understanding of the proposed carbon dioxide capture process and project from technical, cost efficiency, and integrated systems functional perspectives. At a minimum, the description shall include the following:
 - a. A discussion on the current technology status and the extent of laboratory-scale testing and systems design development. Discussion should include the duration of testing indicating ideal or real flue gas conditions.
 - b. A discussion based on findings to date regarding the scalability and feasibility to progress from slipstream to full-scale development (time to commercialization) and ultimate commercial deployment in the targeted market sector.
 - c. Preliminary mass and energy balances for the proposed slip-stream process, with a discussion of how electrical consumption, heat, water, and waste will be managed in the proposed project. Applications shall identify any integrated energy and water conservation measures that would be cost-effective for the immediate project vs. those that might be economically justified over a longer term. For example, waste heat could be utilized by (1) providing heat to other processes (e.g., feed water heating, Organic Rankine Cycle, Stirling engine, etc.), or (2) recovering and using heat from other sources such as flue gas, low quality steam, or CO₂ compressors. (The information requested here, should be provided in units consistent with National Energy Technology Laboratory (NETL) engineering systems reporting; see http://www.netl.doe.gov/energy-analyses/pubs/Bituminous%20Baseline_Final%20Report.pdf)
 - d. A discussion of assumed inlet conditions and expected outlet conditions for start-up, steady-state operation, and shut-down of the proposed process (e.g. gas composition, particulate concentration, temperature, pressure, CO₂ product purity, etc.); illustrating the capability to cost-effectively integrate with upstream and downstream processes in the flue gas path between a coal-fired boiler and CO₂ compression system. Although CO₂ compression and storage are not requested for the slipstream projects, applications must demonstrate that the proposed CO₂ capture process output quality and conditions will be suitable for cost-effective compression and transport of CO₂ without adversely affecting CO₂ compressors, pipelines, and geologic sequestration strata.
 - e. A discussion of any Computational Fluid Dynamics (CFD) modeling to be used for process/project design.
 - f. A discussion of protocols, reference methods, measurements, and quality assurance for baseline and performance testing.
 - g. Applications will also be required to provide relevant information to the Area of Interest specific challenges and requested parameters below. Any data or estimates provided should be supported by citations to previous work performed by the applicant or others, or by example calculations. Numerical values provided should be expressed in SI units unless otherwise noted.

Budget Periods shall not exceed 18 months, with Go/ No Go decisions to advance to subsequent Budget Periods. Deliverables for slipstream projects shall include topical reports on project results and the technical and economic feasibility of advancing to subsequent Budget Period(s) of the proposed project. The Final Scientific/Technical report shall include documentation of project results and their significance;

systems analysis for integration of CO₂ capture/separation and compression within an existing power plant, with cost-effective management of heating and cooling energy and water; expected system benefits; and the technical and economic feasibility of scaling up the technology for a full-scale field test. Additional deliverables will be required as discussed in Part IV, Section C of this Funding Opportunity Announcement.

Area of Interest S1 – Membranes:

Membrane-based capture uses semi-permeable materials that allow for the selective transport and separation of CO₂ from flue gas. Key technical challenges to the use of membranes to capture CO₂ from coal-fired power plant flue gas include: (1) high flue gas volumetric flow rates; (2) relatively low CO₂ concentration (less than 15% by volume); (3) relatively high purity required for captured CO₂ (greater than 95%); (4) low flue gas feed pressure (i.e., small driving force); (5) even lower permeate gas outlet pressure relative to the required CO₂ delivery pressure; (6) presence of flue gas contaminants (e.g., SO₂, trace elements, residual fly ash); and (7) the need to minimize the size and cost of the membrane for this large-scale application. Any commercially available CO₂ capture technologies that do not meet the DOE goal of no more than 35% increase in COE are **NOT** being sought under this Announcement.

Key Parameters

Mechanism

- Membrane transport mechanism

Performance

- Membrane characteristics and CO₂ permeance (in GPU - Gas Permeance Units) and selectivity relative to N₂, H₂O and other gases present in the flue gas stream under realistic operating conditions, including anticipated effects of:
 - Variations in flue gas temperature
 - Gas component interactions
 - Flue gas contaminants (e.g., SO_x, Ar, chlorides, etc.) and water
 - Membrane aging

System Characteristics

- Description of the proposed membrane module, including but not limited to:
 - Expected membrane area packing density (membrane area per unit volume)
 - Expected pressure drop on both sides of the membrane under normal operating conditions
 - Mechanical integrity (maximum allowable pressure differential across membrane)
 - Useful life and life-limiting factors for components
- Process information
 - Pretreatment requirements, if any
 - Heating and/or cooling requirements
 - Special materials of construction for the system
 - Electrical power requirements and other energy requirements for operation of blowers, compressors, vacuum and other pumps, heating/cooling, and other equipment
 - Any wastes that might be generated by the membrane system

Business and Financial Commitment

- Vendor commitment letters describing manufacturing capabilities, pricing of modules to be used in the project along with long-term projected costs of mass produced modules, estimated useful life of membranes, commercial terms, and commitment to deliver to the host site the type and quantity of membrane modules required for the proposed slipstream test.

Area of Interest S2 – Solvents:

Solvent-based systems, typically using amine-based chemical solvents, are in commercial use in scrubbing CO₂ from industrial flue and process gases. However, solvent-based systems have not been applied to removing large volumes of CO₂ as would be encountered in a PC-fired utility boiler flue gas. Key technical challenges to solvent-based systems for capturing CO₂ from coal-fired power plants include (1) high flue gas volumetric flow rate; (2) relatively low CO₂ concentration (less than 15% by volume); (3) presence of flue gas contaminants (e.g., SO₂, trace elements, residual fly ash); and (4) high parasitic steam and power demands for solvent recovery. Any commercially available CO₂ capture technologies that do not meet the DOE goal of no more than 35% increase in COE are **NOT** being sought under this Announcement.

Key Parameters

Mechanism

- For chemical solvents, kinetic data for CO₂ absorption/regeneration cycle, including:
 - Pertinent chemical reactions
 - Kinetic data: rate expressions, constants and activation energies

Performance

- Solvent characteristics
 - Theoretical maximum capacity (mass of CO₂ per mass of solvent), actual measured working capacity, and target capacity, with approaches to reaching the target
 - Theoretical solvent regeneration energy (per mass of CO₂ removed), actual laboratory measured regeneration energy and target
 - Regeneration energy data as a function of working capacity

System Characteristics

- Physical properties
 - Molecular Weight
 - Boiling Point
 - Heat Capacity
 - Density
 - Viscosity
 - Surface Tension
- Chemical and thermal stability of the solvent
 - Experimental data on the chemical stability of the solvent under realistic flue gas and regeneration conditions
 - Degradation pathways for the solvent, supported by experimental studies
 - Corrosion testing data
 - Solvent toxicity data
 - Useful life of solvent
 - Estimated solvent make-up rate due to degradation and solvent loss
- Process information, including:
 - Expected operating temperatures for absorption/stripping processes
 - Anticipated absorber and stripper designs
 - Approach taken for heat removal in the absorber
 - Steam requirements for CO₂ stripping (energy per mass of CO₂ captured)
 - Other heating and/or cooling requirements
 - Special materials of construction for the system
 - Electrical power requirements and other energy requirements for operation of solvent circulation pumps, heating/cooling, and other equipment
 - Useful life and life-limiting factors for components
 - Any wastes that might be generated by the solvent system

Business and Financial Commitment

- Vendor commitment letters describing solvent, manufacturing capabilities, pricing of solvent to be used in the project along with long-term projected costs of mass produced solvent, commercial terms, and commitment to deliver to the host site the type and quantity of solvent required for the proposed slipstream test

Area of Interest S3 – Solid Sorbents:

Solid particles can be used to capture CO₂ from flue gas through chemical absorption, physical adsorption, or a combination of the two effects. Possible configurations for contacting the flue gas with the solid particles include fixed, moving, and fluidized beds. Key technical challenges to sorbent-based systems for capturing CO₂ from coal-fired power plants include: (1) high flue gas volumetric flow rate; (2) relatively low CO₂ concentration (less than 15% by volume); (3) presence of flue gas contaminants (e.g., SO₂, trace elements, residual fly ash, moisture); and (4) high parasitic power demand for sorbent recovery. Solid sorbents used for flue gas CO₂ capture must be capable of having high CO₂ loading capacities while being able to maintain particle performance in the presence of flue gas contaminants. Any commercially available CO₂ capture technologies that do not meet the DOE goal of no more than 35% increase in COE are **NOT** being sought under this Announcement.

Key Parameters

Mechanism

- For chemisorption, kinetic data for CO₂ adsorption/desorption cycle, including:
 - Pertinent chemical reactions
 - Kinetic data: rate expressions, constants and activation energies

Performance

- Sorbent characteristics
 - Theoretical maximum capacity (moles of CO₂ per mass of sorbent), actual measured working capacity, and future target capacity. Working capacity is defined as the difference between the “loaded sorbent” at breakthrough and the sorbent after regeneration; measured at steady-state when cycling between CO₂ absorption and CO₂ regeneration.
 - Adsorption capacity after repeated adsorption/desorption cycles
 - Effect of flue gas contaminants (Hg, NO_x, SO_x, particulate matter) including water vapor if adsorbed
 - Measured heats of adsorption and desorption (per mass of CO₂ removed)
 - Breakthrough curves at expected operating temperatures and pressures

System Characteristics

- Other physical properties
 - True and Packing density
 - Particle Size, Shape and Surface Area
 - Heat Capacity
 - Mechanical Strength
- Chemical and thermal stability of the sorbent, including the following:
 - Experimental data on the chemical stability of the sorbent under realistic flue gas and regeneration conditions
 - Degradation pathways for the sorbent, supported by experimental studies.
 - Sorbent toxicity data
 - Useful life of sorbent
 - Estimated sorbent make-up rate due to degradation and loss
- Process information, including:

- Expected operating temperatures for adsorption/desorption processes
- Proposed configuration for contacting the flue gas with the sorbent
- For fixed-beds, include expected regeneration time
- Approach taken for heat removal in the adsorber
- Sorbent attrition or agglomeration; how sorbent fines will be handled
- Volume of sorbent required for the process; the physical size of facilities to unload, store, reclaim, and utilize the sorbent; and material handling and safety considerations
- Heating and cooling requirements
- Special materials of construction for the system
- Electrical energy requirements and other energy requirements for operation of heating/cooling and other equipment
- Useful life and life-limiting factors for components

Business and Financial Commitment

- Vendor commitment letters describing sorbent, manufacturing capabilities, pricing of sorbent to be used in the project along with long-term projected costs of mass produced sorbent, commercial terms, and commitment to deliver to the host site the type and quantity of sorbent required for the proposed slipstream test.

SECTION II - AWARD INFORMATION

A. TYPE OF AWARD INSTRUMENT

DOE anticipates awarding cooperative agreements under this program announcement (See Section VI, B.2, Statement of Substantial Involvement).

B. ESTIMATED FUNDING

Approximately \$55,000,000 (DOE) is expected to be available for new awards under this Announcement.

After selections have been made and awards negotiated, Recipients will be responsible for any cost overruns that may occur during the performance of the project.

C. MAXIMUM AND MINIMUM AWARD SIZE

- Ceiling (i.e., the maximum amount for an individual award made under this Announcement):

For Bench-Scale - \$ 3,000,000 (DOE)

For Slipstream - \$12,000,000 (DOE)

- Floor (i.e., the minimum amount for an individual award made under this Announcement):
\$500,000 (DOE)

D. EXPECTED NUMBER OF AWARDS

- Bench Scale: 3 – 8 Awards.
- Slip-stream: 1 – 3 Awards.

E. ANTICIPATED AWARD SIZE

Program/Topic Area	Award Size
Program Area: BENCH- SCALE	\$500,000 -- \$ 3,000,000
Program Area: SLIPSTREAM	\$5,000,000 -- \$12,000,000

For the slipstream projects, if you already have a pilot unit available for testing, DOE expects the total project cost to be significantly less than the maximum award size.

F. PERIOD OF PERFORMANCE

DOE anticipates making awards that will run for up to three (3) years. For multiple-year projects, the Applicant shall propose the effort in distinct budget periods with separate budgets, logical end-points and milestones for each budget period. A budget period shall not exceed 18 months in duration, and should include go/no go decision points for proceeding into subsequent budget periods. Continuation into a subsequent budget period would be contingent upon satisfactory performance of the previous budget period, availability of funds, and an acceptable continuation application.

G. TYPE OF APPLICATION

DOE will only accept new applications under this announcement. Renewal applications are requests for additional funding for a period subsequent to that provided by a current award. Renewal applications compete with all other applications and must be submitted by any established due date/deadline or at least six months before additional funding is required if there is no specified due date/deadline. In preparing a renewal application, applicants should assume that reviewers will not have access to previous applications. The application should be developed as fully as though the applicant were applying for the first time. The application must include all the information required for a new project, plus the project narrative section should discuss the results from prior work.

SECTION III - ELIGIBILITY INFORMATION

A. ELIGIBLE APPLICANTS

All types of entities are eligible to apply, except other Federal agencies, Federally Funded Research and Development Center (FFRDC) Contractors, and nonprofit organizations described in section 501(c)(4) of the Internal Revenue Code of 1986 that engaged in lobbying activities after December 31, 1995.

B. COST SHARING

The cost share must be at least **20%** of the total allowable costs of the project (i.e., the sum of the Government share, including FFRDC contractor costs if applicable, and the recipient share of allowable costs equals the total allowable costs of the projects) and must come from non-Federal sources unless otherwise allowed by law.

C. OTHER ELIGIBILITY REQUIREMENTS

- **Federally Funded Research and Development Center (FFRDC) Contractors.** FFRDC Contractors are not eligible for an award under this announcement, but they may be proposed as a team member on another entity's application except the National Energy Technology Laboratory (NETL), subject to the following guidelines:

Authorization for non-DOE/NNSA FFRDCs. The Federal agency sponsoring the FFRDC contractor must authorize in writing the use of the FFRDC contractor on the proposed project and this authorization must be submitted with the application. The use of a FFRDC contractor must be consistent with the contractor's authority under its award and must not place the FFRDC contractor in direct competition with the private sector.

Authorization for DOE/NNSA FFRDCs. The cognizant contracting officer for the FFRDC must authorize in writing the use of a DOE/NNSA FFRDC contractor on the proposed project and this authorization must be submitted with the application. The following wording is acceptable for this authorization.

"Authorization is granted for the _____ Laboratory to participate in the proposed project. The work proposed for the laboratory is consistent with or complimentary to the missions of the laboratory, will not adversely impact execution of the DOE/NNSA assigned programs at the laboratory, and will not place the laboratory in direct competition with the domestic private sector."

Value/Funding. The value of, and funding for, the FFRDC contractor portion of the work will not normally be included in the award to a successful applicant. Usually, DOE/NNSA will fund a DOE/NNSA FFRDC contractor through the DOE field work proposal system and other FFRDC contractors through an interagency agreement with the sponsoring agency.

Cost Share. The applicant's cost share requirement will be based on the total cost of the project, including the applicant's and the FFRDC contractor's portions of the effort.

FFRDC Contractor Effort:

The FFRDC contractor effort, in aggregate, shall not exceed 25% of the total estimated cost of the project, including the applicant's and the FFRDC contractor's portions of the effort.

Responsibility. The applicant, if successful, will be the responsible authority regarding the settlement and satisfaction of all contractual and administrative issues, including but not limited to, disputes and claims arising out of any agreement between the applicant and the FFRDC contractor.

- PERFORMANCE OF WORK IN UNITED STATES

The Recipient agrees that at least 75% of the direct labor cost for the project (including subcontractor labor) shall be incurred in the United States, unless the Recipient can demonstrate to the satisfaction of the Department of Energy that the United States economic interest will be better served through a greater percentage of the work being performed outside the United States.

SECTION IV - APPLICATION AND SUBMISSION INFORMATION

A. ADDRESS TO REQUEST APPLICATION PACKAGE

Application forms and instructions are available at Grants.gov. To access these materials, go to <http://www.grants.gov>, select "Apply for Grants," and then select "Download Application Package." Enter the CFDA and/or the funding opportunity number located on the cover of this announcement and then follow the prompts to download the application package.

B. LETTER OF INTENT AND PRE-APPLICATION

1. Letter of Intent

Not required

2. Pre-application

Not required

C. CONTENT AND APPLICATION FORMS

You must complete the mandatory forms and any applicable optional forms (e.g., Disclosure of Lobbying Activities (SF-LLL)) in accordance with the instructions on the forms and the additional instructions below. Files that are attached to the forms must be in Adobe Portable Document Format (PDF) unless otherwise specified in this announcement.

1. SF 424 (R&R)

Complete this form first to populate data in other forms. Complete all the required fields in accordance with the pop-up instructions on the form. The list of certifications and assurances referenced in Field 17 can be found on the DOE Financial Assistance Forms Page at http://management.energy.gov/business_doe/business_forms.htm under Certification and Assurances.

2. RESEARCH AND RELATED Other Project Information

Complete questions 1 through 6 and attach files. The files must comply with the following instructions:

Project Summary/Abstract (Field 7 on the Form)

The project summary/abstract must contain a summary of the proposed activity suitable for dissemination to the public. It should be a self-contained document that identifies the name of the applicant, the project director/principal investigator(s), the project title, the objectives of the project, a description of the project, including methods to be employed, the potential impact of the project (i.e., benefits, outcomes), and major participants (for collaborative projects). This document must not include any proprietary or sensitive business information as the Department may make it available to the public. The project summary must not exceed 1 page when printed using standard 8.5" by 11" paper with 1" margins (top, bottom, left and right) {single spaced} with font not smaller than 11 point. To attach a Project Summary/Abstract, click "Add Attachment."

Project Narrative (Field 8 on the Form)

The project narrative **must not exceed 35 pages double spaced**, including cover page, table of contents, charts, graphs, maps, photographs, and other pictorial presentations, when printed using standard 8.5" by 11" paper with 1 inch margins (top, bottom, left, and right) with font not

smaller than 11 point. EVALUATORS WILL ONLY REVIEW THE NUMBER OF PAGES SPECIFIED IN THE PRECEDING SENTENCE. The font must not be smaller than 11 point. Do not include any Internet addresses (URLs) that provide information necessary to review the application, because the information contained in these sites will not be reviewed. See Part VIII.D for instructions on how to mark proprietary application information. To attach a Project Narrative, click "Add Attachment."

The project narrative must include the following information that **WILL** count in the Project Narrative page limitation.

- **Project Objectives:** This section should provide a clear, concise statement of the specific objectives/aims of the proposed project.
- **Merit Review Criterion Discussion:** The section should be formatted to address each of the merit review criterion and sub-criterion listed in Part V.A. Provide sufficient information so that reviewers will be able to evaluate the application in accordance with these merit review criteria. DOE WILL EVALUATE AND CONSIDER ONLY THOSE APPLICATIONS THAT ADDRESS SEPARATELY EACH OF THE MERIT REVIEW CRITERION AND SUB-CRITERION.
- **Relevance and Outcomes/Impacts:** This section should explain the relevance of the effort to the objectives in the program announcement and the expected outcomes and/or impacts.
- **Roles of Participants:** For multi-organizational or multi-investigator projects, describe the roles and the work to be performed by each participant/investigator, business agreements between the applicant and participants, and how the various efforts will be integrated and managed.
- **Multiple Principal Investigators:** The applicant, whether a single organization or team/partnership/consortium, must indicate if the project will include multiple PIs. This decision is solely the responsibility of the applicant. If multiple PIs will be designated, the application must identify the Contact PI/Project Coordinator and provide a "Coordination and Management Plan" that describes the organization structure of the project as it pertains to the designation of multiple PIs. This plan should, at a minimum, include:
 - process for making decisions on scientific/technical direction;
 - publications;
 - intellectual property issues;
 - communication plans;
 - procedures for resolving conflicts; and
 - PIs' roles and administrative, technical, and scientific responsibilities for the project.
- **Statement Of Project Objectives (SOP):**

The project narrative must contain a single, detailed Statement of Project Objectives that addresses how the project objectives will be met. The Statement of Project Objectives must contain a clear, concise description of all activities to be completed during project performance and follow the structure discussed below. The Statement of Project Objectives may be released to the public by DOE in whole or in part at any time. It is therefore required that it shall not contain proprietary or confidential business information. The Statement of Project Objectives is generally less than 10 double spaced pages in total for the proposed work. Applicants shall prepare the Statement of Project Objectives in the following format:

TITLE OF WORK TO BE PERFORMED
(Insert the title of work to be performed. Be concise and descriptive.)

A. OBJECTIVES

Include one paragraph on the overall objective(s) of the work. Also, include objective(s) for each phase of the work.

B. SCOPE OF WORK

This section should not exceed one-half page and should summarize the effort and approach to achieve the objective(s) of the work for each Phase.

C. TASKS TO BE PERFORMED

Tasks, concisely written, should be provided in a logical sequence and should be divided into the phases of the project, as appropriate. This section provides a brief summary of the planned approach to this project. An outline of the Project Management Plan (referenced in Task 1.0 below and required to be submitted with your application) is provided later in this Section.

PHASE I

Task 1.0 - Project Management and Planning
(Description includes work elements required to revise and maintain the Project Management Plan and to manage and report on activities in accordance with the plan)

Subtask 1.1
(Description)

Task 2.0 - (Title)

Subtask 2.1
(Description)

PHASE II (Optional)

Task 3.0 - (Title)

D. DELIVERABLES

The periodic, topical, and final reports shall be submitted in accordance with the attached "Federal Assistance Reporting Checklist" and the instructions accompanying the checklist. [Note: The Recipient shall provide a list of deliverables other than those identified on the "Federal Assistance Reporting Checklist" that will be delivered. These reports shall also be identified within the text of the Statement of Project Objectives. See the following examples:

1. Task 1.1 - (Report Description)
2. Task 2.1 - (Report Description)

E. BRIEFINGS/TECHNICAL PRESENTATIONS (If applicable)

The Recipient shall prepare detailed briefings for presentation to the Project Officer at the Project Officer's facility located in Pittsburgh, PA or Morgantown, WV. Briefings shall be given by the Recipient to explain the plans, progress, and results of the technical effort. The Recipient shall make presentations to the NETL Project Officer/Manager at a project kick-off meeting (to be held

within 3 months of award), annual briefings, and a final project briefing.

The Recipient shall provide and present a technical paper(s) at the DOE/NETL Annual Contractor's Review Meeting and at least one other technical conference each year, as approved by the NETL Project Officer/Manager.

(End of SOPO)

- **Identification of Potential Conflicts of Interest or Bias in Selection of Reviewers Appendix:**
This appendix **WILL NOT** count in the Project Narrative page limitation. Provide the following information in this section.
- **Identification of Potential Conflicts of Interest or Bias in Selection of Reviewers Appendix:**
Provide the following information in this section. This appendix will not count in the project narrative page limitation:

Collaborators and Co-editors:

This appendix **WILL NOT** count in the Project Narrative page limitation. List in alphabetical order all persons, including their current organizational affiliation, who are, or who have been, collaborators or co-authors with you on a research project, book or book article, report, abstract, or paper during the 48 months preceding the submission of this application. Also, list any individuals who are currently, or have been, co-editors with you on a special issue of a journal, compendium, or conference proceedings during the 24 months preceding the submission of this application. If there are no collaborators or co-editors to report, state "None."

Graduate and Postdoctoral Advisors and Advisees:

This appendix **WILL NOT** count in the Project Narrative page limitation. List the names and current organizational affiliations of your graduate advisor(s) and principal postdoctoral sponsor(s) during the last 5 years. Also, list the names and current organizational affiliations of your graduate students and postdoctoral associates {Select if commitment letters will be received after selection of applicant}

- **Bibliography & References Cited Appendix:**
This appendix **WILL NOT** count in the Project Narrative page limitation. Provide a bibliography of any references cited in the Project Narrative. Each reference must include the names of all authors (in the same sequence in which they appear in the publication), the article and journal title, book title, volume number, page numbers, and year of publication. Include only bibliographic citations. Applicants should be especially careful to follow scholarly practices in providing citations for source materials relied upon when preparing any section of the application. In order to reduce the number of files attached to your application, please provide the Bibliography and References Cited information as an appendix to your project narrative. Do not attach a file in Field 9.
- **Facilities & Other Resources Appendix:**
This appendix **WILL NOT** count in the Project Narrative page limitation. This information is used to assess the capability of the organizational resources, including subawardee resources, available to perform the effort proposed. Identify the facilities to be used (Laboratory, Animal, Computer, Office, Clinical, and Other). If appropriate, indicate their capacities, pertinent capabilities, relative proximity, and extent of availability to the project. Describe only those resources that are directly applicable to the proposed work. Describe other resources available to the project (e.g., machine shop, electronic shop) and the extent to which they would be available to the project. In order to reduce the number of files attached to your application, please provide the Facility and Other Resource information as an appendix to your project narrative. Do not attach a file in Field 10.
- **Equipment Appendix:**

This appendix **WILL NOT** count in the Project Narrative page limitation. List major items of equipment already available for this project and, if appropriate identify location and pertinent capabilities. In order to reduce the number of files attached to your application, please provide the Equipment information as an appendix to your project narrative. Do not attach a file in Field 11.

Other Attachments (Field 12 on the form)

If you need to elaborate on your responses to questions 1-6 on the "Other Project Information" document, attach a file in field 12.

Also, attach the following files:

Project Management Plan

This plan should be formatted to include the following sections with each section to include the information as described below:

A. Executive Summary: Provide a description of the project that includes the objective, project goals, and expected results. For purposes of the application, this information is included in the Project Management Plan is a stand-alone document.

B. Risk Management: Provide a summary description of the proposed approach to identify, analyze, and respond to perceived risks associated with the proposed project. Project risk events are uncertain future events that, if realized, impact the success of the project. As a minimum, include the initial identification of significant technical, resource, and management issues that have the potential to impede project progress and strategies to minimize impacts from those issues.

C. Milestone Log: Provide milestones for each budget period (or phase) of the project. Each milestone should include a title and planned completion date. Milestones should be quantitative and show progress toward budget period and/or project goals. At a minimum, there should be at least two milestones for each year of the project.

[Note: During project performance, the Recipient will report the Milestone Status as part of the required quarterly Progress Report as prescribed under Attachment 4, Reporting Requirements Checklist. The Milestone Status will present actual performance in comparison with Milestone Log, and include:

- (1) the actual status and progress of the project,
- (2) specific progress made toward achieving the project's milestones, and,
- (3) any proposed changes in the project's schedule required to complete milestones.]

D. Funding and Costing Profile: Provide a table (the Project Funding Profile) that shows, by budget period, the amount of government funding going to each project team member. Also provide a table (the Project Costing Profile) that projects, by month, the expenditure of government funds for the first budget period, at a minimum.

E. Project Timeline: Provide a timeline of the project (similar to a Gantt chart) broken down by each task and subtask, as described in the Statement of Project Objectives. The timeline should include for each task, a start date, and end date. The timeline should show interdependencies between tasks and include the milestones that are identified in the Milestone Log (Section C).

F. Success Criteria at Decision Points: Provide success criteria for each decision point in the project, including go/no-go decision points and the conclusions of budget periods and the entire project. The success criteria should be objective and stated in terms of specific, measurable, and repeatable data. Usually, the success criteria pertain to desirable outcomes, results, and observations from the project. [Note: During negotiation for award, successful applicants will

revise the version of the Project Management Plan that is submitted with their applications by including details from the negotiation process. This Project Management Plan can also be updated by the Recipient as the project progresses. However, any changes to the Project Management Plan must first be approved by the NETL Project Officer/Manager. The Recipient must use the information from this plan to report schedule and budget variances in their quarterly Progress Reports.]

(End of Project Management Plan)

Save this plan in a single file named "PMP.pdf" and click on "Add Attachments" in Field 12 to attach.

Process Flow Diagram and Corresponding Process Description for Bench-Scale and Slipstream Applications

Every application (both bench-scale and slipstream) must contain a process flow diagram and a corresponding process description (as described in Section I of this FOA) that clearly describes the proposed equipment and how the proposed capture process could be cost-effectively integrated along with related CO₂ capture and compression systems into a pulverized coal-fired power plant. The process flow diagram and process description must be a single PDF file, legible at 8.5 inches by 11 inches, named "DIAGRAM.pdf" and click on "Add Attachments" in Field 12 to attach.

Commitment Letters from Third Parties Contributing to Cost Sharing

If a third party, (i.e., a party other than the organization submitting the application) proposes to provide all or part of the required cost sharing, the Applicant must include a letter from the third party stating that it is committed to providing a specific minimum dollar amount of cost sharing. The letter should also identify the proposed cost sharing (e.g., cash, services, and/or property) to be contributed. Letters must be signed by the person authorized to commit the expenditure of funds by the entity and be provided in a PDF format.

If a host site is anticipated for a slipstream project, a letter of commitment from the host site must also be provided and signed by an authorized individual of the host site. Save all letters of commitment and host site commitment letters in a single PDF file named "CLTP.pdf" and click on "Add Attachments" in Field 12 to attach.

Budget for DOE Federally Funded Research and Development Center (FFRDC) Contractor, if applicable.

If a DOE FFRDC contractor is to perform a portion of the work, you must provide a DOE Field Work Proposal in accordance with the requirements in DOE Order 412.1 Work Authorization System. This order and the DOE Field Work Proposal form are available at http://management.energy.gov/business_doe/business_forms.htm. Use the FFRDC name as the file name (up to 10 letters) and attach to the R&R Other Project Information form in Field 12 - Add Attachments.

3. RESEARCH AND RELATED SENIOR/KEY PERSON

Complete this form before the Budget form to populate data on the Budget form. Beginning with the PD/PI, provide a profile for each senior/key person proposed. A senior/key person is any individual who contributes in a substantive, measurable way to the scientific/technical development or execution of the project, whether or not a salary is proposed for this individual. Subawardees and consultants must be included if they meet this definition. Complete a biographical sketch for each senior/key person and attach to the "Attach Biographical Sketch" field in each profile. The biographical information for each person must not exceed 2 pages when printed on 8.5" by 11" paper with 1 inch margins (top, bottom, left, and right) with font not smaller than 11 point and must include:

Education and Training. Undergraduate, graduate and postdoctoral training, provide institution, major/area, degree and year. Research and Professional Experience. Beginning with the current position list, in chronological order, professional/academic positions with a brief description. Publications. Provide a list of up to 10 publications most closely related to the proposed project. For each publication, identify the names of all authors (in the same sequence in which they appear in the publication), the article title, book or journal title, volume number, page numbers, year of publication, and website address if available electronically.

Patents, copyrights, and software systems developed may be provided in addition to or substituted for publications.

Synergistic Activities. List no more than 5 professional and scholarly activities related to the effort proposed.

Current and Pending Support

Provide a list of all current and pending support (both Federal and non-Federal) for the Project Director/Principal Investigator(s) (PD/PI) and senior/key persons, including subawardees, for ongoing projects and pending applications. For each organization providing support, show the total award amount for the entire award period (including indirect costs) and the number of person-months per year to be devoted to the project by the senior/key person. Concurrent submission of an application to other organizations for simultaneous consideration will not prejudice its review. Save the information in a separate file and attach to the "Attach Current and Pending Support" field in each profile.

4. RESEARCH AND RELATED BUDGET (TOTAL FED + NON-FED)

Complete the Research and Related Budget (Total Fed & Non-Fed) form in accordance with the instructions on the form and the following instructions. You must complete a separate budget for each year of support requested. The form will generate a cumulative budget for the total project period. You must complete all the mandatory information on the form before the NEXT PERIOD button is activated. You may request funds under any of the categories listed as long as the item and amount are necessary to perform the proposed work, meet all the criteria for allowability under the applicable Federal cost principles, and are not prohibited by the funding restrictions in this announcement (See Section IV.G).

Budget Justification (Field K on the form).

Provide the required supporting information for the following costs (See R&R instructions): equipment; domestic and foreign travel; participant/trainees; material and supplies; publication; consultant services; ADP/computer services; subaward/consortium/contractual; equipment or facility rental/user fees; alterations and renovations; and indirect cost type. Provide any other information you wish to submit to justify your budget request. If cost sharing is required, provide an explanation of the source, nature, amount, and availability of any proposed cost sharing. Attach a single budget justification file for the entire project period in Field K. The file automatically carries over to each budget year.

5. R&R SUBAWARD (TOTAL FED + NON-FED) FORM

Budgets for Subawardees, other than DOE FFRDC Contractors. You must provide a separate cumulative R&R budget for each subawardee that is expected to perform work estimated to be more than \$100,000 or 50 percent of the total work effort (whichever is less). Download the R&R Budget Attachment from the R&R SUBAWARD BUDGET (Total Fed + Non-Fed) FORM and e-mail it to each subawardee that is required to submit a separate budget. After the Subawardee

has e-mailed its completed budget back to you, attach it to one of the blocks provided on the form. Use up to 10 letters of the subawardee's name as the file name.

6. PROJECT/PERFORMANCE SITE LOCATION(S)

Indicate the primary site where the work will be performed. If a portion of the project will be performed at any other site(s), identify the site location(s) in the blocks provided.

Note that the Project/Performance Site Congressional District is entered in the format of the 2 digit state code followed by a dash and a 3 digit Congressional district code, for example VA-001. Hover over this field for additional instructions.

Use the Next Site button to expand the form to add additional Project/Performance Site Locations.

7. DISCLOSURE OF LOBBYING ACTIVITIES (SF-LLL)

If applicable, complete SF- LLL. Applicability: If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the grant/cooperative agreement, you must complete and submit Standard Form - LLL, "Disclosure Form to Report Lobbying."

8. SUMMARY OF REQUIRED FORMS AND FILES

Your application must include the following documents:

Name of Document	Format	Attach to
SF 424 (R&R)	Form	N/A
RESEARCH AND RELATED Other Project Information	Form	N/A
Project Summary/Abstract	PDF	Field 7
Project Narrative, including required appendices	PDF	Field 8
Budget for DOE FFRDC, if applicable	PDF	Field 12
Project Management Plan	PDF	Field 12
Process Flow Diagram and Corresponding Process Description	PDF	Field 12
Commitment Letters from Third Parties and Host Sites	PDF	Field 12
RESEARCH & RELATED SENIOR/KEY PERSON Profile (Expanded)	Form	N/A
Biographical Sketch	PDF	Attach to appropriate block
Current and Pending Support	PDF	Attach to appropriate block
RESEARCH AND RELATED BUDGET (Total Fed + Non-Fed)	Form	N/A
Budget Justification	PDF	Field K
R&R SUBAWARD BUDGET (Total Fed + Non-Fed) ATTACHMENT(S) FORM, if applicable	Form	N/A

PROJECT/PERFORMANCE SITE LOCATION(S)	Form	N/A
SF-LLL DISCLOSURE OF LOBBYING ACTIVITIES , if applicable	Form	N/A

D. SUBMISSIONS FROM SUCCESSFUL APPLICANTS

If selected for award, DOE reserves the right to request additional or clarifying information for any reason deemed necessary, including, but not limited to:

- Indirect cost information
- Other budget information
- Name and phone number of the Designated Responsible Employee for complying with national policies prohibiting discrimination (See 10 CFR 1040.5)
- Representation of Limited Rights Data and Restricted Software, if applicable
- Commitment Letter from Third Parties Contributing to Cost Sharing, if applicable
- Environmental Questionnaire which can be found at the following website:
http://www.netl.doe.gov/business/forms/451_1-1-3.doc

E. SUBMISSION DATES AND TIMES

Pre-application Due Date: None Required

Application Due Date: Applications **should be received by December 3, 2009, not later than 8:00 PM Eastern Time.** You are encouraged to transmit your application well before the deadline (at least 48 hours in advance). APPLICATIONS RECEIVED AFTER THE DEADLINE WILL NOT BE REVIEWED OR CONSIDERED FOR AWARD.

APPLICANTS ARE REMINDED THAT THEY MUST IDENTIFY THE AREA OF INTEREST TO WHICH THEY ARE APPLYING. The required format for the title of the application will be: "Area of Interest [B1; B2; B3; S1; S2; or S3] (Project Title)" See Section IV, C. 1 and 2.

F. INTERGOVERNMENTAL REVIEW

This program is not subject to Executive Order 12372 – Intergovernmental Review of Federal Programs.

G. FUNDING RESTRICTIONS

Cost Principles. Costs must be allowable in accordance with the applicable Federal cost principles referenced in 10 CFR part 600. The cost principles for commercial organization are in FAR Part 31.

Pre-award Costs. Recipients may charge to an award resulting from this announcement pre-award costs that were incurred within the ninety (90) calendar day period immediately preceding the effective date of the award, if the costs are allowable in accordance with the applicable Federal cost principles referenced in 10 CFR part 600. Recipients must obtain the prior approval of the contracting officer for any pre-award costs that are for periods greater than this 90 day calendar period.

Pre-award costs are incurred at the applicant's risk. DOE is under no obligation to reimburse such costs if for any reason the applicant does not receive an award or if the award is made for a lesser amount than the applicant expected.

H. **OTHER SUBMISSION AND REGISTRATION REQUIREMENTS**

1. Where to Submit

FedConnect

APPLICATIONS MUST BE SUBMITTED THROUGH FEDCONNECT TO BE CONSIDERED FOR AWARD. Submit electronic applications through the FedConnect portal at www.fedconnect.net. Information regarding how to submit applications via Fed Connect can be found at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

Further, it is the responsibility of the applicant, prior to the offer due date and time, to verify successful transmission.

2. Registration Process

There are several one-time actions you must complete in order to submit an application in response to this Announcement (e.g., obtain a Dun and Bradstreet Data Universal Numbering System (DUNS) number, register with the Central Contract Registry (CCR), and register with FedConnect). Applicants, who are not registered with CCR and FedConnect, should allow at least 10 days to complete these requirements. It is suggested that the process be started as soon as possible.

SECTION V - APPLICATION REVIEW INFORMATION

A. CRITERIA

1. Initial Review Criteria

Prior to a comprehensive merit evaluation, DOE will perform an initial review to determine that (1) the applicant is eligible for an award; (2) the information required by the announcement has been submitted; (3) all mandatory requirements are satisfied; and (4) the proposed project is responsive to the objectives of the funding opportunity announcement.

2. Merit Review Criteria

Scientific and Technical Merit (45%)

- (a) Degree to which the proposed technology or methodology represents an important advancement toward achieving the "Funding Opportunity Announcement Objectives" in the targeted Area of Interest.
- (b) The degree to which the proposed work identifies and/or makes progress on new concepts, thereby increasing the likelihood of a new successful technology.
- (c) Feasibility of the proposed concept; the degree to which the proposed work is based on sound scientific and engineering principles.
- (d) Awareness of competing commercial and emerging technologies and how the proposed concept/technology provides significant improvement.
- (f) Explanation of the potential market segment within the electric power sector that could adopt their technology.
- (g) Explanation of the applicant's understanding of the current level of technology development and what is required to apply it to existing coal-fired power plants, demonstrated by discussion of specific Area of Interest information for Mechanism, Performance, System Characteristics, and Cost/Feasibility categories.
- (h) Degree to which the applicant has considered all aspects required to scale up and design their technology for application to an existing coal-fired electric power generation plant.
- (i) Adequacy of the discussion of the technical and process risks associated with the proposed technology.

Technical Approach and Understanding (25%)

- (a) Adequacy and feasibility of the applicant's technical approach and work plan.
- (b) Appropriateness, rationale, and completeness of the proposed Statement of Project Objectives (SOPO).
- (c) Reasonableness of the proposed project schedule, staffing plan and planned travel.

Applicant/Team Capabilities, Organization and Facilities (20%)

- (a) Appropriateness and extent of key personnel credentials, capabilities, and experience.
- (b) Demonstrated experience of the applicant and participating organizations in the technology areas addressed in the application and in managing similar projects.

- (c) Clarity, logic and likely effectiveness of the project organization, including subcontractors; the roles and responsibilities of each partner for each task and the availability of key personnel to complete the proposed project.
- (d) The adequacy (quality, availability, and appropriateness) of the facilities and equipment to perform project tasks.
- (e) The strength of project team members' business and financial commitment to the project, demonstrated by letters of commitment from vendors, host sites, and other team members..

Project Management Plan (10%)

- (a) Completeness, clarity, and effectiveness of the Project Management Plan in establishing a credible project base and in delineating how the SOPO will be successfully executed.
- (b) Effectiveness of the risk management methodologies and procedures, sequencing of project activities (schedule) including milestones, decision points, and success criteria.

B. REVIEW AND SELECTION PROCESS

1. Merit Review

Applications Subject to Merit Review

Applications that pass the initial review will be subjected to a merit review in accordance with the guidance provided in the "Department of Energy Merit Review Guide for Financial Assistance." This guide is available under Financial Assistance, Regulations and Guidance at <http://www.management.energy.gov/documents/meritrev.pdf>.

2. Selection

Selection Official Consideration

The Selection Official will consider the merit review recommendation, program policy factors, and the amount of funds available.

3. Discussions and Award

Government Discussions with Applicant

The Government may enter into discussions with a selected applicant for any reason deemed necessary, including but not limited to: (1) the budget is not appropriate or reasonable for the requirement; (2) only a portion of the application is selected for award; (3) the Government needs additional information to determine that the recipient is capable of complying with the requirements in 10 CFR part 600; and/or (4) special terms and conditions are required. Failure to resolve satisfactorily the issues identified by the Government will preclude award to the applicant.

C. ANTICIPATED NOTICE OF SELECTION AND AWARD DATES

DOE anticipates notifying applicants selected for award and making awards by the third quarter of Fiscal Year 2010.

SECTION VI - AWARD ADMINISTRATION INFORMATION

A. AWARD NOTICES

1. Notice of Selection

DOE will notify applicants selected for award. This notice of selection is not an authorization to begin performance. (See Part IV.G with respect to the allowability of pre-award costs.)

Organizations whose applications have not been selected will be advised as promptly as possible. This notice will explain why the application was not selected.

2. Notice of Award

A Financial Assistance Award issued by the Contracting Officer is the authorizing award document. It normally includes either as an attachment or by reference: (1). Special Terms and Conditions; (2). Applicable program regulations, if any; (3). Application as approved by DOE; (4). DOE assistance regulations at 10 CFR part 600, or if the award is for research and to a university or non-profit, the Research Terms and Conditions; (5). National Policy Assurances To Be Incorporated As Award Terms; (6). Budget Summary; and (7). Federal Assistance Reporting Checklist, which identifies the reporting requirements.

B. ADMINISTRATIVE AND NATIONAL POLICY REQUIREMENTS

1. Administrative Requirements

The administrative requirements for DOE grants and cooperative agreements are contained in 10 CFR Part 600 (See: <http://ecfr.gpoaccess.gov>). Grants and cooperative agreements made to universities, non-profits and other entities subject to OMB Circular A-110 are subject to the Research Terms and Conditions located on the National Science Foundation web site at <http://www.nsf.gov/awards/managing/rtc.jsp>

2. Special Terms and Conditions and National Policy Requirements

Special Terms and Conditions and National Policy Requirements. The DOE Special Terms and Conditions for Use in Most Grants and Cooperative Agreements are located at http://management.energy.gov/business_doe/business_forms.htm. The National Policy Assurances To Be Incorporated As Award Terms are located at DOE http://management.energy.gov/business_doe/business_forms.htm.

Intellectual Property Provisions. The standard DOE financial assistance intellectual property provisions applicable to the various types of recipients are located at http://www.gc.doe.gov/financial_assistance_awards.htm.

Statement of Substantial Involvement

There will be substantial involvement between the DOE and the Recipient during performance of this Cooperative Agreement. The DOE Specialist and DOE Project Officer will negotiate a Statement of Substantial Involvement prior to award in which the DOE and Recipient will collaborate and share responsibility for the management of the project as further described in this section.

RECIPIENT'S RESPONSIBILITIES. The Recipient is responsible for:

Performing the activities supported by this award in accordance with the Project Management Plan, including providing the required personnel, facilities, equipment, supplies and services;

Managing and controlling project activities in accordance with established processes and procedures to ensure tasks and subtasks are completed within schedule and budget constraints defined by the current Project Management Plan;

Implementing an approach to identify, analyze, and respond to project risks that is commensurate with the complexity of the project;

Defining and revising approaches and plans, submitting the plans to DOE for review, and incorporating DOE comments;

Coordinating related project activities with external suppliers, including DOE M&O contractors, to ensure effective integration of all work elements;

Attending annual program review meetings and reporting project status;

Submitting technical reports and incorporating DOE comments; and

Presenting the project results at appropriate technical conferences or meetings as approved by the DOE Project Officer.

DOE RESPONSIBILITIES. DOE is responsible for:

Reviewing in a timely manner project plans, including project management, testing and technology transfer plans, and recommending alternate approaches, if the plans do not address critical programmatic issues;

Participating in project management planning activities, including risk analysis, to ensure DOE's program requirements or limitations are considered in performance of the work elements;

Conducting annual program review meetings to ensure adequate progress and that the work accomplishes the program and project objectives. Recommending alternate approaches or shifting work emphasis, if needed;

Integrating and redirecting the work effort to ensure that project results address critical system and programmatic goals established by DOE FE, in coordination with the DOE Carbon Sequestration Program;

Promoting and facilitating technology transfer activities, including disseminating program results through presentations and publications;

Serving as scientific/technical liaison between awardees and other program or industry staff; Reviewing and approving any milestones or decision points within the Statement of Project Objectives (SOPO) that can hinder technology development. The DOE Project Officer will determine if it is in the best interest of all parties involved to continue the project. Prior to authorizing the Recipient to perform work on a subsequent task, DOE will evaluate the progress made against the standards set forth in the SOPO. If in DOE's opinion, such progress has not been as anticipated, the Recipient hereby agrees that DOE may elect to discontinue the Cooperative Agreement at no additional cost to DOE; and

Reviewing and concurring with ongoing technical performance to ensure that adequate progress has been obtained within the current activities/tasks authorized by DOE before work can commence on subsequent activities/tasks as addressed within the "CONTINUATION APPLICATION AND FUNDING" provision of the Cooperative Agreement.

C. REPORTING

Reporting requirements are identified on the Federal Assistance Reporting Checklist, DOE F 4600.2, attached to the award agreement. For a sample Checklist, see <http://management.energy.gov/documents/DOEF46002PolicyVersion.pdf>.

SECTION VII - QUESTIONS/AGENCY CONTACTS

A. QUESTIONS

Questions regarding the content of the announcement must be submitted through the FedConnect portal. You must register with FedConnect to respond as an interested party to submit questions, and to view responses to questions. It is recommended that you register as soon after release of the FOA as possible to have the benefit of all responses. DOE will try to respond to a question within 3 business days, unless a similar question and answer have already been posted on the website.

Questions and comments concerning this FOA shall be submitted not later than 3 calendar days prior to the application due date. Questions submitted after that date may not allow the Government sufficient time to respond.

B. AGENCY CONTACT

Name:	Thomas J. Gruber
E-mail:	thomas.gruber@netl.doe.gov

SECTION VIII - OTHER INFORMATION

A. MODIFICATIONS

Notices of any modifications to this announcement will be posted on Grants.gov and the FedConnect portal. You can receive an email when a modification or an announcement message is posted by registering with FedConnect as an interested party for this FOA. It is recommended that you register as soon after release of the FOA as possible to ensure you receive timely notice of any modifications or other announcements. More information is available at <http://www.fedconnect.net> and <http://www.compusearch.com/products/fedconnect/fedconnect.asp>.

B. GOVERNMENT RIGHT TO REJECT OR NEGOTIATE

DOE reserves the right, without qualification, to reject any or all applications received in response to this announcement and to select any application, in whole or in part, as a basis for negotiation and/or award.

C. COMMITMENT OF PUBLIC FUNDS

The Contracting Officer is the only individual who can make awards or commit the Government to the expenditure of public funds. A commitment by other than the Contracting Officer, either explicit or implied, is invalid.

D. PROPRIETARY APPLICATION INFORMATION

Patentable ideas, trade secrets, proprietary or confidential commercial or financial information, disclosure of which may harm the applicant, should be included in an application only when such information is necessary to convey an understanding of the proposed project. The use and disclosure of such data may be restricted, provided the applicant includes the following legend on the first page of the project narrative and specifies the pages of the application which are to be restricted: "The data contained in pages [*Insert pages*] of this application have been submitted in confidence and contain trade secrets or proprietary information, and such data shall be used or disclosed only for evaluation purposes, provided that if this applicant receives an award as a result of or in connection with the submission of this application, DOE shall have the right to use or disclose the data herein to the extent provided in the award. This restriction does not limit the government's right to use or disclose data obtained without restriction from any source, including the applicant."

To protect such data, each line or paragraph on the pages containing such data must be specifically identified and marked with a legend similar to the following: information that (name of applicant) requests not be released to persons outside the Government, except for purposes of review and evaluation."

E. EVALUATION AND ADMINISTRATION BY NON-FEDERAL PERSONNEL

In conducting the merit review evaluation, the Government may seek the advice of qualified non-Federal personnel as reviewers. The Government may also use non-Federal personnel to conduct routine, nondiscretionary administrative activities. The applicant, by submitting its application, consents to the use of non-Federal reviewers/administrators. Non-Federal reviewers must sign conflict of interest and non-disclosure agreements prior to reviewing an application. Non-Federal personnel conducting administrative activities must sign a non-disclosure agreement.

F. INTELLECTUAL PROPERTY DEVELOPED UNDER THIS PROGRAM

Patent Rights. The government will have certain statutory rights in an invention that is conceived or first actually reduced to practice under a DOE award. 42 U.S.C. 5908 provides that title to such inventions vests in the United States, except where 35 U.S.C. 202 provides otherwise for nonprofit organizations or small business firms. However, the Secretary of Energy may waive all or any part of

the rights of the United States subject to certain conditions. (See "Notice of Right to Request Patent Waiver" in paragraph G below.)

Rights in Technical Data. Normally, the government has unlimited rights in technical data created under a DOE agreement. Delivery or third party licensing of proprietary software or data developed solely at private expense will not normally be required except as specifically negotiated in a particular agreement to satisfy DOE's own needs or to insure the commercialization of technology developed under a DOE agreement.

Program Covered Under Special Protected Data

Special Protected Data Statutes. This program is covered by a special protected data statute. The provisions of the statute provide for the protection from public disclosure, for a period of up to five (5) years from the development of the information, of data that would be trade secret, or commercial or financial information that is privileged or confidential, if the information had been obtained from a non-Federal party. Generally, the provision entitled, Rights in Data Programs Covered Under Special Protected Data Statutes (10 CFR 600 Appendix A to Subpart D), would apply to an award made under this announcement. This provision will identify data or categories of data first produced in the performance of the award that will be made available to the public, notwithstanding the statutory authority to withhold data from public dissemination, and will also identify data that will be recognized by the parties as protected data.

G. NOTICE OF RIGHT TO REQUEST PATENT WAIVER

Applicants may request a waiver of all or any part of the rights of the United States in inventions conceived or first actually reduced to practice in performance of an agreement as a result of this announcement, in advance of or within 30 days after the effective date of the award. Even if such advance waiver is not requested or the request is denied, the recipient will have a continuing right under the award to request a waiver of the rights of the United States in identified inventions, i.e., individual inventions conceived or first actually reduced to practice in performance of the award. Any patent waiver that may be granted is subject to certain terms and conditions in 10 CFR 784 <http://www.gc.doe.gov/documents/patwaivclau.pdf>. Domestic small businesses and domestic nonprofit organizations will receive the patent rights clause at 37 CFR 401.14, i.e., the implementation of the Bayh-Dole Act. This clause permits domestic small business and domestic nonprofit organizations to retain title to subject inventions. Therefore, small businesses and nonprofit organizations do not need to request a waiver.

H. NOTICE REGARDING ELIGIBLE/INELIGIBLE ACTIVITIES

Eligible activities under this program include those which describe and promote the understanding of scientific and technical aspects of specific energy technologies, but not those which encourage or support political activities such as the collection and dissemination of information related to potential, planned or pending legislation.