

Exhibit A WORK STATEMENT

TECHNICAL TASK LIST

Task #	CPR	Task Name
1	N/A	Administration
2	X	CNT Membrane Development

KEY NAME LIST

Task #	Key Personnel	Key Subcontractor(s)	Key Partner(s)
1	Dr. Olgica Bakajin		
2	Dr. Olgica Bakajin Dr. Aleksandr Noy		

GLOSSARY

Specific terms and acronyms used throughout this scope of work are defined as follows:

Term/ Acronym	Definition
CNT	carbon nanotube
CO ₂	carbon dioxide
CPR	Critical Project Review
DOE	United States Department of Energy
Energy Commission	California Energy Commission
GHG	Green House Gas
MW	megawatt
PAC	Project Advisory Committee
PIER	Public Interest Energy Research
RD&D	Research, Development, and Demonstration

Problem Statement:

Growing concerns about greenhouse gas emissions and global warming drive an increasing need for power plants and other industrial facilities to significantly reduce carbon dioxide (CO₂) emissions to the atmosphere. At present, the majority of technologies used to remove CO₂ from power plant and industrial flue gas emissions are based on reversible solvent absorption processes. These processes use solvents such as alkylamines, methanol, or glycol ethers to provide selective CO₂ removal through physical or chemical interaction with the CO₂ contained in the flue gas. While effective, the need for powerful compressors and solvent regeneration makes the process expensive and energy intensive, using about 27% of a 500 megawatt (MW) power plant's gross energy production capacity.

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Membrane-based separation of CO₂ could potentially deliver more efficient and less expensive separation with lower energy consumption. However, commercially-viable membrane-based CO₂ separation technologies require membranes that are both highly CO₂ selective (capable of transmitting CO₂ gas more readily over other gases) and highly permeable/high flux (allowing a greater volume of gas through a unit area per unit of time). Current polymer-based membranes can be made to be highly selective; however, the chemical modifications necessary to increase selectivity reduce permeability to the point of making the membrane separations economically unviable.

Development of carbon nanotube (CNT) gas separation membranes offers a potential solution to this problem by providing a membrane framework that is already highly permeable. Even if selectivity modifications reduce the permeability of CNT membranes by a few orders of magnitude, the resulting performance will still be economically viable and provide a superior alternative to the solvent-based CO₂ separation processes currently in use. High CNT performance stability is also possible because the pore structure of the CNT membrane is not affected by compaction or swelling, and a matrix can be chosen to provide high mechanical strength and durability independently of the targeted selectivity and permeability.

The enhanced performance of CNT membranes could reduce both facility energy consumption and CO₂ capture costs. CNT membranes with higher permeability and selectivity allow for use of smaller, less expensive compressors, thereby reducing facility energy and capital costs. Much smaller compression ratios are also required for efficient separation, and the richer CO₂ permeate stream generated reduces compression and management requirements for future injection and storage.

Goal of the Agreement:

The goal of this project is to develop highly permeable and highly CO₂ selective CNT membranes for efficient separation of CO₂ from industrial emissions. The potential for reduced energy consumption and greater ease of CO₂ separation supports California's goals for the reduction of greenhouse gas emissions and for carbon capture and storage.

Objective of the Agreement:

The objective of this agreement is to meet United States Department of Energy (DOE) performance targets for CO₂ separation membranes by developing and demonstrating a comprehensive set of chemical and physical modifications of CNT membranes that will enhance the membrane's CO₂ selectivity.

Product Guidelines:

For complete product guidelines, refer to Section 5 in the Terms and Conditions.

TASK 1 ADMINISTRATION

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Task 1.1 Attend Kick-Off Meeting

The goal of this sub-task is to establish the lines of communication and procedures for implementing this Agreement.

The Recipient shall:

- Attend a “Kick-Off” meeting with the Commission Project Manager, the Grants Officer, and a representative of the Accounting Office. The Recipient shall bring its Project Manager, Agreement Administrator, Accounting Officer, and others designated by the Commission Project Manager to this meeting. The administrative and technical aspects of this Agreement will be discussed at the meeting. Prior to the kick-off meeting, the Commission Project Manager will provide an agenda to all potential meeting participants.

The administrative portion of the meeting shall include, but not be limited to, the following:

- Discussion of the terms and conditions of the Agreement
- Discussion of Critical Project Review (Task 1.2)
- Match fund documentation (Task 1.6)
- Permit documentation (Task 1.7)

The technical portion of the meeting shall include, but not be limited to, the following:

- The Commission Project Manager’s expectations for accomplishing tasks described in the Scope of Work
- An updated Schedule of Products
- Discussion of Progress Reports (Task 1.4)
- Discussion of Technical Products (Product Guidelines located in Section 5 of the Terms and Conditions)
- Discussion of the Final Report (Task 1.5)

The Commission Project Manager shall designate the date and location of this meeting.

Recipient Products:

- Updated Schedule of Products
- Updated List of Match Funds
- Updated List of Permits

Commission Project Manager Product:

- Kick-Off Meeting Agenda

Task 1.2 Critical Project Review (CPR) Meetings

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The goal of this sub-task is to determine if the project should continue to receive Energy Commission funding to complete this Agreement and to identify any needed modifications to the tasks, products, schedule or budget.

CPRs provide the opportunity for frank discussions between the Energy Commission and the Recipient. CPRs generally take place at key, predetermined points in the Agreement, as determined by the Commission Project Manager and as shown in the Technical Task List above. However, the Commission Project Manager may schedule additional CPRs as necessary, and any additional costs will be borne by the Recipient.

Participants include the Commission Project Manager and the Recipient and may include the Commission Grants Officer, the Public Interest Energy Research (PIER) Program Team Lead, other Energy Commission staff and Management as well as other individuals selected by the Commission Project Manager to provide support to the Energy Commission.

If DOE is conducting similar meetings, the Recipient shall notify and invite the Commission project manager to participate, either by teleconference or by actual meeting attendance. The DOE required meetings can be used in place of the Commission's CPR meetings, at the discretion of the Commission project manager.

The Commission Project Manager shall:

- Determine the location, date, and time of each CPR meeting with the Recipient. These meetings generally take place at the Energy Commission, but they may take place at another location.
- Send the Recipient the agenda and a list of expected participants in advance of each CPR. If applicable, the agenda shall include a discussion on both match funding and permits.
- Conduct and make a record of each CPR meeting. One of the outcomes of this meeting will be a schedule for providing the written determination described below.
- Determine whether to continue the project, and if continuing, whether or not modifications are needed to the tasks, schedule, products, and/or budget for the remainder of the Agreement. Modifications to the Agreement may require a formal amendment (please see the Terms and Conditions). If the Commission Project Manager concludes that satisfactory progress is not being made, this conclusion will be referred to the Energy Commission's Research, Development and Demonstration (RD&D) Policy Committee for its concurrence.
- Provide the Recipient with a written determination in accordance with the schedule. The written response may include a requirement for the Recipient to revise one or more product(s) that were included in the CPR.

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The Recipient shall:

- Prepare a CPR Report for each CPR that discusses the progress of the Agreement toward achieving its goals and objectives. This report shall include recommendations and conclusions regarding continued work of the projects. This report shall be submitted along with any other products identified in this scope of work. The Recipient shall submit these documents to the Commission Project Manager and any other designated reviewers at least 15 working days in advance of each CPR meeting.
- Present the required information at each CPR meeting and participate in a discussion about the Agreement.

Commission Project Manager Products:

- Agenda and a list of expected participants
- Schedule for written determination
- Written determination

Recipient Product:

- CPR Report(s)

Task 1.3 Final Meeting

The goal of this sub-task is to close out this Agreement. If DOE is conducting a similar final meeting, the Recipient shall notify and invite the Commission project manager to participate, either by teleconference or by actual meeting attendance. The DOE required meeting can be used in place of the Commission's final meeting, at the discretion of the Commission project manager. However, all items listed in this sub-task will need to be covered in the meeting.

The Recipient shall:

- Meet with Energy Commission staff to present the findings, conclusions, and recommendations. The final meeting must be completed during the closeout of this Agreement.

This meeting will be attended by, at a minimum, the Recipient, the Commission Grants Office Officer, and the Commission Project Manager. The technical and administrative aspects of Agreement closeout will be discussed at the meeting, which may be two separate meetings at the discretion of the Commission Project Manager.

The technical portion of the meeting shall present an assessment of the degree to which project and task goals and objectives were achieved, findings, conclusions, recommended next steps (if any) for the Agreement, and recommendations for improvements. The Commission Project Manager will determine the appropriate meeting participants.

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The administrative portion of the meeting shall be a discussion with the Commission Project Manager and the Grants Officer about the following Agreement closeout items:

- What to do with any equipment purchased with Energy Commission funds (Options)
- Energy Commission's request for specific "generated" data (not already provided in Agreement products)
- Need to document Recipient's disclosure of "subject inventions" developed under the Agreement
- "Surviving" Agreement provisions, such as repayment provisions and confidential Products
- Final invoicing and release of retention
- Prepare a schedule for completing the closeout activities for this Agreement.
- Copies of all correspondence and reports discussing DOE's findings on the project, and future disposition of the project, if applicable. When directed by the Commission project manager, recipient will provide copies of any DOE correspondence (emails, reports, letters, etc.) that relate to project performance.

Products:

- Written documentation of meeting agreements
- Schedule for completing closeout activities
- DOE correspondence on project findings and results

Task 1.4 Quarterly Progress Reports

The goal of this sub-task is to periodically verify that satisfactory and continued progress is made towards achieving the research objectives of this Agreement on time and within budget.

The objectives of this sub-task are to summarize activities performed during the reporting period, to identify activities planned for the next reporting period, to identify issues that may affect performance and expenditures, and to form the basis for determining whether invoices are consistent with work performed.

With Commission Project Manager approval, the Recipient can submit a DOE Progress Report in lieu of the required Commission report if it contains the information listed in Attachment 1 of the Terms and Conditions.

The Recipient shall:

- Prepare Quarterly Progress Reports which summarize all Agreement activities conducted by the Recipient for the reporting period, including an assessment of the ability to complete the Agreement within the current

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budget and any anticipated cost overruns. Each progress report is due to the Commission Project Manager within 30 days of the end of the reporting period. The recommended specifications for each progress report are contained in the terms and conditions of this Agreement.

- Unless otherwise directed by the Commission Project Manager, each Progress Report must contain any reports made to DOE, including summaries of meetings with DOE, related to the project outcome and performance. Include names and contacts of DOE representatives.

Product:

- Quarterly Progress Reports
- Copies of DOE progress reports, correspondence, meeting summaries, and special status reports as set forth in the Federal Financial Assistance Reporting Checklist and Instructions

Task 1.5 Final Report

The goal of the Final Report is to assess the project's success in achieving its goals and objectives, advancing science and technology, and providing energy-related and other benefits to California.

The final report shall describe the following at a minimum: a) original purpose, approach, activities performed, results and conclusions of the work done under this Agreement; b) how the project advanced science and technology to the benefit of California's ratepayers and the barriers overcome; c) assessment of the success of the project as measured by the degree to which goals and objectives were achieved; d) how the project supported California's economic recovery in the near term and number of jobs created or sustained; e) how the project results will be used by California industry, markets and others; f) projected cost reduction impact and other benefits resulting from the project; g) discuss the project budget, including the total project cost and all the funding partners and their cost share; h) discuss how the Energy Commission funding was spent on the project, including any unique products and benefits; i) observations, conclusions and recommendations for further RD&D projects and improvements to the PIER project management process.

If a final report is required by DOE, the Recipient will include a copy of it along with the Energy Commission's final report requirements. In addition, the Recipient shall submit the draft final DOE report to the Energy Commission for review at the same time it submits it to DOE.

The Final Report shall be a public document. If the Recipient has obtained confidential status from the Energy Commission and will be preparing a confidential version of the Final Report as well, the Recipient shall perform the following activities for both the public and confidential versions of the Final Report.

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The Recipient shall:

- Provide a draft copy of the Final Report for this Agreement, including a copy of the draft submitted to the DOE in response to the American Recovery and Reinvestment Act Funding Opportunity Notice for which an award was received. The Final Report must be completed on or before the end of the Agreement Term.
- Provide copies of DOE final closeout reports, including patent certification and property certification, as appropriate
- Submit written correspondence from DOE regarding acceptance of the DOE final report.

Products:

- Draft Final Report, including a copy of the draft report submitted to DOE
- Final Report, including a copy of the final report submitted to DOE
- Copies of DOE final closeout reports
- Written correspondence from DOE regarding acceptance of DOE final report

Task 1.6 Identify and Obtain Matching Funds

The goal of this sub-task is to ensure that the match funds planned for this Agreement are obtained for and applied to this Agreement during the term of this Agreement.

The costs to obtain and document match fund commitments are not reimbursable through this Agreement. Although the PIER budget for this task will be zero dollars, the Recipient may utilize match funds for this task. Match funds shall be spent concurrently or in advance of PIER funds for each task during the term of this Agreement. Match funds must be identified in writing and the associated commitments obtained before the Recipient can incur any costs for which the Recipient will request reimbursement.

The Recipient shall:

- Prepare a letter documenting the match funding committed to this Agreement and submit it to the Commission Project Manager at least 2 working days prior to the kick-off meeting. The letter needs to identify the following at a minimum:
 - Amount of each cash match fund, its source, including a contact name, address and telephone number and the task(s) to which the match funds will be applied.
 - Amount of each in-kind contribution, a description, documented market or book value, and its source, including a contact name, address and telephone number and the task(s) to which the match funds will be applied. If the in-kind contribution is equipment or other tangible or real property, the Recipient shall identify its owner and provide a

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- Provide a copy of the letter of commitment from an authorized representative of each source of cash match funding or in-kind contributions that these funds or contributions have been secured.
- Discuss match funds and the implications to the Agreement if they are reduced or not obtained as committed, at the kick-off meeting. If applicable, match funds will be included as a line item in the progress reports and will be a topic at CPR meetings.
- Provide the appropriate information to the Commission Project Manager if during the course of the Agreement additional match funds are received.
- Notify the Commission Project Manager within 10 days if during the course of the Agreement existing match funds are reduced. Reduction in match funds must be approved through a formal amendment to the Agreement and may trigger an additional CPR.

Products:

- A letter regarding match funds
- Copy(ies) of each match fund commitment letter(s)
- Letter(s) for new match funds (if applicable)
- Letter that match funds were reduced (if applicable)

Task 1.7 Identify and Obtain Required Permits

The goal of this sub-task is to obtain all permits required for work completed under this Agreement in advance of the date they are needed to keep the Agreement schedule on track.

Permit costs and the expenses associated with obtaining permits are not reimbursable under this Agreement. Although the PIER budget for this task will be zero dollars, the Recipient shall budget match funds for any expected expenditures associated with obtaining permits. Permits must be identified in writing and obtained before the Recipient can make any expenditures for which a permit is required.

The Recipient shall:

- Prepare a letter documenting the permits required to conduct this Agreement and submit it to the Commission Project Manager at least 2 working days prior to the kick-off meeting. If there are no permits required at the start of this Agreement, then state such in the letter. If it is known at the beginning of the Agreement that permits will be required during the course of the Agreement, provide in the letter:

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- A list of the permits that identifies the:
 - Type of permit
 - Name, address and telephone number of the permitting jurisdictions
 - or lead agencies
- The schedule the Recipient will follow in applying for and obtaining these permits.
- Discuss the list of permits and the schedule for obtaining them at the kick-off meeting and develop a timetable for submitting the updated list, schedule and the copies of the permits. The implications to the Agreement if the permits are not obtained in a timely fashion or are denied will also be discussed. If applicable, permits will be included as a line item in the Progress Reports and will be a topic at CPR meetings.
- If during the course of the Agreement additional permits become necessary, provide the appropriate information on each permit and an updated schedule to the Commission Project Manager.
- As permits are obtained, send a copy of each approved permit to the Commission Project Manager.
- If during the course of the Agreement permits are not obtained on time or are denied, notify the Commission Project Manager within 5 working days. Either of these events may trigger an additional CPR.

Products:

- Letter documenting the permits or stating that no permits are required
- A copy of each approved permit (if applicable)
- Updated list of permits as they change during the term of the Agreement (if applicable)
- Updated schedule for acquiring permits as changes occur during the term of the Agreement (if applicable)

Task 1.8 DOE Contract Management

The goal of this sub-task is to ensure compliance with the Recipient's DOE contract and submittal of all documents and deliverables as appropriate for both DOE and Energy Commission agreements.

The Recipient shall:

- Perform administrative tasks as required by the DOE

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TECHNICAL TASKS

Unless otherwise provided in the individual Task, the Recipient shall prepare all products in accordance with the requirements in the Special Conditions.

TASK 2 CNT MEMBRANE DEVELOPMENTS

Task 2.1 Membrane Fabrication

The goal of this sub-task is to fabricate CNT membranes and identify the most promising fill material and techniques to use for larger-scale demonstration membranes. This sub-task may be performed concurrently with sub-tasks 2.2 and 2.3 to allow for development and evaluation of different techniques, along with step increases in membrane size and permeability/selectivity parameters.

The Recipient shall:

- Fabricate polymer-filled and polymer-based membranes using interfacial polymerization, vapor deposition, and polymer infiltration.
- Identify the most promising membrane fill material and technique.
- Fabricate membranes selected for larger-scale demonstration.
- Continue membrane fabrication as necessary based on functionalization and testing results.
- Provide scientific/technical reports, conference papers/proceedings, and special status reports per DOE's reporting requirements.

Products:

- One copy each of DOE scientific/technical reports, conference papers/proceedings, and special status reports (no drafts)

Task 2.2 Membrane Functionalization

The goal of this sub-task is to functionalize the CNT membranes to facilitate CO₂ separation from N₂ and O₂. This sub-task may be performed concurrently with sub-tasks 2.1 and 2.3 to allow for development and evaluation of different techniques, along with step increases in membrane size and permeability/selectivity parameters.

The Recipient shall:

- Evaluate three functionalization techniques:
 - one where small amine molecules are attached to the tips of the carbon nanotubes to provide sites for CO₂ adsorption;
 - one using CO₂ selective polymeric skin layers; and
 - one using branched amines to functionalize the CNTs at the membrane entrances.

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- Functionalize test membranes using the target techniques and optimize the conditions that produce the highest functionalization yield for each type of polymer CNT matrix used.
- Characterize the functionalization yield of membranes.
- Identify the most promising functionalization technique and modification strategies.
- Continue membrane functionalization as necessary based on fabrication and testing results.
- Provide scientific/technical reports, conference papers/proceedings, and special status reports per DOE's reporting requirements.

Products:

- One copy each of DOE scientific/technical reports, conference papers/proceedings, and special status reports (no drafts)

Task 2.3 Test Membrane Characteristics

The goal of this task is to test and demonstrate the CO₂ permeability and selectivity of the functionalized CNT membranes. This sub-task may be performed concurrently with sub-tasks 2.1 and 2.2 to allow for development and evaluation of different techniques, along with step increases in membrane size and permeability/selectivity parameters.

The Recipient shall:

- Test membrane CO₂ permeability, selectivity, and fouling characteristics.
- Evaluate potential for membrane fouling from water, oxides of sulfur and nitrogen, and ash particles.
- Compare the selectivity yields and quality of different fabrication strategies.
- Identify the candidate CNT fabrication and functionalization processes.
- Continue membrane testing as necessary based on fabrication and functionalization results.
- Demonstrate CNT membrane performance at increasing steps leading to demonstration of membrane performance equivalent to the DOE CO₂ membrane target permeability of 10,000 barrer and CO₂/N₂ selectivity equal to or greater than 100.
- Provide scientific/technical reports, conference papers/proceedings, and special status reports per DOE's reporting requirements.
- Participate in CPR as per Task 1.2.

Products:

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- One copy each of DOE scientific/technical reports, conference papers/proceedings, and special status reports (no drafts)
- CPR report