Exhibit A
SCOPE OF WORK

TASK LIST

Task #	CPR	Task Name
1	N/A	Administration
2		Overall Assessment of California NGCC Plants and CO_2 Capture Technologies for Retrofit
3	X	Engineering Options Analysis Procedure, Site Assessment, and Preliminary Engineering Design for CO_2 Capture Retrofit and New-Build Cases
4		Preliminary Scope, Cost, and Schedule Estimate for a California Pilot-Scale Technology Validation Test of an NGCC Plant with CCS Application

KEY NAME LIST

Task #	Key Personnel	Key Subcontractor(s)	Key Partner(s)
1			
2		Clevenger Geoconsulting (DVBE)	
3			
4		Clevenger Geoconsulting (DVBE)	

GLOSSARY

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

$/kW	dollars per kilowatt
$/MWh	dollars per megawatt-hour
ASU	air separation unit
BTU	British Thermal Unit
CCS	carbon capture and storage
CEQA	California Environmental Quality Act
CHP	combined heat and power
CO_2	carbon dioxide
CPR	Critical Project Review
DOE	United States Department of Energy
DVBE	Disabled Veteran-Owned Business Enterprise
EOR	enhanced oil recovery
GHG	green house gas
GT	gas turbine
HAP	Hazardous Air Pollutant
HHV	high heating value
HRSG	heat recovery steam generator
IGCC	Integrated Gasification Combined Cycle
kWh	kilowatt-hour
LHV	low heating value
MS	Microsoft

MW	megawatt
N/A	Not Applicable
NEMA	National Electrical Manufacturers Association
NEPA	National Environmental Policy Act
NETL	National Energy Technology Laboratory
NGCC	natural gas combined cycle
O&M	Operations and Maintenance
P&ID	Piping and Instrumentation Drawing
PAC	Project Advisory Committee
PC	personal computer
PDF	Portable Document Format
PFD	process flow diagram
PG&E	Pacific Gas and Electric
PIER	Public Interest Energy Research
RD&D	research, development, and demonstration
ROI	return on investment
UCC.1	Uniform Commercial Code (Financing Statement)
UIC	Underground Injection Control
WESTCARB	West Coast Regional Carbon Sequestration Partnership

Problem Statement

A substantial portion of California's power supply is now provided by large, modern natural gas combined cycle (NGCC) units. Between 1995 and 2009, approximately fifty F- and H-Class gas turbines (GTs), in about 28 combined cycle power blocks, were commissioned in the state. With the highest efficiency among the fossil fuel–fired units serving California, many of these units operate at relatively high capacity factors. Consequently, they are among the state's top annual point sources of carbon dioxide (CO_2) emissions.

California also has many smaller NGCC units and GT-based cogeneration units that serve municipal utilities, industrial steam hosts, and enhanced oil recovery steam flood operations. Although these units have lower annual CO_2 emissions, many also operate at high capacity factors to meet distribution system needs or around-the-clock steam demand. Many of these units also offer site-specific advantages for hosting a pilot-scale technology validation field test.

To date, there has only been one application of CO_2 capture on an NGCC unit that has lasted longer than several years (FPL Bellingham Plant in Bellingham Massachusetts using Fluor Econamine FG monoethanol amine post-combustion capture from exhaust slipstream). Furthermore, there are currently relatively few research efforts that specifically address CO_2 capture of GT exhaust, which has a higher oxygen concentration and lower CO_2 concentration than flue gas from coal-fired boilers.

Around the world, research, development, and demonstration (RD&D) efforts are developing and testing numerous technologies that may be ready for commercial-scale CO_2 capture from NGCC units by 2020. Today, the most mature candidate technologies for CO_2 capture from NGCC units involve post-combustion capture of CO_2 from flue gas using direct contact with a liquid chemical sorbent. Such an approach is only one of the options that may be considered for evaluation in this project.

California's utilities need updated information on the near-commercial-ready and emerging options for implementing carbon capture and storage (CCS) on NGCC generating units. This information is crucial for utilities to understand the nature and magnitude of cost and performance impacts associated with CCS operation. Operating flexibility may also be affected by CCS regulatory rules and CCS system dynamics. Overall reliability of the generating unit may be reduced by the added complexity of CO_2 capture and compression/dehydration equipment.

The scope of this project is to enhance the information available to power generation planners and policymakers to decide on investments in greenhouse gas reductions.

Goals of the Agreement
The goal of this Agreement is to evaluate the technical ability to capture CO_2 from NGCC power plants and estimate the associated costs.

Objectives of the Agreement
The objectives of this Agreement are to:

1) Compile and perform a basic evaluation of CO_2 capture technology options for use on NGCC plants.
2) Complete an engineering and economic assessment report of the installation and operation of various CCS technologies, in retrofit and new-build applications, at California utility-scale NGCC plants. If a suitable NGCC plant cannot be determined because of technical or other reasons, the Contractor shall recommend a replacement natural gas system (i.e., a natural gas–fired cogeneration or an oilfield steam flood unit) for the detailed analysis and pilot demonstration elements of this Agreement.
3) Complete a preliminary design for a pilot-scale CO_2 capture, compression/dehydration, and injection well test facility.

TASK 1.0 ADMINISTRATION

MEETINGS

Task 1.1 Attend Kick-off Meeting

The goals of this task are to establish the lines of communication and procedures for implementing this Agreement.

The Contractor shall:

- Attend a "kick-off" meeting with the Commission Contract Manager, the Contracts Officer, and a representative of the Accounting Office. The Contractor shall bring their Project Manager, Contracts Administrator, Accounting Officer, and others designated by the Commission Contract 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 Contract 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:
- Terms and conditions of the Agreement
- Critical Project Reviews (CPRs) (Task 1.2)
- Match fund documentation (Task 1.7)
- Permit documentation (Task 1.8)

The technical portion of the meeting shall include, but not be limited to, the following:
- The Commission Contract Manager's expectations for accomplishing tasks described in the Scope of Work;
- An updated Schedule of Deliverables
- Progress Reports (Task 1.4)
- Technical Deliverables (Task 1.5)
- Final Report (Task 1.6)
- Project Advisory Committee (PAC) Meetings (Task 1.10)

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

Contractor Deliverables:
- An Updated Schedule of Deliverables
- An Updated List of Match Funds
- An Updated List of Permits

Commission Contract Manager Deliverables:
- Final Report Instructions

Task 1.2 CPR Meetings
The goal of this task is to determine if the project should continue to receive Energy Commission funding to complete this Agreement and if it should, are there any modifications that need to be made to the tasks, deliverables, schedule or budget.

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

Participants include the Commission Contract Manager and the Contractor, and may include the Commission Contracts 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 Contract Manager to provide support to the Energy Commission.

The Commission Contract Manager shall:
- Determine the location, date and time of each CPR meeting with the Contractor. These meetings generally take place at the Energy Commission, but they may take place at another location.

- Send the Contractor 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 to modify the tasks, schedule, deliverables and budget for the remainder of the Agreement, including not proceeding with one or more tasks. If the Commission Contract Manager concludes that satisfactory progress is not being made, this conclusion will be referred to the Energy Commission's Research, Development and Demonstration Policy Committee for its concurrence.

- Provide the Contractor with a written determination in accordance with the schedule. The written response may include a requirement for the Contractor to revise one or more deliverable(s) that were included in the CPR.

The Contractor 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 deliverables identified in this Scope of Work. Submit these documents to the Commission Contract Manager and any other designated reviewers at least 5 days in advance of each CPR meeting.

- Present the required information at each CPR meeting and participate in a discussion about the Agreement.

Contractor Deliverables:

- CPR Report(s)
- CPR deliverables identified in the Scope of Work

Commission Contract Manager Deliverables:

- Agenda and a List of Expected Participants
- Schedule for Written Determination
- Written Determination

Task 1.3 Final Meeting
The goal of this task is to closeout this Agreement.

The Contractor shall:

- Meet with the Energy Commission 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 Contractor, the Commission Contracts Officer, and the Commission Contract 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 Contract Manager.

  The technical portion of the meeting shall present findings, conclusions, and recommended next steps (if any) for the Agreement. The Commission Contract Manager will determine the appropriate meeting participants.

  The administrative portion of the meeting shall be a discussion among the Contractor, the Commission Contract Manager, and the Contracts Officer about the following Agreement closeout items:

  - Options of what to do with any state-owned equipment
    - Need to file UCC.1 form re: Energy Commission's interest in patented technology
  - Energy Commission's request for specific data generated during the study, and not already provided in Agreement deliverables
  - Need to document Contractor's disclosure of "subject inventions" developed under the Agreement
  - "Surviving" Agreement provisions, such as repayment provisions and confidential deliverables
  - Final invoicing and release of retention

- Prepare a schedule for completing the closeout activities for this Agreement.

Deliverables:

- Written documentation of meeting agreements and all pertinent information
- Schedule for completing closeout activities

REPORTING

See Exhibit D, Reports/Deliverables/Records.

Task 1.4 Progress Reports
The goal of this task is to periodically verify that satisfactory and continued progress is made towards achieving the research objectives of this Agreement.

The Contractor shall:

- Prepare progress reports that summarize all Agreement activities conducted by the Contractor for the reporting period, including an assessment of the ability to complete the Agreement within the current budget and any anticipated cost overruns. Each progress report is due to the Commission Contract Manager within 10 days after the end of the reporting period with the submittal of each invoice, which is anticipated to be every six to eight weeks, but can be as frequently as monthly. Attachment A-2, Progress Report Format, provides the recommended specifications.

Deliverables:

- Progress Reports

Task 1.5 Test Plans, Technical Reports and Interim Deliverables

The goal of this task is to set forth the general requirements for submitting test plans, technical reports and other interim deliverables, unless described differently in the Technical Tasks. When creating these deliverables, the Contractor shall use and follow, unless otherwise instructed in writing by the Commission Contract Manager, the latest version of the PIER Style Manual published on the Energy Commission's web site:

http://www.energy.ca.gov/contracts/pier/contractors/

The Contractor shall:

- Unless otherwise directed in this Scope of Work, submit a draft of each deliverable listed in the Technical Tasks to the Commission Contract Manager for review and comment in accordance with the approved Schedule of Deliverables. The Commission Contract Manager will provide written comments back to the Contractor on the draft deliverable within 10 working days of receipt. Once agreement has been reached on the draft, the Contractor shall submit the final deliverable to the Commission Contract Manager. The Commission Contract Manager shall provide written approval of the final deliverable within 5 working days of receipt. Key elements from this deliverable shall be included in the Final Report for this project.

Task 1.6 Final Report

The goal of this task is to prepare a comprehensive written Final Report that describes the original purpose, approach, results and conclusions of the work done under this Agreement. The Commission Contract Manager will review and approve the Final Report. The Final Report must be completed on or before the termination date of the Agreement. When creating these deliverables, the Contractor shall use and follow, unless otherwise instructed in writing by the Commission Contract Manager, the latest version of the PIER Style Manual published on the Energy Commission's web site:

http://www.energy.ca.gov/contracts/pier/contractors/

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

Task 1.6.1 Final Report Outline

The Contractor shall:
- Prepare a draft outline of the Final Report.

- Submit the draft outline of Final Report to the Commission Contract Manager for review and approval. The Commission Contract Manager will provide written comments back to the Contractor on the draft outline within 10 working days of receipt. Once agreement has been reached on the draft, the Contractor shall submit the final outline to the Commission Contract Manager. The Commission Contract Manager shall provide written approval of the final outline within 5 working days of receipt.

Deliverables:
- Draft Outline of the Final Report
- Final Outline of the Final Report

Task 1.6.2 Final Report

The Contractor shall:
- Prepare the draft Final Report for this Agreement in accordance with the approved outline.

- Submit the draft Final Report to the Commission Contract Manager for review and comment. The Commission Contract Manager will provide written comments within 10 working days of receipt.

  Once agreement on the draft Final Report has been re ached, the Commission Contract Manager shall forward the electronic version of this report for Energy Commission internal approval. Once the approval is given, the Commission Contract Manager shall provide written approval to the Contractor within 5 working days.

- Submit one bound copy of the Final Report with the final invoice.

Deliverables:
- Draft Final Report
- Final Report

MATCH FUNDS, PERMITS, AND ELECTRONIC FILE FORMAT

Task 1.7 Identify and Obtain Matching Funds
The goal of this 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. While the PIER budget for this task will be zero dollars, the Contractor may utilize match funds for this task. Match funds shall be spent concurrently or in advance of PIER funds during the term of this Agreement. Match funds must be identified in writing, and the associated commitments obtained before the Contractor can incur any costs for which the Contractor will request reimbursement.

The Contractor shall:

- Prepare a letter documenting the match funding committed to this Agreement and submit it to the Commission Contract Manager at least 2 working days prior to the kick-off meeting:

    1. If no match funds were part of the proposal that led to the Energy Commission awarding this Agreement and none have been identified at the time this Agreement starts, then state such in the letter.

    2. If match funds were a part of the proposal that led to the Energy Commission awarding this Agreement, then provide in the letter:

        - A list of the match funds that identifies the:
            - 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 Contractor shall identify its owner and provide a contact name, address and telephone number, and the address where the property is located.

        - 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 significantly 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 Contract Manager if during the course of the Agreement additional match funds are received.

- Notify the Commission Contract Manager within 10 working days if during the course of the Agreement existing match funds are reduced. Reduction in match funds may trigger an additional CPR.

Deliverables:

- A letter regarding Match Funds or stating that no Match Funds are provided
- Letter(s) for New Match Funds
- A copy of each Match Fund commitment letter
- Letter that Match Funds were Reduced (if applicable)

Task 1.8 Identify and Obtain Required Permits

The goal of this 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. While the PIER budget for this task will be zero dollars, the Contractor shall show match funds for this task. Permits must be identified in writing and obtained before the Contractor can incur any costs related to the use of the permits for which the Contractor will request reimbursement.

The Contractor shall:

- Prepare a letter documenting the permits required to conduct this Agreement and submit it to the Commission Contract Manager at least 2 working days prior to the kick-off meeting:

    1. If there are no permits required at the start of this Agreement, then state such in the letter.

    2. 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:

        - A list of the permits that identifies the:
            - Type of permit
            - Name, address and telephone number of the permitting jurisdictions or lead agencies
        - Schedule the Contractor will follow in applying for and obtaining these permits.

- The list of permits and the schedule for obtaining them will be discussed at the kick-off meeting, and a timetable for submitting the updated list, schedule and the copies of the permits will be developed. 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, then provide the appropriate information on each permit and an updated schedule to the Commission Contract Manager.

- As permits are obtained, send a copy of each approved permit to the Commission Contract Manager.

- If during the course of the Agreement permits are not obtained on time or are denied, notify the Commission Contract Manager within 5 working days. Either of these events may trigger an additional CPR.

Deliverables:
- A letter documenting the Permits or stating that no Permits are required
- Updated list of Permits as they change during the Term of the Agreement
- Updated schedule for acquiring Permits as it changes during the Term of the Agreement
- A copy of each approved Permit

Task 1.9 Electronic File Format
The goal of this task is to unify the formats of electronic data and documents provided to the Energy Commission as contract deliverables. Another goal is to establish the computer platforms, operating systems and software that will be required to review and approve all software deliverables.

The Contractor shall:
- Deliver documents to the Commission Contract Manager in the following formats:
  - Data sets shall be in Microsoft (MS) Access or MS Excel file format.
  - PC-based text documents shall be in MS Word file format.
  - Documents intended for public distribution shall be in PDF file format, with the native file format provided as well.
  - Project management documents shall be in MS Project file format.

- Request exemptions to the electronic file format in writing at least 90 days before the deliverable is submitted.

Deliverables:
- A letter requesting exemption from the Electronic File Format (if applicable)

PROJECT ADVISORY COMMITTEE MEETINGS

Task 1.10 Conduct PAC Meetings
The goal of this task is for the PAC to provide strategic guidance to this project by participating in regular meetings or teleconferences.

PAC members may include representatives from the Energy Commission, Pacific Gas and Electric (PG&E), Lawrence Livermore National Laboratory, Bevilacqua-Knight Inc., interested stakeholders, and other qualified professionals selected by the Commission Contract Manager. The number of representatives can vary depending on potential interest and time availability. The Contractor's Project Manager and the Commission Contract Manager shall act as co-chairs of the PAC. The exact composition of the PAC may change as warranted by the needed technical expertise. PAC members serve at the discretion of the Commission Contract Manager.

The PAC may be composed of qualified professionals spanning the following types of disciplines:

- Researchers knowledgeable about the project subject matter
- Members of the trades who will apply the results of the project (e.g., designers, engineers, architects, contractors, and trade representatives)
- Public Interest Market Transformation Implementers
- Product Developers relevant to project subject matter
- U.S. Department of Energy Research Manager
- Public Interest Environmental Groups
- Utility Representatives
- Members of the relevant technical society committees

The purpose of the PAC is to:

- Provide guidance in research direction. The guidance may include scope of research; research methodologies; timing; coordination with other research. The guidance may be based on:
  - technical area expertise
  - knowledge of market applications
  - linkages between the agreement work and other past, present or future research (both public and private sectors) they are aware of in a particular area.
- Review deliverables. Provide specific suggestions and recommendations for needed adjustments, refinements, or enhancement of the deliverables.
- Evaluate tangible benefits to California of this research and provide recommendations, as needed, to enhance tangible benefits.
- Provide recommendations regarding information dissemination, market pathways or commercialization strategies relevant to the research products.

The Contractor shall:

- Discuss the PAC meeting schedule at the kick-off meeting. The number of face-to-face meetings and teleconferences and the location of PAC meetings shall be determined in consultation with the Commission Contract Manager. This draft schedule shall be submitted two weeks after the Kick-off Meeting and finalized at the first PAC meeting.
- Organize and lead PAC meetings in accordance with the schedule. Changes to the schedule must be pre-approved in writing by the Commission Contract Manager.
- Prepare PAC meeting agenda(s) with back-up materials for agenda items.
- Prepare PAC meeting summaries, including recommended resolution of major PAC issues.

Deliverables:

- Draft PAC Meeting Schedule
- Final PAC Meeting Schedule
- PAC Meeting Agenda(s) with Back-up Materials for Agenda Items
- Written PAC meeting summaries, including recommended resolution of major PAC issues

TECHNICAL TASKS

The Contractor shall prepare all deliverables in accordance with the requirements in Task 1.5. Deliverables not requiring a draft version are indicated by marking "(no draft)" after the deliverable name.

TASK 2: OVERALL ASSESSMENT OF CALIFORNIA NGCC PLANTS AND CO_2 CAPTURE TECHNOLOGIES FOR RETROFIT

The goals of this task are to provide both an evaluation of CO_2 capture technologies and an assessment of the suitability of California NGCC facilities for retrofit with CO_2 capture technologies.

Task 2.1: Expanded Assessment of Suitability of NGCC Facilities for CO_2 Capture and Injection Operations

The goal of this task is to update and expand on the West Coast Regional Carbon Sequestration Partnership's (WESTCARB's) Preliminary Assessment Paper on the suitability of California NGCC facilities for CO_2 capture retrofit.

The Contractor shall:

- Update and expand on WESTCARB's Preliminary Assessment Paper on the suitability of California NGCC facilities for CO_2 capture retrofit, using publicly available information sources. [The final version of the WESTCARB Preliminary Assessment Paper will be provided to the Contractor by the Commission Contract Manager after the contract start date.] The Contractor's expanded assessment paper shall include, but not be limited to, the following information:
  - Available plot space at each plant considered or assessed to install CO_2 capture and compression equipment and auxiliary equipment.
  - Assessment of the suitability of subsurface geology for sequestration and the level of added risk from subsurface features (e.g., faults) for each plant site evaluated, including compatibility between surface and subsurface characteristics, proximity of plants to suitable sequestration sites, CO_2 source volume versus reservoir capacity, and depths and number of wells needed to inject (within permissible pressures, etc.) the required amount of CO_2.
  - The feasibility of pipeline construction from the plant to the CO_2 storage location, if applicable (i.e., urban versus rural, terrain, existing pipeline rights of way, distance, etc.).
  - How common the site equipment and configuration are to other PG&E, California, and national NGCC facilities to determine how applicable this study's results are to the rest of California and the nation.
  - Summary of historical and forecasted dispatch frequency, capacity factor, and remaining unit life to assure economic viability for each plant considered or assessed.

- Summary of cooling technologies in use at each plant and the availability of, and potential need for, supplemental water supplies to accommodate CO_2 capture process steam and cooling loads (if applicable) and CO_2 compressor interstage cooling. Consideration should be given to technologies and techniques that minimize or eliminate the water supplies needed for plant operation.
- Supporting data references to substantiate the results of the assessment.

Deliverable:
- Expanded Assessment Paper

Task 2.2: Basic Evaluation of CO_2 Capture Technologies
The goal of this task is to complete a basic evaluation of CO_2 capture technologies.

The Contractor shall:
- Compile and perform a basic evaluation of:
  - CO_2 capture technology options currently available
  - Emerging technologies that warrant consideration
  - New technologies that should be considered for a future pilot demonstration on NGCC plants
    - Characterize each technology's level of development, commercial maturity, and their impact on, or interaction with, plant design and operations for utility-scale NGCC or cogeneration/combined heat and power (CHP) units. The technologies for CO_2 capture shall range from commercially proven to developmental, but each technology should have reasonable prospects for being commercially available by 2020, and each technology must be at a minimum threshold of development of nominally one megawatt (MW) equivalent scale by March 2011. Categorize CO_2 capture technologies by their approach or point of application.
- Provide a screening report that is suitable for assessing and comparing the expected performance and costs of the proposed technologies. The report shall include, but not be limited to, a table comparing the following characteristics of each capture technology:
  - Fundamental operating principles of the CO_2 capture technology as applied to an NGCC plant.
  - Level of development or commercial maturity. Provide definitions of development or commercial maturity levels identified. For processes not yet commercially ready, list the plans for scale-up and demonstration along with associated funding status and any scale-up limitations or concerns.
  - Basic performance characteristics expected from the technology. Indicate the source of the expected performance and costs information (e.g., developer claim, field-test-supported measurement, DOE NETL assessment, etc.). Qualitative ratings may be used in lieu of quantified values for the following characteristics:
    - Thermal and electrical loads
    - Minimum steam conditions for solvent regeneration
    - Capital cost
    - Operations and Maintenance (O&M) costs
    - Solvent make-up
    - Land requirements

    - Cooling and process water demand
    - Material handling and disposal requirements for the solvent
    - Health, safety, and environmental considerations
- Submit an initial evaluation paper categorizing and characterizing CO_2 capture technologies applicable for California NGCC plants and tabulate basic measures of expected performance and cost, development status, and technology-specific design considerations. The paper shall include the Contractor's recommendations of CO_2 capture technologies to evaluate further in Task 2.3 and also describe the process and criteria used to develop these recommendations.
- Participate in a PAC meeting with the Commission Contract Manager to discuss the Contractor's recommendations and select the CO_2 capture technologies for more detailed evaluation in Task 2.3.

Deliverable:
- Screening Report on CO_2 Capture Technologies (no draft)
- Initial Evaluation Paper of CO_2 Capture Technologies

Task 2.3: Detailed Evaluation of CO_2 Capture Technologies Selected in PAC Meeting
The goal of this task is to complete a detailed evaluation of the selected CO_2 capture technologies.

The Contractor shall:
- Perform an expanded and more detailed evaluation on the CO_2 capture technologies recommended for further study by the Commission Contract Manager following the Task 2.2 PAC meeting (expected to be a minimum of three capture technologies). The evaluation shall include an approximate quantitative assessment of the impacts of the capture technology and associated compression, dehydration, and purification requirements. Where approximate quantitative values are unavailable or impractical to develop, qualitative characterizations or other suitable assessment methods may be used. A nominal 550 MW, 2-on-1 F-class NGCC plant in a California setting should be used as the basis for quantitative evaluations, unless different guidance is provided by the Commission Contract Manager following the assessment described in Task 2.1. The detailed evaluation shall include, but not be limited to, the following information as applicable:
    - Detailed process descriptions and process flow diagrams showing inputs, outputs, and boundary conditions (mass flow, temperature, pressure, inlet flue gas composition) for the capture process.
    - Solvent/sorbent regeneration energy required and associated steam demand (mass flow, temperature, and pressure) and/or electric demand.
    - Air Separation Unit (ASU) capacity, electrical load, oxygen purity requirements, and exhaust gas recycle rate.
    - Heat balance of conversion process, water-gas shift stage(s), and capture process; gas constituents pre- and post-shift and post-capture.
    - Auxiliary power requirements, including but not limited to:
        - Capture process unit
        - Flue gas pressure boost fan

    - Compression and dehydration processes
    - Cooling processes
    - Other applicable process changes
  - Impact of capture system operation (including compression train and ASU) on gross and net electric output and gross and net generating efficiency at full load.
  - Impact of CO_2 capture retrofit and operation on plant turndown, ramp rate, and other factors related to operating flexibility and dispatch value.
  - Increase in plant cooling demand.
  - Plot space requirements for additions and modifications to the plant site and operations.
  - Any impacts on combustor operation, mass flows, working fluid characteristics, exhaust backpressure, and other gas turbine design and operating factors.
  - Impacts on plant criteria pollutant and hazardous air pollutant (HAP) emissions.
  - Expected CO_2 quality and potential market value.
  - Materials handling, safety training, disposal impacts, and any public health or environmental concerns associated with chemical release.
  - Other risks associated with the technology.
  - Capital cost of implementing the technology as a retrofit, in dollars per kilowatt ($/kW).
  - Incremental capital cost of implementing the technology on a new unit ($/kW).
  - Change in dispatch cost in dollars per megawatt-hour ($/MWh) and change in levelized cost of electricity (including capital recovery), or alternatively the cost of CO_2 avoided (dollars per metric tonne of CO_2).
    For an example, see Cases 13 and 14 in *Cost and Performance Baseline for Fossil Energy Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity Final Report* (DOE/NETL-2007/1281).
- Submit a detailed evaluation report on the selected CO_2 capture technologies (expected to be a minimum of three). The report shall discuss and quantify, for each selected technology evaluated, the operational, health, safety, and environmental impacts of the technology, as well as the quantitative and qualitative assessments of performance and cost. The report shall also include the Contractor's recommendations for one or more technologies to be considered in the Task 3 site-specific engineering-economic evaluations.
- Conduct a PAC meeting with the Commission Contract Manager to discuss the Contractor's recommendations, and select the technologies to be used for additional analysis in Task 2.4 and Task 2.5.

Deliverable:
- Detailed Evaluation Report of Selected CO_2 Capture Technologies

Task 2.4: Comparison of Cost and Performance Impacts
The goal of this task is to compare the cost and performance impacts of the selected CO_2 capture technologies.

The Contractor shall:

- Compare and contrast the cost and performance impacts of the CO_2 capture technologies selected at the Task 2.3 PAC meeting. Compare and contrast the application of CCS to NGCC plants with the application of CCS to other types of power plants. Comparison cases shall include, but not be limited to:
  - Gas-fired steam power plants
  - Coal-fired power plants, including pulverized coal, circulating fluidized-bed combustion, and Integrated Gasification Combined Cycle (IGCC)
  - Petroleum coke–fueled IGCC
  - Waste-to-energy boilers fired with black liquor, biomass, or refuse-derived fuels
- For each technology, provide a tabular comparison in the required assessment paper (below) of the following parameters for CO_2 capture and non-CO_2 capture cases:
  - CO_2 emissions (pounds/MWh_{net})
  - Gross and net power output (MW)
  - Net efficiency (percentage) and heat rate (British Thermal Unit (Btu)/kilowatt-hour (kWh)), on a consistent basis, either Low Heating Value (LHV) or High Heating Value (HHV)
  - Capital cost ($/kW)
  - Levelized cost of electricity ($/MWh), on a consistent levelization period basis
  - Cost of CO_2 avoided ($/metric tonne CO_2)
- Adjust impact results to reflect comparable capital carrying charges, replacement power costs, cost of water, capacity factor, etc.
- Provide sensitivity tables or charts in the required assessment paper (below) to allow comparison at different fuel costs.
- Submit an assessment paper comparing NGCC-CCS applications to CCS applications on other fossil- and renewable-fueled steam or combined cycle plants. The paper shall summarize the information stated above and provide conclusions from the comparison cases.

Deliverable:

- Assessment Paper comparing CCS applications on different types of power plants

Task 2.5: Regulatory and Permitting Issues

The goal of this task is to identify regulatory and permitting requirements and potential barriers for the implementation of the selected CO_2 capture technologies.

The Contractor shall:

- For the CO_2 capture technologies selected from the Task 2.3 PAC meeting, identify possible regulatory and permitting requirements for the CO_2 capture and compressor retrofit as well as CO_2 transportation and long-term storage issues (e.g., operator liabilities, storage liability, etc.).
- Submit an assessment paper listing expected regulatory and permitting requirements for NGCC-CCS application, explaining any significant distinctions between requirements for different CO_2 capture technologies and CO_2 long-term storage options.

Deliverable:

- Assessment Paper on Regulatory and Permitting Requirements

TASK 3 ENGINEERING OPTIONS ANALYSIS PROCEDURE, SITE ASSESSMENT, AND PRELIMINARY ENGINEERING DESIGN FOR CO_2 CAPTURE RETROFIT AND NEW-BUILD CASES

The goals of this task are to develop an engineering options analysis procedure, site assessment, and preliminary engineering designs for CO_2 capture for facility retrofit and new-build cases.

Task 3.1: Development of Retrofit Engineering Options Analysis Procedure

The goal of this task is to develop a retrofit engineering options analysis procedure for tabulating cost and risk comparisons for applying selected CO_2 capture technologies at California NGCC plant sites.

The Contractor shall:

- Develop a retrofit engineering options analysis procedure that shall include, but not be limited to, the following items that shall be applied in Tasks 3.3 and 3.4:
  - For the CO_2 capture technologies identified in the Task 2.3 PAC meeting, establish an approach to modifying the generic cost and performance impacts developed in Task 2 to account for the site-specific factors for California NGCC sites, including the cost and energy use for CO_2 transportation and injection and any revenue from sale for enhanced oil recovery (EOR).
  - Establish an approach to quantifying heat rate penalties for CO_2 compression and dehydration to account for the site-specific factors for California NGCC sites.
  - Establish an approach to quantifying potential reductions in NGCC unit output, efficiency, and capacity factor (including an estimate of replacement power cost, if applicable) that would affect the levelized cost of electricity, net revenue, or other economic performance metric for a retrofit unit to account for the site-specific factors for California NGCC sites.
  - Establish an approach to quantifying any loss or improvement in the ability to provide ancillary services to the grid to account for the site-specific factors for California NGCC sites.
  - Establish an approach to quantifying any major change in operations, safety preparedness measures, or environmental control/assurance as a result of the properties of CO_2 capture process solvents to account for the site-specific factors for California NGCC sites.
- Submit a paper describing the retrofit engineering options analysis procedure, the basis for each element of the procedure, and a workbook template for applying the procedure.
- Participate in a PAC meeting with the Commission Contract Manager to discuss the Contractor's retrofit engineering options analysis procedure and workbook template for applying the procedure.

Deliverable:

- Paper on Retrofit Engineering Options Analysis Procedure

Task 3.2: Select Sites at Which to Apply the Engineering Options Analysis Procedures
The goal of this task is to select the sites at which to apply the engineering options analysis procedures.

The Contractor shall:
- In consultation with the PAC and the Commission Contract Manager, select sites using the following criteria, as well as additional criteria agreed upon between the Commission Contract Manager and Contractor:
  - Trade-off between number of site and capture-technology combinations evaluated and the level of detail that can be afforded for each site and capture-technology combination based on time available to complete the project.
  - Nominal CO_2 capture efficiency (percentage).
  - Number and type of capture technologies to examine with retrofit cases.
  - Number and type of capture technologies to examine with new-build cases.
- Submit a paper with a ranked list of sites and a description of the evaluation process and criteria used to develop this list.

Deliverable:
- Paper with Ranked List of Sites

Task 3.3: Application of Retrofit Engineering Options Analysis Procedure
The goal of this task is apply the retrofit engineering options analysis procedure to the selected site/technology combinations.

The Contractor shall:
- For each site selected in Task 3.2, apply the retrofit engineering options analysis procedure to examine the following factors in detail as applicable, and quantify the estimated cost and performance impacts:
  - Capital costs on an "overnight cost" basis (i.e., occurring at a single point in time without the cost of interest during construction). Itemize major cost components.
  - Levelized cost of electricity breakdown by capital, fixed O&M, and variable O&M costs including waste disposal, fuel, and CO_2 transportation, storage, and monitoring.
    - Provide separate calculations with appropriate assumptions for a metric preferred by independent power producers (net revenue or return on investment (ROI)).
    - Provide separate calculations with appropriate assumptions for different CO_2 storage options (e.g., well field complexity, income from CO_2 sale for EOR).
  - Measures of CO_2 capture effectiveness and cost.
  - Gross and net power output and other key performance indices.
  - Process flow diagram and table of major process stream values.
  - Simplified heat and mass balance evaluation.
  - Water balance evaluation.
  - Energy balance evaluation.
  - Key capture technology parameters as applicable, including, but not limited to:
    - CO_2 capture technology classification (pre-combustion, oxy-combustion, post-combustion).

    - CO_2 capture system design features and life cycle parameters as applicable, including but not limited to:
        - Description of basic operating principles.
        - Solvent/sorbent/catalyst type, cost, “useful life,” and chemical makeup rates; number and location of solvent/sorbent/catalyst suppliers.
        - Equipment or component refurbishment/replacement cycle and location and capacity of manufacturing facilities.
    - CO_2 loading and sorbent circulation or cycle rate.
    - Sorbent regeneration energy requirements.
    - Process equipment design features.
    - Storage tank size and purpose.
    - Capture system cooling demand.
    - Post-separation CO_2 purification needs.
    - Post-separation CO_2 stream pressure (which affects compression costs).
  - Required equipment and available space for installation.
  - Equipment layout (plot plan) drawings.
  - Modifications to water supply and treatment, and wastewater treatment and disposal.
  - Cooling requirements and options.
  - Requirements for any polishing emissions control or other pre-treatment prior to the CO_2 absorber inlet.
  - Additions and modifications to auxiliary power supply.
  - Impact of CO_2 capture and compression on startup time, ramp rate, and other factors that would affect the ability to provide ancillary services to grid operators.
  - Operations and maintenance staffing changes and associated labor costs.
  - Environmental compliance changes including hazardous material handling and disposal.
  - Other criteria for evaluating compatibility with the owner’s business plans.
- Submit engineering options analysis workbooks for each selected retrofit site/technology combination with preliminary cost estimates, generating unit and capture facility performance evaluations, equipment lists, engineering drawings, and operational impact assessments.
- Conduct a PAC meeting at the end of Task 3.4 with the Commission Contract Manager to discuss the Contractor’s recommendations and select the retrofit site/capture technology combinations to be used for the sensitivity studies in Task 3.5.

Deliverables:

- Engineering Options Analysis Workbooks for Selected Retrofit Site/Technology Combinations

Task 3.4: Application of New-Build Engineering Options Analysis Procedure for With-Capture and Without-Capture Plant Designs

The goal of this task is compare the cost and performance impacts of the selected sites with and without incorporating the selected CO_2 capture technology.

The Contractor shall:

- For each selected new-build site/capture technology combination, conduct a with-capture/without-capture case comparison, including a standard plant design and a plant design incorporating CO_2 capture.
- Modify the retrofit engineering options analysis procedure, as appropriate, to create the new-build engineering options analysis procedure that shall examine the following factors and quantify estimated cost and performance impacts:
  - Capital costs on an overnight cost basis (i.e., without interest charges during construction).
  - Levelized cost of electricity breakdown by capital, fixed O&M, variable O&M (including waste disposal, if applicable), fuel, and CO_2 transportation, storage, and monitoring:
    - Provide separate calculations with appropriate assumptions for a metric preferred by independent power producers (net revenue or ROI).
    - Provide separate calculations with appropriate assumptions for different CO2 storage options (e.g., well field complexity or income from CO2 sale to oilfield operators for enhanced oil recovery).
  - Measures of CO_2 capture effectiveness and cost.
  - Gross and net power output and other key performance indices.
  - Process flow diagram and table of major process stream values.
  - Simplified heat and mass balance diagram evaluation.
  - Water balance evaluation.
  - Energy balance evaluation.
  - Key capture technology parameters including, but not limited to:
    - CO_2 capture technology classification (pre-combustion, oxy-combustion, post-combustion).
    - CO_2 capture system design features and life cycle parameters as applicable, including but not limited to:
      - Description of basic operating principles, such as circulating liquid, circulating bed, fixed bed/cyclic operation, or selective membrane.
      - Solvent/sorbent/catalyst type, cost, “useful life,” and chemical makeup rates; number and location of solvent/sorbent/catalyst suppliers.
      - Equipment or component refurbishment/replacement cycle, and location and capacity of manufacturing facilities.
    - CO_2 loading and sorbent circulation or cycle rate.
    - Sorbent regeneration energy requirements.
    - Process equipment design features.
    - Storage tank size and purpose.
    - Capture system cooling demand.
    - Post-separation CO_2 purification needs.
    - Post-separation CO_2 stream pressure (which affects compression costs).
  - Required equipment and available space for installation.
  - Equipment layout (plot plan) drawings.
  - Modifications to water supply and treatment, and wastewater treatment and disposal.
  - Cooling requirements and options.
  - Requirements for any polishing emissions control or other pre-treatment prior to the CO_2 absorber inlet.

- Additions and modifications to auxiliary power supply.
- Impact of CO_2 capture and compression on startup time, ramp rate, and other factors that would affect the ability to provide ancillary services to grid operators.
- Operations and maintenance staffing requirements and associated labor costs.
- Environmental compliance requirements including hazardous material handling and disposal.
- Other criteria for evaluating compatibility with the owner's business plans.

- Submit an engineering options analysis workbook for each selected new-build site/technology combination without and with CCS including preliminary cost estimates, generating unit and capture facility performance evaluations, equipment lists, engineering drawings, and operational impact assessments.
- Conduct a PAC meeting for Tasks 3.3 and 3.4 with the Commission Contract Manager to discuss the Contractor's recommendations and select the cases to be used for the sensitivity studies in Tasks 3.5 and 3.6 accordingly.

Deliverable:

- Engineering Options Analysis Workbooks for Selected New-Build Site/Technology Combinations

Task 3.5: Sensitivity Analyses for Selected Retrofit Cases

The goal of this task is to perform sensitivity analyses on the cost and performance impacts for the selected retrofit site/technology combinations.

The Contractor shall:

- For the retrofit site/capture technology combinations selected in Task 3.3, perform a series of sensitivity analyses examining the cost and performance impacts of possible design and operation options that shall include, but not be limited to, the following as applicable:
  - Enhanced auxiliary boiler capacity to meet solvent regeneration steam requirements.
  - Expanded use of duct firing to meet solvent regeneration steam requirements, if feasible.
  - Air separation unit (ASU) oxygen purity.
  - Reduced CO_2 capture efficiency (partial capture at reduced cost, such as the number of stages of water-gas shift for partial oxidation pre-combustion).
  - Reduced capacity factor.
  - Part-load operation.
  - Design requirement that the CO_2 capture system can be turned off or bypassed during peak power periods to maximize power delivery to the grid.
  - Any additional items proposed by the Contractor.
- Submit sensitivity analyses workbooks for the selected retrofit site/technology combinations and a report summarizing the results of all the retrofit analyses (i.e., results of Tasks 3.2 and 3.3).

Deliverables:

- Sensitivity Analyses Workbooks for Selected Retrofit Site/Technology Combinations
- Retrofit Analyses Results Report

Task 3.6: Sensitivity Analyses for Selected New-Build Cases
The goal of this task is perform sensitivity analyses on the cost and performance impacts for the selected new-build site/technology combinations.

The Contractor shall:
- For the new-build site/capture technology combinations selected in Task 3.4, perform a series of sensitivity analyses examining the cost and performance impacts of possible design and operation options that shall include, but not be limited to, the following as applicable:
  - Exhaust gas recirculation to increase CO_2 concentration and reduce mass flow of flue gas to the CO_2 absorber or to accommodate oxygen firing.
  - The number of stages of water-gas shift.
  - Alternative steam/CO_2 turbine configurations.
  - Air separation unit (ASU) oxygen purity.
  - Air-cooled condenser and fin-fan heat exchangers for process cooling.
  - Solvent loop in the heat recovery steam generator (HRSG) to meet the regeneration thermal requirement.
  - Capture-ready pre-investment for new plants without CCS, at a level to be determined to facilitate future addition of CCS.
  - Any additional items proposed by the Contractor.
- Submit sensitivity analyses workbooks for the selected new-build site/technology combinations and a report summarizing the results of all the new-build analyses (i.e., results of Tasks 3.2 and 3.4).
- Participate in a CPR meeting with the Commission Contract Manager prior to beginning Task 4. Changes to the schedule must be pre-approved in writing by the Commission Contract Manager.

Deliverables:
- Sensitivity Analyses Workbooks for Selected New-Build Site/Technology Combinations
- New-Build Analyses Results Report
- CPR Report (per Task 1.2) (no draft)

TASK 4 PRELIMINARY SCOPE, COST ESTIMATE, AND SCHEDULE FOR A CALIFORNIA PILOT-SCALE TECHNOLOGY VALIDATION TEST OF AN NGCC PLANT WITH CCS APPLICATION

The goals of this task are to provide a preliminary scope, cost estimate, and schedule for a California pilot-scale technology validation test of an NGCC plant with CCS application.

Task 4.1: Pilot-Scale Project and Location

The goals of this task are to determine the CO_2 capture technology and site for the pilot-scale project.

The Contractor shall:

- In conjunction with the Commission Contract Manager, determine the pilot-scale integrated CCS project type and location(s) in PG&E's service territory that would best advance a pre-commercial CO_2 capture technology toward commercial availability in California.
  - Develop a statement of strategic interests and pilot project goals based on communications with the Commission Contract Manager.
  - Develop a project proposal, at an executive summary level of detail, outlining preliminary scope, schedule, and budget for the proposed CCS pilot project. The proposal should include the rationale for capture technology and site selection, permitting requirements, and potential risk areas. If feasible, adapt the process flow diagrams, heat and mass, balance, water balance, layouts, and other information developed in Task 3.2 to reflect the scale of the proposed pilot project, and provide them as attachments to the executive summary. The CCS pilot may be at the site analyzed in Task 3.3, or at an alternate site better suited for a near-term technology validation test (which may be a new plant).
  - Arrange a meeting with representatives of the owner/operator of the candidate project site(s) to present the proposed project scope, assess interest, and obtain feedback. The meeting shall be attended by the Contractor, Commission Contract Manager, PAC, and other attendees invited by the Commission Contract Manager.
  - Arrange a meeting with representatives of the supplier(s) of the capture technologies to present the proposed project scope, assess interest, and obtain feedback. The meeting shall be attended by the Contractor, Commission Contract Manager, PAC, and other attendees invited by the Commission Contract Manager,
  - Perform a survey of subsurface property rights and commercial and regulatory options for long-term CO_2 storage, albeit with uncertainty given lack of regulatory definition.
- Submit a pilot project proposal containing a statement of strategic objectives and pilot project goals at an executive summary level of detail, outlining preliminary scope, schedule, and budget for the proposed CO_2 capture and storage pilot project.
- Provide notes detailing meetings with representatives of candidate host sites and technology suppliers for the proposed pilot project.
- Submit a paper on policy issues regarding subsurface property rights and commercial and regulatory options for CO_2 injection for long-term storage or sale to oilfield operators for enhanced oil recovery.

- Conduct a PAC meeting with the Commission Contract Manager to discuss the Contractor's recommendations and to select the CCS project type and location(s) to be used for feasibility studies in Tasks 4.2, 4.3, and 4.4.

Deliverables:
- Pilot Project Proposal
- Meeting Notes (no draft)
- Policy Issues Paper

Task 4.2: Project Scope and Schedule for the Pilot Project
The goals of this task are to develop a project scope and schedule for the proposed pilot project.

The Contractor shall:
- Develop a detailed project scope and preliminary project schedule for a feasibility-level study of the pilot project selected in Task 4.1.
  - Develop a detailed project scope description, with input from the host facility owner/operator, capture technology provider, and other project sponsors that fully encompasses the objectives of the selected project.
  - Develop a Gantt chart schedule showing major tasks and dependencies, including, but not limited to:
    - Obtaining project funding
    - Securing an engineering and procurement contractor
    - Obtaining surface and mineral rights for the CO_2 transfer pipeline and injection and monitoring facilities
    - Conducting environmental review and permitting activities:
      - California Environmental Quality Act (CEQA)/National Environmental Policy Act (NEPA) studies for the project
      - Underground Injection Control (UIC) and surface facilities permits for the proposed CO_2 injection and monitoring wells
      - Construction permits for the CO_2 capture and compression facility
      - Construction permits for the CO_2 transfer pipeline
      - Hazardous materials and hazardous waste handling permits, as needed
  - Submit the project scope and schedule to the Commission Contract Manager for review and comment by the PAC. Incorporate review comments and refine the project scope and schedule.
  - Provide a written response to review comments detailing any areas of disagreement with review comments or revisions to project scope and schedule that are not consistent with comments.

Deliverables:
- Proposed Pilot Project Scope and Schedule
- Written Response to Review Comments (no draft)

Task 4.3: Feasibility Study for Proposed Pilot Project
The goal of this task is to determine the feasibility of the proposed pilot project.

The Contractor shall:

- Conduct a feasibility study by developing a preliminary design, performance analysis, and capital cost estimate for the proposed CCS pilot project.
  - Modify Construction Specifications Institute standard specifications for process, piping, mechanical, civil, structural, electrical, and instrumentation/control design, purchase, materials, and construction.
  - Incorporate unit information and vendor feedback to refine the process design. Complete detailed process analysis and prepare the following documents:
    - Process flow diagram (PFD) and stream table, including all relevant information.
    - Heat and mass balance calculations and diagrams, energy balance calculations and tables, and key process parameter tables for CO_2 capture and injection.
    - Plant inputs and outputs table, including:
      - Sorbent purchases
      - Other chemical purchases
      - Waste products and disposal requirements
    - Instrumentation and control system philosophy, including a statement of data to be captured to allow calculation of desired test program results.
  - Submit a simplified piping and instrumentation drawing (P&ID) showing major equipment and key auxiliaries, interconnecting piping and valves (internal and external to the capture facility), and key instrumentation and control elements.
  - Submit a valve list and a line list with piping specifications and approximate lengths of major piping runs.
  - Perform process hazards analysis and risk analysis at a level commensurate with the level of engineering embodied in the feasibility study.
  - Submit preliminary design drawings to include, but not be limited to:
    - An update of an existing site plan
    - Plot plans and basic elevation drawings
    - National Electrical Manufacturers Association (NEMA) Hazard Class requirements for electrical and control equipment
    - An area map
    - Pipeline hydraulic profiles
    - Single-line and elementary electrical drawings showing pertinent changes
    - Injection well and monitoring well detail drawings
  - Submit major equipment and materials lists at the level of detail needed for preparing cost estimates.
  - Develop budgetary estimates for pilot plant and injection and monitoring well construction and startup, using industry accepted data.
    - Capital costs should be on an overnight cost basis and include separate line items for any first-of-a-kind premiums and owner's costs (to be developed in conjunction with other plant owner/operator).
    - Startup costs should include staffing, equipment, services, startup spare parts, initial fill, and startup inventory of sorbents and other chemicals.

- Analyze O&M impacts and O&M cost estimates for the proposed CCS pilot project.
  - Evaluate factors that would impact the host plant's startup time, ramp rate, and other factors that would affect plant operability, availability, and operating cost.
  - Estimate labor, equipment, materials, and makeup power costs for the CO_2 capture, compression, transportation, injection, storage, and monitoring facilities and any added costs for water supply, water treatment, wastewater treatment and disposal, and chemical disposal.
- Submit for review and comment by the PAC a feasibility study for the pilot-scale technology validation test (of an NGCC-CCS application in PG&E's service territory), including the preliminary design, process analysis, capital cost estimates, schedule, operating cost estimates, and other supporting documents required for follow-on engineering and funding solicitation. Contractor shall incorporate review comments provided by Commission Contract Manager to refine the feasibility study.
- Provide a written response to review comments detailing any areas of disagreement with review comments or revisions to the feasibility study that are not consistent with comments.

Deliverables:

- Feasibility Study for Pilot-Scale Technology Validation Test
- Written Response to Review Comments (no draft)