Exhibit A
WORK STATEMENT

DEMONSTRATION OF ADVANCED BIOMASS COMBINED HEAT AND POWER SYSTEMS IN THE AGRICULTURAL PROCESSING SECTOR

TASK LIST

Task #	CPR	Task Name
1		Administration
2		Project Initiation
3	X	Design, Fabrication, and Installation of BCHP System
4		Qualification of the Biomass Feedstock for BCHP Operations
5		Demonstrate Emissions Control Compliance with CARB Standards
6		Demonstrate Recovery of Ash Byproduct from BCHP for Recycling
7		Demonstrate Power Production and Heat Utilization for Agricultural Processing
8		Techno/Economic Models for Commercialization of BCHP
9		Technology Transfer Activities
10		Production Readiness Plan

KEY NAME LIST

Task #	Key Personnel	Key Subcontractor(s)	Key Partner(s)
1	Dr. Matthew Summers (West Biofuels, LLC)		
2	Dr. Matthew Summers (West Biofuels, LLC)		
3	Dr. Matthew Summers (West Biofuels, LLC)		
4	Professor/Investigator	University of California	
5	Dr. Matthew Summers (West Biofuels, LLC) Dr. Robert Cattolica	University of California, San Diego	
6	Dr. Matthew Summers (West Biofuels, LLC) Dr. Robert Cattolica	University of California, San Diego	
7	Dr. Matthew Summers) Dr. Robert Cattolica	University of California, San Diego	
8	Dr. Matthew Summers (West Biofuels, LLC) Dr. Robert Cattolica	University of California, San Diego	
9	Dr. Matthew Summers		

Exhibit A
WORK STATEMENT

Task #	Key Personnel	Key Subcontractor(s)	Key Partner(s)
	(West Biofuels, LLC)		
10	Dr. Matthew Summers (West Biofuels, LLC)		

GLOSSARY

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

Term/ Acronym	Definition
BCHP	Biomass Combined Heat and Power
CARB	California Air Resources Board
CO	Carbon Monoxide
CPR	Critical Project Review
CPUC	California Public Utilities Commission
Energy Commission	California Energy Commission
M&V	Measurement and Verification
NOx	Nitrogen Oxide
PAC	Project Advisory Committee
PIER	Public Interest Energy Research
RD&D	Research, Development and Demonstration
SCR	Selective Catalytic Reduction
SO2	Sulfur Dioxide
VOC	Volatile Organic Compounds

Problem Statement:

This Agreement will demonstrate renewable biomass combined heat and power production (BCHP) in the agricultural processing sector. Deployment of BCHP facilities in the California agricultural processing sector has not occurred due to the following barriers:

- Technological: While biomass gasifiers have existed for many years, there have been insufficient demonstrations of reliable, integrated BCHP systems that can be turn-key for industry.
- Market: Consumer knowledge about BCHP has been limited due to lack of demonstrated, marketable systems. In addition, the major incentive programs of the utilities like the Self-Generation Incentive Program have not considered BCHP for incentives. The California Public Utilities Commission (CPUC) is considering a Feed-In-Tariff for BCHP that could help spurn the industry if the other barriers are addressed.
- Institutional and Environmental: Restrictive emissions control standards in the California air districts are required for deployment of the BCHP technology. In addition, any residues from the BCHP process must be recycled to the land and must not become a disposal issue.

Exhibit A
WORK STATEMENT

This Agreement will address all of these barriers. The team of West Biofuels and Gussing Renewable Energy America will, along with other collaborators, demonstrate a BCHP technology that is ready for rapid deployment in California.

Goals of the Agreement:
The goal of this Agreement is to demonstrate a robust, efficient, and environmentally sound BCHP system that can be commercially deployed in the agricultural processing sector in California.

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

- Qualify the use of almond biomass feedstock for BCHP operations (Target: Establish that the amount of 1.5 million tons of available almond biomass (including shell, pruning, and wood) is feasible for gasification).
- Demonstrate emission controls for BCHP technologies that can meet California Air Resources Board (CARB) and Regional Air District Standards (Targets: nitrogen oxide (NOx) emissions below 0.07 lbs/MW-hr; carbon monoxide (CO) emissions below 0.10 lbs/MW-hr; and volatile organic compounds (VOC) emissions below 0.02 lbs/MW-hr).
- Demonstrate an ash byproduct suitable for recycling as fertilizer back to agriculture (Targets: chromium composition in ash byproduct is less than 500 mg/kg; composition of other compounds below California non-hazardous ash standards).
- Demonstrate electrical efficiency and heat recovery guidelines for BCHP that can be used by California utilities to develop incentive and interconnection programs for BCHP technologies in the agricultural and food processing sector (Targets: Overall electrical efficiency of 22%; combined heat and power efficiency of 65%).
- Develop a techno/economic model for commercialization of BCHP to include a carbon and material life cycle analysis (Targets: Installed cost for commercial system less than $4000 per kWe; Minimum acceptable rate of return of 12% for potential commercial projects; and Carbon emissions that are 70% less than conventional power and heating at an agricultural processing facility).

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

TASK 1 ADMINISTRATION

Task 1.1 Attend Kick-off Meeting

The goal of this 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 Energy Commission Project Manager shall:

- Designate the date and location of this meeting.

Recipient Products:

- Updated Schedule of Products (no draft)
- Updated List of Match Funds (no draft)
- Updated List of Permits (no draft)

Energy Commission Project Manager Product:

- Kick-Off Meeting Agenda (no draft)

Task 1.2 Critical Project Review (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 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.

Exhibit A
WORK STATEMENT

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.

The Energy 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.

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.

Energy Commission Project Manager Products:

- Agenda and a list of expected participants (no draft)
- Schedule for written determination (no draft)
- Written determination (no draft)

Recipient Product:

- CPR Report(s) (no draft)

Task 1.3 Final Meeting

The goal of this task is to closeout this Agreement.

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.

  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

Recipient Products:

- Written documentation of meeting agreements (no draft)
- Schedule for completing closeout activities (no draft)

Task 1.4 Monthly 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 on time and within

budget.

The objectives of this 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.

The Recipient shall:

- Prepare a Monthly Progress Report which summarizes all Agreement activities conducted by the Recipient 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 Project Manager within 10 days of the end of the reporting period. The recommended specifications for each progress report are contained in Exhibit A, Attachment A-2.

Product:

- Monthly Progress Reports (no draft)

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 objectives of the Final Report are to clearly and completely describe the project's purpose, approach, activities performed, results, and advancements in science and technology; to present a public assessment of the success of the project as measured by the degree to which goals and objectives were achieved; to make insightful observations based on results obtained; to draw conclusions; and to make recommendations for further RD&D projects and improvements to the PIER project management processes.

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.

The Recipient shall:

- Prepare an Outline of the Final Report.
- Prepare a Final Report following the approved outline and the latest version of the PIER Final Report guidelines published on the Energy Commission's website at ***http://www.energy.ca.gov/contracts/pier/contractors/index.html*** at the time the Recipient begins performing this task, unless otherwise instructed in writing by the Commission Project Manager. Instead of the timeframe

listed in the Product Guidelines located in Section 5 of the Terms and Conditions, the Commission Project Manager shall provide written comments on the Draft Final Report within fifteen (15) working days of receipt. The Final Report must be completed on or before the end of the Agreement Term.

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

Products:

- Draft Final Report
- Final Report

Task 1.6 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. 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. 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. 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 Recipient shall identify its owner and provide a contact name, address and telephone number, and the address where the property is located
- 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 or stating that no match funds are provided (no draft)
- Copy(ies) of each match fund commitment letter(s) (if applicable) (no draft)
- Letter(s) for new match funds (if applicable) (no draft)
- Letter that match funds were reduced (if applicable) (no draft)

Task 1.7 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. 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:
  - 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 10 days. Either of these events may trigger an additional CPR.

Products:

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

TECHNICAL TASKS

The Recipient shall prepare all deliverables in accordance with the requirements in Task 1.5. Products not requiring a draft version are indicated by marking “no draft” after the product name.

TASK 2 PROJECT INITIATION
The goal of this task is to verify that the project site and a Measurement & Verification (M&V) vendor have been confirmed to participate in the project.

SUBTASK 2.1 CONFIRM PROJECT SITE
The goal of this subtask is to confirm the availability of the project site.

The Recipient shall:

- Verify that the proposed demonstration site can host the project, or obtain a new demonstration site (subject to the Commission Project Manager’s approval).
- At the Project Kickoff Meeting, provide the Commission Project Manager with a Site Agreement between the Recipient and the demonstration site host that includes:
  - Details of testing activities (including dates and length of the activities)

- o Site owner acknowledgement of test conditions
- o Permission to access the site
- o Insurance and indemnity
- o Contingency if damages are caused by testing
- o Timing of equipment installation and removal

Products:

- Site Agreement (no draft)

SUBTASK 2.2 CONFIRM MEASUREMENT AND VERIFICATION CONTRACTOR
The goal of this subtask is to verify that the M&V contractor is confirmed to participate in the Agreement.

The Recipient shall:

- Verify that the proposed M&V contractor can still support the project, or obtain a new contractor (subject to the Commission Project Manager's approval).
- Provide the Commission Project Manager, at the Project Kickoff Meeting, an Agreement between the Recipient and the M&V contractor that includes:
  - o Details of testing (including timing and length of tests)
  - o Description of test methodology
  - o Quality Assurance/Quality Control procedures
  - o Budget
  - o Capabilities and experience of the M&V contractor
  - o Description and timeline for reporting results

Products:

- M&V ContractorAgreement

TASK 3 DESIGN, FABRICATION, AND INSTALLATION OF BCHP SYSTEM
The goal of this task is to complete the modification of the West Biofuels facility with the Gussing Fast Circulating Fluidized Bed gasifier to complete a 250kWe BCHP system on-site. The gasifier design will be provided by Gussing Renewable Energy America, with fabrication and installation accomplished by West Biofuels.

The Recipient shall:

- Design the BCHP system with the assistance of Gussing Renewable Energy America.
- Provide a BCHP Installation Plan to the Commission Project Manager that summarizes the system design and installation plan including:
  - o Process Flow Diagrams
  - o Heat and Mass Balances
  - o Specifications and Operating Procedures
  - o Expected Performance Characteristics
  - o Description of any local permits required for construction

  - Schedule for Construction
  - Revised Budget for Construction
- Fabricate and install the BCHP system at the project facility.
- Provide a Notification Letter to the Commission Project Manager upon completion of the BCHP installation. The letter shall include: written documentation that the BCHP is ready for commissioning testing, the date commissioning shall begin, and photographs.
- Perform the system commissioning.
- Provide a Notification Letter to the Commission Project Manager upon completion of the BCHP commissioning. The letter shall include: written documentation of the BCHP commissioning testing, initial data, and photographs.
- Prepare a CPR Report and present information at the CPR meeting in accordance with Subtask 1.2.

Products:

- BCHP Installation Plan (no draft)
- Notification Letter regarding the completion of the BCHP installation
- Notification Letter regarding the completion of the BCHP commissioning
- CPR Report (no draft)

TASK 4 QUALIFICATION OF THE BIOMASS FEEDSTOCK FOR BCHP OPERATIONS

The goal of this task is to qualify agricultural byproduct biomass as a feedstock suitable for thermochemical conversion based on gasification for the production of power and heat for agricultural processing. Almond byproduct biomass (shells, pruning, and wood) is the primary test case resource, but additional regionally complementary biomass may be included. Qualification will include determination of: geographical availability, thermochemical properties, gasification characteristics, and operational performance.

The Recipient shall:

- Perform a BCHP siting assessment to optimize resource utilization from the geographical distribution of almond byproduct biomass in California.
- Prepare and provide a BCHP Siting Assessment Report to the Commission Project Manager that summarizes the geographical distribution of potential sites for almond biomass facilities including:
  - Biomass tonnages available
  - Geographic location of facilities
  - Spatial mapping
  - Results and analysis
- Perform laboratory studies to determine the thermochemical properties of almond byproduct biomass.
- Prepare a Thermochemical Properties Report that summarizes the studies performed to determine the thermochemical properties of almond byproduct biomass. The Report will include:
  - Experimental design
  - Laboratory methods

  - Results and analysis
- Perform laboratory gasification studies of almond byproduct biomass to determine gasification characteristics.
- Prepare a Gasification Properties Report that summarizes the gasification studies of almond byproduct biomass performed to determine gasification characteristics. The Report will include:
  - Experimental design
  - Laboratory methods and test equipment
  - Results and analysis
  - Discussion of results pertinent to BCHP system operation
- Perform demonstration-scale operations with almond byproduct biomass to determine operational performance.
- Prepare a Demonstration Scale Operations Report that summarizes the demonstration-scale operations with almond byproduct biomass to determine operational performance. The Report will include:
  - Demonstration Scale Apparatus
  - Experimental Design
  - Results and analysis
  - Discussion of results pertinent to BCHP pilot system operation

Products:

- BCHP Siting Assessment Report (no draft)
- Thermochemical Properties Report (no draft)
- Gasification Properties Report (no draft)
- Demonstration Scale Operations Report (no draft)

TASK 5 DEMONSTRATE EMISSIONS CONTROL COMPLIANCE WITH CARB STANDARDS

The goal of this task is to demonstrate that the BCHP system can achieve CARB standards for small power generation systems. Two emissions control systems will be designed and tested: an adsorber with microwave regeneration for the combuster exhaust and a Compact Selective Catalytic Reduction SCR system for the engine exhaust.

SUBTASK 5.1 DESIGN, BUILD AND TEST ADSORBER SYSTEM WITH MICROWAVE REGENERATION

The goal of this subtask is to design an adsorber to remove NOx, VOC, and sulfur dioxide ($SO_{2)}$ from the combustion flue gas generated by the gasifier. The adsorption media will be selected to remove NOx, VOC, and SO_2 from the combustion gas without early breakthrough. A microwave system will be used to regenerate the adsorbent without emissions to the environment.

The Recipient shall:

- Design and build an Adsorber (Filter) System:
  - Review in-house adsorbent test data and select the adsorption media that provide the maximum adsorption period to meet CARB standards

for NOx, VOC, and SO_2 emissions
  - Design the adsorber and prepare an adsorption process flow diagram and adsorber fabrication drawings (if fabricated)
  - Build the adsorber and purchase required media
  - Connect the adsorber to the BCHP gasifier combustion gas outlet
- Provide written notification upon completion of the exhaust adsorption filter to the Commission Project Manager in the form of a letter. The letter shall include: documentation that the system is ready for testing, the date testing shall begin, and photographs.
- Prepare an Adsorber Test Plan with the assistance of the M&V Contractor. The Test Plan shall include:
  - a description of the process to be tested
  - the rationale for why the tests are required
  - predicted performance based on calculations or other analyses
  - test objectives and technical approach
  - a test matrix showing the number of test conditions and replicated runs
  - a description of the facilities, equipment, instrumentation required to conduct the tests
  - a description of test procedures, including parameters to be controlled and how they will be controlled; parameters to be measured and instrumentation to measure them; calibration procedures to be used recommended calibration interval; and maintenance of the test log
  - a description of data analysis procedures
  - a description of quality assurance procedures
  - contingency measures to be considered if the test objectives are not met.
- Test Adsorber Performance and Microwave Regeneration:
  - run the adsorber on the gasifier system up to saturation
  - disconnect the adsorber from the gasifier and transport the adsorber to a microwave regeneration system at the CHA Corporation laboratory in McClellan Park, CA.
  - operate the microwave regeneration system until all saturated media are regenerated
  - transfer regenerated media to the adsorber for additional testing on the gasifier exhaust outlet for continuous operation of the gasifier
  - collect microwave regeneration performance data including: electric power consumed, THC concentrations of oxidizer inlet and outlet gas, and saturated and regenerated media weights
- Prepare an Adsorber and Microwave Regeneration Performance Report (for inclusion in the Final Report) that includes the following:
  - Background – includes the background behind the design
  - Materials and Methods – includes the details of the system and testing
  - Results and Analysis – provides the results and analysis of the testing
  - Conclusions – provides the conclusions drawn from the performance testing

Comment [I1]: CHA refers toDr. Cha who is the lead researcher at this laboratory.

Exhibit A
WORK STATEMENT

Products:

- Written notification of the completion of the exhaust adsorptive filter
- Adsorber and Microwave Regeneration Test Plan (no draft)
- Adsorber and Microwave Regeneration Performance Report (no draft)

SUBTASK 5.2 DESIGN, BUILD, AND TEST COMPACT SCR SYSTEM

The goal of this subtask is to design and test the Compact SCR system to remove NOx, CO, and VOC from the engine generator exhaust.

The Recipient shall:

- Review engine data and select the catalyst media that provide the maximum performance to meet CARB standards for NOx, VOC, and CO emissions.
- Design the Compact SCR system and prepare a process flow diagram and fabrication drawings (if fabricated).
- Purchase system components.
- Install the system on the engine generator at the BCHP facility.
- Provide a Notification Letter to the Commission Project Manager upon completion of the Compact SCR system. The letter shall include: documentation that the system is ready for testing, the date testing shall begin, and photographs.
- Prepare a Compact SCR Test Plan with the assistance of the M&V contractor. The Test Plan shall include:
    - a description of the process to be tested;
    - the rationale as to why the tests are required;
    - predicted performance based on calculations or other analyses;
    - test objectives and technical approach;
    - a test matrix showing the number of test conditions and replicated runs;
    - a description of the facilities, equipment, and instrumentation required to conduct the tests;
    - a description of test procedures, including parameters to be controlled and how they will be controlled; parameters to be measured and instrumentation to measure them; calibration procedures to be used; recommended calibration interval; and maintenance of the test log;
    - a description of data analysis procedures;
    - a description of quality assurance procedures;
    - contingency measures to be considered if the test objectives are not met.
- Check the gasifier-operating group to determine testing run times.
- Run continuous tests and sampling of the exhaust from the engine generator.
- Make modifications and adjustments to the system to obtain optimum emissions control performance.
- Prepare a Compact SCR System Performance Task Report (for inclusion in the Final Report) that includes the following:
    - Background – includes the background behind the design
    - Materials and Methods – includes the details of the system and testing

- o Results and Analysis – provides the results and analysis of the testing
- o Conclusions – provides the conclusions drawn from the performance testing, including air emission data and verification that the BCHP can obtain air pollution control district and CARB permit approval.

Products:

- Written notification of the completion of the Compact SCR System
- Compact SCR Test Plan (no draft)
- Compact SCR System Performance Report (no draft)

TASK 6 DEMONSTRATE RECOVERY OF ASH BYPRODUCT FROM BCHP FOR RECYCLING

The goal of this task is to demonstrate the production of a recyclable ash byproduct from BCHP operations by replacing the olivine bed material used in the gasification/ fluidization process with a synthetic bed material with catalytic enhancement that will not contaminate the ash and will provide comparable or improved operational performance in tar reforming.

The Recipient shall:

- Perform flow-reactor studies of synthetic bed material with catalyst to determine reforming performance on surrogate tar.
- Provide a Flow Reactor Report to the Commission Project Manager that summarizes the flow-reactor studies including:
  - o Experimental design
  - o Laboratory methods
  - o Results and analysis
- Perform a fixed bed reactor study of synthetic bed material with catalyst to characterize tar reforming performance on a slip stream from a laboratory gasifier.
- Provide a Fixed Bed Reactor Report to the Commission Project Manager that summarizes the fixed bed study including:
  - o Experimental design
  - o Laboratory methods
  - o Results and analysis, including ash analysis to verify that it is recyclable.
- Perform a laboratory gasifier study using synthetic bed material with catalyst to determine operational performance.
- Provide a Laboratory Reactor Report to the Commission Project Manager that summarizes the laboratory gasifier study including:
  - o Experimental design
  - o Laboratory methods
  - o Results and analysis
- Perform demonstration-scale gasifier operations using synthetic bed material with catalyst to determine operational performance.
- Report the performance of the media as part of the reporting in Task 7.

Exhibit A
WORK STATEMENT

Products:

- Flow Reactor Report (no draft)
- Fixed Bed Reactor Report (no draft)
- Laboratory Reactor Report (no draft)

TASK 7 DEMONSTRATE POWER PRODUCTION AND HEAT UTILIZATION FOR AGRICULTURAL PROCESSING

The goal of this task is to demonstrate the performance of the BCHP system in conversion of the biomass feedstock selected for the project and to meet the stated efficiency goals.

The Recipient shall:

- Prepare a BCHP System Test Plan with the assistance of the M&V Contractor. The Test Plan shall include:
    - a description of the process to be tested
    - the rationale as to why the tests are required
    - predicted performance based on calculations or other analyses
    - test objectives and technical approach
    - a test matrix showing the number of test conditions and replicated runs
    - a description of the facilities, equipment, and instrumentation required to conduct the tests
    - a description of test procedures, including parameters to be controlled and how they will be controlled; parameters to be measured and instrumentation to measure them; calibration procedures to be used; recommended calibration interval; and maintenance of the test log
    - a description of data analysis procedures
    - a description of quality assurance procedures
    - contingency measures to be considered if the test objectives are not met.
- Run sequential and continuous tests according to the Test Plan.
- Make modifications and adjustments to the system to obtain optimum performance.
- Provide a BCHP System Performance Task Report for inclusion in the final report that includes the following:
    - Background – includes the background behind the design
    - Materials and Methods – includes the details of the system and testing
    - Results and Analysis – provides the results and analysis of the performance testing and discussion of the BCHP targets identified in the objectives of the agreement.
    - Conclusions – provides the conclusions drawn from the performance testing

Products:

- BCHP System Test Plan (no draft)
- BCHP System Performance Task Report (no draft)

Exhibit A
WORK STATEMENT

TASK 8 TECHNO/ECONOMIC MODELS FOR COMMERCIALIZATION OF BCHP

The goal of this task is to develop techno/economic models for the evaluation of the commercialization of BCHP. The models will include: a thermochemical process design model for the BCHP process at demonstration and commercial-scale, a carbon and material life cycle analysis for the BCHP process at commercial-scale, and a pro forma economic model of a commercial-scale BCHP plant based on the almond byproduct biomass resource.

The Recipient shall:

- Develop a thermochemical process design model for the BCHP process at demonstration-scale and evaluate system designs at commercial-scale.
- Prepare a BCHP Process Model Report that describes the thermochemical process model including:
  - Basis of the model
  - Description of the model
  - Model performance relative to the demonstration-scale systems
  - Evaluation of system designs at commercial-scale
- Develop a carbon and material life cycle analysis for the BCHP process at commercial-scale.
- Prepare a BCHP Life Cycle Model Report that summarizes the carbon and material life cycle analysis including:
  - Basis of the model
  - Description of the model
  - Model performance relative to the demonstration-scale systems
  - Evaluation of commercial-scale systems
- Develop a pro forma economic model for a commercial-scale BCHP plant based on demonstration-scale performance and commercial-scale system design.
- Prepare a BCHP Economic Model Report that summarizes the pro forma economic model for the system including:
  - Basis of the model
  - Description of the model
  - Model performance relative to the demonstration-scale systems
  - Evaluation of commercial-scale systems

Products:

- BCHP Process Model Report (no draft)
- BCHP Life Cycle Model Report no draft)
- BCHP Economic Model Report (no draft)

TASK 9 TECHNOLOGY TRANSFER ACTIVITIES

The goal of this task is to develop a plan to make the knowledge gained, experimental results, and lessons learned available to key decision-makers.

The Recipient shall:

- Prepare a Technology Transfer Plan that explains how the knowledge

gained in this project will be made available to the California agricultural processing community. The plan will include details of the M&V results and the techno/economic modeling, as well as a plan to roll out the technology to potential end-users in California. Key elements from the Technology Transfer Plan shall be included in the Final Report.

- Conduct technology transfer activities in accordance with the Technology Transfer Plan. These activities shall be reported in the Monthly Progress Reports.

Products:

- Technology Transfer Plan (no draft)

TASK 10 PRODUCTION READINESS PLAN

The goal of the plan is to determine the steps that will lead to the manufacturing of the technologies developed in this project or to the commercialization of the project's results.

The Recipient shall:

- Prepare a Production Readiness Plan that includes:
  - Identification of critical production processes, equipment, facilities, personnel resources, and support systems that will be needed to produce commercially viable BCHP plants.
  - Internal manufacturing facilities, as well as supplier technologies, capacity constraints imposed by the design under consideration, identification of design-critical elements, and the use of hazardous or non-recyclable materials.
  - A projected "should cost" for the product when in production.
  - The expected investment threshold to launch the commercial product.
  - An implementation plan to ramp up to full production.

Products:

- Production Readiness Plan (no draft)

Exhibit A
WORK STATEMENT

DEMONSTRATION OF ADVANCED BIOMASS COMBINED HEAT AND POWER SYSTEMS IN THE AGRICULTURAL PROCESSING SECTOR

TASK LIST

Task #	CPR	Task Name
1		Administration
2		Project Initiation
3	X	Design, Fabrication, and Installation of BCHP System
4		Qualification of the Biomass Feedstock for BCHP Operations
5		Demonstrate Emissions Control Compliance with CARB Standards
6		Demonstrate Recovery of Ash Byproduct from BCHP for Recycling
7		Demonstrate Power Production and Heat Utilization for Agricultural Processing
8		Techno/Economic Models for Commercialization of BCHP
9		Technology Transfer Activities
10		Production Readiness Plan

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KEY NAME LIST

Task #	Key Personnel	Key Subcontractor(s)	Key Partner(s)
1	Dr. Matthew Summers (West Biofuels, LLC)		
2	Dr. Matthew Summers (West Biofuels, LLC)		
3	Dr. Matthew Summers (West Biofuels, LLC)		
4	Professor/Investigator	University of California	
5	Dr. Matthew Summers (West Biofuels, LLC) Dr. Robert Cattolica	University of California, San Diego	
6	Dr. Matthew Summers (West Biofuels, LLC) Dr. Robert Cattolica	University of California, San Diego	
7	Dr. Matthew Summers) Dr. Robert Cattolica	University of California, San Diego	
8	Dr. Matthew Summers (West Biofuels, LLC) Dr. Robert Cattolica	University of California, San Diego	
9	Dr. Matthew Summers		

Exhibit A
WORK STATEMENT

Task #	Key Personnel	Key Subcontractor(s)	Key Partner(s)
	(West Biofuels, LLC)		
10	Dr. Matthew Summers (West Biofuels, LLC)		

GLOSSARY

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

Term/ Acronym	Definition
BCHP	Biomass Combined Heat and Power
CARB	California Air Resources Board
CO	Carbon Monoxide
CPR	Critical Project Review
CPUC	California Public Utilities Commission
Energy Commission	California Energy Commission
M&V	Measurement and Verification
NOx	Nitrogen Oxide
PAC	Project Advisory Committee
PIER	Public Interest Energy Research
RD&D	Research, Development and Demonstration
SCR	Selective Catalytic Reduction
SO2	Sulfur Dioxide
VOC	Volatile Organic Compounds

Problem Statement:

This Agreement will demonstrate renewable biomass combined heat and power production (BCHP) in the agricultural processing sector. Deployment of BCHP facilities in the California agricultural processing sector has not occurred due to the following barriers:

- Technological: While biomass gasifiers have existed for many years, there have been insufficient demonstrations of reliable, integrated BCHP systems that can be turn-key for industry.
- Market: Consumer knowledge about BCHP has been limited due to lack of demonstrated, marketable systems. In addition, the major incentive programs of the utilities like the Self-Generation Incentive Program have not considered BCHP for incentives. The California Public Utilities Commission (CPUC) is considering a Feed-In-Tariff for BCHP that could help spurn the industry if the other barriers are addressed.
- Institutional and Environmental: Restrictive emissions control standards in the California air districts are required for deployment of the BCHP technology. In addition, any residues from the BCHP process must be recycled to the land and must not become a disposal issue.

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Exhibit A
WORK STATEMENT

This Agreement will address all of these barriers. The team of West Biofuels and Gussing Renewable Energy America will, along with other collaborators, demonstrate a BCHP technology that is ready for rapid deployment in California.

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Goals of the Agreement:
The goal of this Agreement is to demonstrate a robust, efficient, and environmentally sound BCHP system that can be commercially deployed in the agricultural processing sector in California.

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

- Qualify the use of almond biomass feedstock for BCHP operations (Target: Establish that the amount of 1.5 million tons of available almond biomass (including shell, pruning, and wood) is feasible for gasification).
- Demonstrate emission controls for BCHP technologies that can meet California Air Resources Board (CARB) and Regional Air District Standards (Targets: nitrogen oxide (NOx) emissions below 0.07 lbs/MW-hr; carbon monoxide (CO) emissions below 0.10 lbs/MW-hr; and volatile organic compounds (VOC) emissions below 0.02 lbs/MW-hr).
- Demonstrate an ash byproduct suitable for recycling as fertilizer back to agriculture (Targets: chromium composition in ash byproduct is less than 500 mg/kg; composition of other compounds below California non-hazardous ash standards).
- Demonstrate electrical efficiency and heat recovery guidelines for BCHP that can be used by California utilities to develop incentive and interconnection programs for BCHP technologies in the agricultural and food processing sector (Targets: Overall electrical efficiency of 22%; combined heat and power efficiency of 65%).
- Develop a techno/economic model for commercialization of BCHP to include a carbon and material life cycle analysis (Targets: Installed cost for commercial system less than $4000 per kWe; Minimum acceptable rate of return of 12% for potential commercial projects; and Carbon emissions that are 70% less than conventional power and heating at an agricultural processing facility).

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

TASK 1 ADMINISTRATION

Task 1.1 Attend Kick-off Meeting

The goal of this 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 Energy Commission Project Manager shall:

- Designate the date and location of this meeting.

Recipient Products:

- Updated Schedule of Products (no draft)
- Updated List of Match Funds (no draft)
- Updated List of Permits (no draft)

Energy Commission Project Manager Product:

- Kick-Off Meeting Agenda (no draft)

Task 1.2 Critical Project Review (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 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.

Exhibit A
WORK STATEMENT

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.

The Energy 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.

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.

Energy Commission Project Manager Products:

- Agenda and a list of expected participants (no draft)
- Schedule for written determination (no draft)
- Written determination (no draft)

Recipient Product:

- CPR Report(s) (no draft)

Task 1.3 Final Meeting

The goal of this task is to closeout this Agreement.

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.

  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

Recipient Products:

- Written documentation of meeting agreements (no draft)
- Schedule for completing closeout activities (no draft)

Task 1.4 Monthly 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 on time and within

budget.

The objectives of this 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.

The Recipient shall:

- Prepare a Monthly Progress Report which summarizes all Agreement activities conducted by the Recipient 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 Project Manager within 10 days of the end of the reporting period. The recommended specifications for each progress report are contained in Exhibit A, Attachment A-2.

Product:

- Monthly Progress Reports (no draft)

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 objectives of the Final Report are to clearly and completely describe the project's purpose, approach, activities performed, results, and advancements in science and technology; to present a public assessment of the success of the project as measured by the degree to which goals and objectives were achieved; to make insightful observations based on results obtained; to draw conclusions; and to make recommendations for further RD&D projects and improvements to the PIER project management processes.

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.

The Recipient shall:

- Prepare an Outline of the Final Report.
- Prepare a Final Report following the approved outline and the latest version of the PIER Final Report guidelines published on the Energy Commission's website at ***http://www.energy.ca.gov/contracts/pier/contractors/index.html*** at the time the Recipient begins performing this task, unless otherwise instructed in writing by the Commission Project Manager. Instead of the timeframe

listed in the Product Guidelines located in Section 5 of the Terms and Conditions, the Commission Project Manager shall provide written comments on the Draft Final Report within fifteen (15) working days of receipt. The Final Report must be completed on or before the end of the Agreement Term.

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

Products:

- Draft Final Report
- Final Report

Task 1.6 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. 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. 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. 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 Recipient shall identify its owner and provide a contact name, address and telephone number, and the address where the property is located
- 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 or stating that no match funds are provided (no draft)
- Copy(ies) of each match fund commitment letter(s) (if applicable) (no draft)
- Letter(s) for new match funds (if applicable) (no draft)
- Letter that match funds were reduced (if applicable) (no draft)

Task 1.7 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. 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:
  - 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 10 days. Either of these events may trigger an additional CPR.

Products:

- Letter documenting the permits or stating that no permits are required (no draft)
- A copy of each approved permit (if applicable) (no draft)

- Updated list of permits as they change during the term of the Agreement (if applicable) (no draft)
- Updated schedule for acquiring permits as changes occur during the term of the Agreement (if applicable) (no draft)

TECHNICAL TASKS

The Recipient shall prepare all deliverables in accordance with the requirements in Task 1.5. Products not requiring a draft version are indicated by marking "no draft" after the product name.

TASK 2 PROJECT INITIATION

The goal of this task is to verify that the project site and a Measurement & Verification (M&V) vendor have been confirmed to participate in the project.

SUBTASK 2.1 CONFIRM PROJECT SITE

The goal of this subtask is to confirm the availability of the project site.

The Recipient shall:

- Verify that the proposed demonstration site can host the project, or obtain a new demonstration site (subject to the Commission Project Manager's approval).
- At the Project Kickoff Meeting, provide the Commission Project Manager with a Site Agreement between the Recipient and the demonstration site host that includes:
  - Details of testing activities (including dates and length of the activities)

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- Site owner acknowledgement of test conditions
- Permission to access the site
- Insurance and indemnity
- Contingency if damages are caused by testing
- Timing of equipment installation and removal

Products:

- Site Agreement (no draft)

SUBTASK 2.2 CONFIRM MEASUREMENT AND VERIFICATION CONTRACTOR

The goal of this subtask is to verify that the M&V contractor is confirmed to participate in the Agreement.

The Recipient shall:

- Verify that the proposed M&V contractor can still support the project, or obtain a new contractor (subject to the Commission Project Manager's approval).
- Provide the Commission Project Manager, at the Project Kickoff Meeting, an Agreement between the Recipient and the M&V contractor that includes:
  - Details of testing (including timing and length of tests)
  - Description of test methodology
  - Quality Assurance/Quality Control procedures
  - Budget
  - Capabilities and experience of the M&V contractor
  - Description and timeline for reporting results

Products:

- M&V ContractorAgreement

TASK 3 DESIGN, FABRICATION, AND INSTALLATION OF BCHP SYSTEM

The goal of this task is to complete the modification of the West Biofuels facility with the Gussing Fast Circulating Fluidized Bed gasifier to complete a 250kWe BCHP system on-site. The gasifier design will be provided by Gussing Renewable Energy America, with fabrication and installation accomplished by West Biofuels.

The Recipient shall:

- Design the BCHP system with the assistance of Gussing Renewable Energy America.
- Provide a BCHP Installation Plan to the Commission Project Manager that summarizes the system design and installation plan including:
  - Process Flow Diagrams
  - Heat and Mass Balances
  - Specifications and Operating Procedures
  - Expected Performance Characteristics
  - Description of any local permits required for construction

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- o Schedule for Construction
- o Revised Budget for Construction
- Fabricate and install the BCHP system at the project facility.
- Provide a Notification Letter to the Commission Project Manager upon completion of the BCHP installation. The letter shall include: written documentation that the BCHP is ready for commissioning testing, the date commissioning shall begin, and photographs.
- Perform the system commissioning.
- Provide a Notification Letter to the Commission Project Manager upon completion of the BCHP commissioning. The letter shall include: written documentation of the BCHP commissioning testing, initial data, and photographs.
- Prepare a CPR Report and present information at the CPR meeting in accordance with Subtask 1.2.

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Products:

- BCHP Installation Plan (no draft)
- Notification Letter regarding the completion of the BCHP installation
- Notification Letter regarding the completion of the BCHP commissioning
- CPR Report (no draft)

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TASK 4 QUALIFICATION OF THE BIOMASS FEEDSTOCK FOR BCHP OPERATIONS

The goal of this task is to qualify agricultural byproduct biomass as a feedstock suitable for thermochemical conversion based on gasification for the production of power and heat for agricultural processing. Almond byproduct biomass (shells, pruning, and wood) is the primary test case resource, but additional regionally complementary biomass may be included. Qualification will include determination of: geographical availability, thermochemical properties, gasification characteristics, and operational performance.

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The Recipient shall:

- Perform a BCHP siting assessment to optimize resource utilization from the geographical distribution of almond byproduct biomass in California.
- Prepare and provide a BCHP Siting Assessment Report to the Commission Project Manager that summarizes the geographical distribution of potential sites for almond biomass facilities including:
  - o Biomass tonnages available
  - o Geographic location of facilities
  - o Spatial mapping
  - o Results and analysis
- Perform laboratory studies to determine the thermochemical properties of almond byproduct biomass.
- Prepare a Thermochemical Properties Report that summarizes the studies performed to determine the thermochemical properties of almond byproduct biomass. The Report will include:
  - o Experimental design
  - o Laboratory methods

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- Results and analysis
- Perform laboratory gasification studies of almond byproduct biomass to determine gasification characteristics.
- Prepare a Gasification Properties Report that summarizes the gasification studies of almond byproduct biomass performed to determine gasification characteristics. The Report will include:
  - Experimental design
  - Laboratory methods and test equipment
  - Results and analysis
  - Discussion of results pertinent to BCHP system operation
- Perform demonstration-scale operations with almond byproduct biomass to determine operational performance.
- Prepare a Demonstration Scale Operations Report that summarizes the demonstration-scale operations with almond byproduct biomass to determine operational performance. The Report will include:
  - Demonstration Scale Apparatus
  - Experimental Design
  - Results and analysis
  - Discussion of results pertinent to BCHP pilot system operation

Products:

- BCHP Siting Assessment Report (no draft)
- Thermochemical Properties Report (no draft)
- Gasification Properties Report (no draft)
- Demonstration Scale Operations Report (no draft)

TASK 5 DEMONSTRATE EMISSIONS CONTROL COMPLIANCE WITH CARB STANDARDS

The goal of this task is to demonstrate that the BCHP system can achieve CARB standards for small power generation systems. Two emissions control systems will be designed and tested: an adsorber with microwave regeneration for the combuster exhaust and a Compact Selective Catalytic Reduction SCR system for the engine exhaust.

SUBTASK 5.1 DESIGN, BUILD AND TEST ADSORBER SYSTEM WITH MICROWAVE REGENERATION

The goal of this subtask is to design an adsorber to remove NOx, VOC, and sulfur dioxide (SO_2) from the combustion flue gas generated by the gasifier. The adsorption media will be selected to remove NOx, VOC, and SO_2 from the combustion gas without early breakthrough. A microwave system will be used to regenerate the adsorbent without emissions to the environment.

The Recipient shall:

- Design and build an Adsorber (Filter) System:
  - Review in-house adsorbent test data and select the adsorption media that provide the maximum adsorption period to meet CARB standards

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for NOx, VOC, and SO_2 emissions
- Design the adsorber and prepare an adsorption process flow diagram and adsorber fabrication drawings (if fabricated)
- Build the adsorber and purchase required media
- Connect the adsorber to the BCHP gasifier combustion gas outlet

- Provide written notification upon completion of the exhaust adsorption filter to the Commission Project Manager in the form of a letter. The letter shall include: documentation that the system is ready for testing, the date testing shall begin, and photographs.
- Prepare an Adsorber Test Plan with the assistance of the M&V Contractor. The Test Plan shall include:
  - a description of the process to be tested
  - the rationale for why the tests are required
  - predicted performance based on calculations or other analyses
  - test objectives and technical approach
  - a test matrix showing the number of test conditions and replicated runs
  - a description of the facilities, equipment, instrumentation required to conduct the tests
  - a description of test procedures, including parameters to be controlled and how they will be controlled; parameters to be measured and instrumentation to measure them; calibration procedures to be used, recommended calibration interval; and maintenance of the test log
  - a description of data analysis procedures
  - a description of quality assurance procedures
  - contingency measures to be considered if the test objectives are not met.
- Test Adsorber Performance and Microwave Regeneration:
  - run the adsorber on the gasifier system up to saturation
  - disconnect the adsorber from the gasifier and transport the adsorber to a microwave regeneration system at the CHA Corporation laboratory in McClellan Park, CA
  - operate the microwave regeneration system until all saturated media are regenerated
  - transfer regenerated media to the adsorber for additional testing on the gasifier exhaust outlet for continuous operation of the gasifier
  - collect microwave regeneration performance data including: electric power consumed, THC concentrations of oxidizer inlet and outlet gas, and saturated and regenerated media weights
- Prepare an Adsorber and Microwave Regeneration Performance Report (for inclusion in the Final Report) that includes the following:
  - Background – includes the background behind the design
  - Materials and Methods – includes the details of the system and testing
  - Results and Analysis – provides the results and analysis of the testing
  - Conclusions – provides the conclusions drawn from the performance testing

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Exhibit A
WORK STATEMENT

Products:

- Written notification of the completion of the exhaust adsorptive filter
- Adsorber and Microwave Regeneration Test Plan (no draft)
- Adsorber and Microwave Regeneration Performance Report (no draft)

SUBTASK 5.2 DESIGN, BUILD, AND TEST COMPACT SCR SYSTEM

The goal of this subtask is to design and test the Compact SCR system to remove NOx, CO, and VOC from the engine generator exhaust.

The Recipient shall:

- Review engine data and select the catalyst media that provide the maximum performance to meet CARB standards for NOx, VOC, and CO emissions.
- Design the Compact SCR system and prepare a process flow diagram and fabrication drawings (if fabricated).
- Purchase system components.
- Install the system on the engine generator at the BCHP facility.
- Provide a Notification Letter to the Commission Project Manager upon completion of the Compact SCR system. The letter shall include: documentation that the system is ready for testing, the date testing shall begin, and photographs.
- Prepare a Compact SCR Test Plan with the assistance of the M&V contractor. The Test Plan shall include:
    - a description of the process to be tested;
    - the rationale as to why the tests are required;
    - predicted performance based on calculations or other analyses;
    - test objectives and technical approach;
    - a test matrix showing the number of test conditions and replicated runs;
    - a description of the facilities, equipment, and instrumentation required to conduct the tests;
    - a description of test procedures, including parameters to be controlled and how they will be controlled; parameters to be measured and instrumentation to measure them; calibration procedures to be used; recommended calibration interval; and maintenance of the test log;
    - a description of data analysis procedures;
    - a description of quality assurance procedures;
    - contingency measures to be considered if the test objectives are not met.
- Check the gasifier-operating group to determine testing run times.
- Run continuous tests and sampling of the exhaust from the engine generator.
- Make modifications and adjustments to the system to obtain optimum emissions control performance.
- Prepare a Compact SCR System Performance Task Report (for inclusion in the Final Report) that includes the following:
    - Background – includes the background behind the design
    - Materials and Methods – includes the details of the system and testing

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- Results and Analysis – provides the results and analysis of the testing
- Conclusions – provides the conclusions drawn from the performance testing, including air emission data and verification that the BCHP can obtain air pollution control district and CARB permit approval.

Products:

- Written notification of the completion of the Compact SCR System
- Compact SCR Test Plan (no draft)
- Compact SCR System Performance Report (no draft)

TASK 6 DEMONSTRATE RECOVERY OF ASH BYPRODUCT FROM BCHP FOR RECYCLING

The goal of this task is to demonstrate the production of a recyclable ash byproduct from BCHP operations by replacing the olivine bed material used in the gasification/ fluidization process with a synthetic bed material with catalytic enhancement that will not contaminate the ash and will provide comparable or improved operational performance in tar reforming.

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The Recipient shall:

- Perform flow-reactor studies of synthetic bed material with catalyst to determine reforming performance on surrogate tar.
- Provide a Flow Reactor Report to the Commission Project Manager that summarizes the flow-reactor studies including:
  - Experimental design
  - Laboratory methods
  - Results and analysis
- Perform a fixed bed reactor study of synthetic bed material with catalyst to characterize tar reforming performance on a slip stream from a laboratory gasifier.
- Provide a Fixed Bed Reactor Report to the Commission Project Manager that summarizes the fixed bed study including:
  - Experimental design
  - Laboratory methods
  - Results and analysis, including ash analysis to verify that it is recyclable.
- Perform a laboratory gasifier study using synthetic bed material with catalyst to determine operational performance.
- Provide a Laboratory Reactor Report to the Commission Project Manager that summarizes the laboratory gasifier study including:
  - Experimental design
  - Laboratory methods
  - Results and analysis
- Perform demonstration-scale gasifier operations using synthetic bed material with catalyst to determine operational performance.
- Report the performance of the media as part of the reporting in Task 7.

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Exhibit A
WORK STATEMENT

Products:

- Flow Reactor Report (no draft)
- Fixed Bed Reactor Report (no draft)
- Laboratory Reactor Report (no draft)

TASK 7 DEMONSTRATE POWER PRODUCTION AND HEAT UTILIZATION FOR AGRICULTURAL PROCESSING

The goal of this task is to demonstrate the performance of the BCHP system in conversion of the biomass feedstock selected for the project and to meet the stated efficiency goals.

The Recipient shall:

- Prepare a BCHP System Test Plan with the assistance of the M&V Contractor. The Test Plan shall include:
  - a description of the process to be tested
  - the rationale as to why the tests are required
  - predicted performance based on calculations or other analyses
  - test objectives and technical approach
  - a test matrix showing the number of test conditions and replicated runs
  - a description of the facilities, equipment, and instrumentation required to conduct the tests
  - a description of test procedures, including parameters to be controlled and how they will be controlled; parameters to be measured and instrumentation to measure them; calibration procedures to be used; recommended calibration interval; and maintenance of the test log
  - a description of data analysis procedures
  - a description of quality assurance procedures
  - contingency measures to be considered if the test objectives are not met.
- Run sequential and continuous tests according to the Test Plan.
- Make modifications and adjustments to the system to obtain optimum performance.
- Provide a BCHP System Performance Task Report for inclusion in the final report that includes the following:
  - Background – includes the background behind the design
  - Materials and Methods – includes the details of the system and testing
  - Results and Analysis – provides the results and analysis of the performance testing and discussion of the BCHP targets identified in the objectives of the agreement.
  - Conclusions – provides the conclusions drawn from the performance testing

Products:

- BCHP System Test Plan (no draft)
- BCHP System Performance Task Report (no draft)

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Exhibit A
WORK STATEMENT

TASK 8 TECHNO/ECONOMIC MODELS FOR COMMERCIALIZATION OF BCHP

The goal of this task is to develop techno/economic models for the evaluation of the commercialization of BCHP. The models will include: a thermochemical process design model for the BCHP process at demonstration and commercial-scale, a carbon and material life cycle analysis for the BCHP process at commercial-scale, and a pro forma economic model of a commercial-scale BCHP plant based on the almond byproduct biomass resource.

The Recipient shall:

- Develop a thermochemical process design model for the BCHP process at demonstration-scale and evaluate system designs at commercial-scale.
- Prepare a BCHP Process Model Report that describes the thermochemical process model including:
  - Basis of the model
  - Description of the model
  - Model performance relative to the demonstration-scale systems
  - Evaluation of system designs at commercial-scale
- Develop a carbon and material life cycle analysis for the BCHP process at commercial-scale.
- Prepare a BCHP Life Cycle Model Report that summarizes the carbon and material life cycle analysis including:
  - Basis of the model
  - Description of the model
  - Model performance relative to the demonstration-scale systems
  - Evaluation of commercial-scale systems
- Develop a pro forma economic model for a commercial-scale BCHP plant based on demonstration-scale performance and commercial-scale system design.
- Prepare a BCHP Economic Model Report that summarizes the pro forma economic model for the system including:
  - Basis of the model
  - Description of the model
  - Model performance relative to the demonstration-scale systems
  - Evaluation of commercial-scale systems

Products:

- BCHP Process Model Report (no draft)
- BCHP Life Cycle Model Report no draft)
- BCHP Economic Model Report (no draft)

TASK 9 TECHNOLOGY TRANSFER ACTIVITIES

The goal of this task is to develop a plan to make the knowledge gained, experimental results, and lessons learned available to key decision-makers.

The Recipient shall:

- Prepare a Technology Transfer Plan that explains how the knowledge

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gained in this project will be made available to the California agricultural processing community. The plan will include details of the M&V results and the techno/economic modeling, as well as a plan to roll out the technology to potential end-users in California. Key elements from the Technology Transfer Plan shall be included in the Final Report.

- Conduct technology transfer activities in accordance with the Technology Transfer Plan. These activities shall be reported in the Monthly Progress Reports.

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Products:

- Technology Transfer Plan (no draft)

TASK 10 PRODUCTION READINESS PLAN

The goal of the plan is to determine the steps that will lead to the manufacturing of the technologies developed in this project or to the commercialization of the project's results.

The Recipient shall:

- Prepare a Production Readiness Plan that includes:
  - Identification of critical production processes, equipment, facilities, personnel resources, and support systems that will be needed to produce commercially viable BCHP plants.
  - Internal manufacturing facilities, as well as supplier technologies, capacity constraints imposed by the design under consideration, identification of design-critical elements, and the use of hazardous or non-recyclable materials.
  - A projected "should cost" for the product when in production.
  - The expected investment threshold to launch the commercial product.
  - An implementation plan to ramp up to full production.

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- Production Readiness Plan (no draft)