STATE OF CALIFORNIA

GRANTS/CONTINGENT AWARD REQUEST

CEC-270 (Revised 02/10) CALIFORNIA ENERGY COMMISSION

To: Grants and Loans Office Date: 2/25/2013

Project Manager: Mike Kane Phone Number: 916-327-1530

Office: Energy Generation Research Office Division: Energy Research and Development MS- 43

Project Title: Novel Flex Fuel Oxidation for Distributed Generation

Type of Request: *(check one)*

☐ **New Agreement:** *(include items A-F from below)* Agreement Number: Assigned by G&L Office

Program: PIER NG / Renewables

Solicitation Name and/or Number:

Legal Name of Recipient: ZERE Energy and Biofuels, Inc.

Recipient's Full Mailing Address: 851 CHERRY AVE # 27/202

SAN BRUNO, CA 94066-2900

Recipient's Project Officer: George Touchton Phone Number: 510-579-7878

Agreement Start Date: 6/20/2012 Agreement End Date: 3/31/2015

☒ **Amendment :** *(Check all that apply)* Agreement Number: PIR-11-016

- ☐ Term Extension – New End Date:
- ☒ Work Statement Revision *(include Item A from below)*
- ☒ Budget Revision *(include Item B from below)*
- ☐ Change of Scope *(include Items A – F as applicable from below)*
- ☐ Other:

ITEMS TO ATTACH WITH REQUEST:

A. Work Statement
B. Budget
C. Recipient Resolution, if applicable. (Resolution may be requested in Special Conditions if not currently available.)
D. Special Conditions, if applicable.
E. CEQA Compliance Form
F. Other Documents as applicable
- Copy of Score Sheets
- Copy of Pre-Award Correspondence
- Copy of All Other Relevant Documents

California Environmental Quality Act (CEQA)

☐ CEC finds, based on recipient's documentation in compliance with CEQA:

- ☐ Project exempt: NOE filed:
- ☐ Environmental Document prepared: NOD filed:
- ☐ Other:

☒ CEC has made CEQA finding described in CEC-280, attached

Funding Information:

*Source #1: Amount: $ Statute: FY: Budget List #:

*Source #2: Amount: $ Statute: FY: Budget List #:

*Source #3: Amount: $ Statute: FY: Budget List #:

If federally funded, specify federal agreement number:

*** Source Examples include ERPA, PIER-E, PIER-NG, FED, GRDA, ARFVT, OTHER.**

Business Meeting Approval: *(refer to Business Meeting Schedule)*

Proposed Business Meeting Date: 4/30/2013 ☒ Consent ☐ Discussion

Business Meeting Participant: Mike Kane Time Needed:

Agenda Notice Statement: *(state purpose in layperson terms)*

Possible approval of a ☒ Grant / ☐ Contingent Award to…

ZERE ENERGY AND BIOFUELS, INC. Possible approval of amendment 1 to Agreement PIR-11-016 with ZERE Energy and Biofuels, Inc. to address the loss of its Principal Investigator. ZERE is requesting a budget reallocation to add job classifications and minor subcontractors to replace the research functions formerly provided by the Principal Investigator. Neither the total budgeted amount nor the term of the agreement will be modified in this amendment. (PIER Natural Gas funding) Contact: Mike Kane

Project Manager	Date	Office Manager	Date	Deputy Director	Date

STATE OF CALIFORNIA

CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA) COMPLIANCE

CEC-280 (Revised 02/10) CALIFORNIA ENERGY COMMISSION

Award Number: PIR-11-016-1 Date: 3 / 6 / 2013

Note: The Energy Commission Project Managers Manual includes detailed instructions on how to complete this section, with examples of grants that are "Projects" and are not "Projects". When the Project Manager is completing this section, if questions arise as to the appropriate answers to the questions below, please consult with the Energy Commission attorney assigned to review grants or loans for your division.

1. Is grant/loan considered a "Project" under CEQA? ☒ Yes *(skip to question #2)* ☐ No *(continue with question #1)*

   Please complete the following: *[Public Resources Code (PRC) 21065 and 14 California Code of Regulations (CCR) 15378]:*

   Explain why the grant/loan is ***not*** considered a "Project"? The grant/loan will not cause a direct physical change in the environment or a reasonably foreseeable indirect physical change in the environment because grant/loan involves:

2. If grant/loan is considered a "Project" under CEQA: *(choose either **IS** or **IS NOT**)*

   ☒ Grant/loan **IS** exempt:

   ☐ Statutory Exemption: *(List PRC and/or CCR section numbers)*

   ☒ Categorical Exemption: *(List CCR section number)* 14 CCR 15329

   ☐ Common Sense Exemption. *(14 CCR 15061(b)(3))*

   Explain reason why the grant/loan is exempt under the above section:

   The project involves laboratory and pilot-scale design and testing of a combined heat and power system at an existing facility.

Please attach draft Notice of Exemption (NOE). Consult with the Energy Commission attorney assigned to your division for instructions on how to complete the NOE.

☐ Grant/loan **IS NOT** exempt. The Project Manager needs to consult with the Energy Commission attorney assigned to your division and the Siting Office regarding a possible initial study.

Notice of Exemption **Form D**

To: Office of Planning and Research
PO Box 3044, 1400 Tenth Street, Room 222
Sacramento, CA 95812-3044

From: California Energy Commission
1516 Ninth Street, MS-48
Sacramento, CA 95814

Project Title: Novel Flex Fuel Oxidation for Distributed Generation

Project Location – Specific: 5301 Price Avenue McClellan Park, CA 95652

Project Location – City: McClellan Park **Project Location – County:** Sacramento

Description of Project:

The goal of this project is to design, build, demonstrate, and test a fuel flexible biogas combined heat and power system employing the ZERE AIIO process at laboratory and prototype scales. The first 9 months of the project were dedicated to system modeling and laboratory scale experimentation. The next 6-8 months is dedicated to prototype system design, procurement and construction. The remainder of time will be applied to prototype design, fabrication and testing.

Name of Public Agency Approving Project: California Energy Commission

Name of Person or Agency Carrying Out Project: ZERE Energy and Biofuels, Inc.

Exempt Status: (*check one)*

- ☐ Ministerial (Sec. 21080(b)(1); 15268);
- ☐ Declared Emergency (Sec. 21080(b)(3); 15269(a));
- ☐ Emergency Project (Sec. 21080(b)(4); 15269(b)(c));
- ☒ Categorical Exemption. State type and section number 14 CCR 15329
- ☐ Statutory Exemptions. State code number.
- ☐ Common Sense Exemption. 15061(b)(3)

Reasons why project is exempt:

The project involves laboratory and pilot-scale design and testing of a combined heat and power system at an existing facility.

Lead Agency
Contact Person: **Mike Kane** **Area code/Telephone/Ext:** 916-327-1530

If filed by applicant:

1. Attach certified document of exemption finding.
2. Has a Notice of Exemption been filed by the public agency approving the project? ☐ Yes ☐ No

Signature: **Date:** **Title:**

☒ **Signed by Lead Agency**

☐ **Signed by Applicant** **Date received for filing at OPR:**

Exhibit A
Scope of Work

NOVEL FLEX FUEL OXIDATION FOR DISTRIBUTED GENERATION

TECHNICAL TASK LIST

Task #	Task Name
1	Administration
2	Process Screening and Analysis: Simulation Models
3	Preliminary Economic and Life Cycle Analysis
4	AIIO Reactor Design Utilizing CFD
5	Lab Scale Experimentation
6	Calibrate Process Model Using Experimental Data
7	Design ZERE Prototype Flex Fuel CHP Plant
8	Procure and Construct ZERE Prototype Flex Fuel CHP Plant
9	Test ZERE Prototype Flex Fuel CHP Plant
10	Operate Prototype CHP Plant
11	Collect and Analyze Operational Data
12	Commercial System Plan

KEY NAME LIST

Task #	Key Personnel	Key Subcontractor(s)	Key Partner(s)
1,2,3,6, 11	~~George Touchton,~~ **Marisa Zuzga**		
4,7,12	~~George Touchton,~~ **Marisa Zuzga**	Prof. Coronella, University of Nevada, Reno	
5,8	~~George Touchton,~~ **Marisa Zuzga**		Technikon
9,10	~~George Touchton,~~ **Marisa Zuzga**	Prof. Coronella, University of Nevada, Reno	Technikon

GLOSSARY

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

Term/ Acronym	Definition
AIIO	Air Independent Internal Oxidation
BACT	Best Available Control Technology
CAPEX	Capital Expenditure
CARB	California Air Resources Board
CCHP	Combined Cooling Heat and Power
CCM	Commission Contract Manager
CEM	Continuous Emissions Monitor(ing)

Exhibit A
Scope of Work

Term/ Acronym	Definition
CFD	Computation Fluid Dynamics
CHP/CCHP	Combine Heat and Power
CI	Carbon Intensity
CPM	Calibrated Process Model
CPR	Critical Project Review
EISG	Energy Innovation Small Grant
Energy Commission	California Energy Commission
GC	Gas Chromatograph
GHG(s)	Green House Gas(es)
HRSG	Heat Recovery Steam Generator
ICA	International Copper Association
LCA	Life Cycle Analysis
MBtu	Thousand British thermal units
MMBtu	Million British thermal units
MT	Metric tonne
NIREC	Nevada Institute for Renewable Energy Commercialization
NOx	Nitrous oxides
NREL	National Renewable Energy Lab
OC	Oxygen Carrier
O&M	Operation and Maintenance
OPEX	Operating Expenditure
PIER	Public Interest Energy Research
PM10, PM2.5	Particulate matter (microns)
PTP	Prototype Test Plant
RACT	Reasonably Available Control Technology
SCR	Selective Catalytic Reduction
SOP	Standard Operation Procedure
SOx	Sulfur oxides
UHC	Unburned HydroCarbons
UNR	University of Nevada, Reno

Problem Statement:
California and its utility ratepayers need fuel flexible distributed Combine Heat and Power (CHP/CCHP) to provide price stability, lower electric rates, and environmental benefits. In addition, California and its citizens need cost effective fuel flexible technology to reduce or eliminate the problems associated with biogas, bio-liquid, and biomass waste disposal. In particular, there is an immediate need for eliminating or minimizing flaring or venting of gases from dairy wastes, landfills, and waste water treatment facilities. This project will build on work done under a prior California Energy Commission (Energy Commission) Energy Innovation Small Grant (EISG), work done

with the support of the Nevada Institute for Renewable Energy Commercialization (NIREC), and work done with the support of the International Copper Association (ICA).

Present technology for dealing with the immediate biogas problem is venting, flaring, or cleaning the bio-gas and using it in reciprocating engines or gas turbines for CHP/CCHP production. The first two alternatives have serious shortcomings since neither produces a useful product and both have serious air pollution and greenhouse gas impacts on the citizens of California. The third alternative is hampered first by the fact that the carbon dioxide in the biogas seriously impacts the efficiency of the reciprocating engine or gas turbine and biogas contaminants such as hydrogen sulfides and silanes must be scrubbed prior to introducing the gas to the reciprocating engine or gas turbine. The gas cleaning system is expensive, has a significant parasitic load, and is a significant contributor to operation and maintenance (O&M) cost. Finally, even when utilizing Best Available Control Technology (BACT) – lean burn and Selective Catalytic Reduction (SCR) -- both of these end use technologies produce Nitrous Oxide (NOx), particulate, carbon monoxide, Sulfar Oxide (SOx), Unburned HydroCarbons (UHCs), and carbon dioxide.

ZERE has been researching and developing the Air Independent Internal Oxidation (AIIO) technology since 2006. In 2008, ZERE received a $95,000 Energy Commission EISG Award #55181A 07/05. Under this grant, ZERE, in partnership with Dr. Reginald Mitchell/Stanford University, completed a full thermodynamic model of an AIIO system, ran equilibrium models of the AIIO process for multiple fuels matched with multiple oxygen carriers, built and tested a bench scale batch reactor, developed kinetic models of the fuel/metal oxide reaction, performed an evaluation of metal oxides in AIIO systems, and completed the thermodynamic design of a 5 MWe biomass to CHP plant.

The major barrier to commercialization of ZERE technology is the cost of research and development. There are many market factors currently that indicate that fully developed near-zero emissions distributed generation technology would be welcomed by the market place. Development of ZERE technology through prototype testing and commercial system design would make ZERE a good option for private and public investment at a larger scale. Use of Public Interest Energy Research (PIER) funds for ZERE Research and Development would allow ZERE to bring its technology to the market place and allow rate payers to reap the benefits of cost effective near-zero emissions fuel flexible distributed generation.

Goals of the Agreement:
The goal of this Agreement is to design, build, demonstrate, and test a fuel flexible biogas CHP system employing the ZERE AIIO process at the laboratory and prototype scales. The prototype will demonstrate production of electric power and heat in a system fueled with untreated biogases (i.e. dairy digester, waste water treatment), natural gas, and mixtures thereof while outperforming California Air Resources Board (CARB) 2007 emissions standards.

Exhibit A
Scope of Work

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

1. Quantify and rank the technical and economic performance of AIIO systems utilizing multiple flex fuel configurations based on process models.
2. Demonstrate the ability of ZERE CHP systems to operate on untreated biogas.
3. Demonstrate that the CARB 2007 emissions standards are exceeded by ZERE CHP systems while operating on untreated biogas fuels, natural gas or mixtures thereof.
4. Demonstrate ZERE system electrical efficiency and fuel charged to power that when scaled to commercial size will be competitive with existing DG CCHP systems both evaluated at BACT or CARB 2007 emissions levels, whichever is more stringent.
5. Verify ZERE CHP system sustainability through full system life cycle analysis.
6. Develop near term and long term commercialization path for ZERE fuel flexible CHP systems.

Objective 1 – The technical measurement will be based on calculated values of industry standard metrics including ability to utilize multiple fuels alone or together (fuel flexibility), power, efficiency, and fuel charged to power. Economic performance will be based on calculated industry standard metrics such a capital cost, operating and maintenance cost, cost of electricity, return on investment, and net present value.

Objective 2 – The measurements will be based on fuel characterization, reactor bed solids analysis, reactor gaseous product composition measurements carried out according to American Society for Testing and Materials and other protocols. Retention in the reactor bed of 90 weight percent or greater of fuel sulfur and contaminants such as silanes will be regarded as satisfactory. In addition, Heat Recovery Steam Generator (HRSG) fouling and effectiveness will be measured and subject to a pass/fail metric. Pass requires that HRSG performance can be restored to within manufacturers' tolerance with industry standard cleaning methods such as dry ice blasting.

Objective 3 – Standard emissions measurements according to applicable CARB and United States Environmental Protection Agency protocols will be made in the exhaust from the hot air HRSG and at any other points at which gases are exhausted to the atmosphere. The results of these tests will be compared with BACT and CARB 2007 emissions standards.

Objective 4 – The electrical efficiency and fuel charged to power of the Prototype Scale CCHP System will be scaled to commercial size of distributed generation using good engineering practice and compared with existing DG CCHP systems. The evaluation will be based on all systems meeting BACT emissions levels or CARB 2007 whichever is more stringent.

Objective 5 -- Industry standard life cycle analysis (LCA) and sustainability calculations will be used to ensure that the ZERE system meets LCA and sustainability standards mutually agreed upon with the Energy Commission.

Objective 6 – Standard business and accounting practice will be followed in developing the near term and long term commercialization path for ZERE fuel flexible CHP systems. The result will be measured against emerging competitive technologies.

The success of this project will result in increasing the portfolio of available technologies for:

- Increasing energy independence and energy price stability for ratepayers and California citizens – particularly those in rural and agricultural locations
- Reducing atmospheric carbon dioxide levels (in line with AB 32)
- Reducing levels of uncontrolled methane, reactive organic gases, and other pollutants from land disposal open lagooning, and flaring of dairy waste
- Future reduction of pollutants, in particular NOx and $PM_{2.5}$ from open burning, in non-attainment or heavily polluted agricultural areas such as the Central Valley.

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). No work may be done until this documentation is in place.
  - Permit documentation (Task 1.7)
  - Discussion of subcontracts needed to carry out project (Task 1.8)

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

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

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

Recipient Products:

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

Commission Project Manager Product:

- Kick-Off Meeting Agenda

Task 1.2 Critical Project Review (CPR) Meetings

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. The Commission Project Manager may schedule CPRs as necessary, and CPR costs will be borne by the Recipient.

Participants include the Commission Project Manager and the Recipient and may include the Commission Grants Officer, the Division 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 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 section 8 of the Terms and Conditions).

- 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.

Commission Project Manager Products:

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

Recipient Product:

- CPR Report(s)

Task 1.3 Final Meeting

The goal of this task is to close out 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
- Final invoicing and release of retention

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

Products:

- Written documentation of meeting agreements
- Schedule for completing closeout activities

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 Section 6 of the Terms and Conditions of this Agreement.

Product:

- Monthly Progress Reports

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.

Exhibit A
Scope of Work

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 projects and improvements to the 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 Final Report guidelines which will be provided by the Commission Project Manager. 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 at least 60 days before the end of the Agreement Term.
- Submit one bound copy of the Final Report with the final invoice.

Products:

- Draft Outline of the Final Report
- Final Outline of the Final Report
- 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 Energy Commission 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 Energy Commission 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

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:

- o 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.
- o 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. For match funds provided by a grant a copy of the executed grant shall be submitted in place of a letter of commitment.
- 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
- Copy(ies) of each match fund commitment letter(s) (if applicable)
- Letter(s) for new match funds (if applicable)
- Letter that match funds were reduced (if applicable)

Task 1.7 Identify and Obtain Required Permits

The goal of this 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 Energy Commission 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 expenditure for which a permit is required.

Exhibit A
Scope of Work

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 5 working days. Either of these events may trigger an additional CPR.

Products:

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

Task 1.8 Obtain and Execute Subcontracts

The goal of this task is for Recipients to identify any subcontracts required to carry out the tasks under this Agreement and to procure them consistent with the terms and conditions of this Agreement and the Recipient's own procurement policies and procedures. It will also provide the Energy Commission an opportunity to review the subcontracts to ensure that the tasks are consistent with this Agreement, that the budgeted expenditures are reasonable and consistent with applicable cost principles.

Exhibit A
Scope of Work

The Recipient shall:

- Prepare a letter documenting the subcontracts 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 subcontracts required at the start of this Agreement, then state such in the letter. If it is known at the beginning of the Agreement that subcontracts will be required during the course of the Agreement, provide in the letter:
  - A list of the subcontracts that describes the anticipated maximum budget and general scope of work for each,
  - A description of the procurement process to be used, and
  - The schedule the Recipient will follow in applying for and obtaining these subcontracts
- Submit a draft of the subcontract that will include a budget with the information required in the budget details to the Commission Project Manager for review and approval, and incorporate any changes recommended by the Commission Project Manager.
- Submit a final copy of the executed subcontract.

Products:

- Letter describing the subcontracts needed, or stating that no subcontracts are required
- Draft subcontracts
- Final subcontracts

TECHNICAL TASKS

TASK 2 PROCESS SCREENING AND ANALYSIS: SIMULATION MODELS

The goal of this task is to model system yields including electricity, and heat, and project system emissions considering land fill gas, dairy gas, natural gas and combinations thereof as possible fuels; to analyze and screen on an input output basis each of the process models developed herein; and to investigate candidate development paths which would enable adding bioliquids and biomass solids to California's fuel flexibility portfolio.

The Recipient shall:

- Develop a thermodynamic model of the ZERE gaseous fuel to combined heat and power system.
- Run model simulations for a variety of biogas and natural gas mixtures.
- Analyze the results of the system modeling.
- Screen and rank the candidate processes base on thermodynamic viability.
- Augment the down-selected models with top level life cycle and cost data.
- Prepare a database and decision matrix for use in Task 3.
- Investigate options for extending ZERE CHP flex fuel capability to include solid and liquid fuels:

- Identify candidate technologies through surveys of existing technologies and input from industry and technology experts.
- Rank technologies based on technical feasibility and economic potential.
- Complete full system model for top three ranked systems.
- Analyze the results of the system modeling.

- Prepare a Process Screening and Analysis Report. This report shall include, but not be limited to, a written description of the gaseous-input-to-heat-and-electricity-output process model; mass and energy balances for the various gaseous model simulations: a description of the system model analysis and the analysis outcomes, including ranking of thermodynamic viability; a write-up on solid fuel capability, including candidate technologies considered, technology ranking, model results and final analysis.

Products:

- Database and decision matrix
- Process Screening and Analysis Report (no draft)

TASK 3 PRELIMINARY ECONOMIC AND LIFE CYCLE ANALYSIS

Task 3.1 Preliminary Economic Analysis of ZERE System

The goal of this task is to determine the best economic performance of the systems with the best technical performance from task 2.

The Recipient shall:

- Evaluate the systems from task 2 with the best thermodynamic performance.
- Determine system economic performance based on factors including Capital Expenditure (CAPEX), Operating Expenditure (OPEX), input fuel costs, electricity, heating and cooling revenue.
- Prepare a Plant Economic Analysis Write-up based on findings in this task to be included in the Life Cycle Analysis Report in Task 3.2.

Products:

- Plant Economic Analysis Write-up (no draft)

Task 3.2 Life Cycle Analysis of ZERE System

The goal of this task is to determine the best carbon life cycle of the systems with the best technical performance from task 2.

Exhibit A
Scope of Work

The Recipient shall:

- Analyze, screen, rank, and down-select candidate processes (those with the best technical ranking from Task 2) according to carbon life cycle footprint.
- Prepare a Life Cycle Analysis Report which includes, but is not limited to, the results of the life cycle analysis and gives rank standings and the rationale.

Products:

- Life Cycle Analysis Report (no draft)

TASK 4 AIIO REACTOR DESIGN UTILIZING CFD

Task 4.1 CFD Hydrodynamic Model of the Semi Continuous Reactors

The goal of this task is to use modern methods of computational fluid dynamics (CFD) to predict the hydrodynamic performance of the two reactors comprising the AIIO reactor system.

The Recipient shall:

- Estimate operating conditions (temperature, pressure, gas flow rates, reactor diameter, and solid inventory) in both the fuel reactor and the air reactor. This will be done using previous design experience and by synthesizing recent peer-review literature.
- Determine flow regime for each reactor from reaction kinetics, heats of reaction, requirements for heat transfer, scalability, etc.
- Select a single particle size that is consistent with the requirements of both reactors through the use of personal expertise, reactor design texts, and industrial standards.
- Apply the open-source CFD code MFIX to predict the performance of both reactors. Bed heights, particle elutriation, heat transfer rates, bubble size and frequency (if appropriate) will be predicted for selected operating conditions.
- Revise and improve operating conditions, flow regimes, or particle diameter, as a result of insights gained from CFD studies. Repeat CFD simulation using revised conditions.
- Design mechanism for capture of H2S or SO2 present in gaseous fuel to be implemented in the fuel reactor of the prototype design.
- Write a detailed AIIO CFD Design Report that contains the results of these simulations. The report will describe the conditions simulated, the method of simulations, the results of the simulations, and a very brief sensitivity analysis. This report will also include a section with a recommendation for the design of the prototype AAIO reactors, and a section detailing capture of sulfur compounds to be implemented in the prototype AIIO fuel reactor.
    - This report may be made available to the research community by way of a technical presentation at an appropriate technical

conference (such as AIChE), subject to approval of the Commission Project Manager.

Products:

- AIIO CFD Design Report (no draft)

Task 4.2 Model Reaction Kinetics in the Semi-Continuous Reactors
The goal of this task is to predict reaction rates and heat loads in both reactors comprising the AIIO reactor system.

The Recipient shall:

- Identify the rate-limiting step for oxidation of gaseous fuels in the fuel reactor, selecting from internal mass transfer, external mass transfer, and intrinsic reaction kinetics. Inputs include peer-review literature, analysis of diffusion rates in particles, and analysis of hydrodynamic results from Task 4.1.
- Identify the rate-limiting step for oxidation of oxygen carrier by air in the air reactor, selecting from internal mass transfer, external mass transfer, and intrinsic reaction kinetics. Inputs include peer-review literature, analysis of diffusion rates in particles, and analysis of hydrodynamic results from Task 4.1.
- Incorporate predictions of reaction rates, according to rate-limiting step, into the fuel reactor CFD model using MFIX. Incorporate predictions of reaction rates into the air reactor CFD model using MFIX. Determine concentration profiles in both reactors.
- Calculate heat load in both reactors, from overall rates of reaction and basic thermodynamics.
- Write a reaction kinetics section for the Continuous Reactor System Report that contains the results of these simulations. The section will describe the conditions simulated, the method of simulations, the results of the simulations, and a very brief sensitivity analysis. This report will be made available to the research community by way of a technical presentation at an appropriate technical conference (such as AIChE)

Products:

- Reaction Kinetics Section of the Continuous Reactor System Report (no draft)

Task 4.3 Validate Reactor Models
The goal of this task is to establish confidence in the performance of reactor models produced in tasks 4.1 and 4.2, or to identify shortcomings in those models requiring improvement. Validation will be achieved by comparing key performance metrics of the model with experimental prototype reactor performance.

The Recipient shall:

- Select performance metrics to be used for validation, in consultation with all project partners. Likely metrics include fuel breakthrough, SOx breakthrough, heat loads, and pressure fluctuation frequency.
- Adjust CFD model to match prototype experimental conditions.
- Compare metrics simulated by CFD model with experimentally determined values.
- Identify model components that require additional attention to predict reactor performance accurately.
- Write a CFD Validation Section of the Continuous Reactor System Report that makes recommendations for accurate CFD reactor simulations. The section will describe the conditions simulated, the method of simulations, the results of the simulations, and a very brief sensitivity analysis. This report will be made available to the research community by way of a technical presentation at an appropriate technical conference (such as AIChE).

Products:

- CFD Validation Section of the Continuous Reactor System Report (no draft)

Task 4.4 CFD Model of Large-Scale Continuous Reactor System

The goal of this task is to model and predict the performance of a continuous, commercial scale AIIO reactor. This model development will become a key design instrument.

The Recipient shall:

- Select scale of reactor, specify fuel and impurities, select reactor conditions, and select particle size. It is expected that the modeling work done in Tasks 4.1-4.3 will greatly facilitate this preliminary design.
- Identify mechanisms for continuous looping of solids between reactors. It is likely that L-valves, loops seals, and / or seal pots will be used to regulate flow and to seal from gas leakage.
- Adjust CFD models of to allow for continuous feed and withdrawal of oxygen carrier to and from each reactor. Estimate pressure drops across each zone of the continuous integrated unit. Perform the CFD models in MFIX.
- Write a detailed Continuous Reactor System Report that contains results from the CFD modeling and recommendations for implementation of the AIIO reactor at commercial scale. The report will describe the conditions simulated, the method of simulations, the results of the simulations, and a very brief sensitivity analysis.

Products:

- Continuous Reactor System Report (no draft)

TASK 5 LAB SCALE EXPERIMENTATION

The goal of this task is to verify AIIO production of steam and CO_2 and verify near-zero emissions.

Task 5.1 Prepare Lab Scale Test Plan
The goal of this task is to create a test plan for lab scale testing to be accomplished in Tasks 5-2 through 5.7.

The Recipient shall:
Prepare the ZERE Lab Scale Test Plan. The ZERE Lab Scale Test Plan shall include, but is not limited to:

- A description of the ZERE 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 the data analysis procedures;
- A description of quality assurance procedures;
- Contingency measures to be considered if the test objectives are not met.

Products:

- Draft ZERE Lab Scale Test Plan
- Final ZERE Lab Scale Test Plan

Task 5.2 Obtain and Characterize Biogas Fuel Samples
The goal of this task is to obtain and characterize biogas waste fuel samples and simulate sufficient quantities to perform Task 5.3 and 5.4. The simulation of biogas is necessary because animal waste digester gas, landfill gas, waste treatment gas, and others cannot be safely or economically transported from the point of production to the test facility at Technikon.

The Recipient shall:
Those meeting this criterion will be procured in needed quantities and tested for biochemical, chemical, and thermochemical characteristics.

- Obtain biogas fuel samples
- Characterize fuel samples
- Simulate sample biogas fuels in sufficient quantity to perform Task 5.3 and 5.4
- Prepare a Fuel Characterization Report detailing the procurement, screening and characterization outcomes.

Products:

- Fuel Characterization Report to be included in the Lab Scale Test Report (no draft)

Task 5.3 Demonstrate Lab Scale Production of Steam and CO_2 from Biogas and Natural Gas Oxidation

The goal of this task is to demonstrate lab scale production of steam and CO_2 from the oxidation of gaseous fuels in the ZERE lab scale test reactor.

The Recipient shall:

Analyze and characterize the gases produced using laboratory facilities at Technikon. ZERE personnel will monitor and record reactor system input and output temperatures, mass flows, pressures and other operating parameters so that the energy requirements, output gas composition and energy content, and other information can be quantified.

- Operate the ZERE lab scale reactor system in batch mode to produce a product gas containing steam and CO2.
- Monitor and record the product gas composition, energy content, and other parameters.
- Monitor and record operating parameters including steam to fuel ratio, steam to CO2 ratio, and energy input and output.
- Maintain a database of all relevant test data such as reactor mass and energy balances, operating parameters, and system inputs and outputs.
- Write a section of the Lab Scale Test Report that details the planning, operations and outcomes of the gaseous fuel to steam and CO2 production tests.

Products:

- Gaseous Fuel to Steam and CO2 Production Section of the Lab Scale Test Report (no draft)

Task 5.4 Demonstrate Lab Scale Sulfur Capture in Oxidizer Fluid Bed

The goal of this task is to demonstrate the ability of the ZERE system to capture the sulfur in fuel (i.e. H_2S in digester gas) and trap it in the fluid bed for subsequent treatment.

Exhibit A
Scope of Work

The Recipient shall:

- Operate the ZERE lab scale reactor on fuels that contain sulfur
- Monitor gaseous emissions to verify that SOx compounds are not formed or emitted.
- Measure the pre and post test levels of sulfur in the fluid bed.
- Prepare a Sulfur Capture Section of the Lab Scale Test Report which details the procedures and outcomes of the sulfur capture tests including sulfur content of input fuels, and sulfur content of output products.

Products:

- Sulfur Capture Section of the Lab Scale Test Report (no draft)

Task 5.5 Obtain Samples and Characterize Biomass Solids (Augment Prior Study)
The goal of this task is to extend the study performed under EISG funding to include more California problematic biomass waste options such as citrus prunings.

The Recipient shall:

- Obtain samples of problematic California solid biomass waste.
- Characterize the samples obtained.
- Generate a biomass solid fuel input into the Solid Fuel Performance Section of the Lab Scale Test Report, detailing the types and quantities of solid biomass fuels obtained and the characterization of those fuels.

Products:

- Biomass solid fuel input into the Solid Fuel Performance Section of the Lab Scale Test Report (no draft)

Task 5.6 Demonstrate Lab Scale Production of Steam and CO_2 from Biomass Solid Fuel Oxidation (Augment Prior Study)
The goal of this task is to extend the study performed under EISG funding to include more California problematic biomass waste options such as citrus prunings and grape vines.

The Recipient shall:

- Operate the lab scale reactor with solid biomass fuel.
- Measure reactor output gases to confirm conversion of solid fuels to steam and CO2.
- Write a Solid Fuel Performance Section of the Lab Scale Test Report detailing quantity of CO2 produced, quantity and quality (temp and pressure) of steam produced, and fuel use.

Products:

- Solid Fuel Performance Section of the Lab Scale Test Report (no draft)

Task 5.7 Demonstrate Lab Scale Regeneration of Metal to Metal Oxide in Air
The goal of this task is to demonstrate the ability of the metal particles used in fuel oxidation to generate back to metal oxide in air without forming pollutant emissions.

The Recipient shall:

- Operate the lab scale reactor with metal/metal oxide particles that have been used in fuel experiments.
- Measure reactor output gases to confirm that emissions meet or exceed CARB 2007 standards.
- Write a Metal Oxide Regeneration Section of the Lab Scale Test Report detailing the results of the metal oxide regeneration experiments including regeneration rates, and emissions data.

Products:

- Metal Oxide Regeneration Section of the Lab Scale Test Report (no draft)
- Lab Scale Test Report (no draft)

TASK 6 CALIBRATE PROCESS MODEL USING EXPERIMENTAL DATA
The goal of this task is to use the laboratory scale reactor results including databases and operating maps to calibrate the process models to facilitate the ZERE prototype scale design.

The Recipient shall:

- Compare and correlate inputs and outputs from the process models delivered in Task 2.
- Calibrate model outputs to match experimental results.
- Develop final Calibrated Process Model.
- Write a Process Model Report which includes a calibrated process model, input data for the ZERE prototype scale reactor design, and an LCA and cost model based on the experimentally validate process model.

Products:

- Process Model Report (no draft)

TASK 7 DESIGN ZERE PROTOTYPE FLEX FUEL CHP PLANT

Task 7.1 Design Prototype Reactor System
The goal of this task is to create a reactor system design that factors in all data and lessons from tasks 2-6.

The Recipient shall:

- Design a flex fuel prototype reactor system, taking into account all data and information form Tasks 2-6. The reactor system will be designed for continuous operation on natural gas, untreated biogas, and mixtures thereof:
  - o Specify all design elements such that the reactor system can be sourced and built.
  - o Generate 3D models and fabrication drawings of the reactor system.
  - o Generate reactor system bill of materials (BOM).
  - o Reactor system process and instrumentation diagram (P&ID).

Product(s):

- Prototype reactor system design package which includes, drawings, BOM, and P&IDs

Task 7.2 Design Prototype Flex Fuel CHP Plant

The goal of this task is to use the reactor system design as a basis for the design of the prototype plant. The plant design will include all of the system pieces not already addressed in the reactor design including but not limited to heat exchangers, turbine, generator, control system, pumps, blowers, and piping.

The Recipient shall:

Design the ZERE full system prototype plant using the reactor system design created in task 7.1 as the design basis.

- Specify all design elements such that the prototype plant can be sourced and built.
- Generate 3D models and fabrication drawings.
- Generate ZERE prototype plant bill of materials.
- Generate ZERE prototype plant P&IDs.

Product(s):

- ZERE prototype plant design package which includes drawings, BOM, and P&IDs

TASK 8 PROCURE AND CONSTRUCT ZERE PROTOTYPE FLEX FUEL CHP PLANT

Task 8.1 Procure Prototype Scale Reactor System for Fuel Flexible CHP Plant

The goal of this task is to procure the fabricated parts of the prototype CHP plant.

The Recipient shall:

- Get competitive bids for the fabrication of the prototype reactor system based on the design package.
- Select fabrication subcontractor.
- Purchase non-fabricated items in reactor system.
- Receive fabricated and purchased reactor system parts at test facility.

- Complete final assembly of reactor system at test facility.
- Prepare a section of a status report that includes written notification of the completed reactor system, including pictures of the completed system.

Product(s):

- Written notification of reactor system completion in a monthly status report

Task 8.2 Procure off the Shelf Components for Prototype Scale Fuel Flexible CHP Plant

The goal of this task is to procure the prototype plant components that are purchased off –the-shelf items including the turbine, generator, pumps, and blowers.

The Recipient shall:

- Purchase prototype plant materials per the design package developed in Task 7.
- Get multiple bids wherever possible for items greater than $2000.
- Find California sources for materials wherever possible and economical
- Purchase equipment.
- Provide written notification of component procurement in a status report which includes pictures and a list of items received.

Product(s):

- Written notification of component procurement in monthly status report

Task 8.3 Construct Prototype Scale Fuel Flexible CHP Plant

The goal of this task is to construct the ZERE prototype scale CHP plant to be tested and optimized in Task 9.

The Recipient shall:

- Complete on-site assembly of prototype system including instrumentation and monitoring setup.
- Provide written notification in a status report which includes a description of the hardware constructed and pictures of the completed system.

Product(s):

- Written notification of plant completion in a monthly status report

TASK 9 TEST ZERE PROTOTYPE FLEX FUEL CHP PLANT

The goal of this task is to shakedown, and test a prototype scale plant.

Task 9.1 ZERE Prototype Reactor Test Plan

The goal of this task is to create a test plan for ZERE prototype scale testing to be accomplished in Tasks 9.2 through 9.8.

The Recipient shall:

- Prepare the ZERE Prototype Scale Test Plan. The ZERE Prototype Scale Test Plan shall include, but is not limited to:
  - A description of the ZERE 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 the data analysis procedures;
  - A description of quality assurance procedures;
  - Contingency measures to be considered if the test objectives are not met.

Products:

- Draft ZERE Prototype Plant Test Plan
- Final ZERE Prototype Test Plan

Task 9.2 Execute "Shake Down" Runs to Prove Out Integrity and Basic Operability and Safety of ZERE Prototype Unit

The goal of this task is to start up the ZERE prototype plant and confirm operational and monitoring capability.

The Recipient shall:

- Begin operation of the ZERE prototype plant.
- "Shake-down" system to confirm readiness for test operations.
- Provide written notification in a status report that the prototype system is operational.

Products:

- Written notification that prototype plant is operational in a monthly status report

Task 9.3 Demonstrate Complete Reaction of Gaseous Fuels

The goal of this task is to demonstrate the ability of the ZERE system to produce steam and CO_2 with emissions levels below CARB 2007 standards.

The Recipient shall:

- Operate the ZERE prototype system according to the test plan developed in task 8.1.
- Collect and characterize product gas samples.
- Measure product gas (steam and CO2) output rates.

- Generate database of system performance data with fuel inputs and product gas outputs.
- Write a Reaction Completion Section of the Prototype Test Report that includes output gas characterization data and input/output data.

Products:

- Reaction Completion Section of the Prototype Test Report (no draft)

Task 9.4 Demonstrate Biogas Sulfur Capture in the Reactor Bed
The goal of this task is to verify the sulfur capture capability that was shown at the lab scale at the prototype scale.

The Recipient shall:

- Operate and test the ZERE prototype reactor with gaseous fuels that contain sulfur (H2S)
- Verify the ability of the ZERE prototype to trap sulfur in the reactor bed
- Investigate methods of optimizing sulfur capture such as varying particle size of sulfur absorbents and ratio of sulfur absorbents in the reactor bed.
- Analyze and record test results
- Write a Sulfur Capture Test Section of the Prototype Test Report that includes test data and analysis.

Products:

- Sulfur Capture Section of the Prototype Test Report (no draft)

Task 9.5 Demonstrate Continuous Steam Production
The goal of this task is to demonstrate the continuous production of steam over multiple oxidation and regeneration cycles of the reactors.

The Recipient shall:

- Operate the prototype over a minimum of 20 oxidation and regeneration cycles.
- Measure the reactor product outputs.
- Measure steam output vs. fuel input over the operating range of the system.
- Optimize reactor control system to minimize fluctuation in steam output.
- Verify steam output meets the requirements of the steam turbine to be used for electric power generation.
- Write a steam production section of the Prototype test report that includes test results and fuel input vs. steam output data.

Products:

- Steam Production Section of the Prototype Test Report (no draft)

Exhibit A
Scope of Work

Task 9.6 Demonstrate Near-Zero Pollutant Emissions
The goal of this task is to demonstrate through test that the ZERE prototype plant has near zero below BACT and reasonably available control technology (RACT)) of SOx, NOx, CO, and PM10 and PM 2.5.

The Recipient shall:

- Operate and test the ZERE prototype reactor in accord with published test protocols and good engineering practice.
- Measure the prototype air emissions from all sources open to the atmosphere using methods acceptable to CARB.
- Analyze, record, and report test results following California protocols.
- Write a Prototype Emissions Test Section of the Prototype Test Report that includes system inputs and outputs and data from continuous emissions monitoring.

Products:

- Emissions Test Section of the Prototype Test Report (no draft)

Task 9.7 Demonstrate Ability to Separate CO_2
The goal of this task is to operate and test the ZERE prototype scale plant and confirm that CO_2 is available for processing (liquefaction for example) with near zero emissions to the atmosphere.

The Recipient shall:

- Prepare a CO2 Capture Confirmation Test Plan.
- Operate and test the prototype scale plant in accord with the test plan.
- Record and analyze the operational and test data.
- Write a CO2 Capture Section of the Prototype Test Report that includes a CO2 capture confirmation test and operational data.

Products:

- CO_2 Capture Section of the Prototype Test Report (no draft)

Task 9.8 Demonstrate Electric Power Generation
The goal of this task is to demonstrate complete CHP system functionality with the final addition of electric power production.

The Recipient shall:

- Connect output from steam production to steam turbine to generate electric power.
- Perform electric power production tests according to test plan.
- Measure electric power output of CHP system.
- Prepare an Electric Power Production Section of the Prototype Test Report that includes test data including fuel inputs and electric power outputs.

Exhibit A
Scope of Work

Products:

- Electric Power Production Section of the Prototype Test Report (no draft)
- Prototype Test Report (no draft)

TASK 10 OPERATE PROTOTYPE CHP PLANT

The goal of this task is to demonstrate longer term operation of the complete CHP system and verify functionality on multiple gaseous fuels.

The Recipient shall:

- Prepare a Prototype Plant System Operations Plan that includes gaseous fuel and fuel combinations to be used, planned hours of operation on each fuel combination, and expected prototype outputs for each set of operational conditions.
- Operate the prototype CHP plant according to operations plan prepared.
- Maintain a log of prototype operations that contains at a minimum hours of operation, fuel mixture used, and steam and power production achieved.

Products:

- Prototype Plant System Operations Plan (no draft)
- Copy of prototype system operations log

TASK 11 COLLECT AND ANALYZE OPERATIONAL DATA

The goal of this task is to collect and analyze operational data to determine the economic viability and environmental impact of the project. Final analysis of all project data will be included in the Final Report.

The Recipient Shall:

- Collect 3 months of operational data from the CHP system to include:
  - time operating (up and down time),
  - efficiency of conversion of feedstock,
  - heat production rate,
  - electricity produced.
- Estimate natural gas savings and CHP production from a commercial scale plant.
- Explain how the project will reduce criteria air pollutants and air toxics and reduce or avoid multimedia environmental impact, and lead to a decrease, on a life cycle basis, in emissions of water pollutants or any other substances known to damage human health or the environment.
- Explain how the project incorporated and achieved sustainability goals.
- Provide a quantified estimate of the project's carbon intensity values for life-cycle scale greenhouse gas emissions.
- Quantify any water efficiency and water use reduction measures used in the project including, but not limited to, the use of recycled or reclaimed water and the reduction or elimination of point and non-point source wastewater discharge.

- Compare any project performance and expectations provided in the proposal to Energy Commission with actual project performance and accomplishments.
- Describe how the project supports new technology advancement for DG, CHP and CCHP.
- Describe how the project demonstrated the cost-effectiveness of the proposed technology in flex fuel capability of DG systems.
- Provide additional data that may be requested by the Energy Commission during the term of this Agreement, as is reasonably available.

Products:

- Operational Data Collection and Analysis Write Up in the Final Report

TASK 12 COMMERCIAL SYSTEM PLAN

Task 12.1 Size and Design ZERE Commercial Scale System
The goal of this task is to integrate data and lessons learned from tasks 2 through 9 into a commercial scale ZERE plant design.

The Recipient shall:

- Investigate California waste biomass availability an identify targets for commercial scale partnering.
- Determine optimal plant size based on economic viability factors including available feedstock, feedstock price, electric power and heat production, and electric power and heat revenue projections.
- Develop first level commercial system design package that includes plant size, plant capabilities, target capacities, land use requirements, and top level P&ID and BOM.

Products:

- Commercial system design package

Task 12.2 Perform Commercial Scale Life Cycle Analysis
The goal of this task is to determine the life cycle carbon and emissions impact of the commercial scale ZERE plant designed in task 12.1

The Recipient shall:
Perform a life cycle analysis of the commercial system designed in task 12.1
Prepare a report on commercial system life cycle impacts.

Products:

- Life Cycle Impact Section of the Commercialization Plan (no draft)

Exhibit A
Scope of Work

Task 12.3 Perform Commercial System Economic Benefit Analysis
The goal of this task is to perform a per plant economic analysis for the plant designed in task 12.1.

The Recipient shall:

- Investigate feedstock supply cost and cost volatility.
- Investigate product and co-product demand and price volatility.
- Develop estimates for plant capital cost and operating cost.
- Develop estimates for economic side benefits to California rate payers such as job creation, tax revenue, and efficient use of California resources.
- Create a per plant economic model.
- Prepare a commercial system economic benefit analysis

Products:

- Commercial Plant Economic Analysis Section of the Commercialization Plan (no draft)

Task 12.4 Assess Commercial and Rate Payer Benefits of Adding Solid Fuel to AIIO Fuel Flexibility Portfolio
The goal of this task is to assess the commercial and rate payer benefits of being able to use a wider range of waste fuels and increase system fuel flexibility. Benefits to be considered include fuel price stability, fuel supply stability, environmental benefits (such as reduction of open burn emissions), additional sources of renewable fuel, and consistency of energy supply.

The Recipient shall:

- Assess and rank the commercial and rate payer benefits of increased fuel flexibility due to ability to use a wider range of gas, solid, and liquid bio - waste fuels.
- Prepare a Rate Payer Benefit Section of the Final Report detailing commercial and rate payer benefits due to increasing fuel flexibility range.

Products:

- Rate Payer Benefit Section of the Final Report

Task 12.5 Prepare Business Plan to Take Proposed Technology to the Marketplace

The goal is to develop a business plan on how to bring the proposed technology to the marketplace; to be submitted as part of the final deliverable. Find strategic partner/customer for first product.

The Recipient shall:

- Develop plan for customer from our oil-based product in the fields of lubricants, for example.

Exhibit A
Scope of Work

- Initiate discussions to establish strategic partnership with customer for supply of oil-based products upon scale-up to production phase.
- Write a Commercialization Plan that includes a plan to bring ZERE product to market as well as plant economic and life cycle data.

Products:

- Commercialization Plan (no draft)