

GRANTS/CONTINGENT AWARD REQUEST



To: Grants and Loans Office

Date: 4/30/2012

Project Manager: Pablo Gutierrez

Phone Number: 916-327-1542

Office: Energy Generation Research Office

Division: Energy Research and Development

MS- 43

Project Title: Fuel-flexible, hybrid CHP at San Bernardino Municipal Water Department

Type of Request: (check one)

New Agreement: (include items A-F from below) Agreement Number: PIR-11-028

Program: PIER NG / Renewables

Solicitation Name and/or Number: PON-11-507-11 (Hybrid Generation and Fuel-flexible Distributed Generation/Combined Heat and Power/Combined Cooling, Heat and Power (DG/CHP/CCHP) Systems)

Legal Name of Recipient: Gas Technology Institute

Recipient's Full Mailing Address: 1700 S MOUNT PROSPECT RD
DES PLAINES, IL 60018-1804

Recipient's Project Officer: John Pratrapas Phone Number: 847.768.0280

Agreement Start Date: 6/29/2012 Agreement End Date: 3/31/2015

Amendment: (Check all that apply) Agreement Number: _____

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: NG Amount: \$ 1,767,185.00 Statute: 10- FY: 11-12 Budget List #: 501.001E

*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: 6/13/2012 Consent Discussion

Business Meeting Participant: Pablo Gutierrez Time Needed: 5 minutes

Agenda Notice Statement: (state purpose in layperson terms)

Possible approval of a Grant / Contingent Award to...

Possible approval of Agreement PIR-11-028 for a grant of \$1,767,185.00 to the Gas Technology Institute to develop and demonstrate an advanced, fuel-flexible combined heat and power system. This novel system will be developed, built, and demonstrated at the San Bernardino Water Reclamation Plant to assess its technical and economic viability. This project includes \$870,388.00 in match funding. (PIER natural gas funding.) Contact: Pablo Gutierrez. (5 minutes.)

Project Manager _____ Date _____ Office Manager _____ Date _____ Deputy Director _____ Date _____

Exhibit A

Scope of Work

1
2
3

TECHNICAL TASK LIST

Task #	CPR	Task Name
1	N/A	Administration
2		Development of a Hybrid Combined Heat and Power (CHP) Detailed Process Diagram and Identification of Performance Specifications for Major Subsystems for the San Bernardino Water Reclamation Plant (SBWRP)
3		Engineering Design, Fabrication, and Testing of a Partial Oxidation Reactor
4		Conceptual Design, Modeling, and Performance Evaluation of the Partial Oxidation Gas Turbine (POGT)-Turbo Charger and a Hybrid Internal Combustion Engine (ICE)-POGT
5	X	Engineering Design, Construction, Installation, and Performance Testing of the POGT-TC
6		Design, Installation, and Integration of the POGT-ICE at the SBWRP
7	X	Performance Testing of the CHP ICE-POGT Unit at the SBWRP
8		Long-Term Testing and Performance Verification of the Hybrid ICE-POGT Unit at the SBWRP
9		Data Processing and Analysis
10		Technology Transfer Activities
11		Production Readiness Plan

4
5
6

KEY NAME LIST

Task #	Key Personnel	Key SubContractors(s)	Key Partner(s)
1	John M Pratapas	Vronay ES, Alturdyne, EMCo	SBMWD
2-9	Joseph Rabovitser	Vronay ES, Alturdyne, EMCo	SBMWD
10-11	John M Pratapas	Vronay ES, Alturdyne, EMCo	SBMWD

7
8
9

GLOSSARY

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

12

Acronym	Definition
Aspen Plus	Aspen Plus Computer Program for Energy, Mass Balances, Chemistry, Compositions Calculations
CARB	California Air Resources Board
CHP	Combined Heat and Power
CO	Carbon Monoxide
CPR	Critical Project Review
DG	Distributed Generation

Exhibit A

Scope of Work

Acronym	Definition
Energy Commission	California Energy Commission
GQS	Gas Quality Sensor
ICE	Internal Combustion Engine
NOx	Nitric Oxides
ORC	Organic Rankine Cycle
PAC	Project Advisory Committee
PIER	Public Interest Energy Research
POGT	Partial Oxidation Gas Turbine
POR	Partial Oxidation Reactor
POTW's	Publicly Owned Treatment Works
SCAQMD	South Coast Air Quality Management District
SBMWD	San Bernardino Municipal Water Department
SBWRP	San Bernardino Water Reclamation Plant
TC	Turbo Charger
UCC.1	Uniform Commercial Code (Financing Statement)
UV	Ultra Violet
VOC	Volatile Organic Compounds

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28

Problem Statement

Operators of reciprocating engines fueled with renewable, carbon-neutral fuels such as biogas (primarily methane and carbon dioxide) produced from sanitary landfills and biological wastewater treatment processes are facing tightening limits on emissions of regulated air pollutants from their engines. In the Southern California basin, regulated by the South Coast Air Quality Management District (SCAQMD), an ongoing rulemaking will require operators of these bio-fueled engines to meet the same low emissions levels of nitric oxides (NOx), carbon monoxide (CO), and volatile organic compounds (VOCs) as their commercial counterparts operating on natural gas.

These emissions limits are defined in SCAQMD Rule 1110.2 and are comparable to the 2007 California Air Resources Board's (CARB's) distributed generation (DG) standards for fossil-fueled distributed generation. The California Energy Commission's (Energy Commission's) PON-11-507 states that "The 2005 Energy Action Plan established DG/Combined Heat and Power (CHP) as a priority element of California's loading order for meeting new electricity needs stating that after cost-effective efficiency and demand response, the energy plan hinges on renewable sources of power and DG such as CHP." Wastewater treatment plants and landfills affected by the planned SCAQMD Rule 1110.2 revisions may no longer find it economically viable to operate their DG/CHP systems on biogas.

Faced with the significant capital costs needed to comply with pending SCAQMD Rule 1110.2 limits, operators of landfill and digester gas-fueled engines, predominantly public agencies, are faced with ceasing on-site power generation from this free and biogenic fuel source and have indicated that they will have to flare 100% of these gases rather than use them for DG/CHP. Wastewater treatment plants would face the prospect of

Exhibit A

Scope of Work

1 purchasing power to make up for power that was previously avoided by operating their
2 on-site generating facilities. The financial impact of wasting this resource and the
3 resulting financial hardship faced by Publicly-Owned Treatment Works (POTWs) comes
4 at a time when new standards and practices for the cleanliness of discharged
5 wastewater effluent are also increasing, requiring equipment such as reverse osmosis
6 purification and ultraviolet (UV) destruction of microbes, both of which will significantly
7 increase the power needs of POTWs.

8

9 **Goals of the Agreement**

10
11 The goal of this Agreement is to develop and demonstrate a Hybrid Partial Oxidation
12 Gas Turbine (POGT)-Internal Combustion Engine (ICE), including Organic Rankine
13 Cycle (ORC) for waste heat to electrical power generation, as a fuel-flexible, hybrid
14 generation CHP system to improve the performance and advance the market
15 penetration of DG/CHP systems in California with the following broad objectives:

- 16 1. Increasing efficiency;
- 17 2. Reducing cost;
- 18 3. Reducing emissions (including greenhouse gases);
- 19 4. Increasing use of renewable and alternative fuels;
- 20 5. Improving the reliability, load factors, and operational flexibility of integrated
21 systems that can be used in commercial and industrial applications for electricity
22 generation, space conditioning, and process heating; and
- 23 6. Integrating emerging multiple DG/CHP technologies, including fuel flexibility, in
24 diversified applications.

25
26 This Agreement will address the challenges related to the slow penetration of new
27 DG/CHP installations in California, increasing CHP's efficiency, flexibility, and reducing
28 greenhouse gas emissions, while maintaining existing and increasing renewable CHP.

29

30

31 **Objectives of the Agreement**

32
33 The objectives of this Agreement are to develop and demonstrate a fuel-flexible, hybrid
34 generation CHP system at the San Bernardino Water Reclamation Plant (SBWRP)
35 located in a California investor-owned utility service area served by Southern California
36 Gas and Southern California Edison. This project will: demonstrate innovations beyond
37 the current market of CHP. These innovations will result in improvements in overall
38 system performance (including increased fuel-to-electricity efficiency beyond the current
39 state-of-the-art efficiencies, reduced cost, and emissions that are in compliance with
40 CARB's 2007 emissions standards for DG and DG/CHP) without the requirements of
41 adding expensive equipment for removing siloxanes and other contaminants from
42 biogas and catalytic aftertreatment for exhaust gases; and contribute to increased use
43 of renewable and alternative fuels in California.

44
45 The Project will advance technologies that: enable technically viable and cost-
46 competitive integration of renewable resources for hybrid cycle application, and

Exhibit A

Scope of Work

1 increase fuel use efficiency, electrical and thermal utilization efficiency, and load
2 following capability of integrated multiple or fuel-flexible DG/CHP systems. The
3 performance targets include improving efficiency and reducing cost of a fuel-flexible,
4 near-term commercial CHP system powered by a novel gas turbine staged with a
5 reciprocating engine into a hybrid generation system. This advanced hybrid generation
6 system will be developed, built, and demonstrated in California at the SBWRP to
7 provide improved technical viability, performance, and market competitiveness of fuel-
8 flexible (biogas, natural gas, and blends of each) CHP, while exceeding California's
9 environmental standards. The Project includes improved physical, thermal, and
10 electrical integration among multiple DG/CHP sub-systems and components. The Fuel-
11 Flexible, Hybrid Generation POGT-ICE CHP system will be designed to provide
12 operational and fuel flexibility capable of using a range of fuels including natural gas,
13 renewable resources, waste gases, and flare gases as potential energy inputs.

14 15 **TASK 1 ADMINISTRATION**

16 17 **Task 1.1 Attend Kick-off Meeting**

18
19 The goal of this task is to establish the lines of communication and procedures for
20 implementing this Agreement.

21 22 **The Recipient shall:**

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

30
31 The administrative portion of the meeting shall include, but not be limited to, the
32 following:

- 33 ○ Discussion of the terms and conditions of the Agreement
- 34 ○ Discussion of Critical Project Review (Task 1.2)
- 35 ○ Match fund documentation (Task 1.6) No work may be done until this
36 documentation is in place.
- 37 ○ Permit documentation (Task 1.7)
- 38 ○ Discussion of subcontracts needed to carry out project (Task 1.8)

39
40 The technical portion of the meeting shall include, but not be limited to, the following:

- 41 ○ The Commission Project Manager's expectations for accomplishing tasks
42 described in the Scope of Work
- 43 ○ An updated Schedule of Products
- 44 ○ Discussion of Progress Reports (Task 1.4)
- 45 ○ Discussion of Technical Products (Product Guidelines located in Section 5 of the
46 Terms and Conditions)

Exhibit A

Scope of Work

- 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 Fuels and Transportation Division (FTD) 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). If the Commission Project Manager concludes that satisfactory progress is not being made, this conclusion will be referred to the Transportation 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.

Exhibit A

Scope of Work

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46

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 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)

Exhibit A

Scope of Work

- 1 o Energy Commission's request for specific "generated" data (not already provided
- 2 in Agreement products)
- 3 o Need to document Recipient's disclosure of "subject inventions" developed under
- 4 the Agreement
- 5 o "Surviving" Agreement provisions
- 6 o Final invoicing and release of retention

- 7
- 8 • Prepare a schedule for completing the closeout activities for this Agreement.
- 9

10 **Products:**

- 11 • Written documentation of meeting agreements
- 12 • Schedule for completing closeout activities

13

14 **Task 1.4 Monthly Progress Reports**

15

16 The goal of this task is to periodically verify that satisfactory and continued progress is

17 made towards achieving the research objectives of this Agreement on time and within

18 budget.

19

20 The objectives of this task are to summarize activities performed during the reporting

21 period, to identify activities planned for the next reporting period, to identify issues that

22 may affect performance and expenditures, and to form the basis for determining

23 whether invoices are consistent with work performed.

24

25 **The Recipient shall:**

- 26 • Prepare a Monthly Progress Report which summarizes all Agreement activities
- 27 conducted by the Recipient for the reporting period, including an assessment of the
- 28 ability to complete the Agreement within the current budget and any anticipated cost
- 29 overruns. Each progress report is due to the Commission Project Manager within 10
- 30 days of the end of the reporting period. The recommended specifications for each
- 31 progress report are contained in Section 6 of the Terms and Conditions of this
- 32 Agreement.

33

34 **Product:**

- 35 • Monthly Progress Reports

36

37 **Task 1.5 Final Report**

38

39 The goal of the Final Report is to assess the project's success in achieving its goals and

40 objectives, advancing science and technology, and providing energy-related and other

41 benefits to California.

42

43 The objectives of the Final Report are to clearly and completely describe the project's

44 purpose, approach, activities performed, results, and advancements in science and

45 technology; to present a public assessment of the success of the project as measured

46 by the degree to which goals and objectives were achieved; to make insightful

Exhibit A

Scope of Work

1 observations based on results obtained; to draw conclusions; and to make
2 recommendations for further projects and improvements to the FTD project
3 management processes.

4
5 The Final Report shall be a public document. If the Recipient has obtained confidential
6 status from the Energy Commission and will be preparing a confidential version of the
7 Final Report as well, the Recipient shall perform the following activities for both the
8 public and confidential versions of the Final Report.

9 10 **The Recipient shall:**

- 11 • Prepare an Outline of the Final Report.
- 12 • Prepare a Final Report following the approved outline and the latest
13 version of the Final Report guidelines which will be provided by the
14 Commission Project Manager. The Commission Project Manager shall
15 provide written comments on the Draft Final Report within fifteen (15)
16 working days of receipt. The Final Report must be completed at least 60
17 days before the end of the Agreement Term.
- 18 • Submit one bound copy of the Final Report with the final invoice.

19 20 **Products:**

- 21 • Draft Outline of the Final Report
- 22 • Final Outline of the Final Report
- 23 • Draft Final Report
- 24 • Final Report

25 26 **Task 1.6 Identify and Obtain Matching Funds**

27
28 The goal of this task is to ensure that the match funds planned for this Agreement are
29 obtained for and applied to this Agreement during the term of this Agreement.

30
31 The costs to obtain and document match fund commitments are not reimbursable
32 through this Agreement. Although the Energy Commission budget for this task will be
33 zero dollars, the Recipient may utilize match funds for this task. Match funds shall be
34 spent concurrently or in advance of Energy Commission funds for each task during the
35 term of this Agreement. Match funds must be identified in writing and the associated
36 commitments obtained before the Recipient can incur any costs.

37 38 **The Recipient shall:**

- 39 • Prepare a letter documenting the match funding committed to this
40 Agreement and submit it to the Commission Project Manager at least 2
41 working days prior to the kick-off meeting. If no match funds were part of
42 the proposal that led to the Energy Commission awarding this Agreement
43 and none have been identified at the time this Agreement starts, then
44 state such in the letter. If match funds were a part of the proposal that led
45 to the Energy Commission awarding this Agreement, then provide in the
46 letter a list of the match funds that identifies the:

Exhibit A

Scope of Work

- 1 ○ Amount of each cash match fund, its source, including a
2 contact name, address and telephone number and the
3 task(s) to which the match funds will be applied.
- 4 ○ Amount of each in-kind contribution, a description,
5 documented market or book value, and its source, including
6 a contact name, address and telephone number and the
7 task(s) to which the match funds will be applied. If the in-
8 kind contribution is equipment or other tangible or real
9 property, the Recipient shall identify its owner and provide a
10 contact name, address and telephone number, and the
11 address where the property is located.
- 12 • Provide a copy of the letter of commitment from an authorized
13 representative of each source of cash match funding or in-kind
14 contributions that these funds or contributions have been secured. For
15 match funds provided by a grant a copy of the executed grant shall be
16 submitted in place of a letter of commitment.
- 17 • Discuss match funds and the implications to the Agreement if they are
18 reduced or not obtained as committed, at the kick-off meeting. If
19 applicable, match funds will be included as a line item in the progress
20 reports and will be a topic at CPR meetings.
- 21 • Provide the appropriate information to the Commission Project Manager if
22 during the course of the Agreement additional match funds are received.
- 23 • Notify the Commission Project Manager within 10 days if during the
24 course of the Agreement existing match funds are reduced. Reduction in
25 match funds must be approved through a formal amendment to the
26 Agreement and may trigger an additional CPR.

27

28 **Products:**

- 29 • A letter regarding match funds or stating that no match funds are provided
- 30 • Copy(ies) of each match fund commitment letter(s) (if applicable)
- 31 • Letter(s) for new match funds (if applicable)
- 32 • Letter that match funds were reduced (if applicable)

33

34 **Task 1.7 Identify and Obtain Required Permits**

35

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

39

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

45

46 **The Recipient shall:**

Exhibit A

Scope of Work

- 1 • Prepare a letter documenting the permits required to conduct this
2 Agreement and submit it to the Commission Project Manager at least 2
3 working days prior to the kick-off meeting. If there are no permits required
4 at the start of this Agreement, then state such in the letter. If it is known at
5 the beginning of the Agreement that permits will be required during the
6 course of the Agreement, provide in the letter:
 - 7 ▪ A list of the permits that identifies the:
 - 8 ○ Type of permit
 - 9 ○ Name, address and telephone number of the
10 permitting jurisdictions or lead agencies
 - 11 ▪ The schedule the Recipient will follow in applying for and obtaining
12 these permits.
- 13 • Discuss the list of permits and the schedule for obtaining them at the kick-
14 off meeting and develop a timetable for submitting the updated list,
15 schedule and the copies of the permits. The implications to the
16 Agreement if the permits are not obtained in a timely fashion or are denied
17 will also be discussed. If applicable, permits will be included as a line item
18 in the Progress Reports and will be a topic at CPR meetings.
- 19 • If during the course of the Agreement additional permits become
20 necessary, provide the appropriate information on each permit and an
21 updated schedule to the Commission Project Manager.
- 22 • As permits are obtained, send a copy of each approved permit to the
23 Commission Project Manager.
- 24 • If during the course of the Agreement permits are not obtained on time or
25 are denied, notify the Commission Project Manager within 5 working days.
26 Either of these events may trigger an additional CPR.

27 **Products:**

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

34 **Task 1.8 Obtain and Execute Subcontracts**

35 The goal of this task is for Recipients to identify any subcontracts required to carry out
36 the tasks under this Agreement and to procure them consistent with the terms and
37 conditions of this Agreement and the Recipient's own procurement policies and
38 procedures. It will also provide the Energy Commission an opportunity to review the
39 subcontracts to ensure that the tasks are consistent with this Agreement, that the
40 budgeted expenditures are reasonable and consistent with applicable cost principles.
41
42

43 **The Recipient shall:**

- 44 • Prepare a letter documenting the subcontracts required to conduct this Agreement,
45 and submit it to the Commission Project Manager at least 2 working days prior to the
46

Exhibit A

Scope of Work

1 kick-off meeting. If there are no subcontracts required at the start of this Agreement,
2 then state such in the letter. If it is known at the beginning of the Agreement that
3 subcontracts will be required during the course of the Agreement, provide in the
4 letter:

- 5 ○ A list of the subcontracts that describes the anticipated maximum budget and
6 general scope of work for each,
 - 7 ○ A description of the procurement process to be used, and
 - 8 ○ The schedule the Recipient will follow in applying for and obtaining these
9 subcontracts
- 10 • Submit a draft of the subcontract that will include a budget with the information
11 required in the budget details to the Commission Project Manager for review and
12 approval, and incorporate any changes recommended by the Commission Project
13 Manager.
 - 14 • Submit a final copy of the executed subcontract.

15 **Products:**

- 16 • Letter describing the subcontracts needed, or stating that no subcontracts are
17 required
- 18 • Draft subcontracts
- 19 • Final subcontracts

20 **TECHNICAL TASKS**

21 **Task 2 Development of a Hybrid CHP Detailed Process Diagram and Identification** 22 **of Performance Specifications for Major Subsystems for the SBWRP**

23 **Task 2.1- Documentation of Existing Process and Energy Operations**

24 The goal of this task is to evaluate and document the SBWRP baseline operations and
25 possible locations of partial oxidation gas turbine from turbo-charger (POGT-TC),
26 Organic Rankine Cycle (ORC), and Hybrid internal combustion engine (ICE)-POGT
27 units to enhance integration, plant operations disruptions, and maximize performance.
28

29 **The Recipient shall:**

- 30 • Evaluate SBWRP operations including but not limited to: treatment train operation
31 processes, power requirements for operations, water conveyance systems, water
32 disposal, solid waste disposal, quantity and composition of flare gases and
33 utilization, and possible locations of POGT-TC, ORC and Hybrid ICE-POGT units to
34 maximize the SBWRP's performance.
- 35 • Prepare an evaluation of facility requirements and specifications for possible location
36 of POGT-TC, ORC and Hybrid ICE-POGT units. The evaluation will describe how
37 the requirements and specifications would integrate and not interfere with current
38 SBWRP operations.
- 39 • Prepare a Task 2.1 Report that includes the following:
40
 - 41 ○ Schematics of current SBWRP operations and process flow diagrams
 - 42
 - 43
 - 44
 - 45
 - 46

Exhibit A

Scope of Work

- 1 ○ A schematic showing locations of the POGT-TC, ORC, and Hybrid ICE-
2 POGT systems
- 3 ○ A summary of task results on possible adverse and beneficial gains of
4 operation from the integration of the POGT-TC, ORC, and Hybrid ICE-
5 POGT systems.
- 6 ○ A summary of current waste sludge disposal practices, and flare gas
7 analysis and potential energy recovery

8 9 **Products:**

- 10 • Task 2.1 Report (no draft)

11 12 **Task 2.2- Existing Equipment Inventory and Baseline Energy Audit**

13
14 The goal of this task is to conduct an inventory of existing equipment including an
15 energy audit consisting of current electrical and natural gas usage.

16 17 **The Recipient shall:**

- 18 • Prepare an equipment inventory including make, model, age, and ratings.
- 19 • Identify and document the baseline performance of facility energy consuming and
20 recovery equipment including condition, estimated remaining life and capability for
21 integration with the POGT-TC, ORC and Hybrid ICE-POGT equipment.
- 22 • Prepare a list of new components for proposed procurement under this Agreement.
- 23 • Develop requirements and specifications for engineering design of these additional
24 components.
- 25 • Prepare a Task 2.2 Report that includes the following:
 - 26 ○ Existing equipment inventory and current energy consumption or recovery
27 linked to SBWRP operations and process flow diagrams
 - 28 ○ A list of any new proposed equipment to replace existing comparable
29 items including specifications and estimated cost

30 31 **Products:**

- 32 • Task 2.2 Report (no draft)

33 34 **Task 2.3- Process Design for Hybrid ICE-POGT system with ORC for DG/CHP**

35
36 The goals of this task are to develop a detailed process flow diagram of the Hybrid ICE-
37 POGT, ORC and DG/CHP unit, and to define required performance and specification of
38 the major components for procurement, design, and fabrication.

39 40 **The Recipient shall:**

- 41 • Develop a detailed process flow diagram using available baseline data and
42 preliminary assumptions of the Hybrid CHP performances.
- 43 • Conduct preliminary Aspen Plus® calculations to identify the required performance
44 and specifications of the major components.
- 45 • Prepare a list of components for procurement.

Exhibit A

Scope of Work

- 1 • Prepare requirements and specifications for the engineering design of several
- 2 components.
- 3 • Prepare a Task 2.3 Report that includes the following:
- 4 o Schematics of the Hybrid CHP process flow diagram
- 5 o A list of major equipment and specifications for the proposed modifications
- 6 o to accommodate the Hybrid ICE-POGT with ORC for DG/CHP at the host
- 7 o site
- 8 o A summary of results from preliminary modeling studies
- 9

10 **Products:**

- 11 • Task 2.3 Report (no draft)
- 12

13 **Task 3 Engineering Design, Fabrication and Testing of a POR**

14 The goal of this task is to design, build, and test the Partial Oxidation Reactor (POR) at
15 the Alturdyne facility in El Cajon, California. The Contractor and Alturdyne will conduct
16 this task. The Contractor will perform conceptual design of the POR and identify major
17 design parameters. Alturdyne will perform engineering design, procure the required
18 parts, and build the POR. The Contractor and Alturdyne will conduct the testing of POR
19 at the Alturdyne facility in El Cajon, California. The major variables include air flow,
20 natural gas flow, and air/fuel ratio (stoichiometry). Tests will be conducted at 40, 70 and
21 100% design capacity. The following parameters will to be measured: pressure,
22 temperature, and flow rate of inlet air and natural gas; POR wall temperature; and POR
23 exhaust temperature and H₂ content.

24 **The Recipient shall:**

- 25 • Perform engineering design of the POR based on requirements and specifications
- 26 from Task 2.3.
- 27 • Fabricate the POR according to the completed design.
- 28 • Prepare a draft test plan/matrix and submit it to the Commission Project Manager for
- 29 approval.
- 30 • Conduct testing of the POR according to the approved test plan/matrix.
- 31 • Prepare a Task 3 Report that includes the following: a POR conceptual design,
- 32 specifications, a test plan/matrix, and test results.
- 33
- 34

35 **Products:**

- 36 • Task 3 Report (no draft)
- 37

38 **Task 4 Conceptual Design, Modeling, and Performance Evaluation of the POGT-**

39 **TC and Hybrid ICE-POGT**

40 The goals of this task are to develop a detailed conceptual design, conduct Aspen Plus
41 modeling, and evaluate major performance of the POGT-TC in DG and CHP mode
42 operation. This task will be performed at the Contractor's laboratory in Des Plaines, IL,
43 and will be conducted by the Contractor with input from Alturdyne.

44 **The Recipient shall:**

45

46

Exhibit A

Scope of Work

- 1 • Prepare conceptual design of the POGT-TC based on the POR design from Task 3
- 2 and selected turbocharger components, a turbo compressor, and a turbo expander
- 3 from ICE manufacturer product lines.
- 4 • Conduct combustion modeling to predict engine performance on various levels of
- 5 digester gas enriched with the hydrogen-rich gas from the POGT.
- 6 • Perform Aspen Plus modeling of the POGT in both DG and CHP operations.
- 7 • Evaluate major performance metrics of the POGT.
- 8 • Prepare a Task 4 Report that includes the following:
- 9 o A technical summary including schematics of POGT-TC and its
- 10 performance based on results of modeling
- 11 o Results from the combustion modeling and sensitivity study
- 12

Products:

- 14 • Task 4 Report (no draft)
- 15

Task 5 Engineering Design, Construction, Installation, and Performance Testing of the POGT-TC

18 The goals of this task are to complete the engineering design, fabricate, and assemble
19 the POGT unit, and install and conduct performance testing of the POGT at the
20 Contractor's combustion laboratory in Des Plaines, IL. POGT performance testing will
21 include testing at three loads (40, 70 and 100% of design capacity), and two air/fuel
22 ratios (two stoichiometries). The following parameters will be measured: pressure,
23 temperature, and flow rate of air and natural gas; pressure at compressor discharge and
24 expander exhaust; composition and temperature of expander exhaust; and POGT
25 power produced.
26

The Recipient shall:

- 29 • Perform engineering design of the POGT based on the POR design and selected
- 30 turbo compressor and turbo expander.
- 31 • Fabricate and assemble the POGT unit at the Alturdyne facility at El Cajon,
- 32 California.
- 33 • Ship the assembled POGT unit to the Contractor's laboratory in Des Plaines, IL.
- 34 • Install the POGT at the Contractor's combustion laboratory and equip it with required
- 35 auxiliary equipment, controls, and measurements.
- 36 • Prepare a test plan and matrix and submit it to the Commission Project Manager for
- 37 approval.
- 38 • Conduct performance testing according to the test plan/matrix, and analyze the test
- 39 data.
- 40 • Prepare a Task 5 Report that includes: specifics of the POGT system design, test
- 41 cell installation and operation, a test plan/matrix, and test results.
- 42

Products:

- 44 • Task 5 Report (no draft)
- 45

Task 6 Design, Installation, and Integration of the POGT-ICE at the SBWRP

Exhibit A

Scope of Work

1
2 The goal of this task is to design the integrated ICE-POGT unit (including the
3 requirements for using an ORC unit for waste heat recovery), install the POGT at the
4 SBWRP, and integrate the ICE with the POGT. This task will extensively involve Vronay
5 Engineering Services with support from the SBWRP, and input from EMCo Systems
6 Solutions, Inc. and the Contractor.
7

8 **The Recipient shall:**

- 9 • Perform the design of installation of the POGT in the vicinity of the ICE at the
10 SBWRP and integrate with the ICE for the Hybrid ICE-POGT.
- 11 • Install the POGT at the host site and make the required connections.
- 12 • Integrate the POGT with ICE to create the Hybrid ICE-POGT.
- 13 • Prepare a Task 6 Report that includes specifics of design and installation of an
14 integrated Hybrid ICE-POGT with ORC for waste heat recovery.

15 **Products:**

- 16 • Task 6 Report (no draft)
- 17
18
19

20 **Task 7 Performance Testing of the CHP ICE-POGT Unit at the SBWRP**

21 **Task 7.1- Performance Testing of the CHP ICE-POGT Unit at the SBWRP (without** 22 **the ORC)**

23
24
25 The goal of this task is to conduct short-term testing of the Hybrid ICE-POGT without
26 ORC in the DG and CHP mode of operation, and confirm that it is performing
27 consistently with design targets. The team (including Vronay, Alturdyne, and the
28 Contractor) will conduct the testing with support of the SBWRP. Vronay will help lead
29 the project team activities at the SBWRP.
30

31 **The Recipient shall:**

- 32 • Prepare a Draft Test Plan and test matrix and send it to Commission Project
33 Manager for approval prior to the commencement of testing. The test plan will
34 include the following variables: ICE load, 50 and 100 %; POGT load, 40, 70 and
35 100%. The measured parameters will include: air and fuel flow rate, temperature and
36 pressure to ICE and POGT; ICE inlet temperatures; composition and temperature of
37 POGT exhaust and ICE exhaust; ICE and POGT power output.
- 38 • Conduct performance testing of the Hybrid ICE-POGT in DG and CHP configuration
39 according to approved test plan/matrix.
- 40 • Collect and analyze the data and determine the technical performance of the
41 CHP/DG Hybrid ICE-POGT including emissions (NO_x, CO, CO₂, O₂) performance
42 of the engine.
- 43 • Prepare a Task 7.1 Report that includes: a test matrix, performance tests, and and
44 analysis of CHP/DG Hybrid ICE-POGT including emissions (NO_x, CO, CO₂, O₂)
45 performance of the engine data.
46

Exhibit A

Scope of Work

1 **Products:**

- 2 • Task 7.1 Report (no draft)

4 **Task 7.2- Performance Testing of the CHP ICE-POGT Unit at the SBWRP (with the ORC)**

7 The goal of this task is to conduct short-term testing of the Hybrid ICE-POGT with ORC
8 in the CHP mode of operation, and confirm that it is performing consistently with design
9 targets. The ORC will recover waste heat from cooling the syngas (produced by the
10 POGT) to ensure that the hydrogen-enriched biogas fuel delivered by the ICE is within
11 specification. During this task, the project team (including Vronay, EMCo, Alturdyne
12 and the Contractor) will install an Organic Rankine Cycle (ORC) system sold as the
13 ElectraTherm Series 4000 “Green Machine”. The team will conduct the testing with
14 support of the SBWRP. Vronay will help lead the team activities at SBWRP.

16 **The Recipient shall:**

- 17 • Prepare a Draft Test Plan and test matrix and send it to the Commission Project
18 Manager for approval. The test plan will include the following variables: ICE load, 50
19 and 100%; POGT load, 70%; and POGT stoichiometry selected based on results
20 from Task 7.1. The measured parameters will include: air and fuel flow rate,
21 temperature and pressure to ICE and POGT; ICE inlet temperatures; composition
22 and temperature of POGT exhaust and ICE exhaust; ICE and POGT power output;
23 and ORC power output, working fluid inlet and outlet temperature and flow rate.
- 24 • Conduct performance testing of the Hybrid ICE-POGT in CHP configuration with the
25 ORC according to the approved test plan/matrix.
- 26 • Collect and analyze the data and determine the technical performance of the
27 CHP/DG Hybrid ICE-POGT including emissions (NO_x, CO, CO₂, O₂) performance
28 of the engine.
- 29 • Prepare a Task 7.2 Report that describes the performance of Fuel Flexible, Hybrid
30 ICE-POGT operation in CHP mode (with and without an ORC for waste heat
31 recovery) at the SBWRP.

33 **Products:**

- 34 • Task 7.2 Report (no draft)

37 **Task 8 Long-Term Testing and Performance Verification of the Hybrid ICE-POGT Unit at the SBWRP**

40 The goal of this task is to conduct long-term testing of the CHP Hybrid ICE-POGT and
41 document the extent of any degradation of unit performance over time. During this
42 testing, the plan is for the “Green Machine” to provide the host site with electricity for at
43 least 90 days of operation of this ORC for waste heat recovery. The plan includes
44 testing of a commercial prototype Gas Quality Sensor (GQS) that the Contractor
45 projects will be available at the time of the long-term testing. The GQS will provide real-
46 time monitoring of the fuel gas composition from the POGT to the ICE.

Exhibit A

Scope of Work

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43

The Recipient shall:

- Prepare a procedure for long-term testing and send it to the Commission Project Manager for approval.
- Run the Hybrid ICE-POGT unit during the agreed period at operating conditions representative of SBWRP typical requirements.
- Collect and process data for the period of the long-term testing.
- Prepare a Task 8 Report that compares the performance of major critical components and overall system during short-term versus long-term operation.

Products:

- Task 8 Report (no draft)

Task 9 Data Processing and Analysis

The goal of this task is to support the testing activities during the project and to provide objective/substantiated conclusions of test results and system/subsystem performance.

The Recipient shall:

- Process and analyze the collected data for each series of tests performed in Tasks 2 through 8.
- Incorporate and present the processed data into the affected products.
- Prepare a Task 9 Report that includes the results of Tasks 2 through 8.

Products:

- Task 9 Report (no draft)

Task 10 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 public. The level of detail expected is least for research-related projects and highest for demonstration projects. Key elements from this report shall be included in the Final Report for this project.
- Conduct technology transfer activities in accordance with the Technology Transfer Plan. These activities shall be reported in the Monthly Progress Reports.

Products:

- Draft Technology Transfer Plan
- Final Technology Transfer Plan

Exhibit A

Scope of Work

1 Task 11 Production Readiness Plan

2
3 The goal of the plan is to determine the steps that will lead to the manufacturing of the
4 technologies developed in this project or to the commercialization of the project's
5 results.

6 7 **The Recipient shall:**

- 8 • Prepare a Production Readiness Plan. The degree of detail in the Production
9 Readiness Plan discussion should be proportional to the complexity of producing or
10 commercializing the product resulting from this project and its state of development.

11 The plan shall include but not be limited to:

- 12 • Identification of critical production processes, equipment, facilities, personnel
13 resources, and support systems needed to produce a commercially viable
14 product;
- 15 • Internal manufacturing facilities, as well as supplier technologies, capacity
16 constraints imposed by the design under consideration, identification of design
17 critical elements, and the use of hazardous or non-recyclable materials. The
18 product manufacturing effort may include “proof of production processes”;
- 19 • A projected “should cost” for the product when in production;
- 20 • The expected investment threshold to launch the commercial product; and
- 21 • An implementation plan to ramp it up to full production.

22 23 **Products:**

- 24 • Draft Production Readiness Plan
- 25 • Final Production Readiness Plan

26