





## EXHIBIT A Scope of Work

### A. Task List

Task #	CPR	Task Name
1		General Project Tasks
2	X	Systems Design, Engineering, and Planning
3		PDU Fabrication and Construction
4		Start-up Planning
5	X	Start-up Testing
6		Analysis and Evaluations
7		Environmental Performance
8		Evaluation of Project Benefits
9		Technology/Knowledge Transfer Activities

### B. Acronym/Term List

Acronym/Term	Meaning
CAM	Commission Agreement Manager
CAO	Commission Agreement Officer
CPR	Critical Project Review
GREET	Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model
TAC	Technical Advisory Committee
JSB	Jet Spouted Bed
LCOP	Levelized Cost of Power
MSW	Municipal Solid Waste
PDB	Pulse Detonation Burner
PDE	Pulse Detonation Engine
PDU	Process Development Unit
RDB	Refuse Derived Biomass
SR	Stoichiometric Ratio

## I. PURPOSE OF AGREEMENT, PROBLEM/SOLUTION STATEMENT, AND GOALS AND OBJECTIVES

### A. Purpose of Agreement

The purpose of this Agreement is to design, develop, and test a Waste-to-Energy Process Development Unit (PDU) involving Thermal-Catalytic gasification integrated with reforming for conversion of Refuse Derived Biomass (RDB) into clean fuel gas, enabled by Pulse Detonation Technology. This project will start-up and test a 3-pound per minute PDU, evaluate the results, and provide engineering data to design a 30 ton/day plant generating 1-MW.

## **EXHIBIT A**

### **Scope of Work**

#### **B. Problem/ Solution Statement**

##### **Problem**

There is an urgent need to develop modular, environmentally friendly waste-to-energy plants that are cost-effective in California using Municipal Solid Waste (MSW) derived feeds. Californians annually landfill >30-million tons of MSW-organics. There are more than 272 operating gasification plants worldwide with 686 gasifier units, predominantly using coal, coke, or heavy residues<sup>[11]</sup> with a scale of 10,000 to 100,000 ton/day input capacity; whereas Distributed Generation using RDB is optimized at 100 – 1000 ton/day scale. Although there are village-scale gasifiers with <100 kWh capacity, these small-scale up-draft or down-draft gasifiers are too small to meet California goals. Economies of scale have typically favored large mass-burn facilities feeding 1,500 - 3,000 tons per day, with costs >\$5,000/kWh of installed capacity. Existing gasification methods are in the same high cost range.

##### **Solution**

The project objective is to research, develop, and verify thermal catalytic gasification technology that will overcome all technical and economic barriers preventing the use of RDB as an energy resource in California. Completion of the current gasification/reforming test program will enable future scale-up to 30-ton/day RDB-to-energy (1-MWe scale), in preparation for commercial scale design at 300-ton/day, generating 10-MWe net output, as well as larger capacity modular systems up to -20 MWe, with cost <\$3,750/kWh of installed capacity.

#### **C. Goals and Objectives of the Agreement**

##### **Agreement Goals**

The goals of this agreement are to:

- Validate the technical performance of a two-stage thermal-catalytic gasification process operating with experimental data described in the agreement objectives.
- Verify the economic viability of the integrated waste gasification and reforming process from the project findings as described in the agreement objectives.

**Ratepayer Benefits:** This Agreement will result in the ratepayer benefits of greater electricity reliability and lower costs by developing distributed generation capacity that uses a renewable resource otherwise disposed in landfills; 1-ton of MSW contains the energy equivalent of 2-barrels of oil. Assume 30% net conversion to electric power; about 1-ton-MSW is consumed to make 1-MWh of electric power. The Levelized Cost of Power (LCOP) is estimated at \$118/MWh for 10-MW scale, which results in ratepayer savings of approximately \$30/MWh compared to grid supplier power that will likely average \$150/MWh through 2024.

**Technological Advancement and Breakthroughs:** This Agreement will lead to technological advancements and breakthroughs that overcome barriers to achieve the State's energy goals by developing a Pulse-Jet-Spouted-Bed integrated with a Draft-tube Reforming system. Preliminary engineering, resulting in equipment costs estimates based on projected mass & energy balances anticipate system cost is <\$3750/kWh of installed capacity. Design, construction, and start-up testing will provide necessary research and verification of this breakthrough in waste processing.

---

<sup>1</sup> Gasification Technologies Council, retrieved from <http://www.gasification.org/what-is-gasification/the-gasification-industry/>

# EXHIBIT A

## Scope of Work

### Agreement Objectives

The objectives of this Agreement are to:

- Operate the gasification/reforming process continuously for 8-hours, with RDB input of 3-pounds per minute (1.08-mmBTU per hour, based on energy content of 6,000 Btu/lb for RDB), with average fuel-gas output of 0.80-mmBTU/hr, having energy content of 230 BTU/scf, demonstrating 74% net conversion efficiency of feed into fuel-gas.
- Operate the thermal-chemical gasification process with over-all Stoichiometric Ratio (SR) =0.28, using oxygen enriched air to 33%-O<sub>2</sub> to achieve carbon conversion >90% as measured by Feedstock /Products/Char analysis.
- Operate pulse-deflagration burner(s) that heat and power both the gasification and the reforming process with frequency >7-Hz using Transient Plasma ignition, firing the pulse burners with excess air.
- Establish the durability of stainless steel pulse-combustor(s) with no observable failures due to high-temperature and pulse detonation operation during proof-of-concept testing.
- Establish Process Heat & Mass Balance by Semi-empirical Method and Semi-empirical ASPEN process model development.
- Confirm from the project findings that a cost of \$3,750 per kWh of installed-capacity is supported, based on a 300-ton/day modular system.
- Confirm from the project findings that the LCOP of \$118/MWh, including 10% return on equity, is supported based on a 300-ton/day modular system.
- Estimate Carbon footprint for the process and the products by Life Cycle Analysis through GREET.

## II. TASK 1 GENERAL PROJECT TASKS

### PRODUCTS

#### Subtask 1.1 Products

The goal of this subtask is to establish the requirements for submitting project products (e.g., reports, summaries, plans, and presentation materials). Unless otherwise specified by the Commission Agreement Manager (CAM), the Recipient must deliver products as required below by the dates listed in the **Project Schedule (Part V)**. Products that require a draft version are indicated by marking “**(draft and final)**” after the product name in the “Products” section of the task/subtask. If “(draft and final)” does not appear after the product name, only a final version of the product is required. With respect to due dates within this Scope of Work, “**days**” means working days.

## EXHIBIT A Scope of Work

### The Recipient shall:

#### For products that require a draft version

- Submit all draft products to the CAM for review and comment in accordance with the Project Schedule (Part V). The CAM will provide written comments to the Recipient on the draft product within 15 days of receipt, unless otherwise specified in the task/subtask for which the product is required.
- Submit the final product to the CAM once agreement has been reached on the draft. The CAM will provide written approval of the final product within 15 days of receipt, unless otherwise specified in the task/subtask for which the product is required.
- If the CAM determines that the final product does not sufficiently incorporate his/her comments, submit the revised product to the CAM within 10 days of notice by the CAM, unless the CAM specifies a longer time period.

#### For products that require a final version only

- Submit the product to the CAM for approval.
- If the CAM determines that the product requires revision, submit the revised product to the CAM within 10 days of notice by the CAM, unless the CAM specifies a longer time period.

#### For all products

- Submit all data and documents required as products in accordance with the following Instructions for Submitting Electronic Files and Developing Software:

- **Electronic File Format**

Submit all data and documents required as products under this Agreement in an electronic file format that is fully editable and compatible with the Energy Commission's software and Microsoft (MS)-operating computing platforms, or with any other format approved by the CAM. Deliver an electronic copy of the full text of any Agreement data and documents in a format specified by the CAM, such as memory stick or CD-ROM.

The following describes the accepted formats for electronic data and documents provided to the Energy Commission as products under this Agreement, and establishes the software versions that will be required to review and approve all software products:

- Data sets will be in MS Access or MS Excel file format (version 2007 or later), or any other format approved by the CAM.
  - Text documents will be in MS Word file format, version 2007 or later.
  - Documents intended for public distribution will be in PDF file format. The Recipient must also provide the native Microsoft file format.
  - Project management documents will be in Microsoft Project file format, version 2007 or later.
- **Software Application Development**  
Use the following standard Application Architecture components in compatible versions for any software application development required by this Agreement (e.g., databases, models, modeling tools), unless the CAM approves other software applications such as open source programs:
    - Microsoft ASP.NET framework (version 3.5 and up). Recommend 4.0.

## EXHIBIT A Scope of Work

- Microsoft Internet Information Services (IIS), (version 6 and up) Recommend 7.5.
  - Visual Studio.NET (version 2008 and up). Recommend 2010.
  - C# Programming Language with Presentation (UI), Business Object and Data Layers.
  - SQL (Structured Query Language).
  - Microsoft SQL Server 2008, Stored Procedures. Recommend 2008 R2.
  - Microsoft SQL Reporting Services. Recommend 2008 R2.
  - XML (external interfaces).

Any exceptions to the Electronic File Format requirements above must be approved in writing by the CAM. The CAM will consult with the Energy Commission's Information Technology Services Branch to determine whether the exceptions are allowable.

### MEETINGS

#### Subtask 1.2 Kick-off Meeting

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

#### The Recipient shall:

- Attend a "Kick-off" meeting with the CAM, the Commission Agreement Officer (CAO), and any other Energy Commission staff relevant to the Agreement. The Recipient will bring its Project Manager and any other individuals designated by the CAM to this meeting. The administrative and technical aspects of the Agreement will be discussed at the meeting. Prior to the meeting, the CAM will provide an agenda to all potential meeting participants. The meeting may take place in person or by electronic conferencing (e.g., WebEx), with approval of the CAM.

The administrative portion of the meeting will include discussion of the following:

- Terms and conditions of the Agreement;
- Administrative products (subtask 1.1);
- CPR meetings (subtask 1.3);
- Match fund documentation (subtask 1.7);
- Permit documentation (subtask 1.8);
- Subcontracts (subtask 1.9); and
- Any other relevant topics.

The technical portion of the meeting will include discussion of the following:

- The CAM's expectations for accomplishing tasks described in the Scope of Work;
- An updated Project Schedule;
- Technical products (subtask 1.1);
- Progress reports and invoices (subtask 1.5);
- Final Report (subtask 1.6);
- Technical Advisory Committee meetings (subtasks 1.10 and 1.11); and
- Any other relevant topics.

## **EXHIBIT A**

### **Scope of Work**

- Provide an *Updated Project Schedule*, *List of Match Funds*, and *List of Permits*, as needed to reflect any changes in the documents.

#### **The CAM shall:**

- Designate the date and location of the meeting.
- Send the Recipient a *Kick-off Meeting Agenda*.

#### **Recipient Products:**

- Updated Project Schedule (*if applicable*)
- Updated List of Match Funds (*if applicable*)
- Updated List of Permits (*if applicable*)

#### **CAM Product:**

- Kick-off Meeting Agenda

#### **Subtask 1.3 Critical Project Review (CPR) Meetings**

The goal of this subtask is to determine if the project should continue to receive Energy Commission funding, and if so whether any modifications must be made to the tasks, products, schedule, or budget. CPR meetings provide the opportunity for frank discussions between the Energy Commission and the Recipient. As determined by the CAM, discussions may include project status, challenges, successes, advisory group findings and recommendations, final report preparation, and progress on technical transfer and production readiness activities (if applicable). Participants will include the CAM and the Recipient, and may include the CAO and any other individuals selected by the CAM to provide support to the Energy Commission.

CPR meetings generally take place at key, predetermined points in the Agreement, as determined by the CAM and as shown in the Task List on page 1 of this Exhibit. However, the CAM may schedule additional CPR meetings as necessary. The budget will be reallocated to cover the additional costs borne by the Recipient, but the overall Agreement amount will not increase. CPR meetings generally take place at the Energy Commission, but they may take place at another location, or may be conducted via electronic conferencing (e.g., WebEx) as determined by the CAM.

#### **The Recipient shall:**

- Prepare a *CPR Report* for each CPR meeting that: (1) discusses the progress of the Agreement toward achieving its goals and objectives; and (2) includes recommendations and conclusions regarding continued work on the project.
- Submit the CPR Report along with any other *Task Products* that correspond to the technical task for which the CPR meeting is required (i.e., if a CPR meeting is required for Task 2, submit the Task 2 products along with the CPR Report).
- Attend the CPR meeting.
- Present the CPR Report and any other required information at each CPR meeting.

#### **The CAM shall:**

- Determine the location, date, and time of each CPR meeting with the Recipient's input.
- Send the Recipient a *CPR Agenda* and a *List of Expected CPR Participants* in advance of the CPR meeting. If applicable, the agenda will include a discussion of match funding and permits.

## **EXHIBIT A**

### **Scope of Work**

- Conduct and make a record of each CPR meeting. Provide the Recipient with a *Schedule for Providing a Progress Determination* on continuation of the project.
- Determine whether to continue the project, and if so whether modifications are needed to the tasks, schedule, products, or budget for the remainder of the Agreement. If the CAM concludes that satisfactory progress is not being made, this conclusion will be referred to the Deputy Director of the Energy Research and Development Division.
- Provide the Recipient with a *Progress Determination* on continuation of the project, in accordance with the schedule. The Progress Determination may include a requirement that the Recipient revise one or more products.

#### **Recipient Products:**

- CPR Report(s)
- Task Products (draft and/or final as specified in the task)

#### **CAM Products:**

- CPR Agenda
- List of Expected CPR Participants
- Schedule for Providing a Progress Determination
- Progress Determination

#### **Subtask 1.4 Final Meeting**

The goal of this subtask is to complete the closeout of this Agreement.

#### **The Recipient shall:**

- Meet with Energy Commission staff to present project findings, conclusions, and recommendations. The final meeting must be completed during the closeout of this Agreement. This meeting will be attended by the Recipient and CAM, at a minimum. The meeting may occur in person or by electronic conferencing (e.g., WebEx), with approval of the CAM.

The technical and administrative aspects of Agreement closeout will be discussed at the meeting, which may be divided into two separate meetings at the CAM's discretion.

- The technical portion of the meeting will involve the presentation of findings, conclusions, and recommended next steps (if any) for the Agreement. The CAM will determine the appropriate meeting participants.
- The administrative portion of the meeting will involve a discussion with the CAM and the CAO of the following Agreement closeout items:
  - Disposition of any state-owned equipment.
  - Need to file a Uniform Commercial Code Financing Statement (Form UCC-1) regarding the Energy Commission's interest in patented technology.
  - The Energy Commission's request for specific "generated" data (not already provided in Agreement products).
  - Need to document the Recipient's disclosure of "subject inventions" developed under the Agreement.
  - "Surviving" Agreement provisions such as repayment provisions and confidential products.
  - Final invoicing and release of retention.

## EXHIBIT A Scope of Work

- Prepare a *Final Meeting Agreement Summary* that documents any agreement made between the Recipient and Commission staff during the meeting.
- Prepare a *Schedule for Completing Agreement Closeout Activities*.
- Provide *All Draft and Final Written Products* on a CD-ROM or USB memory stick, organized by the tasks in the Agreement.

### Products:

- Final Meeting Agreement Summary (*if applicable*)
- Schedule for Completing Agreement Closeout Activities
- All Draft and Final Written Products

## REPORTS AND INVOICES

### Subtask 1.5 Progress Reports and Invoices

The goals of this subtask are to: (1) periodically verify that satisfactory and continued progress is made towards achieving the project objectives of this Agreement; and (2) ensure that invoices contain all required information and are submitted in the appropriate format.

### The Recipient shall:

- Submit a monthly *Progress Report* to the CAM. Each progress report must:
  - Summarize all Agreement activities conducted by the Recipient for the preceding month, including an assessment of the ability to complete the Agreement within the current budget and any anticipated cost overruns. See the Progress Report Format Attachment for the recommended specifications.
  - Provide a synopsis of the project progress, including accomplishments, problems, milestones, products, schedule, fiscal status, and any evidence of progress such as photographs.
- Submit a monthly or quarterly *Invoice* that follows the instructions in the “Payment of Funds” section of the terms and conditions. In addition, each invoice must document and verify:
  - Energy Commission funds received by California-based entities;
  - Energy Commission funds spent in California (*if applicable*); and
  - Match fund expenditures.

### Products:

- Progress Reports
- Invoices

## **EXHIBIT A**

### **Scope of Work**

#### **Subtask 1.6 Final Report**

The goal of this subtask is to prepare a comprehensive Final Report that describes the original purpose, approach, results, and conclusions of the work performed under this Agreement. The CAM will review and approve the Final Report, which will be due at least **two months** before the Agreement end date. When creating the Final Report Outline and the Final Report, the Recipient must use a Style Manual provided by the CAM.

#### **Subtask 1.6.1 Final Report Outline**

##### **The Recipient shall:**

- Prepare a *Final Report Outline* in accordance with the *Style Manual* provided by the CAM.
- Submit a draft of the outline to the CAM for review and comment.
- Once agreement has been reached on the draft, submit the final outline to the CAM. The CAM will provide written approval of the final outline within 10 days of receipt.

##### **Recipient Products:**

- Final Report Outline (draft and final)

##### **CAM Product:**

- Style Manual

#### **Subtask 1.6.2 Final Report**

##### **The Recipient shall:**

- Prepare a *Final Report* for this Agreement in accordance with the approved Final Report Outline and the Style Manual provided by the CAM.
- Submit a draft of the report to the CAM for review and comment. Once agreement on the draft report has been reached, the CAM will forward the electronic version for Energy Commission internal approval. Once the CAM receives approval, he/she will provide written approval to the Recipient.
- Submit one bound copy of the Final Report to the CAM.

##### **Products:**

- Final Report (draft and final)

### **MATCH FUNDS, PERMITS, AND SUBCONTRACTS**

#### **Subtask 1.7 Match Funds**

The goal of this subtask is to ensure that the Recipient obtains any match funds planned for this Agreement and applies them to the Agreement during the Agreement term.

While the costs to obtain and document match funds are not reimbursable under this Agreement, the Recipient may spend match funds for this task. The Recipient may only spend match funds during the Agreement term, either concurrently or prior to the use of Energy Commission funds. Match funds must be identified in writing, and the Recipient must obtain any associated commitments before incurring any costs for which the Recipient will request reimbursement.

## **EXHIBIT A**

### **Scope of Work**

#### **The Recipient shall:**

- Prepare a *Match Funds Status Letter* that documents the match funds committed to this Agreement. 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 this in the letter.

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

- A list of the match funds that identifies:
  - The amount of cash match funds, their source(s) (including a contact name, address, and telephone number), and the task(s) to which the match funds will be applied.
  - The amount of each in-kind contribution, a description of the contribution type (e.g., property, services), the documented market or book value, the 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 must identify its owner and provide a contact name, address, telephone number, and the address where the property is located.
- A copy of a letter of commitment from an authorized representative of each source of match funding that the funds or contributions have been secured.
- At the Kick-off meeting, discuss match funds and the impact on the project if they are significantly reduced or not obtained as committed. If applicable, match funds will be included as a line item in the progress reports and will be a topic at CPR meetings.
- Provide a *Supplemental Match Funds Notification Letter* to the CAM of receipt of additional match funds.
- Provide a *Match Funds Reduction Notification Letter* to the CAM if existing match funds are reduced during the course of the Agreement. Reduction of match funds may trigger a CPR meeting.

#### **Products:**

- Match Funds Status Letter
- Supplemental Match Funds Notification Letter (*if applicable*)
- Match Funds Reduction Notification Letter (*if applicable*)

#### **Subtask 1.8 Permits**

The goal of this subtask 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, with the exception of costs incurred by University of California recipients. Permits must be identified and obtained before the Recipient may incur any costs related to the use of the permit(s) for which the Recipient will request reimbursement.

## EXHIBIT A Scope of Work

### The Recipient shall:

- Prepare a *Permit Status Letter* that documents the permits required to conduct this Agreement. If no permits are required at the start of this Agreement, then state this in the letter. If permits will be required during the course of the Agreement, provide in the letter:
  - A list of the permits that identifies: (1) the type of permit; and (2) the name, address, and telephone number of the permitting jurisdictions or lead agencies.
  - The schedule the Recipient will follow in applying for and obtaining the permits.

The list of permits and the schedule for obtaining them will be discussed at the Kick-off meeting (subtask 1.2), and a timetable for submitting the updated list, schedule, and copies of the permits will be developed. The impact on the project 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 progress reports and will be a topic at CPR meetings.

- If during the course of the Agreement additional permits become necessary, then provide the CAM with an *Updated List of Permits* (including the appropriate information on each permit) and an *Updated Schedule for Acquiring Permits*.
- Send the CAM a *Copy of Each Approved Permit*.
- If during the course of the Agreement permits are not obtained on time or are denied, notify the CAM within 5 days. Either of these events may trigger a CPR meeting.

### Products:

- Permit Status Letter
- Updated List of Permits (*if applicable*)
- Updated Schedule for Acquiring Permits (*if applicable*)
- Copy of each Approved Permit (*if applicable*)

### Subtask 1.9 Subcontracts

The goals of this subtask are to: (1) procure subcontracts required to carry out the tasks under this Agreement; and (2) ensure that the subcontracts are consistent with the terms and conditions of this Agreement.

### The Recipient shall:

- Manage and coordinate subcontractor activities in accordance with the requirements of this Agreement.
- Incorporate this Agreement by reference into each subcontract.
- Include any required Energy Commission flow-down provisions in each subcontract, in addition to a statement that the terms of this Agreement will prevail if they conflict with the subcontract terms.
- If required by the CAM, submit a draft of each *Subcontract* required to conduct the work under this Agreement.
- Submit a final copy of the executed subcontract.
- Notify and receive written approval from the CAM prior to adding any new subcontractors (see the discussion of subcontractor additions in the terms and conditions).

### Products:

- Subcontracts (*draft if required by the CAM*)

## EXHIBIT A Scope of Work

### **TECHNICAL ADVISORY COMMITTEE**

#### **Subtask 1.10 Technical Advisory Committee (TAC)**

The goal of this subtask is to create an advisory committee for this Agreement. The TAC should be composed of diverse professionals. The composition will vary depending on interest, availability, and need. TAC members will serve at the CAM's discretion. The purpose of the TAC is to:

- Provide guidance in project direction. The guidance may include scope and methodologies, timing, and coordination with other projects. The guidance may be based on:
  - Technical area expertise;
  - Knowledge of market applications; or
  - Linkages between the agreement work and other past, present, or future projects (both public and private sectors) that TAC members are aware of in a particular area.
- Review products and provide recommendations for needed product adjustments, refinements, or enhancements.
- Evaluate the tangible benefits of the project to the state of California, and provide recommendations as needed to enhance the benefits.
- Provide recommendations regarding information dissemination, market pathways, or commercialization strategies relevant to the project products.

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

- Researchers knowledgeable about the project subject matter;
- Members of trades that will apply the results of the project (e.g., designers, engineers, architects, contractors, and trade representatives);
- Public interest market transformation implementers;
- Product developers relevant to the project;
- U.S. Department of Energy research managers, or experts from other federal or state agencies relevant to the project;
- Public interest environmental groups;
- Utility representatives;
- Air district staff; and
- Members of relevant technical society committees.

#### **The Recipient shall:**

- Prepare a *List of Potential TAC Members* that includes the names, companies, physical and electronic addresses, and phone numbers of potential members. The list will be discussed at the Kick-off meeting, and a schedule for recruiting members and holding the first TAC meeting will be developed.
- Recruit TAC members. Ensure that each individual understands member obligations and the TAC meeting schedule developed in subtask 1.11.
- Prepare a *List of TAC Members* once all TAC members have committed to serving on the TAC.
- Submit *Documentation of TAC Member Commitment* (such as Letters of Acceptance) from each TAC member.

## **EXHIBIT A**

### **Scope of Work**

#### **Products:**

- List of Potential TAC Members
- List of TAC Members
- Documentation of TAC Member Commitment

#### **Subtask 1.11 TAC Meetings**

The goal of this subtask is for the TAC to provide strategic guidance for the project by participating in regular meetings, which may be held via teleconference.

#### **The Recipient shall:**

- Discuss the TAC meeting schedule with the CAM at the Kick-off meeting. Determine the number and location of meetings (in-person and via teleconference) in consultation with the CAM.
- Prepare a *TAC Meeting Schedule* that will be presented to the TAC members during recruiting. Revise the schedule after the first TAC meeting to incorporate meeting comments.
- Prepare a *TAC Meeting Agenda* and *TAC Meeting Back-up Materials* for each TAC meeting.
- Organize and lead TAC meetings in accordance with the TAC Meeting Schedule. Changes to the schedule must be pre-approved in writing by the CAM.
- Prepare *TAC Meeting Summaries* that include any recommended resolutions of major TAC issues.

#### **Products:**

- TAC Meeting Schedule (draft and final)
- TAC Meeting Agendas (draft and final)
- TAC Meeting Back-up Materials
- TAC Meeting Summaries

# EXHIBIT A

## Scope of Work

### III. TECHNICAL TASKS

#### TASK 2 SYSTEM DESIGN, ENGINEERING, AND PLANNING

The goal of this task is to plan and prepare for construction of a Jet Spouted Bed (JBS) gasification reactor integrated with a Draft-Tube type tar-reformer intended for conversion of MSW derived RDB into fuel-gas suitable for power generation (after cleaning and conditioning).

##### The Recipient shall:

##### Subtask 2.1 Complete PDU Installation Plan

- Complete detailed drawings of Jet Spouted Bed (JSB) gasification reactor & draft-tube reformer
- Complete Process Flow Diagram
- Complete Piping & Instrumentation Diagram
- Prepare Projection of Mass & Energy Balance
- Summarize Expected Performance Characteristics
- Engineer layout of equipment within support structure
- Prepare and provide a PDU Installation Plan to include:
  - Drawings suitable for fabrication of Gasification Reactor & Draft-Tube Reformer
  - Process Flow Diagram
  - Piping & Instrumentation Diagram

##### Products:

- PDU Installation Plan (draft and final)

##### Subtask 2.2 Specify equipment to be purchased for PDU construction.

- Complete Major Equipment List, with summary equipment specifications
- Complete facility floor-plan with major equipment placement and infrastructure
- Revise Schedule for Construction, if needed (based on long-lead items)
- Prepare and provide a System Design Report to include:
  - Facility floor-plan with major equipment placement and infrastructure layout
  - Major Equipment List, with summary equipment specifications
  - Draft Installation & Construction Plan
- Prepare a CPR Report and participate in a CPR meeting as described in Task 1.3

##### Products:

- System Design Report (draft and final)
- CPR Report

## **EXHIBIT A**

### **Scope of Work**

#### **TASK 3 PDU FABRICATION AND CONSTRUCTION**

The goal of this task is to fabricate, construct, and erect equipment and subsystems used to research and develop an integrated system for RDB gasification and tar-reforming.

**The Recipient shall:**

- Fabricate components of the integrated system for RDB gasification and tar-reforming
- Install equipment and subsystems needed for the research and development of integrated RDB gasification and tar-reforming
- Install instrumentation to measure and record input & output parameters (Non-dispersive infrared detectors for measuring carbon monoxide, carbon dioxide, and methane; a chemi-luminescent detector for NO<sub>x</sub>; grab samples to measure N<sub>2</sub>, H<sub>2</sub>, O<sub>2</sub> and Argon on a limited basis, and thermocouples for temperature measurements
- Test and calibrate instrumentation to demonstrate accuracy within +/-5%; including configuration of continuous analyzers for sampling at three locations.
- Prepare and provide a PDU Fabrication and Construction Report to include:
  - Fabrication, construction, and erection of equipment and subsystems
  - Instrument installation and calibration description
  - Final construction cost

**Products:**

- PDU Fabrication and Construction Report (draft and final)

#### **TASK 4 START-UP PLANNING**

The goal of this task is to plan and perform preliminary start-up testing of PDU.

**The Recipient shall:**

- Perform safety review and safety training
- Conduct Hazardous-Operations review meeting
- Prepare a start-up test plan, including test-matrix, for CAM approval
- Perform preliminary start-up
- Identify modifications that are required after initial start-up tests
- Make required modifications
- Vary the SR to change the operating temperature within the JSB gasifier and in the tar-reformer, holding constant feed rate to find the point of maximum energy output based on fuel-gas composition.
- Vary Pulse-rate of the detonation burner(s) to test for maximum power.
- Measure system inputs & outputs to maximizing performance -- based on feed-rate as a function of the system volume.
- Prepare and provide a *Start-up Planning Report* to include above mentioned operational steps.

**Products:**

- Start-up Planning Report (draft and final)

## EXHIBIT A

### Scope of Work

#### TASK 5 START-UP TESTING

The goal of this task is to test the operation of the PDU and JSB gasification, integrated with Tar-Reforming.

##### The Recipient shall:

- Conduct continuous testing based on start-up matrix.
- Perform tests with RDB feed input of 3-pounds per minute
- Demonstrate fuel-gas output with the objective of energy content of 230 Btu/scf
- Conduct at least two continuous campaigns of 8-hours at near steady state
- Evaluate system durability, looking for erosion, cracking, or other defects
- Test parameters typically result in data that can be plotted to identify optimums
- Prepare and provide a Start-up Testing Report including qualitative aspects of the hardware performance.
- Prepare a CPR Report and participate in a CPR meeting as described in Task 1.3

##### Products:

- Start-up Testing Report (draft and final)
- CPR Report

#### TASK 6 ANALYSIS AND EVALUATIONS

The goal of this task is evaluate test results obtained during continuous testing. Raw data is analyzed and put into a form (usually graphic) that is useful in evaluating the test results, along with discussion that seeks to interpret the results.

##### The Recipient shall:

- Establish Process Heat & Mass Balance by Semi-empirical Method, and summarize complex results based on throughputs.
- Perform cost analysis to determine cost for design, engineering, construction, and installation, with +/- 10% level of confidence for a 30-ton/day Demonstration Plant, and provide preliminary cost projections of this 1-MWe scale Demonstration Plant.
- Confirm from the project findings that a cost of \$3,750 per kW<sub>h</sub> of installed-capacity is supported, based on a 300-ton/day modular system. The cost projections will be based on inputs & outputs as a function of equipment volume, and used to estimate reactor, equipment size and capacity, and associated costs.
- Confirm from the project findings that the LCOP of \$118/MWh, including 10% return on equity, is supported based on a 300-ton/day modular system
- Obtain and provide *Preliminary Cost Estimates for a Commercial Plant*
- Prepare and provide an *Analysis and Evaluation Report*, including
  - Process Heat & Mass Balance
  - Cost analysis
  - Projected system cost

## **EXHIBIT A**

### **Scope of Work**

**Product:**

- Preliminary cost estimates for a Commercial Plant
- Analysis and Evaluation Report (draft and final)

#### **TASK 7 ENVIRONMENTAL PERFORMANCE**

The goal of this task is to evaluate the process environmental performance based on data.

**The Recipient shall:**

- Prepare and provide a *Environmental Performance Report* to include estimation of Carbon footprint for the process and the products by Carbon Life Cycle Analysis through GREET.

**Product:**

- Environmental Performance Report (draft and final)

#### **TASK 8 EVALUATION OF PROJECT BENEFITS**

The goal of this task is to report the benefits resulting from this project.

**The Recipient shall:**

- Complete three Project Benefits Questionnaires that correspond to three main intervals in the Agreement: (1) *Kick-off Meeting Benefits Questionnaire*; (2) *Mid-term Benefits Questionnaire*; and (3) *Final Meeting Benefits Questionnaire*.
- Provide all key assumptions used to estimate projected benefits, including targeted market sector (e.g., population and geographic location), projected market penetration, baseline and projected energy use and cost, operating conditions, and emission reduction calculations. Examples of information that may be requested in the questionnaires include:
  - For Product Development Projects and Project Demonstrations:
    - Published documents, including date, title, and periodical name.
    - Estimated or actual energy and cost savings, and estimated statewide energy savings once market potential has been realized. Identify all assumptions used in the estimates.
    - Greenhouse gas and criteria emissions reductions.
    - Other non-energy benefits such as reliability, public safety, lower operational cost, environmental improvement, indoor environmental quality, and societal benefits.
    - Data on potential job creation, market potential, economic development, and increased state revenue as a result of the project.

## **EXHIBIT A**

### **Scope of Work**

- A discussion of project product downloads from websites, and publications in technical journals.
- A comparison of project expectations and performance. Discuss whether the goals and objectives of the Agreement have been met and what improvements are needed, if any.
- Additional Information for Product Development Projects:
  - Outcome of product development efforts, such copyrights and license agreements.
  - Units sold or projected to be sold in California and outside of California.
  - Total annual sales or projected annual sales (in dollars) of products developed under the Agreement.
  - Investment dollars/follow-on private funding as a result of Energy Commission funding.
  - Patent numbers and applications, along with dates and brief descriptions.
- Additional Information for Product Demonstrations:
  - Outcome of demonstrations and status of technology.
  - Number of similar installations.
  - Jobs created/retained as a result of the Agreement.
- For Information/Tools and Other Research Studies:
  - Outcome of project.
  - Published documents, including date, title, and periodical name.
  - A discussion of policy development. State if the project has been cited in government policy publications or technical journals, or has been used to inform regulatory bodies.
  - The number of website downloads.
  - An estimate of how the project information has affected energy use and cost, or has resulted in other non-energy benefits.
  - An estimate of energy and non-energy benefits.
  - Data on potential job creation, market potential, economic development, and increased state revenue as a result of project.
  - A discussion of project product downloads from websites, and publications in technical journals.
  - A comparison of project expectations and performance. Discuss whether the goals and objectives of the Agreement have been met and what improvements are needed, if any.
- Respond to CAM questions regarding responses to the questionnaires.

The Energy Commission may send the Recipient similar questionnaires after the Agreement term ends. Responses to these questionnaires will be voluntary.

#### **Products:**

- Kick-off Meeting Benefits Questionnaire
- Mid-term Benefits Questionnaire
- Final Meeting Benefits Questionnaire

## EXHIBIT A Scope of Work

### TASK 9 TECHNOLOGY / KNOWLEDGE TRANSFER ACTIVITIES

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

#### The Recipient shall:

- Prepare an *Initial Fact Sheet* at start of the project that describes the project. Use the format provided by the CAM.
- Prepare a *Final Project Fact Sheet* at the project's conclusion that discusses results. Use the format provided by the CAM.
- Prepare a *Technology/Knowledge Transfer Plan* that includes:
  - An explanation of how the knowledge gained from the project will be made available to the public, including the targeted market sector and potential outreach to end users, utilities, regulatory agencies, and others.
  - A description of the intended use(s) for and users of the project results.
  - Published documents, including date, title, and periodical name.
  - Copies of documents, fact sheets, journal articles, press releases, and other documents prepared for public dissemination. These documents must include the Legal Notice required in the terms and conditions. Indicate where and when the documents were disseminated.
  - A discussion of policy development. State if project has been or will be cited in government policy publications, or used to inform regulatory bodies.
  - The number of website downloads or public requests for project results.
  - Additional areas as determined by the CAM.
- Conduct technology transfer activities in accordance with the Technology/Knowledge Transfer Plan. These activities will be reported in the Progress Reports.
- When directed by the CAM, develop *Presentation Materials* for an Energy Commission-sponsored conference/workshop on the results of the project.
- Prepare a *Technology/Knowledge Transfer Report* on technology transfer activities conducted during the project.

#### Products:

- Initial Fact Sheet (draft and final)
- Final Project Fact Sheet (draft and final)
- Presentation Materials (draft and final)
- Technology/Knowledge Transfer Plan (draft and final)
- Technology/Knowledge Transfer Report (draft and final)

### IV. PROJECT SCHEDULE

Please see the attached Excel spreadsheet.

STATE OF CALIFORNIA

STATE ENERGY RESOURCES  
CONSERVATION AND DEVELOPMENT COMMISSION

RESOLUTION - RE: TAYLOR ENERGY

**RESOLVED**, that the State Energy Resources Conservation and Development Commission (Energy Commission) adopts the staff CEQA findings contained in the Agreement Request Form; and

**RESOLVED**, that the Energy Commission approves Agreement EPC-14-045 from PON-14-303 with **Taylor Energy** for a **\$1,499,481** grant to design, develop and test a 3-pound per minute waste-to-energy process development unit, involving thermal-catalytic gasification integrated with reforming for conversion of refuse derived biomass into clean fuel gas, enabled by Pulse detonation technology. This project will evaluate the results and provide engineering data to design a 30 ton/day plant generating 1-MW of electric power; and

**FURTHER BE IT RESOLVED**, that the Executive Director or his/her designee shall execute the same on behalf of the Energy Commission.

**CERTIFICATION**

The undersigned Secretariat to the Commission does hereby certify that the foregoing is a full, true, and correct copy of a Resolution duly and regularly adopted at a meeting of the California Energy Commission held on April 8, 2015.

AYE: [List of Commissioners]

NAY: [List of Commissioners]

ABSENT: [List of Commissioners]

ABSTAIN: [List of Commissioners]

---

Harriet Kallemeyn,  
Secretariat