

GRANTS/CONTINGENT AWARD REQUEST



To: Grants and Loans Office

Date: 4/3/2012

Project Manager: Guido Franco

Phone Number: 916-327-2392

Office: Energy Generation Research Office

Division: Energy Research and Development

MS- 43

Project Title: CO2 to Oil Production Using Kiverdi's Novel Microbial System

Type of Request: (check one)

New Agreement: (include items A-F from below) Agreement Number: Assigned by G&L Office
Program: PIER E / Environmental Area
Solicitation Name and/or Number: PON-11-502-03 (Solicitation to Address Environmental Issues Related to Clean Energy Systems)
Legal Name of Recipient: Kiverdi, Inc.
Recipient's Full Mailing Address: 409 ILLINOIS ST SAN FRANCISCO, CA 94158-2509
Recipient's Project Officer: Peter Dalla-Betta Phone Number: (510) 676-9420
Agreement Start Date: 6/29/2012 Agreement End Date: 6/30/2014

Amendment: (Check all that apply) Agreement Number: PIR-11-025
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:
RECEIVED APR 12 2012 CONTRACTS, GRANTS & LOANS

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: PIER-E Amount: \$ 747,126.00 Statute: 10- FY: 11-12 Budget List #: 501.0271
*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: 5/9/2012 Consent Discussion
Business Meeting Participant: Guido Franco 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-XXX for a grant of \$747,126.00 to Kiverdi, Inc. to field test, refine, and create a commercial scale-ready novel microbial system to capture and convert waste carbon dioxide from power plant flue gas into high value oils (PIER electricity funding.) Contact: Guido Franco. (5 minutes)

Project Manager: [Signature] Date: 4/10/2012 Office Manager: [Signature] Date: 4/10/2012 Deputy Director: [Signature] Date: 4/11/2012

Exhibit A WORK STATEMENT

1
2
3

TECHNICAL TASK LIST

Task #	CPR	Task Name
1	N/A	Administration
2		Obtain and Execute Contracts
3		Establish Renewable Energy Hydrogen Producer
4		R&D Lab Scale Demonstration/Optimization Using Feedstocks
5		Pilot Scale Reactor Design, Development, and Demonstration

4
5
6

KEY NAME LIST

Task #	Key Personnel	Key Subcontractor(s)	Key Partner(s)
1	Peter Dalla-Betta, PhD, Kiverdi Michael Siani-Rose, Kiverdi Gia Calvillo, Kiverdi, Lisa Dyson, PhD, Kiverdi		UCSF QB3 Innovation Center, San Francisco, CA
2	Purabi Thakre, Kiverdi Peter Dalla-Betta, PhD, Kiverdi, Lisa Dyson, PhD, Kiverdi		CHORI, Oakland, CA;
3	Purabi Thakre, Kiverdi Peter Dalla-Betta, PhD, Kiverdi, Lisa Dyson, PhD, Kiverdi		
4	Peter Dalla-Betta, PhD, Kiverdi Michael Siani-Rose, Kiverdi Itzhak Kurek, PhD, Kiverdi Henrik Fyrst, PhD, Kiverdi Alain Ogura, Kiverdi Jil Geller, PhD, LBNL Lisa Dyson, PhD, Kiverdi		
5	Peter Dalla-Betta, PhD, Kiverdi Michael Siani-Rose, Kiverdi Henrik Fyrst, PhD, Kiverdi Alain Ogura, Kiverdi Jil Geller, PhD, LBNL Lisa Dyson, PhD, Kiverdi		

7
8
9

GLOSSARY

Term/ Acronym	Definition
CAM	Commission Agreement Manager
CHORI	Children's Hospital Oakland Research Institute, Oakland, CA

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Term/ Acronym	Definition
CO ₂	Carbon Dioxide
Energy Commission	California Energy Commission
GC	Gas Chromatograph
H ₂	Hydrogen
LBNL	Lawrence Berkeley National Labs
MS	Mass Spectrometry
MTA	Material Transfer Agreement
PIER	Public Interest Energy Research
QC	Quality Control
SOP	Standard Operating Protocol
UCSF	University of California San Francisco

1
2 **Problem Statement:**

3 The Recipient will utilize Carbon Dioxide (CO₂) directly from flue gas sources in the
4 state of California as a carbon feedstock for production of high-value oils and palm oil
5 equivalents. The Recipient microbes perform the conversion of CO₂ to oils by using
6 chemical energy to drive the conversion of CO₂, rather than sunlight as in algae or
7 plants. Barriers to solving the CO₂ emissions problem are primarily scientific and
8 technological. Current microbial approaches to generation of oils and palm oil
9 equivalents have required the capture of CO₂ by sunlight. The photosynthetic
10 approaches (eg. algae) capture CO₂ directly, but require sunlight, which means a very
11 large footprint to maximize access to light. The sugar-based fermentation approaches
12 (e.g. Solazyme, LS9, Amyris) do not capture CO₂ directly since they source carbon from
13 sugars. Sugar-based feedstocks are more expensive than flue gas or other waste as
14 sources of carbon. Social concerns about processing food into chemicals and
15 destruction of natural habitats are fundamental technology issues with agricultural (e.g.
16 palm oil) or sugar-based-microbial approaches to oil production. These concerns are
17 absent from the Recipient's technology. In addition, there is a large cost advantage of
18 using flue gas as a carbon source rather than sugar.

19
20 The Recipient's chemoautotrophic approach means that CO₂ is captured directly from
21 flue gas emissions in a bioreactor with a small footprint since it does not require light.
22 The Recipient microbes grow on waste carbon sources and withstand many of the
23 contaminants which can be toxic to many strains of bacteria and algae. Kiverdi has
24 shown lab-scale Proof of Concept. Optimization, scale-up and commercialization of the
25 Recipient's technology can directly capture the CO₂ in flue gas in state of California.
26 Development of a skid-mounted system will allow us to co-locate our systems adjacent
27 to flue gas sources.

28
29 **Goals of the Agreement:**

30 The goal of this agreement is to (1) mitigate waste CO₂ outflow from power plants,

Exhibit A WORK STATEMENT

1 which is currently flared, and (2) create a high value product from the waste gases.
2

3 **Objectives of the Agreement:**

4 The objectives of this agreement are to:

- 5 1. Identify a site and pilot gas partner: power plant flue gas + renewable energy
6 source of hydrogen (H₂).
- 7 2. Optimize current lab-scale production of palm oil equivalent using CO₂ and H₂.
- 8 3. Develop a pilot scale reactor for the Recipient microbes, based on current lab-
9 scale reactors at the Recipient.
- 10 4. Performance specifications:
 - 11 a. Create technology to use flue gas feedstock to produce palm oil
12 equivalent.
 - 13 i. Determine safety profile for product
 - 14 b. Determine and achieve a conversion efficiency for CO₂ to palm oil.
 - 15 c. Meet corporate partner purchase specs (cost and safety profile).
- 16 5. Design skid-mounted pilot plant for scaling reaction to commercial production.
17

18 **TASK 1 ADMINISTRATION**

19 **Task 1.1 Attend Kick-off Meeting**

20 The goal of this task is to establish the lines of communication and procedures for
21 implementing this Agreement.
22

23 **The Recipient shall:**

- 24 • Attend a "Kick-Off" meeting with the Commission Project Manager, the
25 Grants Officer, and a representative of the Accounting Office. The
26 Recipient shall bring its Project Manager, Agreement Administrator,
27 Accounting Officer, and others designated by the Commission Project
28 Manager to this meeting. The administrative and technical aspects of this
29 Agreement will be discussed at the meeting. Prior to the kick-off meeting,
30 the Commission Project Manager will provide an agenda to all potential
31 meeting participants.
32

33 The administrative portion of the meeting shall include, but not be limited
34 to, the following:

- 35 ○ Discussion of the terms and conditions of the Agreement
- 36 ○ Discussion of Critical Project Review (Task 1.2)
- 37 ○ Match fund documentation (Task 1.6) No work may be done until
38 this documentation is in place.
- 39 ○ Permit documentation (Task 1.7)
- 40 ○ Discussion of subcontracts needed to carry out project (Task 1.8)
41

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

- 44 ○ The Commission Project Manager's expectations for accomplishing
45 tasks described in the Scope of Work
46

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- 1 ○ An updated Schedule of Products
- 2 ○ Discussion of Progress Reports (Task 1.4)
- 3 ○ Discussion of Technical Products (Product Guidelines located in
- 4 Section 5 of the Terms and Conditions)
- 5 ○ Discussion of the Final Report (Task 1.5)

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

9 **Recipient Products:**

- 10 • Updated Schedule of Products
- 11 • Updated List of Match Funds
- 12 • Updated List of Permits

14 **Commission Project Manager Product:**

- 15 • Kick-Off Meeting Agenda

17 **Task 1.2 Critical Project Review (CPR) Meetings**

18
19 The goal of this task is to determine if the project should continue to receive Energy
20 Commission funding to complete this Agreement and to identify any needed
21 modifications to the tasks, products, schedule or budget.

22
23 CPRs provide the opportunity for frank discussions between the Energy Commission
24 and the Recipient. The Commission Project Manager may schedule CPRs as
25 necessary, and CPR costs will be borne by the Recipient.

26
27 Participants include the Commission Project Manager and the Recipient and may
28 include the Commission Grants Officer, other Energy Commission staff and
29 Management as well as other individuals selected by the Commission Project Manager
30 to provide support to the Energy Commission.

32 **The Commission Project Manager shall:**

- 33 • Determine the location, date, and time of each CPR meeting with the
34 Recipient. These meetings generally take place at the Energy
35 Commission, but they may take place at another location.
- 36 • Send the Recipient the agenda and a list of expected participants in
37 advance of each CPR. If applicable, the agenda shall include a
38 discussion on both match funding and permits.
- 39 • Conduct and make a record of each CPR meeting. One of the outcomes
40 of this meeting will be a schedule for providing the written determination
41 described below.
- 42 • Determine whether to continue the project, and if continuing, whether or
43 not modifications are needed to the tasks, schedule, products, and/or
44 budget for the remainder of the Agreement. Modifications to the
45 Agreement may require a formal amendment (please see section 8 of the
46 Terms and Conditions).

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- 1 • Provide the Recipient with a written determination in accordance with the
2 schedule. The written response may include a requirement for the
3 Recipient to revise one or more product(s) that were included in the CPR.
4

The Recipient shall:

- 5
6 • Prepare a CPR Report for each CPR that discusses the progress of the
7 Agreement toward achieving its goals and objectives. This report shall
8 include recommendations and conclusions regarding continued work of
9 the projects. This report shall be submitted along with any other products
10 identified in this scope of work. The Recipient shall submit these
11 documents to the Commission Project Manager and any other designated
12 reviewers at least 15 working days in advance of each CPR meeting.
13 • Present the required information at each CPR meeting and participate in a
14 discussion about the Agreement.
15

Commission Project Manager Products:

- 16
17 • Agenda and a list of expected participants
18 • Schedule for written determination
19 • Written determination
20

Recipient Product:

- 21
22 • CPR Report(s)
23

Task 1.3 Final Meeting

24
25
26 The goal of this task is to closeout this Agreement.
27

The Recipient shall:

- 28
29 • Meet with Energy Commission staff to present the findings, conclusions,
30 and recommendations. The final meeting must be completed during the
31 closeout of this Agreement.
32

33 This meeting will be attended by, at a minimum, the Recipient, the
34 Commission Grants Office Officer, and the Commission Project Manager.
35 The technical and administrative aspects of Agreement closeout will be
36 discussed at the meeting, which may be two separate meetings at the
37 discretion of the Commission Project Manager.
38

39 The technical portion of the meeting shall present an assessment of the
40 degree to which project and task goals and objectives were achieved,
41 findings, conclusions, recommended next steps (if any) for the Agreement,
42 and recommendations for improvements. The Commission Project
43 Manager will determine the appropriate meeting participants.
44

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1 The administrative portion of the meeting shall be a discussion with the
2 Commission Project Manager and the Grants Officer about the following
3 Agreement closeout items:

- 4 ○ What to do with any equipment purchased with Energy Commission
5 funds (Options)
- 6 ○ Energy Commission's request for specific "generated" data (not
7 already provided in Agreement products)
- 8 ○ Need to document Recipient's disclosure of "subject inventions"
9 developed under the Agreement
- 10 ○ "Surviving" Agreement provisions
- 11 ○ Final invoicing and release of retention
- 12 ● Prepare a schedule for completing the closeout activities for this
13 Agreement.

14 **Products:**

- 15 ● Written documentation of meeting agreements
- 16 ● Schedule for completing closeout activities

17 **Task 1.4 Quarterly Progress Reports**

18 The goal of this task is to periodically verify that satisfactory and continued progress is
19 made towards achieving the research objectives of this Agreement on time and within
20 budget.

21 The objectives of this task are to summarize activities performed during the reporting
22 period, to identify activities planned for the next reporting period, to identify issues that
23 may affect performance and expenditures, and to form the basis for determining
24 whether invoices are consistent with work performed.

25 **The Recipient shall:**

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

34 **Product:**

- 35 ● Quarterly Progress Reports

36 **Task 1.5 Final Report**

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1 The goal of the Final Report is to assess the project's success in achieving its goals and
2 objectives, advancing science and technology, and providing energy-related and other
3 benefits to California.
4

5 The objectives of the Final Report are to clearly and completely describe the project's
6 purpose, approach, activities performed, results, and advancements in science and
7 technology; to present a public assessment of the success of the project as measured
8 by the degree to which goals and objectives were achieved; to make insightful
9 observations based on results obtained; to draw conclusions; and to make
10 recommendations for further projects and improvements to the Energy Commission
11 project management processes.
12

13 The Final Report shall be a public document. If the Recipient has obtained confidential
14 status from the Energy Commission and will be preparing a confidential version of the
15 Final Report as well, the Recipient shall perform the following activities for both the
16 public and confidential versions of the Final Report.
17

18 **The Recipient shall:**

- 19 • Prepare an Outline of the Final Report.
- 20 • Prepare a Final Report following the approved outline and the latest
21 version of the Final Report guidelines which will be provided by the
22 Commission Project Manager.
- 23 • The Commission Project Manager shall provide written comments on the
24 Draft Final Report within fifteen (15) working days of receipt. The Final
25 Report must be completed at least 60 days before the end of the
26 Agreement Term.
- 27 • Submit one bound copy of the Final Report with the final invoice.
28

29 **Products:**

- 30 • Draft Outline of the Final Report
- 31 • Final Outline of the Final Report
- 32 • Draft Final Report
- 33 • Final Report
34

35 **Task 1.6 Identify and Obtain Matching Funds**

36
37 The goal of this task is to ensure that the match funds planned for this Agreement are
38 obtained for and applied to this Agreement during the term of this Agreement.
39

40 The costs to obtain and document match fund commitments are not reimbursable
41 through this Agreement. Although the Energy Commission budget for this task will be
42 zero dollars, the Recipient may utilize match funds for this task. Match funds shall be
43 spent concurrently or in advance of Energy Commission funds for each task during the
44 term of this Agreement. Match funds must be identified in writing and the associated
45 commitments obtained before the Recipient can incur any costs for which the Recipient

Exhibit A WORK STATEMENT

1
2 **The Recipient shall:**

- 3 • Prepare a letter documenting the match funding committed to this
4 Agreement and submit it to the Commission Project Manager at least 2
5 working days prior to the kick-off meeting. If no match funds were part of
6 the proposal that led to the Energy Commission awarding this Agreement
7 and none have been identified at the time this Agreement starts, then
8 state such in the letter. If match funds were a part of the proposal that led
9 to the Energy Commission awarding this Agreement, then provide in the
10 letter a list of the match funds that identifies the:
11 ○ Amount of each cash match fund, its source, including a contact name,
12 address and telephone number and the task(s) to which the match
13 funds will be applied.
14 ○ Amount of each in-kind contribution, a description, documented market
15 or book value, and its source, including a contact name, address and
16 telephone number and the task(s) to which the match funds will be
17 applied. If the in-kind contribution is equipment or other tangible or
18 real property, the Recipient shall identify its owner and provide a
19 contact name, address and telephone number, and the address where
20 the property is located.
21 • Provide a copy of the letter of commitment from an authorized
22 representative of each source of cash match funding or in-kind
23 contributions that these funds or contributions have been secured. For
24 match funds provided by a grant a copy of the executed grant shall be
25 submitted in place of a letter of commitment.
26 • Discuss match funds and the implications to the Agreement if they are
27 reduced or not obtained as committed, at the kick-off meeting. If
28 applicable, match funds will be included as a line item in the progress
29 reports and will be a topic at CPR meetings.
30 • Provide the appropriate information to the Commission Project Manager if
31 during the course of the Agreement additional match funds are received.
32 • Notify the Commission Project Manager within 10 days if during the
33 course of the Agreement existing match funds are reduced. Reduction in
34 match funds must be approved through a formal amendment to the
35 Agreement and may trigger an additional CPR.

36
37 **Products:**

- 38 • A letter regarding match funds or stating that no match funds are provided
39 • Copy(ies) of each match fund commitment letter(s) (if applicable)
40 • Letter(s) for new match funds (if applicable)
41 • Letter that match funds were reduced (if applicable)

42
43 **Task 1.7 Identify and Obtain Required Permits**
44

Exhibit A WORK STATEMENT

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

4
5 Permit costs and the expenses associated with obtaining permits are not reimbursable
6 under this Agreement. Although the Energy Commission budget for this task will be
7 zero dollars, the Recipient shall budget match funds for any expected expenditures
8 associated with obtaining permits. Permits must be identified in writing and obtained
9 before the Recipient can make any expenditure for which a permit is required.

10 11 **The Recipient shall:**

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

38 39 **Products:**

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

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1 **Technical Advisory Committee (TAC)**
2

3 **Task 1.8 Establish the TAC**
4

5 The goal of this task is to create an advisory committee for this Agreement.
6

7 The TAC shall be composed of diverse professionals. The number can vary depending
8 on potential interest and time availability. The exact composition of the TAC may
9 change as the need warrants. TAC members serve at the discretion of the Energy
10 Commission Project Manager.
11

12 The TAC may be composed of, but is not limited to, qualified professionals spanning the
13 following types of disciplines:

- 14 • Researchers knowledgeable about the project subject matter.
- 15 • Members of the trades who will apply the results of the project (for
16 example, designers, engineers, architects, contractors, and trade
17 representatives).
- 18 • Public Interest Market Transformation Implementers.
- 19 • Product Developers relevant to project subject matter.
- 20 • U.S. Department of Energy Research Manager.
- 21 • Public Interest Environmental Groups.
- 22 • Utility Representatives.
- 23 • Members of the relevant technical society committees.
24

25 The purpose of the TAC is to:

- 26 • Provide guidance in research direction. The guidance may include scope
27 of research; research methodologies; timing; coordination with other
28 research. The guidance may be based on:
 - 29 ○ Technical area expertise
 - 30 ○ Knowledge of market applications
 - 31 ○ Links between the agreement work and other past, present or
32 future research (both public and private sectors) they are aware of
33 in a particular area
- 34 • Review products. Provide specific suggestions and recommendations for
35 needed adjustments, refinements, or enhancement of the products.
- 36 • Evaluate tangible benefits to California of this research and provide
37 recommendations, as needed, to enhance tangible benefits.
- 38 • Provide recommendations regarding information dissemination, market
39 pathways or commercialization strategies relevant to the research
40 products.
41

42 **The Recipient shall:**

- 43 • Prepare a draft list of potential TAC members that includes name,
44 company, physical and electronic address, and phone number and submit
45 it to the Energy Commission Project Manager at least 2 working days prior

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1 to the kick-off meeting. This list will be discussed at the kick-off meeting
2 and a schedule for recruiting members and holding the first TAC meeting
3 will be developed.

- 4 • Recruit TAC members and ensure that each individual understands the
5 member obligations described above, as well as the meeting schedule
6 outlined in Task 1.9.
- 7 • Prepare the final list of TAC members.
- 8 • Submit letters of acceptance or other comparable documentation of
9 commitment for each TAC member.

10 **Products:**

- 11 • Draft List of TAC Members
- 12 • Final List of TAC Members
- 13 • Letters of acceptance, or other comparable documentation of commitment
14 for each TAC Member (no draft)
- 15
- 16

17 **Task 1.9 Conduct TAC Meetings**

18 The goal of this task is for the TAC to provide strategic guidance to this project by
19 participating in regular meetings or teleconferences.
20

21 **The Recipient shall:**

- 22 • Discuss the TAC meeting schedule at the kick-off meeting. The number of
23 face-to-face meetings and teleconferences and the location of TAC
24 meetings shall be determined in consultation with the Energy Commission
25 Project Manager. This draft schedule shall be presented to the TAC
26 members during recruiting and finalized at the first TAC meeting.
- 27 • Organize and lead TAC meetings in accordance with the schedule.
28 Changes to the schedule must be pre-approved in writing by the Energy
29 Commission Project Manager.
- 30 • Prepare TAC meeting agenda(s) with back-up materials for agenda items.
- 31 • Prepare TAC meeting summaries, including recommended resolution of
32 major TAC issues.
33

34 **Products:**

- 35 • Draft TAC Meeting Schedule
- 36 • Final TAC Meeting Schedule
- 37 • TAC Meeting Agenda(s) with Back-up Materials for Agenda Items (no
38 draft)
- 39 • Written TAC meeting summaries, including recommended resolution of
40 major TAC issues (no draft)
- 41
- 42

43 **TECHNICAL TASKS**

44 **TASK 2 Obtain and Execute Contracts**

Exhibit A WORK STATEMENT

1
2 The goal of this task is for Recipients to identify any subcontracts required to carry out
3 the tasks under this Agreement and to procure them consistent with the terms and
4 conditions of this Agreement and the Recipient's own procurement policies and
5 procedures. It will also provide the Energy Commission an opportunity to review the
6 subcontracts to ensure that the tasks are consistent with this Agreement, that the
7 budgeted expenditures are reasonable and consistent with applicable cost principles.
8

9 **The Recipient shall:**

- 10 • Prepare a letter documenting the subcontracts required to conduct this
11 Agreement, and submit it to the Commission Project Manager at least 2
12 working days prior to the kick-off meeting. If there are no subcontracts
13 required at the start of this Agreement, then state such in the letter. If it is
14 known at the beginning of the Agreement that subcontracts will be
15 required during the course of the Agreement, provide in the letter:
 - 16 ○ A list of the subcontracts that describes the anticipated maximum
17 budget and general scope of work for each,
 - 18 ○ A description of the procurement process to be used, and
 - 19 ○ The schedule the Recipient will follow in applying for and obtaining
20 these subcontracts
- 21 • Submit a draft of the subcontract that will include a budget with the
22 information required in the budget details to the Commission Project
23 Manager for review and approval, and incorporate any changes
24 recommended by the Commission Project Manager.
- 25 • Submit a final copy of the executed subcontract.
26

27 **Products:**

- 28 • Letter describing the subcontracts needed, or stating that no subcontracts
29 are required (no draft)
- 30 • Draft subcontracts
- 31 • Final subcontracts
32

33 **Task 2.1 Establish CO₂ Flue Gas Supplier**

34
35 The goal of this task is to establish a relationship and put an agreement in place with a
36 supplier of flue gas for initial fermentation runs and ultimately as a long-term partner for
37 the commercial generation of product for sale.
38

39 **The Recipient shall:**

- 40 • Explore and evaluate sources of flue gas in the state of California
- 41 • Determine flue gas compositions
- 42 • Arrange for transfer of sample bottled flue gas and provide written documentation
43 about the sampled flue gas to the Commission Agreement Manager (CAM)
- 44 • Put a Material Transfer Agreement (MTA) in place and provide a copy of the
45 MTA to the CAM

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- 1 • Maintain relationship to be expanded to address regular supplies as process is
2 scaled up
3

4 **Products:**

- 5 • Written documentation of the sample bottled flue gas (no draft)
6 • MTA for flue gas (no draft)
7

8 **TASK 3 Establish Renewable Energy H₂ Producer**

9

10 The goal of this task is to establish a relationship and put an agreement in place with a
11 supplier of H₂ generated by renewable energy for initial fermentation runs and ultimately
12 as a long-term partner for the commercial generation of product for sale.
13

14 **The Recipient shall:**

- 15 • Explore and evaluate sources of H₂ generated by renewable energy in the state
16 of California; consider alternative scenarios
17 • Arrange for transfer of bottled H₂ generated by renewable energy
18 • Create written documentation of the sample bottled H₂ and provide the
19 documentation to the CAM
20 • Put a MTA in place and provide a copy of the MTA to the CAM
21 • Maintain relationship to be expanded to address regular supplies as process is
22 scaled up
23

24 **Products include:**

- 25 • Written documentation of sample bottled H₂ generated by renewable energy (no
26 draft)
27 • MTA for H₂ generated by renewable energy (no draft)
28

29 **TASK 4 R&D Lab Scale Demonstration/Optimization Using Feedstocks**

30

31 The recipient has successfully genetically-engineered *C. necator* to produce, shorter-
32 chain fatty acids, alkanes and to grow under heterotrophic and chemoautotrophic
33 conditions.
34

35 The goal of sub-tasks 4.1-4.7 is to systematize and optimize current lab-scale
36 fermentation on CO₂/H₂ mix, then confirm with actual bottled flue gas/ H₂ mix from flue
37 gas source. In addition, the goal is to optimize and standardize extraction and
38 purification of final oil or palm oil equivalent product.
39

40 **Task 4.1 Lab-Scale Demonstration to Convert Flue Gas/H₂ Mix Into Feedstocks**

41

42 The goal is to show lab-scale fermentations on flue gas/H₂ mix, which matches flue gas
43 from California source. Using the Recipient's fermentation conditions (gas feed rate,
44 mixing speeds, temperature, nitrogen feeding, pH balance, etc.) demonstrate cell
45 growth and oil production.

Exhibit A WORK STATEMENT

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The Recipient shall:

- Determine flue gas composition and create laboratory gas mix in the Recipient's reactor to match streams of flue gas and H₂
- Perform standard bioprocessing parameters to show cell mass production of the Recipient's manufacturing chemoautotrophic strain. Variables include: gas/H₂ ratio, gas feed rate, pH, nitrogen feeding, mixing rates, etc.
- Perform analytical runs (Gas Chromatography and Mass Spec analysis) to confirm production of oil product, and provide report to the CAM
- Perform quality control (QC) runs to confirm consistent yields, and provide report to CAM

Products:

- Report on fermentation data for the Recipient's strain on flue gas/H₂ mix (no draft)
- Gas Chromatography and Mass Spec analysis report (no draft)
- Quality control report (no draft)

Task 4.2 Develop Manufacturing Analytical Protocols for Palm Oil Equivalent

The goal is to standardize protocols for analytical runs on palm oil equivalent production and generate Standard Operating Protocol (SOPs).

The Recipient shall:

- Perform lab-scale analytical extraction of lipids on dried cell mass from optimized reactor runs
- Systematize the gas chromatograph (GC) and mass spectrometry (MS) runs
- Implement QC processes for all reagents, including solvents used for extraction
- Perform QC runs to confirm consistent yields
- Generate manufacturing SOPs to capture extraction/GC-MS runs, and create written documentation to provide to the CAM

Products:

- Written documentation of SOPs (no draft)

Task 4.3 Convert Bottled Flue Gas/H₂ Into Feedstocks

The goal is to optimize fermentations on flue gas/H₂ mix, which matches flue gas from California source. Optimize fermentation conditions (gas feed rate, mixing speeds, temperature, nitrogen feeding, pH balance, etc.) to maximize cell density and palm oil equivalent production. Generate SOPs.

The Recipient shall:

- Determine flue gas composition and create laboratory gas mix in the Recipient's reactor to match streams of flue gas and H₂

Exhibit A WORK STATEMENT

- 1 • Optimize standard fermentation parameters to maximize cell mass production of
- 2 the Recipient's manufacturing chemoautotrophic strain. Variables include:
- 3 gas/H₂ ratio, gas feed rate , pH, nitrogen feeding, mixing rates, others. Provide
- 4 written documentation of the optimized fermentation protocols to the CAM.
- 5 • Perform analytical runs (GC and MS analysis) to confirm production of palm oil
- 6 equivalent product, and provide reports on the optimization of production.
- 7 • Perform QC runs to confirm consistent yields
- 8 • Generate manufacturing SOPs to capture optimized process

9 10 **Products:**

- 11 • Written documentation of optimized fermentation protocols (no draft)
- 12 • Gas Chromatography and Mass Spec Reports (no draft)
- 13 • Written documentation of SOPs for optimized cell mass production (no draft)

14 15 **Task 4.4. Standardize Lab-Scale Extraction/Purification**

16
17 The goal is to perform extraction and purification of the cell mass from flue gas/H₂

18 reactor runs. Ensure extraction/purification is scalable and meets industry standards.

19 Write SOPs.

20 21 **The Recipient shall:**

- 22 • Establish an industrial extraction protocol based on current the Recipient's
- 23 analytical methods (Saskatoon, SK, Canada)
- 24 • Establish an industrial purification protocol for desired palm oil equivalent with
- 25 corporate partner POS Bio-Science, (Saskatoon, SK, Canada)
- 26 • Perform extraction/purification on gram scale quantities from 1L reactor runs
- 27 • Perform extraction/purification on 1 kg scale quantity

28 29 **Products:**

- 30 • Written documentation of standardized protocol for scalable extraction protocol
- 31 for lipids from dry cell mass (no draft)
- 32 • Written documentation of SOPs for extraction (no draft)
- 33 • Written documentation of standardized protocol for scalable purification of palm
- 34 oil equivalent from extracted lipids (no draft)
- 35 • Written documentation of SOPs for purification (no draft)

36 37 **Task 4.5 Convert From Batch Runs To Continuous Runs Production**

38
39 The goal is to convert production runs to continuous runs so that cell mass product is

40 harvested and reactor run may continue for 100 hours. The current reactor design

41 allows this.

42 43 **The Recipient shall:**

- 44 • Perform continuous runs & create written documentation

Exhibit A WORK STATEMENT

1 **Products:**

- 2 • Continuous run report (no draft)
- 3

4 **Task 4.6 Demonstrate 1 Liter Fermentor Production Run Producing Palm Oil**

5

6 The goal is to perform a full fermentation, extraction and purification of the desired palm
7 oil equivalent, demonstrating production of more than 16 g/L palm oil equivalent.

8

9 **The Recipient shall:**

- 10 • Perform fermentation under optimized conditions with flue gas/H₂ combination to
11 the Recipient's manufacturing strain; perform extraction of lipids from cell
12 biomass; and purify palm oil equivalent from lipid extract
- 13 • Perform QC runs to confirm production and yield
- 14

15 **Products:**

- 16 • Final Report confirming full manufacturing process, SOPs, and QC records (no
17 draft)
- 18

19 **TASK 5 Pilot Scale Reactor Design, Development, and Demonstration**

20

21 The goal of Task 5.0 is to perform pilot scale reactor design and build, and
22 demonstration of palm oil equivalent production in the pilot reactor.

23

24 **Task 5.1 Design And Build Pilot Scale Reactor, Analytical Lab And Extraction
25 Purification System.**

26

27 The goal is to design and build a pilot scale reactor, analytical laboratory, and extraction
28 and purification system.

29

30 **The Recipient shall:**

- 31 • Develop integrated process flow sheet and heat and material balance
- 32 • Define performance parameters for demonstration unit
- 33 • Select site (currently the Recipient's laboratories, San Francisco, CA)
- 34 • Engage engineering company for design/build skid-mount pilot scale reactor
- 35 • Subcontract for specialized expertise. In compliance with State Contract Manual
36 3.06, Contractor shall select the subcontractor using a bidding process requiring at
37 least 3 bids from responsible bidders
- 38 • Include Energy Commission Contract Manager or designee in proposal review
39 process
- 40 • Notify Energy Commission Contract Manager of Subcontractor Awardee
- 41 • Fabricate and installation of pilot unit
- 42 • Hire manufacturing personnel and train them
- 43 • Build pilot scale oil extraction system, including manufacturing SOPs
- 44 • Build pilot scale analytical lab, including manufacturing SOPs
- 45

Exhibit A WORK STATEMENT

1 **Products:**

- 2 • Subcontractor Notice of Award (no draft)
- 3 • Provide proof and confirmation of pilot reactor installed at site, the Recipient's
- 4 laboratories, San Francisco, CA (no draft)
- 5 • Written documentation of Sample transfer and extraction SOPs (no draft)
- 6 • Written documentation of Bioprocessing run sampling and analytical SOPs (no
- 7 draft)
- 8 • Written documentation of extraction system for processing cell mass from pilot
- 9 reactor (no draft)
- 10 • Provide proof and confirmation of analytical laboratory set-up for performing
- 11 regular QC on reactor runs (no draft)
- 12

13 **Task 5.2 Plan And Execute “Shakedown” Runs To Prove Out Integrity And Basic**

14 **Operability And Safety Of Unit.**

15

16 The goal is to establish the pilot system is fully operational in preparation for full-scale

17 pilot manufacturing runs.

18

19 **The Recipient shall:**

- 20 • Perform detailed performance tests
- 21 • Demonstrate stable reliable continuous runs on bottled flue gas
- 22 • Optimize reactor runs, integrated with full analytical studies, demonstrating target
- 23 conversion and selectivity at design throughput
- 24 • Establish "operating window" for bioreactor at higher and lower-than-design
- 25 throughput
- 26 • Confirm reactor heat balance and temperature control
- 27 • Provide report on results of the pilot system performance runs to the CAM
- 28

29 **Products:**

- 30 • Pilot System Performance Report (no draft)
- 31

32 **Task 5.3 Demonstrate fermentation of flue gas and full-functionality of pilot**

33 **fermentation system**

34

35 The goal is to demonstrate fermentation with flue gas in a full pilot scale fermenter.

36

37 **The Recipient shall:**

- 38 • Demonstrate successful production of dried, lipid-rich biomass, including the
- 39 performance and reliability of the transport systems
- 40 • Confirm mechanical performance and reliability of machinery such as pumps,
- 41 conveyors, extruders, etc.
- 42 • Confirm process performance of machinery, especially that it does not damage,
- 43 downgrade or contaminate the biomass
- 44

45 **Products:**

Exhibit A WORK STATEMENT

- 1 • Pilot plant demonstration report (no draft)
- 2 • Equipment performance study and report (no draft)
- 3 • QC report on biomass and performance of fermenter, extraction, purification (no
- 4 draft)

6 **Task 5.4 Demonstrate lipid extraction and purification of palm oil equivalent**

7
8 The goal is to extract and purify palm oil equivalent from the Recipient's production
9 strain.

11 **The Recipient shall:**

- 12 • Demonstrate successful extraction of lipids from biomass
- 13 • QC protocols for solvents for extraction and equipment for purification
- 14 • Confirm mechanical performance and reliability of extraction ware, and provide
- 15 equipment study and performance report to CAM
- 16 • Demonstrate successful purification of palm oil equivalent from lipid extract
- 17 • Create pilot-level extraction demonstration report for lipid extract and report on
- 18 the successful demonstration of purification of palm oil equivalent from the lipid
- 19 extract

21 **Products:**

- 22 • Written documentation of SOPs for extraction and purification reagents (no draft)
- 23 • Equipment performance study and report (no draft)
- 24 • Pilot-level extraction demonstration report and Successful demonstration of
- 25 purification of palm oil equivalent from the lipid extract report (no draft)

27 **Task 5.5 Establish production**

28
29 The goal is to perform a full-fledged and repeatable production run in pilot facility.

31 **The Recipient shall:**

- 32 • Establish production through to palm oil equivalent product
- 33 • Demonstrate compatibility with palm oil equivalent product infrastructure
- 34 • Confirm production of on-specification product
- 35 • Establish the Process Capability Index (Cpk) to ensure product consistency
- 36 within specifications, and provide a copy of the Cpk to the CAM

38 **Products:**

- 39 • On-specification product report. To include, but not be limited to: yields,
- 40 reproduced runs, etc. (no draft)
- 41 • Process Capability Index (no draft)

43 **Task 5.6 Business plan to take technology to the marketplace**

Exhibit A WORK STATEMENT

1 The goal is to develop a business plan on how to bring the technology to the
2 marketplace; to be submitted as part of the final deliverable. Find strategic
3 partner/customer for first product.
4

5 **The Recipient shall:**

- 6 • Develop a business plan for customers of our oil-based product in the fields of
7 lubricants
- 8 • Initiate discussions to establish strategic partnership with customers for supply of
9 oil-based products upon scale-up to production phase

10
11 **Products:**

- 12 • Completed business plan for commercialization of oil based product (no draft)

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