

GRANT REQUEST FORM (GRF)

CEC-270 (Revised 02/13)

CALIFORNIA ENERGY COMMISSION

New Agreement ARV-15-008 (To be completed by CGL Office)

| Division | Agreement Manager: | MS- | Phone |
|---------------------------------------|--------------------|-----|--------------|
| 600 Fuels and Transportation Division | Matthew Ong | 27 | 916-653-5285 |

| Recipient's Legal Name | Federal ID Number |
|---|-------------------|
| The Regents of the University of California, Davis Campus | 94-6036494 |

| Title of Project |
|--|
| Improving Microalgae Feedstock for Biofuel Production using CO2 and Waste Nutrients from Anaerobic Digesters |

| Term and Amount | Start Date | End Date | Amount |
|-----------------|----------------|----------------|------------|
| | 10 / 14 / 2015 | 12 / 31 / 2018 | \$ 598,168 |

Business Meeting Information
 ARFVTP agreements under \$75K delegated to Executive Director.

| | | | |
|--------------------------------|----------------|----------------------------------|--|
| Proposed Business Meeting Date | 10 / 14 / 2015 | <input type="checkbox"/> Consent | <input checked="" type="checkbox"/> Discussion |
| Business Meeting Presenter | Matthew Ong | Time Needed: | 5 minutes |

Please select one list serve. Altfuels (AB118- ARFVTP)**Agenda Item Subject and Description**

Proposed resolution approving Agreement ARV-15-008 with The Regents of the University of California, Davis Campus for a \$598,168 grant to design and operate a pilot-scale coupled algae cultivation and anaerobic digester system that treats effluent from two commercial digesters—UC Davis Renewable Energy Anaerobic Digester and New Hope Dairy Digester—to produce nutrients-rich water for the algae production system. The project will incorporate carbon dioxide capture, nutrients recovery, recycling of algae residues, and infrared drying to seek reductions in the overall cost and energy consumption of algae-based biodiesel production. (ARFVTP Funding). Contact: Matthew Ong

California Environmental Quality Act (CEQA) Compliance

- Is Agreement considered a "Project" under CEQA?
 - Yes (skip to question 2) No (complete the following (PRC 21065 and 14 CCR 15378)): Explain why Agreement is not considered a "Project": Agreement will not cause direct physical change in the environment or a reasonably foreseeable indirect physical change in the environment because .
 - If Agreement is considered a "Project" under CEQA:
 - a) Agreement **IS** exempt. (Attach draft NOE)
 - Statutory Exemption. List PRC and/or CCR section number:
 - Categorical Exemption. List CCR section number: 15301. Existing Facilities
15306. Information Collection
 - Common Sense Exemption. 14 CCR 15061 (b) (3)
 Explain reason why Agreement is exempt under the above section:
Negligible expansion of use involving construction of a small pilot-scale 100 gallon algae pond, installation of minimal skid-mounted components, and use of currently available utility services at the existing 480,000 gallon capacity UC Davis Renewable Energy Anaerobic Digester facility. Laboratory work will be conducted at existing research facilities and will not result in a serious or major disturbance to an environmental resource.
 - b) Agreement **IS NOT** exempt. (Consult with the legal office to determine next steps.)
- Check all that apply
- | | |
|---|---|
| <input type="checkbox"/> Initial Study | <input type="checkbox"/> Environmental Impact Report |
| <input type="checkbox"/> Negative Declaration | <input type="checkbox"/> Statement of Overriding Considerations |
| <input type="checkbox"/> Mitigated Negative Declaration | |

List all subcontractors (major and minor) and equipment vendors: (attach additional sheets as necessary)

| Legal Company Name: | Budget |
|---------------------|-----------|
| CleanWorld | \$ 89,000 |
| USDA ARS | \$ 0 |
| | \$ 0 |

List all key partners: (attach additional sheets as necessary)

GRANT REQUEST FORM (GRF)



Legal Company Name:

Budget Information

| Funding Source | Funding Year of Appropriation | Budget List No. | Amount |
|-----------------------------------|-------------------------------|----------------------|-----------|
| ARFVTF | 15/16 | 601.118H | \$598,168 |
| Funding Source | | | \$ |
| R&D Program Area: N/A | | TOTAL: | \$ 0 |
| Explanation for "Other" selection | | | |
| Reimbursement Contract #: | | Federal Agreement #: | |

| Recipient's Administrator/ Officer | | | | Recipient's Project Manager | | | |
|------------------------------------|---|------|-----|-----------------------------|---|------|-----|
| Name: | Jessica Goodall | | | Name: | Annaliese Franz | | |
| Address: | Department of Chemistry, UC Davis One Shields Avenue | | | Address: | Department of Chemistry, UC Davis One Shields Avenue | | |
| City, State, Zip: | Davis, CA 95616-5270 | | | City, State, Zip: | Davis, CA 95616-5270 | | |
| Phone: | 530-752-0500 | Fax: | - - | Phone: | 530-752-9820 | Fax: | - - |
| E-Mail: | jgoodall@ucdavis.edu | | | E-Mail: | akfranz@ucdavis.edu | | |

Selection Process Used

Competitive Solicitation
 First Come First Served Solicitation

Solicitation #: PON-14-602

The following items should be attached to this GRF

| | | |
|---|---|--|
| 1. Exhibit A, Scope of Work | <input checked="" type="checkbox"/> | Attached |
| 2. Exhibit B, Budget Detail | <input checked="" type="checkbox"/> | Attached |
| 3. CEC 105, Questionnaire for Identifying Conflicts | <input checked="" type="checkbox"/> | Attached |
| 4. Recipient Resolution | <input checked="" type="checkbox"/> N/A | <input type="checkbox"/> Attached |
| 5. CEQA Documentation | <input type="checkbox"/> N/A | <input checked="" type="checkbox"/> Attached |

 Agreement Manager Date Office Manager Date Deputy Director Date

Exhibit A
SCOPE OF WORK

TECHNICAL TASK LIST

| Task # | CPR | Task Name |
|--------|-----|--|
| 1 | | Administration |
| 2 | | Analysis and Treatment of Anaerobic Digester Effluent for Microalgae Cultivation |
| 3 | X | Algae Cultivation Using Digester Effluent |
| 4 | X | Harvesting and Infrared Drying of Microalgae |
| 5 | | Lipid Extraction and Transesterification to Evaluate Biodiesel Product |
| 6 | | Determining Energy Production Potential of Biodiesel from Algal Lipid and Biogas from Algae Residues |
| 7 | | Techno-Economic and Life-Cycle Analyses Modeling |

KEY NAME LIST

| Task # | Key Personnel | Key Subcontractor(s) | Key Partner(s) |
|--------|--|-------------------------|----------------|
| 1 | Annaliese Franz | -- | -- |
| 2 | Ruihong Zhang | CleanWorld, USDA ARS | -- |
| 3 | Annaliese Franz, Jean VanderGheynst | CleanWorld | -- |
| 4 | Ruihong Zhang, Zhongli Pan | CleanWorld, USDA ARS | -- |
| 5 | Annaliese Franz, Jean VanderGheynst | -- | -- |
| 6 | Ruihong Zhang | USDA ARS | -- |
| 7 | Alissa Kendall | -- | -- |

GLOSSARY

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

| Term/ Acronym | Definition |
|------------------|---|
| AB | Assembly Bill |
| AD | Anaerobic Digester |
| ARFVTP | Alternative and Renewable Fuel and Vehicle Technology Program |
| ASTM | American Society for Testing and Materials |
| CAM | Commission Agreement Manager |
| CAO | Commission Agreement Officer |
| CO ₂ | Carbon Dioxide |
| CPR | Critical Project Review |

| Term/ Acronym | Definition |
|--------------------------|---|
| Energy Commission | California Energy Commission |
| FTD | Fuels and Transportation Division |
| GHG | Greenhouse Gas |
| IR | Infrared |
| LCA | Life-Cycle Assessment |
| LCFS | Low Carbon Fuel Standard |
| Recipient | The Regents of the University of California, Davis Campus |
| SAF | Suspended Air Floatation |
| TEA | Techno-Economic Analysis |
| UC Davis | University of California, Davis |

BACKGROUND

Assembly Bill (AB) 118 (Núñez, Chapter 750, Statutes of 2007) created the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP). The statute authorizes the California Energy Commission (Energy Commission) to develop and deploy alternative and renewable fuels and advanced transportation technologies to help attain the state’s climate change policies. AB 8 (Perea, Chapter 401, Statutes of 2013) re-authorizes the ARFVTP through January 1, 2024, and specifies that the Energy Commission allocate up to \$20 million per year (or up to 20 percent of each fiscal year’s funds) in funding for hydrogen station development until at least 100 stations are operational. The Energy Commission has an annual program budget of approximately \$100 million and provides financial support for projects that:

- Develop and improve alternative and renewable low-carbon fuels;
- Optimize alternative and renewable fuels for existing and developing engine technologies;
- Produce alternative and renewable low-carbon fuels in California;
- Decrease, on a full fuel cycle basis, the overall impact and carbon footprint of alternative and renewable fuels and increase sustainability;
- Expand fuel infrastructure, fueling stations, and equipment;
- Improve light-, medium-, and heavy-duty vehicle technologies;
- Retrofit medium- and heavy-duty on-road and non-road vehicle fleets;
- Expand infrastructure connected with existing fleets, public transit, and transportation corridors; and
- Establish workforce training programs, conduct public education and promotion, and create technology centers.

The Energy Commission issued solicitation PON-14-602 with the availability of up to \$3 million in grant funds for biofuels projects that are in the early/pre-commercial technology development stage, putting an emphasis on transformative technology solutions to significant biofuels industry problems that increase yields, productivity, or cost effectiveness of biofuel production; and/or that target a significant unmet need in California's biofuels industry. In order to be eligible for funding under PON-14-602, the projects must research diesel substitutes, gasoline substitutes, or biomethane, as well as be consistent with the Energy Commission's ARFVTP Investment Plan updated annually. In response to PON-14-602, The Regents of the University of California, Davis Campus (Recipient) submitted application number 39, which was proposed for funding in the Energy Commission's Notice of Proposed Awards on June 24, 2015. PON-14-602 and the Recipient's application are incorporated by reference to this Agreement in their entirety.

In the event of any conflict or inconsistency between the terms of the Solicitation and the terms of the Recipient's Application, the Solicitation shall control. In the event of any conflict or inconsistency between the Recipient's Application and the terms of the Energy Commission's Award, the Energy Commission's Award shall control. Similarly, in the event of any conflict or inconsistency between the terms of this Agreement and the Recipient's Application, the terms of this Agreement shall control.

The Recipient is subject to all federal, state, and local rules and regulations, whether specified or not in this agreement, and must comply with these rules and regulations along with any changes made to them throughout the term of this agreement.

Problem Statement:

Despite the promising characteristics of microalgae as a feedstock, a number of studies have shown that algal biofuels are currently energy and GHG-intensive to produce, and innovations are required to transform this technology to be market ready. Commercial-scale production of algal biofuels has still not been achieved, though many large pilot-scale sites have been developed. Three primary limitations exist for current microalgae production technologies: (1) access to inexpensive and low environmental impact inputs for microalgae cultivation, (2) high energy requirements for harvesting and drying microalgae, and (3) the need to produce valuable co-products that lead to profitable and environmentally preferable commercial-scale systems.

Nutrient products used during microalgae cultivation can contribute to approximately half of the energy consumption and greenhouse gas (GHG) emissions related to algal biomass production, or as much as a quarter of the life-cycle energy demand and GHG emissions attributable to algal biodiesel production. In addition to the environmental concerns, increasing the utilization efficiency of nutrients is essential for algal biodiesel to be price-competitive in the fuel market.

Economical and effective drying technologies are also critical because most chemical conversion processes do not tolerate wet algae biomass, thus requiring water removal. Centrifuge and conventional drying technologies are currently energy-intensive and new drying technologies are needed to reduce energy consumption and GHG emissions.

Solution:

Anaerobic digestion is increasingly being used commercially to address the disposal and treatment of dairy and livestock waste and food and urban waste, and can valorize organic wastes through the generation of biogas. Although anaerobic digestion addresses the methane emissions from organic waste, it still produces a nutrient-rich liquid effluent from the digestate stream and outputs carbon dioxide (CO₂). By coupling algae production with anaerobic digesters, nutrient, water, and CO₂ demands are met with waste flows, thereby reducing cost and transport issues associated with both processes and providing environmental services.

An innovative infrared (IR) drying technology that has been proven in the food industry will then be applied to potentially significantly reduce the energy burdens of drying algae. The IR emitter generates IR radiation energy by catalyzing natural gas or biomethane to produce heat along with small amounts of water vapor and carbon dioxide as byproducts. The proposed IR drying process is expected to provide a reduction in energy use that is estimated to be 4.2 – 6 therms of natural gas and 8.4 – 12 kWh of electricity per ton of biomass. Based upon a preliminary estimate of 30 – 50 percent natural gas savings (up to 4.2 million therms per year), this would have an annual economic value of roughly \$4 million.

The integrated system will divert the remaining algae residue for anaerobic digestion to increase production of biomethane, a valuable co-product of the algae production system. Solid digestate may be used as a nutrient-rich soil amendment, and glycerin byproducts from biodiesel production can be sold for food, pharmaceutical, or cosmetic purposes.

Goals of the Agreement:

The goals of this agreement are to:

- Improve production of microalgae-based biofuels (biodiesel and biomethane) based on lower cost and improved sustainability by using enhanced methods and technologies for microalgae cultivation, harvesting, and processing.
- Divert the waste by-products from anaerobic waste digesters, including effluent water, nutrients, and CO₂, to grow microalgae producing glycerol-based lipids that will be converted to biodiesel via transesterification.
- Conserve and protect natural resources which include water, energy, air, and climate.
- Document the benefits in cost and energy savings using Anaerobic Digester (AD) effluent and IR drying technology on an algae production system connected to a commercial anaerobic digester system that can treat up to 50 tons of mixed organic waste per day.

Objectives of the Agreement:

The objectives of this project are to:

- Design, construct and operate a pilot-scale treatment system for the AD effluent from two commercial digesters, UC Davis Renewable Energy Anaerobic Digester and New Hope Dairy Digester, to produce nutrients-rich water for algae growth.
- Design, demonstrate, and optimize a pilot-scale algae production system coupled with an anaerobic digester for CO₂ capture, digestate treatment, and recycling of algae residues.
- Demonstrate and optimize improved algae growth in open ponds using synergistic co-culturing with mixed bacteria and algae.
- Design, develop, implement, and optimize a pilot-scale integrated algae harvesting system that consists of filtration and IR drying operations (with an expected drying capacity of 25 kg per hour on a wet weight basis) to achieve a decrease energy consumption for drying microalgae by 50% compared to conventional heat drying.
- Determine the energy potential of the biodiesel produced from algae lipids and the biomethane produced from the algae residues after lipid extraction, and analyze the biodiesel according to biodiesel specification ASTM D6751.
- Develop and implement an engineering model that will be used as a foundation for coupled Life-Cycle Assessment (LCA) and Techno-Economic Analysis (TEA) models to assess the environmental and economic performance of the production pathways proposed in this research, including the life-cycle carbon intensity of the biofuels, resource and cost constraints, and overall economic benefits and energy savings.

TASK 1 ADMINISTRATION

Task 1.1 Attend Kick-off Meeting

The goal of this task is to establish the lines of communication and procedures for implementing this Agreement. The Commission Agreement Manager (CAM) shall designate the date and location of this meeting and provide an agenda to the Recipient prior to the meeting.

The Recipient shall:

- Attend a “Kick-Off” meeting with the CAM, the Commission Agreement Officer (CAO), and a representative of the Energy Commission Accounting Office. The Recipient shall bring their Project Manager, Agreement Administrator, Accounting Officer, and any others determined necessary by the Recipient or specifically requested by the CAM to this meeting.
- Discuss the following administrative and technical aspects of this Agreement:

- Agreement Terms and Conditions
- Critical Project Review (Task 1.2)
- Match fund documentation (Task 1.6) No reimbursable work may be done until this documentation is in place.
- Permit documentation (Task 1.7)
- Subcontracts needed to carry out project (Task 1.8)
- The CAM's expectations for accomplishing tasks described in the Scope of Work
- An updated Schedule of Products and Due Dates
- Monthly Progress Reports (Task 1.4)
- Technical Products (Product Guidelines located in Section 5 of the Terms and Conditions)
- Final Report (Task 1.5)

Recipient Products:

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

Commission Agreement Product:

- Kick-Off Meeting Agenda

Task 1.2 Critical Project Review (CPR) Meetings

CPRs provide the opportunity for frank discussions between the Energy Commission and the Recipient. 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.

The CAM may schedule CPR meetings as necessary, and meeting costs will be borne by the Recipient.

Meeting participants include the CAM and the Recipient and may include the CAO, the Fuels and Transportation Division (FTD) biofuel lead, other Energy Commission staff and Management as well as other individuals selected by the CAM to provide support to the Energy Commission.

The CAM 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. Prepare 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 CAM concludes that satisfactory progress is not being made, this conclusion will be referred to the Lead Commissioner for Transportation for his or her concurrence.
- Provide the Recipient with a written determination in accordance with the schedule. The written response may include a requirement for the Recipient to revise one or more product(s) that were included in the CPR.

The Recipient shall:

- Prepare a CPR Report for each CPR that discusses the progress of the Agreement toward achieving its goals and objectives. This report shall include recommendations and conclusions regarding continued work of the projects. This report shall be submitted along with any other products identified in this scope of work. The Recipient shall submit these documents to the CAM 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.

CAM 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 CAM, and the CAO. 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 CAM.

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 CAM will determine the appropriate meeting participants.

The administrative portion of the meeting shall be a discussion with the CAM and the Grants Officer about the following Agreement closeout items:

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

Recipient Products:

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

Task 1.4 Monthly Progress Reports

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

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

The Recipient shall:

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

- In the first Monthly Progress Report and first invoice, document and verify match expenditures and provide a synopsis of project progress, if match funds have been expended or if work funded with match share has occurred after the notice of proposed award but before execution of the grant agreement. If no match funds have been expended or if no work funded with match share has occurred before execution, then state this in the report. All pre-execution match expenditures must conform to the requirements in the Terms and Conditions of this Agreement.

Recipient Products:

- Monthly Progress Reports

Task 1.5 Final Report

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

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

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

The Recipient shall:

- Prepare an Outline of the Final Report, if requested by the CAM.
- Prepare a Final Report following the latest version of the Final Report guidelines which will be provided by the CAM. The CAM shall provide written comments on the Draft Final Report within fifteen (15) working days of receipt. The Final Report must be completed at least 60 days before the end of the Agreement Term.
- Submit one bound copy of the Final Report with the final invoice.

Recipient Products:

- Outline of the Final Report, if requested
- Draft Final Report
- Final Report

Task 1.6 Identify and Obtain Matching Funds

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

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

The Recipient shall:

- Prepare a letter documenting the match funding committed to this Agreement and submit it to the CAM at least 2 working days prior to the kick-off meeting. If no match funds were part of the proposal that led to the Energy Commission awarding this Agreement and none have been identified at the time this Agreement starts, then state such in the letter. If match funds were a part of the proposal that led to the Energy Commission awarding this Agreement, then provide in the letter a list of the match funds that identifies the:
 - Amount of each cash match fund, its source, including a contact name, address and telephone number and the task(s) to which the match funds will be applied.
 - Amount of each in-kind contribution, a description, documented market or book value, and its source, including a contact name, address and telephone number and the task(s) to which the match funds will be applied. If the in-kind contribution is equipment or other tangible or real property, the Recipient shall identify its owner and provide a contact name, address and telephone number, and the address where the property is located.
- Provide a copy of the letter of commitment from an authorized representative of each source of cash match funding or in-kind contributions that these funds or contributions have been secured. For match funds provided by a grant a copy of the executed grant shall be submitted in place of a letter of commitment.
- Discuss match funds and the implications to the Agreement if they are reduced or not obtained as committed, at the kick-off meeting. If applicable, match funds will be included as a line item in the progress reports and will be a topic at CPR meetings.
- Provide the appropriate information to the CAM if during the course of the Agreement additional match funds are received.
- Notify the CAM within 10 days if during the course of the Agreement existing match funds are reduced. Reduction in match funds must be approved through a formal amendment to the Agreement and may trigger an additional CPR meeting.

Recipient Products:

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

Task 1.7 Identify and Obtain Required Permits

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

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

The Recipient shall:

- Prepare a letter documenting the permits required to conduct this Agreement and submit it to the CAM at least 2 working days prior to the kick-off meeting. If there are no permits required at the start of this Agreement, then state such in the letter. If it is known at the beginning of the Agreement that permits will be required during the course of the Agreement, provide in the letter:
 - A list of the permits that identifies the:
 - Type of permit
 - Name, address and telephone number of the permitting jurisdictions or lead agencies
 - The schedule the Recipient will follow in applying for and obtaining these permits.
- Discuss the list of permits and the schedule for obtaining them at the kick-off meeting and develop a timetable for submitting the updated list, schedule and the copies of the permits. The implications to the Agreement if the permits are not obtained in a timely fashion or are denied will also be discussed. If applicable, permits will be included as a line item in the Progress Reports and will be a topic at CPR meetings.
- If during the course of the Agreement additional permits become necessary, provide the appropriate information on each permit and an updated schedule to the CAM.
- As permits are obtained, send a copy of each approved permit to the CAM.
- If during the course of the Agreement permits are not obtained on time or are denied, notify the CAM within 5 working days. Either of these events may trigger an additional CPR.

Recipient Products:

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

Task 1.8 Obtain and Execute Subcontracts

The goal of this task is to ensure quality products and to procure subcontractors required to carry out the tasks under this Agreement consistent with the Agreement Terms and Conditions and the Recipient's own procurement policies and procedures. It will also provide the Energy Commission an opportunity to review the subcontracts to ensure that the tasks are consistent with this Agreement, and that the budgeted expenditures are reasonable and consistent with applicable cost principles.

The Recipient shall:

- Manage and coordinate subcontractor activities.
- Submit a draft of each subcontract required to conduct the work under this Agreement to the CAM for review.
- Submit a final copy of the executed subcontract.
- If Recipient decides to add new subcontractors, then the Recipient shall notify the CAM.

Recipient Products:

- Draft subcontracts
- Final subcontracts

TECHNICAL TASKS

TASK 2 ANALYSIS AND TREATMENT OF ANAEROBIC DIGESTER EFFLUENT FOR MICROALGAE CULTIVATION

The goal of this task is to design, construct and operate a pilot-scale treatment system for the AD effluent from two commercial digesters, UC Davis Renewable Energy Anaerobic Digester and New Hope Dairy Digester, to produce nutrients-rich water for algae growth. A pilot-scale ultrafiltration system is planned to be used to produce nutrient-rich water for microalgae growth in 100 gallon tanks for the pilot-scale system.

The Recipient shall:

- Acquire digestates from two commercial digesters—UC Davis Renewable Energy Anaerobic Digester and New Hope Dairy Digester—and characterize their nutrients and volatile fatty acids contents.

- Develop treatment methods and conduct laboratory tests to process the AD effluent and optimize the operational parameters in order to produce liquid that meets the water quality and nutrient requirements for algae to achieve optimum growth with low energy consumption.
- Conduct pilot tests for treatment of the digestates and further optimize the operation parameters to produce nutrients-rich liquid for algae growth.
- Analyze the biochemical oxygen demand and macro- and micronutrients contents of the liquid that support the algae growth.

Recipient Products:

- Test plan for AD effluent treatment for microalgae cultivation
- Report on characteristics of the two AD effluents and chemical composition of nutrient-rich liquid after filtration processing
- Operational Parameters for Effluent Treatment Report

TASK 3 ALGAE CULTIVATION USING DIGESTER EFFLUENT

The goal of this task is to design, construct, optimize, and demonstrate pilot-scale algae production systems coupled with anaerobic digester for CO₂ capture, digestate treatment, and recycling of algae residues.

The Recipient shall:

- Conduct laboratory experiments to characterize waste streams for compatibility with production of specific strains of algae.
- Develop a test plan and conduct demonstration tests and laboratory experiments to evaluate and select algae strains for optimum growth in digester effluent.
- Conduct laboratory experiments to optimize cultivation and productivity of microalgae with AD effluent on laboratory scale.
- Design and determine layout of the 100 gallon pilot-scale algae reactor at the UC Davis Renewable Energy Anaerobic Digester.
- Test for improved growth rates using mixotrophic cultivation with AD effluent and recycled carbon-rich waste streams from within the production system, and determine the effect of digester bacterial communities on algal growth.
- Test for improved biomass and lipid productivity from the addition of cofactors and/or additives.
- Demonstrate and optimize algae growth on pilot scale with AD effluent.
- Perform engineering review and analysis of flue gas collection for CO₂ capturing and supply system from the UC Davis Renewable Energy Anaerobic Digester system by measuring the temperature and composition of exhaust gas from the biogas-fired microturbines, determining conditioning and treatment needs to meet algae growth requirements, and describing details and developing design drawings.

Recipient Products:

- Test plan to evaluate and select algae strains for optimum growth in digester effluent
- Engineering Design and Layout of Pilot-Scale Algae Reactor
- Report on recommendations for selection of algae strain and growth conditions on wastewater for algae accumulation of lipids
- Report on algae cultivation in AD effluent and effects of synergistic co-culturing and addition of cofactors and/or additives
- Engineering analysis and design drawings of flue gas collection for CO₂ capture, and supply system

TASK 4 HARVESTING AND INFRARED DRYING OF ALGAE

The goal of this task is to optimize the design and operation parameters for an energy efficient pilot harvesting and drying system for algae. At the end of this task, an integrated system that consists of suspended air floatation (SAF), microfiltration, and IR operations will be developed, optimized, and implemented on a pilot-scale with a target drying capacity of 25 kg/hour on a wet weight basis.

The Recipient shall:

- Conduct laboratory experiments to determine the optimum operational parameters of SAF and microfiltration processes for algae harvesting.
- Conduct laboratory experiments to determine the effect of IR drying operating parameters (i.e., heating time, residence time and IR intensity) on drying characteristics and oil quality of algae and energy consumption.
- Conduct pilot tests of algae harvesting and drying, and demonstrate an integrated microfiltration and drying system with a capacity of producing 5 kg of dry algae per hour.
- Estimate capital and operational costs of the algae harvesting and drying system, and develop a scaled-up design and equipment selection plan for a system with a capacity to process the algae produced from the digester effluent of the UC Davis Renewable Energy Anaerobic Digester and New Hope Dairy Digester.

Recipient Products:

- Algae Harvesting and Drying Process Design, Operational Parameters, and Performance Data Report
- Scale-Up Design and Equipment Selection Plan and Cost Analysis

TASK 5 LIPID EXTRACTION AND TRANSESTERIFICATION TO EVALUATE BIODIESEL PRODUCT

The goal of this task is to perform lipid extraction and transesterification of microalgae-derived lipids grown using digester effluent and harvested with IR drying in order to evaluate the resulting biodiesel product.

The Recipient shall:

- Perform lab-scale lipid extraction from microalgae grown using digester effluent and harvested with IR drying, and perform transesterification of resulting lipids to produce biodiesel.
- Analyze the microalgae-derived biodiesel properties according to ASTM D6751: Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels.

Recipient Products:

- ASTM D6751 Chemical Analysis Report

TASK 6 DETERMINING ENERGY PRODUCTION POTENTIAL OF BIODIESEL FROM ALGAL LIPIDS AND BIOGAS FROM ALGAE RESIDUES

The goal of this task is to determine the energy potential of the biodiesel produced from algae lipids, and the biomethane produced from the algae residues after lipid extraction.

The Recipient shall:

- Conduct laboratory experiments to determine the macro- and micronutrient chemical composition and biomethane production potential from algal residues after lipid extraction.
- Determine the energy production potential for a full-scale integrated system producing biodiesel and biomethane from algae.

Recipient Products:

- Digested Algae Residues Macro- and Micronutrients Contents Report
- Biomethane and Energy Production Potential from Algae Residues Report
- Full-Scale Integrated System Energy Production Potential Report

TASK 7 TECHNO-ECONOMIC AND LIFE-CYCLE ANALYSES MODELING

The goal of this task is to develop and implement an engineering model that will be expanded into coupled LCA and TEA models to assess the environmental and economic performance of the production pathways proposed in this agreement. The recipient shall use LCA and TEA upfront during the research and development stage to guide environmentally preferable and economically viable innovation. The model will be used to improve decision making to minimize the cost and environmental burdens of algal biodiesel, including consideration of byproduct utilization. The aim is to predict the life-cycle carbon intensity of the resultant fuel throughout the development process and assess resource and cost constraints and address them during development.

The Recipient shall:

- Develop a flexible engineering model representative of the two AD pathways for biodiesel and biomethane production at commercial scale.

- Build an LCA model based on the engineering model that will examine global warming intensity, water use, net energy use, and other impact categories such as criteria air pollutant emissions for the biodiesel and biomethane products.
- Develop a coupled TEA model that produces LCA and TEA results concurrently. The TEA model will include estimates of both capital and operational costs for the production system at a commercial scale.

Recipient Products:

- Draft engineering models of two AD pathways for biodiesel and biomethane production
- Report on predicted cost, life-cycle carbon intensity for fuel products, and other life-cycle metrics
- Report on sensitivity and scenario analysis for cost and carbon intensity based on important identified features (e.g., economies of scale, resource constraints, geographic variability, etc.)
- Final engineering models of two AD pathways for biodiesel and biomethane production

STATE OF CALIFORNIA

STATE ENERGY RESOURCES
CONSERVATION AND DEVELOPMENT COMMISSION

RESOLUTION - RE: UNIVERSITY OF CALIFORNIA, DAVIS

RESOLVED, that the State Energy Resources Conservation and Development Commission (Energy Commission) adopts the staff CEQA findings contained in the Agreement or Amendment Request Form (as applicable)]; and

RESOLVED, that the Energy Commission approves ARV-15-008 with The Regents of the University of California on behalf of the Davis Campus for a \$598,168 grant to design and operate a pilot-scale coupled algae cultivation and anaerobic digester system that treats effluent from two commercial digesters—UC Davis Renewable Energy Anaerobic Digester and New Hope Dairy Digester—to produce nutrients-rich water for the algae production system. The project will incorporate carbon dioxide capture, nutrients recovery, recycling of algae residues, and infrared drying to seek reductions in the overall cost and energy consumption of algae-based biodiesel production; 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 October 14, 2015.

AYE: [List of Commissioners]

NAY: [List of Commissioners]

ABSENT: [List of Commissioners]

ABSTAIN: [List of Commissioners]

Tiffany Winter,
Secretariat