

Exhibit A Scope of Work

TECHNICAL TASK LIST

Task #	CPR	Task Name
1	N/A	Administration
2		Life Cycle Analysis
3		Road Map
4	X	High Throughput (HT) Processes
5	X	Genetic Toolbox
6	X	Metabolic Engineering
7	X	Protection of Biofuel Organism from Pests and Pathogens
8	X	Harvesting and Extraction
9	X	Co-Products
10		Water and Nutrient Recycling

GLOSSARY

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

Acronym	Definition
CILMSF	California Initiative for Large Molecule Sustainable Fuels
CPR	Critical Project Review
Energy Commission	California Energy Commission
GREET	California Greenhouse gases, Regulated Emissions, and Energy use in Transportation
HT	High Throughput
LCA	Life Cycle Analysis
LCI	Life Cycle Inventory
LMSF	Large Molecule Sustainable Fuels
PIER	Public Interest Energy Research
R&D	Research and Development
SD-CAB	San Diego Center for Algae Biotechnology
TAC	Technical Advisory Committee
UCC.1	Uniform Commercial Code (Financing Statement)
UCSD	University of California, San Diego

Problem Statement:

Conventional petroleum based transportation fuels (gasoline, diesel, jet) are nonrenewable and contribute to air quality degradation and climate change through carbon release. Reliance upon them stands in the way of California's energy independence. Biofuels, or liquid fuels produced from biomass, have the potential to replace petroleum as a source of transportation fuels, and by so doing address many of the problems associated with petroleum based fuels. However, before biofuels can compete with petroleum economically, more research and development is required. By establishing a research, development and deployment initiative for large molecule sustainable fuels (LMSF), California can lead the nation in the development of a sustainable, environmentally favorable sustainable fuels industry.

The California Initiative for Large Molecule Sustainable Fuels (CILMSF) will:

- Advance science and technology leading to the viable commercial deployment of fungible (drop-in) alternative transportation fuels.
- Provide timely and valuable information for policy makers, industry professionals, consumers, and the environmental community with regard to sustainable drop-in fuels to address California's transportation energy challenges; and
- Support drop-in fuel demonstration and related efforts in California.
- Support the nascent California bioenergy industry and green collar job creation.
- Ensure California's preeminent position with respect to a frontier technology industry.
- Foster California's ability to meet its transportation fuels demand with in-state production.

Large molecule drop-in fuels represent a promising and revolutionary set of technologies for reducing California's petroleum dependence, safeguarding our environment, and supporting the continued success of California's economy. These fuels are designed and engineered to be fungible with conventional fuels, *i.e.* transparent to the end users. As such, they are also compatible with existing infrastructure, obviating massive and disruptive investments in new bulk transportation, storage, and distribution systems.

Large molecule fungible fuels can be produced through a variety of technologies, including, but not limited to, biosynthesis (algae, bacteria, yeast), thermochemical processing of biomass, and processing of oil bearing farm crops. They offer Californians the following benefits:

- Reduced petroleum dependence and corresponding improvements in economic security.
- Reduced environmental and public health risks through reductions in greenhouse gas emissions and criteria pollutant emissions.
- Increased diversification of the transportation energy supply through fuels production via multiple pathways.

Goal of this Agreement

The goal of this Agreement is to promote research and development for sustainable, low carbon, drop-in large molecule liquid fuels to meet California's transportation needs. In accordance with the State Alternative Fuels Plan, these large molecule fuels must be compatible with existing fuel refining and distribution infrastructure (hence the term drop-in), and production of these fuels should not compete with production of food. This ongoing Research and Development (R&D) effort will be spearheaded by a new research initiative of the California Energy Commission (Energy Commission) operated in collaboration with the University of California, San Diego (UCSD).

Establishing the CILMSF will:

- further position California as a leader in the development and production of alternative, renewable, and sustainable low-carbon fuels,
- help to decrease the carbon footprint of transportation fuels in California, and
- help to establish a robust workforce-training program that can supply the needed personnel for this new “green collar” industry.

For this new industry to be successful, it will require a diverse pool of well-trained technical personnel and professional scientists. In addition, investments in university-led basic research will be essential to developing the next generations of large molecule biofuel technologies and related materials.

The CILMSF will partner with regional and statewide economic and workforce development organizations, as well as the university and community college systems of California, to help develop a robust curriculum to train scientists and technicians for the green collar jobs being created by the emerging biofuel industry. It will also facilitate the transfer of technology to the commercial sector, as well as foster interaction and collaboration with regional and state policy makers regarding the development of large molecule fuels for economic and environmentally sustainable energy production.

The CILMSF will operate from a platform of technological neutrality, involving research scientists from the fields of biology, chemistry, bioengineering and chemical engineering, with a primary mission to develop the knowledge, tools, and industrial practices that will allow the production of economically viable and fungible large molecule fuels from sustainable renewable sources. The research projects conducted as part of this initiative will use multi-disciplinary research teams that address the most significant barriers to economic viability of large molecule biofuels, while training the next-generation scientific and technical workforce essential to the future success of a sustainable renewable liquid transportation fuels industry in California.

The products of the CILMSF will be fourfold:

- 1) Development of advanced, near term tools, protocols and industrial processes to make renewable, sustainable large-molecule fuels viable for large-scale commercial production.

- 2) Identification of existing challenges to the economic viability of large molecule fuel production from sources that do not compete with production of food, and an enhanced capability to effectively assess related emerging biofuel technologies.
- 3) A trained work force ready to staff this industrial sector as it develops.
- 4) Economically significant spinoff technologies and co-products that will enable sustainable production of a variety of bioproducts, such as:
 - a) green chemistry, including biological alternatives for existing environmentally unfavorable chemical processes
 - b) new wastewater remediation methodologies and processes
 - c) bio-polymers, including bio-plastics and biodegradable polymers
 - d) industrial enzymes
 - e) nutraceuticals
 - f) enhanced animal feeds
 - g) human & animal therapeutics

Objectives of the Agreement

The objectives of this agreement will initially be divided into nine research categories: 1) Life cycle analysis of potential LMSF organisms and production processes, 2) Road mapping to identify new technologies and biofuel sources, 3) Development of high throughput technologies for rapid LMSF characterization, 4) Development of a genetic toolbox for biofuel organisms, 5) Development of metabolic engineering tools for biofuels organisms, 6) Development of biofuel organism protection strategies, 7) Development of improved harvesting and extraction techniques for LMSFs, 8) Development of co-products for improved economic viability of biofuel organisms, and 9) Development of technologies to optimize nutrient utilization and recycling in biofuel organisms. All of these research objectives are aligned with the Energy Commission's overall goal of bringing sustainable, drop-in large molecule fuels to commercial viability as rapidly as possible.

A fundamental limitation for the production of large fuel molecule fuels from energy crops, algae, or any other sustainable biomass feedstock lies in the scarcity of state of the art molecular and genetic tools for many of these species, as well as the high throughput industrial practices required to develop these organisms into efficient fuel-producing organisms. In comparison to modern industrial organisms and agricultural crops, most biomass organisms that can be cultivated at large scale on non-arable land lack a strong foundation in fundamental biological information and all but the most basic genetic tools and industrial practices. By developing these tools and protocols, the CILMSF can accelerate the rate at which these organisms become an economically viable source of sustainable large molecule fuels.

TASK 1.0 ADMINISTRATION

MEETINGS

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 Contractor shall:

- Attend a “kick-off” meeting with the Commission Contract Manager, the Contracts Officer, and a representative of the Accounting Office. The Contractor shall bring their Project Manager, Contracts Administrator, Accounting Officer, and others designated by the Commission Contract Manager to this meeting. The administrative and technical aspects of this Agreement will be discussed at the meeting. Prior to the kick-off meeting, the Commission Contract Manager will provide an agenda to all potential meeting participants.

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

- Terms and conditions of the Agreement
- CPRs (Task 1.2)
- Match fund documentation (Task 1.7)
- Permit documentation (Task 1.8)

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

- The Commission Contract Manager’s expectations for accomplishing tasks described in the Scope of Work;
- An updated Schedule of Deliverables
- Progress Reports (Task 1.4)
- Technical Deliverables (Task 1.5)
- Final Report (Task 1.6)
- Establish the TAC (Task 1.10)
- TAC Meetings (Task 1.11)

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

Contractor Deliverables:

- An Updated Schedule of Deliverables
- An Updated List of Match Funds
- An Updated List of Permits
- Schedule for Recruiting TAC Members

Commission Contract Manager Deliverables:

- Final Report Instructions

Task 1.2 CPR Meetings

The goal of this task is to determine if the project should continue to receive Energy Commission funding to complete this Agreement and if it should, are there any modifications that need to be made to the tasks, deliverables, schedule or budget.

CPRs provide the opportunity for frank discussions between the Energy Commission and the Contractor. CPRs generally take place at key, predetermined points in the Agreement, as determined by the Commission Contract Manager and as shown in the Technical Task List above and in the Schedule of Deliverables. However, the Commission Contract Manager may schedule additional CPRs as necessary, and, if necessary, the budget will be reallocated to cover the additional costs borne by the Contractor, but the overall contract amount will not increase.

Participants include the Commission Contract Manager and the Contractor, and may include the Commission Contracts Officer, the PIER Program Team Lead, other Energy Commission staff and Management as well as other individuals selected by the Commission Contract Manager to provide support to the Energy Commission.

The Commission Contract Manager shall:

- Determine the location, date and time of each CPR meeting with the Contractor. These meetings generally take place at the Energy Commission, but they may take place at another location.
- Send the Contractor the agenda and a list of expected participants in advance of each CPR. If applicable, the agenda shall include a discussion on both match funding and permits.
- Conduct and make a record of each CPR meeting. One of the outcomes of this meeting will be a schedule for providing the written determination described below.
- Determine whether to continue the project, and if continuing, whether or not to modify the tasks, schedule, deliverables and budget for the remainder of the Agreement, including not proceeding with one or more tasks. If the Commission Contract Manager concludes that the project needs a formal amendment or that satisfactory progress is not being made and the project needs to be ended, these conclusions will be referred to the Commission's Research, Development and Demonstration Policy Committee for its concurrence.
- Provide the Contractor with a written determination in accordance with the schedule. The written response may include a requirement for the Contractor to revise one or more deliverable(s) that were included in the CPR.

The Contractor 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 deliverables identified in this Scope of Work. Submit these documents to the Commission Contract Manager and any other designated reviewers at least 15 working days in advance of each CPR meeting.
- Present the required information at each CPR meeting and participate in a discussion about the Agreement.

Contractor Deliverables:

- CPR Report(s)
- CPR deliverables identified in the Scope of Work

Commission Contract Manager Deliverables:

- Agenda and a List of Expected Participants
- Schedule for Written Determination
- Written Determination

Task 1.3 Final Meeting

The goal of this task is to closeout this Agreement.

The Contractor shall:

- Meet with the Energy Commission 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 Contractor, the Commission Contracts Officer, and the Commission Contract Manager. The technical and administrative aspects of Agreement closeout will be discussed at the meeting, which may be two separate meetings at the discretion of the Commission Contract Manager.

The technical portion of the meeting shall present findings, conclusions, and recommended next steps (if any) for the Agreement. The Commission Contract Manager will determine the appropriate meeting participants.

The administrative portion of the meeting shall be a discussion with the Commission Contract Manager and the Contracts Officer about the following Agreement closeout items:

- What to do with any state-owned equipment (Options)
- Need to file UCC.1 form re: Energy Commission's interest in patented technology
- Energy Commission's request for specific "generated" data (not already provided in Agreement deliverables)
- Need to document Contractor's disclosure of "subject inventions" developed under the Agreement
- "Surviving" Agreement provisions, such as repayment provisions and confidential deliverables
- Final invoicing and release of retention
- Prepare a schedule for completing the closeout activities for this Agreement.

Deliverables:

- Written documentation of meeting agreements and all pertinent information
- Schedule for completing closeout activities

REPORTING

See Exhibit D, Reports/Deliverables/Records.

Task 1.4 Monthly Progress Reports

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

The Contractor shall:

- Prepare progress reports which summarize all Agreement activities conducted by the Contractor for the reporting period, including an assessment of the ability to complete the Agreement within the current budget and any anticipated cost overruns. Each progress report is due to the Commission Contract Manager within 10 working days after the end of the reporting period. Attachment A-2, Progress Report Format, provides the recommended specifications.

Deliverables:

- Monthly Progress Reports

Task 1.5 Test Plans, Technical Reports and Interim Deliverables

The goal of this task is to set forth the general requirements for submitting test plans, technical reports and other interim deliverables, unless described differently in the Technical Tasks. When creating these deliverables, the Contractor shall use and follow, unless otherwise instructed in writing by the Commission Contract Manager, the latest version of the PIER Style Manual published on the Energy Commission's web site:

<http://www.energy.ca.gov/contracts/pier/contractors/index.html>

The Contractor shall:

- Unless otherwise directed in this Scope of Work, submit a draft of each deliverable listed in the Technical Tasks to the Commission Contract Manager for review and comment in accordance with the approved Schedule of Deliverables. The Commission Contract Manager will provide written comments back to the Contractor on the draft deliverable within 10 working days of receipt. Once agreement has been reached on the draft, the Contractor shall submit the final deliverable to the Commission Contract Manager. The Commission Contract Manager shall provide written approval of the final deliverable within 5 working days of receipt. Key elements from this deliverable shall be included in the Final Report for this project.

Task 1.6 Final Report

The goal of this task is to prepare a comprehensive written Final Report that describes the original purpose, approach, results and conclusions of the work done under this Agreement. The Commission Contract Manager will review and approve the Final Report. The Final Report must be completed on or before the termination date of the Agreement. When creating these deliverables, the Contractor shall use and follow, unless otherwise instructed in writing by the Commission Contract Manager, the latest version of the PIER Style Manual published on the Energy Commission's web site:

<http://www.energy.ca.gov/contracts/pier/contractors/index.html>

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

Task 1.6.1 Final Report Outline

The Contractor shall:

- Prepare a draft outline of the Final Report.
- Submit the draft outline of Final Report to the Commission Contract Manager for review and approval. The Commission Contract Manager will provide written comments back to the Contractor on the draft outline within 10 working days of receipt. Once agreement has been reached on the draft, the Contractor shall submit the final outline to the Commission Contract Manager. The Commission Contract Manager shall provide written approval of the final outline within 5 working days of receipt.

Deliverables:

- Draft Outline of the Final Report
- Final Outline of the Final Report

Task 1.6.2 Final Report**The Contractor shall:**

- Prepare the draft Final Report for this Agreement in accordance with the approved outline.
- Submit the draft Final Report to the Commission Contract Manager for review and comment. The Commission Contract Manager will provide written comments within 10 working days of receipt.

Once agreement on the draft Final Report has been reached, the Commission Contract Manager shall forward the electronic version of this report for Energy Commission internal approval. Once the approval is given, the Commission Contract Manager shall provide written approval to the Contractor within 5 working days.

- Include within the report the Initiative's role in the development of a skilled workforce – indicators of success to include: the number of undergraduate and graduate degrees conferred; student authorship on publications, scientific professional society conference abstracts, patent applications; enrollment in university courses that have a biofuels focus
- Submit one bound copy of the Final Report with the final invoice.

Deliverables:

- Draft Final Report
- Final Report

MATCH FUNDS, PERMITS, AND ELECTRONIC FILE FORMAT**Task 1.7 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. While the PIER budget for this task will be zero dollars, the Contractor may utilize match funds for this task. Match funds shall be spent concurrently or in advance of PIER funds during the term of this Agreement. Match funds must be identified in writing, and the associated commitments obtained before the Contractor can incur any costs for which the Contractor will request reimbursement.

The Contractor shall:

- Prepare a letter documenting the match funding committed to this Agreement and submit it to the Commission Contract Manager at least 2 working days prior to the kick-off meeting:
 1. 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.
 2. 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 Contractor shall identify its owner and provide a contact name, address and telephone number, and the address where the property is located.
 - 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.
- Discuss match funds and the implications to the Agreement if they are significantly reduced or not obtained as committed, at the kick-off meeting. If applicable, match funds will be included as a line item in the progress reports and will be a topic at CPR meetings.
- Provide the appropriate information to the Commission Contract Manager if during the course of the Agreement additional match funds are received.
- Notify the Commission Contract Manager within 10 working days if during the course of the Agreement existing match funds are reduced. Reduction in match funds may trigger an additional CPR.

Deliverables:

- A letter regarding Match Funds or stating that no Match Funds are provided
- Letter(s) for New Match Funds
- A copy of each Match Fund commitment letter

- Letter that Match Funds were Reduced (if applicable)

Task 1.8 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 reimbursable under this Agreement. Permits must be identified in writing before the Contractor can incur any costs related to the use of the permit(s) for which the Contractor will request reimbursement.

The Contractor shall:

- Prepare a letter documenting the permits required to conduct this Agreement and submit it to the Commission Contract Manager at least 2 working days prior to the kick-off meeting:
 1. If there are no permits required at the start of this Agreement, then state such in the letter.
 2. 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
 - Schedule the Contractor will follow in applying for and obtaining these permits.
- The list of permits and the schedule for obtaining them will be discussed at the kick-off meeting, and a timetable for submitting the updated list, schedule and the copies of the permits will be developed. 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, then provide the appropriate information on each permit and an updated schedule to the Commission Contract Manager.
- As permits are obtained, send a copy of each approved permit to the Commission Contract Manager.

- If during the course of the Agreement permits are not obtained on time or are denied, notify the Commission Contract Manager within 5 working days. Either of these events may trigger an additional CPR.

Deliverables:

- A letter documenting the Permits or stating that no Permits are required
- Updated list of Permits as they change during the Term of the Agreement
- Updated schedule for acquiring Permits as it changes during the Term of the Agreement
- A copy of each approved Permit

Task 1.9 Electronic File Format

The goal of this task is to unify the formats of electronic data and documents provided to the Energy Commission as contract deliverables. Another goal is to establish the computer platforms, operating systems and software that will be required to review and approve all software deliverables.

The Contractor shall:

- Deliver documents to the Commission Contract Manager in the following formats:
 - Data sets shall be in Microsoft (MS) Access or MS Excel file format.
 - PC-based text documents shall be in MS Word file format.
 - Documents intended for public distribution shall be in PDF file format, with the native file format provided as well.
 - Project management documents shall be in MS Project file format.
- Request exemptions to the electronic file format in writing at least 90 days before the deliverable is submitted.

Deliverables:

- A letter requesting exemption from the Electronic File Format (if applicable)

Task 1.10 Establish the TAC

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

The Technical Advisory Committee (TAC) should be composed of diverse professionals. The number can vary depending on potential interest and time availability. The exact composition of the TAC may change as the need warrants. TAC members serve at the discretion of the Commission Contract Manager.

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

- Researchers knowledgeable about the project subject matter
- Members of the trades who 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 project subject matter
- U.S. Department of Energy Research Manager
- Public Interest Environmental Groups
- Utility Representatives
- Members of the relevant technical society committees

The purpose of the TAC is to:

- Provide guidance in research direction. The guidance may include scope of research; research methodologies; timing; coordination with other research. The guidance may be based on:
 - technical area expertise
 - knowledge of market applications
 - linkages between the agreement work and other past, present or future research (both public and private sectors) they are aware of in a particular area.
- Review deliverables. Provide specific suggestions and recommendations for needed adjustments, refinements, or enhancement of the deliverables.
- Evaluate tangible benefits to California of this research and provide recommendations, as needed, to enhance tangible benefits.
- Provide recommendations regarding information dissemination, market pathways or commercialization strategies relevant to the research products.

The Contractor shall:

- Prepare a draft list of potential TAC members that includes name, company, physical and electronic address, and phone number and submit it to the Commission Contract Manager at least 2 working days prior to the kick-off meeting. This 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 and ensure that each individual understands the member obligations described above, as well as the meeting schedule outlined in Task 1.11.
- Prepare the final list of TAC members.
- Submit letters of acceptance or other comparable documentation of commitment for each TAC member.

Deliverables:

- Draft List of TAC Members
- Final List of TAC Members
- Letters of acceptance, or other comparable documentation of commitment for each TAC Member

Task 1.11 Conduct TAC Meetings

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

The Contractor shall:

- Discuss the TAC meeting schedule at the kick-off meeting. The number of face-to-face meetings and teleconferences and the location of TAC meetings shall be determined in consultation with the Commission Contract Manager. This draft schedule shall be presented to the TAC members during recruiting and finalized at the first TAC meeting.
- Organize and lead TAC meetings in accordance with the schedule. Changes to the schedule must be pre-approved in writing by the Commission Contract Manager.
- Prepare TAC meeting agenda(s) with back-up materials for agenda items.
- Prepare TAC meeting summaries, including recommended resolution of major TAC issues.

Deliverables:

- Draft TAC Meeting Schedule
- Final TAC Meeting Schedule
- TAC Meeting Agenda(s) with Back-up Materials for Agenda Items
- Written TAC meeting summaries, including recommended resolution of major TAC issues

TECHNICAL TASKS

The Contractor shall prepare all deliverables in accordance with the requirements in Task 1.5. Deliverables not requiring a draft version are indicated by marking “(no draft)” after the deliverable name.

Task 2: Life Cycle Analysis

The goal of this task is to develop robust life cycle analyses (LCA) for large molecule biofuel production. LCAs will provide an objective assessment of the environmental aspects and potential impacts associated with production of sustainable alternative large molecule fuels. For each biofuel production process, the associated inputs and releases will be factored into an evaluation of potential impacts. Such impacts include demands on natural resources, environmental impacts, and increased or decreased burdens upon other industries. The results of the LCAs will be the basis for informed decision-making and will promote greater public understanding about biofuel production. The analyses will also help to identify aspects of the processes and externalities that may need improvement or reconsideration.

The Contractor shall:

- Develop an LCA for each biofuel organism and production process used for large molecule biofuel production.
- The LCA will:
 - Define system boundaries (inputs/outputs), define specific requirements (land/water/CO₂), and identify biofuel pathways, including potential co-products (feeds/fertilizers/etc.), for a variety of non-crop based biofuel organisms.
 - Facilitate the development of a complete inventory of associated processes used in each biofuel production scheme for large molecule fuel production, called a life cycle inventory (LCI). Facilitate the integration and expansion of LCI data for any viable non-crop biofuel production species.
 - Develop LCI data for large molecule fuel production.
 - Integrate and expand LCI data for viable non-crop biofuel production species.
 - Compare outputs to California Greenhouse gases, Regulated Emissions, and Energy use in Transportation (GREET) model outputs.
- Prepare an LCA report vetted by experts in the field of biofuel production processes.

Deliverables:

- LCA report

Task 3: Road Map

The goal of this task is to develop a long-term strategy for the identification and development of new research areas and technologies that may be useful for the sustainable production of LMSFs.

The roadmap will be developed with community input from biofuels researchers and other stakeholders in the public and private sectors. An iterative process involving workshops and ongoing communication will address issues such as the allocation of research resources and the identification and incorporation of new technologies (from, for example, agriculture science, aquaculture engineering, and fuel processing) into research projects.

The Contractor shall:

- Identify potential new areas of research and perform gaps analysis identifying unmet research needs in the topic area suitable for public funding through workshops and road mapping sessions with extended stakeholder groups, including commercial sector partners.
- Incorporate planning activities into an iterative process for determining research resources allocation to ensure continued incorporation of new research ideas.
- Identify and incorporate new technologies (agriculture science, aquaculture engineering, biofuel processing, etc.) into research projects by integration of diverse scientific disciplines.

- Assist the Commission Project Manager in organizing a public workshop to vet the roadmap.
- Prepare an annual report on annual meeting of biofuels researchers, stakeholders and interested members of the public.
- Prepare an annual scientific and technical report on biofuel research and technology development for publication in peer reviewed journals.
- Prepare an annual community-informed assessment report regarding the most promising research directions and technological developments relevant to the production of large-molecule biofuels.

Deliverables:

- Annual report on annual meeting of biofuels researchers, stakeholders and interested members of the public
- Annual scientific and technical report
- Annual community-informed assessment report

Task 4: High Throughput (HT) Processes

The goal of this task is to develop HT processes (high-volume capacity) for rapid selection and evaluation of biofuel organisms. The incorporation of HT processes for biomolecule manipulation and analysis has enabled enormous advances in the biomedical sector over the last ten years. Similar processes have yet to be developed for biofuels organisms, although existing HT technologies and processes appear to be well suited for this purpose.

The Contractor shall:

- Design HT analytical techniques to identify potential biofuel production strains.
- Create an HT process that incorporates sample preparation, analysis, and data organization into a streamlined operation.
- Identify, classify and characterize potential biofuel organism species for their commercial potential.
- Develop advanced HT techniques for large molecule fuel characterization.
- Create a database of biofuel targets and associated metabolic pathways from diverse species.
- Prepare an analytical core facility plan for biofuel strain evaluation, selection, and optimization
- Create a database of protocols for analytical evaluation of biofuels strains.
- Prepare a report on protocols for analytical evaluation of biofuel strains.
- Prepare a report on curated collection of algal biofuel strains.
- Participate in a CPR per Task 1.2.

Deliverables:

- Analytical core facility plan
- Report on protocols for analytical evaluation of biofuel strains
- Report on curated collections of algal biofuel strains
- CPR Report

Task 5: Genetic Toolbox

The goal of this task is to develop a suite of genetic tools for non-food biomass organisms for biofuel applications. In order to facilitate the adoption of new biofuel technology by other academic and industrial laboratories, a suite of molecular tools will be developed and made broadly available to others.

The Contractor shall:

- Develop new methods to control gene expression and cell viability.
- Create methods for genetic transformation of previously non-transformed species.
- Produce additional selectable markers and crop protection tools.
- Develop combinatorial genetic manipulation for directed evolution in biofuel species.
- Develop genetic tool methods and protocol content for website.
- Prepare report on genetic tools and methods developed in this program for distribution according to university guidelines.
- Prepare report on patent applications for genetic tools and methods relevant to production of LMSF.
- Prepare annual presentations about the development and application of new genetic tools and methods to diverse audiences, including researchers, the business community and the public.
- Participate in a CPR per Task 1.2.

Deliverables:

- Report on genetic tools and methods
- Verification of website development
- Report on patent applications for genetic tools and methods
- Copies of annual presentations
- CPR Report

Task 6: Metabolic Engineering

The goal of this task is to develop metabolic engineering techniques for improved industrial characteristics. Food crops and livestock have been selectively bred for centuries to obtain the efficient agricultural production species that we use today. A similar process of selection and modification of biofuels organisms will be conducted, in order to develop the efficient optimized production species that will be required for economic viability of biofuel production. To achieve this within a reasonable time frame, new metabolic engineering techniques and strategies will be developed to enable improved accumulation of biofuel

molecules in production strains.

The Contractor shall:

- Employ a systems-based strategy to optimize feedstock supply.
- Define metabolic networks controlling carbon partitioning in biofuel organisms and modify metabolic pathways.
- Use modern genomic (DNA analysis), proteomic (protein analysis), and metabolomic (small molecule analysis) technologies to define target pathways and regulatory systems.
- Engineer enhanced large molecule fuel precursor production in oil-producing organisms.
- Prepare a report on new biofuel organisms and strains for scientific and potentially commercial use, documented by manuscript submission for publication and distributed according to university guidelines.
- Prepare annual assessment report of progress toward metabolic engineering goals, including highlights of most promising research results, and discussion of any approaches deemed not to be worthy of continued pursuit.
- Participate in a CPR per Task 1.2.

Deliverables:

- Report on new biofuel organisms and strains
- Annual assessment report
- CPR Report

Task 7: Protection of Biofuel Organism from Pests and Pathogens

The goal of this task is to develop biotechnology strategies to protect new biofuel crops (plants and algae) against pests and other unwanted wild organisms. Just as agricultural scientists have devised improved methods to protect food crops from pests and pathogens, so must biofuel scientists aim to protect bioenergy crops.

The Contractor shall:

- Develop anti-viral technologies (e.g., pathogen-derived resistance).
- Develop anti-bacterial and anti-fungal technologies.. (e.g., antibiotic co-production).
- Develop anti-parasitic technologies (e.g., protein toxin co-production).
- Prepare a report on new strains of pest-resistant biofuel organisms, documented by publication and distributed according to university guidelines.
- Prepare a report on protocols for measuring the effectiveness of new crop protection technologies, documented by publication and distributed according to university guidelines.
- Prepare a report on technical and non-technical descriptions of the new technologies and their potential applications documented by publication and distributed according to university guidelines.
- Participate in a CPR per Task 1.2.

Deliverables:

- Report on new strains of pest-resistant biofuel organisms
- Report on protocols for measuring the effectiveness of new crop protection technologies
- Report on technical and non-technical descriptions of the new technologies
- CPR Report

Task 8: Harvesting and Extraction

The goal of this task is to develop economically viable technologies to collect and purify biofuels from plant and algal biomass.

The Contractor shall:

- Develop efficient harvesting technologies, e.g. secretion of biofuel precursor molecules from biofuel species.
- Employ genetic engineering to increase oil accumulation and efficient extraction.
- Examine the potential of biofuel secretion.
- Evaluate bioreactor and/or aquaculture design to maximize harvesting and extraction.
- Prepare a report on new methodologies for the extraction and collection of biofuels.
- Develop content for website on demonstration aquaculture pilot project for research and education.
- Prepare a report on technical and non-technical descriptions of new harvesting methodologies that include estimates of economically realizable improvements, documented by publication and distributed according to university guidelines.
- Participate in a CPR per Task 1.2.

Deliverables:

- Report on new methodologies for the extraction and collection of biofuels
- Verification of website development
- Report on technical and non-technical descriptions of new harvesting methodologies
- CPR Report

Task 9: Co-Products

The goal of this task is to engineer value-added products into producer organisms for non-biofuel applications, a further critical factor in economic viability of biofuels. A large portion of plant and algal biomass will be composed of non-fuel molecules, including proteins, carbohydrates, and other water-soluble biomolecules. This non-hydrocarbon biomass may be used for a variety of purposes, including animal feeds and fertilizers, industrial enzymes and a variety of bio-products. Moreover, organisms may be engineered to produce additional value-added co-products within this biomass, including nutritional, therapeutic, or ecologically beneficial biomolecules.

The Contractor shall:

- Develop economic and environmentally sound ways of using the residual biomass.

- Create new industrial enzymes and enhanced animal feeds.
- Develop chemical technologies (e.g. pyrolysis) for conversion of biomass into liquid fuels.
- Prepare a report detailing projections of the current and potential yields of agriculturally and commercially usable co-products associated with biofuel production.
- Evaluate complementary metabolic pathways for co-product production or strain improvement.
- Prepare a quarterly updated list of known end uses for biofuels co-products annotated to show relative feasibility of scale-up based on best available information from commercial partners.
- Participate in CPR per Task 1.2.

Deliverables:

- Report detailing projections of the current and potential yields of agriculturally and commercially usable co-products
- Quarterly updated list of known end uses for biofuels co-products
- CPR Report

Task 10: Water and Nutrient Recycling

The goal of this task is to develop new strategies to recycle wastewater and associated nutrients and minimize biofuel waste streams. A final component of biofuel production will be reduction of environmental impact of this technology as it grows into large-scale application. A top concern is water sourcing and utilization. Use of waste streams and nutrient runoff will be analyzed.

The Contractor shall:

- Evaluate recycling of agricultural and urban wastewater.
- Evaluate recycling of algal wastewater for re-use.
- Evaluate water reconditioning for municipal use.
- Determine algal wastewater by-products for environmental impact and recycling potential.
- Perform resource assessment and site selection analysis for new biofuels organisms.
- Prepare a report on demonstration water and nutrient reclamation pilot project for biofuel organisms.
- Prepare a report on projections of the water requirements associated with the scale-up of production of LMSFs.
- Prepare a report on compositional analysis of wastewater associated with LMSF production.
- Prepare a report estimating the relative economic feasibility of recycling wastewater for and from scaled-up LMSF production facilities.

Deliverables:

- Report on demonstration water and nutrient reclamation pilot project
- Report on projections of the water requirements associated with the scale-up of production of LMSFs
- Report on compositional analysis
- Report estimating the relative economic feasibility of recycling wastewater