

## Statement of Work

### PHASE 1 (BASE) 18 MONTHS:

**Task 0100 – Integration.** The task objective is to provide integrating models and analyses needed to ensure that this complex project focuses on critical issues and proceeds efficiently. Specifically, GA will maintain and update a detailed cost model for algae oil production throughout the test program. The model will be based on the one described in Section 7.2. Near the midpoint of Phase 1, an architectural and engineering firm will be contracted to prepare a preliminary design and independent cost-estimate for an algae oil production facility. UOP and EERC will prepare cost-estimates for jet fuel production from the algae oil. The algae oil and jet fuel production cost-estimates will be documented in a detailed cost-estimate report. In parallel, GA (with input from UOP, EERC, Boeing, REG, HBE, BioSelect, Blue Sun Biodiesel, and Tellurian Biodiesel) will prepare and update a commercialization plan that defines a path to reach commercially viable production of affordable and widely available JP-8. UOP and EERC are currently under contract to prepare qualification plans for triglyceride oil derived jet fuel. These plans will be modified as necessary to prepare a qualification plan for algae triglyceride oil derived jet fuel. Boeing will provide input to the qualification plan. The main task deliverable is the Commercialization Plan along with supporting deliverables of cost projections and the Qualification Plan. The Commercialization Plan and the Cost Model are living documents that will provide direction throughout the project; therefore, there are no exit criteria unless it is found that the project's oil or JP-8 cost goals cannot be met.

**Task 0200 – Species Selection.** The task objective is to identify multiple strong-candidate species for commercial algae oil production. Martek Biosciences will conduct rapid screening of potential species. Martek Biosciences, ASU, SIO, Sapphire Energy, USU, and GA will conduct more detailed evaluation of the most promising strains by measuring attributes that impact the cost of algae oil production. The task deliverables are cost-model input data for each of the species, recommended operating conditions for each species, and a ranking of the species for use in the outdoor integrated tests.

**Task 0300 – Oil Optimization.** The task objective is to optimize the oil content, composition, and accumulation rate based on their combined impact on production cost. GA will conduct the testing with Martek Biosciences support for experimental design and analysis. UOP and EERC will provide input on the cost impact of oil composition. The task deliverable is a list of recommended strain/growth-condition combinations for the integrated outdoor tests.

**Task 0400 – Photosynthetic Efficiency.** The task objective is to improve the photosynthetic efficiency to minimize the algae oil production cost. SIO will conduct the strain/growth-condition testing. GA will lead the reactor design effort with input from ASU, USU, and Sapphire Energy. The task deliverables are recommendations for reactor design, growth conditions, and strain combinations for integrated outdoor tests.

**Task 0500 – Nutrient Recycle.** The task objective is to maximize the recycle of nutrients and water within the system. GA will conduct tests to evaluate species for nutrient recycle and establish the required treatment level. The task deliverables are recommendations for recycle treatment, approach, and species combinations for integrated outdoor tests.

**Task 0600 – Carbon Dioxide Supply.** The task objective is to minimize the cost of carbon dioxide supply to the system. TSD will lead the testing to characterize the important carbon

dioxide supply variables. A number of potential carbon dioxide sources will be evaluated. Deliverables are the design of the carbon dioxide supply for the outdoor integrated tests and cost model input for carbon dioxide supply from various sources.

**Task 0700 – Harvesting.** The task objectives are to measure the cost parameters for the harvesting technologies, and to demonstrate the efficacy of the technologies under conditions of algae oil production. GA will conduct the tests using outdoor bioreactor systems. The task deliverables are cost-model input for harvesting and establishment of the harvesting process for the integrated outdoor tests.

**Task 0800 – Oil Extraction.** The task objective is to minimize the cost of oil extraction by demonstrating the efficacy of low-cost technologies. The task will consist of an evaluation phase followed by a down-select to the top two technologies for further development and demonstration. At the conclusion of Phase 1, one technology will be selected for use in Phase 2. GA will work with the technology providers to specify success criteria for tests that will establish key parameters in the evaluation phase. Blue Sun Biodiesel, Inventure, ESI, Crown Iron Works, Incitor, Altex, GA/Martek Biosciences will conduct tests to measure the key parameters for cost and efficacy. Then the technologies will be ranked based on a combination of technical risk, cost for full-scale implementation, and efficacy. The task deliverable is cost-model input for oil extraction and selection of the oil-extraction technology for scale-up in Phase 2.

**Task 0900 – Inoculation.** The task objectives are to develop a low-cost inoculum production system and measure the productivity parameters for the cost model. GA will lead the inoculum system design with input from ASU, USU, KAS, SE, and MB. Different inoculation systems will be installed at the various integrated outdoor test sites. KAS, TALR, ASU, and GA will test low-cost inoculum systems. The task deliverables are inoculum systems installed for the integrated outdoor test facilities and cost-model input for the inoculation systems.

**Task 1000 – Integrated Outdoor Tests.** The task objectives are to produce oil for jet fuel samples, develop low-cost high-efficiency bioreactor systems, develop mechanisms for microbial stability, and collect cost-model data on outdoor systems integrating the advances developed in Tasks 200 through 900. GA will lead the task. ASU, HBE, TALR and GA will operate outdoor test facilities. SIO will conduct microbial system assessment and analysis. ASU and USU will investigate novel, low-cost PBRs and hybrid systems. Sapphire Energy, Martek Biosciences, J. Lamoureux, and A. Belay will provide input on the analysis and optimization of the bioreactor systems. Task deliverables will include test reports and oil samples.

**Task 1100 – Co-Products.** GA, MB, SIO, UOP, and EERC will work to identify potential co-products. The task deliverable will be a list of co-products including an estimate of their market size, price, cost of separation, and their potential impact on algae oil production. Testing of the promising candidates will be conducted as part of the system optimization in Phase 2. Typical co-products have a low-cost impact for the type of cost reduction needed in Phase 1. High-value co-products tend to have a relatively small market, and co-products with markets large enough to be important in a large fuel industry typically do not provide the order of magnitude type of cost reduction needed in Phase 1.

**Task 1200 – Jet Fuel Production.** The objective is to produce on-specification jet fuel from algae oils with an economical process. EERC and UOP will develop the process and produce samples. Deliverables are 2-liter jet fuel samples at 6, 9, 12, and 15 months after receipt of contract (ARC); and a 100-liter jet fuel sample 18 months ARC. EERC and UOP will each produce two of the 2-liter samples, and one company will be selected to produce the 100-liter

sample based on quality of the samples and estimated conversion cost including co-products and integration with algae oil production. The task will conclude with production of the jet fuel samples and cost-model input data on the conversion of algae oil to jet fuel.

**Task 1300 – Phase 1 Management.** The task objective is to ensure that the project delivers on its budget and schedule commitments and stays focused on achieving its primary objective of providing an alternative source of JP-8 for DOD. GA will perform this task using existing ISO 9001 certified procedures. The number of subcontractors involved and the complexity of the process optimization will place a premium on strong communications, transparent goals, and clear objectives. GA will use well-proven processes for subcontract administration, quality assurance, and project control through integrated master schedules that drive earned value management. GA will also establish and maintain a clear risk reduction plan and regular communication channels, including cross-corporate committees, to ensure that information exchange is rapid and complete. More detail on the risk reduction plan is presented in Section 6. The deliverables are monthly technical status and cost reports, quarterly technical progress reports, and a final technical report covering the project achievements in Phase 1.

#### **PHASE 2 (OPTION 1) 18 MONTHS:**

Phase 2 focuses on optimization and demonstration at the pre-pilot scale. The specific subcontractors are dependent upon the results and technology down-selections in Phase 1.

**Task 1400 – Integration.** The task objective is to update the commercialization plan and cost model with results from Phase 2 research and development. GA will lead this task. The deliverable for this task is an updated Commercialization Plan with detailed cost backup.

**Task 1500 – Optimization.** The task objective is optimization of the algae oil production process and definition of an optimal process for demonstration at pre-pilot scale. GA will lead this task with support from subcontractors, dependent on the results and technology down-selections in Phase 1. The task endpoints will be based on Phase 1 results and an assessment of the technical progress required prior to commercialization. The deliverable will be a report that feeds into the cost model and the Commercialization Plan.

**Task 1600 – Pre-Pilot-Scale Demonstration.** Task objectives are to demonstrate algaederived JP-8 technology at pre-pilot scale and mitigate risks sufficiently to enable commercialization. GA will lead this task with support from subcontractors. An algae bioreactor system of approximately 30–50 acres will be constructed for the pre-pilot-scale demonstration. System location will be based on the site selection analysis contained in the Commercialization Plan.

**Task 1700 – Jet Fuel Production.** EERC or UOP will produce 10-liter jet fuel samples at quarterly intervals and will then scale-up their process for production of a 4,000-liter jet fuel sample. The deliverables are 10-liter jet fuel samples at 6, 9, 12, and 15 months ARC; and a 4,000-liter sample at 18 months ARC.

**Task 1800 – Phase 2 Management.** Task objectives are the same as those of Phase 1, as are the plans. Deliverables are monthly technical status and cost reports, quarterly technical progress reports, and a final technical report covering the project achievements in Phase 2.