native feedstocks (biomass sugars) for the bioproduction of lactic acid and polylactide polymers, and at the National Renewable Energy Laboratory (NREL), where he was responsible for analyses to support the objectives of the DOE Biomass Program. While at NREL he was also accountable to DOE for the planning and execution of NREL and outside subcontracted research of approximately $20 million annually for advancing the National Biofuels Program.

13.5. Renewable Energy Group

Team member Renewable Energy Group, Inc. is the largest producer of biodiesel and crude glycerin in the United States. REG has expertise in design, process engineering, permitting and registration, safety management, site preparation, construction services, and fuel accreditation for biodiesel manufacturing plants. The company has commercialized biodiesel production from diverse oils including white grease, poultry fat, yellow grease, canola, palm and corn from DDG, and has produced biodiesel at non-commercial scale from camelina, jatropha, and moringa. REG has also successfully converted Solazyme's algal oil into high quality biodiesel on multiple occasions. **Glen Meier**, Director, Technology & Feedstock Development will manage all activities within the project scope. Glen evaluates new technologies that are complementary to REG's business. His department also supports the Quality, Production, Procurement and Construction departments.

13.6. UOP LLC

Team member UOP LLC is a subsidiary of Honeywell Corporation, in its Specialty Materials Strategic Business Enterprise. UOP has been delivering cutting-edge technology to the refining, petrochemical, and gas processing industries for over 90 years. UOP is a leader in the development of technology to convert triglyceride oils to green renewable diesel with properties indistinguishable from petroleum-based fuels. The Ecofining™ process to produce green diesel was co-developed with the Italian refiner Eni. Two Ecofining process units are in development today, with more anticipated this year. The first Ecofining license is to Eni, which plans to start up its facility in 2010 in Livorno, Italy. Galp Energia of Portugal also plans to start up a facility in 2010. The resulting biofuels not only meet but often exceed current specifications for their petroleum equivalents. UOP has successfully converted Solazyme's algal fuel into high quality renewable diesel using the Ecofining process. Work within the scope of the project will be managed by **Andrea Bozzano**, Development Manager – Renewables. Andrea is responsible for Process Development of the UOP technologies Ecofining and Renewable Jet technologies, as well as other technologies based on renewable feedstocks.

14. Intellectual Property Summary

Solazyme owns all the intellectual property necessary to accomplish the tasks set out in this proposal. The intellectual property rights owned by Solazyme have not been licensed to any other parties. None of these intellectual property rights have been licensed from another party. Partners BlueFire Ethanol and Abengoa Bioenergy New Technologies will provide feedstock materials derived from cellulosic biomass to Solazyme. These companies have confirmed that they own all the intellectual property necessary to produce and deliver these materials. Partners Renewable Energy Group and UOP will refine algal oil provided by Solazyme into transportation fuels and return the finished fuels to Solazyme. These companies have confirmed that they own all the intellectual property necessary to perform these operations. The Intellectual Property Statement Attachment contains further discussion.

The data contained in every page (pages 1 to 3) of this application have been submitted in confidence and contain trade secrets or proprietary information, and such data shall be used or disclosed only for evaluation purposes, provided that if this applicant receives an award as a result of or in connection with the submission of this application, DOE shall have the right to use or disclose the data herein to the extent provided in the award. This restriction does not limit the U.S. government's right to use or disclose data obtained without restriction from any source, including the applicant.

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IP Statements and Support Documentation

IP Statements

Solazyme owns all the intellectual property necessary to accomplish the tasks set out in this proposal. The intellectual property rights owned by Solazyme have not been licensed to any other parties. There are no intellectual property rights that have been licensed from another party.

Solazyme's Partners have confirmed the following:

"To the best of its knowledge, UOP LLC owns or will have a license to all the intellectual property rights necessary to convert Solazyme's purified algal oil into renewable diesel as set out in proposal in response to DE-FOA-0000096. Limited licenses will be granted to Solazyme only to the extent necessary to use the resulting fuel."

"To the best of its knowledge, Bluefire owns or will have a license to all the intellectual property rights necessary to provide concentrated cellulosic sugars to Solazyme to carry out algal fermentations to produce purified algal oil to be refined into transportation fuels as set out in proposal in response to DE-FOA-0000096. Limited licenses will be granted to Solazyme only to the extent necessary to accomplish the tasks set out in the proposal."

"To the best of its knowledge, The Renewable Energy Group owns or will have a license to all the intellectual property rights necessary to convert Solazyme purified algal oil into FAME biodiesel as set out in proposal in response to DE-FOA-0000096. Limited licenses will be granted to Solazyme only to the extent necessary to use the resulting Fuel."

"To its knowledge, Abengoa Bioenergy New Technologies has all the intellectual property rights necessary to provide concentrated cellulosic sugars to Solazyme. Limited licenses will be granted to Solazyme only to the extent necessary to carry out algal fermentations to produce purified algal oil to be refined into transportation fuels as set out in this proposal."

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Overview

Solazyme's proprietary platform utilizes non-photosynthetic cultivation of oil-bearing microalgae and other microbes for the production of non-alcohol based fuels and other hydrocarbon or lipid compositions on a large scale for use in transportation fuels. The platform includes: (1) microalgae strain selection; (2) feedstock selection and processing; (3) genetic engineering of microalgae strain(s) and other microbes; (4) scale up and optimization of fermentation processes; (5) oil extraction; and (6) oil to fuel conversion.

REDACTED
EXEMPTION 4

Strain/Feedstock Selection, Cultivation and Genetic Engineering

Some microalgae strains can be cultured under heterotrophic conditions (non-photosynthetic process using fermentation tanks) in which a fixed carbon source or feedstock provides energy for growth and lipid accumulation. These microalgae strains can utilize a variety of fixed carbon sources including sucrose, glycerol and cellulosic materials.

REDACTED
EXEMPTION 4

Listed below are patent applications filed and owned by Solazyme regarding microalgae strain selection, feedstock selection and genetic engineering of microalgae strains and cultivation of these microalgae strains for the production of biomass and oils.

REDACTED
EXEMPTION 4

Oil Extraction Process

Once the oil-bearing microalgal biomass has been produced, the oil contained within the microalgal cells, typically in the form of triacylglycerides (TAGs), need to be extracted or separated from the cells. Part of Solazyme's platform technology includes several processes to extract the oil from the microalgal cells. The oil extraction process also include filtration, separation or purification steps needed before the crude algal oil (TAGs) can be subjected to chemical modifications to produce fuels. Listed below are patent applications filed and owned by Solazyme regarding oil extraction from oil-bearing microalgal biomass.

REDACTED
EXEMPTION 4

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Oil to Fuel Conversion

Because the crude oil produced by microalgae strains is in the form of TAGs, chemical modification of the crude oil needs to be performed in order to generate fuels. These chemical modifications include transesterification to produce biodiesel (fatty acid methyl esters, FAMEs), hydrotreating to produce renewable diesel and a combination of hydrotreating and hydrocracking to produce aviation/jet fuel. Listed below are patent applications filed and owned by Solazyme regarding the conversion of crude microalgal oil/high oil-bearing microalgal biomass into transportation fuels such as biodiesel (FAMEs), renewable diesel, and aviation/jet fuel.

REDACTED
EXEMPTION 4

Solazyme may own additional intellectual property in various forms that covers methods and compositions useful in the proposed project that are not listed above, including inventions conceived but not yet reduced to practice and inventions reduced to practice but not yet described in a filed patent application, as well as trade secrets.

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PROJECT NARRATIVE COVER SHEET
Recovery Act – Demonstration of Integrated Biorefinery Operations
Funding Opportunity Announcement Number: DE-FOA-0000096
CFDA Number: 81.087 Renewable Energy Research and Development

Applicant Information	
Applicant Name:	Solazyme, Inc.
Project Title:	**Solazyme Integrated Biorefinery (SzIBR): Diesel Fuels from Heterotrophic Algae**
Major Project Subcontractors:	**BlueFire Ethanol Fuels Inc., Abengoa Bioenergy Corp., Renewable Energy Group, Inc., UOP LLC, Cherokee Pharmaceuticals LLC**
Major Project Vendors:	Ex 4 PROPRIETARY
Key Individuals:	**David Brinkmann (PI)**

Topic Area (Select ONLY one)

Each applicant is allowed to submit only one application to this FOA. Applicants that submit to none or more than one topic area will be excluded from further review. Select one and only one topic area below.

☐ Topic Area 1 ☐ Topic Area 3 ☒ Topic Area 5
☐ Topic Area 2 ☐ Topic Area 4 ☐ Topic Area 6

Lifecycle Greenhouse Gas Emissions Reduction (mandatory for Topic Areas 5 and 6. Important – See Note): 80.09**%**

Technical Description		
Feedstock(s):	**Sucrose (from cane); municipal green waste; switchgrass**	
Primary Product:	**Biodiesel and Renewable Diesel from Purified Algal Oil**	
Co-Products:	Ex 4	
Location of Proposed Facility:	On the site of Cherokee Pharmaceuticals (Riverside, PA) PROPRIETARY	
Throughput of Proposed Facility (dry tonnes of feedstock per day):	Ex 4 **MT/day**	
Conversion Technology:	☒ Biochemical	☐ Thermochemical
	☒ Algae	☐ Other (Describe)
Short Description: **Heterotrophic algae are grown in fermentation tanks on the feedstocks shown above. The algae convert the sugars to oil, which is extracted, purified and refined to diesel fuels.**		

Project Financing Description			
10% Minimum required cost share (%) for the selected topic area.	15% Applicant's cost share (%)	$2,562,285 Minimum required cost share ($) for the selected topic area. (See FOA, Appendix C for the calculation method)	$3,857,111 Applicant cost share ($, from SF-424a, box 5(f))
$25,622,849 - Total Allowable Cost (Total Project Cost, from SF-424a, box 5(g))			

This form is required. It must be completely filled in and be included as the cover page for the "Project Narrative" (FOA, Subpart IV.C. b.). This form may contain confidential /business proprietary information IF it properly marked, but it must not contain any Personally Identifiable Information (PII). This form will count toward the page limit stated in the FOA, Subpart IV.C.b. Non-compliant applications will not be reviewed and will not be eligible for selection.

Note: The Energy Independence and Security Act of 2007 ("EISA") requires that the Secretary of Energy shall not make an award to a project that does not achieve at least an 80 percent reduction in lifecycle greenhouse gas emissions.

The data contained in every page (pages 1 to 15) of this application have been submitted in confidence and contain trade secrets or proprietary information, and such data shall be used or disclosed only for evaluation purposes, provided that if this applicant receives an award as a result of or in connection with the submission of this application, DOE shall have the right to use or disclose the data herein to the extent provided in the award. This restriction does not limit the government's right to use or disclose data obtained without restriction from any source, including the applicant.

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Solazyme Integrated Biorefinery (SzIBR): Diesel Fuels from Heterotrophic Algae

Project Narrative

Topic 5 Pilot-Scale Project

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1. Project Summary

Purpose

Solazyme proposes to build, operate and optimize a pilot-scale "**S**olazyme **I**ntegrated **B**iorefinery." SzIBR will demonstrate integrated scale-up of Solazyme's novel heterotrophic algal oil biomanufacturing process, validate the projected commercial-scale economics of producing multiple advanced biofuels, and enable Solazyme to collect the data necessary to complete design of the first commercial-scale facility.

Significance

Solazyme's approach forges the crucial link from high-impact, domestic, renewable *lignocellulosic* feedstocks to *oil-based* fuels that leverage and remain fully compatible with the petroleum economy.

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Conversion Technology

In Solazyme's innovative process, algae grow efficiently in the dark in industrial fermentation vessels at very high cell densities. They ingest and metabolize carbon substrates provided in the growth media and convert them to triglycerides – nearly identical in composition to common vegetable oils – at very high titers REDACTED EXEMPTION 4 The purified algal oil can be transesterified to yield biodiesel, or hydrotreated to yield renewable diesel or jet fuels. (See Figure N-1.)

Project Feedstocks

Solazyme's commercial vision is to derive fermentable sugars from lignocellulosic feedstocks to enable the greatest commercial scalability and impact. However, in order to meet critical scale objectives cost-effectively and expeditiously, SzIBR will utilize domestically-sourced sucrose (from sugar cane grown in Louisiana) as the "transitional" primary feedstock in Period 2. The life cycle analysis detailed in Attachment R demonstrates an 80.1% reduction in GHG emissions utilizing sucrose as the feedstock, confirming that it is acceptable as the primary feedstock for the pilot plant under Topic Area 5.

A limited number of campaigns at SzIBR will utilize fermentable sugars derived from cellulosic feedstocks (municipal green waste, switchgrass, corn stover and/or wheat straw). The project is structured to accelerate technical performance on lignocellulosic feedstocks relative to sucrose and enable Solazyme to transition to them immediately following the project, prior to construction of the first commercial plant.

Commercial Feedstocks

In commercial deployment, Solazyme's proprietary algal strains will exploit a wide range of **non-food** carbon feedstocks, including but not limited to switchgrass, miscanthus, bagasse, sugar beet pulp, molasses, corn stover, wheat straw, energy cane, sorghum, poplar, industrial byproducts, municipal green waste and other waste streams. In aggregate, these feedstocks can be found throughout the US and potentially could supply tens of billions of gallons per year of liquid transportation fuels derived from algal oil.

Products

The project's primary products will be biodiesel (ASTM D6751) and renewable diesel (ASTM D975), which are fully compatible with existing petroleum infrastructure, including distribution and vehicles.

REDACTED
EXEMPTION 4

Throughput

Throughput will reach 13 metric tons/day of *sucrose* by the end of Period 2. (The initial sugar *cane* biomass is much higher.) This number represents a logical and well-supported scale up from current non-integrated pilot scale activities. It will also satisfy due diligence criteria of private investors, prove readiness to proceed directly to commercial scale, and significantly accelerate commercialization.

Campaigns on cellulosic-derived sugars will reach EX 4

Project Site

Solazyme proposes to create SzIBR on the site of team member Cherokee Pharmaceuticals' existing commercial biomanufacturing facility in Riverside, PA. Setting up SzIBR at Cherokee will dramatically reduce the time, cost, complexity and risk of the project. All the fermentation tanks and extensive supporting infrastructure required to grow algae heterotrophically are already in place and fully operational. Solazyme will purchase and install the equipment to recover the oil from the algae. These items are all commercially available and will be delivered mounted on skids for rapid installation in an existing process building, which has all needed utilities. Leveraging Cherokee's spare fermentation capacity will save the project over EX 4 and allow operations to commence at least EX 4 is sooner compared with building a greenfield pilot plant. An independent environmental consultancy that Solazyme has retained to assist with NEPA related issues believes that the site will qualify the project for a categorical exclusion (CX).

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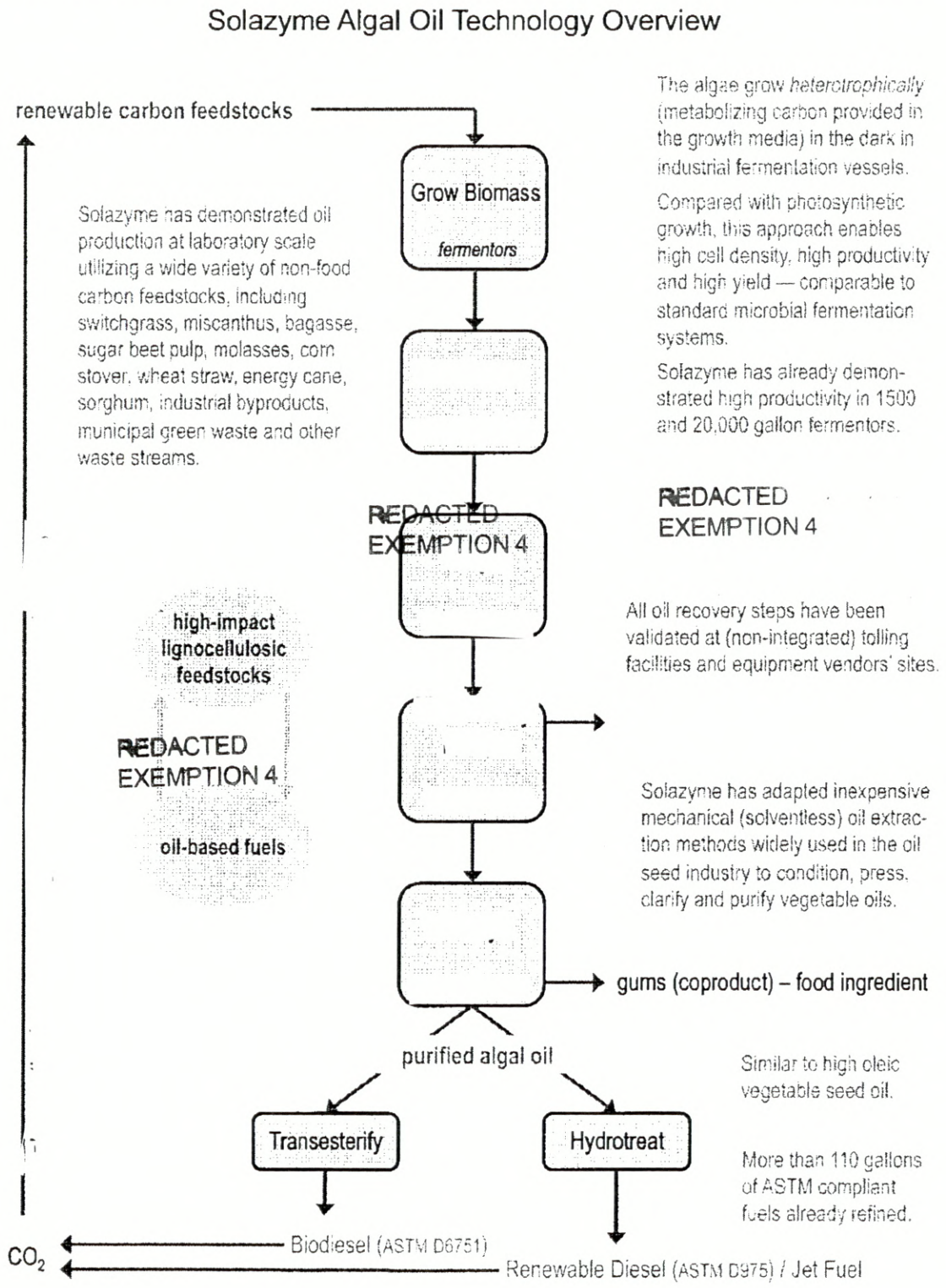

Figure N-1. Summary of Solazyme's process technology.

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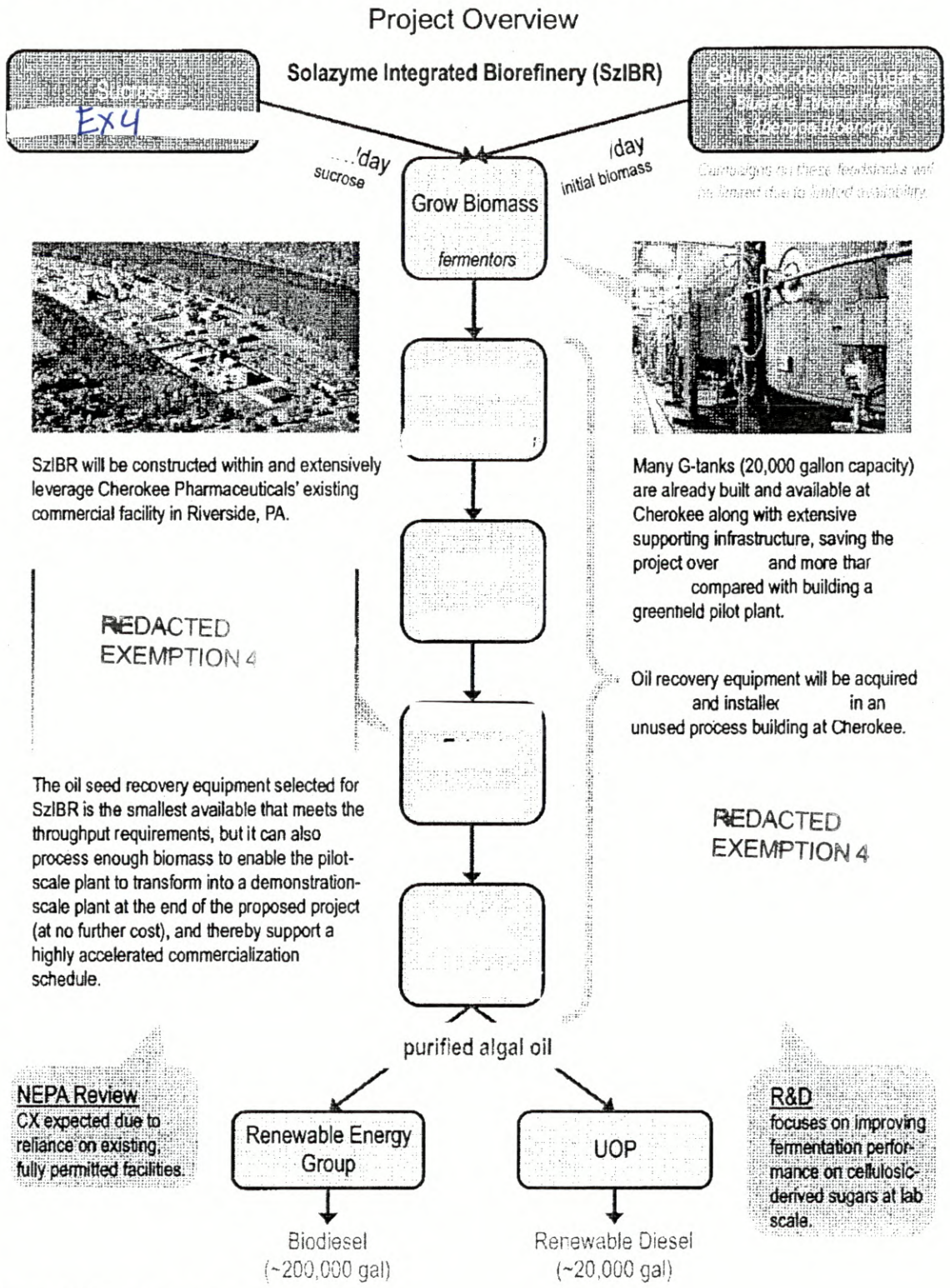

Figure N-2. Outline of the project.

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Team Members

Cherokee Pharmaceuticals is providing the project site, much of SzIBR's infrastructure, and extensive operational support.

BlueFire Ethanol Fuels and Abengoa Bioenergy are providing fermentable sugars, which they will derive from lignocellulosic biomass at their existing facilities and deliver to SzIBR.

UOP and Renewable Energy Group (REG) will refine the purified algal oil produced at SzIBR to renewable diesel and biodiesel, respectively, leveraging existing refining facilities.

Readiness to Proceed to Integrated Pilot Scale

Solazyme has already successfully demonstrated heterotrophic algal fermentation at the same scale as proposed for SzIBR (20,000 gallon fermentors). All the downstream recovery unit operations have also been demonstrated separately (non-integrated) at tolling facilities or at the facilities of equipment vendors at scale sufficient to guarantee successful scale up. Independent laboratories have confirmed that biodiesel and renewable diesel created from Solazyme's algal oil comply with ASTM specifications.

2. Overview of Solazyme's Innovative Heterotrophic Algal Oil Biofuel Process

Some algae possess internal biochemical pathways that synthesize oil more efficiently than any other known natural or engineered process. Under the right conditions, certain algal species produce so much oil that the oil constitutes over EX 4 so it's not surprising that the world's petroleum deposits consist largely of the fossilized remains of prehistoric algal blooms.

Many strains of algae are *heterotrophic*: they can grow in the dark by ingesting and metabolizing organic molecules derived from domestic, renewable, scalable, and environmentally sustainable biomass sources. Solazyme has identified and isolated strains of algae that achieve high cell densities, high carbon flux (productivity), high carbon yield (utilization), and fast cell doubling times — comparable to standard microbial fermentation systems. This breakthrough enables Solazyme to exploit the proven, mature technology of industrial biomanufacturing, but for the first time apply it to produce inexpensive, high-quality **renewable oil**.

Solazyme has already produced over 70 metric tons of dried algal biomass in the same size fermentors that will be employed in the proposed project and has extracted over 2,000 gallons of algal oil from a small portion of the biomass produced. Existing oil refineries can transesterify Solazyme's algal oil neat or blended to yield biodiesel (ASTM D6751), or hydrotreat it to make renewable diesel, which is identical to petroleum diesel (ASTM D975). More than 110 gallons of Solazyme's algal oil have already been transformed into these standard fuels, and independent tests confirm that they comply fully with specifications. Renewable jet fuel has passed the critical subset of tests that have been performed in work to date.

Figure N-3. Left to right: **(a)** Laboratory scale fermentation of algae **(b)** Dried algal biomass **(c)** Purified algal oil **(d)** Thousands of gallons of algal oil have been produced in non-integrated tolling facilities, of which over a hundred gallons have been refined to transportation fuels **(e)** Solazyme's biodiesel and renewable diesel have powered a light truck and three cars with unmodified diesel engines for thousands of miles on the open road (with blends ranging from B20 to B100).

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Solazyme's novel biomanufacturing technology provides several key advantages:

- Algae produce lipids with the ideal chain length and chemical structure for conversion to diesel and other fuels, in contrast to the short chain alcohols produced by other biofuel processes. Solazyme's purified algal oil is a high quality triglyceride oil composed predominantly of oleic acid.
- Algal oil feeds directly into the vast infrastructure that refines, distributes, retails and consumes petroleum products. Other scalable biofuel approaches present significant incompatibilities with pre-existing infrastructure and vehicles. Solazyme aims to capture rather than disrupt the petroleum economy.
- Solazyme's process is efficient and cost-effective. Algae have evolved to tolerate the oil they produce, enabling high titers, and Solazyme has discovered and honed an inexpensive method to extract the oil EX 4 Ethanol, in contrast, poisons yeast, and distilling it is energy intensive.
- Algae are robust organisms, better suited to tolerate the toxic compounds released during conversion of lignocellulosic biomass into fermentable sugars, and they thrive on a wide range of feedstocks.

Solazyme's approach forges the crucial link from high-impact, domestic, renewable lignocellulosic feedstocks to oil-based transportation fuels that leverage and remain fully compatible with the petroleum economy. Most competing biofuel approaches that utilize lignocellulosic biomass produce fuels — such as alcohols — that are not fully compatible with petroleum-based infrastructure and vehicles, and which exhibit less desirable physical and chemical properties than petroleum-based fuels. A few other approaches do yield oil-based fuels, but they are either not scalable (e.g. biodiesel from vegetable oil or waste grease) or they are inefficient and not environmentally sustainable (e.g. long chain F-T synthesis).

It's important to distinguish Solazyme's novel approach from conventional algal biofuel concepts, which rely on *autotrophic* algae to produce their own sugar via photosynthesis. Directly photosynthetic approaches are sensible for high-priced nutraceuticals, but remain far from being economically viable for commodity fuels. A discussion of the technical and economic hurdles they confront is beyond the scope of this proposal. None of the valid criticisms of conventional algal biofuel concepts pertain to Solazyme's approach, which uniquely exploits *heterotrophic* growth to produce algal oil in a well-established industrial context, far more efficiently than is possible via photosynthesis. Of course, the biomass feedstocks fed to the algae exploit photosynthesis. Converting sunlight and CO_2 directly to oil sounds seductive, but separating the processes of photosynthesis and oil synthesis turns out to be most cost effective.

3. Project Objectives

3.1. Critical Success Factors for the Proposed Project

In the proposed project, the following critical success factors (CSFs) will guide consideration to proceed along the path to build a full-scale commercial plant:

- Expeditiously commence construction and operations in earnest.
- Integrate all unit operations successfully into a unified biorefinery.
- Validate low cost production at commercial scale.
- Demonstrate refining of the algal oil into fully-compliant liquid transportation fuels.
- Accelerate high-impact lignocellulosic feedstocks to near parity with interim transitional feedstocks.
- Successfully complete the project on schedule.

These CSFs for the proposed project build upon earlier CSFs that Solazyme has already realized, discussed in the Project Execution Plan (PEP) Section 2.1, and also tie into further CSFs that pertain to full-scale commercialization, discussed in the Business and Commercialization Plan (BCP) Section 2.1.

3.2. Specific Project Objectives

To achieve the above CSFs, Solazyme will accomplish the following specific project objectives:

- Complete all preliminary project activities (including engineering, permitting, and NEPA review) on schedule by preparing in advance to the extent possible and employing best management and environmental assessment practices guided by experts in these areas.

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- Build a pilot-scale integrated biorefinery (SzIBR) quickly by leveraging spare fermentation capacity at a pre-selected, pre-existing, fully-operational, commercial-scale bioproduction facility (Cherokee Pharmaceuticals) and adding and integrating the necessary algal oil extraction and purification equipment — all standard commercial equipment that vendors will build quickly to order, deliver and install.
- Operate SzIBR successfully and achieve all technical performance objectives necessary to validate production cost projected to full commercial scale. Solazyme has already developed credible cost models and will refine them based on technical data collected and proven at integrated pilot scale. Quantitative technical objectives are embodied in the project's Key Performance Parameters (KPPs), which are tabulated in PEP Section 2.1. The KPPs describe the expected improvement of fermentation productivity and oil recovery efficiencies over the course of the project. The project milestones, summarized in PEP Section 5.3, tie the KPPs to the project schedule. The productivity improvements expected as part of the scale-up activity at SzIBR are well within bioproduction industry norms at this stage of scale up.
- Refine the purified algal oil to biodiesel and renewable diesel, with the assistance of partners REG and UOP, at a scale sufficient to demonstrate quality consistency of the biofuels and support engine testing.
- Optimize fermentation on sugars derived from at least two high-impact lignocellulosic feedstocks (by BlueFire and Abengoa via distinct cellulosic conversion processes) at laboratory scale and transition these feedstocks to integrated pilot scale at SzIBR, with technical performance rapidly approaching parity with the interim transitional feedstock (sucrose).
- Maintain a flexible project plan and adhere to best project management practices to meet all objectives on or ahead of schedule and on or below budget.

The project plan is flexible and robust because it extensively leverages existing infrastructure, benefits from (but does not pay extra for) redundancies, follows a very straightforward critical path with remarkably few critical dependencies, and offers workarounds for nearly all potential problems and failures.

3.3. Value Proposition

Solazyme's value proposition for customers includes:

- *Supply the **renewable, scalable, environmentally sustainable, oil-based fuels** — including biodiesel, renewable diesel, and jet fuel — that customers want.* The Energy Information Administration predicts that wholesale ethanol prices will remain steady or fall in real terms over the next decade even as domestic diesel fuel prices rise considerably. This stark contrast concisely captures the added value to the customer of converting lignocellulosic biomass to petroleum-equivalent biofuels rather than alcohols.
- *Remain fully compatible with existing petroleum-based infrastructure — including pipelines and other forms of distribution, storage, retailing, and end-use vehicles.* Biofuels refined from Solazyme's algal oil not only displace but also directly *replace* existing petroleum-based fuels. Other biofuels, such as ethanol, imperfectly substitute for petroleum-based fuels.
- *Deliver high quality and high performance biofuels.* REDACTED EXEMPTION 4 REG, the leading US biodiesel refiner (and project team member) has stated, "REG has extensive experience in producing biodiesel from a wide variety of feedstock including moringa oleifera, jatropha, camelina and many others. Over the last two years, REG has received algal oil produced by Solazyme, converted the oil to biodiesel in our pilot scale production system and analyzed the quality of the finished product. We have found the final biodiesel quality to be excellent and the performance characteristics to be superior to that of other oils we have converted." REDACTED EXEMPTION 4
- *Compete on cost with petroleum-derived fuels* — The projected cost of production ranges from EX4 per gallon of purified algal oil, depending on the scenario and assumptions. See Section 5.3 for further discussion.

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3.4. Justification of Federal Investment

Federal investment in the proposed project is justified because it advances several top-tier national priorities, including energy independence and security, climate and environmental goals, and economic development. Solazyme's value proposition for the collective national interest includes all the points discussed in the previous section and also the following:

- ***Connect the domestic resource potential of renewable, sustainable, high-impact lignocellulosic biomass feedstocks to production of advanced biofuels fungible with petroleum.***
- REDACTED EXEMPTION 4
- *Address a significant fraction of the RFS requirements* — the fast commercialization pathway could potentially result in installed capacity that reaches nearly
- REDACTED EXEMPTION 4
- *Counteract "food vs. fuel" pressures* — Solazyme's process applied to lignocellulosic biomass not only avoids the use of food crops as a feedstock, but will also generate premium quality animal feed as a co-product, even from biomass sources such as switchgrass.

Solazyme's value propositions that further justify federal investment include:

- *Enhance the value of a wide range of complementary biomass technologies already funded by DOE* — many technically promising technologies that might not be commercially viable producing ethanol may become competitive if linked to Solazyme's back-end process. Solazyme's technology therefore provides a valuable hedge for a significant portion of DOE's lignocellulosic technology portfolio.
- *Leverage existing facilities, substantial private investment, and substantial investments by Solazyme* in R&D activities in parallel with but outside the project scope to maximize return on DOE's investment.
- *Obtain essentially a pilot-scale facility and a demonstration-scale facility for the cost of a pilot project.*
- *Execute a project plan tailored specifically for speed to address the company's commercialization objectives, national RFS goals, and ARRA objectives.*
- *Catapult the technology* — DOE funds will enable Solazyme to consolidate technology validation and demonstrations steps at a critical inflection point, accelerating progress along the commercialization pathway far faster than Solazyme could accomplish without a partnership with DOE. DOE funds will complement and enhance private investment, not replace it, and therefore achieve a large impact.

4. Project Description

4.1. Overview of Project Activities and Tasks

Period 1 (Months EX4

Period 1 is devoted to planning, engineering, NEPA and other regulatory activities. Key tasks include:

- Submit application for Period 2
- Complete NEPA review process
- Finalize risk management plan
- Prepare Cherokee site (complete engineering drawings, submit permit applications, finalize equipment specifications, finalize sucrose supply agreement, update safety plan)
- Prepare South San Francisco site (laboratory R&D work)
- Generate initial quantities of cellulosic-derived sugars (BlueFire/Abengoa)
- Submit reports (financial, technical, ARRA)

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Period 2 (Months EX 4

Period 2 begins with a construction phase (Months EX 4 to assemble and start-up SzIBR. Oil recovery major equipment items will be ordered and work will begin immediately to prepare the process building at Cherokee to receive them. The oil purification equipment has the longest lead time and won't be fully installed and operational until Month EX 4 However, enough equipment will be installed by Month EX 4 to begin major operational campaigns; the crude algal oil produced early on will be stored and purified later.

In the operational phase (Months), SzIBR will run on sucrose through campaigns leading up to demonstrations at full throughput EX 4 and the shakedown test. These campaigns will enable us to collect the data necessary to optimize the process and design the first commercial-scale facility. They will also demonstrate a series of key productivity milestones, culminating in the technical Key Performance Parameters necessary for profitable commercial-scale operation. Several process runs will also be conducted utilizing cellulosic-derived sugar streams provided by team members BlueFire and Abengoa.

In parallel with the above activities at SzIBR,

- Solazyme will conduct laboratory work at the company's headquarters in South San Francisco, CA to optimize fermentation performance. This work will primarily focus EX 4 on cellulosic-derived sugar streams but will also support EX 4 the campaigns on sucrose.
- BlueFire and Abengoa will generate larger quantities of cellulosic-derived sugar streams to support both laboratory R&D as well as the cellulosic campaigns at SzIBR.
- UOP and REG will refine the purified algal oil produced at SzIBR in several large batches.

Period 3 (Months EX 4

Work in Period 3 is outside the project scope/budget, except for reporting. Period 3 will continue optimization on cellulosic-derived sugar streams and expand the throughput at which these campaigns are run. A key objective is to attain the same KPPs on a cellulosic-derived sugar stream by the middle of Period 3 as specified for sucrose at the end of Period 2. The throughput of these campaigns in Period 3 remains to be determined and depends on the availability and cost of cellulosic-derived inputs from demonstration-scale cellulosic biorefineries either already or soon to be under construction. Solazyme will negotiate supply agreements in Period 2, and may add new partners in addition to BlueFire and Abengoa in Period 3.

4.2. Schedule, Outcomes and Decision Points

Key project milestones include:

- NEPA process, detailed engineering, and other preliminary activities completed (Month
- SzIBR fully built, integrated and qualified for operation (Month
- KPP "Level 2" integrated process performance demonstrated on sucrose (Month
- Fermentation demonstrated at SzIBR on at least one cellulosic feedstock (Month
- **KPP "Level 3" integrated process performance demonstrated over a campaign on sucrose (this KPP level corresponds to commercial targets) – key project outcome (Month**
- Independent Engineer Performance Tests (IEPT) completed (Month
- Integrated process demonstrated on 1-2 cellulosic feedstocks (KPP "Level 2" targets) (Month
- "Level 3" integrated process performance demonstrated on 1-2 cellulosic feedstocks – note: this milestone is outside the project scope and budget; it is listed here for context only (Month

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EXEMPTION 4

Key decision points include:

- Go/No-go to Period 2? Depends on successful completion of Period 1 activities (Month
- Continue with both planned cellulosic-derived feedstocks or find a substitute (Months
- Demonstrate one or both cellulosic-derived feedstocks for the Month 39 milestone
- Go/No-go to Period 3? Continue with same feedstocks/partners in Period 3 or add partners (Month

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Figure N-4 depicts a simplified schedule for the subset of time-critical activities at SzIBR in Periods 1-2.

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Figure N-4. Overview of the project schedule focusing only on the subset of time-critical activities at SzIBR (Cherokee) and only for Periods 1-2. The critical path is highlighted in blue. Key milestones are indicated in green and refer to Table PEP-5.

4.3. Resource Loaded Plan and Spend Plan

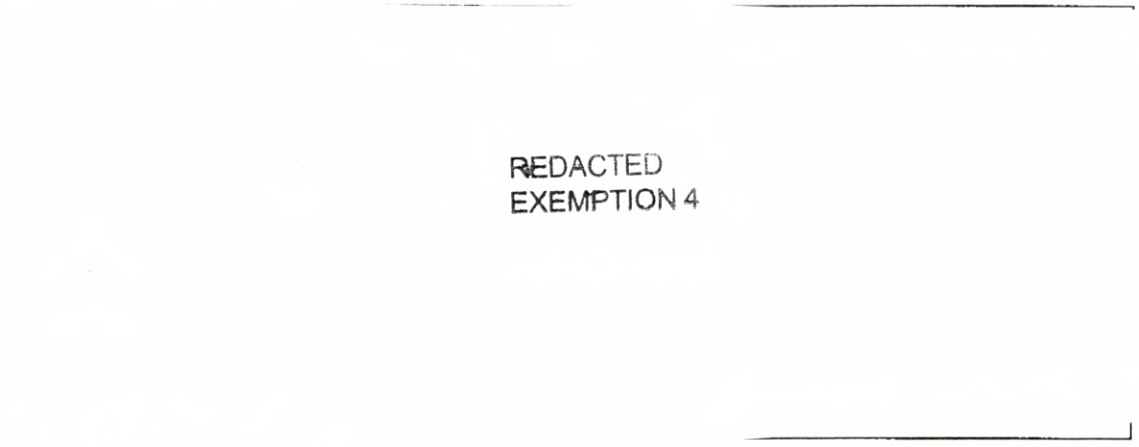

Figure N-5. Summary spend plan.

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WBS	Short Title	Months	Solazyme	Cherokee	Other Partner	Total
1.0	**Period 1**					
1.1	Period 2 Application					
1.2	NEPA					
1.3	Risk Management Plan					
1.4	Cherokee Site					
1.5	South San Francisco Site					
1.6	Abengoa Feedstocks					
1.7	BlueFire Feedstocks					
1.8	Reports					
2.0	**Period 2**					
2.1	SzIBR Construction					
2.2	SzIBR Operation					
2.3	Abengoa Feedstocks					
2.4	BlueFire Feedstocks					
2.5	Laboratory R&D					
2.6	Fuel Refining					
2.7	Reports					
3.0	**Period 3**					
3.1	Reports					
	TOTAL COSTS					

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Table N-1. Summary resource loaded plan.

5. Forecast Commercial-Scale Integrated Biorefinery Summary

5.1. Overview of the Commercialization Pathway

Commercial facilities arising out of the technology pathway embodied in this proposal will comprise a front-end module that converts lignocellulosic biomass to fermentable sugars coupled to a back-end module that converts the fermentable sugars to purified algal oil. The back-end module will implement Solazyme's cellulosic-sugar-to-algal-oil technology that the pilot-scale SzIBR will develop and demonstrate. Front-end modules will be provided by Solazyme's commercialization partners. Each facility will be a single entity, which will likely take the form of a joint venture between Solazyme and a partner, but might alternatively involve a partner licensing Solazyme's technology. We envision building facilities all around the US with multiple partners providing different front-end technologies utilizing a wide range of lignocellulosic feedstocks.

Solazyme is actively engaging dozens of partners and potential partners that span the entire value chain from biomass to sugar to oil to fuel to consumer, including: strategic feedstock growers; universities, national laboratories, and early-stage companies with nascent cellulosic conversion technologies; established companies that are actively deploying advanced cellulosic conversion technologies such as BlueFire and Abengoa; engineering companies with expertise in building large bioproduction facilities; key equipment vendors; partners that can help accelerate development and demonstration, such as Cherokee: fuel refiners and distributors such as REG, UOP, and Chevron; consumers of coproducts such as EX 4 engine and vehicle manufacturers; airlines; and potential customers with large vehicle fleets.

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The modular process design, non-exclusive partnership strategy and expected broad range of feedstocks combine to support a massively scalable commercialization strategy that can be replicated across every region of the country. Solazyme's proprietary algal strains will exploit a wide range of **non-food** carbon feedstocks, including but not limited to switchgrass, miscanthus, bagasse, sugar beet pulp, molasses, corn stover, wheat straw, energy cane, sorghum, poplar, biodiesel glycerol, other industrial byproducts, and municipal green waste. In aggregate, these feedstocks can be found throughout the US and potentially could supply tens of billions of gallons per year of liquid transportation fuels derived from algal oil.

The ability of SzIBR to serve as both a pilot and a demonstration scale facility (at no extra cost) plays a critical role in expediting the commercialization timeline.

5.2. Commercial Products and Sales

ComIBR's primary product, purified algal oil, will be sold to refiners, who will convert it to biodiesel or renewable diesel and then either resell the fuels to a wholesale distributor or distribute them directly. Solazyme expects to negotiate off-take agreements with a fixed price schedule over a term sufficient to pay back the debt portion of ComIBR's financing. Interest in algal biodiesel is extremely high and will almost certainly exceed Solazyme's ability to ramp production for the foreseeable future. Discussions with many of the top US energy and refining companies validate this expectation. While confidentiality agreements preclude disclosing the details of most of these discussions, the interest of Chevron and team member Renewable Energy Group can be mentioned. Chevron Technology Ventures is an investor in Solazyme, and REG, the largest marketer of biodiesel in the US, has expressed strong interest in refining and marketing Solazyme's algal biodiesel.

Biodiesel (ASTM D6751) is a certified and accepted fuel. Inspectorate America Corporation and the Southwest Research Institute have both independently verified that biodiesel refined from Solazyme's algal oil complies with all of the specifications. REG has determined that it exceeds the requirements for the company's highest value biodiesel, REG-9000-1.

Renewable diesel meets the same specification as petroleum diesel (ASTM D975) and therefore more closely resembles currently available petroleum diesel products than biodiesel. However, the EPA has not yet certified renewable diesel for sale in the United States. Dynamic Fuels (a joint venture between Syntroleum, Inc. and Tyson Foods) is expected to complete construction of the first renewable diesel fuel refining facility in the US in early 2010. Because the hydrotreating process takes all feedstocks to normal paraffins, which are then isomerized and fractionated, the chemical composition of the final product is independent of the feedstock. Thus, once a renewable diesel facility is certified for fuel production, no further testing will be required in order to use algae oil as a renewable diesel feedstock.

5.3. Commercial Economics

Solazyme projects that at commercial scale, the cost to produce one gallon of purified algal oil will range initially from to The range corresponds to different assumptions

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These numbers also rely on our partners' projections for the costs associated with the front-end modules necessary to form a unified integrated biorefinery. The front-end and back-end modules have been designed separately, and we have not yet accounted for synergies that will result from combining the two into a single plant, which should further reduce costs.

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The pro forma financial model for ComIBR conservatively corresponds to the high end of the cost range EX 4 . The estimated *wholesale* offtake price of algal oil in our model closely tracks the *retail* price (including taxes) of ultra-low sulfur diesel (ULSD): the blender's and RIN credits offset the cost of trans-esterification to biodiesel and retail markup. We apply the Energy Information Administration's most recent projections for ULSD prices in the time frame of commercial operation and assume that current biofuel credits and incentives are extended, but no new ones (e.g. carbon cap and trade) are introduced. This model — presented in the ProForma spreadsheet —results in a very attractive return on equity for investors in the plant. If we had used the more beneficial assumptions mentioned above, the returns would be even more impressive. (BCP Sections 2.5-2.6 discuss the financials in greater detail.)

5.4. Commercial Replication Schedule

We anticipate optimizing and qualifying additional front-end processes at SzIBR after construction of ComIBR EX 4 month period from financing to operation ending in EX 4 we expect to begin construction of EX 4 additional facilities with different partners at intervals of EX 4 . Once these initial facilities come on line and prove that they can operate according to design specification, we expect the pace of replication starting in EX 4 to increase to one new plant every EX 4 This schedule will result in EX 4 of capacity by EX 4 The steeply rising RFS mandates will likely make ethanol increasingly difficult to market late in the decade and thereby make renewable oil-based fuels even more attractive and valuable just at the time necessary to drive the inflection in the rate of plant construction. DOE's support for the proposed project is critical for the technology to reach maturity in time to exploit this window of commercial opportunity.

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6. Greenhouse Gas Reductions / Compliance with EISA 2007, Section 207(b)

The life cycle analysis detailed in Attachment R demonstrates an EX 4 GHG emissions for the primary biofuel (biodiesel) utilizing sucrose as the feedstock, compared with petroleum diesel in 2005, confirming that it is acceptable as the primary feedstock for the pilot plant under Topic Area 5 of the FOA in compliance with EISA 2007, Section 207(b). Commercial facilities utilizing *lignocellulosic* feedstocks will reduce GHG emissions by EX 4 , depending on the specific feedstocks and plant locations,

7. American Recovery and Reinvestment Act Information

7.1. Schedule for Completion Prior to 2015

Solazyme assures DOE that we can rapidly implement the project, successfully complete the scope, and submit all invoices long before September 30, 2015. The schedule for completing the project scope EX 4 as summarized in Figure N-4 on page 11 and further discussed in the PEP and PMP. Solazyme is prepared to begin the project immediately and believes that a project start date of January 2010 is possible if awards are made quickly. However, even in the scenario where the project does not begin until the last date permitted in the FOA (September 2010), Solazyme will still complete the project scope by EX 4 , long before the deadline imposed by the Recovery Act. In this scenario, even Period 3 (which is out of the project scope except for reporting) will be completed by

7.2. Job Creation and Preservation

The proposed project will create and preserve jobs in diverse regions across the country, including a preponderance of manufacturing, construction, and agricultural processing jobs, as tabulated in Table N-2. The project will directly create or preserve EX 4 jobs per year and indirectly create or preserve an estimated EX 4 jobs per year for a total of EX 4 jobs. The project will also help to establish US leadership in advanced renewable fuels and lay the foundation for hundreds of thousands of future "green" jobs which, by the nature of biofuels, cannot be exported.

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Component	State	Job Type	Jobs	Source
REDACTED EXEMPTION 4				
Total direct jobs				
Indirect jobs (manufacturing sector)			2.9X	Josh Bivens. Updated Employment Multipliers for the U.S. Economy (2003). EPI #268.
Indirect jobs (other sectors)			1.5X	
Total indirect jobs				
Total jobs created / preserved				

Table N-2. Estimated job creation and preservation for the proposed project.

8. Cost Share

Solazyme and team members Cherokee Pharmaceuticals, Abengoa Bioenergy, and UOP together propose to cost share Ex 4 of the total project costs, as documented in the project budget and the attached letters of commitment.

We believe this level of cost share is justified and appropriate because

- Solazyme is investing and will continue to invest heavily in technologies and process improvements that are complementary to, but outside the formal scope of, the proposed project. Examples include ongoing REDACTED EXEMPTION 4 . These activities have been excluded from the project scope to remain consistent with the guidance of the FOA. They nevertheless will proceed in parallel with the project, will enhance the commercial viability of the technology, will directly impact and accelerate the commercialization pathway, and effectively represent a much higher level of co-investment in the technology beyond the formal cost share.
- Solazyme is absorbing all the risk of project cost overruns and contributing its share entirely in cash.
- The proposed technology offers unique public benefits, which accrue to the nation, not found in other projects. The combination of (i) oil-based renewable biofuels that identically replace petroleum equivalents, (ii) a fast commercialization pathway, and (iii) complementarity with a wide range of front-end lignocellulosic conversion technologies and feedstocks offers an exceptional opportunity to help the US meet and exceed the ambitious goals of the RFS and achieve energy security. (Cf. Section 3.4.)
- Access to capital remains at an historic low point. Solazyme successfully closed a $57M Series C funding round in June, demonstrating extraordinary interest in the technology despite the general investment climate. However, the company must exercise extreme fiscal prudence in the current environment. A higher level of public support is in the national interest from a counter-cyclical perspective and will position the technology for wholly private support at the commercial level in the time frame when the investment situation is expected to be reversed.

9. Project Differentiation

The scope of the proposed project does not overlap with any other current or prospective awards.

American Recovery and Reinvestment Act of 2009, P.L. 111-5 (Recovery Act) Additional Budget Justification Information Applicable to ship provide information which validates that all laborers and mechanics on projects funded directly by or assisted in whole or in part by and through funding appropriated by the Recovery Act are paid wages at rates not less than those prevailing on projects of a character similar in the locality as determined by submitted in 31 Chapter 31 of the 40, United States Code (Davis-Bacon Act). For guidance on how to comply with this provision, see http://www.dbl.gov/esa/whd/contracts/dbra.htm

To satisfy this requirement, please provide a written affirmation that you will comply with the Davis-Bacon Act, as identified above, along with

Affirmed by

Johannes Wolfram, CEO

Solazume Inc.

CHEROKEE
PHARMACEUTICALS
A PRWT LIFE SCIENCES COMPANY

Cherokee Pharmaceuticals LLC
1835 Market Street – Suite 1100
Philadelphia, PA 19103

Manufacturing Site:
100 Avenue C
P.O. Box 367
Riverside, PA 17868

+1 215 988 8979 office
+1 225 933 1515 mobile
+1 215 569 1925 fax
dennis.bauer@cherokee-pharma.com

June 29, 2009

Mr. Tyler Painter
Chief Financial Officer
Solazyme, Inc.
561 Eccles Avenue
South San Francisco, CA 94080

RE: Cost Share - Integrated Biorefinery Operations

Dear Tyler:

Cherokee Pharmaceuticals LLC looks forward to the opportunity to participate in the U.S. Department of Energy project for the Demonstration of Integrated Biorefinery Operations in response to Funding Opportunity Announcement Number DE-FOA-0000096.

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EXEMPTION 4

We are pleased that you have selected us as the site for your integrated biorefinery and we will endeavor to help make the project a success. We believe that Solazyme's heterotrophic algal technology represents an important advance both for renewable biofuels and for industrial bioproduction, and we are excited to play a pivotal role in this project.

Best regards,

Dennis P. Bauer, Ph.D.
Vice President – Sales & Marketing

cc: Mkt Files, Elliot, Haney, Noll

UOP LLC
25 E. Algonquin Rd.
Des Plaines, IL 60017-5017

Tel: 847.391.2000
Fax: 847.391.2253
www.uop.com

June 16, 2009

Dr. Matthew Frome
Director of Business Development
Solazyme
561 Eccles Avenue
South San Francisco, CA 94080

RE: Letter of support for the cost share for the DOE-FOA-0000096 application:
Solazyme Integrated Biorefinery (SzIBR): Diesel Fuels from Heterotrophic Algae

Dear Dr. Frome:

UOP, LLC looks forward to the opportunity to participate in the U.S. Department of Energy project for the Demonstration of Integrated Biorefinery Operations in response to Funding Opportunity Announcement Number DE-FOA-0000096.

UOP LLC is a leading international supplier and licensor of process technology, catalysts, adsorbents, process plants, and consulting services to the petroleum refining, petrochemical, and gas processing industries. Launched in late 2006, our Ecofining™ process technology is the first commercial product from UOP's Renewable Energy & Chemicals business unit. UOP is developing and commercializing technology to produce transportation fuels and chemicals from biofeedstocks ranging from vegetable and algal oils to second generation cellulosic waste feedstocks like corn stover or wood chips.

As a member of this project team, we agree to contribute cost share of EX4 of the project costs if the program is selected. Based on the current budget, the UOP costs are expected to be EX4 with UOP contributing EX4

We are pleased to be included in this program to produce renewable diesel from Solazyme's algae oil. We believe that Solazyme's heterotrophic algal technology represents an important advance for renewable biofuels, and are excited to play an important role in this project.

If you have any questions, please feel free to contact me.

Best Regards,

Jennifer Holmgren
General Manager
Renewable Energy and Chemicals

ABENGOA BIOENERGY
ABENGOA BIOENERGY NEW TECHNOLOGIES

11500 W 13th Avenue
Lakewood, CO 80215
Telephone (+) 303-928-8500
Fax (+) 303-928-8510

June 26, 2009

Dr. Tony Day
Solazyme, Inc.
561 Eccles Avenue
South San Francisco, CA 94080

Dear Dr. Day,

I write in support of your application "Sustainable Feedstock Production Supply Systems to Support Cellulosic Biorefinery Industries" to be submitted to the U. S. Department of Energy's Funding Opportunity.

Your efforts in the utilization of algae to ferment sugars, specifically derived from cellulosic, to lipid based fuels aligns with our research, demonstration and production of low cost fermentation sugars from biomass. We are willing to produce fermentable sugars from biomass in our pilot plant in York, NE for your use in the production of lipid oils from algae. If your proposal is awarded by the DOE, we agree to contribute cost share of EX4 of the cost of producing fermentable sugars from biomass in our pilot plant up to a maximum of EX4

We look forward to your success in this project.

Sincerely,

Robert J. Wooley, PhD, PE
Director, Process Engineering

Science. Solutions. Service

OMB Number: 4040-0010
Expiration Date: 08/31/2011

Project/Performance Site Location(s)

Project/Performance Site Primary Location ☐ I am submitting an application as an individual, and not on behalf of a company, state, local or tribal government, academia, or other type of organization.

Organization Name: Solazyme, Inc.

DUNS Number: 1458620120000

* Street1: 561 Eccles Avenue

Street2:

* City: South San Francisco County: San Mateo

* State: CA: California

Province:

* Country: USA: UNITED STATES

* ZIP / Postal Code: 94080-1906 * Project/ Performance Site Congressional District: CA-012

Project/Performance Site Location 1 ☐ I am submitting an application as an individual, and not on behalf of a company, state, local or tribal government, academia, or other type of organization.

Organization Name: Cherokee Pharmaceuticals LLC

DUNS Number: 0137325420000

* Street1: 100 Avenue C

Street2:

* City: Riverside County: Northumberland

* State: PA: Pennsylvania

Province:

* Country: USA: UNITED STATES

* ZIP / Postal Code: 17868-0367 * Project/ Performance Site Congressional District: PA-010

Project/Performance Site Location 2 ☐ I am submitting an application as an individual, and not on behalf of a company, state, local or tribal government, academia, or other type of organization.

Organization Name: Bluefire Ethanol, LLC

DUNS Number: 8014268960000

* Street1: 31 Musick

Street2:

* City: Irvine County: Orange

* State: CA: California

Province:

* Country: USA: UNITED STATES

* ZIP / Postal Code: 92618-1638 * Project/ Performance Site Congressional District: CA-048

Project/Performance Site Location(s)

Project/Performance Site Location 3

☐ I am submitting an application as an individual, and not on behalf of a company, state, local or tribal government, academia, or other type of organization.

Organization Name: Abengoa Bioenergy Corp

DUNS Number: 8748198400000

* Street1: 1414 Road O

Street2:

* City: York County: York

* State: NE: Nebraska

Province:

* Country: USA: UNITED STATES

* ZIP / Postal Code: 68467-8236 * Project/ Performance Site Congressional District: NE-003

Project/Performance Site Location 4

☐ I am submitting an application as an individual, and not on behalf of a company, state, local or tribal government, academia, or other type of organization.

Organization Name: Renewable Energy Group

DUNS Number: 7881177160000

* Street1: PO Box 888

Street2:

* City: Ames County: Story

* State: IA: Iowa

Province:

* Country: USA: UNITED STATES

* ZIP / Postal Code: 50010-0888 * Project/ Performance Site Congressional District: IA-005

Project/Performance Site Location 5

☐ I am submitting an application as an individual, and not on behalf of a company, state, local or tribal government, academia, or other type of organization.

Organization Name: UOP, LLC

DUNS Number: 0442842920000

* Street1: 175 W Oakton St

Street2:

* City: Des Plaines County: Cook

* State: IL: Illinois

Province:

* Country: USA: UNITED STATES

* ZIP / Postal Code: 60018-1834 * Project/ Performance Site Congressional District: TX-022

Solazyme Integrated Biorefinery (SzIBR): Diesel Fuels from Heterotrophic Algae

Topic 5 Pilot-Scale Project in Response to DE-FOA-0000096
PI: David Brinkmann

Project Objectives and Significance

Solazyme, Inc. proposes to build, operate and optimize a pilot-scale "**S**ola**z**yme **I**ntegrated **Bio**r**e**finery." SzIBR will demonstrate integrated scale-up of Solazyme's novel heterotrophic algal oil biomanufacturing process, validate the projected commercial-scale economics of producing multiple advanced biofuels, and enable Solazyme to collect the data necessary to complete design of the first commercial-scale facility.

Solazyme's approach forges the crucial link from high-impact, domestic, renewable *lignocellulosic* feedstocks to *oil-based* fuels that leverage and remain fully compatible with the petroleum economy. The technology can efficiently transform a wide range of environmentally sustainable, domestically available biomass sources into biofuels identical to the petroleum-based fuels they replace, at comparable cost. Competing approaches, in contrast, offer imperfect fuel substitutes rather than chemically identical replacements. Solazyme's approach will enhance national energy security and help the US to reach the goals of the Renewable Fuel Standard (RFS) not only by displacing petroleum imports, but also by maintaining full compatibility with existing petroleum refining, distribution, storage, retailing and vehicle infrastructure. The proposed project will substantially accelerate the technology along the pathway to full commercialization.

Technical Approach and Project Partners

Some algae possess internal biochemical pathways that synthesize oil more efficiently than any other known natural or engineered process. Under the right conditions, certain algal species produce so much oil that the oil constitutes over 75% of the dry weight of the cells, so it's not surprising that the world's petroleum deposits consist largely of the fossilized remains of prehistoric algal blooms.

In Solazyme's innovative process, algae grow efficiently in the dark in industrial fermentation vessels to very high cell densities. They ingest and metabolize carbon substrates provided in the growth media and convert them to triglycerides – nearly identical in composition to common vegetable oils. The quantity of oil produced per day per liter of fermentor volume is extremely high. This high productivity makes the process extremely capital efficient and economically far more attractive than biofuel concepts that rely on photosynthetically grown algae, or that produce ethanol or many other non-ideal fuel substitutes.

Solazyme has also pioneered methods to recover and purify the algal oil inexpensively with high yield. Existing oil refineries can either transesterify the purified algal oil to yield biodiesel, or hydrotreat it to yield renewable diesel or jet fuels. Solazyme has already produced thousands of gallons of algal oil and has refined algal oil into fuels that comply with applicable ASTM standards without any blending with other fuels or fuel feedstocks. Partners Renewable Energy Group and UOP will convert the algal oil produced in the project to finished transportation fuels.

SzIBR will primarily utilize sucrose as a transitional feedstock in the project to advance technology scale up as rapidly as possible. Solazyme will also demonstrate production at SzIBR of algal oil derived entirely from lignocellulosic feedstocks (switchgrass, corn stover, wheat straw and/or municipal green waste) as part of the project. Solazyme's biofuels derived from these feedstocks will reduce lifecycle greenhouse gas emissions by over 90%. Partners Abengoa Bioenergy and BlueFire Ethanol will provide the complementary technology needed to convert these feedstocks into a form that the algae can metabolize.

Solazyme will build SzIBR on the site of an existing commercial bioproduction facility, which the project will extensively leverage to reduce the time, cost, and risk of commencing pilot-scale operations.

DAVID F. BRINKMANN
561 Eccles Avenue
South San Francisco, CA 94040
650-780-4777
dbrinkman@solazyme.com

PRINCIPAL INVESTIGATOR

Chemical Engineer with over 33 years experience in process development, operations management, and technical leadership, mostly in the bio-process industry. Mr. Brinkmann has successfully developed and scaled up fermentation and downstream processes for a wide variety of bio-based products and organisms. He demonstrates extensive experience at design and management of bio-process facilities, as well as coordination of CROs & CMOs. Strengths include techno-economic modeling and strong communication skills.

PROFESSIONAL EXPERIENCE

Solazyme Inc – South San Francisco CA
Vice President Manufacturing (Mar'09 – present)
Senior Director Process Development & Manufacturing (Jul'07 – Feb'09)
• Responsible for Fermentation and Downstream Process Development teams, including in-house activities as well as scale up and toll manufacturing of Solazyme products at CROs & CMOs.
• Built a very strong Process Development Team. Designed and implemented highly functional fermentation and downstream process development lab facilities.
• Developed detailed techno-economic models for algal oil manufacturing. Contracted with a capital engineering firm for development of detailed mfg plant design and capital cost.
• Achieved very significant (many fold) improvements in fermentation productivity and mfg cost for algal oils, mainly via fermentation process optimization.
• Developed a functional process for extraction and conversion of algal oil.
• Transferred process technology and produced large quantities of algal oil at multiple CMOs.
• Coordinated closely with Solazyme Research, Bus Dev and Product Dev teams.
• Functioned as part of Solazyme senior management team. Presented to venture capitalists and potential strategic partners.

CP Kelco – San Diego CA
Director Biospecialties Operations (Apr'04 – Jul'07)
Manager Biotechnology Pilot Plant Operations (Jul'97 – Apr'04)
• Responsible for $7M operating budget and all operational aspects of a large Biotechnology Pilot Plant & Semiworks (up to 75 m3 fermentation scale) located at a xanthan gum mfg plant site.
• Member of Kelco's Site Management Team.
• Co-founded Kelco's Biospecialties Group (KBG). Collaborated closely on a) KBG strategic planning, and b) scouting and identification of potential KBG business venture partners.
• Served as primary contact for technical inquiries regarding KBG capabilities and services.
• Provided operational, technical, and mfg economics input for evaluation and negotiation of KBG deal structures and contracts.
• Directed on-site technical evaluation and implementation of KBG opportunities, including technology transfer and equipment modifications within BPP & Semiworks.
• Interfaced with Process R&D and Mfg Support teams to provide techno-economic modeling and to prioritize BPP fermentation & downstream process activities in support of Kelco biogums programs such as productivity improvement, cost reduction, introduction of new/differentiated biogums, etc.

• Directed and prioritized Semiworks production of a) new Kelco biogums for market evaluation, and b) toll mfg contracts for KBG products.
• Responsible for providing monthly KBG sales and mfg forecasts. Functioned as primary interface with KBG customers regarding technical performance, contract orders, shipments, invoices, etc.
• KBG opportunities spanned a very wide range, including fermentation and downstream processing for: algal oils (HUFAs & others), biodegradable plastics, enzymes, pharma intermediates, vitamins, antiviral proteins, carotenoids, flavors & fragrances, biopesticides, etal. Organisms included: bacteria, yeast, algae, and fungi.

A.E. Staley Manufacturing Co (Tate & Lyle) – Decatur IL
Manager Bioengineering Development (Oct'94 – Jul'97)
• Designed, implemented, and directed a biotechnology development lab / pilot plant located on-site at a large corn wet milling facility.
• Directed process development activities for lactic acid (bacterial) and citric acid (fungal).
• Provided operational, technical and mfg economics expertise in evaluation of potential new biochemicals ventures.

Weyerhaeuser – Federal Way WA
Sr. Bioengineering Specialist (Jan'88 – Oct'94)
• Responsible for process development and commercialization of bacterial cellulose ("Cellulon").
• Scaled up the Cellulon process (fermentation and downstream) from lab scale to commercial scale.
• Directed pilot scale fermentation development program at contract research facility.
• Designed, implemented and directed industrial scale (185 m3) production at toll manufacturing facility, to provide Cellulon in quantities suitable for market development.
• Provided detailed process technology transfer to potential Cellulon business venture partners / buyers.

Stauffer Chemical Co – Rochester MN
Technical Superintendent (May'84 – Dec'87)
• Designed, implemented, and directed on-site fermentation support lab at a whey-based fermentation and spray drying plant.
• Directed process development activities for anaerobic bacterial organic acid fermentation process.
• Scaled up aerobic bacterial polysaccharide process from lab scale to commercial scale.
• Implemented and directed industrial scale (175 m3) production at toll manufacturing facility, to provide product in quantity for market development.

Stauffer Chemical Co – San Jose CA
Manager Fermentation Operations (Nov'82 – May'84)
Fermentation Superintendent (Oct'81 – Nov'82)
Sr. Process Engineer (Jun'80 – Oct'81)

Diamond Shamrock Corp –Fairport Harbor OH and Redwood City CA
Process Engineering Supervisor, Redwood City CA (Aug'79 – Jun'80)
Process Engineer, Redwood City CA (Jul'77-Aug'79)
R&D Engineer, Fairport Harbor OH (Jun'75 – Jul'77)

EDUCATION
Case Western Reserve University, Cleveland, OH
BS Chemical Engineering *magna cum laude* **(Jun'75)**