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Clean Transportation Program

FINAL PROJECT REPORT

Bakersfield Biodiesel and Glycerin Production Plant Expansion

Prepared for: California Energy Commission
Prepared by: Crimson Renewable Energy, L.P.

Gavin Newsom, Governor
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Finally, this project could not have succeeded without the hard work of our own team members, including Joel Pierce, Cory Busby, Bharathwaja Vignesh, John Bindert, and Steve Bond.

Harry Simpson

President

Crimson Renewable Energy, L.P.

PREFACE

Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007) created the Clean Transportation Program, formerly known as the Alternative and Renewable Fuel and Vehicle Technology Program. The statute authorizes the California Energy Commission (CEC) to develop and deploy alternative and renewable fuels and advanced transportation technologies to help attain the state's climate change policies. Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) reauthorizes the Clean Transportation Program through January 1, 2024, and specifies that the CEC allocate up to $20 million per year (or up to 20 percent of each fiscal year's funds) in funding for hydrogen station development until at least 100 stations are operational.

The Clean Transportation Program has an annual budget of about $100 million and provides financial support for projects that:

- Reduce California's use and dependence on petroleum transportation fuels and increase the use of alternative and renewable fuels and advanced vehicle technologies.
- Produce sustainable alternative and renewable low-carbon fuels in California.
- Expand alternative fueling infrastructure and fueling stations.
- Improve the efficiency, performance and market viability of alternative light-, medium-, and heavy-duty vehicle technologies.
- Retrofit medium- and heavy-duty on-road and nonroad vehicle fleets to alternative technologies or fuel use.
- Expand the alternative fueling infrastructure available to existing fleets, public transit, and transportation corridors.
- Establish workforce-training programs and conduct public outreach on the benefits of alternative transportation fuels and vehicle technologies.

The Energy Commission issued solicitation Program Opportunity Notice (PON)-13-601, to provide funding opportunities under the ARFVTP to produce sustainable, alternative, and renewable low-carbon fuels in California to reduce dependence on petroleum, increase alternative and renewable fuels, help attain state climate policies and goals, and stimulate in-state economic development. To be eligible for funding under PON-13-601, the projects must also be consistent with the Energy Commission's ARFVTP Investment Plan, updated annually. The recipient submitted an application in response to PON-13-601; Crimson Renewable Energy LP.'s application was proposed for funding in the Energy Commission's notice of proposed awards on November 7, 2013, and executed as ARV-13-007 on December 19, 2013. Staff completed and closed the project May 30, 2017.

ABSTRACT

Crimson Renewable Energy LP. proposed to increase the production capacity of its existing biodiesel production facility, located in Bakersfield (Kern County), via a series of process upgrades that were designed to reduce existing bottlenecks and speed throughput. Crimson Renewable Energy LP. completed key process improvements in seven categories: (1) expansion of the biodiesel wash water system; (2) installation of a new crude glycerin processing system; (3) improvements to feedstock washing and drying throughput; (4) improvements to transfer rates from feedstock drying to acid esterification processes; (5) installation of additional heating capacity; (6) installation of a new transesterification reactor; and (7) expansion of biodiesel production capacity to 17 million gallons per year. These upgrades were also designed to enable the plant to complete an additional future Phase-2 capacity expansion that, with additional upgrades, would allow the plant to reach a total capacity of 22 million gallons per year.

During the execution of this project, Crimson Renewable Energy LP. not only met all critical objectives, but exceeded its original Phase-1 production goal of 17 million gallons per year in 2016 by producing approximately 19.6 million gallons per year.

In accordance with Energy Commission requirements, Crimson Renewable Energy LP. operated the upgraded plant and collected data over a six-month demonstration period, which began on October 1, 2016 and ended on March 31, 2017.

Utilizing the plant as currently configured with equipment and systems installed over the course of the project, Crimson Renewable Energy LP. estimates a total production volume of 21 million gallons per year for 2017, an increase of 23.5 percent versus the proposed 17 million gallons per year production goal identified under ARV 13-007.

Keywords: Crimson Renewable Energy LP., biodiesel, alternative fuels, carbon intensity, greenhouse gas, glycerin, transesterification.

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EXECUTIVE SUMMARY

Introduction

Crimson Renewable Energy LP. operates its Bakersfield Biodiesel & Glycerin Production Plant, which is one of the largest commercial biodiesel production facilities in California and the western United States. Prior to implementation of the project, the baseline plant converted ultra-low-carbon-intensity feedstocks such as used cooking oil, animal fats, and waste corn oils from the ethanol production process into biodiesel. Product fuel amounted to a maximum of 10.6 million gallons per year of clean-burning, drop-in American Society for Testing and Materials D6751 biodiesel that is sold into the California market; however, plant throughput was limited by a number of equipment and process challenges, which hindered Crimson Renewable Energy LP.'s ability to increase biodiesel production.

Energy Commission funding for this project grant totaled $5 million. Crimson Renewable Energy contributed just over $6 million in private match funding. Total project cost was $11,017.047.

Project Purpose

The project sought to deploy a series of upgrades to help address baseline constraints on biodiesel production rate, and to address key Assembly Bill 118 goals. These goals included producing sustainable, alternative, and renewable low-carbon fuels in California to reduce California's reliance on petroleum transportation fuel, increasing use of alternative and renewable fuels, helping to attain state climate change policies, and stimulating economic development in state. To this end, the project team completed strategic upgrades to Crimson Renewable Energy LP.'s baseline biodiesel production facility to increase throughput to 17 million gallons per year. Crimson Renewable Energy LP.'s team achieved this upgrade through a series of specific, targeted equipment and process upgrades that included:

1. Removing bottlenecks that prevented the plant from maximizing its baseline potential production capacity;
2. Increasing the plant's ability to process available lower carbon intensity feedstock (i.e., waste corn oil from ethanol plant distiller's grains), thereby reducing biodiesel carbon intensity;
3. Expanding the baseline plant to increase ultra-low carbon intensity biodiesel production throughput to 17 million gallons per year; and
4. Laying the groundwork for a second Phase-2 expansion to follow completion of the project, ultimately supporting an increase in throughput to 22 million gallons per year, processing of lower quality feedstock, further reducing water consumption, and staying ahead of market-driven fuel standards.

Project Results

By completing various targeted and carefully researched/investigated upgrades at Crimson Renewable Energy LP.'s Bakersfield facility, the project was able to successfully increase plant throughput from 10.6 million gallons per year to 19.6 million gallons per year, exceeding initial targets. With support from the Energy Commission, Crimson Renewable Energy LP. achieved this increase while reducing energy and water demand per unit biodiesel production, providing

10 new permanent operations period jobs, and supporting over $500 million in economic activity over the project lifetime.

Based on the successes of this project, future recommendations applicable to Crimson Renewable Energy LP. and to biodiesel producers in general include continued evaluation and identification of process bottlenecks, and opportunities to improve water use and energy use efficiency. Project upgrades that support these improvements while also enabling the use of a wider array of feedstock are especially critical to the future development and expansion of biodiesel production in California, as needed to meet state statutory goals with respect to renewable energy production and use.

Project Benefits

The project resulted in the following key benefits:

- Increased biodiesel production by 9.0 million gallons per year
- Offset 8.5 million gallons per year of conventional fossil diesel consumption
- Reduced greenhouse gas (GHG) emissions by 94,164 metric tons per year
- Demonstrated process optimization and removal of biodiesel production bottlenecks to substantially increase biodiesel production throughput and efficiency
- Optimized energy usage at the facility
- Total reduction in plant water consumption of 29.3 percent on average
- Reduced diesel particulate matter emissions by 49,115 lb/year, hydrocarbon emissions by 54,927 lb/year, carbon monoxide by 542,013 lb/year, and sulfur dioxide by 42,969 lb/year
- Supported 33.9 full time equivalent construction jobs and 10 full time equivalent, permanent operations jobs
- Laid groundwork for future expansion of Crimson Renewable Energy LP.'s facility to 22 million gallons per year

CHAPTER 1: Introduction

Project Recipient

Crimson Renewable Energy LP. (Crimson) is a California limited partnership and biodiesel producer with strong energy industry production and logistics experience. Crimson has more than eight years of large-scale/high-volume industrial biodiesel production experience in California and is currently the state's largest producer of low- and ultra-low-carbon biodiesel within California. Additionally, Crimson has eight years of experience marketing biodiesel in California, with a current customer base that includes all active California petroleum refiners and several major fuel wholesalers and truck stop operators. Crimson also has a proven in-house engineering and plant operations team that has demonstrated its ability to manage the design, construction, and operation of a large-scale biodiesel production facility, while successfully and consistently operating at high-capacity utilization rates.

Crimson maintains a deep commitment to product quality. Since 2012, the existing Crimson biodiesel production facility has been BQ-9000®[1]-certified, a sign of Crimson's longstanding track record of producing biodiesel that exceeds industry standards. Thanks in part to funding received under this grant, Crimson was able to produce approximately 17.9 million gallons of biodiesel in 2016, effectively replacing imports with approximately 7.3 million gallons of new in-state production in comparison with the pre-expansion plant's production output. Presently, Crimson is planning further expansion of its existing facility, a process that is expected to bring the company's total annual California production to 36 million gallons per year in 2019.2

Project Overview: Purpose, Goals, and Objectives

Through implementation of the Bakersfield Biodiesel and Glycerin Production Plant Expansion project, the Recipient sought to address Assembly Bill 118 goals of producing sustainable, alternative, and renewable low-carbon fuels in California by implementing the following project goals:

1. Increase the volume of cost-competitive, ultra-low-carbon -intensity biodiesel available for blending in California's transportation fuels.
2. Encourage the development of a thriving, California-based ultra-low-carbon-intensity feedstock production market.

To achieve these goals, Crimson pursued and achieved the following objectives:

- Remove critical bottlenecks that prevented the existing plant from achieving its nameplate production capacity, using ultra-low-carbon-intensity feedstock. Activities targeting this objective included:

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[1] The National Biodiesel Accreditation Program is a cooperative and voluntary program for the accreditation of producers and marketers of biodiesel fuel called BQ-9000®. (http://biodiesel.org/production/bq-9000)

- Improvement and expansion of the biodiesel washing system by adding new additional washing systems also anticipated to reduce water consumption by up to 40 percent
- Installation of a new continuous process Glycerin Processing System capable of matching acid and transesterification throughput and increasing recovery of unprocessed and partially processed oils
- Improvement of feedstock pretreatment system throughput by adding a new, larger capacity decanting centrifuge and upgrading pumps and other equipment
- Improvement of throughput from feedstock drying to acid esterification processes by reducing the time needed to fill the acid esterification reactor by 65 to 80 percent, increasing acid esterification throughput by 25 percent
- Increasing biodiesel production capacity from 10.6 million gallons per year to 17 million gallons per year
- Laying the groundwork for Phase-2 improvements to further increase production capacity to 22 million gallons per year
- Installation of a new, higher capacity steam heating system, sufficient for methanol recovery, glycerin processing, and feedstock drying demands of the plant operating at 22 million gallons per year.
- Install a new 8,000-gallon transesterification reactor to provide a total reactor capacity of 24,000 gallons

These activities comprise the project, and are described in detail below.

Project Elements

The project focused on optimizing system inefficiencies and bottlenecks in order to greatly improve biodiesel throughput. To that end, Crimson designed a project that comprised seven discrete project elements, each of which targeted an objective outlined above.

Improvement and Expansion of Biodiesel Wash System

Before Crimson began the project, its biodiesel water wash system acted as a bottleneck that prevented further production increases. Furthermore, these systems required improvement to reduce the volumes of water being utilized for this unit process—approximately 0.4 gallons of water per gallon of biodiesel produced—that later had to be removed during the subsequent methanol recovery and glycerin processing steps. The removal process, particularly as part of the glycerin processing system, required large amounts of energy and was a major factor that had limited the existing biodiesel plant's production to 10.6 million gallons per year. Therefore, one critical project objective was to expand the capacity of the biodiesel wash system in a manner that would reduce overall plant water consumption by up to 40 percent, in comparison to the baseline plant, which had a total water consumption that ranged from approximately 1.2 to 1.6 gallons of water per gallon of biodiesel produced.

New Glycerin Processing System

During operation of the baseline biodiesel production plant, the glycerin processing system acted as a significant bottleneck for system capacity, primarily due to inefficiencies in the design of the plant's neutralization and acidulation process. Additionally, the baseline system for recovery of unprocessed oil and partially processed esters operated as a batch process, and, as a result, was unable to wholly recover unprocessed oil or partially processed esters. Under the project, Crimson directly addressed this issue by installing a new glycerin processing system to allow for continuous neutralization and acidulation as a single process function. The new glycerin processing system also served to increase the efficiency of the plant's salt removal system. In this manner, this portion of the project was designed to increase throughput rates to match the capacity/processing rates of the existing acid esterification and transesterification systems. The new continuous neutralization system also significantly improved the recovery of unprocessed oil and partially processed esters. These recaptured flows could then be re-processed, contributing to further increases in overall plant output on an annual basis.

Improve Feedstock Washing Throughput

The plant's original centrifuge was prone to frequent stoppages due to fouling of the disk stack by the incoming feedstock. This was caused by particles and other solid contaminants contained in the incoming feedstock, which easily fouled the disk-stack. The objective of this element of the project was to reduce downtime by adding a new, larger-capacity three-phase centrifuge that would offer greater reliability in comparison to the baseline disc-stack centrifuge for feedstock washing. The proposed centrifuge was anticipated to be better able to handle solids in the incoming feedstock, helping to precipitate those with water and/or a combination of water and acid. Additionally, certain elements of the baseline feedstock pretreatment system were to be changed and enlarged, in order to improve the overall capacity of the feedstock washing system and to reduce fouling in the heat exchangers.

Improve Throughput from Feedstock Drying to Acid Esterification

Before this project, the baseline acid esterification reactor was functional, but fill rates were limited by the flow rate of the feedstock drying systems. Improvements to the feedstock drying system and the addition of a new process vessel upstream of the acid esterification reactors reduced the time needed to fill the acid esterification reactor by 65-80 percent and, thereby, increased throughput of the acid esterification reactors by 25 percent overall. Thus, Crimson added a new buffer vessel and transfer pumps to facilitate continuous input from the feedstock drying process, while enabling transfer of feedstock into the acid esterification reactors at a rate of 250 gallons per minute.

Steam Heating Capacity

Additional steam heating capacity was needed to provide sufficient heating for methanol recovery, glycerin processing, and the feedstock drying systems that would ultimately operate at flow rates necessary for an annual production rate of 22 million gallons per year. Crimson added a new 28 million British thermal units per hour steam heating system to meet this objective, sufficient to support a Phase-2 biodiesel plant capacity of 22 million gallons per year.

Install New Reactor Capacity

The project included updates to the baseline biodiesel transesterification reactor system. Specifically, the project installed a single new, 8,000 gallon transesterification reactor. This new reactor increased overall plant transesterification reactor capacity from 16,000 gallons to 24,000 gallons, allowing for more rapid throughput.

Increase Biodiesel Production to 17 Million Gallons per Year

The above mentioned upgrades were expected to be sufficient to enable the plant to increase its production capacity from approximately 10.6 million gallons per year to 17 million gallons per year. Further, the project was expected to lay the groundwork for future Phase-2 improvements that would increase production capacity to 22 million gallons per year, and that would include the addition of a new biodiesel distillation system. However, the new systems and improvements implemented during 2014 through 2016 (partially funded by this grant) performed better than originally anticipated. Presently, Crimson believes that it can achieve 21 million gallons per year of annual production in 2017, using its currently installed equipment and systems, and feedstock with free fatty acids of up to 16 percent.

Reduce Biodiesel Carbon Intensity

Although not included as an explicit project objective, the above-mentioned upgrades were also expected to provide process efficiency improvements that would, overall, reduce biodiesel carbon intensity values during the project operation phase. Crimson estimated that these upgrades would be sufficient to reduce carbon intensity values from 14 grams of carbon dioxide equivalent (CO_2e)/megajoule in the baseline plant to 12 grams CO_2e/megajoule or less at the end of Phase-1.

Figure 1 shows the Crimson's biodiesel and glycerin production facility in 2013, prior to the upgrades that were completed under this project.

Figure 1: Biodiesel and Glycerin Production Facility in 2013

Source: Crimson Renewable Energy LP

Project Team

Crimson Renewable Energy LP.

- Harry Simpson, President
- Cory Busby, Plant Manager
- Bharathwaja Vignesh, Plant Engineer

Denuo Energy

Joel Pierce – Senior Process Engineer (currently Director of Engineering for Crimson Renewable Energy LP.)

BDI Industries

- Johann Schlögl, Head of Mechanical Engineering
- Dr. Martin Ernst, Head of Biofuels Working Group
- Wolfgang Jeitler

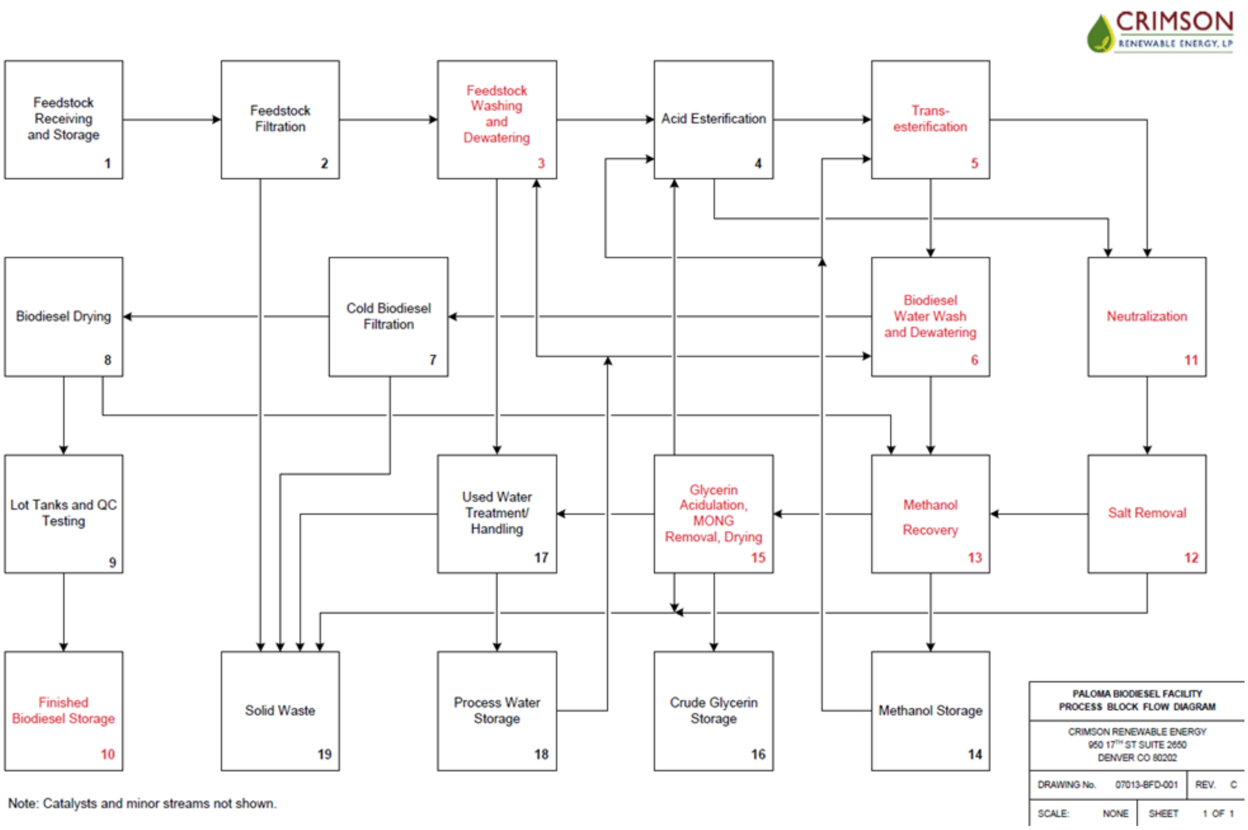
Engel & Company, Engineers

- Steve Bluhm, Professional Engineer

CHAPTER 2: Project Implementation

Project implementation included specific activities that addressed each of the objectives listed in Section 1.3. The following discussion summarizes baseline facilities and condition; reviews actions and activities, including equipment installations, completed under the project; and discusses minor changes to the proposed installations that were made during the implementation process. Overall, the proposed upgrades enabled the plant to transition from the processes and flows of the original plant to the upgraded facility, as shown in the block flow diagram in Figure 2. During the project, Crimson eliminated several process bottlenecks and completed several energy efficiency upgrades, including steam heat supply improvements, vacuum system updates, significantly reduced water use via an upgraded biodiesel wash system, and improved efficiencies of scale. The specific updates completed in support of the project are detailed below. Figure 2 is a block flow diagram for Crimson's biodiesel and glycerin production facility, as built and operating in 2013 (black), and with unit processes that were modified and upgraded during 2014-2016 under the project (red).

Figure 2: Modified flow diagram



Source: Crimson Renewable Energy LP.

Feedstock Pretreatment

Crimson replaced select components of its existing feedstock pretreatment system, which used a disc-stack technology. Unfortunately, this original system was not sized to support biodiesel production operations in excess of 10.6 million gallons per year and was also prone to stoppages. Under this project, Crimson successfully installed a new, second three-phase centrifuge with a total capacity of 50 gallons per minute. This second three-phase centrifuge supports a combined maximum flow rate of 80 gallons per minute, and provides redundancy allowing for maintenance or repair work to be performed on centrifuge A while the original centrifuge continues to operate. Installation of the new centrifuge (Figure 3) was completed in spring of 2015. Key realized benefits of the new centrifuge system include, based on operation to date, improved reliability and much greater uptime between cleanings. The transition to parallel operation of two centrifuges has substantially increased reliability and uptime of the feedstock pretreatment system.

Figure 3: Upgraded Decanting Centrifuge

Source: Crimson Renewable Energy LP

In addition to the second three-phase centrifuge, Crimson also completed minor modifications to other components of the feedstock pretreatment system, including enlargement of select fittings, pumps, and feedstock handling equipment to allow for parallel operation of two centrifuges and to help improve throughput and reduce fouling. Overall, these other minor feedstock pretreatment system elements improved feedstock washing flow rates and provided more consistent biodiesel output quality.

Feedstock Drying and Throughput to Acid Esterification

Crimson completed several modifications to its baseline feedstock drying system, which possessed a limited capacity and suffered from several performance limitations. The baseline vacuum system needed to be upgraded to have enough capacity to support the proposed biodiesel production upgrade. Vacuum system upgrades included replacement of the existing vacuum system with a higher capacity vacuum pump, which was installed in June of 2014. The upgrade also facilitated the future Phase-2 expansion.

In order to help reduce system fouling, Crimson also installed two new heat exchangers into the baseline feedstock drying system in Spring of 2015. They have provided the added benefits of improving system reliability and minimizing downtime needed for system cleaning.

To support the feedstock drying process, Crimson added a new heated and insulated, 25,000 gallon capacity stainless steel vessel to receive the output of this process. This installation included new, advanced instrumentation and controls, along with new, higher capacity 25 hp transfer pumps (Figure 4), allowing the tank to be continuously fed from the feedstock drying process (Figure 5), at a rate of 250 gallons per minute. The new pumps facilitate more rapid transfer of feedstock to the acid esterification reaction system, resulting in an average reactor filling time of 45 minutes, in comparison with 150 minutes under the baseline system. This reduction in filling time has enabled better utilization of the acid esterification reactors, thereby increasing the biodiesel output from the acid esterification system, while still relying on the previously existing acid esterification reactor system.

Figure 4: Upgraded 25 h.p. Transfer Pumps.

Source: Crimson Renewable Energy LP.

Figure 5: Upgraded Feedstock Drying System Equipment

Source: Crimson Renewable Energy LP.

Acid Esterification and Methanol Recovery Upgrades

The project incorporated recovery of excess methanol that is utilized during the acid esterification process. Methanol recovery supports recycling of methanol on site, reducing the volume of methanol needed for biodiesel production, while also supporting a reduced carbon intensity value due to reduced fresh methanol feed volumes. Under the upgraded system, which was completed in May 2014, methanol separates from water and glycerin in a distillation column and then the methanol vapor is condensed via a condenser. The recovered condensed, high-purity methanol is then sent back to the methanol storage tank for subsequent use in the production process. Crimson installed new stainless steel trays within the methanol distillation column (Figure 6), and also installed a new larger reboiler to expand the overall throughput rate of the methanol recovery system.

Figure 6: Upgraded Methanol Distillation Column

Source: Crimson Renewable Energy LP.

In total, the new methanol recovery system captures 10,000-12,000 gallons of methanol per day. The updated process control systems save an additional 8,000 gallons of methanol per day, for a total methanol savings of 18,000-20,000 gallons per day. This volume directly offsets demand for an equivalent volume of new methanol, saving chemical costs and reducing indirect carbon emissions associated with methanol production.

Crimson also implemented a series of improvements to its acid esterification system that included:

- Process control improvements to improve methanol utilization and reaction controls during the acid esterification process
- Upgrading the feedstock drying system to increase plant throughput and reaction efficiency
- Installation of a buffer vessel (Figure 7) downstream of the feedstock drying systems

Figure 7: Installed Buffer Vessel

Source: Crimson Renewable Energy LP

These process improvements served to reduce excess methanol usage, which allows for an increase in feedstock volume for each batch, and a resulting increase in overall biodiesel output. The process improvements and equipment changes were implemented while improving the quality and quantity of output.

Transesterification

Under this project, Crimson upgraded the plant's baseline transesterification process to increase capacity and throughput. First, Crimson added a new, 8,000-gallon transesterification reactor and associated piping, instrumentation, controls and pumps to its existing process line, increasing transesterification capacity to a total of 24,000 gallons. Crimson installed the new transesterification reaction tank adjacent to the existing transesterification system. These updates were completed in August 2014.

To manage the larger volume of transesterification capacity now available, Crimson also installed new, larger pumps, including two 25 hp electric pumps with variable speed drives, along with new high-flow-rate instrumentation and gauging, in July and August 2016. These new pieces of equipment were incorporated into the plant's existing control system. Collectively, the new pumps, along with the new tank (Figure 8) and updated control and monitoring system will be sufficient to meet transesterification demands for the designed flow rate of the project, with a transesterification process flow rate of 52 gallons per minute. These updates will also be sufficient to meet the transesterification demand of a 22 million gallons per year system, under a subsequent Phase-2 expansion without further modification of this process.

Figure 8: Upgraded Transesterification System Tank.

Source: Crimson Renewable Energy LP.

Biodiesel Washing and Dewatering

During operation of the baseline plant, the biodiesel washing system relied on a conventional wet washing process to remove glycerin and other impurities from the biodiesel. This baseline wet wash process resulted in the consumption of approximately 0.4 gallons of water per gallon biodiesel produced. The project introduced several improvements to that biodiesel wash system, targeting improved ability to manage product quality fluctuations and reductions in overall water consumption through the reduction of the volume of water required to wash the biodiesel.

Installed improvements included:

- Installation of new piping and controls that allowed reuse of water from the wash vessels
- Modification of a previously-existing surge vessel to convert it into a 2nd stage biodiesel wash vessel
- Installation of additional vessels for biodiesel washing and separation.

Installation of these improvements was completed in July 2016 (Figure 9). Together, these improvements enable biodiesel washing as a continuous rather than batch process. The end result was an approximately 30 percent savings in water utilized for biodiesel washing compared to the baseline plant. Not only did this upgrade reduce water consumption, but it also substantially reduced the volume of water that previously had to be removed during the methanol recovery and crude glycerin processing steps. Water removal under these unit processes had consumed a substantial amount of energy. As a result, the new, improved, and more water-efficient process resulted in a net savings in energy consumption of 20 percent per-gallon of fuel produced.

Figure 9: Upgraded Biodiesel Washing System

Source: Crimson Renewable Energy LP.

Crude Glycerin Neutralization and Processing

During the transesterification process, a "heavy layer" of thick, alkaline glycerin is produced as a byproduct, and resides in solution with unconsumed methanol, high pH catalyst, and small volumes of fatty acids and methyl esters. This is typically referred to as 'crude glycerin' and must be separated from the biodiesel and further processed to remove as much as possible the methanol, catalyst, fatty acids and methyl esters. As of 2013, Crimson's then-existing crude glycerin neutralization and processing system was a major bottleneck preventing production increases. A series of changes and new systems were installed for crude glycerin neutralization and processing. These updates included a new process vessel downstream of the transesterification reactors, designed to continuously feed the crude glycerin solution into a new set of process vessels and equipment, to continuously neutralize crude glycerin, remove salts created via neutralization, remove fatty acids, and remove methyl esters.

In 2014, Crimson upgraded the glycerin evaporation system by upgrading the heat exchangers and pumps, and by enlarging steam supply and vapor return lines. These changes improved the system's ability to remove water and increase overall throughput.

In 2016, a series of process changes with new vessels and equipment were installed to replace the existing crude glycerin neutralization and processing system with a new continuous system. The new continuous system included:

- New process vessel downstream of the transesterification reactors, designed to continuously feed the crude glycerin solution into the new neutralization system
- New set of process vessels and equipment for crude glycerin neutralization, as well as recovery of methyl esters, unreacted fatty acids, and glycerides
- New decanting centrifuge and dryer for salt removal
- Installation of electrical systems (including a new motor control center), piping, instrumentation, and controls necessary for the operation of the new vessels and equipment

The neutralization process vessels continuously add acid or caustic as needed to neutralize the incoming crude glycerin solution and achieve a consistent pH. The salt that is created during this neutralization process is then removed by the new centrifuge, dried via the new dryer, and collected in a bin for offsite disposal as solid waste in accordance with applicable federal and state regulations. The aqueous phase coming off the centrifuge is further neutralized using a new neutralization vessel, and then introduced into the methanol recovery system. There, it is processed through the existing methanol distillation column, where the resulting methanol is purified and recovered using existing equipment and processes. In this system, however, the bottom stream from the methanol distillation column is now fed to the glycerin evaporator system that was upgraded in 2014, where the glycerin undergoes a final drying process. The resulting crude glycerin has a glycerin purity of 80-85 percent and is pumped to quality control tanks, tested for quality and finally transferred to ship tanks for sale.

The new crude glycerin neutralization system (Figure 10) was fully installed in August 2016. It results in more consistent output quality, improved removal of salts created via neutralization, improved separation, better recovery of residual methyl esters and unreacted fatty acids and glycerides, and significantly increased overall system throughput. The new crude glycerin neutralization system supports increased biodiesel yield via recycling of recovered residual methyl esters and unreacted fatty acids and glycerides with approximately 80 percent of unreacted fatty acids and glycerides and residual methyl esters being recovered.

Figure 10: Upgraded Glycerin Neutralization and Processing System

Source: Crimson Renewable Energy LP.

Expansion of Steam and Electrical Capacity

Prior to the updates completed under the project, the acid esterification and transesterification reactors were not being used to their maximum capacity, primarily due to insufficient heating capacity provided by the plant's boiler system. Additional heating capacity was needed to support the methanol recovery and crude glycerin processing systems operating a plant production rate of 22 million gallons per year. To address the heating needed to support the proposed production increase, the project included installation of a new, 28 million British thermal units per hour steam generator (Figure 11). Crimson installed the new steam generator, which replaced the two original 7.6 million British thermal units per hour steam generators, in May 2014.

Figure 10: New Steam Generator

Source: Crimson Renewable Energy LP.

The additional heating capacity provided by the new steam generator has proven to be sufficient to operate all baseline and new systems in the plant at maximum project design throughput capacity. Note that this increase in throughput capacity is in part due to the increased capacity of the steam system, and in part because of the reduced volume of water contained in the methanol and glycerin streams under the project as a result of improvements in those other systems. Less water in these streams requires less energy for water removal, resulting in reduced heating requirements and increased energy efficiency.

Prior to project implementation, the plant included pump controls and electrical equipment needed to run the existing boilers, but these controls and equipment were of insufficient capacity to support the new, larger steam generator. As a result, while installing the new steam generator, Crimson also replaced the existing motor control system and control center panels that ran all of the equipment in the Boiler Building and expanded this building. To support the increased electrical requirements of the new steam system, a new 450kVA transformer was also installed.

Two new outdoor-rated motor control centers were also installed to support the many new motors that were installed as part of the new biodiesel washing and crude glycerin neutralization systems, the new transesterification reactor, and other new process vessels.

Expansion of Automation System

Prior to the upgrades completed under the project, the plant operated using a Delta-V distributed control system and associated hardware. This system as originally installed had limited capacity for expansion due to limited spare capacity for additional digital and analog inputs/outputs. The software licensing available for the system also carried minimal spare capacity for upgrading. Thus, in this project, Crimson replaced the baseline Delta-V hardware with an upgraded Delta-V hardware system, added new controllers to expand capacity and provide redundancy, and several new additional board sets for additional inputs/outputs. This work was completed in June 2016. Additionally, the Delta-V software license was upgraded to support the additional inputs/outputs and redundant controllers and to provide updated functionality necessary to support all of the changes and updates to the plant (Figure 12) that were completed under the project.

Figure 11: Upgraded and Expanded Automation System

Source: Crimson Renewable Energy LP

CHAPTER 3: Project Results

This chapter provides an overview of the key results of the project, as measured during project implementation, including during the demonstration period. The baseline period referenced below ran from January 1, 2014 to December 31, 2014, serving as a point of comparison immediately prior to project deployment. The six-month project demonstration period ran from October 1, 2016 through March 31, 2017, which included all post-implementation data collection reported here.

Data Collection and Results Summary

Crimson collected six-months of operational data during the project. These data included the following:

Time Operating

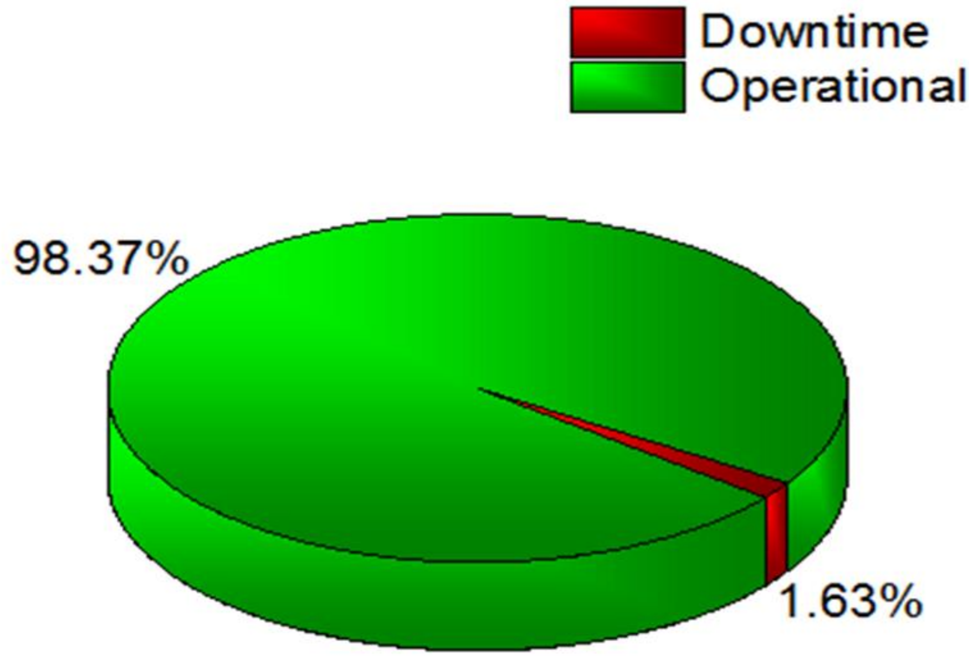
Time operating includes up and down time over the six-month demonstration period. Crimson achieved an exceptionally high plant up-time, at 4,296 hours out of a total of 4,368 hours during the demonstration period, equivalent to a 98.4 percent uptime (Table 1 and Figure 13). The plant was run constantly except for three days of downtime in December, caused by a minor issue with the methanol tower.

Table 1: Total Operating Time During the Demonstration Period

Month	Hours per Month	Monthly Up Hours	Percent Operational
October, 2016	744	744	100%
November, 2016	720	720	100%
December, 2016	744	672	90.3%
January, 2017	744	744	100%
February, 2017	672	672	100%
March, 2017	744	744	100%
Total	**4,368**	**4,296**	**98.4%**

Source: Crimson Renewable Energy LP.

Figure 12: Plant Performance During the Demonstration Period



Source: Crimson Renewable Energy LP.

Feedstock Amounts

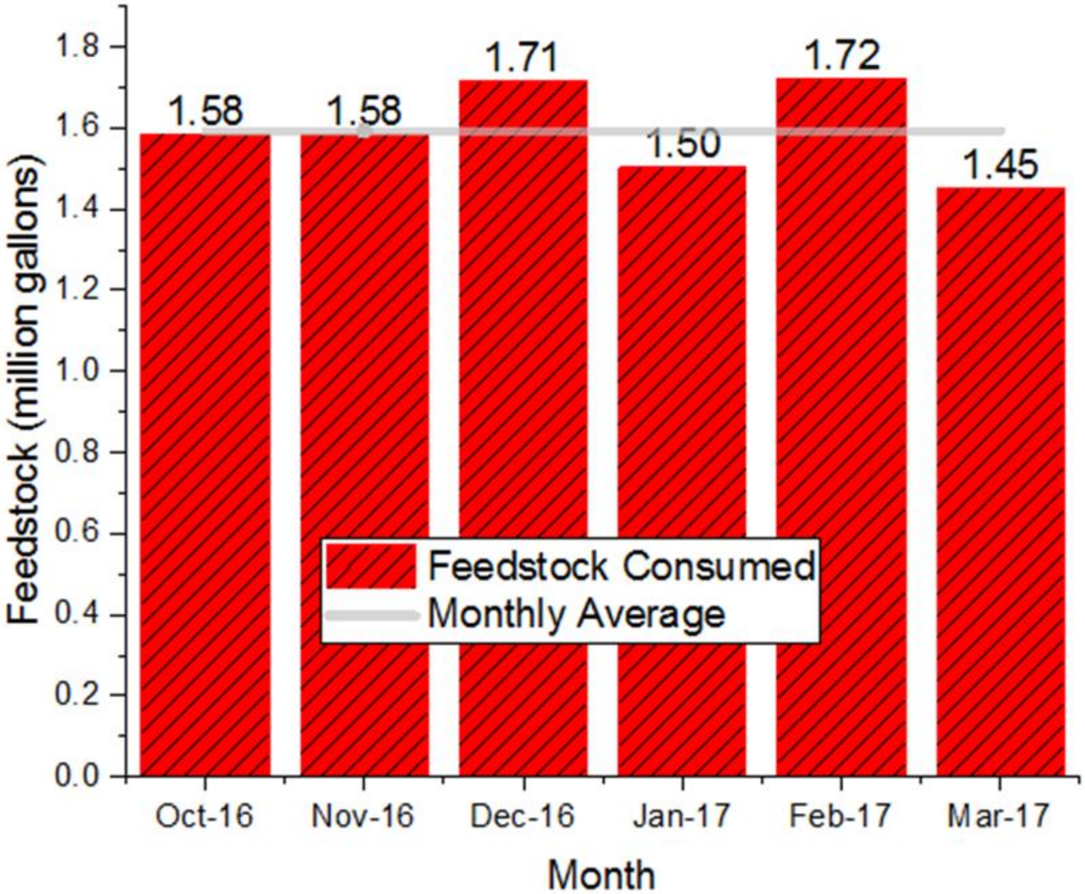
Crimson maintained a consistent supply and throughput of feedstock during the demonstration period. Crimson collected feedstock from in-state as well as out of state suppliers. This feedstock included used cooking oil and distillers' corn oil and inedible animal fats. Table 2 shows the 2016 feedstock utilization by type. Figure 14 summarizes monthly and average feedstock amounts processed during the demonstration period. As shown, feedstock consumption was relatively consistent; it averaged 1.6 million gallons per month, ranging from 1.45 million gallons in March of 2017 to 1.72 million gallons in February of 2017.

Table 2: Average Percent of Total Feedstock by Feedstock Type in 2016

Feedstock Type	Percent of Total Feedstock
Animal Fats	1%
Distillers Corn Oil	22%
Used Cooking Oil	77%
Total	**100%**

Source: Crimson Renewable Energy LP.

Figure 13: Monthly and Average Feedstock Use

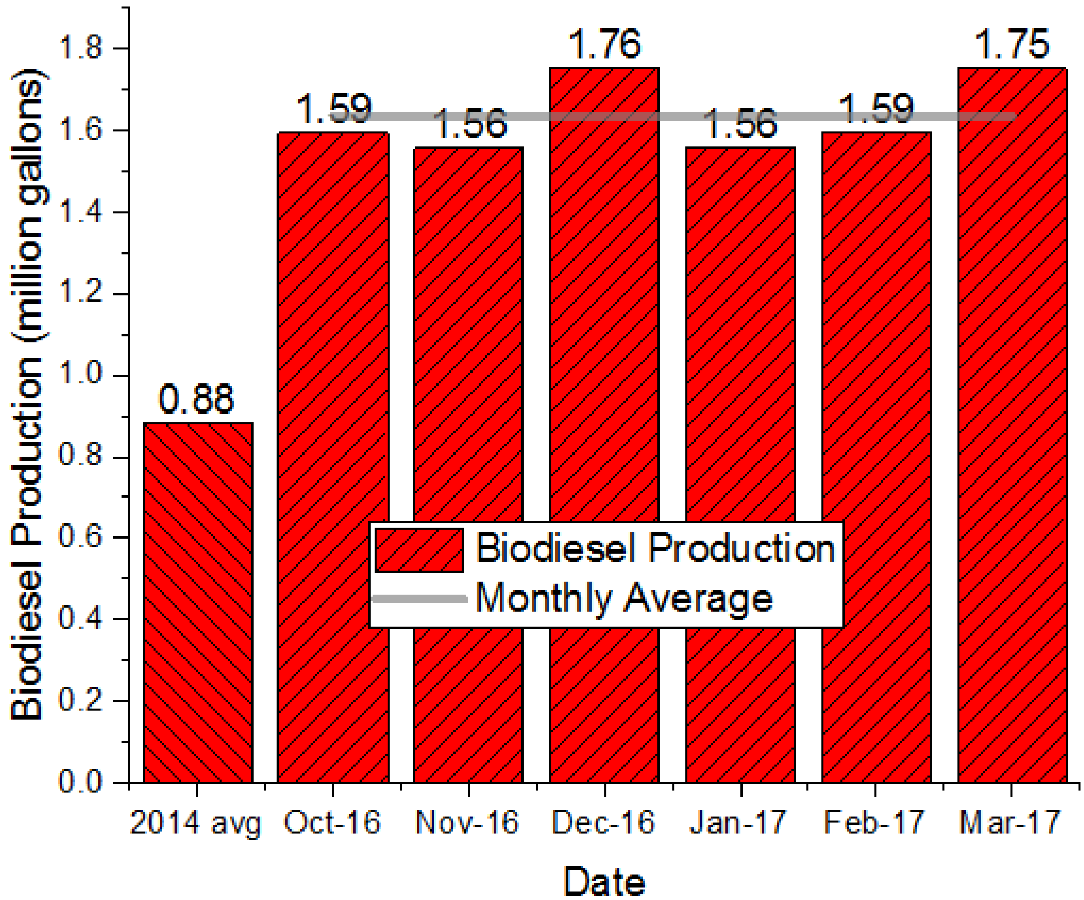


Source: Crimson Renewable Energy LP.

Biodiesel Production

The project achieved (and exceeded) its objective of increasing production capacity from 10.6 to 17 million gallons per year equivalent (i.e., 17 million gallons per year is 1.42 million gallons per month), as demonstrated between October 2016 and March 2017. Figure 15 summarizes monthly biodiesel production achieved during the 2014 baseline period, monthly biodiesel production during the six-month operations period, and average biodiesel production during the six-month operations period. As shown, production rates ranged from a minimum of 1.56 million gallons in November of 2016 and January of 2017, to a peak of 1.76 million gallons in December of 2016, for an average monthly production rate of 1.64 million gallons (equivalent to 19.6 million gallons per year). In comparison, prior to project implementation, the plant produced an average of 0.88 million gallons per month during the baseline period, (equivalent to 10.6 million gallons per year).

Figure 15: Monthly Average Biodiesel Production



Source: Crimson Renewable Energy LP.

Biodiesel Quality

All biodiesel produced by Crimson at its Bakersfield facility undergoes a stringent quality control process conducted at a certified laboratory. All fuel is produced in accordance with American Society for Testing and Materials standards, is also of sufficient quality to meet strict specifications maintained by regional fuel blenders. Crimson has consistently maintained its reputation as a producer of consistent and high quality biodiesel.

Estimate of Carbon Intensity

Crimson identified the reduction of the carbon intensity scores of its biodiesel production process as a goal of the project. As discussed previously, the carbon intensity value for the plant prior to project implementation (i.e., during the baseline period) was estimated to be 14.0 grams CO_2e/megajoule. Crimson's proposal to the Energy Commission estimated that the project would result in a carbon intensity value for produced biodiesel of 12.0 grams CO_2e/megajoule. During the time between submission of the original grant application and contracting, and 2017, a methodology update for the calculation of carbon intensity values was implemented by ARB, adhering to new pathways contained in the *Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model.* These changes provided revised carbon intensity values for the various feedstock used by Crimson as summarized in Table 3.

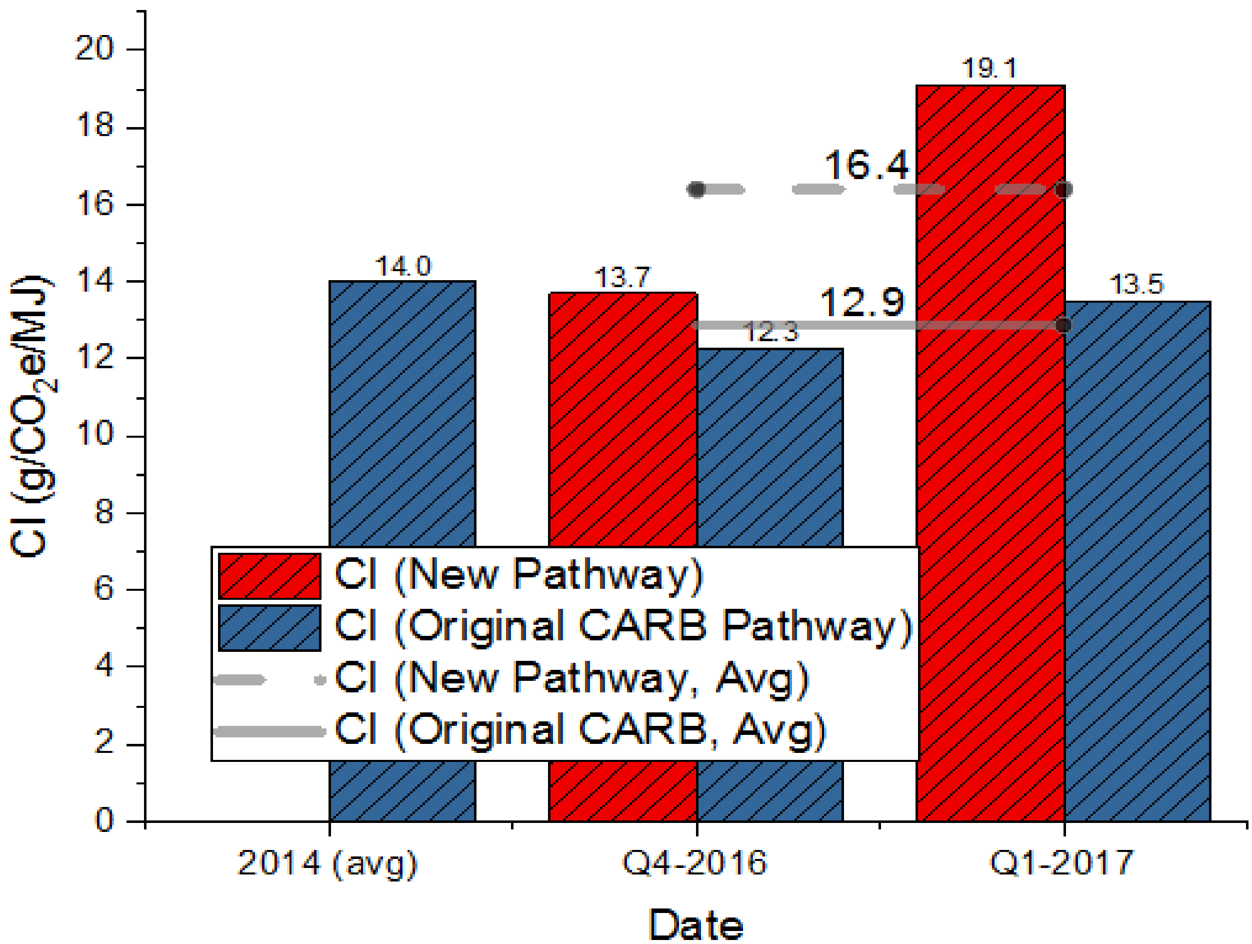
Table 3: Comparison of Pathways

Feedstock Category	Original Default ARB Pathway/Carbon Intensity Value (gram CO_2e/megajoule)	New Pathways Using Greenhouse Gasses, Regulated Emissions, and Energy Use in Transportation Model 2.0 Pathway/Carbon Intensity Value (gram CO_2e/megajoule)
Cooked, Used Cooking Oil, from California	BIOD002/15.84	Pending approval as of 5/15/17; expected carbon intensity 16.89
Uncooked, Used Cooking Oil, from California	BIOD003/11.76	Pending approval as of 5/15/17; expected carbon intensity 13.1
Cooked, Used Cooking Oil, from North America Outside of California	BIOD004_1/18.72	BDU203/18.18
Uncooked, Used Cooking Oil, from North America Outside of California	BIOD005_1/13.83	BDU204/13.1
Cooked, Used Cooking Oil, Global from Outside of North America (ocean transport)	N/A	BDU205/23.28
Tallow/Animal Fats from California	None	BDT204/28.45
Tallow/Animal Fats from North America Outside of California	BIOD008/carbon intensity 40.18/used until 3/31/16	BDT203/30.1
Corn Oil, Dried Distillers Grain, United States (with California)	BIOD007/carbon intensity 4.0/used until 12/31/16	N/A
Corn Oil, Wet Distillers Grain with Solubles, from California	None	BDC202/27.45
Corn Oil, Wet Distillers Grain with Solubles, from the United States Outside of California	BIOD021/carbon intensity 29.27/used until 03/31/16	BDC203/28.48

Source: Crimson Renewable Energy LP.

Figure 16 summarizes carbon intensity values calculated based on both the original ARB pathways (blue bars and solid horizontal line in the Figure) and the new, Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model based pathways (red bars and dashed horizontal line), to demonstrate how carbon intensity values at the plant changed as a result of the project. The new pathway, shown in red in the Figure, is presently applicable to Crimson. However, as shown in Table 3, it is difficult to compare carbon intensity values from the old pathway to the new pathway. During 2014, the carbon intensity value is estimated at 14.0 grams CO_2e/megajoule, consistent with the grant proposal. During the demonstration period, carbon intensity values increased to 16.4 grams CO_2e/megajoule, on average, using the new Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model based pathways. However, for comparison, using the original CARB pathways, the new carbon intensity value for the demonstration period would be 12.9 grams CO_2e/megajoule, on average. Therefore, the project resulted in a net increase in energy efficiency, from approximately 14.0 to 12.9 grams CO_2e/megajoule, a reduction of roughly 1.1 grams CO_2e/megajoule. However, based on the new accounting method, carbon intensity value actually increased during the demonstration period, to 16.4 grams CO_2e/megajoule.

Figure 14: Carbon Intensity Values

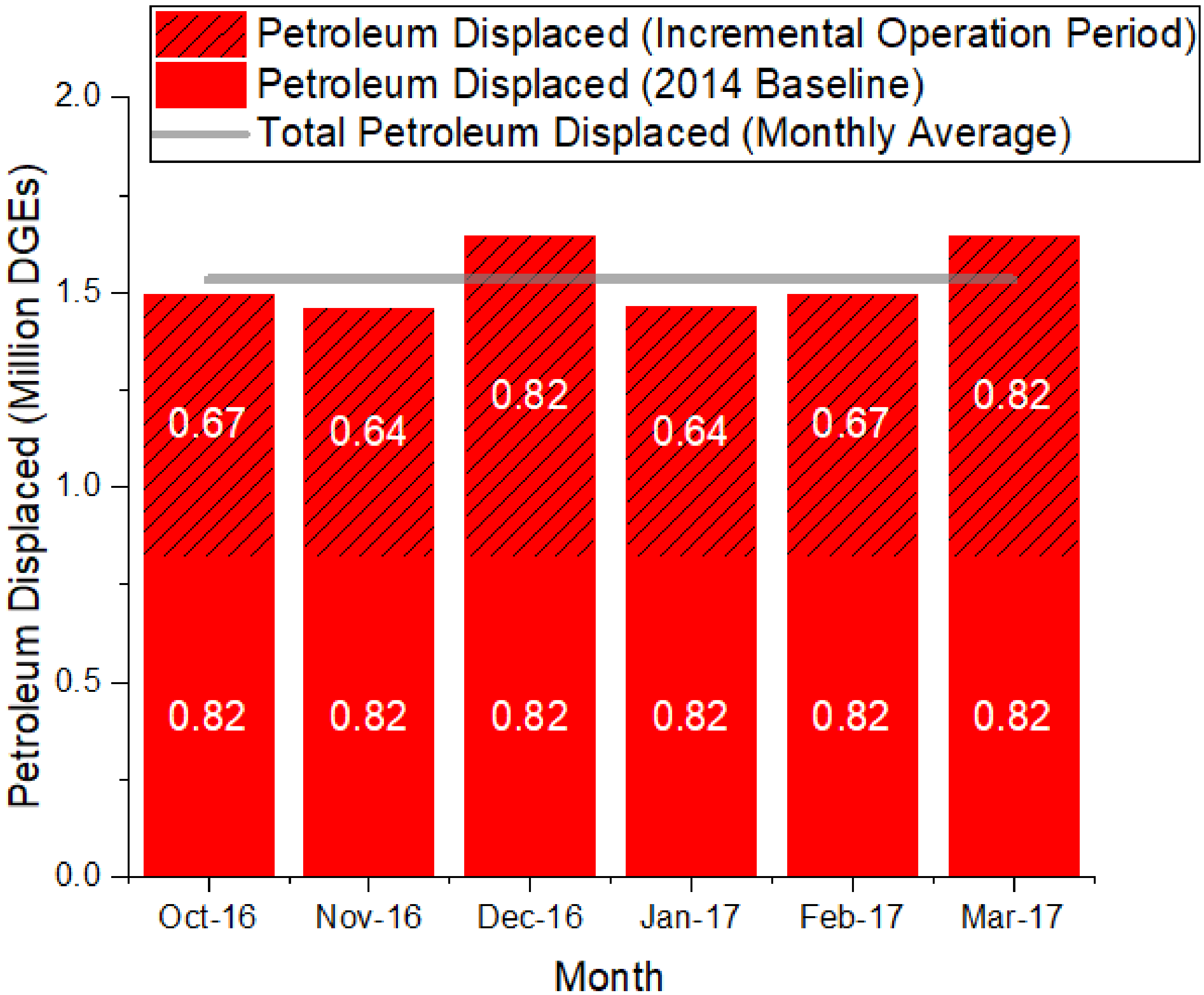


Source: Crimson Renewable Energy LP.

Petroleum Fuel Displacement

Consumption of biodiesel reduces the volume of conventional diesel that is consumed for transportation and other activities. Therefore, petroleum fuel displacement is directly proportional to the volume of biodiesel produced, assuming that all produced biodiesel is consumed. Assuming that biodiesel contains, on average, 126.13 megajoules of energy per gallon, and that conventional diesel contains 134.47 megajoules per gallon (Source: Table 3 in https://www.arb.ca.gov/regact/2015/lcfs2015/lcfsfinalregorder.pdf), Crimson's facility offset 0.82 million gallons per month, on average, of biodiesel during the baseline period. During the demonstration period, production from the updated plant displaced 1.53 million gallons per month on average, representing an average increase in petroleum displacement of 0.71 million gallons per month under the project as shown in Figure 17.

Figure 15: Incremental and Total Monthly Petroleum Displacement

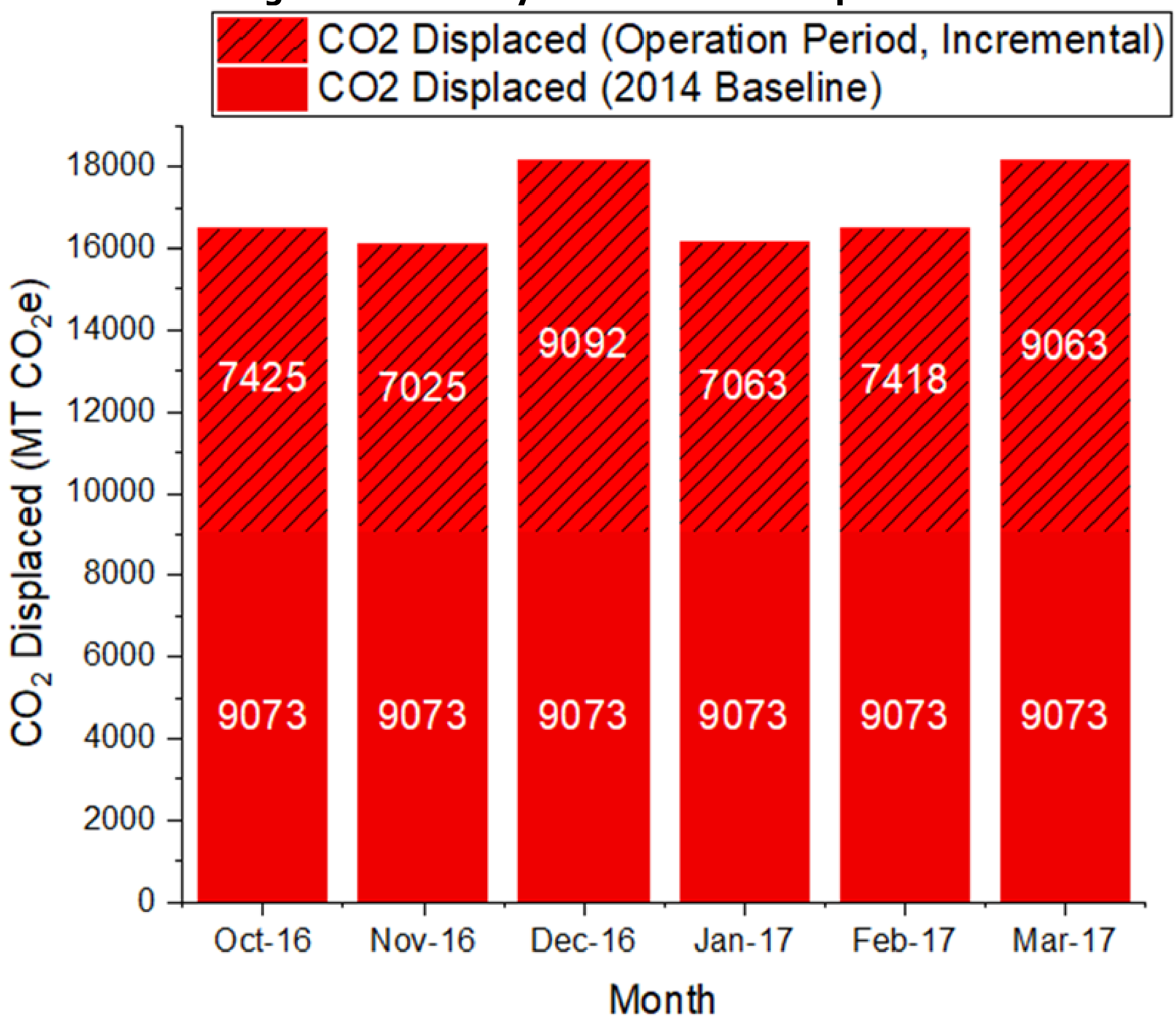


Source: Crimson Renewable Energy LP.

Greenhouse Gas and Air Emissions Offset

Biodiesel combustion results in a net reduction of GHG emissions, as well as several key criteria pollutant emissions, in comparison to conventional fossil diesel fuel. These include particulate matter, unburned hydrocarbons, carbon monoxide and sulfur dioxide. GHG emissions offsets were estimated by calculating the total amount of GHGs (expressed in CO_2 equivalent) emitted by conventional diesel, on a per megajoule basis, subtracting the total amount of GHGs emitted by Crimson's biodiesel (based on the carbon intensity values discussed previously) on a per megajoule basis, and multiplying by the total megajoules of diesel offset during each month. Results are shown in the Figures below, for both the 2014 baseline facility, and the upgraded facility at present, including baseline production (solid bar) and incremental additional GHG emissions offset from the project (hashed bar). As shown, the total GHG emissions displacement (Figure 18) ranged from 16,097 metric tons in November of 2016 to 18,164 metric tons in March of 2017. Incremental increases since implementation of the project ranged from 7,025 metric tons to 9,091 metric tons during those same two months.

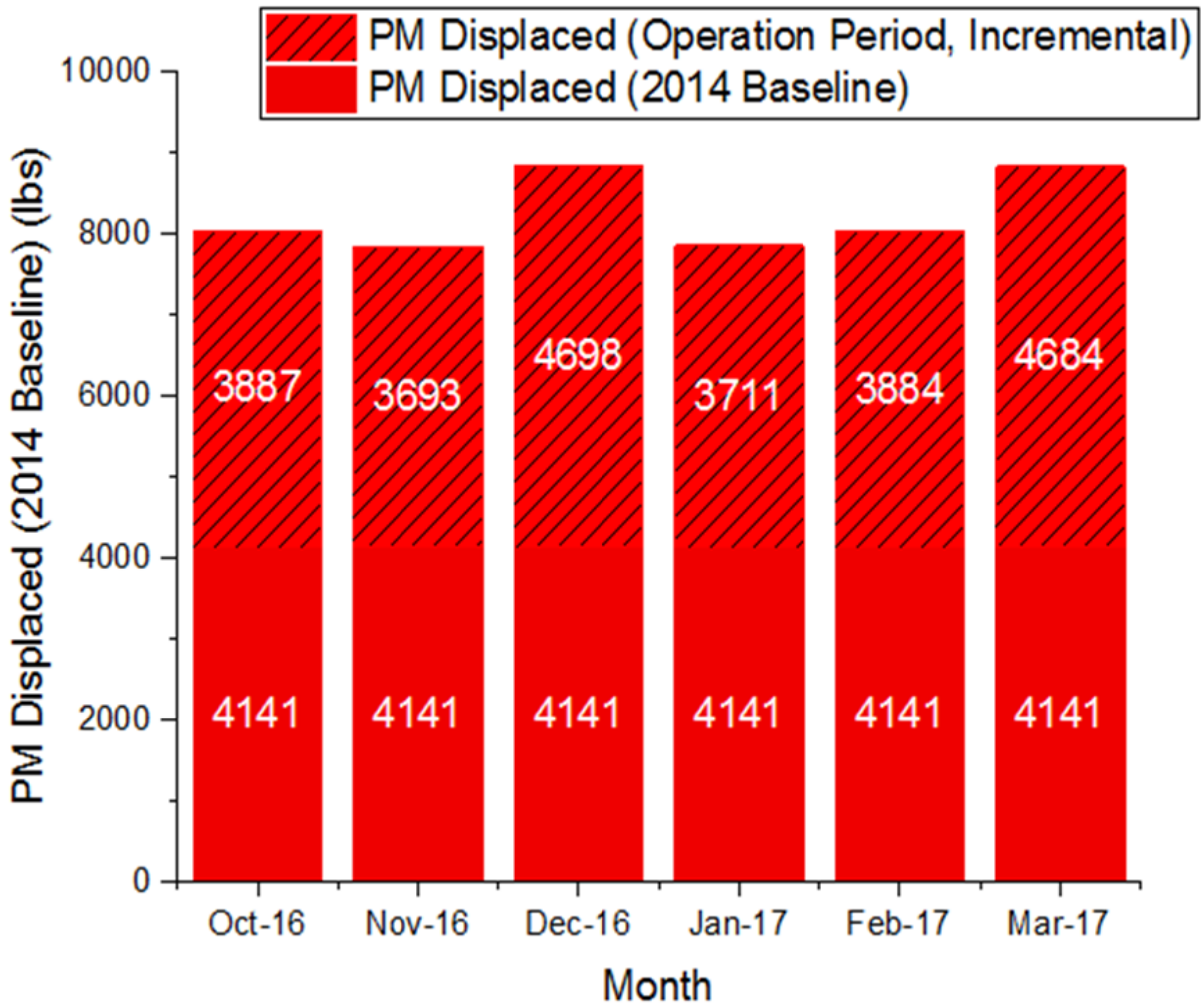
Figure 18: Monthly GHG Emissions Displaced



Source: Crimson Renewable Energy LP.

Displacements of diesel particulate matter were evaluated in a manner similar to that discussed for GHG emissions, where emissions typically resulting from biodiesel combustion were subtracted from conventional diesel emissions, on a per million British thermal units basis. This resulted in an emission displacement rate of 4.21 x 10^{-8} lb particulate matter emissions per million British thermal units of fuel, or 0.005036 lb particulate matter per gallon of biodiesel. Results are shown in Figure 19, which shows an average total displacement rate of 8,234 lb particulate matter emissions per month, of which 4,141 lb/month was already being displaced during the 2014 baseline period, while incremental increases under the project ranged from 3,693 lb/month (November of 2016) to 4,698 lb/month (December of 2016).

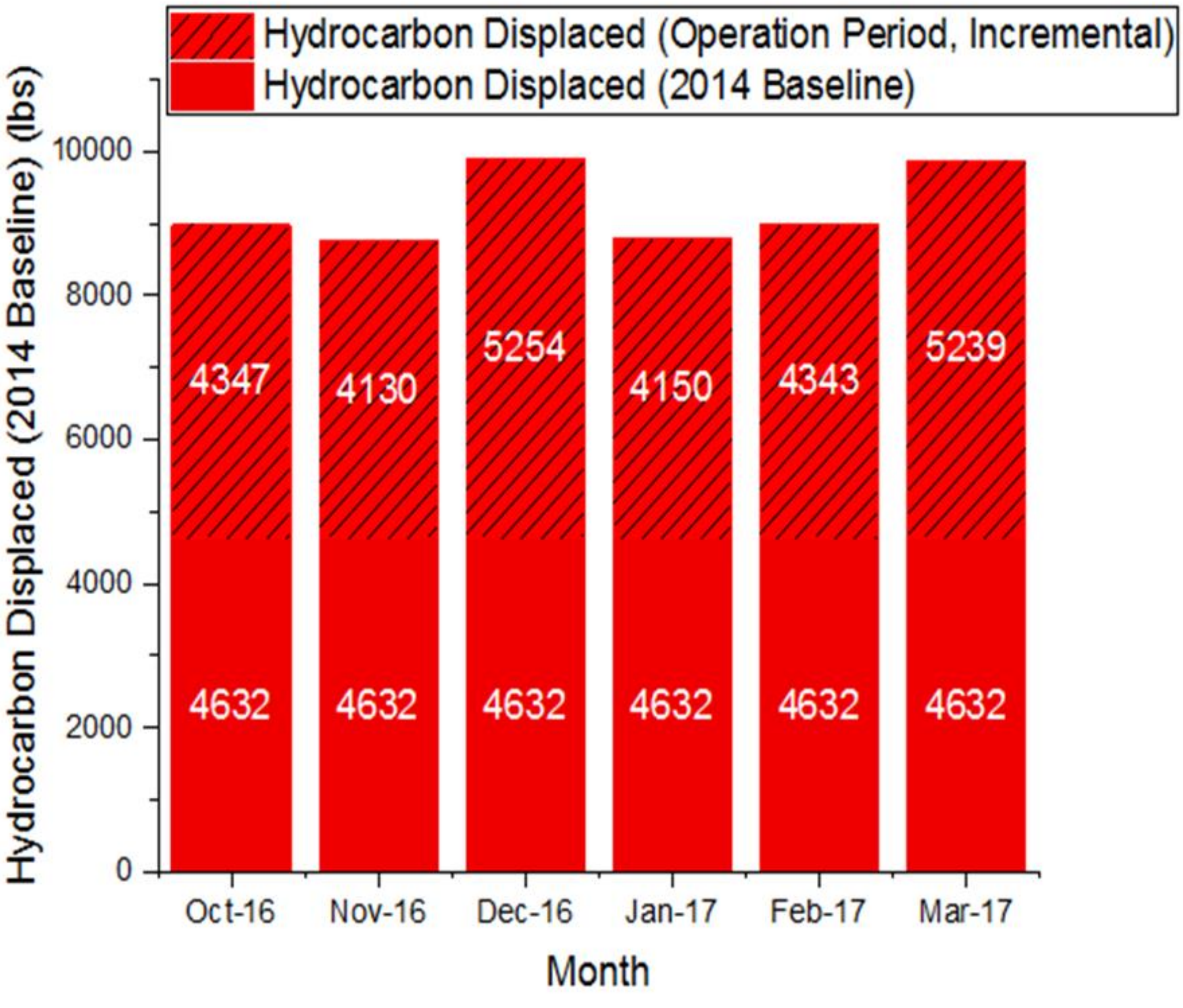
Figure 16: Monthly Particulate Matter Emissions Displaced



Source: Crimson Renewable Energy LP

Displacements of hydrocarbons were evaluated in a manner similar to that discussed for GHG and particulate matter emissions, where emissions typically resulting from biodiesel combustion were subtracted from conventional diesel emissions, on a per million British thermal units basis. This resulted in an emission displacement rate of 4.71 x 10^{-8} lb hydrocarbon emissions per million British thermal units of biodiesel, or 0.005632 lb hydrocarbons displaced per gallon of biodiesel. Results in Figure 20 show an average total displacement rate of 9,208 lb hydrocarbon emissions per month, of which 4,632 lb/month was already being displaced during the 2014 baseline period, while incremental increases under the project ranged from 4,130 lb/month (November of 2016) to 5,254 lb/month (December of 2016).

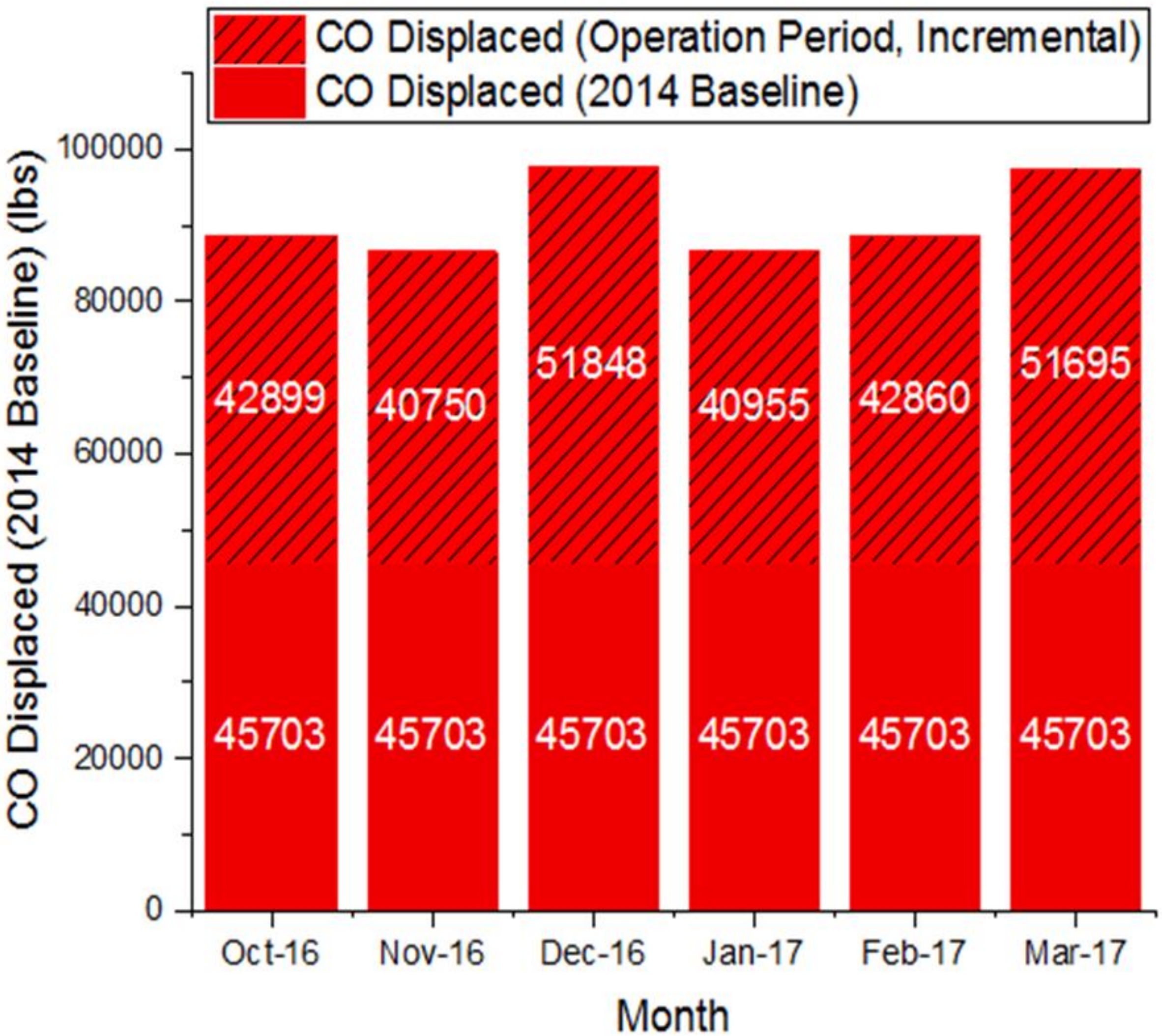
Figure 17: Monthly Unburned Hydrocarbon Emissions Displaced



Source: Crimson Renewable Energy LP

Displacements of carbon monoxide were evaluated in a manner similar to the other pollutants discussed above, where emissions typically resulting from biodiesel combustion were subtracted from conventional diesel emissions, on a per million British thermal units basis. This resulted in an emission displacement rate of 4.65 x 10^{-7} lb carbon monoxide emissions per million British thermal units of fuel, or 0.05557 lb carbon monoxide displaced per gallon of biodiesel. Results are summarized in Figure 21, which show an average total displacement rate of 90,871 lb carbon monoxide emissions per month, of which 45,703 lb/month was already being displaced during the 2014 baseline period. This results in an incremental increase under the project that ranged from 40,750 lb/month (November of 2016) to 51,848 lb/month (December of 2016).

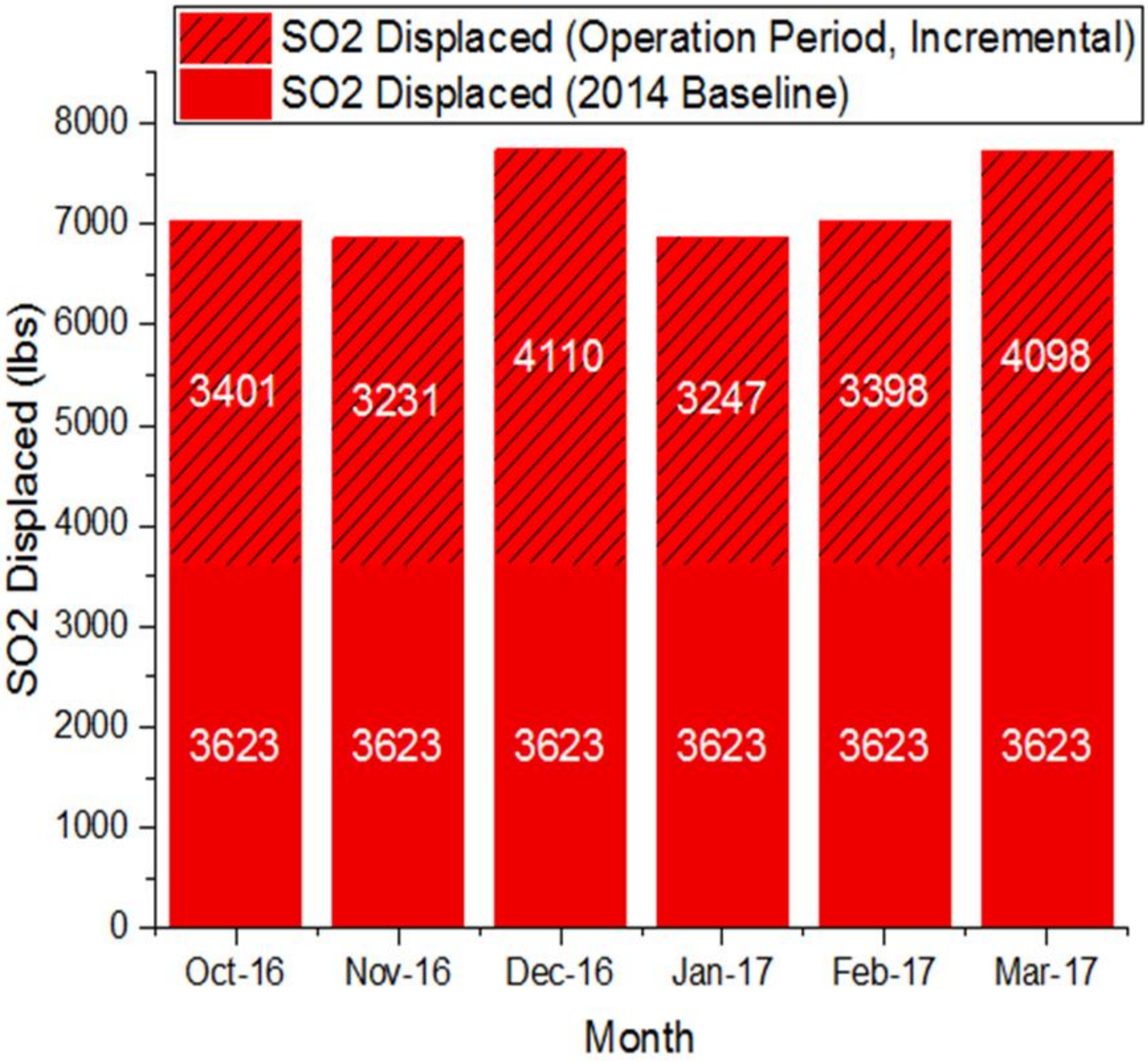
Figure 18: Monthly Carbon Monoxide Emissions



Source: Crimson Renewable Energy LP.

Displacements of sulfur dioxide (SO_2) were evaluated in a manner similar to the other pollutants discussed above, where emissions typically resulting from biodiesel combustion were subtracted from conventional diesel emissions, on a per million British thermal units basis. This resulted in an emission displacement rate of 3.69×10^{-8} lb SO_2 emissions per million British thermal units of fuel, or 0.004406 lb SO_2 displaced per gallon of biodiesel. Results summarized in Figure 22 show an average total displacement rate of 7,204 lb SO_2 emissions per month, of which 3,623 lb/month was already being displaced during the 2014 baseline period. This results in an incremental increase under the project that ranged from 3,231 lb/month (November of 2016) to 4,110 lb/month (December of 2016).

Figure 19: Monthly SO_2 Emissions Displaced

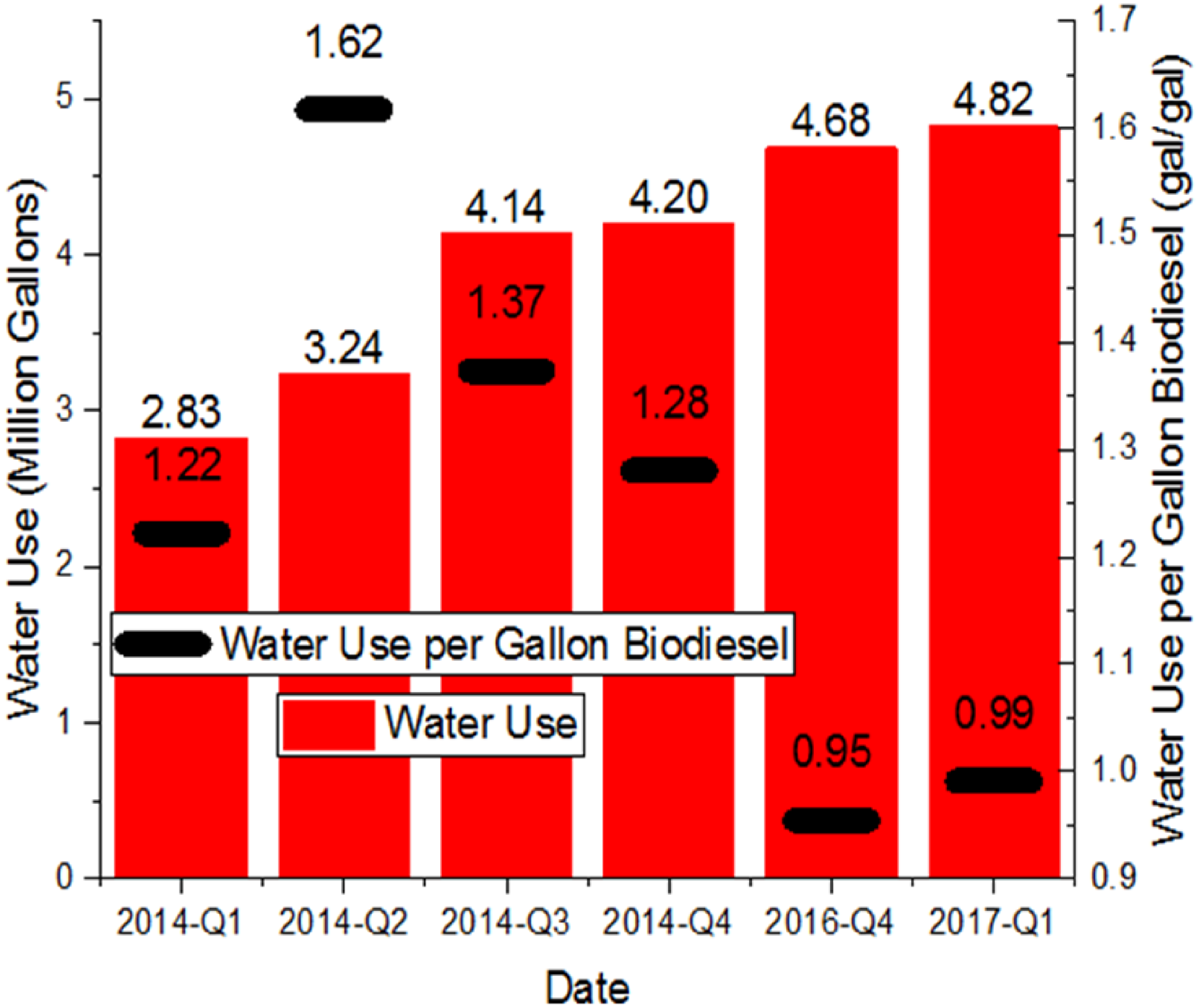


Source: Crimson Renewable Energy LP.

Water Use

Reduction in water used as part of the biodiesel washing process was another objective of the project. By reducing process water consumption, the project was able to realize substantial increases in energy efficiency and throughput improvement in the methanol recovery system, due to reduced heat demand to separate water from methanol and glycerin. Crimson tracked water use during and after implementation of the project, as shown in Figure 23. The project resulted in a net decrease in water use for biodiesel washing, and a total reduction in plant water consumption of 29.3 percent on average. As shown in Figure 23, Crimson's facility increased water consumption overall, but this water was used much more efficiently during the demonstration period, in comparison to the baseline period. For example, water consumed per gallon of biodiesel production dropped to below 1.0 gallon during the demonstration period, in comparison to 1.2 to 1.6 gallon during the baseline period.

Figure 20: Quarterly Total Water Use and Per Gallon of Biodiesel



Source: Crimson Renewable Energy LP.

Environmental Impact

The project has resulted in several categories of environmental benefits. These benefits include the following:

- **Reduced GHG Emissions:** The project has increased production sufficient to offset a project-specific incremental amount of 94,164 metric tons CO_2e per year, nearly doubling GHG emissions offset of the original facility prior to project implementation.
- **Petroleum Diesel Fuel Displacement:** As of the end of the demonstration period, the project was producing an annualized volume of 19.6 million gallons per year of biodiesel, in comparison to 10.6 million gallons per year during the baseline period, representing an increase in biodiesel production of approximately 9.0 million gallons per year, equivalent to a petroleum displacement volume of approximately 8.38 million gallons per year of Diesel.
- **Reduced Water Use Intensity:** Project implementation resulted in a substantial reduction in water consumption during operation of the facility. The project reduced average water use intensity from 1.37 gallons of water per gallon biodiesel to 0.96 gallons of water per gallon biodiesel. This is a 29.3 percent reduction in water use intensity, illustrating a significant savings over baseline conditions.
- **Reduced Air Pollutants:** The project also indirectly reduced criteria air pollutants and toxic air contaminants due to an offset of fossil diesel combustion, including thousands of pounds per year of particulate matter, hydrocarbons, carbon monoxide, and sulfur dioxide.

CHAPTER 4: Project Successes and Advancements

Project Performance Compared to the Proposal

The project proposal specified target expectations for the production of biodiesel, at a rate of 17 million gallons per year, as compared to 10.6 million gallons per year of realistically available capacity in the previously existing plant. The 17 million gallons per year production rate was exceeded as a result of the project, with annualized production recorded during the demonstration period that exceeded 19.6 million gallons per year.

The project proposal also provided performance expectations regarding the timing of the initiation of project operation, where operations were expected to be initiated by the end of 2014. Timing of the project was subsequently extended, in order to provide sufficient time to complete engineering and procurement, alongside other updates that Crimson began planning at that time.

The six-month demonstration period commenced in October of 2016.

Other expectations from the proposal included:

- **Remove Production Bottlenecks:** Crimson successfully removed production bottlenecks, as evidenced by the observed annualized biodiesel production rate of over 19.6 million gallons per year during the demonstration period.
- **Reduce Carbon Intensity to 12 grams CO_2e/megajoule or Less:** As discussed previously, a change in ARB's required calculation and accounting mechanisms has resulted in an increase in carbon intensity value, to 16.4 grams CO_2e/megajoule during the six-month demonstration period, on average. If prior calculation methods were used instead, the project could have shown a reduction from 14.0 to 12.9 grams CO_2e/megajoule. Therefore, while the project did not reach the 12.0 mark for carbon intensity value, the project did quantifiably reduce the energy intensity of biodiesel production at the plant, in comparison to the baseline period.
- **Lay Groundwork for 22 Million Gallons per Year Expansion:** Completed upgrades were designed and installed, as planned, to be consistently sized for future improvements to 22 million gallons per year. Systems that are upgraded or newly installed to support an annualized 22 million gallons per year production rate included: Steam heating, vacuum, instrument air, electrical and motor control infrastructure, feedstock pretreatment, transesterification, crude glycerin neutralization, glycerin evaporation, and biodiesel washing.
- **Reduce Water Consumption by 50 Percent or More:** As discussed previously, the project successfully reduced water consumption by 29.3 percent, in comparison to the baseline period.
- **Increase Throughput of Feedstock Washing and Drying systems to 50 gallon per minute:** As discussed in Chapter 2, upgrades to these systems sufficient to meet 50 gallons per minute were successfully achieved.

- **Reduce Acid Esterification Reactor Filling Time by 80 percent:** As discussed in Chapter 2, the completed acid esterification upgrades resulted in a reduction in filling time from 150 minutes to 45 minutes, equivalent to a 70 percent reduction in filling time.
- **Install 28 million British thermal units/hour Steam Capacity:** This amount of steam capacity was successfully installed with installation of the upgraded boilers, as discussed in Chapter 2.
- **Increase Transesterification Throughput to 50 gallons per minute:** As discussed in Chapter 2, the completed transesterification system updates resulted in a throughput increase to 45 gallon per minute for that unit process.
- **Short-Term Construction Jobs:** Workers involved in project construction and installation totaled 72, including:
    - Engineering: support for 16 jobs.
    - Welding and piping installation: support for 22 jobs.
    - Electrical system installation: support for 14 jobs.
    - Concrete and structural installation – support for 20 jobs.
- **Full-Time Operational Jobs:** With implementation of the project, Crimson has hired new workers, including four new plant operators and loaders, one lab tech, one safety tech, one maintenance mechanic, one operations training supervisor, one junior plant engineer, and one director of engineering, for a total of 10 new full time equivalent jobs. The project has also increased hours for Crimson's existing plant manager and plant engineer.

Technology Advancement

The project successfully installed an upgraded biodiesel production system that reduces carbon intensity through a series of process and equipment improvements, as outlined above. Crimson has completed and documented these upgrades in part to support development and implementation of similar upgrades at other existing biodiesel production facilities. As such, the upgrades completed by Crimson have resulted in meaningful gains in plant operational and energy efficiency, resulting in a significant increase in throughput, and providing valuable technology advancement information regarding methods to streamline the biodiesel production process and increase throughput.

Greenhouse Gas Emissions Reduction

As discussed previously, the project has successfully increased biodiesel production at Crimson's facility, from a baseline value of 10.6 million gallons per year to 19.6 million gallons per year, for a net increase of approximately 9.0 million gallons per year. As discussed earlier, the 9.0 million gallons per year incremental increase in biodiesel production results in an annualized offset of 94,164 metric tons CO_2e, as a direct result of project implementation. Similar levels of annual GHG emissions reduction are expected for the life of the project, with additional benefits anticipated based on additional future upgrades currently being planned by Crimson

Cost Effectiveness

Conservatively assuming that the project will maintain a steady net production increase of 9.0 million gallons per year over baseline, this would result in a net production of 180 million gallons over the 20-year lifespan of the project, equivalent to a net GHG emissions offset of 1,883,282 metric tons of CO_2e. At a total Energy Commission funding amount of $5 million the project maintained a net cost of $2.65 per metric ton CO_2e offset over the life of the project. With anticipated future production increases, including to 22 million gallons per year by 2019, actual realized benefits of the project are anticipated to be even more substantial.

Benefits to California Firms

Benefits to California firms other than Crimson include monies spent on project construction and equipment procurement, which supports job retention at affected firms, as well as new job creation at those firms. California-based contractors local to the Bakersfield area also benefitted from acquisition of additional experience with biodiesel production system upgrading and retrofits intended to reduce fuel carbon intensity scores.

Other Project Benefits

Other project benefits include state sales tax revenues paid on project equipment, which benefit the state's general fund, and enhancement of California's and the United States' energy independence and energy security through the reduction of the consumption of petroleum based transportation fuel.

Crimson was awarded state grant funding that will allow it to deploy a new, third generation biodiesel production facility adjacent to the existing facility (the "Phase-3 Plant"). This new project will combine acid and base-catalyzed reactions into a single process, significantly reducing post processing, and enabling processing of high (up to 80 percent) free fatty acid feedstock, while also managing sulfur and other impurities. Specific feedstock for the Phase-3 Plant will include acidulated soap stocks, brown grease, and very low quality fats from dead stock animals.

CHAPTER 5: Observations, Conclusions, and Recommendations

Observations

Crimson was able to successfully increase its nameplate and actual production capacity at its biodiesel production facility located in Bakersfield (Kern County). The expansion was highly successful and included the achievement of key goals and objectives, reducing California's dependence on fossil fuel, increasing the production and use of alternative (renewable biodiesel) fuels, substantially reducing GHG emissions, and stimulating economic development. Unforeseen timing issues associated with planning for multiple rounds of upgrades at Crimson's Bakersfield site resulted in engineering, design, and procurement related delays to the initially proposed project schedule. Nonetheless, Crimson was able to overcome these challenges by rectifying the project design and proposed equipment with future additional anticipated upgrades in mind. This process ultimately resulted in a facility that is presently able to produce 19.6 million gallons per year of biodiesel, which substantially exceeds the original target production rate of 17.0 million gallons per year within the original project budget. Deployment of similar upgrades at other biodiesel production facilities could help to meaningfully expand in-state biodiesel production, even with constraints on capital expenditures.

Conclusions and Recommendations

Goals and Objectives

The project included four goals and seven objectives. Within this framework, the project successfully completed the following:

Goal 1: Reduce California's use and dependence on petroleum transportation fuels.

The project increased rated production capacity at Crimson's plant from 10.6 million gallons per year to an annualized 19.6 million gallons per year during the demonstration period; therefore, the project exceeded the proposed goal of increasing production to 17 million gallons per year, by 2.6 million gallons per year, and Goal 1 is considered to be 100 percent achieved.

Goal 2: Increase the use of alternative and renewable fuels.

In comparison to the baseline facility, the project provided, on average, an additional 9.6 million gallons per year of biodiesel, which is a renewable and alternative fuel, for consumption in California's fuels market. The product fuel was incorporated primarily as blendstock into state-required diesel blends, and to the knowledge of Crimson, was wholly consumed, primarily within California. This additional volume of fuel will be produced on an ongoing basis, and will be further increased, based on additional facility upgrades already being planned by Crimson therefore, Goal 2 is considered to be 100 percent achieved.

Goal 3: Help attain the State's climate change policies, including reducing greenhouse gas emissions and displacing petroleum fuel demand.

During the demonstration period alone, Crimson's total biodiesel production resulted in a net reduction of 16,920 metric tons CO_2e emissions per month (equivalent to 203,046 metric tons CO_2e per year), in comparison to conventional diesel consumption. Of this amount, an average of 7,847 metric tons CO_2e emissions per month reduction during the six-month demonstration period (equivalent to 94,164 metric tons CO_2e per year) was above and beyond that of the baseline period, and was a direct result of project implementation. Similarly, total petroleum displacement during the demonstration period was 9.13 million DGE (equivalent to 18.26 million gallons per year). Of this amount, 4.19 million DGE (equivalent to 8.38 million gallons per year) directly resulted from project implementation, above and beyond baseline fuel production. Additionally, the technology and process improvements utilized in Crimson's plant, as deployed under the project, are applicable to other biodiesel production facilities in California and out of state. To the extent that these are deployed at other locations, the project will also help to support GHG emissions offsets and therefore GHG emissions reductions at other facilities where similar throughput expansion and efficiency processes are developed. Therefore, Goal 3 is considered to be 100 percent achieved.

Goal 4: Stimulate economic development in state.

The project resulted in the direct injection of $5 million into California's economy, including combined funds from the Energy Commission and private match funds. Assuming a multiplier of 1.5, consistent with secondary economic development associated with industrial project installation, the project is anticipated to result in an additional $7.5 million in economic activity. Additionally, sales of the biodiesel produced by the incremental increase achieved under the project amount to an additional $27 million in economic activity each year. Employee salaries contribute an additional $550,000 per year on an ongoing basis, leaving the total economic impact of the project, over its 20-year lifetime, at $563,500,000. Therefore, the project significantly stimulated economic development in California, and Goal 4 is considered to be 100 percent achieved.

Objective: Remove critical bottlenecks that prevented the existing plant from achieving its nameplate production capacity, using ultra-low-carbon-intensity feedstock. Activities targeting this objective are summarized in Section 4.1.

For a review of project performance relative to objectives, refer to Section 4.1. As discussed therein, the project successfully achieved improvement in all target objectives. In some cases, as discussed in Section 4.1, improvements did not meet the level proposed in the original grant application. Nonetheless, process design improvements were more than sufficient to meet (and even exceed) proposed increases in facility throughput. Therefore, this objective is considered to be 100 percent achieved.

Project Conclusions

By completing various targeted and carefully researched/investigated upgrades at Crimson's Bakersfield facility, the project was able to successfully increase plant throughput from 10.6 million gallons per year to 19.6 million gallons per year, exceeding initial targets. With support from the Energy Commission, Crimson achieved this increase while reducing energy and water demand per unit biodiesel production, providing 10 new permanent operations period jobs, and supporting over $500 million in economic activity over the project lifetime.

Project Recommendations

Based on the successes of this project, future recommendations applicable to Crimson and to biodiesel producers in general include continued evaluation and identification of process bottlenecks, and opportunities to improve water use and energy use efficiency. Project upgrades that support these improvements, while also enabling the use of a wider array of feedstock, are especially critical to the future development and expansion of biodiesel production in California, as needed to meet state statutory goals with respect to renewable energy production and use.

GLOSSARY

CALIFORNIA ENERGY COMMISSION (CEC)—The state agency established by the Warren-Alquist State Energy Resources Conservation and Development Act in 1974 (Public Resources Code, Sections 25000 et seq.) responsible for energy policy. The Energy Commission's five major areas of responsibilities are:

1. Forecasting future statewide energy needs
2. Licensing power plants sufficient to meet those needs
3. Promoting energy conservation and efficiency measures
4. Developing renewable and alternative energy resources, including providing assistance to develop clean transportation fuels
5. Planning for and directing state response to energy emergencies.

CALIFORNIA CODE OF REGULATIONS (CCR) -- The official compilation and publication of the regulations adopted, amended or repealed by state agencies pursuant to the Administrative Procedure Act (APA). Properly adopted regulations that have been filed with the Secretary of State have the force of law.[3]

CALIFORNIA AIR RESOURCES BOARD (ARB) -- The "clean air agency" in the government of California, whose main goals include attaining and maintaining healthy air quality; protecting the public from exposure to toxic air contaminants; and providing innovative approaches for complying with air pollution rules and regulations.

CARBON DIOXIDE (CO2) - A colorless, odorless, non-poisonous gas that is a normal part of the air. Carbon dioxide is exhaled by humans and animals and is absorbed by green growing things and by the sea. CO2 is the greenhouse gas whose concentration is being most affected directly by human activities. CO2 also serves as the reference to compare all other greenhouse gases (see carbon dioxide equivalent). The major source of CO2 emissions is fossil fuel combustion. CO2 emissions are also a product of forest clearing, biomass burning, and non-energy production processes such as cement production. Atmospheric concentrations of CO2 have been increasing at a rate of about 0.5% per year and are now about 30% above preindustrial levels. (EPA)

GREENHOUSE GAS -- Any gas that absorbs infra-red radiation in the atmosphere. Greenhouse gases include water vapor, carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), halogenated fluorocarbons (HCFCs) , ozone (O3), perfluorinated carbons (PFCs), and hydrofluorocarbons (HFCs). (EPA)

1000 VOLT-AMPERES (kVA) -- A volt-ampere (VA) is the voltage times the current feeding an electrical load. A kilovolt-ampere (kVA) is 1000 volt-amperes.[4]

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[3] Office of Administrative Law (OAL) Website: (https://oal.ca.gov/publications/ccr/)

[4] Maxim Integrated Website: (https://www.maximintegrated.com/en/glossary/definitions.mvp/term/kVA/gpk/574)

SULFUR DIOXIDE (SO_2) -- A strong smelling, colorless gas that is formed by the combustion of fossil fuels. Power plants, which may use coal or oil high in sulfur content, can be major sources of SO_2 and other sulfur oxides contribute to the problem of acid deposition. SO_2 is a criteria air pollutant