CALIFORNIA ENERGY COMMISSION

CALIFORNIA NATURAL RESOURCES AGENCY

California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

Renewable Diesel Production

Prepared for: California Energy Commission

Prepared by: AltAir Fuels, LLC

January 2022 | CEC-600-2022-034

California Energy Commission

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ACKNOWLEDGEMENTS

Special thanks to the California Energy Commission who helped guide AltAir Fuels, LLC through to a successful launch of the first commercial scale renewable diesel facility in California. In addition, this facility is the first of its kind to co-produce renewable jet at commercial scale.

PREFACE

Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007) created the Clean Transportation 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.

To be eligible for funding under the Clean Transportation Program, a project must be consistent with the CEC's annual Clean Transportation Program Investment Plan Update. The CEC issued PON-13-609 to support production of low carbon renewable biofuels. In response to PON-13-609, the recipient submitted an application which was proposed for funding in the CEC's notice of proposed awards July 18, 2014, and the agreement was executed as ARV-14-022 on September 17, 2014.

ABSTRACT

The project involved the expansion of an under-construction biorefinery in Paramount, California from a domestic manufacturing capacity of 30 million gallons of renewable diesel fuel by an additional 33 percent. In addition, to expanded capacity, the project expanded functionality to co-produce a renewable jet fuel that is market ready and of the quality that meets customer specifications, whether those customers are the U.S. Military, commercial aviation, or other fuel users.

To expand capacity AltAir Fuels installed two new reactors, five new heat exchangers, four new vessels, one new compressor, and a hydrogen receiving, storage and vaporizing facility. In addition, much of the existing equipment was reworked to make it compatible with renewable feedstocks including heaters, compressors, a reactor, upgrading control systems and support units such as amine and caustic, steam, cooling water and flare systems used to support the new process requirements.

In the first quarter 2016, AltAir Fuels sold renewable F-76 diesel to the US military, renewable road diesel to fuel users and renewable jet fuel to commercial aviation. Production flow rates have been demonstrated at 40 million gallons of renewable fuel per year. Delivering this renewable fuel into California’s diesel and jet fuel supply will displace equal amounts of petroleum per year and the associated reduction in greenhouse gas and other harmful emissions.

Keywords: Biorefinery, renewable diesel, renewable jet, U.S. Military, F-76 Military diesel fuel, AltAir Fuels, compressor, hydrogen, feedstock

Please use the following citation for this report:

Sherbacow, Brian. 2022. *Renewable Diesel Production*. Publication Number: CEC-600-2022-034.

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EXECUTIVE SUMMARY

Agreement ARV-14-022 added additional functionality and capacity to a commercial scale renewable diesel facility. AltAir Fuels developed one of California's first commercial scale renewable diesel facility using private capital. Only two other renewable diesel facilities exist in the United States, with California adding the third commercial facility. This facility is the first of its kind internationally to also co-produce renewable jet at commercial scale.

This new biorefinery takes advantage of unused infrastructure capacity at an existing petroleum refinery in Paramount, a brownfield retrofit construction project that reduced or avoided lifecycle environmental costs associated with building a new facility. Locating the project within an existing refinery ensured maximum usage of existing equipment, leveraged expertise for operations and maintenance and greatly simplified permitting needs. The California location is also strategic in its proximity to feedstock suppliers upstream and established customers downstream, thereby sustaining and creating jobs for the California economy.

The technology employed by AltAir Fuels and its partners is feedstock flexible, allowing the new biorefinery to process multiple feed types. This includes nonfood sources of feedstocks that can be grown on marginal lands and with minimal water, such as camelina oil. It also includes other emerging feedstocks such as algae. Due to this flexibility, this project will have the capacity to process new triglyceride feed stocks as they become commercially available.

The new Phase I biorefinery, without the Phase II expansion would have expanded domestic manufacturing capacity by 30 million gallons of renewable diesel and jet fuel annually. The expansion funded by this California Energy Commission-funded project increased the capacity of the new biorefinery by an additional 33 percent (to 40 million gallons per year) while also allowing use of additional feed stocks.

Greenhouse gas emissions from renewable diesel are up to 80 percent lower than from petroleum diesel and approximately 40 percent less than from soy biodiesel. The co-produced renewable jet fuels are from naturally occurring oils. They are estimated to deliver up to 80 percent reduction in Greenhouse Gas emissions relative to petroleum-derived jet fuel.

The objective of this Agreement was to expand capacity and functionality of the recently completed biorefinery in Paramount, California. The facility now produces market-ready renewable diesel fuel and co-produces renewable jet and a byproduct chemical and gasoline component, naphtha.

- A measurement of this Agreement's success is the establishment of a facility that is now capable of producing at least 40 million gallons per year, which is an increase of over 33 percent of the facility's capacity prior to the expansion.
- A secondary measurement is the quality of the products and attainment of customer specifications, whether those customers are the U.S. Military, commercial aviation, or other fuel users.

In the first quarter 2016, AltAir Fuels sold renewable F-76 diesel to the US Navy, renewable road diesel to fuel users including United Parcel Service and renewable jet fuel to United Airlines. Production flow rates have been demonstrated at 40 million gallons of renewable fuel per year. Delivering this renewable fuel into California's diesel and jet fuel supply will displace equal amounts of petroleum per year and the associated reduction in greenhouse gas and other harmful emissions.

CHAPTER 1: Project Overview and Description

1.1 Project Overview

AltAir Fuels, LLC sought $5 million in grant funding from the CEC under PON-13-609, to be matched with $31.6 million in funding to increase the capacity and expand feedstock options at our California commercial scale renewable diesel facility. With support from the CEC, California now houses AltAir Fuels' expanded commercial scale facility. There are only two other renewable diesel facilities in the United States. AltAir Fuels' facility is also the first of its kind to produce renewable jet at commercial scale. It is important to understand that renewable diesel or "second generation diesel," is a molecularly identical fuel to petro-diesel, derived from biological sources, that is chemically not an ester and thus distinct from biodiesel. Renewable diesel meets the American Society for Testing and Materials D975 quality standard, which is the existing standard for on-road diesel fuel. Renewable diesel provides a direct replacement to petro-diesel without any need for changes to existing fuel distribution networks or engines. Additionally, third-party analysis demonstrates that renewable diesel has higher energy content, better cold weather performance, and lower Greenhouse Gas (GHG) production than soy biodiesel.

AltAir Fuels has partnered with Universal Oil Products, a subsidiary of the Honeywell Corporation, to deploy proprietary technology for the production of second-generation renewable diesel and jet fuels. Unlike first-generation biofuels, renewable diesel and jet fuels are essentially molecular equivalents to their petroleum-derived counterparts and are hence fungible and compatible with liquid fossil fuel. The produced renewable diesel and jet fuels have the same approximate energy content as petroleum-derived fuels and will displace a total of 40 million gallons per year of petroleum fuels, including co-products. California modified Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation modeling shows greenhouse gas emission reductions of over 75 percent from petroleum, reducing carbon dioxide emissions by approximately 1 billion pounds annually and 26 million metric tons over 20 years.

The AltAir Fuels project is being constructed in three phases. The initial phase (Phase I) was designed to produce 30,000,000 gallons of renewable fuel per year. With the CEC's investment AltAir Fuels completed Phase II in Q1 of 2016 and expanded this production to 40,000,000 gallons per year. Importantly, the additional tankage added in Phase II is scaled to allow a third phase of expansion to an approximate 150,000,000 gallons per year. While substantial additional investment of approximately $100 million will be required by AltAir Fuels to move from Phase II to Phase III the CEC grant enabled critical tankage and piping infrastructure to be added. All equipment funded in Phase II was scaled with the anticipation of Phase III. Much of the basic infrastructure for Phase III expansion is already in place at the Alon USA facility. This refinery produced approximately 750,000,000 gallons per year of conventional fuel before curtailing operations at the end of 2012. It is management's belief that this staged expansion schedule is the prudent course of action to optimize systems and reduce project risk. Without the CEC grant AltAir Fuels would likely have been unable to complete Phase II, which in turn would have eliminated the ability to proceed to Phase III.

The initial cost to construct Phase I of this facility was approximately $50M. Phase I repurposed existing petroleum processing equipment located at an Alon USA refinery in Paramount resulting in a 30 million gallons per year biofuel facility. AltAir Fuels successfully raised the required capital for Phase I, allowing the company to repurpose existing facilities at the Alon USA refinery in Paramount.

AltAir Fuels sought $5M from the CEC for Phase II of the project, which expanded production of the facility from 30 million Gallons per Year to 40 million Gallons per Year and allowed processing of additional feedstocks. Under Phase I, AltAir Fuels only had one tank capable of accepting feedstock and only one finished tank for renewable diesel and was capable of only processing one feedstock. The CEC grant, along with matching funds provided by AltAir Fuels, allowed for the addition of a second feedstock tank and additional finished renewable diesel tanks. The additional feedstock tank allows AltAir Fuels to accept California produced feedstocks including, but not limited to camelina and algae oil.

A peer-reviewed analysis conducted by Michigan Tech University showed that camelina is an ideal feedstock for renewable diesel, demonstrating significant Carbon Dioxide (CO2) reductions compared to petroleum fuels.[1] Recent evaluations of renewable diesel derived from camelina oil indicated no differences in fuel performance compared to petroleum-based products, with significantly lower exhaust and GHG emissions.

The AltAir Fuels project has executed definitive Cost Plus agreements with World Fuel Services and United Airlines, totaling 10 million Gallons per Year for 3 years (30 million Gallons per Year total). In addition, AltAir Fuels has been awarded fuel supply contracts with the U.S. Defense Logistics Agency for the U.S. Navy as well as United Parcel Services. By re-utilizing existing permitted equipment at Alon USA's Paramount refinery, the project greatly reduced capital and operating costs and allowed for expedited California Environmental Quality Act permitting.

1.2 Problem Statement

Growing worldwide demand for diesel fuel, coupled with concerns over global warming, has sparked interest in renewable alternatives that show the potential for reduced GHG emissions at a reasonable cost of production. Diesel-based transportation – for such uses such as long-haul commercial trucking – and aviation is fundamental to the global economy and way of life. For example, worldwide aviation transports 2.2 billion passengers annually as well as 35 percent of all international trade in goods (by value). Its global economic impact is estimated at $3,560 billion and generates 32 million jobs globally.

Unlike first-generation biofuels, renewable diesel fuels are essentially molecular equivalents to their petroleum-derived counterparts and are hence fungible and compatible with liquid fossil fuels. This characteristic allows existing infrastructure for production, transportation and storage of these second-generation fuels, in addition to alleviating the need to alter existing engines. AltAir Fuels and its partners have successfully developed, produced, and tested renewable diesel fuels in a variety of settings and for a variety of uses.

It is important to understand that "green diesel" or "second generation diesel," refers to petro diesel-like fuels derived from biological sources that are chemically not esters and thus distinct

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1 David R. Shonnard, Larry Williams, and Tom N. Kalnes (2010). Camelina-derived jet fuel and diesel: Sustainable advanced biofuels. Environmental Progress & Sustainable Energy, 29: 382–392. doi: 10.1002/ep.10461

from biodiesel. Renewable diesel meets the American Society for Testing and Materials D975 quality standard, which is the existing standard for on-road diesel fuel. Renewable diesel has been subjected to rigorous on-road fleet testing throughout the US and Canada. The data from this testing indicates that renewable diesel has advantages over biodiesel for the end-user. These advantages include a higher energy content and better cold weather performance compared to biodiesel.

1.3 Process

1.3.1 Process Overview

The AltAir Fuels Renewable Fuels Project converts up to 3,000 Barrels per Day of technical beef tallow and vegetable oils, including Refined, Bleached and Deodorized soy and Refined, Bleached and Deodorized canola into renewable jet and diesel fuel. Small quantities of renewable naphtha and Liquefied Petroleum Gas (LPG) are produced as byproducts. The technology for the process is called Ecofining and is provided by Universal Oil Products. Ecofining is a two-stage hydrotreating process, similar to conventional jet and diesel hydrotreating processes. This project allowed for repurposing of the existing Number 5 Hydrodesulphurization Unit into the new Renewable Fuels Unit and alternate or concurrent use of the existing Naphtha Splitter and portions of the existing Isomerization Unit to convert the tallow and vegetable oils into diesel, jet fuel, naphtha and LPG. Auxiliary treating and stripping units are used to handle the corrosive nature of feed stocks. Hydrogen for the process is supplied by Praxair in liquid form, which is vaporized for use in the units. Existing infrastructure and tankage are used to support the operation. Products leave the refinery by truck using existing loading racks as well as pipeline.

1.3.2 Feed Stock and Tankage

The primary feed stock is technical beef tallow with Refined, Bleached and Deodorized vegetable oils as pricing dictates. The melting point for tallow and oils is about 104 F, so low-pressure steam heating of the rail cars and storage tank is provided as needed to keep the feeds in liquid form. The existing rail unloading rack was modified to add segregated loading arms, a pump, and heated piping to transfer the new feedstock to the feed tank. An existing truck rack was modified to add an unloading arm and piping to unload trucked feedstock. Tank 80003 was modified from a floating roof tank into a fixed roof tank with odor control. The odors from the tank are vented to carbon drums. Tank 80003 will be heated. However, the vapor pressure of tallow and vegetable oil are both below 0.001 Pounds per Square Inch at 120 degrees Fahrenheit, therefore no fugitive emissions result from the operation of the feedstock storage tank.

Approximately 50 rail cars per week of beef tallow and vegetable oils are delivered to the Refinery with approximately seven railcars of feedstock offloaded at the rail unloading rack per day. Feedstock is also occasionally delivered by truck and unloaded at the existing tank truck unloading rack 1. Beef tallow, and occasionally vegetable oils, are delivered by heated rail car and offloaded to tank T-80003. In route to the tank, the feed passes through a filter to remove larger particulate matter. A nitrogen blanket is kept on the oil in the tank to prevent oxidation of the oil. The tank is lined to prevent long-term corrosion from the acidic feed stocks. Tank circulation through low pressure steam heat exchangers keeps the product temperature at about 120 F. Tallow or Vegetable oils delivered by truck are offloaded at Unloading Rack 1 and go through the same filter and to T-80003.

1.3.3 First Stage Processing (Feed pretreating and Deoxygenation)

The First Stage operation processes the feed through two new reactors, RA-502 and RA-503, each with specific catalysts. The first reactor contains a guard bed to remove particulates and a pretreat catalyst to remove trace contaminants in the feed, such as sulfur, nitrogen, metals and phospholipids. This catalyst also removes some oxygen from the feed. The second reactor contains a de-oxygenation catalyst that removes all remaining traces of oxygen from the feed to protect the catalyst in the Second Stage reactor. Prior to entering the reactors, a small amount of sulfiding chemical, Dimethyl Disulfide, from drum D-1510 is injected into the feed stream to maintain optimum catalyst condition in the First Stage reactors. Some recycle hydrogen and a liquid recycle stream from new hot product separator D-504 is added to dilute the feed and keep reactor temperatures in their desired range of operation. Some of the existing piping around the reactors was replaced with stainless steel or other alloy piping for corrosion protection.

Effluent from RA-503 flows through new heat exchanger X-514 to heat the feed to the Second Stage isomerization reactor. This exchanger is a key energy conservation device and helps keep air emissions to a minimum. The effluent then flows to feed/effluent exchangers X-515 where it preheats the first stage reactor feed. After leaving the feed/effluent exchanger, effluent flows to new hot separator D-504, which separates hydrogen and light ends from heavier components. Hot liquid from the bottoms of D-504 goes to existing First Stage stripper tower W-501, while the overhead from D-504 is condensed then directed to new cold separator D-506. D-506 and the tube bundle in XF-516 were replaced with stainless steel and rated for 650 Pounds per Square Inch Gauge operation. Use of a hot separator is another key energy efficiency device that reduces fired heater duties. Wash water pump P-1718 helps keep air cooler XF-516 free from salt deposits.

Overhead gases from D-506 consist of recycle hydrogen, CO2, propane and a small amount of Hydrogen Sulfide (H2S). This stream flows through modified amine scrubber W-201 where H2S and CO2 are removed by a CO2-selective amine. W-201 was replaced with a vessel rated for 650 pounds per square inch gauge operation. The treated recycle stream then flows through compressor knockout drum D-513 to modified recycle compressor C-121, and from there back to the first stage reactor feed line. Makeup hydrogen enters the unit at the suction side of C-121 via compressor knock-out drum D-513, which was rated for 650 pounds per square inch gauge operation.

Liquid from hot separator D-504 and cold liquid from D-506 combine and go to existing stripper tower W-501, where light gases and liquids are stripped from the First Stage product. Heat for stripping comes from existing fired reboiler H-502, which also supplies heat for the Second Stage fractionator tower. W-501 overheads are condensed, then flow to reflux drum D-503. A portion of the overheads become reflux to the tower. Overhead gases from D-503 are caustic treated in D-725 to remove small amounts of H2S and are used as fuel gas as is currently done in the existing refinery operation.

The bottoms product from W-501 exchanges heat with incoming feed, then goes to the Second Stage feed surge drum D-1516. Heat exchangers XF-507B, D-513 and X-1511A/B are available to cool W-501 bottoms if they are sent to tankage. This stream is called “green paraffinic diesel”, an exceptionally high-quality diesel product, which is the feed to the Second Stage Processing unit.

1.3.4 Second Stage Processing (Isomerization/Hydrocracking)

Green paraffinic diesel from the First Stage is fed to the Second Stage to produce renewable jet and diesel. At low reactor temperatures the catalyst isomerizes the feed to produce desired cold flow properties for jet and diesel, i.e., freeze point for jet, and cloud and pour point for diesel. At higher reactor temperatures, some of the diesel is hydrocracked to jet, naphtha and LPG.

The paraffinic diesel from First Stage stripper tower bottoms goes to the modified feed surge drum D-1516. Hydrogen from Praxair's new hydrogen offloading and vaporizing system is added to the diesel and the combined feed is preheated in existing feed/effluent heat exchangers and hydrocracked in existing reactor RA-501, then separated by existing hot separator D-502.

Bottoms from D-502 go to new Second Stage fractionator tower W-1601. Overhead vapors from D-502 are cooled and condensed in heat exchangers XF-507A and X-508, and then sent to existing cold separator D-505. Liquid from D-505 combines with liquid from D-502 and goes to fractionator W-1601.

Fractionation of Second Stage reactor effluent into finished products takes place in existing fractionator towers W-1601 and W-1502. All vessels, pumps and heat exchangers associated with these towers pre- existed A new jet side cut stripper was added to W-1601 to produce renewable jet fuel. Finished products are renewable diesel; renewable jet; renewable naphtha; LPG and fuel gas.

The liquid streams from D-502 are preheated in heat exchangers X-1610A/B before entering W- 1601. Heat to the tower is supplied by First Stage fired heater H-502 and reboiler X-1603. Tower overhead products include light gases, LPG (propane and butanes) and naphtha, which are condensed in heat exchanger XF-1601, then flow to reflux drum D-1601. A portion of the overheads provide reflux to the tower and a small stream of light naphtha goes to W-1502.

Remaining light gases from D-1601 are compressed in compressor C-123, cooled in heat exchanger X-123, then flow to fuel gas mix drum D-712. Overhead light gases and propane from D-712 go to fuel gas distribution. Knock out drum D-1517 and pump P-1517 prevent liquid from carrying over into C-123

Light naphtha from D-1601 going to fractionator W-1502 is heated with hot bottoms product from W-1601 in reboiler X-1528. Heavy naphtha bottoms product from W-1502 is pressured through coolers XF-1519 and X-1520A/B/C to storage. Heavy naphtha is blended back into product diesel. Off spec heavy naphtha is either stored in D-1201 for reprocessing in W- 1601 or reprocessed through W-304. W-1502 overheads are condensed in heat exchangers XF- 514 and X-1515, then flow to reflux drum D-1511. LPGs are stored in Refinery Bullets D-1201/1201/1203 or are reprocessed in W-304. If W-304 is used to further fractionate naphtha, the overhead stream of light naphtha/LPG will go to bullets D-709/710, while any heavy naphtha that cannot be blended into diesel is sent to a naphtha storage tank, then be reprocessed in W- 1601 or sold.

Jet side cut from W-1601 goes to side cut stripper W-1602 and is reboiled with H-502 pump around diesel in reboiler X-1605. Side cut pump P-1516 pumps renewable jet through coolers XF-1536 and X-1602 to storage.

Diesel product from the bottoms of W-1601 supplies heat to the tower in reboiler X1603, then flows through surge drum D-1604 and feed/bottoms exchangers X-1610 to bottoms pumps P-

1603A/B. Flow from P-1603 is used to reboil W-1502, then flows to air cooler XF-1602 and trim cooler X-1602 before going to storage.

Existing tankage is used for jet rundown and finished storage. Diesel and jet leave the refinery by tank truck via loading racks 19 or 21. Butanes and naphtha will leave by LPG trucks via the loading rack 22.

1.3.5 Acid Gas Disposal

Overhead gases generated in the First Stage process are treated in the Amine/Fuel Gas Treating unit to remove H2S and CO2 by a CO2-selective amine. The treated recycle stream goes back to the First stage feed line. Scrubber W-201 was replaced with a vessel rated for 650 Pounds per Square Inch Gauge operation.

Amine used to remove CO2 and H2S in the First Stage is regenerated in the Refinery amine regeneration unit. Acid gas from the overhead of W-208 will contain about 91 percent CO2, 4 percent H2S and some light gases. There are about 50 Pounds per Hour of H2S in this stream, a small fraction of the roughly 2,000 Pounds per Hour from the existing operation.

In the refinery operation, overhead sour gas from the amine regenerator tower and the Sour Water Stripper go to the Refinery Sulfur Recovery Unit then to the Tail Gas Treating Unit. The Caustic Scrubber is used as a backup to the Sulfur Recovery Unit. In Renewable Fuels operation, overhead gas from both the Amine Regenerator and Safe Water System go to the caustic scrubber for H2S removal using sodium hydroxide (caustic). Treated gas goes to the Refinery incinerator, the same as for the current operation. Caustic usage is approximately 84 pounds per hour. Spent caustic is accumulated in Tank 1000. Periodically the spent caustic is transported by truck to re-use or to disposal facilities.

1.3.6 Other Facilities

The Project generates about 6 Gallons per Minute of sour water, which goes directly to effluent water treating. Approximately 1,000 Pounds per Hour of steam is required for amine stripping. This steam comes from the existing refinery boilers. Plant and instrument air, nitrogen and fuel gas are supplied as in the current operation. As with the refinery operation, natural gas from SoCal Gas Company supplements the refinery fuel gas system when needed. Once the process units were running, overhead gas from First Stage Stripper Tower W-501 and Second Stage Fractionator W-1601 provided enough fuel to fire H-501 and H-502, with about 25 million British Thermal Units per hour of excess gas. Maximum firing duty on H-501/502 is 28 British Thermal Units per hour, the permitted firing limit on these heaters. There are no other fired heaters in the Project.

1.4 Goals of the Agreement

The goal of this Agreement was to obtain $5 million in grant funding from the California Energy Commission to add additional functionality and capacity to a commercial scale renewable diesel facility. AltAir Fuels developed California's first commercial scale renewable diesel facility using private capital, with a total project cost in excess of $31.6 million dollars of new capital and approximately $50 million dollars of existing contributed assets. There are only two other renewable diesel facility in the United States, and California houses the third commercial facility. This facility is the first of its kind to also co-produce renewable jet at commercial scale.

This new biorefinery takes advantage of previously unused infrastructure capacity at an existing petroleum refinery in Paramount, a brownfield retrofit construction project that l reduced or avoided the lifecycle environmental costs associated with building a new facility. Locating the project within an existing refinery ensured maximum usage of existing equipment, leverages expertise for operations and maintenance and greatly simplified permitting needs. The California location is also strategic in its proximity to feedstock suppliers upstream and established customers downstream – thereby sustaining and creating jobs for the California economy.

The technology employed by AltAir Fuels and its partners is feedstock flexible, allowing the new biorefinery to process multiple sources. This includes nonfood sources of transportation feedstocks that can be grown on marginal lands and with minimal water, such as camelina oil. It also includes other emerging feedstocks such as algae. Due to this flexibility, this project has the capacity to process new triglyceride feed stocks as they become commercially available.

The new Phase I biorefinery, without the Phase II expansion, would have expanded domestic manufacturing capacity to 30 million gallons of renewable diesel and jet fuel annually. The expansion funded by this CEC project increased the capacity of the new biorefinery by an additional 33 percent (to 40 million gallons per year) while also allowing use of additional feed stocks.

Greenhouse gas emissions from renewable diesel are up to 80 percent lower than from petroleum diesel and approximately 40 percent less than from biodiesel. The co-produced renewable jet fuels are from naturally occurring oils. They are also estimated to deliver up to an 80 percent reduction in GHG emissions relative to petroleum-derived jet fuel.

1.5 Objectives of the Agreement

The objectives of this Agreement were to expand capacity and functionality of a biorefinery in Paramount, California. The facility now produces market-ready renewable diesel fuel as well as renewable jet and a byproduct chemical and gasoline component.

- A measurement of this objective's success is the establishment of a facility that is capable of producing at least 40 million gallons per year, which is an increase of over 33 percent of the facility's capacity prior to the expansion.
- A secondary measurement of this objective is the quality of the product and its ability to meets customer specifications, whether those customers are the U.S. Military, commercial aviation, or other fuel users.

CHAPTER 2: Performance of Project Tasks

2.1 Project Administration

This task comprised several activities critical to efficiently planning, implementing, and managing the project activities and maintaining open lines of communication with the Commission. AltAir Fuels prepared monthly progress reports and submitted them to the commission. Each monthly report contained a summary of what AltAir Fuels planned to accomplish during the period, what was actually accomplished during the period, and what we expected to accomplish during the next period. The reports also contained an update on the status of project milestones and products, a description of any significant problems or changes to the project, and a summary of current and cumulative budget expenditures.

Invoices summarizing total amount billed and match funding detailed by budgeted task summary and category summary were submitted throughout the project. Copies of paid invoices also accompanied the invoices submitted. A total of $5,000,000 of Commission Reimbursable funds and $24,364,381 of Match funding was submitted for a total of $29,364,381 of total funding.

2.2 Process Design and Construction Engineering

This task involved process design and construction engineering to support the timely installation of equipment for expanding the existing biorefinery. This task also included the design and engineering for instrumentation, controls, and piping associated with all of the equipment and other ancillary items.

2.3 Procurement and Construction

2.3.1 Equipment Procurement

The goal of this task was to complete equipment procurement in a manner that minimizes lead-time for equipment at an affordable cost while meeting all equipment specifications identified during engineering. This included the purchasing of vessels, heat exchangers, pumps, compressors, instrumentation, and electrical gear.

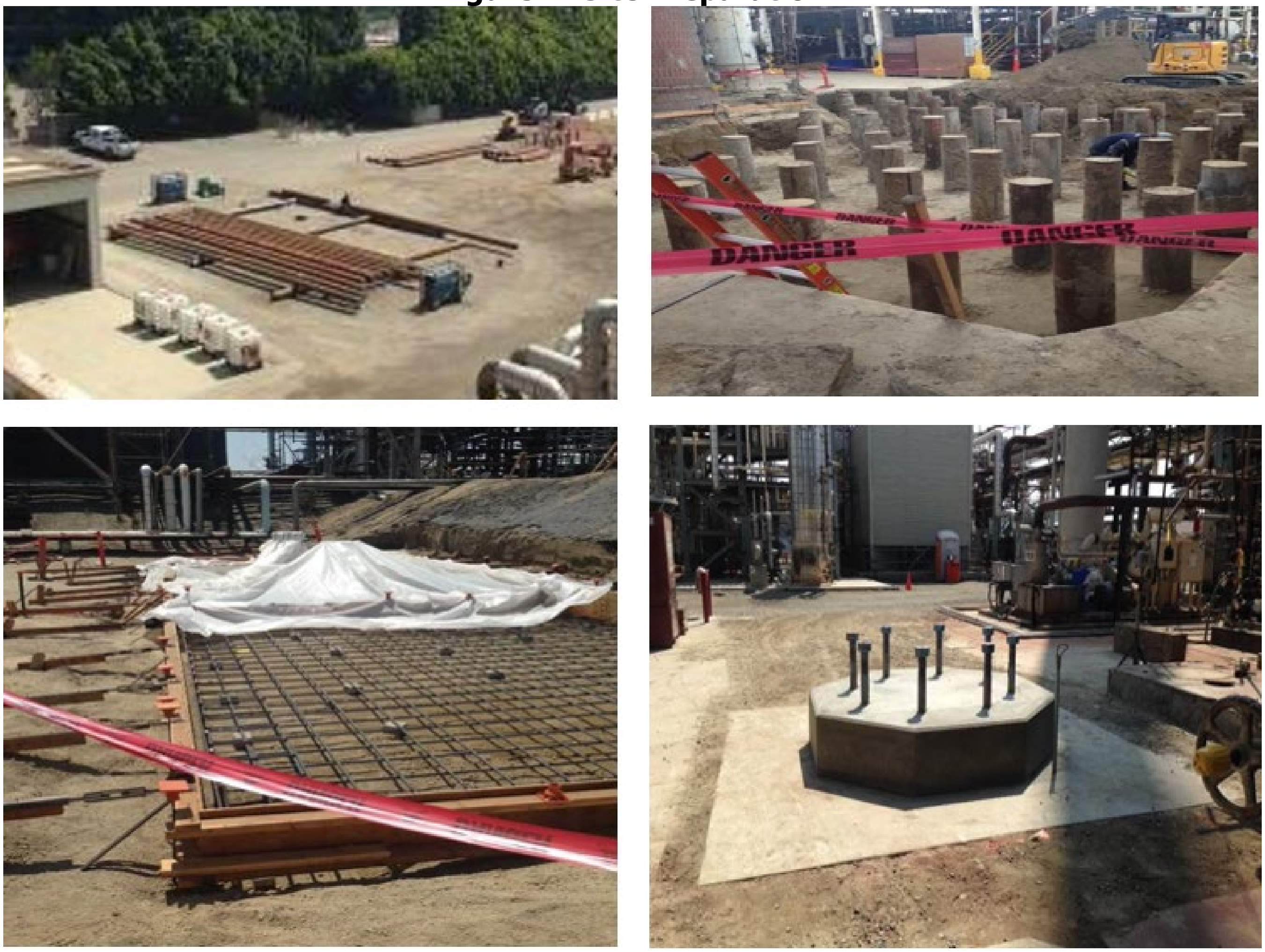
2.3.2 Demolition and Site Preparation

The goal of this task was to complete demolition and prepare the project site for construction activities and equipment installation. This included the completion of piling and foundation work for the hydrogen delivery system and a new reactor tower. Figures 1 and 2 show the AltAir Fuels Biorefinery and the site preparation for construction.

Figure 1: AltAir Fuels Biorefinery in Paramount, California

Source: AltAir Fuels, LLC

Figure 2: Site Preparation



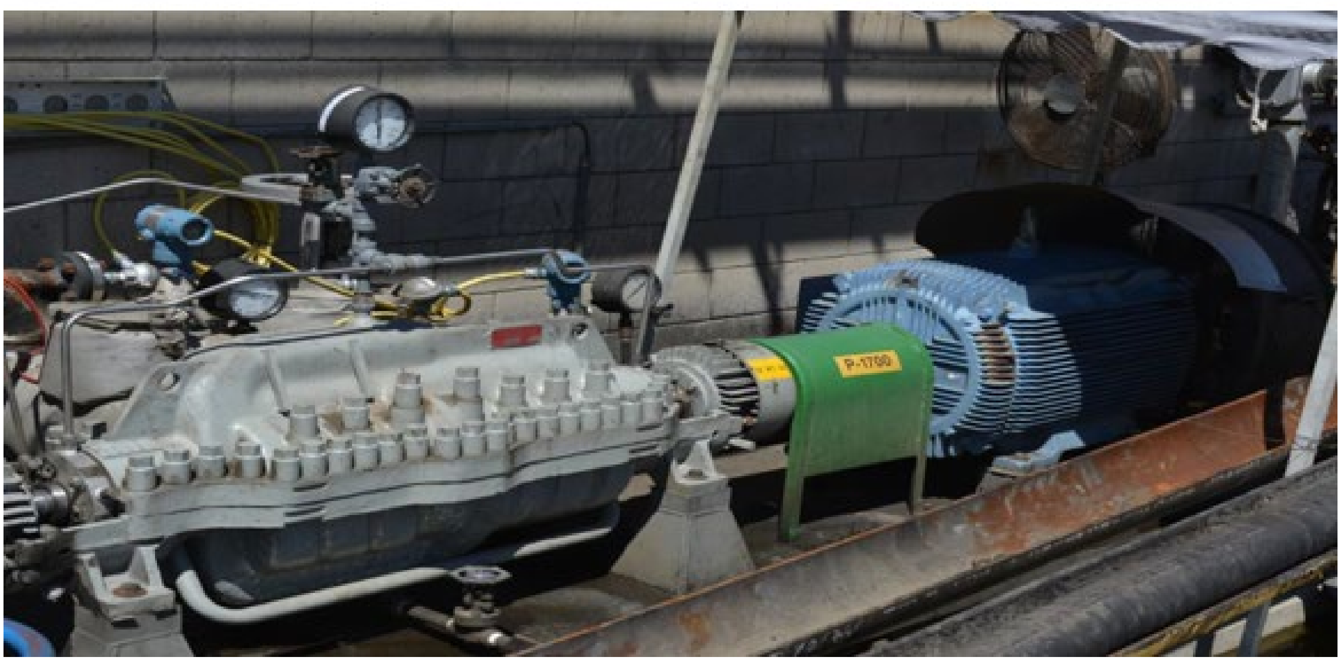
Note: Top Left: Pilings - Staged, Top Right: Pilings - Driven for foundation, Bottom Left: Foundation for Hydrogen delivery system, Bottom Right: Foundation for Reactor Tower (RA-502)
Source: AltAir Fuels, LLC

2.3.3 Construction and Equipment Installation

The goal of this task was to complete all construction related activities in a safe and efficient manner. This included purchasing new equipment, rework of existing equipment to make it compatible with renewable feedstocks and products and install new equipment.

Ancillary equipment was installed with all new equipment. Ancillary equipment included, but was not limited to, pumps, valves, seals, sight glass, instrumentation, insulation, gauges, meters, and filters as shown in Figure 3. Each installation also required electrical wiring and connections and mechanical installation that included placement, piping and all ancillary equipment installation. After new equipment was installed, programming was completed to enable operation of the equipment through the facility's automated control system. Phase 2 work completed the Renewable Fuels Project and prepared the plant for operation through startup and into commercial operations. Major activities included the following activities: Purchase of new equipment (Figure 3), rework of existing equipment for renewable fuels (Figures 4, 12); installed new equipment (Figures 5 – 10, 13); and integrated old and new controls (Figure 11).

Figure 3: New Equipment Photos



Note: Top: Fresh Hydrogen Compressor (C-122, above), Bottom: Tallow Feed Charge Pump (P-1700)
Source: AltAir Fuels, LLC

Figure 4: Reworked Existing Equipment for Renewable Feedstocks and Products

Figure 5: Installed New Reactors with New Internals and Temperature Thermometry

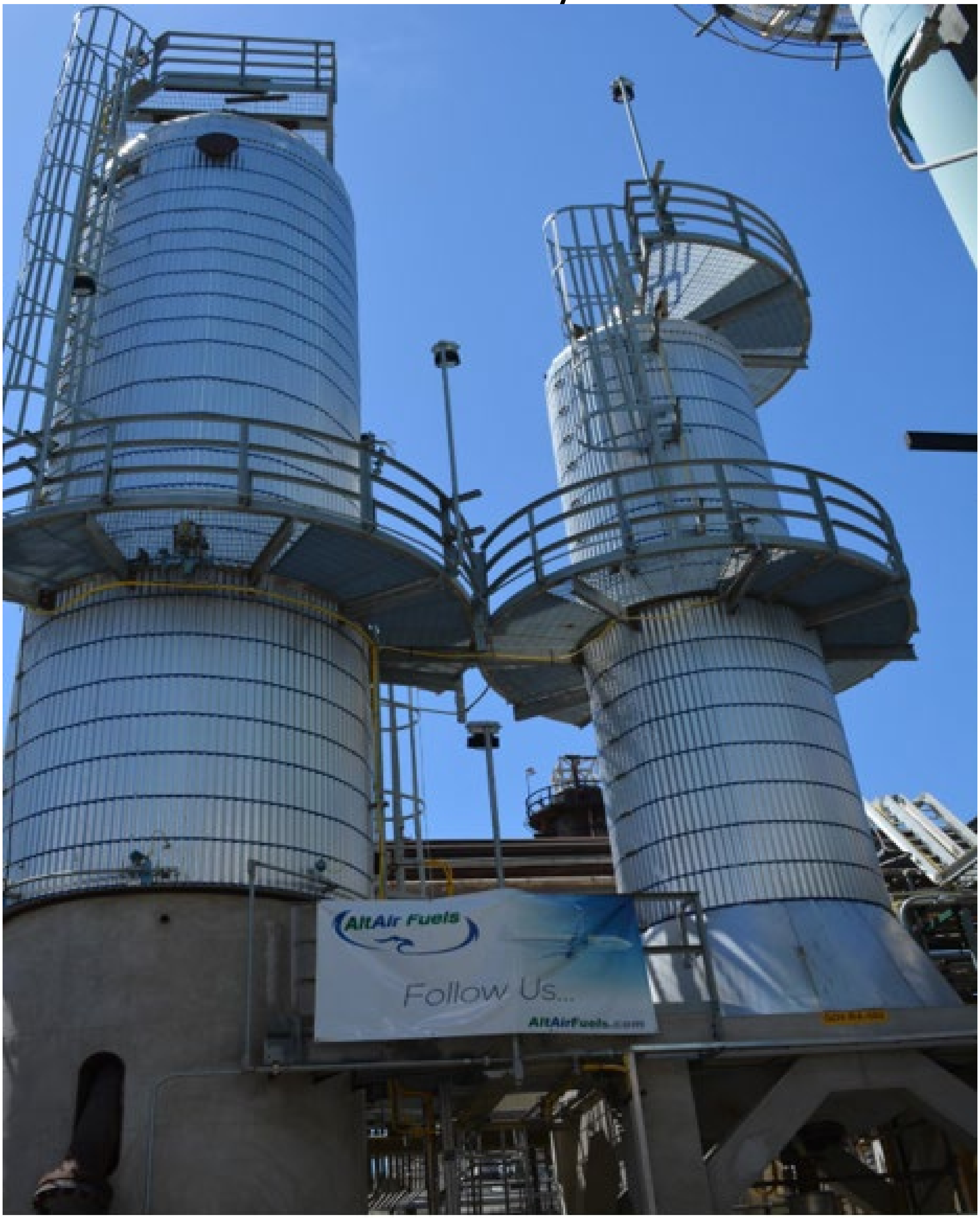


Figure 6: Five New Heat Exchangers, New Pumps, Four New Vessels, One New and Two Reworked Compressors

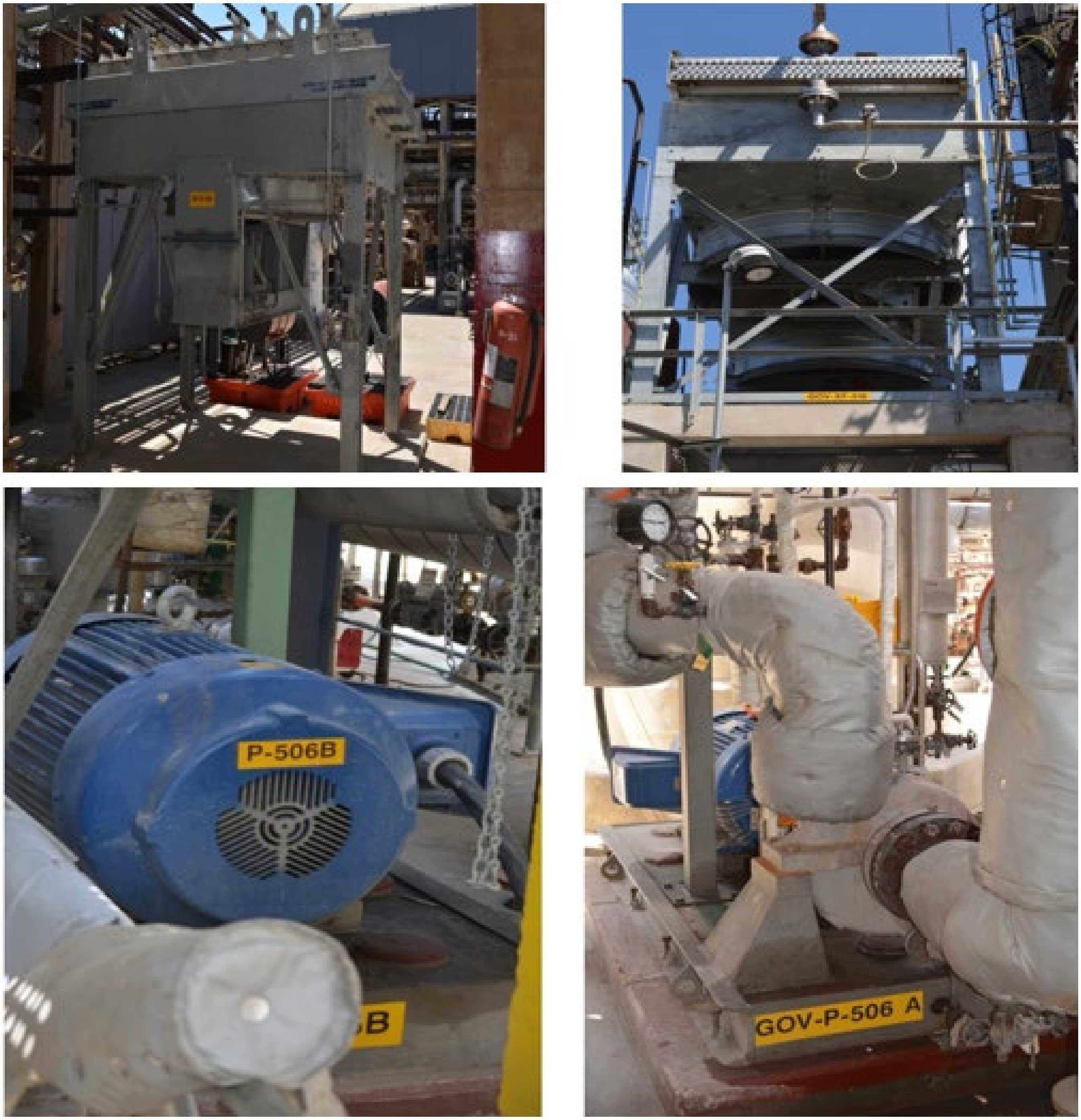


Figure 7: Installed Stainless Steel and Alloy Reactor Loop Piping and Valves

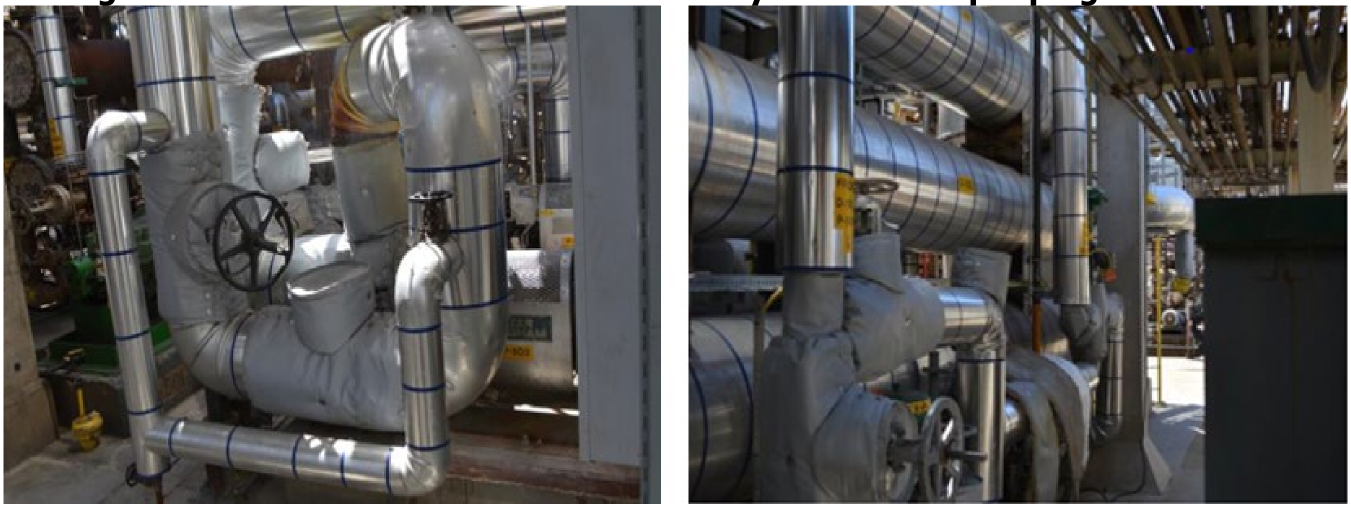


Figure 8: Retubed Reactor Charge Heaters with Stainless Steel Tubing

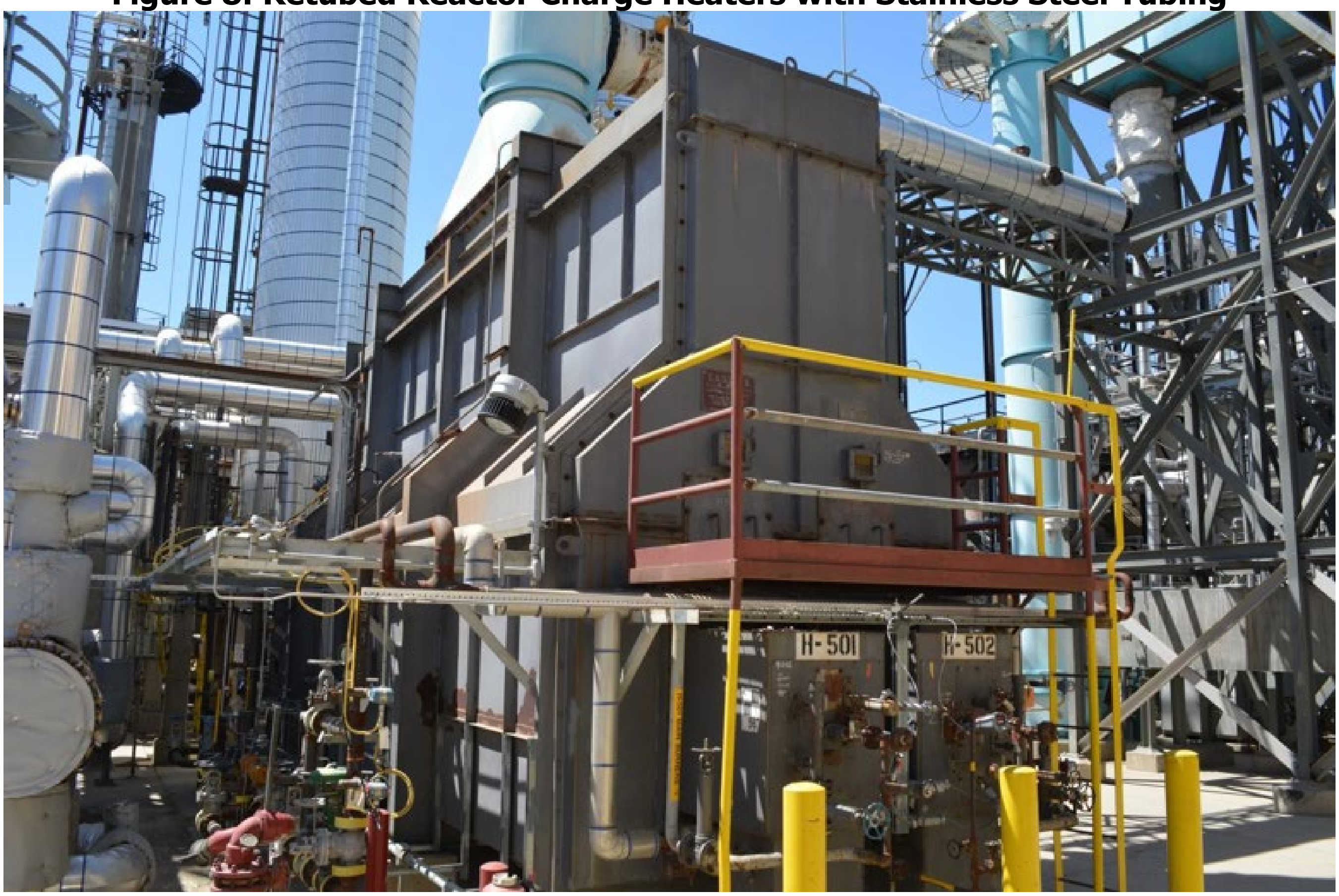


Figure 9: Hydrogen Receiving, Storage and Vaporization Facilities

Figure 10: New and Reworked Meters and Associated Equipment to Make A State-Of-The-Art Control System

Figure 11: Migrated Existing Control Equipment into a New Control Room with New Computer Control System

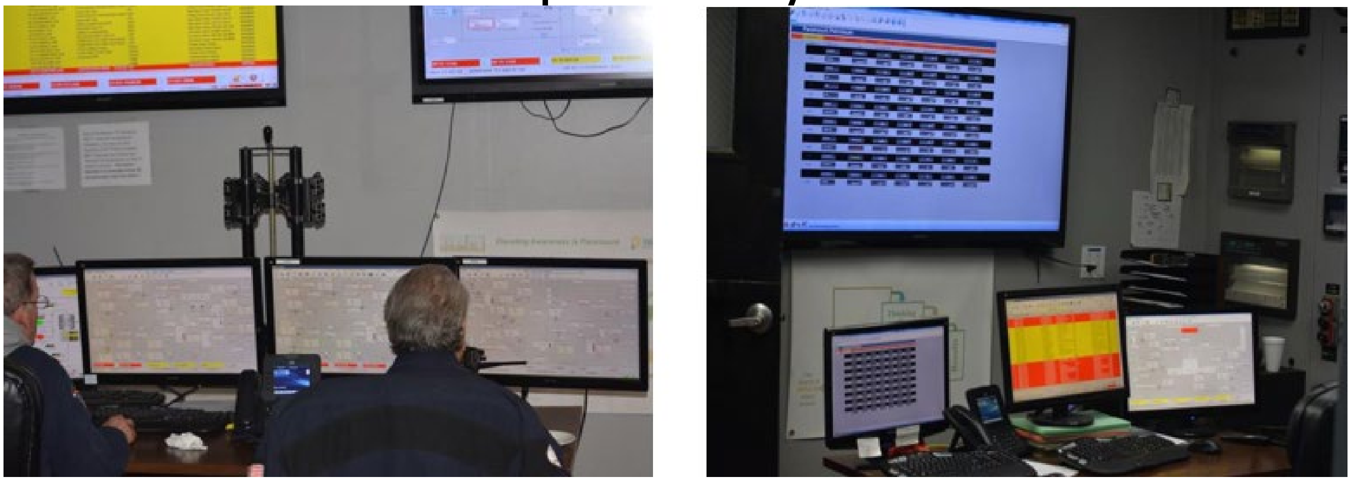


Figure 12: Reworked Support Units, Including Cooling Water and Naphtha Splitter to Support the New Processing Requirements

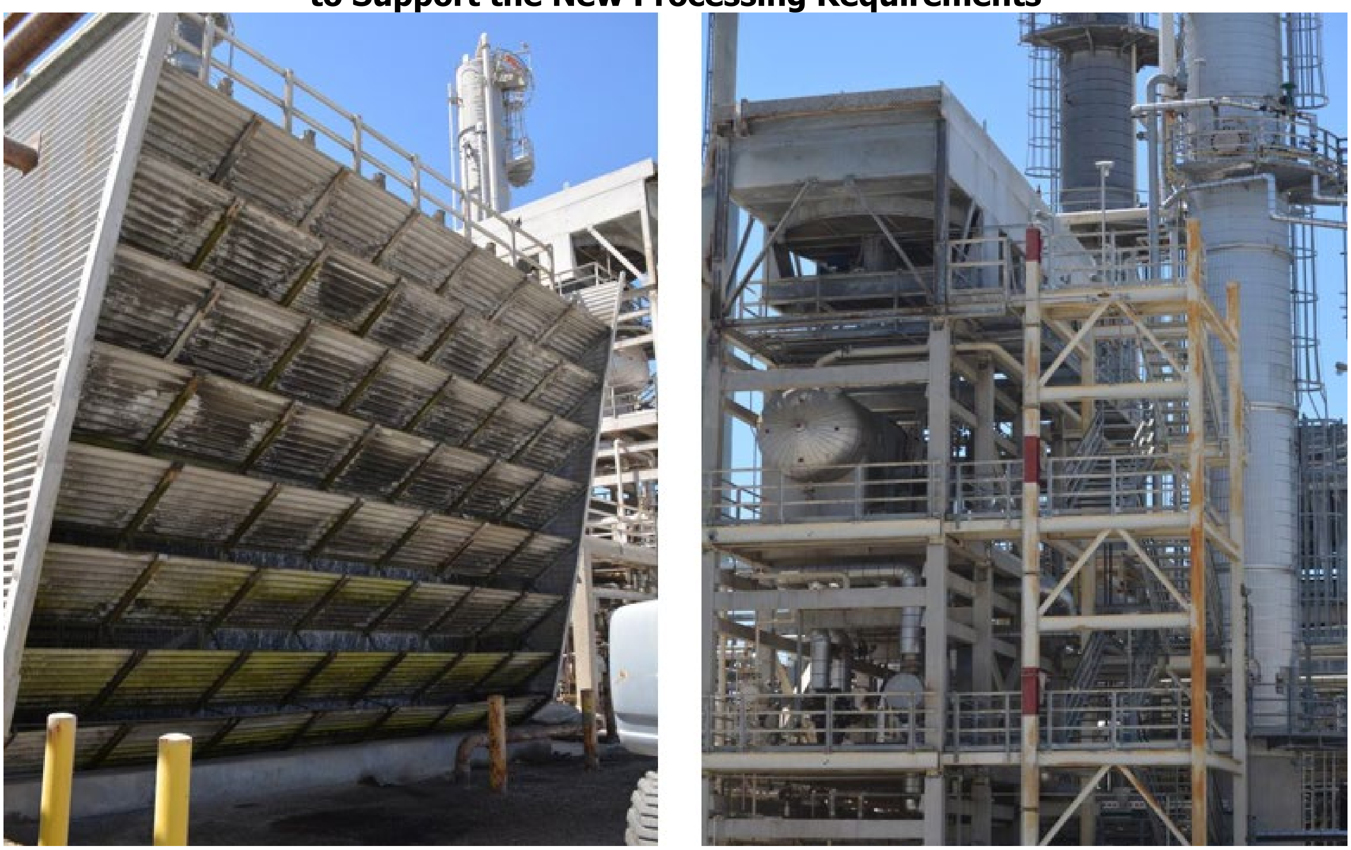
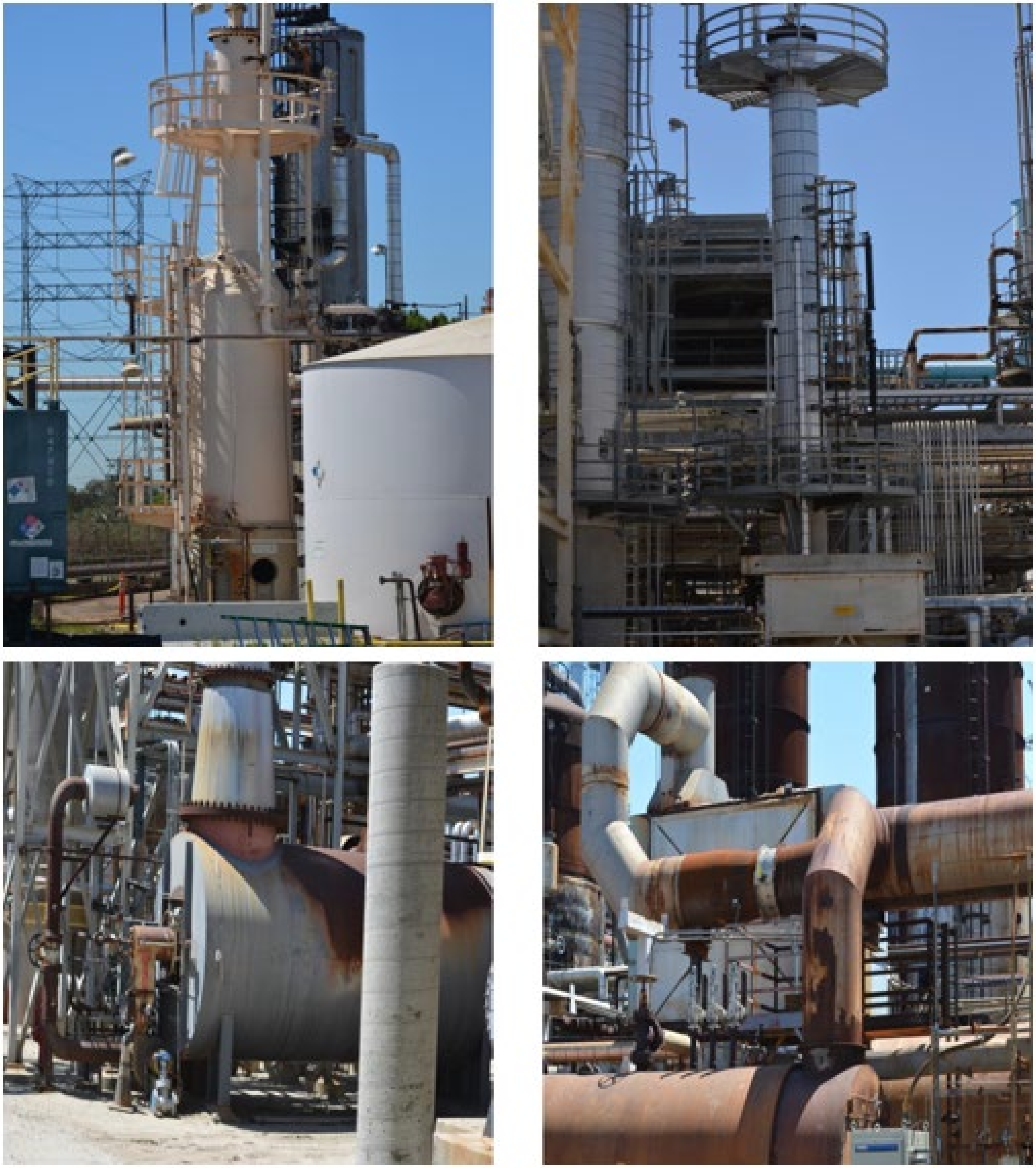
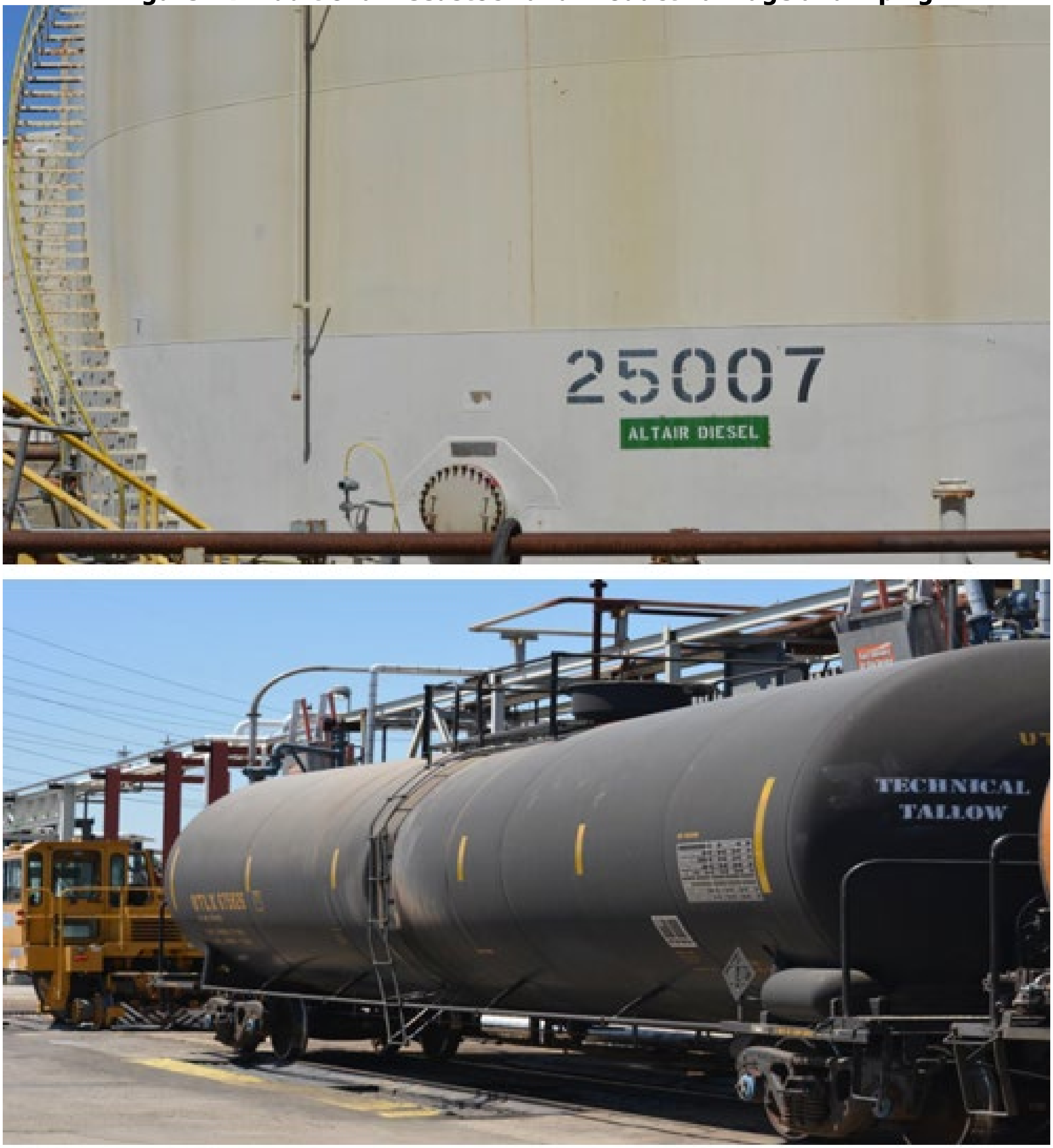


Figure 13: Reworked Support Units Including Caustic Scrubber, Sidecut Stripper, Caustic burner, and SOX Burner Unit.



Note: Top Left: Caustic Scrubber (W-206), Top Right: Sidecut Stripper (W-1602), Bottom Left: Caustic System – Burns and cleans waste liquids, Bottom Right: SOX Burner Unit (H-908)
Source: AltAir Fuels, LLC

Figure 14: Additional Feedstock and Product Tankage and Piping



Note: Top: Refurbished AltAir Diesel Tank #25007 able to store 1,050,000 gallons of Renewable Diesel, Bottom: Refurbished railcar offloading facility
Source: AltAir Fuels, LLC

2.4 Plant Commissioning and Yield Testing

This task involved the testing of all new installations to ensure proper operation. Once operational parameters were confirmed, applicable standard operating procedures were updated. Employees were trained on new procedures for safe and compliant operations. AltAir Fuels performed necessary testing to ensure products met customer specifications to ensure 100 percent of products are saleable and meets product specifications. In addition, testing to ensure that utility consumption volumes relative to feedstock consumption rates meet customer specification and technology guarantees.

2.5 Operations, Maintenance and Quality Control

The goal of this task is to operate the plant safely and reliably while optimizing yield, throughput and efficiently with the use of energy and chemicals and to maintain the facility in compliance with all applicable regulatory standards.

Part of this task was to develop and utilize a Quality Control Plan to meet product requirements and specifications. The plan includes the following information:

- Facility specifications
- Laboratory procedures
- Feedstock handling and storage procedures
- Product handling procedures
- Product segregation procedures
- Operator qualifications

2.6 Data Collection and Analysis

The goal of this task was to collect operational data from the project to analyze that data for economic and environmental impacts. This included the following:

- Develop data collection test plan
- Troubleshoot any issues identified
- Collection of throughput usage and operational data from the project including:
  - Maximum capacity of the new fueling system
  - Gallons of gasoline and/or diesel fuel displaced (with associated mileage information)
  - Expected air emissions reduction
  - Duty cycle of the current fleet and the expected duty cycle of future vehicle acquisitions
  - Specific jobs and economic development resulting from this project
- Identify the source of the alternative energy
- Describe any energy efficiency measures used in the facility that may exceed Title 24 standards in Part 6 of the California Code Regulations
- Provide data on potential job creation, economic development, and increased state revenue as a result of expected future expansion
- Provide a quantified estimate of the project's carbon intensity values for life-cycle greenhouse gas emissions

Figure 15 provides an illustration of actual AltAir Fuels' production data for Renewable F76 Diesel, Renewable Road Diesel and Renewable Jet Diesel.

Figure 15: Sample – Production Analysis

February 2016 AltAir Fuels Production Report

Renewable F76 Diesel Production

Date	BBLs	GAL
2/1/2016	969	40,698
2/2/2016	-	-
2/3/2016	-	-
2/4/2016	-	-
2/5/2016	-	-
2/6/2016	-	-
2/7/2016	-	-
2/8/2016	-	-
2/9/2016	22	924
2/10/2016	1,912	80,304
2/11/2016	1,902	79,884
2/12/2016	1,918	80,556
2/13/2016	955	40,110
2/14/2016	-	-
2/15/2016	544	22,848
2/16/2016	-	-
2/17/2016	-	-
2/18/2016	1,850	77,700
2/19/2016	1,957	82,194
2/20/2016	1,967	82,614
2/21/2016	1,978	83,076
2/22/2016	214	8,988
2/23/2016	830	34,860
2/24/2016	2,133	89,586
2/25/2016	2,231	93,702
2/26/2016	1,595	66,990
2/27/2016	2,071	86,982
2/28/2016	-	-
2/29/2016	-	-
		-
		-
		-
Feb 2016 Production	**25,048**	**1,052,016**

Renewable Diesel Production

Date	BBLs	GAL
2/1/2016	499	20,958
2/2/2016	539	22,638
2/3/2016	1,541	64,722
2/4/2016	1,612	67,704
2/5/2016	1,638	68,796
2/6/2016	1,692	71,064
2/7/2016	1,567	65,814
2/8/2016	1,737	72,954
2/9/2016	1,599	67,158
2/10/2016	-	-
2/11/2016	-	-
2/12/2016	-	-
2/13/2016	1,016	42,672
2/14/2016	1,598	67,116
2/15/2016	1,683	70,686
2/16/2016	1,673	70,266
2/17/2016	1,626	68,292
2/18/2016	-	-
2/19/2016	-	-
2/20/2016	-	-
2/21/2016	-	-
2/22/2016	-	-
2/23/2016	-	-
2/24/2016	-	-
2/25/2016	-	-
2/26/2016	-	-
2/27/2016	730	30,660
2/28/2016	1,850	77,700
2/29/2016	2,030	85,260
		-
		-
Feb 2016 Production	**24,630**	**1,034,460**

Renewable Jet Production

Date	BBLs	GAL
2/1/2016	29	1,218
2/2/2016	125	5,250
2/3/2016	309	12,978
2/4/2016	305	12,810
2/5/2016	220	9,240
2/6/2016	187	7,854
2/7/2016	338	14,196
2/8/2016	172	7,224
2/9/2016	389	16,338
2/10/2016	-	-
2/11/2016	-	-
2/12/2016	-	-
2/13/2016	17	714
2/14/2016	324	13,608
2/15/2016	339	14,238
2/16/2016	325	13,650
2/17/2016	329	13,818
2/18/2016	-	-
2/19/2016	-	-
2/20/2016	-	-
2/21/2016	-	-
2/22/2016	-	-
2/23/2016	-	-
2/24/2016	-	-
2/25/2016	-	-
2/26/2016	-	-
2/27/2016	-	-
2/28/2016	503	21,126
2/29/2016	30	1,260
Feb 2016 Production	**3,941**	**165,522**

Source: AltAir Fuels, LLC

Figure 16 provides an illustration of actual AltAir Fuels' throughput analysis report for the first quarter 2016.

Figure 16: Sample – Throughput Analysis

Altair Fuels LLC Unit Operation in Barrels First Quarter 2016	January		February		March		1st. Qtr.	
	BBLs	per Day	BBLs	per Day	BBLs	per Day	BBLs	per Day
Raw Materials								
Beef Tallow	18,699	603	59,800	2,062	71,813	2,317	150,312	1,652
Canola Oil	122	4	1,141	39	1,241	40	2,504	28
Total thru-put	18,821	607	60,941	2,101	73,054	2,357	152,816	1,679
Finished product								
Jet Fuel								
Renewable Jet Fuel	-	-	3,941	136	5,832	188	9,773	107
Diesel								
Renewable F76 Diesel	14,329	462	25,048	864	19,507	629	58,884	647
Renewable Road Diesel			24,630	849	35,362	1,141	59,992	659
Total Renewable Diesel	14,329	462	49,678	1,713	54,869	1,770	118,876	1,306
Other								
Renewable Hexane	252	8	1,081	37	84	3	1,417	16
Renewable Naphtha	570	18	4,361	150	6,454	208	11,385	125
Other	3,437	111		-	-	-	3,437	38
Total Renewable Other	4,259	137	5,442	188	6,538	211	16,239	178
Total Renewable Finished Product	18,588	600	59,061	2,037	67,239	2,169	144,888	1,592
Liquid Recovery %	98.76%		97.11%		96.18%		96.88%	
Renewable Sales in barrels								
Renewable Road Diesel (Includes UPS)		-	10,830	373	34,456	1,111	45,286	498
Renewable F76 Diesel (Department of Defense)	38,016	1,226	17,001	586	32,022	1,033	87,039	956
JET Sales Bbl. (includes United Airlines)	-	-	1,082	37	2,274	73	3,356	37
Total Sales	38,016	1,226	28,913	997	68,752	2,218	135,681	1,491

Source: AltAir Fuels, LLC

CHAPTER 3: Achievement of Project Objectives

The objectives of this plant were to expand capacity and functionality of a currently under-construction biorefinery in Paramount, California. The facility produces market-ready renewable diesel fuel and co-produces a renewable jet and a byproduct chemical and gasoline component.

- A measurement of this objective's success is the establishment of a facility that is capable of producing at least 40 million gallons per year, which is an increase of over 33 percent of the facility's capacity prior to the expansion.
- A secondary measurement of this objective is the quality of the product and meeting customer specifications, whether those customers are the U.S. Military, commercial aviation, or other fuel users.

In the first quarter 2016, AltAir Fuels sold renewable F-76 diesel to the US military, renewable road diesel to fuel users and renewable jet fuel to commercial aviation. Production flow rates have been demonstrated at 40 million gallons of renewable fuel per year. Delivering this renewable fuel into California’s diesel and jet fuel supply displaces equal amounts of petroleum per year and the associated reduction in GHG and other harmful emissions.

CHAPTER 4: Conclusions and Recommendations

The project contributes substantially to the increase of renewable fuels production within California by introducing up to 40 million gallons of renewable diesel and jet fuel production capacity. AltAir Fuels is California's first commercial scale renewable diesel facility. There are only two other renewable diesel facilities in the United States, and California now has the third commercial facility. This facility is the first of its kind to also co-produce renewable jet at commercial scale.

This new biorefinery took advantage of unused infrastructure capacity at an existing petroleum refinery in Paramount California, a brownfield retrofit construction project that reduced or avoided the lifecycle environmental costs associated with building a new facility.

Locating the project within an existing refinery ensured maximum usage of existing equipment, leveraged expertise for operations and maintenance and greatly simplified permitting needs.

The California location is also strategic in its proximity to feedstock suppliers upstream and established customers downstream - thereby sustaining and creating jobs for the California economy.

The technology employed by AltAir Fuels and its partners is feedstock flexible, allowing the new biorefinery to process multiple sources. This includes nonfood sources of transportation feedstocks that can be grown on marginal lands and with minimal water. It also includes other emerging feedstocks such as algae. Due to this flexibility, this project will have the capacity to process new triglyceride feed stocks as they become commercially available.

Greenhouse gas emissions from renewable diesel are up to 80 percent lower than from petroleum diesel and approximately 40 percent less than from biodiesel. The co-produced renewable jet fuels are from naturally occurring oils. They are estimated to also deliver up to an 80 percent reduction in GHG emissions relative to petroleum-derived jet fuel.

AltAir Fuels' biorefinery was specifically designed to accommodate multiple phases of expansion. As market demand for diesel grows, the production capacity and processing capabilities of the facility may be expanded further.

Due to California's comprehensive permitting requirements and higher overall operating costs, California renewable fuel producers can be at a competitive disadvantage relative to producers in other states or countries. In order for Californians to realize the economic benefits of low carbon fuels, it is important to develop in-state production capabilities and to support in-state producers. The Clean Transportation Program has been successful in stimulating the development and expansion of multiple in-state alternative fuel producers, including AltAir Fuels.

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. Funding for the CEC's activities comes from the Energy Resources Program Account, Federal Petroleum Violation Escrow Account, and other sources.

CARBON DIOXIDE (CO2)—A colorless, odorless, nonpoisonous gas that is a naturally occurring part of air. CO2 is the greenhouse gas whose concentration is affected directly by human activities. CO2 also serves as the reference to compare all other greenhouse gases (see carbon dioxide equivalent).

GREENHOUSE GAS (GHG)—Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include water vapor, carbon dioxide (CO2), methane (CH4), nitrous oxide (NOx), halogenated fluorocarbons (HCFCs), ozone (O3), per fluorinated carbons (PFCs), and hydrofluorocarbons (HFCs).

HYDROGEN SULFIDE (H2S)—A highly flammable, explosive gas. H2S burns and produces other toxic vapors and gases, such as sulfur dioxide. [2]

LIQUEFIED PETROLEUM GAS (LPG)—A mixture of gaseous hydrocarbons, mainly propane and butane that change into liquid form under moderate pressure. LPG or propane is commonly used as a fuel for rural homes for space and water heating, as a fuel for barbecues and recreational vehicles, and as a transportation fuel. It is normally created as a by-product of petroleum refining and from natural gas production.

2 U.S. Department of Labor, available at https://www.osha.gov/SLTC/hydrogensulfide/hazards.html