Oil & Gas Research Program

North Dakota Industrial Commission

Application

Project Title:

Local Production of Diesel for Bakken crude through micro-refining technology

Applicant:

Lund Oil, Inc

Date of Application:

May 31, 2024

Amount of Request

Grant: $1,000,000

Loan: $0.00

Total Amount of Proposed Project:

$10,151,000

Duration of Project:

12 Months

Point of Contact (POC):

Brady Lund

Guillermo Barreto

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ABSTRACT

Objective:

Lund Oil, Inc. is respectfully requesting a grant from the Oil & Gas Research Council to research, test, and evaluate the impact of Enhanced Catalytic System (ECS) reactor units. Lund Oil has already constructed and will operate a facility in McKenzie County, near Watford City that will serve as the site to research and test the proprietary designed Enhanced Catalytic System (ECS) reactor units, which can create commercial grade hydrocarbon products from Bakken crude oil at low temperature and low pressure. The primary goals of this project are to operate our skidded micro refining unit to process 350 barrels a day of crude oil into commercial grade diesel (DF2) fuel, diluent for the Canadian tar sands market or other marketable applications, and enhanced Bakken crude that has an assay similar to West Texas Intermediate crude, all in the local area. This technology allows the refinement of naphtha diluent and diesel fuel directly from crude oil near where the oil is extracted. This small-scale unit will demonstrate that deployment of this technology could dramatically reduce the amount of diesel fuel that needs to be imported into the Bakken region to meet oil production needs, thereby significantly reducing the environmental impact of transporting the oil to a refinery then transporting refined product back to North Dakota. This technology transforms the current oil refining process by changing the physical location of where refining occurs, from large expensive refineries with environmental and permitting issues, to smaller footprint point-of-sale plants.

Currently, Lund Oil estimates a production cost of approximately $2.50 a gallon for DF2 utilizing ECS reactors. This project will help us more precisely determine that exact cost.

The ECS process is a unique refining process that uses low temperatures in low-pressure vessels to create a vapor mix of hydrocarbons which is then passed over an array of several catalysts simultaneously to affect a change in the crude while in the vapor state. It operates by continuously feeding Bakken crude into a heated reactor, then diffusing locally procured natural gas through it. As the bubbles of the gas rise up through the liquid, they carry some of the longer-chain molecules from the liquid with them. The mix of methane gas and hydrocarbon vapors are drawn up above the liquid level and come into contact with a catalytic array which chemically alters some of the vapor. The vapors are then passed through a heat exchanger, condensed back into economically valuable liquids, and pumped to storage. The unused gas is recycled back through the reactor while a portion of the Bakken crude in the reactor is drawn off and also pumped to storage as a more stable and safer crude. Lund Oil has operated bench scale, and test versions of the ECS reactor.

Expected Results:

Lund Oil anticipates the project will result in a precise determination of a per-gallon cost to locally produce DF2 and will give a close approximation of the positive environmental impact from reducing truck transport of diesel fuel back into the region. Additionally, the project will produce detailed commercial development plans for creation of increased scale plants capable of processing up to 10,000 barrels a day of Bakken crude.

Duration: Expected duration of the project is 12 months.

Total Project Cost: $10,151,000 USD

Participants: Members of Lund Oil include Brady Lund and Guillermo Barreto.

PROJECT DESCRIPTION

Objectives:

The objectives of this project are to construct and operate a portable micro-refining skid capable of processing 350 barrels a day of Bakken crude. This unit should produce approximately 100 barrels a day of diesel fuel, 35 barrels of high-grade diluent, and 215 barrels of Bakken crude with assay properties very similar to West Texas Intermediate crude, all of which have an economic value higher than or equal to the base crude alone.

Lund Oil has already started work on construction of the 350 barrel-a-day reactor unit and has identified a location near Watford City where crude oil from the field is brought into day tanks for settling before refining. It is expected that the first micro refining skid unit will arrive in North Dakota in June of 2024, and be operational in July of this year. After three months operation, we expect to have accurate models on how to up-scale the facility and/or build other facilities like it that can process 10,000 barrels a day of crude, plus three months of real-life data on the possible reduction in emissions and truck exhaust pollution across the state. Additionally, we expect to have precise data on the cost to produce a gallon of DF2 diesel fuel, which is currently estimated to be approximately $2.50 a gallon.

At the end of the project, Lund Oil expects to have a complete, economically viable commercial package that can affect a significant change in how oil producers and refiners process Bakken oil and can produce diesel fuel for the local market for less than $3.00 a gallon. This package and the fuel produced by it can then be offered to businesses in North Dakota. Lund Oil also expects to create a new knowledge base on catalytically processing hydrocarbons in a vapor state, which may lead to other oil processing companies to invest in research and development of this alternative method to refining crude. Currently, the industry standard is high temperature, high pressure refining. The low temperature, low pressure reactor could change that to a more economical process that has a significantly smaller impact on the environment. To date, Lund Oil has invested 600,000 usd into the fabrication of our first unit.

Methodology:

The design of the 350 barrel a day micro refining skid is complete, and the build price is known. Upon starting initial facility construction, a review will be made of the final reactor design and all test data to validate the operational parameters for maximum production of the desired hydrocarbon products, being diesel fuel and diluent. If needed, design updates will be made at that time.

The critical data points that need to be evaluated to determine successful operation of the micro refining skids are the chemical properties of the output products as compared to ASTM D975, customer specifications for the diluent, plus the final total per-gallon cost to produce DF2.

Anticipated Results:

It is anticipated that the small-scale plant will conclusively demonstrate the economic viability of larger scale plants and prove that developing such plants can significantly reduce pollution in the region while generating significant economic benefits.

Facilities:

Lund Oil research and development team are located at our Watford City office / shop located at 3605 4th Ave NE, Watford City, ND 58854. Currently there are two reactor units, a prototype unit and a scale unit. The first micro refining skid will be commissioned in the vicinity of Watford City between Watford and Johnsons Corner in June of 2024.

Techniques to Be Used, Their Availability and Capability:

The micro refining system utilizes several known refining technologies, but in different manners. The technology concept has been proven through five years of laboratory construction and testing and commercial sales. Construction of the 350 barrel-a-day reactor unit will follow the same procedures used in previous builds. Design of the reactor unit shelter will be based upon the layout of the local gathering facility and will be based upon state construction codes and economic considerations.

Environmental and Economic Impacts while Project is Underway:

Lund Oil anticipates no negative environmental or economic impacts while the project is underway. When complete, the system is expected to be installed as a plug-in module to existing infrastructure in the Bakken region. Ideally, the best place to utilize this technology is at a trans-loading facility where Bakken crude is gathered for onward rail or pipeline shipment, minimizing any environmental impact from construction. In preliminary emission studies we have conducted, a locally processed gallon of diesel will be up to 4 lbs. of CO2 lighter than a business-as-usual gallon coming from the Mandan or Billings refineries which currently serve most of the Bakken fuel needs.

Ultimate Technological and Economic Impacts:

The current industry process for refining crude oil requires large facilities that are both expensive to build and to operate. Most catalytic processes in refineries occur at extremely high temperatures and pressures. Lund Oil knows of no current refining processes that attempts multiple catalytic reactions simultaneously in a vapor state. Development of this new methodology could open entirely new areas of knowledge on effective methods and best locations for the refining of crude oil. This new methodology could enhance safety of the Bakken crude and reduce the environmental impact of producing and refining that crude, all while providing a significant economic bonus.

Why the Project is Needed:

Commercial development of the process would be beneficial to North Dakota because it can demonstrate a new method of creating commercial grade hydrocarbons from domestic oil reserves economically, with a reduced carbon footprint, without the need to build a full-sized refinery. Additionally, it could significantly reduce the cost of diesel in the region while still maintaining excellent profit margins.

Business as Usual (BAU) Scenario (with 200-mile transpiration):

1. **Transport to Refinery** (200 miles): 0.021 lbs. CO2/gallon
2. **Refining**: 3.95 lbs. CO2/gallon
3. **Transport to Wellhead** (200 miles): 0.021 lbs. CO2/gallon
4. **Total BAU Emissions**: 0.021+3.95+0.021=3.992 lbs. CO2/

Wellhead Refining Scenario:

1. **Refining**: 0.0000376 MWh/gallon×0.35 tons CO2e/MWh×2204.62 lbs./ton=0.0289 lbs. CO2/gallon
2. **Total Local Refining Emissions**: 0.0289 lbs. CO2/gallon

Delta between the Two Processes:

• Delta: 3.992−0.0289 = ***3.9631 lbs. CO2/gallon***

This would mean that for one 350 BBL processing unit, we would achieve a monthly emission reduction of 221.5 Metric Tons (MT).

STANDARDS OF SUCCESS

Overall project success will be measured by comparing the market value for each product, diluent, diesel, and processed crude, and the per barrel cost to operate, against the market value of the original feedstock crude oil. If the system does indeed create a significant increase in the market value of the processed oil over the feedstock oil while covering the costs of operation and equipment construction, then the project will be deemed a success. Valuation for the products will be taken from current market sources such as the Oil Price Information Service (OPIS) and NASDAQ.

When used to process Bakken crude, our system creates three possible streams of commercially valuable hydrocarbon products, a light-end diluent, a DF2 cut, and a stabilized crude cut.

Diluent. From a barrel of Bakken crude, the micro refining process yields a fraction of approximately 9% by volume of a light-end product. This cut has been analyzed via gas chromatograph and standard ASTM laboratory tests. It has an average specific gravity of 680 kg/m3 (API of 76.5) and a constituency ranging from less than 1% C3, up to over 35% C7, and down to less than 5% C9+, distributed as approximately 40% paraffins, 40% naphthene, and 20% aromatics. Sulfur content averages less than 1 part per million.

DF2 blend cut. From a barrel of Bakken crude, the micro refining process yields a fraction of approximately 30% by volume of a near-ASTM D975 compliant diesel product. This cut has also been analyzed via gas chromatograph and standard ASTM laboratory tests. The product meets all D975 specifications for DF2 with the exception of sulfur content. Sulfur content averages 17 parts per million, slightly above the maximum D975 limit of 15 ppm. It should be noted that this fraction has consistently tested out to have a cloud point of below -30°C.

Enhanced Bakken crude. After processing, the remaining 60% volume of a barrel of Bakken crude is stabilized to far safer levels than current industry practice. Laboratory and gas chromatograph analysis show the Enhanced Bakken Crude to have a flash point of 25°C, an initial boiling point of over 80°C, a vapor pressure of less than 1 psi, and an API ranging around 38 +/- 1. Constituent results range from C7 to C30+ with the highest content in the C11 to C18 cut, distributed overall as approximately 65% paraffins, 10% naphthene, and 25% aromatics. This is the full range of hydrocarbon molecules needed to refine gasoline, diesel, jet fuel, and other products at a full-scale refinery.

Value of diluent. In April 2022, the Canadian Association of Petroleum Producers set the price of diluent purchased for the tar sands market at CDN$701.04 per cubic meter through their Equalization Steering Committee with provisions for price bonuses depending upon the constituency of the diluent (https://industryeq.ca/wp-content/uploads/2020/11/2020-Condensate-and-Crude-Equalization-Data.pdf). At this price, a 9% yield of diluent from a barrel of Bakken feedstock would have a value of US$7.754.

Value of DF2 blend cut. Though the DF2 blend cut does not meet the D975 specification for ultra-low sulfur diesel (ULSD) for sulfur content, it can be blended as-is with existing ULSD fuel to bring the total sulfur concentration to below the 15-ppm limit. Most ULSD used in the Bakken region averages 6 to 8 ppm of sulfur. Blending the DF2 cut with ULSD at a 50-50 ratio would yield a final product with a sulfur content between 11 and 13 ppm. Conservatively, blending at 75-25 would drop the content to approximately 9 to 10 ppm, well below the maximum allowed. Still, this should fix the value of the DF2 blend cut at parity with ULSD prices. In April 2022 the average rack price per gallon for ULSD in the Bakken region was $5.359 pre-tax, or $205.17 a barrel (https://www.globalpetrolprices.com/USA/ North_Dakota/diesel_prices/). Thus, the 30% yield of the DF2 blend cut from the ECS process would be valued at $61.551 a barrel.

Value of ECS Bakken. The remaining Enhanced Bakken Crude still has a full range of hydrocarbon constituency that refineries can process through their normal slate. Many refineries that have difficulty in processing regular Bakken crude due to the large quantity of light ends may find Enhanced Bakken Crude a more valuable product. Not only does the micro refining process alleviate the light-end problem, but it also creates a crude that is safer to transport by lowering the vapor pressure and raising the flash point of the final product. Enhanced Bakken Crude is still Bakken crude oil and can be blended right back into the

large quantity of regular Bakken crude that is produced every day with no ill effect. Analysis of Enhanced Bakken Crude shows it to have an API, flash, sulfur, and molecular constituency within the established limits for WTI crude. As such, it could be argued the value of Enhanced Bakken Crude should be on parity with WTI (at an average of $101.782/bbl in April 2022, (https://oilprice.com/oil-price-charts/), however, for the purpose of this calculation the value of Enhanced Bakken Crude will be left at parity with regular Bakken. In April 2022 the average price of Bakken crude was $95.138 a barrel (https://www.oilmonster.com/crude-oil-prices/united-states/north-dakota/229). The value of the 60% cut of ECS Bakken would therefore be $57.083 per barrel.

Totaling the values of each cut from the ECS process gives a per barrel value of $7.754 + $61.551 + $57.083, or $126.388 versus the initial value of $95.138 a barrel for regular Bakken crude. This shows the possibility of a $31.25 per barrel differential for profit, less expenses.

Micro Refining Operating Expense. A 350 barrel a day refining skid consumes approximately 75 kW of electricity and 180 standard cubic feet of hydrocarbon or flare gas per barrel processed during operation. The design of the system utilizes excess natural gas from the reactor to generate a portion of electricity for itself. Lund Oil estimates the average total cost to operate an ECS reactor including license and consumables to be less than $2.50 per barrel, depending upon prices in the local market.

Program Benefits. After 90 days of operations are complete, operational data will show a precise number of gallons of diesel fuel ECS processing will yield from a barrel of Bakken crude, and the characteristics of that fuel. These numbers can then be extrapolated out to show how many gallons of diesel fuel a 10,000 barrel a day skidded facility would produce. Using testing data as a starting point for calculations, a 10,000 barrel a day skidded facility should produce approximately 126,000 gallons a day of DF2, or 45,360,000 gallons a year.

With the average weight of a gallon of DF2 being 6.94 pounds, a skidded plant should produce 314,798,400 pounds of DF2 annually. The average freight truck in the U.S. emits 161.8 grams of CO2 per ton-mile (0.3567 pounds). At an average carrying capacity of 9,000 gallons, a fuel tanker truck is hauling a load of 62,460 pounds, or just over 31 tons. Therefore, in an average trip of 225 miles, a fuel tanker creates 2,488 pounds of pollution.

Reducing the need to transport 314,798,400 pounds of diesel could eliminate over 56,000 tons of pollution from being exhausted into North Dakota's air – all while earning up to $31 a barrel in profit. These numbers are approximated examples, a fully funded project would refine them significantly.

Further commercialization of the micro refining technology could double that positive environmental impact by increasing the amount of diesel fuel refined in the local area and thus reducing the amount that needs to be trucked back in. Additionally, further commercialization would create permanent jobs to operate the micro refining skid facilities and an increase in local taxes for the fuel generated by those facilities.

BACKGROUND/QUALIFICATIONS

Lund Oil Inc.

In May of 1950, local western North Dakota natives, Don & Virginia Lund, with the help of many local farmers, started delivering fuel for farm operations in Western North Dakota running under the name of Independent Farmers Oil. After a few years of managing Independent Farmers Oil, Don saw another opportunity to simultaneously manage propane operations for Westland Oil and also run a convenience store in New Town North Dakota. During this time, the oil boom started to move into the area and Don realized the need for selling refined products in the industry. The people of Independent Farmers Oil were fine with Don running his own operation in the oilfield as long as he continued to service their customer base.

In July of 1981, Don & Virginia began Lund Oil, Inc. alongside their son, Jayson, and his wife, Mary Lou. The family worked side by side selling refined products, mainly diesel fuel, oil and lubes primarily to different drilling and completion operations. Along with the delivery business, they ran the gas station in Keene. In September of 1994, Lund Oil opened a convenience store called One Stop which is located on the west side of Watford City. In 1996, Mary Lou passed away in a car accident. Shortly after Mary Lou's passing, Lund Oil relocated from Keene to Watford City.

With the move to Watford City, Lund Oil was able to establish themselves as the premier refined products service company in the residential and commercial sector while still maintaining their presence in the oilfield. While always maintaining their presence at home, Lund Oil has always followed drilling and completion operations throughout Western North Dakota and Eastern Montana serving as a major player in the Bakken and Williston Basin area.

With 60 plus years of experience, Lund Oil is committed to being your safe and reliable source for all of the Bakken's gas, fuel, propane, and lubricant needs. Lund Oil is committed to serving the people in the community we have been a part of for over 60 years.

Brady Lund – 3rd generation at the helm of the company. Brady's leadership will ensure the project succeeds and gets full vertical integration into the existing business relationships in the state.

Guillermo (Memo) Barreto – Fuel Innovation, New Projects, Business Development and Sales at Lund Oil. Mr. Barreto has been a resident of North Dakota and actively involved with the states Oil & Gas industry since November of 2012. With over 1 million miles driven in The Bakken, Memo has intimate knowledge of the lay of the land and who the producing operators in the region are. Mr. Barreto brings operational expertise through his background in temporary onsite power generation and electrical distribution for both large scale and smaller projects, and his understanding of the unique challenges associated with winter operations in the Williston Basin. Mr. Barreto has interacted and provided onsite temporary power

generation and electrical distribution equipment for most every producer in The Bakken for the last decade. Currently Mr. Barreto has been focused on providing flare management solutions to capture excess or stranded gas for producers in the region. His experience and dedication will help this project be a success.

Previously, Mr. Barreto managed The Coca Cola account for Mexico and Latin America for their premium and promotional programs, from the conceptualization of a promotional item through the design, engineering, costing, manufacturing and finally shipping and logistics to serve multiple international markets simultaneously.

Jon Ramer, Project Leader

After serving for 25 years in the US Air Force as a petroleum and logistics officer, Jon provides CR industry-leading expertise in cost-effective refining of multiple types of hydrocarbons as well as management, quality control, and small and large-scale petroleum storage operations. While serving as unit Commander, Jon managed $2.2B of petroleum contracts annually and oversaw management of 127 bulk fuel terminals. Jon was a lead member of a design team for a $167M fuel facility replacement project at Naval Base Point Loma in San Diego, CA, was Department of Defense lead for a $52M breakout tank and resupply pipeline at Travis Air Force Base, CA, and facilitated the completion of a $22M project storage facility at Marine Corps Air Station Miramar, CA. Jon has been awarded nine meritorious, commendation, achievement, and humanitarian medals from the US military.

William Clugston

William graduated from the Singapore American School in 1985 then spent two years at California State University, Fullerton in the pursuit of international business studies. In 1987 he accepted a position with an international restaurant company in Abu Dhabi where he was operations manager, opening and operating American style restaurants throughout the United Arab Emirates. In 1990, he accepted a position with a prestigious restaurant in Waikiki, Hawaii as Assistant General Manager. He returned to the continental US in 1992 and joined a petroleum maintenance/sales company as regional manager for the Northern California branch and developed a customer base with revenues in excess of $1.5 million annually for 11 years. He moved to Reno, NV where he managed a pipeline loading terminal for ten years before moving to an alternative fuel refinery as Operations Manager then Vice President of Sales. Currently he resides in Washington state and has been the Northwest region sales manager for a petroleum equipment manufacturing company since 2019.

Philip Bridges

As a green energy and waste management expert with more than 35 years of experience, Philip brings expertise to CR in sustainable environmental processes with focus on advanced pyrolysis/gasification technology applications. He has founded three technology companies and negotiated worldwide sales agreements to market the M3RP pyrolysis system, which converts organic materials to synfuel and carbon. He was a leader in the procurement and implementation of a $3.5M product development contract with American Plastics Council, and assisted in the design and construction of a $3M advanced technology tire

and plastics recycling system. Philip serves CR with his extensive knowledge of project management and oversees sales, design, and construction as well as marketing of synfuels.

MANAGEMENT

The total time for the project is anticipated to be no more than 270 days from the receipt of funding, conducted in three phases. Phase one is sourcing of a third-party manufacturers and negotiations for access to a Bakken crude gathering facility in North Dakota, expected to take 30 days. Phase two is construction of the ECS reactors and facility, estimated at 90 to 120 days. And phase three is operation of the facility, estimated to be 90 to 120 days. Progress reports will be generated and submitted within 14 days of the completion of each phase.

A Final Technical Report will include the complete economic valuation of all costs to build and operate the system at mass production rates, with the estimated possible annual profit margin. It will also include copies of all lab tests on all products fed into and created from the system to validate the economic value of the system. The project will be managed by the project leader, tracking construction and processing goals according to the established 270-day project timeline below.

Evaluation points will be the cost and time to manufacture the ECS reactor, the catalyst for the reactor, access to and the design of the reactor housing structure in the Bakken region, the construction of said facility, initial operation date and continuous operation of the facility once construction is complete, and finally, the collection of cost data for consumables and feedstock and the sale of products from plant production.

TIMETABLE

Phase one is to install our first micro refining skid expected to arrive into Watford City by next month and take 30 days to commission. Phase two is operation of the micro refining skid and facility, estimated to go live in July. Progress reports will be generated and submitted within 14 days of the completion of each phase.

BUDGET

Project Associated Expense	NDIC Grant	NDIC Loan	Applicant's Share (Cash)	Other Project Sponsor's Share	Total
Phase 1					
Determine site location	$0.00				$0
Phase 2					
Construct reactor facility	$50,000				$50,000
Construct ECS reactor	$0.00		$600,000		$600,000
Transport of reactor to site	$25,000				$25,000
Rent hydrocarbon liquid storage tanks for site	$40,000				$40,000
Crude Purchasing	$398,000		$8,422,000		8,820,000
Phase 3					
Site operator payroll (4 persons, 4 months @ $3,000 a month each)	$48,000		$48,000		$96,000
Project managers (3 persons, 9 months @ $3,000 a month each)	$81,000		$81,000		$162,000
Site utilities (12 months)	$100,000				$100,000
Project managers travel	$20,000				$20,000
Laboratory testing of fuel products	$150,000				$150,000
Overage buffer (~10%)	$88,000				$88,000
Total	$1,000,000		$9,151,000		$10,151,000

Should less than the requested funding be awarded, the project managers will first reduce the amount of laboratory testing performed on hydrocarbon samples, then reduce payroll.

CONFIDENTIAL INFORMATION

The only confidential information expected to be utilized in this project is the precise make-up of the catalyst used in the micro refining skid. This information is proprietary and is already developed. It will not be listed in any progress or final technical reports.

PATENTS/RIGHTS TO TECHNICAL DATA

We utilize trade secret laws to protect the exact make-up of the catalyst utilized inside the micro refining reactor and the operational parameters of the system. No new IP is anticipated to be developed in the course of this project, only an extension of existing IP. We reserve the right to maintain the make-up of the catalyst as a trade secret or possible patent application in the future.

STATE PROGRAMS AND INCENTIVES

Lund Oil Inc. has not received any previous funding from the Commission for this project or any other projects.

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Dear Grant Application Review Board,

I am writing to express our full support for Lund Oil Inc's grant application for the local processing of crude into diesel in North Dakota. Lund Oil Inc has been a cornerstone of our community in Western North Dakota, consistently demonstrating commitment and leadership in fuel innovation projects.

Lund Oil Inc's long history of reliability and dedication to advancing fuel technologies has not only benefited our local economy but has also contributed significantly to the advancement of sustainable energy practices in our region. With their expertise and experience, Lund Oil Inc is well-positioned to spearhead the important initiative of local processing of crude into diesel, which will have long-lasting positive impacts on our community and beyond.

I am confident that supporting Lund Oil Inc in this endeavor will not only further enhance their contributions to our community but also align with the goals of promoting economic development and environmental sustainability in North Dakota.
Thank you for considering Lund Oil Inc's grant application. I wholeheartedly endorse their proposal and believe that their project will be a valuable asset to our region.

Please do not hesitate to contact me at clarsen@fibt.com or (701) 774-1424 if you have any additional questions.

Sincerely,

Chris Larsen
Assistant Vice President
First International Bank & Trust