Oil and Gas Research Program

North Dakota

Industrial Commission

Application

Project Title: ElectroGrow methane to propane conversion

Applicant: Calvin Liu

Principal Investigator: Calvin Liu

Date of Application: June 2, 2025

Amount of Request: $614,516

Total Amount of Proposed Project: $809,423

Duration of Project: 6 months

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TABLE OF CONTENTS

***Please use this table to fill in the correct corresponding page number*.**

ABSTRACT

Objective:

ElectroGrow has demonstrated a technology that can convert natural gas into oil. This can be seen in patent US 10,308,885 B2 published in 2019 (accessible at https://patents.google.com/patent/US10308885B2/en?oq=10308885).

The ElectroGrow technology was originally developed for intermittent operation to produce fixed nitrogen from curtailed electricity. The requirements for commercial gas to oil production includes 24/7/365 operational capability as well as the capability to potentially operate in multiple stages of the natural gas production life cycle. While Electrogrow technology is proven, it is necessary to develop a completely different architecture in order to be able to fulfill methane liquefaction (methane to oil) operational requirements.

While Enhanced Oil Recovery (EOR) techniques exist for increasing the percentage of hydrocarbon recovery in standard oil formations, there are to date no such technologies for hydrofracked shale oil formation EOR such as in the Bakken. As such, it is estimated to only 10% of the hydrocarbons in Bakken formations are being recovered in contrast to the 60%+ in standard oil formations.

This capability gap is being researched using many different types of surfactants ranging from carbon dioxide (CO_2), biological materials, water, propane and more. While there are massive incentives for CO_2 sequestration, which would be an outcome of using CO_2 for EOR, there are many large short and medium term challenges to bringing significant quantities of CO_2 into North Dakota. Biological materials are unlikely to be either scalable or strategically wise. Water and brine are unlikely to provide large benefits. Propane has promise, but the availability of sufficient quantities of propane, as well as the cost, are problematic as well. Nonetheless, there is an ongoing water and propane pilot project for EOR ongoing in North Dakota since approximately February 2025.

This grant request is to enable ElectroGrow to modify its existing methane liquefaction technology to instead convert methane to propane. While this capability is absolutely technically possible, ElectroGrow has been focused on gas to liquid because of higher efficiency and conversion ratios, hence economic viability. In the context of wellhead methane value vs EOR production improvements, the economic value of propane is secondary compared to enhanced hydrocarbon recovery because each extra percentage of increased hydrocarbon recovery via EOR would increase yield of existing wells by 10%, and EOR capabilities on the scale of conventional oil EOR would increase production by as much as 600%.

Expected Results:

Demonstrate core gas to gas capability by converting methane to propane in a field deployable system.

Duration:

6 months

Total Project Cost:

$809,423

Participants:

ElectroGrow

EERC

PROJECT DESCRIPTION

Objectives:

ElectroGrow has developed a gliding arc reactor which ionizes methane from CH_4 to CH_2 and CH_3. Pumping the CH_2 and CH_3 into an existing oil or natural gas liquids (NGLs) causes the CH_2 and CH_3 ions to chemically bond to existing oil and NGL hydrocarbons. The result is a higher volume of heavier oil.

If the CH_2 and CH_3 ions created by the reactor are instead allowed to recombine with each other – the outcomes will be heavier combinations than the input methane ranging from ethane (2 ions combining) to propane (3 ions combining) to butane and other NGLs.

The system needed for gas 2 gas conversion is significantly different than gas 2 liquid (methane liquefaction).

This proposal is to develop a new system around the ElectroGrow field version plasma arc reactor which is able to convert gas to gas, specifically methane to propane, as opposed to gas to liquid.

Methodology:

The existing ElectroGrow field version plasma arc reactor is a single stage process where methane is ionized and then pumped into oil or NGLs. The ElectroGrow Gas2Gas system will require at least the following:

1) Development of a recombination chamber as opposed to simple reservoir of oil or NGLs
2) Recirculation of reactor output into a recombination chamber
3) A method of removing propane from the recombination chamber to prevent propane being converted to heavier hydrocarbons, although this may be acceptable/desirable
4) First pass optimization of the recombination chamber via pressure, temperature or other methods in order to optimize the gas to gas yield
5) It is very possible, even likely, that gas 2 gas will require multiple ElectroGrow reactors in a larger system

Anticipated Results:

A field capable system that can convert methane to propane

An economic model based on existing methane to propane conversion rates for potential EOR exploration, should propane show ongoing promise for EOR

A base upon which improved rates of propane formation can be built upon

Facilities:

ElectroGrow R & D facilities

Potential parallel facilities in North Dakota (EERC and/or UND)

Resources:

Physical:

1 ElectroGrow reactor system

Human:

EERC TBD

ElectroGrow design team

ElectroGrow management and project management.

Techniques to Be Used, Their Availability and Capability:

ElectroGrow plasma reactor technology (already proven)

ElectroGrow next generation plasma reactors (in development)

Environmental and Economic Impacts while Project is Underway:

No environmental impacts by design.

Leakage of natural gas or spillage of NGLs is possible if mechanical failures occur.

Fire and or explosion is possible given the presence of high voltage electricity and combustible gases and liquids – this is to be mitigated by following industry standard Class 1, Division 1 Electrical code when designing the ElectroGrow reactor and overall system.

Ultimate Technological and Economic Impacts:

Each extra percentage of increased hydrocarbon recovery via EOR would increase yield of existing wells by 10%, and EOR capabilities on the scale of conventional oil EOR would increase production by as much as 600%.

Propane is likely the only scalable input surfactant available for EOR in the short and medium term, but only if propane can be created on site from methane.

Successful EOR increases the economic value extracted from each Bakken well by 10% per 1% of EOR; the range of possible outcomes extends up to a 600% increased recovery based on conventional EOR.

Increased hydrocarbon recovery per well extends the production lifetime of the Bakken.

Increased hydrocarbon recovery per well increases industry, and therefore tax revenue per well.

Successful fracking EOR will position North Dakota as a leader in the fracking space.

Why the Project is Needed:

EOR is likely only possible in the short term, at scale, with propane because CO2 pipelines from Wyoming will take a decade or multiple decades to get approvals and be built, due to massive public resistance to having CO2 pipelines anywhere nearby.

STANDARDS OF SUCCESS

Standards of Success should include: The measurable deliverables of the project that will determine whether it is a success; The method to be utilized in measuring success; The value to North Dakota; An explanation of what parts of the public and private sector will likely make use of the project's results, and when and in what way; The potential that commercial use will be made of the project's results; How the project will enhance the education, research, development and marketing of North Dakota's oil and natural gas resources; How it will preserve existing jobs and create new ones; How it will otherwise satisfy the purposes established in the mission of the Program; How it will be reporting on the success of the project.

Demonstration of base gas to gas, specifically methane to propane, conversion capability.

Demonstration of the first phase of an ongoing effort by which the yield and efficiency of the methane to propane production process can be improved.

Demonstration that the core system can operate in a field situation as opposed to just under laboratory conditions.

BACKGROUND/QUALIFICATIONS

Please provide a summary of prior work related to the project conducted by the applicant and other participants as well as by other organizations. This should also include a summary of the experience and qualifications pertinent to the project of the applicant, principal investigator, and other participants in the project.

The ElectroGrow design team has extensive experience in designing new systems ranging from its existing nitric acid/fixed nitrogen plasma reactors to past electrical, mechanical and industrial systems of many varieties.

Calvin Liu is a serial entrepreneur. Calvin started as a chip designer for Advanced Micro Devices; worked in the semiconductor and chip design software industries for over a decade including managing Cadence Design Systems' relationship with Taiwan Semiconductor (TSMC). His work as Senior Foundry manager at Cadence including sourcing designs into TSMC from the Cadence Design Foundry (former Westinghouse design team), creating reference design flows for joint Cadence/TSMC customers and joint development and deployment of new technology including optical proximity correction (OPC) for the 45 nm design node. He has since developed a parking app plus mapped all parking regulations for all streets for 5 major cities (New York, Boston, San Francisco, City of Los Angeles and Santa Monica) as well as founded a cybersecurity company (Venture Enterprise Risk Management) in 2016. Calvin founded ElectroGrow based on his original education as an electrical engineer. ElectroGrow was originally created to modernize the Birkelande Eyde process – which uses electricity, air and water to create fixed nitrogen in the form of nitric acid – the modernization process which resulted in the first generation ElectroGrow gliding arc plasma reactor. Methane liquefaction arose when Calvin attended the North Dakota Petroleum Council annual meeting in 2023 and discovered the North Dakota need for something to make use of a large quantity of natural gas production excess to state usage and offtake capacity.

MANAGEMENT

*A description of **how** the applicant will manage and oversee the project to ensure it is being carried out on schedule and in a manner that best ensures its objectives will be met, **and a description of the evaluation points to be used** during the course of the project.*

Project development will be performed on site at ElectroGrow facilities.

Status updates including project execution vs. plan provided to EERC or other designated ND representative at 2 week intervals via Zoom.

Project status will also be contrasted to previous Gas2Liquid and Nitric acid reactor development.

TIMETABLE

Please provide a project schedule setting forth the starting and completion dates, dates for completing major project activities, and proposed dates upon which the interim reports will be submitted.

Start date: after the Gas2Liquid reactor is designed and initially placed in the field for testing (Target October 2025)

The project to develop a pilot machine for field tests at a chemical plant spans 120 business days, from June 16, 2025, to November 7, 2025. The schedule below outlines start and completion dates, major activities, and interim report submission dates. Tasks are organized into five phases, with mechanical design, electrical design, and simulations running in parallel, followed by mock-ups and prototype production. Critical path tasks—power supply procurement, parameter table finalization, and testing—are prioritized, with 7 buffer days allocated to mitigate delays. Milestone dates are flexible to accommodate parallel task adjustments.

Phase	Start Date	End Date	Major Activities
Mechanical Design	06/16/2025	08/05/2025	Drafting, 3D models, documentation; Milestone: 3D models completed (07/23/2025)
Electrical Design	06/26/2025	08/12/2025	BOM, control system integration; Milestone: Control system integrated (07/29/2025)
Simulations & Calculations	06/16/2025	08/26/2025	Parameter table finalization, power supply design; Milestone: Parameter table completed (07/25/2025)
Mock-ups & Testing	07/25/2025	10/17/2025	Material procurement, mock-up production; Milestone: Mock-ups produced (10/17/2025)
Prototype Production	07/24/2025	10/21/2025	Parts manufacturing, assembly; Milestone: Prototype debugged (10/21/2025)
Testing	08/05/2025	11/07/2025	Mechanics/electronics testing; Milestone: Testing reports completed (11/07/2025)

BUDGET

*Please use the table below to provide an **itemized list** of the project's capital costs; direct operating costs, including salaries; and indirect costs; and an explanation of which of these costs will be supported by the grant and in what amount. The budget should identify all other committed and prospective funding sources and the amount of funding from each source, differentiating between cash, indirect costs, and in-kind services. Justification must be provided for operating costs not directly associated to the costs of the project. Higher priority will be given to those projects that have matching private industry investment equal to at least 50% or more of total cost. (Note ineligible activities or uses are listed under OGRP 2.02) **Please feel free to add columns and rows as needed.***

Project Associated Expense	NDIC's Share	Applicant's Share (Cash)	Applicant's Share (In-Kind)	Other Project Sponsor's Share
Development Labor Expenses	$454,782		$194,907	
Detail of Labor Expenses				
R&D Engineer @432 hrs		$71,280		
Lead Mechanical Engineer @432 hrs		$71,308		
Mechanical Engineer @277 hrs		$45,815		
Mechanical Engineer 2 @239 hrs		$39,545		
Electrical Engineer @355 hrs		$58,657		
Simulation Lead @442 hrs		$72,930		
Simulation Engineer @187 hrs		$30,937		
Production Engineer @953 hrs		$157,327		
Technician @150 hrs		$16,087		
Project Management @520 hrs		$85,800		
BOM for Mock-up	$23,800			
BOM for system including Power Supply	$92,624			
ElectroGrow system transport to ND	$20,000			
Field Testing, ElectroGrow			$13,310	
Field Testing EERC	$10,000			

Please use the space below to justify project associated expenses, and discuss if less funding is available that that requested, whether the project's objectives will be unattainable or delayed.

Development Labor Expenses consist of the design, development, analysis and testing associated with the modification of the existing ElectroGrow field version, methane liquefaction system into a field version, methane to propane conversion system. The work outlined will result in a base functional system but will very likely require ongoing refinement for improving efficiency.

Non-Development Labor Expenses are primarily the major hardware components of the proposed ElectroGrow methane to propane conversion system. The majority of this expense is the power supply – a high frequency, high voltage 10 kW power supply. It is possible that the power supply will cost less than the budgeted $60,000 but this cannot be guaranteed until the design is complete. ElectroGrow will make all effort possible to minimize the power supply expense due to this cost affecting capital cost for future mass production.

The second major expense is the transport and setup of the ElectroGrow methane to propane conversion system to North Dakota for field testing. This can only be foregone if field testing is not deemed necessary.

The reason for charging the prototype, entirely to the NDIC is that the resulting system will remain in North Dakota for further research and testing by interested industry partners, EERC and/or UND and other state related interested parties.

CONFIDENTIAL INFORMATION

Any information in the application that is entitled to confidentiality and which the applicant wants to be kept confidential should, if possible, be placed in an appendix to allow for administrative ease in protecting the information from public disclosure while allowing public access to the rest of the application. Such information must be clearly labeled as confidential and the applicant must explain why the information is entitled to confidentiality as described in North Dakota Century Code 54-17.6. Oil and gas well data that is a result of financial support of the Council shall be governed by North Dakota Century Code 38-08-04(6). ***If there is no confidential information please note that below.***

ElectroGrow reactor specifications

ElectroGrow Gas2Gas system specifications

PATENTS/RIGHTS TO TECHNICAL DATA

Any patents or rights that the applicant wishes to reserve must be identified in the application. ***If this does not apply to your proposal, please note that below.***

ElectroGrow reactor specifications

ElectroGrow Gas2Gas system specifications

STATUS OF ONGOING PROJECTS (IF ANY)

If the applicant is a recipient of previous funding from the Commission, a statement must be provided regarding the current status of the project.

No ongoing or past funding.

There is a parallel application for the field version of the ElectroGrow reactors and system for methane liquefaction.

APPLICATION CHECKLIST

Use this checklist as a tool to ensure that you have all of the components of the application package. Please note, this checklist is for your use only and does not need to be included in the package.

☐	Application
☐	Transmittal Letter
☐	$100 Application Contribution
☐	Tax Liability Statement
☐	Letters of Support (If Applicable)
☐	Other Appendices (If Applicable)

When the package is completed, send an electronic version to Mr. Reice Haase at rhaase@nd.gov, and 2 hard copies by mail to:

Reice Haase, Deputy Executive Director
North Dakota Industrial Commission
State Capitol – 14th Floor
600 East Boulevard Ave Dept 405
Bismarck, ND 58505-0840

For more information on the application process please visit:
http://www.nd.gov/ndic/ogrp/info/ogrcsubgrant-app.pdf

Questions can be addressed to Mr. Haase at 701-328-3726 or Brent Brannan at 701-425-1237.